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UNITED STATES NATIONAL MUSEUM

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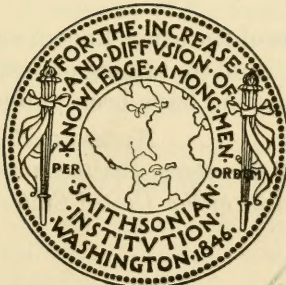
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The scientific publications of the National Museum consist of two series—Proceedings and Bulletins.

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The present volume is the forty-first of this series.

The Bulletin, publication of which was begun in 1875, is a series of more elaborate papers, issued separately, and, like the Proceedings, based chiefly on the collections of the National Museum.

A quarto form of the Bulletin, known as the "Special Bulletin," has been adopted in a few instances in which a larger page was deemed indispensable.

Since 1902 the volumes of the series known as "Contributions from the National Herbarium," and containing papers relating to the botanical collections of the Museum, have been published as Bulletins.

RICHARD RATHBUN,
*Assistant Secretary, Smithsonian Institution,
In charge of the United States National Museum.*

MAY 20, 1912.

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THE STRUCTURE AND RELATIONSHIPS OF CERTAIN ELEUTHEROZOIC PELMATOZOA.

By EDWIN KIRK,
Of the United States Geological Survey.

INTRODUCTION.

As a result of observations covering several years both in the laboratory and in the field, it has become increasingly evident that many of the commonly accepted ideas relative to the habits of the Pelmatozoa are in need of a considerable amount of revision. I have been fortunate in having the extensive collections of Mr. Frank Springer and of the United States National Museum placed at my disposal for study, and the observations made upon this material and embodied in the present paper go far toward establishing the conclusions here set forth. I wish here to express my thanks to Mr. Springer and to Dr. R. S. Bassler for the many favors extended to me during the preparation of this paper, and I am further indebted to Dr. Bassler for help received in the preparation of a number of the illustrations here used. Mr. Austin Hobart Clark, of the United States National Museum, has reviewed my manuscript and has very kindly offered a number of valuable suggestions. Advantage has been taken of these in several instances, and in all cases are accredited to him where used.

The division of the Echinoderma into two grades, Pelmatozoa and Eleutherozoa, clearly reflects the common concept of the Echinoderms as consisting of freely moving forms on the one hand and statozoic types on the other. As a matter of fact no sharp line of demarcation may be drawn on the basis of the relative freedom of the animals, for the Pelmatozoa, or supposedly statozoic echinoderms, show this character to but an indifferent degree. It is probable indeed that we may hold the Edrioasteroidea alone as consistently affixed types.

SYSTEMATIC DISCUSSION.

In the following paper an attempt is made to bring together some of the more important points relating to certain Pelmatozoa that for a part of their lives lead a free or semifree existence. Other forms

that have no jointed column, but nevertheless are attached, usually by a short thick stalk, are likewise discussed. These *Pelmatozoa* in a way are to be regarded as intermediate between the *statozoic* and *eleutherozoic* forms, as regards their mode of life, and may be dealt with to advantage in the present paper. Material throwing not a little light on certain questions concerning these various types has become available and the evidence thus afforded may prove of some interest.

There are many well-known *eleutherozoic Pelmatozoa*, but it seems probable that the assumption of a free or semifree existence has been far more prevalent among these forms than is generally conceded. Aside from the mere enumeration of the *eleutherozoic* forms, a discussion of the structure of the animals is given in so far as this may throw light on their genetic affinities. In some cases where the observed facts seem to warrant the drawing of conclusions in regard to the derivation and relationships of a certain type, this has been done. The assumption of an *eleutherozoic* existence by certain *Pelmatozoa* is of interest as bearing not only on the forms affected, but also on the habits of the *Pelmatozoa* in general. For this reason the influence of an *eleutherozoic* existence on the distribution and segregation of the *Pelmatozoa* has been indicated though not treated in any considerable detail. Finally, a general though brief discussion of the maintenance of such a life among the *Pelmatozoa* in its various aspects is given.

It is here held the *Echinodermata* as we now know them are descended primitively from an *eleutherozoic* stock. The *eleutherozoic* archetype gave rise to a line of descendants among which a sessile habit was gradually assumed. This form of life became deeply ingrained in the fiber of the stock, and has left an indelible impress on the structure of the organisms. When the term "*eleutherozoic stock*" is hereafter used the primitive organisms that had not as yet acquired a sessile habit are meant. Similarly by "*statozoic* or sessile stock" we designate that body of *echinoderms* among which a fixed mode of life was primarily assumed. It may well be that absolute fixation did not obtain in all the phyletic lines of the *Echinodermata*. In the case of the *Holothurioidea* particularly the evidence is highly inconclusive.

A tendency to break away from the sessile *echinoderm* stock and to reassume a free mode of life is to be observed from practically the earliest times to the present. Springing from the early, less specialized *statozoic echinoderms*, certain of these aberrant forms established lines that have been perpetuated as the great classes of the *Eleutherozoa*. It is not within the scope of the present paper to deal with these large groups except in a very general way. In later times, as offshoots from the more highly specialized *Pelmatozoa*, the

eleutherozoic types appeared sporadically, founding, as a rule, short-lived lines that although successful in a small way, had the Pelmatozoan structure too deeply impressed upon them to permit of any considerable deviation from the parent stock.

With the possible exception of the Holothurioidea, we may hold, I think, that such eleutherozoic echinoderms as are known to us have been derived from statozoic ancestors. It is but natural that upon the acquisition of a detached or semidetached form of life changes should begin to appear in the structure of the organism. If given sufficient time, these changes so deeply affect the structure of the animal that it is a very difficult matter accurately to establish lines of descent. This is true to a far greater extent than among those forms that remain attached. Among the latter evolution of adult characters is largely orthogenetic in its tendencies, and it is possible to reconstruct the ancestral forms as well as predict the types to come with a fair degree of certainty. In the case of the eleutherozoic forms, however, we have one newly acquired set of tendencies superimposed upon another set. These secondary tendencies, induced as they are by a form of life widely at variance with that under which the first set operated, tend to vitiate the force of many of the primary tendencies, if not indeed to nullify some of them. In addition certain of these newly acquired tendencies initiate structural changes which diverge widely in their nature from the given line of evolution, and are of such a type as largely to mask and render unintelligible the characters that go to help in determining the genetic affinities of the animal. Such being the case, one's efforts to establish relationships among these aberrant forms are apt to be unsatisfactory at best. In many cases, however, the eleutherozoic Pelmatozoa stand so near the points of inception of their several lines that the problem is not greatly complicated by the presence of altered or superimposed structures.

DIVISIONS OF THE PELMATOZOA.

The Pelmatozoa to be discussed may be divided into three main groups:

I. Those forms retaining jointed columns throughout life, but not using them for permanent attachment.

II. Those forms which at some stage of development permanently lose all or the greater part of their columns, becoming truly eleutherozoic.

III. Those forms that are permanently attached by means of a base of varying composition as regards the constituent elements. No true jointed column is present. The members of this group I shall here style pedunculate forms, for convenience of reference.

This grouping, as well as other classifications employed throughout the paper, is a purely artificial and arbitrary one. The intention is merely to bring such forms together as show a certain similarity in structure, and thus aid in simplifying the discussion of the modifications exhibited by different types.

As might be expected, one genus may contain species that fall under two different groups, as, for instance, *Edriocrinus*, certain species of which belong to Group II and others to Group III. Even a single species may have representatives referable to two different groups. Thus certain specimens of *Millericrinus prattii* may be referred to Group I, while by definition other individuals fall in Group II.

GROUP I.

The group comprising those forms that do not become detached from their columns, and yet, during a portion of their lives at least, are capable of more or less free movement, is a very large one. As a matter of fact, it is probable that the greater part of the Pelmatozoa, with the exception of the Edrioasteroidea and those forms here included in Group II, are safely referable to this assemblage. This is a sweeping statement, but one thoroughly justified, I believe, by the evidence at hand. In referring to an eleutherozoic period during the lives of the Pelmatozoa, one is meant subsequent to the free-swimming larval stage, and after the formation of a column. In most cases, perhaps, this period of detachment from the bottom came at a comparatively early stage in the ontogeny of the animals, and was followed by the reattachment of the organisms. Frequently, however, the animals retained their freedom throughout life. Again, it is probable that in the lifetime of some forms at least there were several alternating periods of attachment and freedom. In the case of some of the Cystidea, it is possible that the animals were never firmly affixed at any stage in their development. In the discussion of this group the Cystidea will be dealt with first, to be followed in turn by the Blastoidea and Crinoidea.

CYSTIDEA OF GROUP I.

It is probable that a large proportion of the Cystidea led a free or semifree form of existence. Many were undoubtedly capable of active movement, while others, attached or unattached at will, were comparatively passive. It is but natural that eleutherozoic forms should be more abundant among the Cystidea than among the Crinoidea or Blastoidea, for they more nearly approximate to the eleutherozoic archetype of all the Echinoderma. With the Cystidea, then, in some cases, the eleutherozoic forms may be considered in the light of organisms which had not yet attained true pelmatozoan fixation. In other lines fixation, though acquired, was such a novel

character and became so irregularly effective that the return to a purely eleutherozoic habit was a comparatively simple matter. In the case of the Blastoidea and Crinoidea, however, the free forms represent aberrant types which have reverted to this type of existence after a considerable period of perfected fixation.

Divisions of the Cystidea of Group I.—The eleutherozoic Cystidea may be divided into three "types" or subgroups for the purpose of convenience:

1. This type is reserved for certain Cystidea which did not have true columns, but when attached at all, were cemented to the bottom by an outgrowth from the body wall. It seems possible from the evidence at hand that certain of these forms were free-swimming or floating organisms, at least during a portion of their lives.

2. In this type are placed those Cystidea provided with a prehensile column which attached themselves at will, probably not by cementation, but rather by looping the distal portion of the stem about some fixed object.

There is a group of Crinoidea directly comparable with these forms.

3. This type includes those Cystidea which propelled themselves along the bottom, making use of their brachioles and possibly their columns as organs of locomotion.

CYSTIDEA, TYPE 1.

In this group are chiefly to be found those primitive, many-plated Cystidea which had not yet evolved a column for purposes of attachment. These are the forms that in this regard represent the connecting link between the eleutherozoic echinoderm ancestor and the Pelmatozoa. With them fixation was a novelty, and in many of the more primitive types, no doubt, was irregularly acquired in the different lines. In some cases a very rudimentary stem seems to have been present, but the possession of such an organ appears to have been an indifferent character at best. The stem apparently might be absent or not, within the limits of a single species, and when present probably functioned in the same way as the stem in those genera referred to Group III.

The genera referred by Bather to the families Aristocystidæ and Echinosphæridæ may all provisionally be placed in this group. Permanent attachment by cementation to the bottom undoubtedly occurred in many forms, at least in the adult stages, and as noted above, rudimentary stems are occasionally present. In many cases, however, it seems probable that the period of fixation, if there were such, was of but short duration and irregular occurrence.

Echinosphæra.—The genus *Echinosphæra* may be taken as characteristic of the group. The conclusions to be drawn from the evidence afforded by this genus may be held to apply with greater or less force to the other forms here referred. *Echinosphæra aurantium*, Plate 1,

figure 11, has a subglobose theca composed of a great number of irregular, polygonal plates. These plates are remarkably thin, and, considering the size of the animal, the skeletal structure must have been exceptionally light. In a Russian specimen of average size the plates measured but 0.25 mm. in thickness. Even this does not represent solid stereom, as the substance of the plates is traversed by innumerable series of radiating tubes. The brachial appendages were no doubt comparatively slender and weak.

In the aboral portion of the theca there is usually a slight projection, which when present doubtless served as a point of attachment for the organism. This protuberance is apparently an evagination of the body wall and seems to be restricted to no closely circumscribed area as to location, other than that it is near the aboral pole. So far as the descriptions of the species are concerned, this projection seems to be constantly present in European specimens. In the American forms, which are apparently specifically identical with the European, the protuberance is apparently wanting at times, but a cicatrix marks its former location. There are signs of resorption and secondary deposition of stereom, indicating that although attached at one time the animals had subsequently become free.

Even when present, this projection, because of its relatively insignificant size, seems quite inadequate as a support for an adult animal. So far as I have been able to see in the specimens I have examined the distal end of the projection shows no signs of attachment such as one would expect to find were the animals cemented to the bottom at the time of their death. Rather, the free end seems irregularly broken, but not exhibiting in many cases the clearly defined angles of a fresh fracture. Furthermore there is no considerable thickening of the plates of the pedicle as preserved and no obliteration of sutures, features that are usually characteristic of that portion of a Pelmatozoan lying in immediate proximity to the point of cementation.

Again, if the adult cystids were attached by means of such a short pillar, it seems probable that the area immediately surrounding the point of attachment would be more or less in contact with the bottom and would show signs of such apposition. This is especially to be looked for in cases where the point of attachment is asymmetrically located at some distance from the aboral pole as in Plate 1, figure 11. No signs of abrasion or contact modifications are to be noted, however.

In other many-plated Cystidea that were unquestionably affixed to the bottom in their adult stages evident signs of attachment are to be observed. An examination of the figures of *Aristocystis*, *Fungocystis*, and *Craterina* as given by Barrande clearly shows the effect of such cementation. In *Aristocystis bohemicus*, Plate 1, figures 1, 2, the animal is cemented to a gastropod shell which it has

almost completely grown over. It is to be noted that the area immediately surrounding the point of attachment is smooth and of quite different appearance than the remainder of the theca. Again in the case of figures 7, 8, which represents the base of another specimen of the same species, as well as in figures 9, 10, where the theca was turned at somewhat of an angle to the plane of the area of attachment, it may be seen that one side of the theca, which apparently grew in contact with some object, is quite smooth. In all these genera mentioned, the area of attachment is large and well defined.

It may be argued that *Echinosphæra* has a column of sufficient length to raise the theca above the bottom and thus preclude the possibility of contact phenomena and other features to be observed in the genera cited above. This argument is inadmissible, however, on various grounds. In the first place the sometimes extremely excentric location of the fragment retained would not permit of such support. Again the extremely small size of the pedicle compared to that of the theca makes such an hypothesis quite untenable.

Were a column to have been acquired by certain forms of *Echinosphæra* it could not have approached that possessed by *Arachnocystis* in degree of specialization. These columns, as figured by Barrande in the case of *Arachnocystis infaustus*, were never of any considerable length, and apparently were never attached permanently to the bottom.

I think that one is justified in concluding that fixation did not obtain in the adult stages of *Echinosphæra*, at least in the majority of individuals. It seems probable that at some comparatively young stage in the lives of the animals fixation by cementation took place. Subsequently the cystids became detached. Occasionally fixation may have persisted throughout life.

In connection with this apparent lack of consistent fixation in the case of *Echinosphæra* must be considered the enormous range of the genus. Originally described from the Baltic region, *Echinosphæra* has been found throughout the United States from the Appalachians to the Rocky Mountains. Notwithstanding its great horizontal range, its vertical range is very small, at least in the United States, where it is restricted to a well-defined zone. Moreover, as mentioned above, the American species is probably specifically identical with the Baltic. *Echinosphæra aurantium* then has quite as great a range as *Uintacrinus socialis*. Such wide distribution argues for a pelagic habit, but one hesitates to apply this explanation to *Echinosphæra*.

One may conceive perhaps that *Echinosphæra* might have been a floating organism. The extremely thin plates and consequent lightness of the animal might well indicate adaptation to such a form of life. The globose theca likewise points in the same direction. The specific gravity of certain Echinoderms is at no time so very much

greater than that of the surrounding medium. A decrease in the weight of the animal, by a reduction of the amount of calcareous matter to the minimum, and perhaps an increase in the buoyancy of the organism, by an inconsiderable accumulation of gas within the body would serve to reverse conditions. Movement of the brachial appendages, however slight, would aid in sustaining the animal.

If *Echinosphæra* were indeed a floating organism, it could have been transported these great distances by current action. Certainly one would not expect the comparatively weak brachioles to perform very great service as organs of locomotion. Nor could the transportation of the larvæ alone account for the wide dispersal of the species. If we attribute such powers of dispersal to the larvæ of *Echinosphæra*, how may we well deny them to the young of closely related types? It scarcely seems probable, though of course it is possible, that this one genus should at that time have had larvæ capable of such widespread dissemination. No other cystids apparently have the range of *Echinosphæra*, as no doubt they would have, were larval distribution the only factor. Furthermore, the fact that the projection by which the animal was at one time attached is, in the adult specimens, generally obscure and at times obsolete is positive evidence in favor of a detached existence. That, subsequent to its detachment, the animal did not remain passive is evidenced by the character of the plates, which show no signs of the theca having rested upon the bottom. It is possible that *Echinosphæra* may have crawled on the bottom by means of its brachioles, but this is doubtful, to say the least. The evident slenderness of the brachioles and their probable lack of specialization indicate that they were not fitted to function as ambulatory organs.

Detachment in other many-plated Cystidea.—As we have seen, certain specimens of *Aristocystis*, *Fungocystis* and *Craterina* show clear evidence of attachment to extraneous objects. Such an attachment was not of universal occurrence, however, as an examination of Barrande's (1887) figures plainly shows. From the evidence afforded by these figures one may postulate detachment of the organism, after a period of fixation. Some of the figures indicate that fixation may never have become effective, but one hesitates to draw such extreme conclusions.

As has been indicated above, a marked localized smoothing of the plates and a complete covering of all pore structure may be noted wherever definite fixation obtains. On the other hand, the presence of pores opening outward may, I think, be held as indicating that those plates bearing such pores were not in contact with some extraneous object. It is held by Barrande and Bather that the openings of these canals to the exterior were covered. Bather describes this covering as probably a hard epidermis, but not a truly calcified

epistereom. The functions of such canals, were they covered either by a calcified layer or by a hard, impermeable epidermis would probably at once be destroyed. It seems probable that the exterior of the theca was covered by an integument of some sort, but of such a nature as to render possible communication between the canals and the surrounding medium.

Be this as it may, it is apparent that a covering of these pores by a secondary deposition of stereom may be looked for at the point of attachment of the cystid or in any portion of the theca that may have been in contact with some foreign substance. Hence, where we find canals opening freely to the exterior we may be sure that at that point the cystid was not attached at the time of its death. It is conceivable that pores once closed by a calcified layer might after the detachment of the organism be reopened by a resorption of the covering substance, and so we may explain certain cases described hereafter. Bearing these facts in mind, it is interesting closely to examine the figures of *Aristocystis* as given by Barrande. Some of the more instructive figures are here reproduced on Plate 1.

Aristocystis.—Figures 1 and 7 undoubtedly indicate cementation and show the normal effects of such attachment. Figures 5, 6, 9, and 10 as well as other specimens figured by Barrande illustrate a modification of structure however. It is obvious from the flattened area at the base of the theca that the animal was at one time attached. From the size of the region of contact one may judge that the specimen was affixed until a late stage in its development. Subsequently, it probably became detached. That we are justified in assuming such to have been the case seems to be shown by the structure of the base. The plates show no signs of secondary stereom, such as would be deposited in case of cementation, and the pores are open. Again, the impress of the object to which the cystid was attached is not clearly defined, as it would be were the animal to have been attached at the time of its death, or for some time preceding.

Figures 5, 6 represent a case in which attachment was doubtless had at an early stage in the ontogeny of the animal. Subsequently an eleutherozoic habit seems to have been maintained. There is no basal impress or flattening to indicate that the cystid was at any time affixed to the bottom, but a slight asymmetry and the presence of a definite apical plate point to this conclusion.

Under the name *Aristocystites? subcylindricus*, which he gives as a variety of *A. bohemicus*, Barrande figures a number of specimens which seem in no case to have been affixed. Barrande noted the uniform absence of basal depressions and wrote as follows regarding the material in the explanation of Plate 13:

Les divers spécimens, que nous avons figurés sous ce nom, semblent se distinguer, d'abord par leur forme allongée, arrondie au bout, et ensuite par la disposition des

plaquettes, qui constituent leur extrémité inférieure. Celle-ci ne présente point la cavité simulante une ouverture, que nous avons figurée en divers spécimens sur la Pl. 12, et qui appartiennent au type: *Aristoc. Bohemicus*.

It is to be noted in the case of these specimens that there is no basal depressed area, no marked asymmetry of the theca, and the plates all show clearly defined diplopores. Furthermore, the central apical plate is sometimes wanting, and when present is frequently fused to one of the circumjacent plates of the proximal ring. The plates are tumid, and fixation may only be predicated at a very remote stage in the ontogeny of the animals. *Aristocystis desiratus* figured by Barrande on Plate 20, figures 1 and 2, indicates a very similar condition of affairs.

Craterina.—In the case of *Craterina* evidence of non-attachment similar in all respects to that just given respecting *Aristocystis* might be adduced, although as a rule fixation seems to have been maintained until a relatively later stage in development. In a number of instances the pit indicating the former area of attachment has tubercles over the surface which obviously could not have been present at the time of fixation, and must consequently have been formed subsequent to the detachment of the animals.

Pyrocystis.—*Pyrocystis* likewise furnishes conclusive evidence that in its adult stage fixation was but irregularly effective. A specimen of *Pyrocystis pirum* figured by Barrande (Pl. 29, II, figs. 23, and 24) shows no signs of having been cemented to the bottom. The base of the theca is rounded; there is no impressed area, and the entire surface is quite strongly tubercular. The assumption of freedom by this type is somewhat remarkable in that the general form of the theca indicates a fairly well established stazoic habit. The marked constriction of the lower portion of the theca which is the precursor of a differentiated pedicle or column, and the symmetrical arrangement of the food grooves point most strongly to this conclusion.

Orocystis.—The placing of *Orocystis* in this group rests upon somewhat uncertain evidence. In a view of the basal portion of a specimen given by Barrande (Pl. 7, fig. 15) there is no sign of a point of attachment. Barrande points out this fact, but says "nous croyons reconnaître sa place." Without an examination of the specimen itself it is impossible to determine the status of the form. The chances are, however, that if the point of fixation were so inconspicuous as not to be indicated in the figure, we are safe in assigning *Orocystis helmhackeri* to the eleutherozoic Cystidea. Fixation if effective in such a form, at least in the adult stage, would leave an unmistakable impress on the structure of the organism. Considering the remarkably fine preservation of the material, any evidence of fixation should be at once apparent.

It is not necessary, I think, to cite further cases of freedom in adult stages among these primitive types. A sufficient number of instances have been given clearly to indicate that an eleutherozoic habit was largely maintained among these many-plated, early Cystidea. It may no doubt be safely assumed that this form of life may be postulated for many such organisms. It may well be that in some instances fixation was effective throughout the life of the animals, but it is probable that these form exceptions to the rule.

It is evident that the members of this subgroup do not exactly fall within the limits of Group I as defined. There is no column unless one considers that such be potentially present. It is in this sense that the forms were classified as they are here found. They could not be listed with Group II where the column had been differentiated and subsequently lost, nor well with Group III; and it did not seem best to create a new group for their reception.

This subgroup is of great interest as containing the first variants from an attached existence. As has been elsewhere noted, the assumption of an eleutherozoic existence by these forms is less in the nature of an abandonment of a statozoic habit as an imperfect acquirement of such a form of life. For this reason these types may be held as truly intermediate between the primitive eleutherozoic stock and the primitive statozoic forms. It by no means follows that these genera are the actual progenitors of the more typical Pelmatozoa, but nevertheless they indicate the stages through which such ancestral types may have passed.

These forms are likewise of great interest as showing that even when the tendency toward a statozoic existence had its inception, a time the tendency should be perhaps in greatest force, reversion to an eleutherozoic habit should have obtained. This shows how vitally the eleutherozoic habit had impressed itself upon the pelmatozoan stock. It is not surprising therefore that in the later forms, when the force of this tendency toward fixation should have somewhat spent its strength, that the assumption of a free existence should have become almost universally effective.

It is somewhat difficult to determine what form of life must have been led by the Cystidea referred to this subgroup. As has been shown in the cases cited above, there is apparently no indication of the animals having rested upon or in contact with any extraneous object. Such being the case we must postulate an existence of such a nature as to render the organisms quite free from contact with the bottom, or else to admit of free motion along the bottom as among the bottom-crawling Holothurians.

As has been argued above in the case of *Echinosphæra*, it seems quite possible that this form at least was freely floating. It may be that in such a case the brachial appendages, feeble though they are,

might be of considerable assistance in determining slight movement. Many of the other forms referred to this group, from the considerable weight of their thecal plates and the generally cumbrous aspect of the body, seem not to be equally well fitted for a pelagic habitat, however. On the other hand, it is impossible to ascribe a sessile form of life to these organisms for the reasons given above.

If a free swimming existence be barred in such cases we have the alternative of comparatively free motion upon the sea bottom. Owing to the rather feeble nature of the brachial appendages one may not consider them as capable of functioning to any considerable extent as ambulatory appendages. In some cases, as in *Protocrinus*, where pseudo-ambulacra are well developed there is a possibility of structures comparable in a degree to the podia of the Echinoidea having been present. Even in the case of the *Diploporita* where numerous vertical canals perforate the thecal walls, it is perhaps not inconceivable that organs of a similar function may have been present. The diplopores themselves in certain cases may have harbored such specialized organs. This hypothesis is not as improbable as it may sound at first. We know that in the earliest echinoids such as *Bothriocidaris*, podia or organs of similar function must have been present. Such a form we may only conceive to have been derived from a line of these many-plated cystids. The chances are, therefore, that podia should be represented in these ancestral forms by similar or equivalent organs. Certain it is that we must postulate organs of locomotion of some sort in the very early common eleutherozoic ancestor of the Echinoderma. Lacking brachial appendages what could be more natural than that some such sort of ambulatory organs should have been present? Upon the assumption of a purely statozoic existence by certain lines of this primitive stock, such organs would in time become eliminated through disuse.

There is an interesting structural feature which is apparently intimately associated with the assumption of a statozoic existence by these many-plated cystids. This is the presence of a definite central apical plate. It is needless to more than mention the lengthy discussion that has been carried on in regard to the origin and homologies of such a plate. Its significance in this particular group of organisms alone will be discussed at this time.

It is to be noted in the case of all figures of the bases of these cystids where the sutures of the plates are visible, that there is a well-defined apical plate surrounded by a ring composed of a variable number of plates. This apical plate seems in all cases to be the center of the area of attachment. One may infer that attachment was had primarily by means of this plate alone. Whether this plate represents a definite skeletal element of any morphological significance is a question difficult of solution. I believe it does not.

Fixation may have become effective so early in the ontogeny of such cystids as to have preceded the formation of a definite skeletal structure. If such were the case attachment would take place at the aboral pole irrespective of plate orientation. Under such circumstances it is obvious that at the point of fixation a plate would be formed, and that the circumjacent plates would of necessity assume a somewhat definite arrangement. Even had fixation occurred subsequent to the formation of definite skeletal elements, it is apparent that the point of cementation must have been a plate, and that this plate must necessarily be located somewhere near the aboral pole. Subsequent to the attachment of the animal, a readjustment of the plates of the basal portion of the theca must have taken place, which would give the proximal ring as we find it. The apparently variable location of the point of fixation seems to preclude the possibility of cementation constantly taking place through the agency of a definite plate.

According to this hypothesis then, the formation of the central apical plate is a secondary matter and entirely dependent upon the fixation of the animal. It may well be that in the phylogeny of the Pelmatozoa this plate might acquire a certain fixed status and be perpetuated as a definite element, perhaps homologous to the terminal ossicle of the pentacrinoid stem of *Antedon*.

CYSTIDEA, TYPE 2.

This group, as opposed to the preceding, consists of Cystidea which have well-developed columns. It is probable that all of the forms here referred were freely moving organisms, during the greater part of their lives at least. Some maintained an erect position, while in the case of other forms we note a tendency toward the assumption of a prostrate habit. This tendency becomes more marked and reaches its maximum development among those forms referred to the next subgroup. The column in all cases probably functioned merely as an organ for temporary attachment. Attachment in this group was apparently never by means of radicular cirri, and seldom by cementation. In the majority of cases the distal portion of the column seems to have been more or less prehensile and it is probable that anchorage was effected by looping this portion of the stem about some stationary object. In all these forms the entire stem appears to have been quite flexible.

Structure of stem in type 2.—The columns possessed by such Cystidea, with the exception of the most primitive types, are essentially similar in structure. The columnals are circular and are of large size next the theca. Distad the diameter of the column decreases rapidly. After a certain point, where the stem is comparatively slender, the column continues to taper, but at a greatly diminished

rate. Measurements of the stem of a *Pleurocystites filitextus* will illustrate these features admirably. The specimen is an unusually large one, and the stem as preserved measures 70 mm. in length. Probably not more than 5 or 10 mm. of the stem is wanting. Possibly the column is essentially complete.

The proximal columnal measures 6.1 mm. in diameter and the most distal columnal preserved 1.2 mm. The stem tapers most rapidly in the first 16 mm. where it decreases from 6.1 to 4 mm. in diameter. Distad from this point the rate of decrease is lower and comparatively uniform. The proximal 16 mm. of the stem consists of short sharply annulated columnals. Distad there is a gradual transition from the short ossicles to comparatively long subcylindrical columnals. These soon reach their maximum length which in this species is 2 mm. Continuing, the ossicles rapidly become smaller and smaller, their length in some instances being a trifle greater than their breadth.

The proximal, rapidly tapering portion of the columns in these forms has a remarkably large central perforation. This seems to be less in the nature of an axial canal than a cavity for the reception of a portion of the visceral mass. Again, it may well be that this cavity lodged the musculature which largely controlled the movement of the column. If we assume the degree of movement that seems to be indicated by the structure of the columns of these forms, we must assume a corresponding high development of muscles to bring about such movement. Such a musculature could not be contained within the narrow confines of the average axial canal. As a result of the large size of the perforation, the walls are thin and this portion of the stem is frequently found considerably flattened. A feature which is not specially noticeable in *Pleurocystis* but which is strikingly shown by *Cheirocrinus* is the mode of articulation of the columnals in this portion of the stem. The arrangement is such that great freedom of motion is possible.

Type of life led.—As indicated above, some of the members of this group maintained an erect position, while others were prostrate. The second type was probably derived from the first, and represents a divergent off shoot comparable in mode of life to Type 3 among the Cystidea, and such a form as *Eleutheroocrinus* among the Blastoidea. There is apparently no parallel case among the Crinoidea. It is to be expected that the different genera referred to one of these divisions will partake to a greater or less extent of the nature of the other. A typical prostrate cystid is *Pleurocystis* while *Glyptocystis* may be chosen as an example of the other division.

Detachment among the erect, stalked Cystidea.—The evidence afforded by the erect types as to the maintenance of an eleutherozoic habit is as a rule inconclusive, but yet convincing. It is probable that a

very large proportion of the stalked Cystidea not included in Type 3 or not otherwise disposed of in the present group may be held as erect, detached forms. Among the more primitive Cystidea, particularly, it seems highly probable that permanent fixation was of comparatively rare occurrence. It is among these more simple types particularly that we are able conclusively to prove nonfixation, for here we have complete columns more frequently preserved. Among the later and more specialized cystids the structure of the column and its marked flexibility, which is frequently made more apparent through a looping of its distal portion, indicates anything but adaptation to a purely statozoic form of life. Wherever the type of column heretofore described as generally typical of the greater number of forms referable to this group is found, I think we may be safe in assuming an eleutherozoic habit.

Arachnocystis.—The most primitive type that may be assigned to this subgroup is *Arachnocystis*, a genus with the highly interesting *Echinosphærites infaustus* of Barrande as the genotype. In this form we have one of the most rudimentary columns known among the Pelmatozoa. In other genera we have evagination of the body wall and marked constriction of the basal portion of the theca, but here is to be found the simplest column that may be called such with justice. In *Arachnocystis* we find that the column has been differentiated to the extent of being composed of a regular vertical series of imbricating plates therein differing from a mere evagination of the thecal wall. Figures 5, 6, Plate 2, give a fair notion of the structure of the column. From the figures given, there appear to be five rows of plates, but according to Barrande (1887, p. 28) there may be five or six ranges. The column is in most cases of marked brevity, none figured exceeding a length of 50 mm. There is in no case where the distal extremity is preserved any indication of attachment by the organism.

The column of *Arachnocystis* must have differed functionally as well as structurally from that of the more specialized members of this group. Although mobile to a certain extent, the column of *Arachnocystis* was not sufficiently slender nor properly constructed to function as a prehensile organ. Subsequent to the assumption of an eleutherozoic habit, which obtained during the adult stages of the animals, such a column could not have been other than a hindrance. The sole service it could render the cystid would be as a sort of ballast. Considering the relative insignificance of the column compared with the bulk of the theca, this function must have been of inconsiderable consequence.

It is evident that this genus has been derived from a type not greatly dissimilar to *Echinosphæra*. The slight protuberance to be noted in that genus has, however, been considerably accentuated.

It seems probable that in these forms attachment was had in the young stages by a central apical plate. Continued fixation eventually caused a considerable constriction of the lower portion of the theca even though attachment did not continue throughout the individual lives of the animals. This condition of affairs has already been noted in the case of *Pyrocystis pirum*. A continuation of the process would eventually result in a definite orientation of the plates comprising the pedicle, and a further differentiation of this portion of the animal.

In *Arachnocystis* is to be noted a very considerable development of the brachioles. These are fairly stout, and apparently have a length of at least twice that of the theca. They are biserial, and either two or three are borne by an individual. Taking into account the probable buoyancy of the animal, it is not inconceivable that these brachioles might have constituted fairly effective swimming organs.

The high interest that such a form holds is due in no small part to the continued activity of a tendency in modifying an animal, even though the conditions of life for which the modifications are fitted are but imperfectly and irregularly effective. A more extended discussion of this topic will be given in a subsequent portion of the paper.

Ascocystis.—In the remarkable genus *Ascocystis*, we have indubitable evidence of the nonattachment of the organism. The column is extremely short, being but a fraction of the length of the theca. It tapers rapidly and apparently ends in a point. There is absolutely no evidence of fixation. This genus is equipped with a large number of brachial appendages which completely encircle the distal portion of the theca. It seems quite reasonable to expect that with its considerable development of brachioles the genus may have been well adapted to a free-swimming existence.

Macrocystella.—Among the earliest of the forms referable to this group, though by no means the most simple, is the curious genus *Macrocystella* which might better perhaps be described as a tricyclic crinoid than as a cystid. Figure 7, Plate 2, copied from Bather gives a reconstruction of this remarkable Upper Cambrian genus. As may be seen, the distal portion of the column is quite slender, and it seems probable that it was used to loop about some stationary object. The characters of the stem agree in all essential respects with those given as typical of the majority of the members of this group.

In connection with the eleutherozoic habit of this type is to be noted the total absence of a column in the case of *Lichenoides*, a genus probably closely allied to *Macrocystella*, and referred to the same family by Bather.

Glyptocystis.—In the case of *Glyptocystis* a detached existence is predicated largely on the basis of the column structure. It is to be

noted that this is one of the few genera to which an eleutherozoic habit has been ascribed by former writers. The column is of the type given as characteristic of the members of this group, and there is no evidence of fixation. In addition to the figures given in various publications I have personally examined and collected a considerable number of beautifully preserved specimens referable to this genus, and in no case have found any evidence of a terminal plate or other structural modification for purposes of attachment. The column is in many instances remarkably short, scarcely exceeding the length of the theca. Probably in no case was it of more than twice the length of the theca. It tapers quite rapidly, and gives evidence of having been unusually flexible.

In *Glyptocystis* the negative evidence of the lack of special adaptation to a prostrate mode of life points strongly to the conclusion that in this genus an erect position was constantly maintained. This fact argues against the derivation of *Glyptocystis* from *Cheirocrinus* as has been suggested by Jaekel, inasmuch as in the latter genus are to be noted marked modifications pointing to the assumption of a prostrate habit.

Lepadocrinus.—The genus *Lepadocrinus* with its curious column is worthy of special mention in connection with this group. In this genus a considerable number of the distal columnals are fused to form an elongate subcylindrical body. (Pl. 5, figs. 6, 7.) There are no signs of cirri, and the distal end of the column is smoothly rounded off. Subsequent to the fusion of the columnals there was a secondary deposition of stereom, causing a marked enlargement of this portion of the column. The resemblance of this fused portion, barring the lack of modified cirri, to "*Ancyrocrinus*" is worthy of note. It seems quite possible that in this instance, as in the case of the crinoid, the fused appendage served as ballast or as a drag. It may be that the distal portion of the column in *Lepadocrinus* was buried in soft mud, but if such were the case fixation must have been of a most precarious sort. Attachment by cementation apparently never took place. It is of particular interest to note an eleutherozoic habit in the case of *Lepadocrinus*, inasmuch as this was the last known representative of the erect, stalked Cystidea.

Evidence of a prostrate habit in type 2.—In many of the genera probably referable to this group we know little or nothing regarding the structure of the column. Owing to this fact we may not with certainty ascribe an eleutherozoic habit to them. It is not until we come to treat of those forms in which the modifications incident to the assumption of a prostrate existence become manifest that we may safely postulate a free existence from the evidence afforded by the theca alone. These changes are, if well developed, unmistakable and of necessity infallibly point to a detached existence.

The more obvious features to be noted are: The acquisition of a marked asymmetry, the theca being differentiated into an upper and a lower surface; the localization of pore-rhombs on one (the upper) surface; the atrophy of certain food grooves; and finally the shifting of the anal opening to the extreme proximal portion of the theca. These features may be present in varying degrees, and are usually accompanied by characteristic minor phenomena. It is to be noted that these modifications are even more characteristic of those forms constituting type 3. There, however, the same results are often attained by different methods.

Dendrocystis.—In *Dendrocystis* we have a very primitive type which may well be referred to the prostrate division of this group. A close comparison of the figures given by Barrande shows that we may differentiate between an upper and lower surface of the theca. Moreover, the anal aperture has been carried well backward, and is situated in the extreme proximal portion of the theca.

But a single brachiote is borne by the animal. This is remarkably stout, and doubtless served in the propulsion of the animal. It has been considered by Barrande and others that this organ is a closed tube. Bather, on the other hand, believes that a ventral groove was present, which is as a rule closed by the apposition of the lateral rows of plates forming the brachiote. It seems highly probable that the latter view is correct.

The theca of *Dendrocystis* is composed of a great number of irregularly arranged plates. Nevertheless it seems possible to distinguish an upper and lower surface. Barrande's figures indicate rather diverse structural conditions, which may be due to actual variation within the species, or, what seems fairly probable, to the fact that there are two species represented. For this reason and because of the fact that I have been able to examine but indifferent original material, I am unwilling to draw other than tentative conclusions in regard to the form.

The column in its proximal portion is made up of a great number of irregularly arranged plates. Distad the plates become larger, and a more definite arrangement is to be noted. The greater part of the column is slender and composed of a double series of elongate, alternating plates. This arrangement indicates a considerable degree of flexibility. Such a column could not have been effective other than as an organ by which temporary attachment might be had through the looping of its distal portion about some stationary object.

Before discussing the typical prostrate form *Pleurocystis*, attention should be called to a few genera that show a more or less clearly defined tendency toward the assumption of such a form of existence.

Such types are *Erinocystis*, *Amygdalocystis*, and *Cheirocrinus*. All these cystids may be held as eleutherozoic forms, and the further assumption of a partially perfected prostrate habit rests largely on the evidence of such structural modifications as have hitherto been cited as characterizing such a form of life.

Amygdalocystis.—*Amygdalocystis* has an unusually short and feeble column which generally gives evidence of having been looped. The probable proximal ancestor of the genus, which is as yet undescribed, is a subcylindrical form with three food grooves. The flattening of the theca and the atrophy of one of the food grooves, as well as the nature of the column, seem to point to the assumption of a prostrate form of life. One has difficulty in explaining such a compression of the theca on any other basis. A spherical or subcylindrical type, if an erect position be constantly maintained, will tend to give rise to a line in which the radial symmetry is made more and more perfect. The almost equal convexity of the two sides, as shown in *Amygdalocystis* and *Platycystis*, would seem to indicate at least that the animal did not constantly rest on one side, even were a prostrate condition maintained.

Erinocystis.—This tendency toward the assumption of a prostrate condition is quite marked in the small group to which Jaekel has given the name *Erinocystis*. This genus was short-lived and apparently left no descendants. *Erinocystis* illustrates modifications which are of considerable interest in that they differ in a marked degree from those to be observed in the other types to be discussed.

In such a form as *Erinocystis volborthi*, Plate 2, figure 3, a marked asymmetry is to be noted. One side of the theca is decidedly flattened. The lower flattened side of the theca is well shown in figure 8, Plate 2, which illustrates a closely allied type, *Echinoencrinus angulosus*. The anal opening has been carried outward and backward to a marked degree and is situated at the end of an extraordinary projection of the theca formed by the hypertrophy of certain of the calycal plates. This lateral backward extension of the thecal plates is especially to be noted in the case of *Erinocystis angulata*. The column, as may be seen in Plate 2, figures 3, 8, is of the general type characteristic of the group as a whole.

Cheirocrinus.—In the genus *Cheirocrinus* we find imperfectly developed the same general modification to bring about a flattening of one surface of the animal that is to be noted in *Pleurocystis*. This flattening, instead of being acquired through the readjustment and modification of plates already present in the theca, is obtained through the excessive multiplication of circum-anal plates. If this multiplication of plates be continued, it is obvious that one side of the theca will in time largely be composed of such

plates. Such is the case in *Pleurocystis*, where the definite skeletal elements are restricted mainly to the upper surface and extend below as a rule only as marginals.

In *Cheirocrinus* this process has not been carried so far, but in such a form as *Cheirocrinus penniger* (Pl. 2, figs. 1, 2) it is to be noted that there is an appreciable flattening of the theca and a remarkable enlargement of the circum-anal area. *Scoliocystis* seems to show an intermediate stage in the evolution of this type of structure, comparable in degree with that shown by *Cheirocrinus walcottii*.

Pleurocystis.—*Pleurocystis* undoubtedly led an eleutherozoic existence, and one, as elsewhere suggested, quite at variance in certain respects with that to be found in the case of most of the detached Pelmatozoa. All the structural evidence afforded by the genus points clearly to the assumption by the form of a purely prostrate habit. For this type of life *Pleurocystis* is only excelled in the perfection of its adaptation by the members of the next subgroup, which doubtless represent the constant assumption of this sort of existence for a long period of time.

An examination of specimens of *Pleurocystis*, or even of figures, such as figure 4, Plate 2, and figure 3, Plate 3, will clearly show the extent of these modifications. The marked asymmetry of the genus which can only be accounted for on the basis of the assumption of a prostrate habit, is a most peculiar and striking feature. One notes the extreme flattening of the anal (ventral) side and the strong convexity of the antanal side; the atrophy of all but two of the food grooves; the location of all the pectini-rhombs on the dorsal convex side; the extreme posterior location of the anal opening; the fact that the column is constantly coiled in the same plane as that of the flattened theca; and other characteristic features. All these facts point to the same conclusion.

A free or semifree type of existence could be of little benefit to an animal were it not for the possession of organs of locomotion. Possibly the brachioles of *Pleurocystis* might have been used in somewhat the same manner as the flagellæ of certain Protozoa. By a lashing or rowing motion of these organs it is quite conceivable that locomotion might have been effected. The brachioles are too long, slender, and flexible to function as ambulatory appendages, but they may have caught the bottom laterally and in this way have served as organs of propulsion. The column in this group probably in no case helped give impetus to the animal's movements as seems to have been the case in the next subgroup.

The column of *Pleurocystis* is comparatively short and quite stout in the proximal portion. Distally it tapers rapidly until it becomes remarkably slender, Plate 3, figure 3. The distal two inches or so of

the column are, in all cases that have come under my observation, somewhat coiled. In two or three specimens that I have examined there could scarcely have been more than half an inch of the distal portion of the columns lacking. Possibly the stems were complete. In no case was there the slightest trace of rootlets, and no evidence of a distal basal expansion such as is common among the Crinoidea. The evidence seems to point to the conclusion that *Pleurocystis* was never firmly rooted to any one spot but anchored itself by hooking the tenuous distal portion of its stem about some extraneous object.

The analysis of the theca and the figures of *Pleurocystis* as given by Jaekel and Bather are inaccurate in several important features. Plates 1 and 4 as given by them should be split vertically and portions united with 2 and 3. Plate 13 is not present in the cup, the apophyses of Plates 12 and 14 uniting without the intervention of another plate. This plate was present in very primitive types but was crowded out subsequently. A full discussion of this subject will be given in a paper which treats in detail of the Pleurocystidæ. In the present paper it was thought best rather to illustrate an actual specimen than to give a reconstruction. It will be noted that the structure of the column is quite different from that given by either Bather or Jaekel.

The marked asymmetry of *Pleurocystis* is unquestionably secondary. What the ancestral erect cystid was like is an interesting question. Bather, in Lankester, derives *Pleurocystis* from *Cheirocrinus* and places both genera in the subfamily Glyptocystidæ. I am personally inclined to derive *Pleurocystis* from a form having essentially the structure of *Echinoencrinus*. This genus is not the ancestor of *Pleurocystis*, but both were probably derived from a common ancestor not far removed.

CYSTIDEA, TYPE 3.

We have here probably the most aberrant type of evolution to be found among the Echinoderma, and one which in the nature of things, one would least expect. To find among the Pelmatozoa a group of organisms that are perhaps more highly specialized for purposes of locomotion than a large proportion of the Eleutherozoa is a novel experience. So unlike Echinoderms are they in certain respects that some of them have been described as Crustacea, which indeed they closely simulate. The members of this group moved actively over the bottom, using both column and "brachioles," when present, as organs of locomotion. In this regard, they may be looked upon as going a step beyond that reached by type 2, and are closely comparable to *Eleutheroocrinus*. The departure from the beaten path seems to have been quite successful, for these types range from the Cambrian to the very latest cystid appearance in the Devonian (Oriskany).

There is a general unity of structure among these forms that strongly argues for a monophyletic origin of the group. In all, the theca is flattened on one side and more or less highly arched on the other. The theca is elongate and comparatively narrow. The stem is large in the proximal portion and tapers rapidly distad. It is short and composed of a double row of curiously imbricating ossicles Plate 3, figures 1, 5, 6—a feature which gives the column great flexibility. The brachioles when present are two in number and comparatively slender, reminding one strongly of the jointed appendages of the Crustacea. No pore-rhombs are present. A more detailed description of the structural features which characterize the group will be found under the discussion of the different genera.

In the discussion of this subgroup a somewhat unusual treatment will be accorded the forms. Owing to the remarkable modifications exhibited by the members of the group and the evidence of their having lived quite differently from the majority of the cystids, it has been thought best to treat of the best known and more specialized forms first. *Anomalocystis* as representing the terminal member of a highly specialized line, necessarily possesses the most striking adaptations to the form of life which had been assumed by the group as a whole. For this reason it is possible to predicate with a fair degree of certainty the habits of the animal. Whatever type of life obtained in the case of *Anomalocystis* we may be fairly sure was possessed to a certain degree by the other forms referred to the group. Furthermore, by taking the most complex form first, we may note its modifications and trace more or less perfectly the steps by which they were brought about.

Anomalocystis.—The genus *Anomalocystis* was founded by Hall (1859, p. 132) with the Helderbergian cystid *A. cornutus* as genotype. In the same volume he refers another species *disparilis*, from the Oriskany, to the genus. As a matter of fact the generic description as given by Hall is based upon both species. Bather in Lankaster, refers *cornutus* doubtfully to *Ateleocystis*, Billings, and *disparilis* to *Placocystis*. Were *Anomalocystis* and *Ateleocystis* proved to be the same, it is doubtful which name should hold. According to the date of publication, it seems that *Ateleocystis* had precedence. Billings himself, however, in describing the genus (1858, p. 72) says: "Should it be ascertained hereafter that the two genera are identical, this species must be referred to *Anomalocystis*, which has the precedence." In this case, Hall had sent out advance sheets containing a description of the genus, which antedated Billings's publication. If these advance sheets are to be recognized, the date of *Anomalocystis* must be shifted back a year or more.

It may be held, I think, that *A. cornutus* and *A. disparilis* are congeneric. Indeed there is no good reason why the later type

should not have been a lineal descendant of the earlier Helderbergian form. I have examined a very considerable series of both species and although as a rule the specimens of *A. cornutus* are in an unsatisfactory state of preservation I feel that this is a safe assumption. Furthermore it may be, as is held by Bather, that *disparilis* and the forms referred to *Placocystis* are congeneric. I personally feel that this is not the case, there being sufficient difference in the arrangement of the plates to warrant a generic distinction being made. *A. cornutus*, on the other hand, I feel quite certain is distinct from *Ateleocystis*. If this be the case and if *cornutus* and *disparilis* be congeneric *Placocystis* must of necessity fall into synonymy with *Anomalocystis* providing Bather's stand be well taken.

The following description is taken mainly from *A. disparilis* of which figures are given on Plate 3, figures 9 to 11. *Anomalocystis* has an elongate theca highly arched on one side, and flattened-concave on the opposite side. The distal portion of the body is less highly arched and broader than the proximal. Lying on the flat side, without any appendages, the whole body slants downward toward the distal end.

It is to be noted that lying in its natural position, the greater portion of the lower side does not come in contact with the surface upon which the theca rests. Rather the body rests upon the downward produced edges of the theca, which act as runners. In *Placocystis*, Plate 3, figures 1, 2, an interesting variation is to be noted. Here the body is raised above the bottom by means of a central, longitudinal keel, which passes well forward from the base of the theca. There are apparently no lateral produced edges. These runners are of obvious advantage in minimizing the amount of friction to be overcome by the animal in pushing along over the sea bottom. It is to be noted in the case of *Anomalocystis* that the lateral keels are most strongly developed in the posterior portion of the theca, and it is largely due to them that the body is given the forward tilt that is so noticeable when a specimen is laid upon a flat surface.

The anterior (distal) portion of the theca presents structural features not paralleled in any other group of the Cystidea. The body terminates rather abruptly, and in the face thus formed there is to be found an elongate opening. This opening is oblong, with the long axis parallel to the flattened base of the theca. The opening is but a trifle less than one-half the breadth of the anterior end, and is approximately twice as broad as high. It seems possible, as will be subsequently pointed out, that this terminal aperture harbored both the mouth and anal opening. The margin of the theca below the mouth projects somewhat forward, this projection being largely formed by a median plate on the bottom of the theca. This plate is better developed and possibly was of great importance to the

organisms among the older representatives of the *Anomalocystidæ*. In the dorsal surface of the theca the margin projects but slightly over the terminal aperture. In some cases it is practically flush with the opening. Laterally the margin is considerably extended, forming an appreciable overhang. This invagination of the margin for the length of the aperture is quite marked.

There is a very interesting structure connected with the thecal opening that has apparently not hitherto been observed. This is a sort of trapdoor or flap that depends from the upper margin of the opening. The composition of this flap may not be determined with certainty. In two specimens where preserved it is somewhat raised, and projects beyond the margin of the theca. It maintains its shape, which is that of the aperture, perfectly. This fact and other evidence relative to the hinging of the structure would make it appear that we have to deal with a solid plate. This may have been formed by the fusion of a number of small plates, however.

It is evident that the function of this plate was to close the terminal aperture. On the lower surface of the plate and running longitudinally across it near the outer margin, is a pronounced ridge. When the plate is dropped this ridge rests on the inner floor of the opening. The portion of the plate anterior to the ridge fits over the lower margin of the theca, and the opening is tightly closed. The invagination of the margin above the opening seems not to be without a reason, for if the margin projected uniformly across the anterior end it would be impossible for this plate to be completely raised.

The mechanics of the operation of this plate are comparatively simple. A specimen from which the dorsal surface has largely been removed shows the interior of the distal portion of the theca quite clearly. On either side of the opening is a process which extends to the top of the aperture. On these processes the plate was no doubt hinged. On the floor of the theca are two deep longitudinal pits. These probably served as the points of attachment for the muscles that raised and lowered the plate.

The lateral appendages of *Placocystis* and *Anomalocystis* are a peculiar and special modification. By Haeckel (1896, p. 40) they have been restored in the case of *Placocystis* as true brachioles. Bather (1900) considers that such an appendage "may have served as an arm, i. e., as the bearer of a tentaculate extension of the water system, and of a ciliated path to the mouth." So far as may be observed, these appendages show no signs of being jointed, and in the case of *Placocystis*, on the authority of Bather, may reach a length of two-thirds that of the theca. In *Anomalocystis* the appendages seem to have been considerably shorter. The spines, as Bather styles them, are somewhat curiously articulated at the distal angles of the theca.

Each of these appendages, I believe, may be looked upon as a modified marginal plate. The spine has no communication with the interior and the musculature which controls its movements is external. The muscles were doubtless lodged in the lateral, somewhat depressed areas on either side of the terminal opening. The spines, as I shall subsequently point out, almost certainly had no other function than to raise the adoral portion of the body. It seems possible, further, that they may have functioned to some extent as ambulatory organs.

The structure of the column is but imperfectly known. It apparently is not essentially different from that possessed by other members of the group, however. It is composed of two longitudinal series of ossicles. In the proximal portion of the column there seems to be a semifusion of the apposed half-segments, resulting in the formation of complete rings. That this fusion has been but imperfectly acquired is shown by an individual in which the column is broken. In this case the line of fracture clearly indicates the original longitudinal division of the stem. The column in its proximal portion is of large size, but apparently tapers rapidly distad. The stem ossicles are remarkably thin and this gives the column a relatively enormous central perforation. This cavity probably lodged the muscles that controlled the movements of the column.

The articulation of the column with the theca is of considerable interest. It is to be noted, as shown in figure 11, plate 3, that the cavity within which the proximal portion of the column is lodged is quite deep and socket-like in its conformation. All available evidence points to unusually free motion of the column within this cavity, both laterally and vertically. Taken in conjunction with the great flexibility of the column itself, and the evidence of a highly developed musculature, it is evident that the stem was capable of a great range of movement. All these facts point strongly to the conclusion that the column had very special functions, quite different from those normally assigned to the pelmatozoan stem.

A brief discussion of the habits of this type as they are believed to have been will illustrate clearly the probable functions of the various parts and the reasons for the modifications to be noted in the gross structure of the organism. It is believed that the animals propelled themselves along the bottom by means of their column. This was pulled forward, elevating the posterior portion of the theca; pressure was then exerted which drove the animal forward. It is here that we see the probable use to which the anterior appendages were put. With the posterior portion elevated and a forward pressure applied it is obvious that the tendency would be to drive the adoral part of the animal into the sediment of the bottom. However, were the anterior appendages to be slightly drawn inward so as to elevate the anterior portion of the theca somewhat above the

bottom, this forward movement would result simply in sliding the animal along the bottom instead of burying it. While in motion it is probable that the flap, which has been described above, was pulled down. This covered the anterior opening and prevented the intrusion of undesirable matter.

The feeding habits of *Anomalocystis*, as indicated by the structure of the animal, seem to be peculiar to itself and the associated forms referred to the subgroup, at least among the Pelmatozoa. Lacking food-gathering appendages, it is obvious that food must have entered the mouth directly. It seems highly probable that when feeding, the terminal aperture was kept open and the animal without elevating the adoral portion of the theca pushed itself along the bottom. By this process the cystid could fill itself with bottom ooze, in which its food was contained.

Trochocystis.—*Trochocystis*, which may be considered the most simple known type and perhaps constitutes the radicle from which sprung the remaining genera of the group, is a Cambrian genus described by Barrande. The various interpretations of the genus given by Jaekel (1901), Haeckel (1896), and Bather (1900), are so diverse that one with no more evidence than is afforded by figures alone feels a considerable degree of hesitancy in coming to any definite conclusions regarding the form. This is unfortunate, for upon the correct interpretation of this genus depends to a great extent one's ability fully to comprehend the origin of certain structures to be found in the later types. The uncertainty relative to the structure of *Trochocystis* is to a great part due to the preservation of the specimens, which occur largely as molds, and as such they have been figured. The difficulties attendant upon the elucidation of such material are very great, and are almost insuperable when one has but figures to deal with.

In *Trochocystis* we find the theca flattened, indicating the assumption and probably fairly long maintenance of a prostrate existence. The two surfaces of the theca are composed of a great number of polygonal plates which are surrounded by 12 comparatively massive marginal plates. A dorsal and ventral surface may apparently be distinguished, both through the relative number of plates comprising the two sides and by the relative extent to which the marginals take part in the structure of the two areas. Aborally the marginals pass insensibly into the column, which is composed of a double alternating series of plates. (Pl. 3, fig. 5.)

It is probable that the stem in *Trochocystis* was far less specialized in function than the equivalent organ in later forms. Owing to its structure, considerable freedom of lateral movement was made possible, but even this is due to the flexibility of the column itself. There was but little or no play at the junction of the column with

the theca. As a result, the possibilities of vertical movement were far more limited than in the case of the later types. It seems reasonable to expect that even in *Trochocystis* the column performed no slight service in the propulsion of the animal. If Jaekel (1901) be correct in assuming the presence of marginal ambulacral structures it might follow that movement was to some extent performed by brachioles or their equivalents. The presence of food-grooves in this type I feel is far from proved, however.

In numerous figures given of *Trochocystis* by Barrande (1887) is to be noted a curious central distal plate, of which an enlargement is here given on Plate 3, figure 4. This plate is at times extended beyond the theca, and at times folded down apparently covering the central anterior aperture. The structure of this plate and its apparent relation to the theca at once suggest a function similar to that of the hinged plate described in the case of *Anomalocystis*. It seems probable indeed that we are here dealing with homologous structures. If such be the case, the surface to which the plate is hinged in *Trochocystis* corresponds to the dorsal side of *Anomalocystis*.

Concerning the terminal openings of *Trochocystis* but little can definitely be said. There certainly is a central aperture corresponding essentially with that of later types. Barrande (1887), Haeckel (1896), and Bather (1900) state that there are two other openings, one on either side of this central aperture. Jaekel (1901) admits of but one other opening, to which he claims the ambulacral grooves run, thus proving it to be the mouth. Doubtless the question will not be settled until someone makes satisfactory impressions from external molds. It would seem more reasonable on the whole to consider the central opening the mouth, although this view is at variance with the stand taken by former writers who have presumably had an opportunity to study good material.

Mitrocystis.—In *Mitrocystis*, Plate 3, figures 6–8, is to be found a type intermediate in structure between *Trochocystis* and the later genera of the group. In all essential details the genus approximates more nearly to the later forms than it does to *Trochocystis*.

There is to be noted a marked differentiation into an upper (dorsal) and a lower (ventral) surface. In the ventral surface there has been a very considerable consolidation of the plates, the number of those inclosed in the circumference of the marginals numbering but a half dozen at most. The dorsal surface is still composed of numerous irregularly arranged plates, although they are fewer in number than in the case of *Trochocystis*. Bilateral symmetry in respect to a vertical longitudinal plane is as yet scarcely appreciable.

Perhaps the most notable structural difference between *Mitrocystis* and *Trochocystis* lies in the fact that *Mitrocystis* has but a single terminal aperture, therein agreeing with the Silurian and

Devonian genera. The uncertainty that obtains relative to the nature of the openings of *Trochocystis* has been noted above. Whatever be the structure in that genus, it is quite certain that we have here an aperture that represents the confluence of the openings of *Trochocystis*, if, indeed, there be more than one. It is interesting to observe the presence of the central, hinged plate in the case of *Mitrocystis*. In Plate 3, figure 8, which represents the under (inner) surface of the plate, there are to be noted several longitudinal ridges. The grooves between these ridges may well represent the points of attachment for the muscles that move the plate.

The column of *Mitrocystis* seems to be in all essential regards quite similar to that possessed by the later genera referable to the Anomalocystidæ. Bather (1900, p. 51) describes it in part as follows: "Stem of about four alternating rows of plates, often provided with thorn-like processes." Barrande's figures do not seem to justify this portion of the description. The column apparently is composed of the normal, double row of ossicles, which seem to be apposed in many cases instead of alternating. In some instances indeed partial fusion seems to have taken place, such as has been described in the case of *Anomalocystis*. The thorn-like processes described by Bather are supposed to be shown in Plate 3, figure 6, which is copied from Bather (1900), who in turn copied it from Barrande. These processes, I believe, are more apparent than real, and are due to the preservation of the specimen rather than to the actual structure of the column. Other specimens illustrated by Barrande show no signs of such spines and agree with allied genera in this regard. It is evident, I think, that in the case of this specimen the substance of the plates has been removed and the processes, if they represent anything, are ridges of ferruginous matter deposited by infiltration in the stem cavity and between the segments.

The articulation of the column with the theca in *Mitrocystis* represents a decided step in advance over the structure shown in the case of *Trochocystis*. There is apparently a fair invagination of the proximal portion of the theca for the reception of the column, and the stem may well have had considerable freedom of motion both in a horizontal and vertical direction.

General discussion of type 3.—There are several other genera referable to this group, but inasmuch as they exhibit no special modifications of structure other than those shown by the forms described, it has not been thought best to include them in the present discussion.

The essential unity in structure shown by the genera referred to this group is notable and argues strongly in favor of their monophyletic origin. Derived no doubt, as suggested by Bather (1900), from a form not widely dissimilar to *Aristocystis*, a prostrate habit of life was early assumed and constantly maintained. In consequence the

changes to be observed in the evolution of the group all tend in one direction—toward the perfection of the type for a prostrate, eleutherozoic life.

There is one structural feature of considerable importance concerning which we have insufficient information. That is the location of the anal opening. According to all writers except Haeckel (1896) this opening is adoral in position. Haeckel in *Placocystis* locates it on the ventral surface of the animal at the junction of the column with the theca. As a matter of fact, considering the high degree of specialization to be found in this group, one would naturally expect an adcolumnal location for the opening, which would only be consistent with modifications to be observed in the case of other prostrate, actively moving Cystidea. If the anal opening in *Trochocystis* actually be adoral, then I feel that we may well postulate the same position for it in the case of the later forms, however. It is quite inconceivable that between *Trochocystis* and *Mitrocystis* this opening should have shifted from the distal portion of the theca to its extreme proximal extremity.

General discussion of the Cystidea of Group I.—Consideration of the facts as here presented in regard to the stalked Cystidea indicates that an eleutherozoic habit was maintained among these forms from the earliest times down to their latest appearance. Indeed, it will be noted that the last cystid of which we have a record, *Anomalocystis disparilis*, of the Middle Devonian, is the most highly specialized of all the eleutherozoic Cystidea. The list of genera given above might be increased appreciably. A sufficient number of forms have been cited, however, to indicate the widespread acquisition of this form of life among the most diverse groups of the Cystidea. We know, indeed, that a few stalked cystids, particularly in the Silurian and Devonian, were permanently affixed by cementation of the distal portion of their columns. The majority of the cystids, I think we may be safe in assuming, were detached at least for the greater part of their existence, however.

This almost universal freedom among the cystids is of particular interest as apparently in no wise impairing the acquisition of symmetry and structures supposed to characterize a stazoic existence. The reason for this is no doubt that in most cases freedom among these forms merely represents non-attachment. For the greater part of their lives the animals, though free, were but slightly less sessile than cemented or rooted forms. The obvious advantages and, indeed, the necessity for postlarval free stages and their bearing on the ecology of the organisms is much the same as that among the Crinoidea. A discussion of this phase of the question is given in the case of crinoids, and most of the statements there made are equally applicable to the present types.

BLASTOIDEA OF GROUP I.

In the case of the Blastoidea, evidence relative to the maintenance of an eleutherozoic habit by the stalked forms is quite limited owing to the fact that specimens with the columns preserved are seldom found. In the case of *Pentremites*, however, a considerable number of individuals are known the columns of which are essentially complete. In these specimens it is to be noted that the stems are short and in the distal portion taper rapidly, apparently coming to a point. Weak radicular cirri are present and extend for a short distance up the column. It may be held, I think, that in this genus permanent fixation by the adults did not obtain.

Whether we may extend this conclusion so as to apply to the remainder of the Blastoidea, it is impossible to say. Considering the extreme type of an eleutherozoic habit maintained by certain Blastoidea such as *Eleutheroocrinus*, it would seem that there was a decided tendency among the members of this class toward the assumption of a free mode of life. This fact and the considerable acquisition of an eleutherozoic habit by the Pelmatozoa in general point strongly to the conclusion that among the Blastoidea a detached existence was largely maintained. The evidence afforded by the distribution and segregation of the Blastoidea argues quite as strongly in support of this conclusion as in the case of the Crinoidea, where this phase of the subject will be fully discussed.

CRINOIDEA OF GROUP I.

To put upon a firm footing the statement elsewhere made that the great majority of crinoid types have at one time or another, subsequent to the formation of a column, been free and capable of moving about at will, is not an easy matter. In the very nature of things the statement is incapable of absolute demonstration. The evidence in support of the contention is of two sorts. In the first place we have positive evidence as afforded by individuals in which the column is complete and shows no signs of attachment. We also have the less satisfactory evidence given by residual roots which in some instances probably indicate detachment during the life of the crinoids—whether voluntary or not we may but conjecture. On the other hand we have the more or less indirect evidence afforded by the facts of crinoid distribution and segregation. It will be unnecessary to go fully into this phase of the subject. Such facts as we have may only satisfactorily be explained, I believe, on the assumption that post-larval migration plays a part of considerable importance in the lives of the Crinoidea.

The number of stalked genera referable to the Crinoidea which were and are truly eleutherozoic during the greater portion of their lives is quite large. Inasmuch as we can only certainly postulate

such a condition of life for these forms in which we have the distal portion of the stem preserved and showing no signs of permanent fixation, it is surprising that the list is as long as it is. Were complete columns more frequently found, our list would no doubt be materially increased. In addition to those forms which from having examined complete individuals we know not to have been cemented or rooted to the bottom, we may reasonably ascribe a similar existence to many more. The reasons for such reference will be given subsequently under the discussion of the various forms. Not only are many crinoids to be considered as eleutherozoic for the greater portion of their lives, but also a far greater number are to be considered as having occasional periods of freedom during which migration is possible. In this category are probably to be placed the majority of Crinoidea.

General classification of the Crinoidea of Group I.—For convenience of reference we may divide the detached stalked Crinoidea into two groups and later subdivide these. On the one hand we have those crinoids that for the greater part of their lives are not attached to the bottom by a root or by cementation. These forms may be capable of voluntary locomotion at will, without an attendant disruption of the column. On the other hand we have those crinoids that are normally firmly affixed to the bottom, which at irregular intervals, governed no doubt by external conditions, break or are broken loose from their basal attachment and in some cases swim about freely. It is obvious that these two divisions are arbitrary at best, and differ in degree rather than in kind. In one case after a period of attachment the crinoid becomes free and thereafter remains so, barring accidental fixation. In the other case the crinoid has alternating periods of freedom and fixation. It is probable that in both divisions detachment becomes irregularly effective in different individuals, dependent no doubt on the conditions under which the particular form lives.

The crinoids that are free for the greater part of their existence may be divided according to their mode of life. Most of the types may be considered as vagile or vagrant benthos. Some undoubtedly were epi-plankton, while at least one genus may well be classed as a true plankton. In the latter cases perhaps the first step in the evolution of the forms away from the sessile stock was the assumption of a type of existence approximating to that of a vagile benthos. Gradually the exigencies of this life may be seen to have induced modifications of structure either tending toward greater freedom of movement or toward a better control of movement. As by far the most striking example of the first type of modification we may take *Scyphocrinus*, hereafter discussed, the float of which has been variously described as *Camarocrinus* and *Lobolithus*, not to mention its reference to the Echinoidea. As an example of the second sort,

the whorls of cirri of the Pentacrinidæ and other forms may be cited. The attachment of certain Crinoidea to floating bodies by which they are carried from place to place might perhaps be expected of the very young stages, but that this epi-planktonic existence should largely be assumed by certain adult forms, as we know it to be, is surprising, to say the least.

The vagile benthos.—In discussing the group of vagile benthos it may be well to deal first with those forms which from structural evidence we know to have passed a very considerable portion of their lives as detached organisms. This evidence consists either of the possession of specialized organs adapted to the maintenance of an eleutherozoic existence or a lack of special organs fitted for the permanent attachment of the crinoid.

Although permanent fixation does not become effective among these types, it is obvious that the ability to attach themselves temporarily would be of considerable advantage to the crinoids. Even among those forms referred to Group II active swimming periods are apparently of irregular occurrence and of but brief duration. Having located in some favorable spot, the crinoid needs a slight anchorage to maintain its position, as it tends to be changed by current or wave action. To meet such conditions we find various modifications, and a rough grouping may be made on the basis of similarity of such structures.

Types of temporary fixation among the vagile benthos.—Three types of temporary attachment may be recognized. In the first place, the crinoid may hold onto the bottom by a looping of the distal portion of the column about some stationary object. Secondly, there may be no true attachment, but the presence of a distal knob or anchor may serve to ballast the crinoid and maintain it in approximately the same position. Finally, as is the case more commonly among the Mesozoic and later forms, we find that attachment to other objects is effected by means of prehensile cirri borne upon the column. The order here given indicates in a broad way the general degree of complexity of the types of structure involved. The second type of fixation, if such it may be called, is quite out of the regular line of evolution, and represents both simple and complex conditions. For instance, the terminal knobs elsewhere described as occurring either on *Dolatocrinus* or *Megistocrinus* columns probably represents secretion of stereom induced by and following a violent disruption of the column. On the other hand the grapnel of *Ancyrocrinus* is a highly specialized organ resulting from the modification of radicular cirri. In the treatment of these crinoids the forms will be discussed as grouped above. The order will be changed, however, the most complex types being taken first. This is done in order immediately to make available the evidence afforded by the living Crinoidea.

Isocrinus and *Metacrinus*.—There is much evidence available proving conclusively that among certain recent crinoids provided with a well-developed column, a free or semifree existence is largely maintained. This conclusion was perhaps first reached by Sir Wyville Thomson, and the evidence was subsequently verified and added to by Carpenter and other writers. Carpenter's (1884, p. 18) statement of the case as affecting the genus *Isocrinus* is here given. "At the same time there appears to be ample evidence that a *Pentacrinite* may lead the same sort of free life that a *Comatula* does, attaching itself temporarily by its cirri." Sir Wyville Thomson long ago pointed out, in the case of *Pentacrinus decorus* (1864, p. 7), "that the animal seems to have had the power of detaching itself" at any of the syzygies of the stem in the same sort of way as the arms are thrown off during life or break up after death. He described an individual in which the stem terminated below in a worn and rounded nodal joint, and he supposed it "to have finally parted from its attachment and to have led a free life." He stated some years afterwards that this was the case in all the complete specimens which he had seen, "showing that the animal must have been for long free from any attachment to the ground." He then went on to describe the same condition as it occurs in *Isocrinus wyville-thomsoni*. "All the stems of mature examples of this species end inferiorly in a nodal joint surrounded by its whorl of cirri, which curve downwards into a kind of grappling root. The lower surface of the terminal joint is in all smoothed and rounded, evidently by absorption, showing that the animal had for long been free. I have no doubt whatever that this character is constant in the present species, and that the animal lives loosely rooted in the soft mud, and can change its place at pleasure by swimming with its pinnated arms; that it is, in fact, intermediate in this respect between the free genus *Antedon* and the permanently fixed Crinoids." The recent species to which a semifree existence has specifically been ascribed by Carpenter (1884, p. 19) other than the ones already noted are: *Isocrinus parrae* (*maclearanus*), *I. alternicirrus*, and *Metacrinus angulatus*.

The phenomena associated with the assumption of an eleutherozoic habit by the recent forms are of very considerable interest, and are of great value because of the perfect preservation of the material. Being fairly certain as to the conditions under which such types have acquired freedom, and knowing to a certain extent the habits of the crinoids, one may draw certain general conclusions relative to the fossil forms in regard to which we are not so well informed.

Method of detachment among the Pentacrinidæ.—The disruption of the column immediately distad to a nodal, and the subsequent secondary deposition of stereom on the exposed face, as shown in

Isocrinus wyville-thomsoni (Pl. 5, fig. 13), seem to be more or less characteristic of the Pentacrinidæ as a whole. In some cases it is to be noted that the deposit of stereom smoothly rounds off the entire exposed face of the distal ossicle and forms an appreciable knob. In other specimens a small plug is formed which merely closes the axial canal. In these individuals the radial striæ are at times still to be seen. It may be that these differences in the structure represent stages in the attainment of freedom, or it may be that in different species there is a certain degree of variation in this regard. The essential feature after all is the plugging of the axial canal. Subsequent deposition of calcareous matter seems merely somewhat to protect the distal nodal from fracture.

The method of detachment as it obtained among these forms is open to some question. Thomson (1869-72, p. 768) says: "There can be no doubt that in early life the Crinoid is attached and that it becomes disengaged by the withering of the lower part of the stem." Carpenter (1884, p. 22) says: "The free mode of life appears to be attained in these individuals, not by actual fracture of the stem at a node so as to shorten it more or less, but by the lower and therefore older part remaining undeveloped, while new joints appear in succession above it, each growing to a larger size than those previously formed. The stem thus becomes slender and tapering and but ill adapted for attaching itself below; but its length is not diminished so much as if it were broken at a node."

These conclusions have been based upon the fact that in many specimens there is a decided diminution in the size of the column in its distal portion. At times this decrease seems to be effected through the gradual tapering of the stem. In other cases the column tapers somewhat distad, and then decreases abruptly in diameter from nodal to nodal. As has been pointed out by Carpenter (1884), such variation in the diameter of the stem is far from being a uniform character. It is significant that adult specimens apparently do not show this structure.

On the whole, from the evidence available one would judge that a gradual tapering of the column such as is figured by Carpenter and reproduced here (Pl. 4, fig. 2) in the case of *Isocrinus decorus* is such as is due to normal growth. In cases where the column suddenly becomes smaller distad from a given point this explanation does not seem wholly adequate. It would appear that in such a case, after the detachment of the organism, a certain portion of the column ceases to enlarge.

Both Thomson and Carpenter, as quoted above, take a stand against the actual disruption of the column, but it is inconceivable that detachment could have occurred except as the result of such a process. A "withering" or nondevelopment of the distal portion of

the column would scarcely serve to separate the crinoid from its base of attachment. Whether such disruption was voluntary or performed more or less through the agency of outside forces, it is impossible to state. Involuntary detachment in the majority of cases seems the more reasonable hypothesis, however.

Concerning the exact steps in the acquisition of a detached existence in the case of the Pentacrinidæ we can not, of course, be absolutely certain. The evidence at hand permits us to draw some rather definite conclusions in regard to the matter, however. A statement of the conditions under which it is thought freedom is acquired, and of the consequent modifications in the structure of the animal, may be of value as meeting some of the objections that can be brought against the views of Thomson and Carpenter. It is possible that in different cases we have to deal with somewhat different factors—or, rather, with factors operating in variable degrees. On the whole, however, I think we are justified in assuming that the process is essentially uniform in its action.

Knowing as little as we do in regard to the embryology and very young stages of the Pentacrinidæ, we are scarcely able to form definite conclusions in regard to the nature of the immature column. The specimen of *Isocrinus decorus* (Pl. 4, fig. 2) gives us some interesting data, however. In this specimen it may be noted that the column up to within a short distance of the theca is composed of round ossicles. The proximal portion of the stem shows the characteristic pentalobate cross-section that distinguishes the adults of this type. It is probable that the distal portion of the column as shown represents the actual shape of the ossicles in the young and does not indicate a secondary deposition of stereom filling the reentrant angles of the columnals. Were the change in form brought about through such a process we would find a gradual transition instead of an abrupt change, and some of the altered columnals would be pentagonal in outline. Such, however, does not seem to be the case. The comparatively rapid change from round to pentalobate ossicles, such as may be noted in this specimen and even more clearly in a specimen of the same species figured by Carpenter (1884, Pl. 25, fig. 2), perhaps indicates a resting stage in the development of the organism after which the typical pentalobate columnals are acquired.

It is approximately at this period in the lives of the organisms that detachment occurs. As stated above, this disruption is abrupt. In all probability the point of separation comes well down in the stem. It is probable, however, that there is no definite point for the disruption of the column. Among these young specimens the length of the stem is apparently quite variable, indicating such to be the case. It is scarcely possible that in these individuals any considerable

sloughing of columnals, such as is hereafter described, could have taken place.

Subsequent to the disruption of the crinoid from its base of attachment increase in the length of the column takes place by the constant intercalation of ossicles in the proximal portion of the column. These naturally are all pentalobate in section. The first of such columnals formed agree in size with the proximal portion of the primary column, if one may so designate that portion of the stem composed of round ossicles. Subsequently, however, with the growth of the theca, there is a concomitant increase in the diameter of the columnals. This results in a marked disparity in size between the distal and proximal portions of the stem, and in periods of rapid growth, even between juxtaposed internodal series. Such a condition may well account for the structures described by Thomson and Carpenter. Such an explanation is only justified upon the assumption that there is during the period of intercalation of new columnals no considerable increase in the diameter of those already formed. I feel that we are justified in considering this to be the case.

We may well wonder in the growth of the column whether a freshly intercalated columnal, having reached the size at that time attained by the stem, is ever capable thereafter of any considerable increase in size. I doubt if such often be possible. Whenever we have an increase in the diameter of the column which is secondary its nature is immediately obvious. Usually an obliteration of sutures and an appreciable irregularity of surface mark such enlargement. In the case of adult *Isocrinus*, in the distal portion of the stem, where a secondary deposition of calcareous matter apparently occurs, the resultant columnals are no greater in diameter than the original ossicles. According to this hypothesis crinoids showing tapering columns represent normal growth without loss of distal columnals. On the other hand, forms in which the column is of practically uniform diameter indicate a considerable loss of stem ossicles. The importance of such a conclusion, were it possible definitely to establish it, is immediately obvious, inasmuch as we could then postulate a detached existence for the majority of the stalked Crinoidea.

The fact that in adult detached Pentacrinidæ we do not find any trace of this comparatively tenuous terminal portion of the column seems to indicate that it has been lost. Were it present it could only be represented as greatly enlarged by a secondary deposition of stereom. It could not be other than circular in cross section, for in old portions of the stem, even with pentalobate instead of round columnals as a base, this is the form that the ossicles tend to assume. In a few species in the distal portion of adult stems are to be found columnals that are approximately circular in outline. This form, which closely simulates that shown by the ossicles of the young

crinoid, is probably a secondary one, being caused by a deposition of calcareous matter within the reentrant angles of the columnals. In most cases the original form of the ossicles is indicated by the more or less distinct pentagonal section of the column. In many species, however, truly pentalobate columnals are to be found in the adult stages even in the most distal portion of the stem as preserved, proving conclusively that a considerable portion of the column has been lost.

If we grant the dropping off of columnals during the lives of the animals, a feature that is directly comparable to the condition found in *Millericrinus*, hereafter described, we may readily account for the structure of all the stems known to us among the Pentacrinidæ. In very young stages we should find, as we do, considerable portions of the original column of the individual. Gradually more and more of this drops off until it entirely disappears. It is probable that this dropping of columnals extends well into the pentalobate portion of the column in some species.

It is possible that the gradual loss of the distal portion of the column may be ascribed to periods of attachment followed by disruption of the crinoid from its base. In such cases detachment may occur immediately below the most distal nodal or at some higher point. The uniform termination of the columns by nodals among such types as *Endoxocrinus* suggests that detachment was had at such points. It may be, however, that the column if broken within an internode would subsequently drop off a sufficient number of ossicles so as to bring a nodal at the end of the column. The advantage of this arrangement is obvious, as the presence at the distal extremity of the column of a verticil of cirri as shown by Carpenter (1884) in *Isocrinus blakei* (Pl. 31, fig. 1), in *E. wyville-thomsoni* (Pl. 19, fig. 1), and in other species, would enable the animals readily to grasp a projection upon the bottom, and thus temporarily anchor themselves.

Factors governing length of column.—The degree to which the column is shortened probably depends to a great extent either upon the physical conditions under which the animal lives or upon the structure of the organism itself. The main factor, however, is perhaps the abundance of cirriferous nodals in a given length of column. This in turn depends upon the length of the internodals. This structural feature probably varies in different species, and may perhaps vary within any given species. A case of shortening of the internodes is shown in *Isocrinus parræ* (*maclearanus*) (Pl. 4, fig. 1). This species exhibits perhaps the highest degree of specialization known among the recent Pentacrinidæ in this regard. It will be noted in this form that each internode consists of but a single plate. Even greater compression of the nodals would give us essentially the structure to be observed in Group II. In most cases it will be observed that

forms with long internodes have comparatively longer columns than those with nodals situated more closely together. The reason for this seems to be that a certain number of cirri by which the animal is able temporarily to attach itself is essential to the welfare of the crinoid. So in cases where the internodes are long there must be a considerable length of column in order to bear an adequate number of cirri. Where a considerable compression of nodals obtains it is obvious that a much shorter column suffices.

Specialization of cirri.—The degree of specialization shown by the cirri of the recent Pentacrinidæ although not as marked as in the case of the fossil forms hereafter described, is nevertheless notable. It will be observed that the cirri are of considerable length and are equipped with terminal claws. They are quite flexible and motion is readily had in a vertical direction. The junction of the cirrus with the column is marked by a well developed articular face. The structure is clearly indicative of adaptation to considerable freedom of motion and the development of a fairly strong musculature. As has been observed in the case of living *Isocrinus* the cirri move with fair rapidity and are capable of grasping and holding tenaciously to extraneous objects.

Conclusions relative to the recent Pentacrinidæ.—From the evidence as given above, it may be concluded, I believe, that the majority of the recent Pentacrinidæ pass the greater part of their lives as detached organisms. It may be that in some individuals, after the initial period of attachment, the animal passes through alternating periods of freedom and fixation. In the majority of cases, however, it is probable that prolonged fixation only obtains in the case of the very young forms. Permanent attachment when had by the Pentacrinidæ seems to be entirely by cementation. Specimens brought up on cables show this type of structure.¹ It is quite conceivable that after a period of freedom the crinoid may well settle down and by such a secretion of stereom as is to be noted in all the specimens on the distal end of the column, cements itself to the bottom. While cementation is becoming effective, the animal could hold itself in place by means of its terminal cirri. These, after cementation, are lost.

Detached conditions among the fossil Pentacrinidæ.—Having found such universal freedom in the case of the living Pentacrinidæ we may well look for similar conditions of life among the related fossil types.

¹Mr. A. H. Clark informs me that the statement relative to the cementation of *Isocrinus* to telegraph cables as reported by Agassiz and quoted by Carpenter (1884, p. 18) is erroneous. It is Mr. Clark's belief that fixation by cementation never becomes effective after the primary detachment of the organism. It may be that such is the case, but there seems to be no special reason why recementation should not occur. It is obvious that those physical conditions that bring about the detachment of a crinoid are not particularly conducive to its reattachment. They need by no means be prohibitive, however. There seems quite positive evidence in favor of the theory of alternate periods of fixation and freedom in the case of the Paleozoic Crinoidea, and if such conditions obtained here it does not seem at all improbable that we may have a similar habit expressed by the modern forms.

The evidence afforded by numerous writers points strongly to the conclusion that among these fossil forms a detached mode of life was largely maintained. Indeed in many of these early Pentacrinidæ, the degree of specialization exhibited by the organism is even greater than in the case of the recent forms.

Pentacrinus.—Perhaps the first ascription of a detached existence to a stalked crinoid may be credited to Buckland. In writing of the fossil *Pentacrinus* he says in part (1837, vol. 1, p. 436):

The root of the Briarean Pentacrinite was probably slight, and capable of being withdrawn from its attachment. The absence of any large solid secretions, like those of the Pear Encrinite, by which this Pentacrinite could have been fixed permanently to the bottom, and the further fact of its being frequently found in contact with masses of drifted wood converted into jet, leads us to infer that the Briarean Pentacrinite was a locomotive animal, having the power of attaching itself temporarily either to extraneous floating bodies, or to rocks at the bottom of the sea, either by its side arms, or by a movable articulated small root.

Not only did Buckland consider these forms free, but as will be shown subsequently, in many cases he supposed an epi-planktonic existence to have been assumed by the crinoids.

Quenstedt and de Loriol both predicate a free existence for *Pentacrinus briareus*¹ and its allies, a conclusion in which Carpenter concurs. According to Quenstedt (1876, p. 271) he believed that they "köntenn gleichsam als eine Comatula betrachtet werden, deren Knopf zu grösserer Länge in einer Zeit heranwuchs, wo es noch keine eigentlichen Comateln gab." de Loriol (1878, p. 12) goes rather more into detail relative to the maintenance of an eleutherozoic habit by these forms. It is to be noted that he offers a rather novel suggestion relative to the method of locomotion in the case of these animals. He believes: "qu'ils avaient, à l'état adulte, une tige court, libre, et qu'à l'aide de leurs cirrhes très nombreux et très longs ils pouvaient nager facilement et se transporter, rapidement peut-être, d'un lieu à un autre; ils avaient aussi la faculté de se fixer a quelque objet, lorsqu'ils en avaient le désir, au moyen des crochets dont est munie l'extrémité de leurs cirrhes."

The column of *Pentacrinus briareus* as described by de Loriol (1884-1889, p. 385) is short and composed of columnals of uniform size. Each columnal is a nodal and bears a verticil of cirri. These cirri are long and highly specialized. On the whole this species indicates a degree of specialization in its adaptation to a detached existence scarcely approached by any recent form. A column essentially similar in structure has been described by de Loriol (1878, p. 7) in the case of *Pentacrinus dargniesi*. The stem in this species is held to be short and is thickly set with cirri which range

¹ Bather (1898) gives *Pentacrinus briareus* as a synonym of *P. fossilis* of Blumenbach. I here use *P. briareus* as that is the designation employed by the various authors cited. I, however, feel in no wise competent to pass on the validity of the name.

up to 100 mm. in length, each columnal bearing a verticil. Although a careful examination was made, no signs of attachment were shown by the individuals. It would seem on the evidence of these writers that *P. briareus* and its allies have essentially the same column structure, and that we may well postulate a similar habit for such forms.

Structure of Pentacrinus cirri.—The cirri in the case of these types show special and peculiar modifications that are well worthy of more than casual notice. For instance the cirri of *Pentacrinus*, as shown by *P. collenoti*, indicate a degree of specialization scarcely attained by any other stalked genus. Figures of the cirri of this species as given by de Loriol are here copied and given on Plate 5, figures 1-3. It will be noted that a terminal claw has been developed, which in itself is clearly indicative of a part of the functions of the cirri. The shape of the constituent ossicles is of very great interest. Instead of being round, they are considerably flattened. Each ossicle at its outer margins has processes projecting backward and overlapping the next preceding ossicle. There seems also to have been a less pronounced process in the median line of each ossicle. These processes and the type of articulation indicate great flexibility in a vertical direction and slight possibilities of movement laterally.

Function of Pentacrinus cirri.—The high degree of differentiation exhibited by these cirri suggest that they may well be adapted to function otherwise than simply to grasp objects. Indeed, a cirrus which is circular or somewhat oval in section and equipped with a terminal claw, would appear to have the optimum structure for such purposes. The flattening of the cirri would be of no particular value in perfecting them as grasping organs, and the very considerable development of articular ridges and pits indicates a greater mobility than would be developed were the cirri merely prehensile organs. Bearing these facts in mind, the suggestion of de Loriol quoted above relative to the part the cirri may have taken in effecting movement does not seem wholly untenable. Considering the very considerable development of cirri on one of these forms, both as to length and number, it is conceivable that even a slow movement of the cirri would be of no little value in swimming, the action of the cirri tending to elevate the crinoid.

At first blush, it seems rather far-fetched, perhaps, to consider a cirrus in any other light than as a prehensorium. When one considers, however, that in its natural medium the crinoid is practically without weight, it will be seen that even a moderate lashing motion of the numerous long cirri would have a marked effect on the animal. From the observations made by Agassiz (1888, vol. 2, p. 120), it would appear that in the recent *Isocrinus decorus* the cirri are capable of very considerable activity, it being stated that they move more

rapidly than the arms. If actually assisting in the locomotion of the animal it is evident, as suggested above, that the cirri functioned merely in raising the animal from the bottom. Lateral motion could only be effected through the action of the arms, which, on the other hand, would have slight value in bringing about vertical movement.

Effect of detachment on habits of the Pentacrinidæ.—The life history of the Pentacrinidæ as bearing on their colonial habit may be dealt with to better advantage in a subsequent paper where the facts relating to the segregation of the Crinoidea are treated in detail. A description of the conditions under which *Isocrinus* has been dredged, as given by Agassiz (1888, vol. 2, p. 117), may well be quoted at this time, however, as perhaps indicating the general habits of the detached forms. "A similar entangling also occurred among the specimens dredged by the *Blake*, and it was often very difficult to separate specimens, the cirri of which had become attached to adjoining stems. It is possible that they live gregariously, more or less united either by the twisting of the stem or the grappling of the cirri, and be only loosely attached to the ooze in which they live, or anchored more firmly by the terminal whorl to some projecting piece of rock or gorgonia stem." Döderlein (1907, p. 30) has described similar colonies in the case of adult *Metacrinus*. In this genus a considerable length of the distal portion of the column lies horizontally upon the bottom and is inextricably entangled with the columns of other individuals, corals, and other lime-secreting organisms. His description of such a colony is here given in part:

Da, wie es scheint, diese Crinoiden gewöhnlich in grösseren Mengen beisammen stehen, förmliche "Wälder" bildend, so ist anzunehmen, dass die horizontalen Teile ihrer Stiele über und neben einander auf dem Boden liegend, mit ihren unzähligen Ranken in einander verkrallt, ein unentwirrbares, innig zusammenhängendes Geflecht bilden, das als eine mächtige, fast unzerreissbare Masse den Untergrund eines Crinoidenwaldes bildet, aus dem sich dann die einzelnen Kelche auf mehr oder weniger langen, geraden Stielen frei erheben.

In the case of both *Isocrinus* and *Metacrinus* I hold that this mutual entangling of the organisms follows a period of complete detachment during which a certain degree of movement is possible. During this period of freedom selective migration of a more or less effective sort may take place.

In this connection may be mentioned a curious belief of the Japanese fishermen relative to the location of *Metacrinus rotundus*. As is well known a large number of the specimens of *Metacrinus rotundus* have been obtained by the Japanese fishermen, who, upon hauling in their enormous trawls, occasionally find a *Metacrinus* entangled in the hooks. In this way, also, are obtained many of the exceedingly rare sponges and other organisms of this region. I have been

informed by Doctor Yatsu, of the University of Tokio, that the fishermen in laying out their lines in a given direction seldom if ever bring up specimens of *Metacrinus*. On the other hand, lines laid out at right angles to this direction frequently bring up specimens. This fact the fisherman explains by assuming that the crinoids are aligned in long courses which are some distance apart. When the tackle is laid out parallel to these lines, few crinoids are taken, but when laid across them, the conditions are more favorable. When the great length of these set lines is considered, for I have been told that they are at times a mile or more in length, it does seem surprising that were the crinoids restricted to large roughly circular areas, lines set in one direction would not be quite as apt to entangle specimens as those set in another direction.

A semilinear arrangement of small colonies rather than an approximately radial one is perhaps not wholly in accord with current ideas relative to the distribution of the crinoids, but the facts as given by Doctor Yatsu are at least worthy of consideration. It is possible that such a linear arrangement might be voluntarily assumed as directly affecting food supply. For instance, rows of crinoids at right angles to a current would have a far better food supply than closely segregated groups of individuals. On the other hand, such a linear arrangement of the crinoids may well bear a direct relation to the bathymetric range of the animals.

Evolution of the Pentacrinidæ.—The evolution of the Pentacrinidæ may only completely be worked out with the aid of extensive collections of the fossil representatives of the family. As indicated by Bather (1900) we have in all probability to start with some such type as *Dadocrinus*. We next have *Holocrinus* where the appearance of verticils of cirri is to be noted. The next stage is one that is more distinctively like the typical members of the family, and perhaps is represented by *Balanocrinus*. From such stock at least two divergent lines may be held to have arisen. One line—that characterized by *Pentacrinus*—is comparatively short lived and terminates with the group of species characterized by *P. fossilis (briareus)*. On the other hand, we have the line that for a considerable period was no doubt made up of forms essentially similar to *Isocrinus* in structure. From this line probably are to be derived the modern representatives of the family.

Having demonstrated the widespread occurrence of a free existence in the case of certain living Crinoidea and their comparatively recent fossil representatives, it will be interesting to note similar instances of a detached mode of life among the Paleozoic forms. Only those cases will be given at this time that are of unquestioned standing. Subsequently, in the general treatment of eleutherozoic conditions as they appear to have obtained among the paleozoic Crinoidea,

those types in which detachment is predicated on the evidence of analogous structures, or for other cause, will be discussed. As more perfect material is secured, it is probable that this list of determinable free stalked crinoids will be appreciably augmented.

Mariacrinus.—A number of observers have noted that the columns of *Mariacrinus* are frequently found coiled in their distal portion. No complete stems have hitherto been recorded, however, so it has been impossible to determine the significance of this fact. Several specimens of *Mariacrinus paucidactylus* have recently come to light, the columns of which are essentially complete. From the evidence afforded by this material certain interesting conclusions may be drawn relative to the habits of this species, and by inference, of the genus.

In these specimens, which represent fairly mature individuals, the stem is remarkably short. It tapers evenly but with moderate rapidity distad and in its extreme distal portion becomes comparatively tenuous. In each individual observed, there is a loop in the distal portion of the column that forms at least one complete revolution. There are no radicular cirri present, nor is there any evidence that such appendages ever existed. Furthermore, there are no signs of cementation by a terminal plate, though to be sure, this may have been broken off. The columns as preserved indicate a fair degree of flexibility other than is shown by the looping noted above.

There can be little doubt but that this species led a detached existence for the greater part of its life. The lack of structures adapted to function as organs of attachment, and the distal coiling of the column point strongly to this conclusion. Even were fixation had by means of a terminal plate present in life, and not preserved to us at the present time, we could scarcely account for the looping of the column. This is not a feature such as is shown by stazoic types. It is probable that *Mariacrinus paucidactylus* was able to move from place to place by means of swimming motions of its arms. When the animal wished to attach itself it could readily do so by looping the distal portion of its stem about some object on the sea bottom, or perhaps about the column of another individual. The bottom of the Helderbergian sea was in places literally covered with prostrate crinoid columns and these at times may well have served as points of anchorage.

Looping of the column seems to have been present in other species of *Mariacrinus*, and we may be fairly safe in assuming that a detached existence was largely maintained in this genus. A notable instance is that of the type specimen of *Mariacrinus warreni*, which exhibits a marked coiling of the distal portion of the stem. The presence of this character in species ranging from the Niagaran to the Helderbergian strongly suggests that we are dealing with a persistent and

widespread structural feature. Hall in the third volume of the "Paleontology of New York" describes some well-developed roots as pertaining to *Mariacrinus*. This reference has slight evidence in its favor, and such roots may well belong to quite distinct genera. It is possible, however, that fixation by roots or terminal cementation occasionally became effective, and may even have persisted the greater portion of the animal's life.

Woodocrinus.—In *Woodocrinus macrodactylus* from the Carboniferous of England we have a type that unquestionably maintained a free existence. A figure of this form is here given, plate 4, figure 3, as copied from Zittel (1896), adapted from de Koninck (1854).

It will be noted that the column is fairly stout in its proximal portion and tapers rapidly distad. It is likewise quite short. There is no evidence of attachment by cementation and there are no cirri in the distal portion of the stem. The three cirri that are shown are located well up on the column, and could scarcely have been effective for purposes of permanent fixation. The distal portion of the stem is not shown as being looped but from the manner in which the column is flexed it would appear that this portion might well have been fairly mobile, and possibly prehensile. The arms are stout, and though short, might well form effective swimming organs. The cirri in this form are of considerable interest. Though not sufficiently specialized to function to any extent as prehensile organs, they yet mark the tendency to be noted in all the detached stalked crinoids toward the acquisition of such appendages.

Glyptocrinus.—In the form described and figured by Miller (1880, p. 233, pl. 7, fig. 3 *a-c*) as *Glyptocrinus schafferi*, which is almost certainly the young of *Glyptocrinus dyeri*, we have shown a most remarkable case of temporary attachment by means of a prehensile column. This type seems further to elucidate certain structures observed in widely divergent geological periods.

In this species, as shown by figures 3*b* and 3*c*, the distal portion of the column is found spirally coiled about the stem of an adult crinoid. As described by Miller the *Glyptocrinus* stem tapers distad until it becomes remarkably tenuous. In its extreme distal portion it is stated to be so small as scarcely to be visible to the naked eye. In the specimen figured by Miller the column makes no less than seven complete turns about the supporting stem. It is obvious, as suggested by Miller, that the crinoid was a freely swimming form and attached itself by will by wrapping the prehensile distal portion of its column about some object.

Unidentifiable spirally coiled columns.—In the Hamilton, Niagaran, and at other geological horizons we are well acquainted with other similar spirally coiled columns. In such cases, however, we have no means of determining the identity of the crinoids. In many of these

instances features are to be observed not to be noted in the case of *Glyptocrinus*. Although capable of attaching and detaching themselves at will, it apparently was not unusual for the crinoid to remain in any given location for a considerable period of time. As a result it frequently happens that we find the coiled and supporting columns fused together by a secondary deposit of stereom. In such cases it is no uncommon thing to find the sutures of the attached columns completely obliterated. The supporting stem is as a rule somewhat enlarged in the region where it is inclosed. In many cases it appears that the crinoid which had coiled itself about the other column, voluntarily detached itself prior to the death of the supporting organism. In other instances the fracture of the two columns appears equally sharp and indicates a simultaneous disruption.

From the wide geological range of this structure we may hold that many crinoids, particularly in their young stages, attached themselves by wrapping the prehensile distal portion of their columns about some extraneous object, preferably other crinoid stems. In many, perhaps in most cases, there was a resultant fusion of the two stems. Still later, the crinoid became detached and perhaps led a free existence. In some instances observed the large size of the spirally wound column, and the fact that it does not become tenuous in its distal portion points to the conclusion that this mode of attachment was assumed by fairly adult individuals after a period of freedom.

Mastigocrinus.—In the case of *Mastigocrinus loreus* Bather (1892, p. 200, pl. 11, fig. 3) describes and figures a specimen in which the stem is comparatively short, and smoothly rounded off at its distal extremity. It is to be noted in this individual that barring a slight tapering in its proximal portion, the stem is of notably uniform diameter. Considering the splendid preservation of the specimen there would seem to be no explanation for this termination other than that it is a normal feature, and one acquired during the life of the organism.

Calceocrinus.—Bather (1893, p. 75) cites the case of a *Calceocrinus interpres* from the Silurian of Sweden which apparently had no permanent distal attachment. The column in this specimen is 44 mm. in length. In the distal portion of the stem the ossicles diminish gradually in diameter. The last three columnals taper off abruptly "so that the stem looks very like a common earthworm." It is evident that we have here a case of complete detachment of the organism, which is all the more remarkable when one considers the extraordinary structure of the crinoid involved. As Bather says, it is scarcely safe to assume that such detachment is normal to this genus. If it were capable of being maintained in the case of one specimen there is no good reason why it should not be assumed by other individuals, however.

Ancyrocrinus.—Under the name *Ancyrocrinus* (pl. 5, fig. 9) Hall (1862) described a curious column from the Hamilton. The distal extremity of the stem is rounded off smoothly. A short distance from the end is typically to be found a verticil consisting of four spur-like appendages. These spurs may be short and stout, as is characteristic of the Hamilton of southern Indiana, or long and slender, as is shown by the New York specimens. They are perforated through the center by a very small canal which apparently does not communicate with the exterior.

At times the spurs depart from the normal arrangement, where all are in the same plane, and are variously situated at different levels. Occasionally more than four are present. However disposed vertically, their relative peripheral arrangement is the same, the orientation conforming to that of the axial canal. The spurs are directed upward, and when but four are present the resemblance to a grapnel is very marked. It is obvious that these spurs are modified radicular cirri, in which all traces of the original segmentation as a rule have been obliterated by a secondary deposition of stereom.

Bather (1900) refers to *Ancyrocrinus* as the anchor of *Myrtillocrinus*. This reference is quite unsupported by known facts. *Myrtillocrinus* is found in America in the Onondaga limestone where no signs of *Ancyrocrinus* have ever been seen, while in the Hamilton, where *Ancyrocrinus* is fairly abundant, no trace of *Myrtillocrinus* has yet been found. Moreover, the stem of *Ancyrocrinus* is quadrangular in cross section, while that of *Myrtillocrinus* is round. Furthermore, the size of these grapnels and that of the column is out of all proportion to that of any known *Myrtillocrinus* theca.

We may hold, I think, that this grapnel of *Ancyrocrinus* served rather as a drag and ballast than as a true anchor. In a quiet sea, the animal no doubt was steadied and maintained in a fairly stable state by the weight of the terminal organ. If affected by current or wave activity, however, the grapnel might be dragged along the bottom and aid appreciably in controlling the motion of the animal. As will be noted subsequently, it is quite conceivable that the Paleozoic stalked Crinoidea, as well as their modern representatives, often lived well within the zone of wave activity. Under such conditions the advantage of such a drag is immediately obvious.

Megistocrinus or *Dolaticrinus*.—In connection with the curious grapnel of *Ancyrocrinus* should be noted certain columns found in the Hamilton group of New York State. These columns are referable either to *Megistocrinus* or *Dolaticrinus* in all probability. In these cases, the animal seems to have been detached as the result of a violent disruption. The break took place above the radicular cirri, if such were present, for there are no signs indicative of such cirri on the columns as preserved. The size of the column and its uniform

diameter likewise indicate that the break took place well up on the stem. Subsequent to the breaking off of the column, there was a secondary deposition of stereom over the fracture. Lime continued to be deposited until a knob of very considerable size was formed at the end of the stem. Such a knob is quite irregular in shape and shows no signs of cementation to the bottom. It apparently served as a ballast or drag for some freely swimming crinoid.

Such structures recall the knobs formed at the distal extremities of the columns of *Metacrinus* and *Isocrinus*, as reported by Carpenter and noted above. In the latter cases, however, the deposits of lime are of no very great size, little more than plugging the axial canal, and smoothly rounding off the end of the column. The curious object to which Barrande (1887, Pl. 4, III, figs. 1-6) gives the name *Neocystites bohemicus* seems quite certainly to be such another distal knob formed over the fractured surface of a ruptured column. The stem is unquestionably, I believe, that of a crinoid.

Herpetocrinus.—The genus *Herpetocrinus* is here held as a detached form on the authority of Bather (1893 and 1900). In this genus the column, which is a most remarkably modified organ, is coiled about the body of the crinoid, the coiling taking place in a single plane. Along a very considerable portion of the stem there are borne two rows of cirri, which are given off toward the inner portion of the coil. In *Herpetocrinus* as found, the crown lies entirely concealed between these rows of cirri.

It is evident under normal living conditions that the crinoids did not maintain this close coiling of the column, which was probably only assumed in case of irritation. It is likewise obvious that the plane of coiling could scarcely be that of the sea bottom. We must then assume when the animal was temporarily attached that it grasped some object with the cirri of the distal portion of the column, an erect position being maintained. At special times the animal could retract and assume a closely coiled position. The advantages of this coiling are not on the whole immediately obvious. A somewhat similar structure is to be observed among the Camerata, in the case of *Camptocrinus*, so the modification appears to have some good reason for its existence, divergent from the normal tendency though it be. It can scarcely be considered as purely protective, for why should one genus acquire such highly specialized protective structures when the associated organisms apparently have no need for anything of the sort, and when the physical conditions of environment appear to be quite normal?

It seems probable during the greater portion of the life of this form that a detached existence was maintained, and that attachment when effective was but temporary, and brought about through the clasping action of the cirri. It is interesting in this connection to

note that some of the cirri in the distal portion of the column are longer than the remainder, indicating that they were specially modified as grasping organs. The comparatively minute size of the crown and the extraordinary development of cirri suggest that the activity of the latter organs may have been of no small service in the propulsion of the animal. Bather (1893) has suggested that the alternate spring-like action of coiling and uncoiling on the part of the stem may have brought about movement.

Brachiocrinus.—*Brachiocrinus*, of which probably only portions of the column are known, undoubtedly was not permanently affixed. I have examined the distal portions of several *Brachiocrinus* columns and in each instance have found the same fused into a small knob (Pl. 5, fig. 8) and showing no signs of cementation.

Brachiocrinus is structurally similar to *Herpetocrinus* in that the column bears two rows of cirri. These are much heavier than in the case of *Herpetocrinus* and are composed of bead-like ossicles. The column is round, and it does not seem wholly certain that any but the distal portion bears lateral appendages. In one or two instances the portion of the column preserved appears involute. This coiling suggests, however, that the *distal* portion of the column forms the center of the coil, and not the proximal end, with the attached crown. If such be the case, we must consider *Brachiocrinus* as having the distal portion of the column flexible, more or less prehensile, and occasionally involute. For a short distance up the column is a double row of cirri, by means of which objects could be grasped. So considered *Brachiocrinus* is not closely comparable to *Herpetocrinus*, as has hitherto been thought.

Millericrinus prattii.—In the case of *Millericrinus prattii*, from the Jurassic, we have one of the most remarkable manifestations of an eleutherozoic habit to be noted among the stalked Pelmatozoa. Indeed, according to the classification here employed, it is a matter of no little uncertainty as whether to place *Millericrinus prattii* in this or the succeeding group. Dependent upon the variable degree of specialization shown by certain individuals, the species might indifferently be placed in either division. In all the preceding types we may note that the column is persistently present. It is moreover functional to a certain degree, acting as a ballast, drag, or organ of attachment for the organism. In this species, however, there is a strong tendency toward the complete elimination of the column. This form has been excellently figured and described by Carpenter (1882). Several of his figures are reproduced here on Plate 6. The characters shown by this species are apparently distinctive and not common to any other member of the genus.

The column is round and tapers quite rapidly distad. The longest stem noted is a trifle more than 50 mm. in length in the case of the

English specimens. In a specimen from France referred to this species Carpenter gives the column a length of somewhat more than 60 mm. In any case the column at its maximum is remarkably short and probably scarcely exceeds the length of the crown. In the majority of figures given by Carpenter there is no sign of basal attachment. In the case of one column, however (1882, Pl. 1, fig. 5), there seems to have been cementation or possibly attachment by lateral root-like processes. It is probable that in all cases observed other than this the animals were detached. In one specimen figured by Carpenter there is a slight flexure of the distal end of the column suggesting that this portion was prehensile and possibly employed for looping about some object as in forms elsewhere noted. The column in this individual is comparatively small. The most striking feature in connection with the stems of this species is their extremely variable length. This varies from a column having about 70 ossicles to one consisting of but a single columnal. Various intermediate stages are represented. From the facts as we have them it seems probable that the shortening of the column as shown in these forms is due to the dropping off of some of the distal columnals accompanied by more or less resorption. It does not necessarily follow, however, that this resorption is as a rule other than purely local in its action and is effective merely in rounding off the terminal ossicles. When the stump of the column is unusually short, resorption seems to affect all the ossicles to the extent of forming them into a subconical knob (Pl. 6, fig. 1). The probable steps in the process by which this shortening of the column is brought about will be given later.

The process by which freedom was attained by *Millericrinus prattii*, and the changes through which the animals subsequently passed as regards the structure of the column, hold no small interest for us, for in this process we probably see outlined the phylogenic history of the assumption of an eleutherozoic habit by the Comatulæ. Indeed, were *Millericrinus* to have possessed cirri, there is small doubt but that this very species would have formed the radicle of a line essentially comatulid in habit, and perhaps of considerable vigor. Detachment from the cemented base probably did not take place very early in the life of *Millericrinus prattii*: perhaps at a not much younger stage than is figured by Carpenter (1882, Pl. 1, figs. 6 and 8). It should be noted, by the way, that in the case of all the fairly long columns figured by Carpenter the stems are transversely fractured other than at the distal extremity, and the parts somewhat thrown out of line. This separation of the column comes at various altitudes, in one instance (1882, Pl. 1, fig. 8) being quite near the crown. It is evident that the union between the columnals is not a strong one at best. Furthermore, disruption may apparently take place at

any point; not being confined to a syzygy as in the case of the *Pentacrinidæ*.

Perhaps the most important question relative to the shortening of the column is as to whether the extremely abbreviated stems, as shown in figures 1 and 3, Plate 6, were produced directly by the detachment of practically the entire column, or whether the stem was shortened by degrees. Doubtless the primary disruption frequently took place well up in the proximal portion of the column, but in some cases where it did not we may well conceive of secondary shortening having occurred. In a highly specialized type we might well look for the fracture consistently to occur in the immediate proximal portion of the column. In this species, however, we should expect the location of the line of separation to be largely fortuitous. So far as our knowledge of the species goes, it appears in a general way that the older the specimen the shorter the stem. This would surely indicate a shortening of the column subsequent to the primary detachment of the organism, if found to be constantly true.

If the abbreviation of the column has been brought about by more than one disruption, such action should take place in one of two ways. In the first place we could have a shortening through the alternate fixation and detachment of the organism. The other method would be simply the dropping off of some of the distal columnals. A shortening of the column by the first method seems to be shown by the specimen previously referred to as being the only one in which attachment has been found. The column in this individual is of considerable size and would seem to indicate reattachment subsequent to a period of freedom; this in turn being followed by the detachment of the organism. Again, Carpenter says in regard to the distal portions of some of the columns that the sutures are somewhat obscured and smoothed over. This indicates perhaps not so much resorption as proximity to a point of attachment. The gradual loss of the major portion of the column by the successive shedding of columnals is quite within the bounds of possibility and would unfortunately leave no distinguishing marks. One may not conceive, however, of this process taking place by gradual resorption and the loss of one or two columnals at a time. The specimens indicate an abrupt separation of the column, resorption playing a purely secondary and minor part.

A very interesting result of this more or less complete elimination of the column is the formation of a type closely comparable to the members of Group II. On Plate 6, figure 4, may be seen a form in which but a single partially resorbed ossicle remains attached to the proximal columnal. In figure 6 this process has been carried still further, resulting in the complete loss of the column with the exception of the proximale. It is to be noted that all traces of the axial

canal and surface features of the inferior face of this ossicle, such as are shown in figure 5, have been filled and smoothed over by a secondary deposit of calcareous matter. The modified channel as thus formed simulates a centrale to a remarkable degree. It may not be styled a centrale, however, for it is a modified columnal, which a centrale is not, as will subsequently be shown. The proximale of *Millericrinus* and such stumps of columns as are illustrated by figures 1 and 3 are directly comparable with the centrodorsal of the comatulids, however, and are the result of practically an identical process working on columns of different yet not greatly unrelated types. The differences in the two cases are simply those of degree of specialization of the columns involved.

The whole tendency to be noted within this species seems to be toward the elimination of the column. It is of very great interest, then, to observe in practically all of the specimens figures by Carpenter that even in the shortened column there is a distinct counter-tendency toward a lengthening of the stem by the intercalation of new columnals. In some of the specimens this addition of new ossicles is quite marked, as in figure 1, Plate 1, of Carpenter's paper. Relative to the intercalation of new ossicles in the stem, there are features of no small interest to be noted in connection with the structure of the proximal columnal.

Structure of the "proximale" in Millericrinus.—Wachsmuth and Springer (1897) and Bather (1900) have placed the Apiocrinidæ in the Flexibilia Pinnata, doubtless on the supposition that there is a proximale. According to the figures of Carpenter (1882), it does not seem that there is such a persistent columnal in *Millericrinus prattii*. On the contrary, it would appear, as Carpenter himself notes, that there frequently is to be observed the formation of a new ossicle between the basals and what was formerly the proximal columnal. Figures 11, 20*b*, and 17, as given by Carpenter, may well indicate the successive stages by which the external appearance of such a columnal is marked. At first between and beneath the basals appear small subtriangular plate-like patches. These, as Carpenter says, are certainly not infrabasals. In figure 20*b*, as shown in the right-hand portion of the figure, it would appear that the radial patches had run together beneath the basals in certain portions of the periphery. In figure 17 there seems to be a continuous plate formed. In this figure it is interesting to note that those portions of the plate lying between the basals are of considerably greater height than the intermediate connecting portions lying directly beneath them. This clearly indicates the formation of the columnal by such a series of stages as has been outlined. It would appear, then, that at least during certain stages of the growth of *Millericrinus prattii* new columnals were formed immediately beneath the basals.

Possible appearance of infrabasals externally in Millericrinus and Apiocrinus.—A very interesting feature is shown by certain of these specimens, as, for example, figures 1, 3, and 4, in the appearance within the cup of certain apparently incongruous plates. Similar plates are to be noted in *Apiocrinus*, as shown in figures 7 and 8, which are copied from de Loriol. These represent *A. elegans* and *A. roissyanus*. The presence of such plates has been noted from the earliest times and by a considerable number of writers. No one apparently has endeavored to account for them except as being abnormalities. Carpenter (1882, p. 35) says:

I can form no idea as to the meaning of these accessory plates; they are evidently without any morphological importance, or they would be more constant in their occurrence.

As here held, these plates have a definite morphic significance. In brief, I consider them to be infrabasals. The curious occurrence of these plates is due to the structure of the base. It will be noted in figure 12 as given by Carpenter, or in any figures of the proximal columnal of *Apiocrinus* figured by various authors; that this ossicle extends far up within the cavity formed by the basals. The infrabasals where observed lie, as they necessarily should, at the extreme apex of this subpyramidal plate. This gives them a horizontal position of approximately that of the top of the basals, or even higher. It may readily be seen if for any reason these infrabasals should become hypertrophied and extend outward to the surface of the theca that they would appear either between the basals or at the juncture of the basals and radials. The extension of these plates downward so as to come in contact with the proximal columnal in an external view may perhaps be considered a secondary feature. However, this condition might be reversed were the infrabasals to extend outward at a much earlier stage in the ontogeny of the crinoid. This may account for the conditions as we find them in *Apiocrinus roissyanus* (Pl. 6, fig. 7), although one hesitates to deny that the structure here observed may represent the formation of a new proximal columnal, after the manner of *Millericrinus prattii*.

This hypothesis relative to the identity of these plates with the infrabasals is not perhaps capable of demonstration without the careful dissection of a theca showing such structures. It is, however, inconceivable that the plates can represent anything else. The reason for such an appearance of the infrabasals is not obvious. The sporadic appearance of entirely new plates is even more inexplicable, however. It must be borne in mind that the forms which show such plates are near the ends of their respective lines, and it is among such types that unusual structural features are apt to appear.

The relationships of Millericrinus.—The relationships of *Millericrinus* have received but scant attention, particularly as regards the

antecedent types. As noted above, because of the supposed possession of a persistent proximal columnal the genus has been placed within the Flexibilia. The validity of the grouping upon which the order Flexibilia rests will be discussed more at length during a consideration of the affinities of the members of Group II. In this connection will be given a more detailed discussion of the homologies of the proximale and its value in classification. As has been described above, there seems every reason to believe that in the case of *Millericrinus* there is no justification of this reference, inasmuch as new columnals seem to be formed immediately beneath the basals. The structure of *Millericrinus* seems to point strongly to a derivation not far out of the line from which the Pentacrinidæ were evolved. In any case I can see but slight reason for removing the Apiocrinidæ from the Inadunata. One of the main difficulties in the discussion of the genus is the apparently heterogenous character of the forms referred to *Millericrinus* by de Loriol. It is evident that we have here included highly divergent types, and until these have been resolved into their proper groups by a careful study of the material we can get but an imperfect idea as to the status of the various types.

Epi-plankton: Pentacrinus.—Whereas the majority of the crinoids upon temporarily abandoning their sessile habits live as vagile benthos, a few assume the somewhat surprising rôle of epi-plankton. As has been noted above, Buckland (1837, p. 437), in addition to postulating a detached existence for *Pentacrinus*, assumed that in many instances the animals attached themselves to drifting bits of wood and were then carried from place to place. The arguments for such a mode of life can scarcely be better presented than in the words of Buckland himself:

The specimen of Briarean Pentacrinite at Plate 52, figure 3, from the Lias at Lyme Regis, adheres laterally to a portion of imperfect jet, which forms part of a thin bed of lignite in the Lias marl between Lyme and Charmouth.

Throughout nearly its whole extent Miss Anning has constantly observed in this lignite the following curious appearances: The lower surface *only* is covered by a stratum entirely composed of Pentacrinites, and varying from one to three inches in thickness; they lie nearly in a horizontal position, with the foot stalks uppermost, next to the lignite. The greater number of these Pentacrinites are preserved in such high perfection that they must have been buried in the clay that now invests them before decomposition of their bodies had taken place. It is not uncommon to find large slabs several feet long whose *lower* surface only presents the arms and fingers of these fossil animals, expanded like plants in a Hortus Siccus, whilst the *upper* surface exhibits only a congeries of stems in contact with the under surface of the lignite. The greater number of these stems are usually parallel to one another, as if drifted in the same direction by the current in which they last floated.

The mode in which these animal remains are thus collected, immediately *beneath* the lignite and never on its *upper* surface, seems to show that the creatures had attached themselves in large groups (like modern barnacles), to the masses of floating wood, which, together with them, were suddenly buried in the mud, whose accumulation gave origin to the marl, wherein this curious compound stratum of animal and

vegetable remains is embedded. Fragments of petrified wood occur also in the Lias, having large groups of *Mytili*, in the position that is usually assumed by recent *mytili*, attached to floating wood.

I have examined similarly preserved material, and attached to one bit of wood not more than 15 inches in length by 3 inches in diameter there were to be found 20 or more *Pentacrinus*. Walther has brought forward similar evidence relative to the fossil *Pentacrinidæ*. It is probable in such cases that the attachment was not one of cementation. Although the nature of the association could not be accurately determined in the material examined, it seems highly probable that attachment was had by means of the radicular cirri. Walther considers the crinoids to have wound their stems about the drifting wood, as may well have been the case in some instances. As he shows, the attachment was so firm that frequently the crinoids were carried up into brackish or fresh water embayments, where they were deposited in the coal beds then forming. In such cases the driftwood with the appended crinoids may well have been driven in by storms.

It may be argued that in the cases above cited the wood to which the crinoids were attached was not floating at the surface, but had become water-logged and sunk to the bottom. Indeed, it is hard to see how the crinoids primarily became attached to the wood, providing the latter were at the time freely floating. Although one may concede considerable freedom of motion to the vagrant stalked crinoid, it does not seem probable or possible that the forms could swim freely at the surface. The mero-planktonic larvæ apparently offer the most feasible solution of the problem, but here another factor must be considered, and that is the length of time wood will float. Obviously in the present instance the period would have to be of sufficient length to permit of the maturation of the crinoid from an early larval stage. The arguments presented by Buckland and quoted above seem fairly conclusive that the wood with its pendant crinoids did float at the surface. The evidence brought forward by Walther likewise tends to prove that the crinoids were true epi-plankton. Were this not the case, it would obviously be impossible for the crinoids to have been driven into the brackish-water deposits where they were found. If this be true, it seems probable that the animals had passed the greater portion of their lives so attached.

Plankton: Scyphocrinus.—Unquestionably the widest deviation from the normal habit of the stalked Crinoidea is to be found in the case of the genus *Scyphocrinus*. For a crinoid to assume the rôle of a vagile benthos is not remarkable, and indeed one is not surprised to find an epi-planktonic existence sporadically maintained, as in the case of *Pentacrinus*. To find a stalked crinoid acquiring such structures as enable it to maintain a truly planktonic existence, however, is a most anomalous condition of affairs. Nevertheless, such we find to be the case in *Scyphocrinus*.

The question as to the relationship of *Scyphocrinus* to the curious bodies described as *Camarocrinus* by Hall and *Lobolithus* by Barande has never satisfactorily been decided. The latest author (Schuchert, 1904) to deal with the subject leaves the matter open for further evidence. He, however, inclines to the belief that "*Camarocrinus*" is the distal expansion of a crinoid stem. This crinoid, in his opinion, may or may not be *Scyphocrinus*. I have recently determined *Scyphocrinus* from the "*Camarocrinus*" beds of Oklahoma, western Tennessee, and West Virginia. The material is in an excellent state of preservation and there is no question as to its generic affinities. The specimens are closely associated with "*Camarocrinus*," in some cases the crinoid lying in contact with fragments of the bulb. The finding of *Scyphocrinus* associated with "*Camarocrinus*" in such widely separated regions as Bohemia, Tennessee, Oklahoma, and West Virginia is practically proof positive that the bulb "*Camarocrinus*" is a part of the crinoid *Scyphocrinus*. Of the fact that "*Camarocrinus*" forms the distal extremity of a crinoid stem there can be no question.

Schuchert (1904, p. 268) points out that the one "weak point in the argument that *Camarocrinus* is the float or specialized root of a crinoid" lies in the fact that there are no beds bearing quantities of *Scyphocrinus* crowns to correspond with those beds bearing vast numbers of *Camarocrinus*. The reason is obvious. Let it be assumed that *Scyphocrinus* was a floating organism, and pelagic in habitat. Upon the death of the animal, as is well argued by Schuchert, the crown and stem would drop off, leaving the bulb free. The point is that the decay of the tissues would probably result first in the disintegration of the arms, next the disarticulation of the constituent elements of the theca, and finally in the breaking up of the stem. The result of such a process would be the widespread dissemination of crown and stem fragments. Under exceptional conditions the theca might separate from the stem while still intact and be so preserved. Again, the segregation of bulbs indicates that they were pocketed, as it were, in an area of comparatively quiet water after having been transported by current or wind action. The animals themselves might well have been pelagic organisms, living far out in areas still covered by the ocean. If so, the crown and stem might have been lost in most cases before coming within the range of known deposits.

Both Jahn and Jaekel (in Schuchert, 1904, p. 259) consider it probable that the bulbs may belong to different genera of crinoids. Schuchert favors this view also. Jaekel's point of view may be summed up in his own words:

I am still the more convinced that they are bladder-like developments of roots. These at all times had an indifferent character and under similar local conditions did develop similar forms at very diverse places in the Pelmatozoa.

Apparently the main objection to referring all the "*Camarocrinus*" to *Scyphocrinus* lies in the vertical range of the forms. Putting aside the Bohemian beds, the correlation of which, with American formations, can be but approximate at best, we have "*Camarocrinus*" ranging from the late Manlius into what is correlated with the lower New Scotland.¹ This is certainly not an excessive vertical range for a crinoid genus. On the other hand, the possibility of the acquisition of such a highly specialized organ, which is without a close parallel in all the Pelmatozoa, as a result of parallelism or convergence, is beyond the bounds of legitimate speculation. It is probable that during the long period of time in which this highly specialized float was being evolved sufficient changes may have taken place in the crown to warrant generic separations. Among the forms as we know them, however, the float has essentially the same structure, and it seems probable that the animals themselves did not vary greatly. Again, the Bohemian occurrence is considered the lowest, while the Tennessee-Oklahoma occurrence is at the highest known horizon in which "*Camarocrinus*" occurs. If the crinoids to which the floats belong are referable to the same genus, even though found at the extremes of the geological range of "*Camarocrinus*," there seems no way of escaping the conclusion that the intermediate forms likewise must be considered as belonging to *Scyphocrinus*. It seems as firmly established, then, as such a thing may well be, that the bodies known as *Camarocrinus* or *Lobolithus* are the distal expansions of *Scyphocrinus* stems.

Schuchert (1904) has so thoroughly described the structure of these loboliths that there is little more to be said in that regard. More recently Sardeson (1908) has written in regard to these bodies, particularly as to their evolution. An extended discussion of the subject is somewhat out of place in the present paper and will be reserved until such time as the species of *Scyphocrinus* in America, of which there are no less than four, are described.²

¹ Fritsch (1907, p. 5) has described and figured a large roughly lobate object from a quartzite of Etage D as *Camarocrinus (Lobolithes) quarzitarum*. The nodular mass is some 21 cm. in breadth by 15 cm. in length, and seems to be divided into five irregular lobes. There is apparently no good reason for considering this mass other than in the light of a quartzitic concretion. It certainly bears no relation to "*Camarocrinus*."

² In connection with the remarkable habits of *Scyphocrinus* should be noted an interesting feature occasionally shown by the stalked young of *Antedon bifida (rosacea)*. Mr. A. H. Clark has called my attention to a passage by W. B. Carpenter (1866, p. 726) in which the young are described as floating at the surface in an inverted position. How this position is maintained is not stated, but it would appear that the expanded basal disk has much to do with the matter. It even seems possible that cavities within the disk may convert this organ into a sort of float not greatly dissimilar to that of *Scyphocrinus*.

In *Antedon* the acquisition of such structures may be pathologic, but the case nevertheless suggests many interesting possibilities. For instance, it may well be that the float of *Scyphocrinus* had its inception in such an aberrant saltation, being first acquired in a rudimentary way by the very young crinoids. Again, it does not seem impossible that such floating disks may largely have been possessed by various crinoid lines as normal structural features. If this be true it is evident that we have a factor that might be of high importance as affecting the distribution of the Crinoidea.

Crinoidea probably referable to Group I.—In the foregoing discussion of the eleutherozoic stalked crinoids only those forms have been cited regarding which there can be no question as to the validity of the asseveration. There are a number of genera, however, which we may hold to have largely maintained a detached existence with almost as much reason as in the forms described. Still it is only because of the known association of a detached existence with certain structural features that we may reasonably predicate a similar mode of life in the case of the following genera. It will be noted in these various types that we have structures analogous to those that obtain in many of the eleutherozoic crinoids hitherto described.

Porocrinus.—*Porocrinus* is perhaps the most primitive type to be considered in this collection. The notable breadth of the column in its proximal portion and the marked rapidity with which it tapers distad, together with the comparative tenuity of its distal portion, strongly indicates that we have here a column comparable to that possessed by many of the detached cystids. In all probability we may consider that the members of this genus led the existence of vagile benthos and attached themselves at will by wrapping the distal portion of the stem about some object.

The Rhodocrinidæ.—In the case of the *Rhodocrinidæ* we find at least three genera in which we may well consider a detached existence is largely maintained. In *Rhodocrinus* itself, as shown by the Kinderhook species where the columns are well preserved, the stem is comparatively short and we may note a marked tendency toward looping in its distal portion. In *Acanthocrinus rex*, as figured by Jaekel (1895) we find the distal portion of the column coiled, which is evidence that the stem was not firmly affixed to the bottom. It does not seem improbable that the crinoid may well have been temporarily attached by wrapping its column about some object. From the size of the stem in this specimen one would scarcely think of it as being prehensile, however. Jaekel lays considerable stress on this coiling of the column, and uses it as one of the characters to differentiate the genus from *Rhodocrinus*. As noted above, the feature is probably quite as characteristic of *Rhodocrinus*. In *Diamenocrinus jouani* as figured by Oehlert (1891) the distal portion of the column is represented as closely rolled into a coil consisting of at least three volutions. This coil is in a single plane. As in the case of *Acanthocrinus*, the column is of large size, and from the tightness of the coil one might conceive that its function was rather in the nature of a ballast or drag than a means of temporary attachment by looping about some object. The same explanation may well apply to *Acanthocrinus*. From the remarkable similarity which we observe in these three rather divergent genera as regards the coiling of the

distal portion of the column I think we may well assume that a detached existence was largely maintained within this family.

Homocrinus scoparius.—In *Homocrinus scoparius* cirri are borne for a considerable distance along the distal portion of the column. These cirri are short and feeble, and both because of their extent and their structure may not be held as roots. In well preserved specimens it will be noted that the extreme distal portion of the column is coiled into several volutions. Such a stem is figured by Talbot. (1905, pl. 3, fig. 3.) It seems highly probable from the structure of stem in this species that a detached existence was maintained. In an earlier species of the genus the distal coiling is perhaps even more marked, but there is no sign of the presence of radicular cirri.

Camptocrinus.—In *Camptocrinus*, which simulates to a remarkable degree the column structure of *Herpetocrinus* heretofore described, we may perhaps predicate a detached existence on the basis of this similarity alone. Furthermore, a careful examination of a large number of well preserved individuals of the genus has failed to show any signs of permanent distal fixation. The functions of the cirri in this genus may be held as similar to those of *Herpetocrinus*.

The Platycrinidæ.—Among the Platycrinidæ there is a certain compact assemblage of types marked by such forms as *Hapalocrinus* and *Cordylocrinus* in which the presence of verticils of cirri strongly point to the conclusion that these forms were free. I have examined hundreds of examples of *Cordylocrinus* and seldom have found the column greatly to exceed the height of the crown. There is no sign of permanent fixation. Where the preservation justifies an opinion it seems that the column ends distally with a cirriferous nodal, after the manner of the Pentacrinidæ. In *Cordylocrinus plumosus* the cirri reach an extraordinary length. In some cases those cirri borne by the proximal nodals reach beyond the tips of the arms. The presence of verticils of cirri may in any case be held as strongly indicative of the eleutherozoic habit of the animal to which they belong. Such an excessive development of these appendages points almost with certainty to this conclusion.

Evidence relative to widespread detachment among the stalked Crinoidea.—The list of stalked crinoids which probably maintained a detached existence might largely be increased. A sufficient number of cases has been adduced, however, clearly to show the prevailing tendency to be noted among the Crinoidea. Examples have been chosen from each order and from widely dissimilar families. If a detached mode of life obtains among these divergent types uniformly and not as the result of fortuitous disruption, we may well expect among other related families and genera that a similar tendency is manifest. It rarely, if ever, is found that in a relatively homogeneous group like the crinoids any decided departure from the normal

is restricted to an isolated group of organisms. Rather, such departures are found to have taken place again and again in a more or less marked manner, not only in contemporaneous, but in antecedent and subsequent forms. As regards this particular modification, or rather habit, we find evidence that indicates its appearance from the earliest times to the present, and among most diverse types.

In the case of the majority of the crinoids described above, freedom may be held to obtain during a considerable part of the lives of the animals, at least throughout the greater portion of the adult stages. Among the Crinoidea as a whole we shall consider that detachment becomes effective for variable periods, and perhaps alternates with times of fixation. This is sufficiently inclusive, I think, to cover any case. It is obvious that it is among types where detachment becomes irregularly effective that we have the progenitors of those forms which constantly assume and maintain an eleutherozoic habit. It is no doubt among these forms again that we have the ancestors of those crinoids which in the aggregate make up Group II. No line, except of the most arbitrary sort, may be drawn between the types in which detachment is the exceptional condition and those among which it is the rule. In all we observe to a greater or less extent the operation of the same tendency becoming progressively more effective.

In the following discussion evidence of detachment by the crinoids, whether structural or of whatsoever nature, is given. The matter relative to crinoid segregation and migration has a most important bearing on the question, besides indicating in part the reasons for the assumption of such a type of existence. Such evidence as is submitted is more or less general in that such facts as are adduced from specific types may be held to apply with greater or less force to the remainder of the stalked Crinoidea. In the case of the structural evidence again the material in most instances is incapable of exact identification and can only be credited in an indefinite way to the then existing crinoid fauna.

The evidence relative to these crinoids that are universally supposed to be firmly affixed from the time the column is formed and in which an eleutherozoic habit becomes but irregularly effective, is of necessity not conclusive. Such facts as are available, however, seem to make the conclusion that sporadic and perhaps long-continued periods of freedom are of comparatively common occurrence, the only feasible one. It is these post-larval periods of detachment that probably have had more to do with the segregation of the Crinoidea than the aimless wanderings of their ciliated larvæ, and it is no doubt in no small part due to the same factor that the Crinoidea owe their perpetuation as a virile stock.

In the Paleozoic rocks we have considerable evidence going to show that the Crinoidea became detached from their roots or disks of cementation at various stages in their development. In a very great number of cases it seems quite certain that these residual roots as we find them do not indicate the death and disintegration of the crinoid, but rather a separation of the crinoid from its point of attachment during the life of the individual. In some cases, at least, disraption seems to have been voluntary, resorption apparently taking place at the point of detachment.

In certain formations—the Hamilton for instance—one is accustomed to see large numbers of calcareous disks attached to brachiopods, corals, crinoid stems, and every conceivable support. Each of these disks has a stem cicatrix, and at one time obviously constituted the distal extremity of a pelmatozoan column. As a rule these basal expansions are small, ranging from 2 to 5 mm. in diameter. The stem cicatrix is seldom sharply defined, showing that there was probably a partial resorption of the stereom at the junction of the disk and column. It is evident that these disks pertain to young crinoids and are directly comparable in function to the so-called “dorso-central” of *Antedon*. It is equally evident, I think, that these young crinoids became detached and shifted to another locality where they may or may not have become permanently anchored.

An interesting locality where such basal disks are particularly plentiful is in the Trenton limestone of Kirkfield, Ontario. Here at one time the sea advanced over an eroded limestone surface. With the advancing sea, and probably in very shallow water, came in large numbers of crinoids. The old limestone bottom is covered with basal disks, as many as fifty having been counted in an area of a square foot. Most of these disks are small, but occasionally the highly specialized basal expansions of *Cleiocrinus* are found, ranging up to 5 or 6 cm. in diameter. In many cases it seems probable that the crinoids became voluntarily detached. Stems and crowns are rarely associated with these basal expansions, and frequently the zone of detachment shows signs of resorption. It may be argued that instead of being a case of resorption in these instances it is a case of partial solution of the calcareous matter subsequent to the violent disruption of the column from the base. The splendid condition of such crinoids as are found at this horizon where the most delicate ornamentation is beautifully preserved, and the unaltered sharp angles of broken columns tend to refute this argument, however. Another example of this sort is in the Silurian of Waldron, Indiana. Here in one bed are found great numbers of crinoid roots, most of them probably belonging to *Eucalyptocrinus*. Stems and crowns, again, are rarely associated with these roots. It seems probable that here

was a colony of adult *Eucalyptocrinus*, the members of which for some reason or other, became detached and left this immediate locality.

It must necessarily follow upon the death and decay of a crinoid that residual roots or basal disks are left and many roots referable to adult specimens may no doubt be assigned to this category. The vast number of immature disks which are to be found can not, I think, be explained on this basis, however. Again, in the case of detachment for this reason, there would be no sign of resorption at the line of separation, such as is indicated in many examples. This point is equally effective against the hypothesis of violent disruption in such instances as it is to be observed. Even were there no signs of resorption at the point of detachment these basal disks need by no means be considered as having been left by the death and decay of the animals. Disruption of the column may well become effective elsewhere than at its juncture with the base. Indeed from the little we know in regard to such matters it appears that the separation of the column occurs with great frequency at higher points. Subsequent to such a type of detachment, which on the whole I think we may consider, as a rule, involuntary, the residual columnals will become disarticulated and leave a base with a sharply defined stem cicatrix.

In connection with these residual disks should be recalled those spirally coiled columns noted above under the discussion of *Glyptocrinus*. In these specimens the distal portion of a stem has been spirally wound about the column of another crinoid, in many cases being laid on as neatly as thread upon a spool. Subsequently, a fusion has taken place between the two columns resulting in the absolute fixation of the attaching organism. Most of the stems attached in this manner indicate that as in the case of *Glyptocrinus*, the crinoids were comparatively young forms, and became detached later in life.

It must be granted that those forms in which the distal portions of the columns do not bear roots or disks of cementation were not firmly affixed to the bottom. Furthermore, those types having cirri obviously adapted for grasping or in which there is a very considerable development of the cirri, may be considered to have led an eleutherozoic existence. It seems possible to carry this postulate of a free existence among the stalked crinoids still further. In other words, it seems quite probable that many crinoids having rootlets were never permanently attached. This reference is made from conditions as we have them in the preservation of crinoids in the colonies of paleozoic times.

Were the crinoids to have been truly rooted, the distal portion of the stem must of necessity have been buried in the material composing the bottom. Upon the death of such forms it is obvious that without very considerable disturbance of the sediment surrounding these

roots they could not have been freed without at least destroying the comparatively delicate cirri. An examination of the crinoids composing a colony where the animals are almost perfectly preserved furnishes no indication of any considerable disturbance. The bottom upon which they lived is in apparently the same condition as it was in Paleozoic times. Notwithstanding this fact a very large number of crinoids which retain their columns have the radicular cirri preserved most perfectly, and the distal portions of the stems are essentially complete. Such conditions apparently indicate that those particular crinoids were never firmly rooted.

In the case of the Waldron bed, containing large numbers of roots probably pertaining to *Eucalyptocrinus*, it would seem that the opposite condition of affairs obtains, and that here the roots were buried in the sediment. As found to-day, such a root is practically as perfect as during the life of the animal, but, unlike the free type of radicular cirri, it is not found attached to complete columns. It is evident that such roots as those of *Eucalyptocrinus* were buried in life, and upon the disruption of the column remained behind. One complete specimen of *Eucalyptocrinus* has been found, but this is a young individual with a comparatively small root. A notable difference is to be observed in the structure of such roots as have just been mentioned and those which are found free. In the former case the roots are confined to a comparatively small portion of the distal part of the column. They are numerous and branch frequently, having much the appearance of the roots of a tree. In the latter cases the cirri are comparatively delicate, irregularly placed along the column, and few in number. It seems possible, then, when we observe columns of the latter type to predicate a semifree existence for the crinoids. The number of such forms is very considerable, and in most cases such evidence of an eleutherozoic habit is supplemented by a coiling or looping of the distal portion of the column.

Were the majority of crinoids firmly affixed in their adult stages, as has been commonly assumed, we should find a far greater number of roots obviously pertaining to mature animals. It is a fact that will at once strike anyone having to do with the Paleozoic rocks, and particularly those beds in which the Crinoidea are comparatively abundant, that large roots are of great rarity. This is the more remarkable when one considers the nature of these organs. Either as basal disks or radicular cirri they are, as a rule, stout and reenforced with a secondary deposition of stereom. Those roots composed of radicular cirri clearly indicate in the majority of instances inclusion in the substance of the sea bottom. Under these conditions, with deposition in quiet waters, there is no reason why practically all of the roots should not be preserved to us to-day. The preservation of the roots at Waldron, Ind., above described, should be the rule and not the

exception. Here the cirri are preserved even to the most tenuous extremities.

Crinoid crowns, with their comparatively weak articulations, are found in the utmost perfection. These, moreover, lay upon the sea bottom and were not already covered. Comparing the two extremities of a crinoid, all the chances for preservation lie with the roots. The relative proportions in which the two are found, however, would tend to prove quite the opposite. The crowns and calices far outnumber the roots. The only logical deduction from these facts is that there were in reality more crowns than roots—in other words, that a very great number of the Paleozoic Crinoidea, like their modern relatives, led a semifree existence. 'At any rate, we may assume that they had no highly specialized organs for purposes of permanent fixation.

One must constantly bear in mind that universal freedom is not predicated for any given time or for any given group. It was constantly assumed in a number of sporadic lines, but these may be held as exceptions to the general rule. In some species and genera, no doubt, an eleutherozoic existence was of very rare occurrence. Certain specialized roots bear witness to this fact by their great abundance. In the case of the easily recognized "*Aspidocrinus*," for example, which is the basal expansion of some apparently adult crinoid column, hundreds of specimens may be collected in certain beds. No crinoid crowns are found associated, having doubtless decayed and been reduced to their constituent elements. Such an instance illustrates the proper proportion one would think should obtain between crowns and roots, were there originally an equal number of each, and were the bases of attachment practically indestructible under normal conditions. The proportion should be more nearly equalized in cases where the roots are composed of cirri, perhaps, for here there is a greater chance for the roots to be destroyed.

The evidence as afforded by available facts relative to the material discussed above seems to warrant the drawing of two general conclusions. In the first place we are fairly safe in assuming a fixation of the crinoids in their early stages, which was frequently, perhaps universally, followed by a period of detachment and freedom. In the second place it seems highly probable that there was a widespread lack of fixation among the mature crinoids. Given freedom and more or less ability to move, we may easily see that the crinoids could largely determine and control their movements, and consequently their environment.

As suggested above, it seems highly probable that these periods of postlarval freedom bear largely on the distribution and segregation of the crinoid elements in the various faunas and have much to do

with the cosmopolitan nature of many forms. The facts relative to the distribution of the Crinoidea, on the other hand, offer many convincing arguments in favor of the widespread freedom of the adult crinoids. Inasmuch as these facts apply with equal force to all the Pelmatozoa discussed in the paper, it has seemed best to postpone a treatment of this phase of the subject until the different groups have been discussed in detail.

In such Crinoidea as those above noted in which a detached existence has been shown, there can be no question but that for a large part of their lives the animals were capable of more or less free movement. In the case of any given species where such freedom of movement has been established, it is not held that every individual necessarily enjoys the same freedom. In any species of *Isocrinus*, say, it may be found that there are individuals the greater part of whose lives is passed cemented or rooted to one spot, while others undoubtedly pass long periods of time during which there is no such fixation. It should be borne in mind, however, that the status of such a free type is not that of a sport, freedom being accidentally acquired and inadvertently maintained. Rather it should be held that such a type of life is, as one might say, optional with the crinoid, freedom in such instances perhaps being accidentally acquired, but in most cases being voluntarily maintained. In all such types freedom is the expression of a general tendency toward the assumption of an eleutherozoic habit and in all probability would not be perpetuated were it not for this fact.

GROUP II.

As previously defined, this group contains those Pelmatozoa which have lost all or the greater portion of their columns. In certain fossil forms the stem is completely eliminated, not even the proximal columnal being retained. In one very large, and perhaps the most important division of the group, however, it is next to impossible to draw a line separating the constituent members from the forms characterizing Group I. In this division, the "Comatulæ," the proximal portion of the column is retained, which is, as a rule, profusely cirriferous. It seems to be a question as to whether these genera should be placed in Group I or whether such a type as *Milleriocrinus prattii* should be listed under Group II. Division has here been made on the basis of the degree of specialization of the forms involved. Thus, among the Comatulæ a stem is only had in the embryonic stages and is consistently lost as a column among the adult crinoids. Among the ancestors of these forms, however, we come eventually to a type which is indifferently stalked or detached and hence in a way to be held as intermediate between Group I and Group II.

It is among the members of Group II that we find the highest expression of an eleutherozoic habit among the Pelmatozoa. This does not signify that among these forms we have the highest degree of specialization and modification, although even in these respects the crinoids are notable. We have here, however, the most perfect adaptations to a free-swimming life. Such adaptations are best shown among the Crinoidea and but imperfectly developed in the case of the Cystidea and Blastoidea. This is obviously due to the fact that among the latter classes the brachial appendages have been but indifferently developed, and are scarcely able to function as active swimming organs. Among the members of this group we have a wide range in the habits of the animals. The majority of the forms may be classed as vagile benthos, locomotion being effected either by crawling along the bottom or by more or less extensive swimming movements. From such types we pass to those in which a truly pelagic existence is maintained.

Bather's classification.—Bather (1896, p. 995) considers that unstalked crinoids "fall into three distinct groups." These are:

First, the group in which a portion of the stem remains, becoming modified into a cirrus-bearing centro-dorsal, as in *Antedon*, *Eudioerinus*, and *Thaumatoerinus*. These forms anchor themselves by their cirri, and though capable of crawling, climbing, and swimming, do not often exercise their faculty of locomotion. Secondly, the group in which either a portion of remaining stem, or the lower part of the cup (i. e., basals or infrabasals), becomes solidified, usually by additional deposition of stereom, into a knob, which, one may suppose, serves as ballast or as a sea-anchor; such forms are *Agassioerinus*, *Edriocrinus*, and *Millerierinus pratti*. Both of these groups have a small calycal cavity with thick walls, and there can be little doubt but that all are attached by a stem in the earlier stages of ontogeny. The third group, comprising *Marsupites*, *Saccocoma*, and *Vintacrinus*, has no trace of a stem or of any anchoring structure, but is in all respects adapted for free locomotion; the calycal cavity is large in proportion to the thickness of the arms, and is enclosed by thin flexible walls.

Classification of Group II here employed.—For the purpose of the present paper I have thought it more expedient to use a somewhat different classification. This grouping, like the one used by Bather, is a purely physiological one—widely divergent types being placed together because of a certain unity of structure in the apical portion of the dorsal cup. The grouping likewise includes several Cystidea and Blastoidea, which as regards their mode of acquisition of an eleutherozoic habit are structurally comparable to the Crinoidea of this division.

Among the majority of the forms here described under Group II the loss of the stem is a constant character and acquired as the result of a definite evolutionary process. There are, however, several crinoids where the loss of the column, though complete, appears either to be a sporadic feature, or forced upon the animal by violent disruption of the column. These crinoids shed considerable light on

the origin of certain structures to be observed in crinoids where a loss of the stem normally obtains. Because of this fact they will be discussed in connection with Group II. As will hereafter be noted, the chief interest of these aberrant types is in connection with the origin of the centrale, characteristic of Type 2.

The genera of the first division may be grouped together according to the way in which the plates of the dorsal cup and the proximal columnals become modified as a result of the loss of their articulated stalks.

Type 1.—In this type of structure the proximale (and occasionally a few of the columnals) fuses with the infrabasals forming what is known as a centro-dorsal. This centro-dorsal is usually cirriferous throughout the free-swimming stage of the individual. In some forms however, the cirri are lost in the adult. The centro-dorsal also lodges the chambered organ. Some of the genera representing this type of structure are:

Antedon.

Actinometra.

Eudiocrinus.

Atelecrinus.

Thaumatocrinus.

Type 2.—Here we find that after the loss of the stem, which is entirely detached from the crown, there is introduced an entirely new element into the dorsal cup. To this plate we shall apply Bather's term centrale. At times, as will be explained later, the centrale may fuse with all or a part of the plates in the proximal circlet of the dorsal cup. This centrale functioned as a plug to stop up the apical opening through which communication was established between the visceral cavity and the stem lumen in the stalked condition. The genera illustrating this type of structure are:

Uintacrinus.

Marsupites.

Saccocoma.

Type 3.—In this case again, the stem is entirely lost. In the typical crinoid of this group, *Agassizocrinus*, the infrabasals, which are quite large and massive, fuse, and together with a secondary deposition of stereom, close the axial canal. Apparently no centrale is formed. Some species of *Edriocrinus* are structurally analogous to *Agassizocrinus* as regards the fusion of the proximal circlet, and the secondary deposition of stereom.

Type 4.—This group has been made for the sake of completeness, to include two Blastoids and certain Cystidea. In these forms no centrale exists nor is there a fusion of the proximal circlet, and a secondary deposition of stereom. Instead, the basals unite very closely,

leaving no opening, therefore obviating the necessity of any secondary structures.

These four types of structure will now be taken up in the order here given, and a more detailed discussion given to each group.

TYPE 1.

The Crinoidea constituting this assemblage are entirely restricted to Mesozoic and recent forms. In the present seas representatives are very numerous and have an enormous range. It seems highly probable that the Comatulæ represent a number of genetic lines, and that even some of the families as defined by Bather are polyphyletic in origin. Whether sufficient material and information will ever become available to enable one closely to discriminate between these convergent lines it is impossible to say. The component genera after all have an essential unity of structure, and have doubtless been derived from not widely divergent types. Such being the case, and inasmuch as these forms are so well and widely known, no attempt will be made to discuss any given genus in considerable detail. Certain points regarding the structure of the animals are given, however, because of the bearing they have on questions dealt with in the present paper. The probable origin and development of the centro-dorsal is treated at some length, for instance, not only because of its importance in this group, but also because of the bearing it has on larger systematic questions.

During the past two or three years the comatulid genera as recognized by Carpenter have been divided and subdivided into numerous genera, chiefly through the efforts of Austin Hobart Clark. Inasmuch as the descriptions of these genera are of a more or less preliminary nature, one may be pardoned for not making use of the new appellations. For the purposes of the present paper extreme nomenclatorial refinements are after all in no wise essential. On this account very largely, no attempt has been made to depart from the nomenclature of Carpenter, and the generic names of the free-swimming crinoids as here employed are those commonly accepted.

The structure and development of the centro-dorsal.—In the well-known *Antedon*, as well as in the other genera of this group, the central apical portion of the dorsal cup consists of a centro-dorsal. This is made up chiefly of the proximale, which either persists alone, or possibly has a limited number of columnals fused with it. To the proximale also are probably fused in all cases the infrabasals. These, because of their size, are a negligible quantity in a consideration of the general composition of the adult centro-dorsal. The centro-dorsal is cirriferous, except in the adults of certain species, where the cirri have been lost.

The development of the centro-dorsal in the case of *Antedon* has been described as follows by Carpenter (1888, p. 11):

The centro-dorsal is at first a simple ring, in no way different from the other stem joints, but when the basals come to assume a definite shape and the calyx acquires the doubly conical form of the Cystid phase, the centro-dorsal becomes distinctly wider than the annular stem joints below it and takes on a pentagonal shape. The basals rest against the sides of the pentagon, and its angles which fit in between them are therefore radial in position. * * * At this early stage the basals are only in contact with the centro-dorsal by their lower edges, but it soon begins to increase in diameter and extends itself over the bottom of the calyx. * * * It increases at the same time in vertical depth, and the first cirri make their appearance. These are radial in position, and the portion of the centro-dorsal between every two sockets rapidly enlarges, so that it comes to project beneath each basal plate, and the angles of the centro-dorsal thus become interradial instead of radial. This change is very clearly seen in larvæ which have only one or two cirri, so that one part of the centro-dorsal shows the primitive radial symmetry and another part the acquired interradial symmetry.

In this form the proximale, without the addition of other columnals, forms the centro-dorsal.

The further growth of the centro-dorsal is described on page 12:

I merely wish to point out that as soon as the centro-dorsal of the early larva of *Comatula* takes a definite shape its angles are distinctly radial. * * * But when the cirri appear on the centro-dorsal and the basals begin to be transformed into the rosette, the outline of the centro-dorsal changes. The basals are no longer the principal plates in the calyx, but they undergo metamorphosis into the small rosette, and the centro-dorsal increases rapidly in size, more so than any other part of the skeleton, "so that it soon comes to pass beyond the circlet of basals and to abut on the proximal edge of the first radials; and instead of stopping here it continues to increase in diameter until it conceals the whole inferior surface of the first radials and sometimes even encroaches somewhat on the second."

Carpenter, in these passages, as elsewhere, insists upon the primitive radial position of the centro-dorsal, as opposed to the views of Wachsmuth and Springer (1879-86, pt. 3, p. 298 (222)). Moreover, he proves his point conclusively by giving two figures of larval *Antedon*, one of which is reproduced here. (Pl. 7, fig. 6.) In the very early stages, and before the appearance of the cirri, the centro-dorsal conforms to the pentagonal opening formed by the basals, and hence by necessity the angles must be radial in position.

In their Monograph of the Camerata (1897, vol. 1, p. 64), Wachsmuth and Springer try to controvert the statements of Carpenter above cited. On Plate 6, figs. 18 and 19, they reproduce two figures taken from W. B. Carpenter. Discussing these figures in the text, they make the following statement:

The centro-dorsal at the Pentacrinoid stage of the Comatulæ, as may be seen by examining Pl. 6, figs. 18 and 19, agrees closely with that of the Apiocrinidæ. It is interradially disposed at the proximal face, and also at the distal face, so that its angles correspond with the angles of the basals as in those dicyelic Crinoids whose infrabasals are hidden by the column, and even in the prefloating stage the centro-dorsal retains its interradial position.

Figure 19, according to the explanation of the plate, is an adult specimen, and figure 18 certainly does not represent a very young stage. Wachsmuth and Springer apparently overlook the fact that Carpenter described the centro-dorsal in the later stages of development as having interradian angles and conclusively proved that this was purely a result of secondary growth. Indeed, as quoted above, Carpenter states that in larvæ in which only one or two cirri have appeared, the centro-dorsal in the noncirriferous portion is radial, while in the remaining portion the angles of the plate are interradian, as a result of secondary change of form induced by the presence of the cirri.

Bather (1898, p. 425) again emphasizes this fact:

That such secondary formation of stereom does take place is no hypothesis; it has been described in *Antedon* by W. B. Carpenter, H. Bury, and others. In fact, the odd thing about that genus is that the very features on which Wachsmuth and Springer relied in their famous prediction that it would be proved dicyclic are of purely secondary nature.

Thus we find that the early form of the centro-dorsal in *Antedon* is entirely dependent upon the nature of the adjacent basals and is largely governed in subsequent growth by the addition of cirri and the concomitant increase in size of the plate itself.

It would have proved much more effective had Wachsmuth and Springer applied their law to the primary verticil of cirri, instead of attempting to make the centro-dorsal conform to their law; for these cirri are radial in position, as they should be in a dicyclic form. The later cirri are given off apparently without regard to position.

It is to be noted in the case of *Antedon* that the proximal columnal fuses with the infrabasals at an extremely early stage in the ontogeny of the animal. Indeed such fusion apparently takes place before the constituent plates of the theca have assumed definite positions and have become apposed. Such a condition of affairs shows a high degree of acceleration and clearly indicates the comparatively ancient acquisition of a detached existence by this line. As a result of this early fusion of the proximal columnal with the infrabasals the centro-dorsal assumes a position within the basal circle as soon as the plates acquire a definite form. This condition is quite different from that to be noted in earlier and less specialized types, as will be indicated in the discussion of the phylogeny of the centro-dorsal.

In its adult expression among the Comatulæ the centro-dorsal assumes widely different forms. Primitively low and bearing but few cirri, in some forms it reaches an extraordinary development. In *Antedon* (*Solanocrinus*) *scrobiculatus* (Pl. 8, fig. 3), for example, it will be noted that the centro-dorsal is of great length. As opposed to this condition of affairs a number of species of *Actinometra* have the organ greatly reduced and noncirriferous. This type of struc-

ture has been described by various authors and some figures of *A. nobilis* are here given as copied from Carpenter. In younger specimens of this species the centro-dorsal is normally cirriferous. Subsequently, however, the cirri are lost and the centro-dorsal becomes largely resorbed (Pl. 6, figs. 9-11). Still another variant is to be observed in the case of such a form as *Antedon laticirra* (Pl. 8, figs. 1, 2). But few cirri are borne by the centro-dorsal and these are of relatively enormous size. Again, in many of the species of Comatulæ, both recent and fossil, the centro-dorsal bears large numbers of cirri either regularly or irregularly arranged. The shape of the centro-dorsal seems, therefore, to vary largely both as to shape, size, and number of cirri borne. This variation seems to obtain not only among different genera and species, but within the same species, dependent upon the degree of maturity of the individual.

Definition of the centro-dorsal.—Before discussing even in a most general way the interrelationships of the forms referred to the Comatulæ, or to endeavor to establish a connection between any of these types and their stalked ancestors it will be necessary to enter rather deeply into a discussion of the evolution of the centro-dorsal, the organ that is so characteristic of these eleutherozoic forms. It may perhaps be best to limit and define the term centro-dorsal. The centro-dorsal may be held to consist in its simplest form of the proximal columnal to which the infrabasals have been fused. Furthermore, centro-dorsal as here used may only apply to a cirriferous organ. It is evident that the terms proximale and centro-dorsal cover an essentially similar structure. Indeed, as here defined, the only essential difference lies in the fact that one bears cirri and the other does not. It is obvious that this distinction is a most arbitrary one. It is nevertheless a matter of some convenience to draw such a line. It is quite within the bounds of possibility, as will subsequently be shown, that the term "centro-dorsal" may apply to two quite different structures. As above defined and as immediately discussed hereafter, the organ is held as having the same position generally assigned to it. After having indicated in a general way the evolution of this type of centro-dorsal, the evidence for another and divergent type will be given.

Evolution of the centrale.—The question of the evolution of the centro-dorsal involves necessarily the question of the evolution of the centrale. This in turn involves questions which are quite without the province of the present paper. It is necessary, however, to state, even though briefly, an opinion relative to these topics. The presence of a persistent proximal columnal has been used by Wachsmuth and Springer and by subsequent authors as a character of prime importance in the classification of the Crinoidea. It is on this structure that the Order Flexibilia was established. I do not believe that

this structure has the importance assigned to it, but that it is a character independently acquired in several lines of evolution.

It is evident that the forms with a proximale have been derived from those having normal stem structure where new columnals are formed immediately beneath the proximal circlet of thecal plates. If this character were acquired in a single genetic line it would doubtless be of considerable value, although it would be difficult at best to distinguish between the primitive forms having such a columnal and those from which they were derived. We are dealing, however, I think, with a type of structure which may be shown to have been independently acquired by numerous offshoots from the Inadunata.

It is a question whether there consistently be such a proximale as a matter of fact. We may certainly postulate its existence in many adult crinoids, but it appears to me highly probable that in the ontogeny of many such forms we might well find fresh columnals forming immediately beneath the theca. In a number of forms referred to the Flexibilia in which the so-called proximale is notable because of its high degree of differentiation it is probable that we may frequently have the formation of new columnals proximad to this ossicle. Such, for instance, is apparently the case in the genus *Millericrinus*.

The appearance of an apparently persistent proximal columnal in *Millericrinus* is of considerable interest inasmuch as it seems to have been but imperfectly acquired within the genus. In such a form, for example, as *M. gracilis* the proximal columnal may be seen to be but slightly differentiated. In *M. prattii* as described above (p. 51) the proximal columnal, although apparently well formed, seems at times to be superseded by the formation of a new plate between it and the theca. In *Millericrinus recubariensis* as described and figured by Bather (1897), a species that Mr. A. H. Clark refers to *Bathycrinus*, the proximal columnal is said "to be incomplete; it only occupies a portion of the basal surface of the cup, and some of the basals rest, in whole or part, on the columnal next following." It will be unnecessary to enter further into a discussion of this primitive *Millericrinus*, but I think it is evident that we have here good evidence of the formation of a new columnal between the former proximal columnal and the theca. Again, within the genus we have cases in which the proximal columnal appears quite as highly differentiated as in any form to which a proximale has been ascribed.

In certain species, as in *M. charpyi* (Pl. 7, fig. 1), and less notably perhaps in *M. beaumonti* (Pl. 7, fig. 2), the proximal columnal is of great height and is considerably differentiated from the remainder of the columnals. In such cases one would not be surprised to find detachment becoming effective immediately beneath this columnal, and the crinoid assuming an eleutherozoic existence. We know that

the tendency toward this life is quite marked, as shown by the modifications of *M. prattii*.

Whether there be a truly persistent proximal columnal or not it certainly is true that in many genera at a certain stage in the growth of the organism the proximal columnal becomes differentiated in a more or less marked manner from the remaining ossicles of the column. The tendency is constantly toward a higher degree of specialization in this regard, and no doubt the structure becomes considerably affected by acceleration. A proximal columnal may only be safely called a proximale, I think, when fusion, more or less complete, has taken place between it and the infrabasals. Such a fusion alone may definitely preclude the possibility of an intercalation of columnals immediately beneath the theca. The infrabasals in any case must be small, if not practically obsolete. In consequence of this fact the proximal columnal comes to lie within the basal circlet. It is evident, however, that its contact with the circumjacent basals is not of the same nature as that of a centrale with its juxtaposed plates.

The proximale as it is shown by different genera is too well known to warrant extended description. Carpenter (1884, p. 25) describes the proximale as follows in the case of *Rhizocrinus*:

But the uppermost joint of all is of a different character altogether. It has a pentagonal outline, and the surface, which rises gradually from the circumference toward the center by five radiating ridges into an equal number of trapezoidal fossæ that receive the lower ends of the elongated basals. Here, therefore, we find the top stem joint presenting the same character that it does in *Apiocrinus* and *Millericrinus*, and entering to some extent into the composition of the cup, while the new joints are probably intercalated below it.

Such is the essential structure of the proximale in the Bourguetierinidæ, with which we are immediately concerned. The "proximale" as had by other families referred to the Flexibilia will not be discussed, as having but slight bearing on the origin of the centro-dorsal. It is to be noted in the description above that the proximale of *Rhizocrinus* does not present "the same character that it does in *Apiocrinus* and *Millericrinus*." In the case of *Rhizocrinus* fusion of the proximal columnal with the infrabasals has apparently become completely effective, whereas in the other two genera cited such fusion is by no means universal.

The evolution of the centro-dorsal.—Having briefly outlined the ontogenetic development of the centro-dorsal in the case of *Antedon* and discussed in a general way the structure of the proximale and centro-dorsal, we may indicate the stages by which these structures have been acquired phylogenetically. As above mentioned the generally accepted type of centro-dorsal will be dealt with first.

We must of necessity begin with a crinoid in which columnals were normally produced immediately beneath the theca. In all

probability we need not go back into the Paleozoic for such a form. Subsequently among the descendants of such a type we may postulate a tendency toward the acquisition of a proximale. The essential factor in such an evolutionary process is naturally a decrease in the formation of ossicles immediately beneath the theca and a lengthening of the stem by the intercalation of new columnals distad to the proximal columnal. It is doubtful if there are many forms among which formation of columnals immediately beneath the cup does not take place even in post-larval stages of development. The differentiation of a persistent proximal columnal may no doubt be accounted for very largely on a purely mechanical basis, though concerning its exact nature one can not be entirely certain. It is sufficient to note that at some stage in the development of the animal the topmost columnal becomes intimately associated with the proximal elements of the theca. This comes as the direct result of a gradual diminution in the size of the infrabasals. Such a tendency toward the elimination of the infrabasals brings them within and at the apex of an inverted cup in the base of the theca. This results in the introduction of the proximal columnal within the basal circle, as regards horizontal position.

Having acquired a proximal columnal that retains its position as such for an extended period during the adult stages, there begins an appreciable differentiation of this ossicle, as separating it from the remainder of the columnals. These differences lie chiefly in a lengthening of the columnal, which may become very marked. (Pl. 7, fig. 1.) At the same time there is a more and more marked inclusion of the ossicle within the basal circle accompanied by an increasingly close union between it and the infrabasals. Eventually in some of the later stages of development there is a complete fusion between the infrabasals and proximal columnal. At this stage we may call the columnal a "proximale" in its strictest sense.

Subsequent to the differentiation of the proximal columnal there was no doubt a constant tendency on the part of the crinoid to break loose from its column immediately beneath this ossicle. The process may in a general way be held to have evolved somewhat in the manner to be observed in the case of *Millerierinus prattii*, certain specimens of which as already described are essentially comatulid, barring the lack of specialization relative to the centro-dorsal that is to be noted in the case of the later forms. From types in which detachment occurs infrequently and perhaps at different points in the column we come to forms among which detachment becomes universally effective. Detachment at first is to be found only in adult stages, but, as affected by acceleration, was pushed farther and farther back in the ontogeny of the organisms.

The next step is marked by the acquisition of cirri borne by the proximale. This, according to definition, would constitute the formation of the first true centro-dorsal. The extreme irregularity as regards the appearance of these cirri and their variable number point to the conclusion that they are not modified verticils of cirri originally borne by a nodal. In such forms, indeed, I think we have to look among stalked Crinoidea without verticils of cirri upon the column for the ancestors of the free types. The cirri in such cases I conceive to have been evolved in direct response to the needs of an eleutherozoic habit. At the same time I do not believe that such cirri could have been evolved were it not for the fact that within this genetic line there was a tendency toward the acquisition of such organs. These cirri appearing first in the free-swimming stages perhaps are progressively found earlier and earlier in the ontogeny of the animals until, no doubt, cirri were borne at an early stalked stage in the development of the organ.

Subsequent to the acquisition of cirri the changes in the gross structure of the crinoid skeleton are of a less fundamental nature. Detachment from the column takes place at progressively earlier ontogenetic stages, as does the appearance of the cirri. There is, moreover, a constant tendency toward an increase in the number of cirri. The infrabasals continually decrease in size and importance, and a reduction in the size of the basals is to be noted. The basals, moreover, unite to form a "rosette" and do not appear externally. Naturally there are also changes in the musculature of the arms and in the type of union between the ossicles. The degree of specialization is in direct proportion to the length of time that has elapsed since the assumption of an eleutherozoic existence.

Phylogenetic steps in evolution of centro-dorsal.—The steps in the evolution of the centro-dorsal as briefly outlined above find expression in well-known fossil genera. These genera may not represent actual links in an evolutionary chain, but they have the character that such ancestral forms undoubtedly possessed. Indeed, it is by no means certain that these genera did not give rise to successful comatulid lines. If they themselves did not, forms not widely unrelated may be held to constitute the necessary ancestral types.

One may well, I think, start with such a form as the Cretaceous *Mesocrinus*, which has been described and figured by Carpenter (1881). This genus apparently has a fairly well-developed proximale, which may or may not be fused with the infrabasals. It is inserted well up in the cup formed by the basal circlet. The proximale is small, however, and bears no cirri. The columnals in the upper portion of the stem are circular in section, but the distal ossicles have oval articular faces. The column evidently pertains to the Bourgueticrinidæ. The stem in its distal portion is comparatively heavy and

bears radicular cirri. These are obviously for purposes of attachment. Apparently never more than two cirri are borne by a columnal.

In another Cretaceous genus, *Thiollicerinus* (Pl. 7, figs. 3-5), we have made a great advance. In this genus detachment had become universally effective, disruption occurring immediately beneath the proximal columnal. Even though detachment took place late in the life of the organism, as is evidenced by the large size of the articular face on the lower surface of the centro-dorsal (Pl. 7, fig. 5), the very fact of disruption being actually effective at this point, shows clearly that an eleutherozoic habit had long been maintained. This is further indicated by the presence of cirri on the centro-dorsal. As is shown by *T. herberti* (Pl. 7, fig. 3), the cirri are small, few in number, and irregularly placed. In *T. flexuosus* (fig. 4 on the same plate) the cirri are comparatively larger, more numerous, and form a practically continuous ring about the centro-dorsal. From the shape of the articular face as preserved on the centro-dorsal (Pl. 7, fig. 5) it is evident that this genus had a typical *Bourgueticerinus* column. Such a crinoid as *Thiollicerinus* might well serve as a point of inception for a comatulid line. If such be the case, it seems probable that in this particular evolutionary line none of the columnals other than the proximal one goes to form the incipient centro-dorsal. This seems to be indicated from the fact that, owing to the structural peculiarities of the stems involved, disruption constantly takes place immediately beneath the proximal columnal. From such evidence as is available, it seems possible that in many of the comatulid lines other columnals fuse with the proximale, however.

Such fusion of columnals seems clearly to be indicated in the ontogenetic development of *Antedon* as figured by Carpenter (1888, Pl. 14). Some of the figures are here reproduced (Pl. 7, figs. 6-10). These figures serve equally well to show the development of the cirri on the centro-dorsal. Figures 8 to 10 represent stages in development of a single species and as such are not subject to the structural variations that apparently obtain in the case of different species.¹

In figure 7, the proximale is shown as the shortest columnal in the stem. There is no indication of the presence of cirri. In figure 8, the proximal columnal is still very short, but bears a verticil of incipient cirri. These are five in number and radially disposed. It is to be noted that immediately distad to the proximale there are three

¹ Mr. A. H. Clark says that these three specimens identified by Carpenter as *A. multispina* do not appear to belong to the same species and, indeed, may be referable to different groups. Furthermore he states that the figures are inaccurate. It scarcely seems probable that the draftsman could go far wrong in regard to the columnals, however, and the evidence of fusion having taken place, though by no means conclusive, still seems fairly good.

Mr. Clark believes that the centro-dorsal never consists of any columnals other than the proximal one. This is unquestionably true in many species, and possibly in many phyletic lines, but such inconclusive evidence as is at present available scarcely warrants a postulate of similar conditions as a universal attribute of the Comatulae.

short columnals. The fifth columnal is much higher, and is of a rather peculiar shape. It expands from below upward, and contracts slightly in its immediate proximal portion. The shape of this columnal is unique among the other elements of the stem, and may be recognized in the succeeding two figures. Such being the case it may well serve as a datum plane for identifying the columnals.

In the stage represented by figure 9 there has apparently been a fusion of the columnals. The cirri are borne on a much longer columnal, which apparently represents the proximal columnal plus the next succeeding ossicle. This fusion can not be demonstrated, but it seems probable, inasmuch as there are but two columnals shown between the cirriferous segment and the characteristic "fifth" ossicle. This does not prove anything, for one may argue that the number of columnals between the proximale and "fifth" ossicle varies, as, for all that we know, it may. However, an extremely close union is indicated between the cirriferous segment and the next lower ossicle. As here given the suture between the two elements it drawn as well marked, whereas in Carpenter it is little more than indicated. The next lower ossicle is somewhat smaller in diameter.

In the next stage (fig. 10) there has been a complete fusion between the cirriferous element of the former figure and the next lower columnal. The "fourth" columnal has enlarged and is of practically the same diameter as the centro-dorsal above it. It would appear that a very close union exists between this ossicle and the centro-dorsal, and that the two elements are well on the way toward fusion. Upon detachment it appears that the point of disruption would logically be between the "fifth" ossicle and the practically consolidated centro-dorsal. The union between the two seems to be of a comparatively loose nature.

From the facts as shown by these specimens we may reasonably assume, I believe, that there has been a fusion of columnals with the proximale to form the centro-dorsal in this species. Indeed, I think we may be reasonably sure that three columnals in addition to the proximale go to make up the centro-dorsal. By the direct evidence as apparently afforded by a living species we may conclude then that the centro-dorsal may at times be composed of several fused columnals. The same condition seems to obtain in the case of the fossil *Comatulæ*, but in regard to them the evidence is even less conclusive.

Whether the fusion of several columnals to form the centro-dorsal indicates independent derivation from that had by forms in which the centro-dorsal is composed merely of the proximale such as is doubtless the case in *Thiolliericrinus*, is a question. The columnals of the stalked *Antedon*, as shown in figures 11 and 12, Plate 7, have a decidedly *Bourgueticrinus* type of structure. The evidence seems to point strongly to the conclusion, therefore, that we have to look among

the Bourgueticrinidæ for the ancestors of this genus, though not necessarily by way of either *Mesocrinus* or *Thiollicricrinus*. It may well be that fusion of columnals with the proximale is a character progressively acquired in a manner comparable to that in which we note the appearance of cirri on the centro-dorsal. Fusion of additional columnals in such a case would then merely indicate a comparatively high degree of specialization.

Polyphyletic nature of the Comatulæ.—As has been elsewhere suggested, it is highly probable that the Comatulæ represent terminal members of a number of lines of development in each of which an eleutherozoic existence has been independently acquired. They may all be considered as offshoots of the same general stock, and convergence has served to evolve strikingly uniform types. Again, the different lines have had their inception at widely different time periods as is evidenced by the extremely variable degree of specialization exhibited by contemporaneous forms. It is probable that we must look among the Apiocrinidæ as defined by Bather (1900) as well as among the Bourgueticrinidæ for the ancestors of the Comatulæ. Again, it is quite within the bounds of possibility that the Pentacrinidæ may have given rise to such eleutherozoic forms.

The structural characters that seem to indicate the presence of a number of genetic lines among the Comatulæ may not here be gone into in any considerable detail. The evidence on the whole is suggestive rather than conclusive and will only become of positive value when the several lines are worked out and their mutual relationships established. The nature of the evidence is of two sorts. The first is as regards the relative specialization of contemporaneous types as indicating the relative remoteness from stalked ancestors. The second relates to the structure of the organisms, as indicating the mutual interrelationships of the forms.

The disparity in degree of specialization among the eleutherozoic forms at any given time may, if judiciously considered, be given considerable weight. Thus in the Cretaceous *Thiollicricrinus* we may well have the point of inception for a comatulid line. Living at the same time were highly specialized Comatulæ, and these were preceded even as far back as early Jurassic time by equally distinctive eleutherozoic types. Concerning the high degree of development to be observed in these early fossil forms Carpenter (1884) writes as follows:

Besides their tendency to combine the characters of recent generic types, the Jurassic Comatulæ are remarkable for their large size, as are also the Cretaceous species. The centro-dorsal may reach from 9 to 13 mm. in diameter, which is greater than that of nearly every recent species except *Antedon eschrichti*; while this type and *Actinometra robusta* are almost the only living Comatulæ with arm-bases anything like as massive as those of the fossil species. Some of the Cretaceous forms must have been very large. Thus the united centro-dorsal and radials of *Antedon campichei* from the Neocomian of Switzerland may reach 15 mm. in height and over 20 mm. wide;

while several centro-dorsals of *Antedon* from the Upper Chalk are almost equally gigantic.

The massive arms of many of the Comatulæ seem to mark the animals as far from primitive, and certainly not as ancestral to modern types. In certain cases a biserial arrangement of the arm ossicles is had, such as for instance in *Antedon thiollieri* figured by de Loriol (1884-1889, Pl. 224). A similar form, possibly congeneric, has been described and figured by Jaekel (1891) as *Pachyantedon beyrichi*. The lack of any recorded tendency toward the acquisition of similar types of arm structure elsewhere among the Comatulæ seems to indicate that these crinoids form a distinct off-shoot from the comatulid stock, if indeed it does not indicate a separate origin for them. Bather (1900, p. 195), states that "there is also traceable in the arms a gradual attenuation * * *" when considering the evolution of the Antedonidæ. The differences to be observed are not evolutionary in the sense that there is a gradual diminution in the thickness of the arms, but rather points to a polyphyletic origin of the forms involved, or at least a considerable divergence within the stock.

Again, among most of the fossil Comatulæ as is shown by figures 3, 4, 7, 8, Plate 8, the basals are well developed and appear prominently on the exterior of the theca. Among recent forms the basals are greatly reduced (Pl. 5, figs. 10 to 12) and seldom are to be seen externally. In many cases this reduction in size may be held to be the result of a gradual evolutionary process subsequent to the assumption of an elutherozoic habit. On the other hand, as is shown by *Thiolliericrinus* (Pl. 7, figs. 3 and 4), the basals have become obsolete in the adult stages, as regards their appearance on the outer surface of the cup. This elimination became effective while the stock was yet attached or but irregularly elutherozoic.

The axial canal traversing the central-dorsal of a comatulid is as a rule closed and smoothed over by a secondary deposit of stereom. In many cases, however, the lumen is open at the distal face of the centro-dorsal, so that its nature may be ascertained. In *Thiolliericrinus* (Pl. 7, fig. 5), the perforation is circular, or somewhat oval, corresponding to the shape of the stem-lumen in the Bourgueticrinidæ in general. In many cases, as, for instance, in certain species figured by Carpenter (1880*b* and 1881), the central perforation of the centro-dorsal is pentagonal to sharply stellate in section. How much reliance can be placed upon these features as determining independence of derivation it is hard to say on account of the insufficient data at hand. It appears, however, that they are of some value. In this connection should be noted the observation of Carpenter that the centro-dorsal of *Antedon* has a stellate lumen when the animal becomes detached from the column. This is somewhat remarkable

when one considers the *Bourgueticrinus* type of columns possessed, and the fact that the stem lumen is circular in section (Pl. 7, fig. 12).¹

The evidence relative to the nature of the perforation of the centro-dorsal being inconclusive because of our lack of exact knowledge, it is necessary to fall back on other more obvious and satisfactory characters. On Plate 8, figure 7, is given a view of the lower surface of the theca of *Antedon depressa* from which the centro-dorsal has been removed. Figure 8 shows the normal appearance of a cup with the centro-dorsal attached. To be compared with this is the basal view of the theca of *Pentacrinus (Extracrinus) dargniesi* (Pl. 8, fig. 5). In both forms we may note a general similarity in structure, particularly as regards the development of the basals. The basals of *Antedon* in this instance, however, quite lack the petaloid markings characteristic of the *Pentacrinus* and the *Pentacrinidæ* in general. The specimen of *Antedon (Solanocrinus) scrobiculata* here figured (Pl. 8, fig. 4) is noteworthy in this regard. As may be seen, the articular faces of the basals have the characteristic markings of the same plates in the case of the *Pentacrinidæ*. Carpenter (1880b) has figured *Comatulæ* exhibiting the same type of structure. Such for instance is his *Actinometra cheltonensis* (Pl. 11, fig. 20b). He likewise figures a specimen of *Antedon (Solanocrinus) scrobiculata* in which the markings are very distinct. This type of articulation may only I think be attributed to forms in which a pentalobate column is possessed at that point. The natural inference is that the stalked ancestors of such types are referable to the *Pentacrinidæ*, although this need not necessarily follow. It seems impossible, however, to derive these types directly from the *Bourgueticrinidæ*.

In connection with the statement made above relative to the possibility of *Pentacrinus* or some member of the *Pentacrinidæ* having formed the radical from which might have sprung a line of comatulids, should be noted certain curious structural features in the case of *Pentacrinus (Extracrinus) collenoti* as figured by de Loriol (1884-89, Pl. 199, figs. 3, 3a, 3b) showing a most remarkable modification of the normal *Pentacrinus* stem structure. In this form it is to be noted that the column in its proximal portion is of normal size, but distad it contracts rapidly forming a stump of exceeding brevity. This stem fragment consists of something like 10 columnals. In every way it reminds one of conditions as they are to be found in *Millericrinus prattii* where a few of the proximal columnals remain attached

¹ The type of column possessed by the larval comatulid is after all directly comparable to that to be found in the very young *Isocrinus*. As figured by Clark (1908, p. 88, text figs. 3 and 4), the distal portion of the column of *Isocrinus decorus* has oval columnals, essentially similar to those here figured in the case of *Antedon*. This fact again indicates a close relationship of the *Pentacrinidæ* and at least certain lines of the *Comatulæ*. Indeed in both types there is an essential unity of structure up to the time detachment from the larval column becomes effective. Subsequent to that time the critical difference is that the *Pentacrinidæ* form new columnals and maintain a column whereas the comatulids do not.

to the theca. In the present case there has probably been a disruption of the column in its proximal portion succeeded by a partial resorption of the columnals. The result of this process is the formation of a structure closely approximating to a centro-dorsal. The specimen of *P. sorlinensis*, figured by de Loriol in the same volume (Pl. 205), apparently may be explained as having the same type of structure. In this case the columnals bear numerous long cirri which had probably not yet been acquired in the specimen previously described. Such a disruption of the column in the case of *Pentacrinus*, taken in connection with what we know relative to the wide maintenance of a detached existence by these forms, indicates that there was a strong tendency among the Pentacrinidæ toward the formation of essentially comatulid types. Such forms as those described above need but a fusion of the columnals, and an increase in the number and specialization of the cirri to make very fair Comatulæ.

Another feature which is not of great importance but nevertheless is somewhat suggestive of a similar derivation is the distinctly pentagonal section of many of the fossil comatulid centro-dorsals. This, for instance, may be noted in *Antedon (Solanoecrinus) scrobiculata* (Pl. 8, fig. 3), in *Antedon depressa* (Pl. 8, fig. 8), and in many other fossil comatulids as figured by various authors. In the case of *A. scrobiculata* it is further to be noted that the cirrus sockets have an alternating "biserial" arrangement which points rather strongly to the conclusion that each successive cirrus on any given face of the centro-dorsal pertains to a distinct columnal. The pentagonal cross-section of such centro-dorsals may be held as resulting from secondary changes as induced by the presence of cirri, but comparison of these centro-dorsals with subglobose or bowl-shaped types seems to indicate that this may not necessarily be the case. Indeed the tendency toward modification of the shape of the centro-dorsal points rather toward the acquisition of a quite dissimilar type of organ.

It is not impossible that we may look among the species of *Millerierinus*, as defined by de Loriol, for ancestors of certain comatulid lines. This genus, as defined by de Loriol, contains many highly divergent types which at best may not be held as congeneric. Certain species tend toward *Apiocrinus*, which was doubtless derived from these forms, while others simulate in a marked degree members of the *Pentacrinidæ*. The genus is not as far removed from the Pentacrinidæ as is currently held, but whether these strikingly similar types represent members of quite distinct phyletic lines or are the result of convergence it is impossible to say. The evidence certainly points to a common ancestor not far removed. Taking *Millerierinus* in its accepted sense one might explain the petaloid markings of certain Comatulæ, as noted above, as the result of derivation from

this genus, for many of the species referred to *Millericrinus* have such a type of articulation. A careful examination of these forms may prove that they are after all referable to the Pentacrinidæ rather than to the Apiocrinidæ. The high degree of differentiation of the proximale in certain species of *Millericrinus* may indicate a tendency within the genus toward the formation of Comatula-like types by a disruption of the column immediately distad to this ossicle, after the manner of *Thiollicricrinus*. Such a type of structure has already been noted in the case of *M. prattii*, although cirri were not acquired by this form.

Relationships of the Comatulæ.—Having briefly shown some of the reasons for assuming that the Comatulæ represent terminal members of a number of genetic lines, it may be well, broadly, to indicate the relationship of these forms to the Crinoidea at large. Bather and other authors have referred the Comatulæ, together with a number of other post-Paleozoic Crinoidea, to the Flexibilia. For the reception of this assemblage Bather has erected the Grade Pinnata. I believe that the Pinnata should be transferred bodily to the Order Inadunata. The presence of a persistent proximale, if there be such a columnal, has certainly not been established in the case of these forms, as has elsewhere been pointed out. On the other hand, the structural affinities of these organisms seem to lie far more with the Inadunata. Among all the known post-Paleozoic Crinoidea there is an essential unity of structure that points strongly to a not widely diverse origin. The ancestors of these Crinoidea may not, I think, be found in any known Paleozoic genera, but must be sought in early Mesozoic or late Paleozoic forms of minute dimensions.

TYPE 2.

The genera referable to this group probably constitute the only Crinoidea that maintain a truly eleutherozoic existence through their own exertions as freely swimming organisms. With them detachment from the column comes at a very early stage and results, as I hold, in the complete loss of that organ. The space inclosed by the proximal circlet of plates—either basals or infrabasals—through which the axial organs passed in the stalked ancestral forms is closed by a pentagonal plate, to which Bather has applied the name “centrale.” Concerning the nature and origin of this plate it will be necessary to go into considerable detail. One of the most curious features about these crinoids is their apparent lack of antecedents. When first seen they are full-fledged pelagic types of a most remarkable degree of specialization, and it is a matter of exceeding difficulty even approximately to predicate the nature of their progenitors except in a very broad way.

The three genera constituting this group have been described and illustrated so adequately by various authors that it will scarcely be necessary to give any description of the forms other than may be required in a consideration of the broader aspects of certain structural features here discussed. Of prime importance in a consideration of these types is the question of the origin and homologies of the central apical plate, or centrale, which has been the subject of a considerable amount of speculation. This topic bears largely not only on the structure and relationships of these three genera, but also on many broader morphologic and taxonomic questions.

Bather on the "centrale."—Bather (1896, p. 979), in speaking of the centrale of *Uintacrinus*, says:

The centrale is pentagonal, but in specimens examined not quite regular * * *. It is perfectly smooth, showing no signs either of a stem-attachment or of partition into more than one original element. Its homologies are therefore doubtful, as its structure and position permit it to represent either a relic of a stem or a fused infrabasal circlet, or even, as some would have it, an additional element altogether, to which the name "dorsocentral" might strictly be applicable. I have recently given reasons for rejecting the term and the idea "dorsocentral." Which of the other alternatives be correct is to be decided, if at all, by reference to the affinities and origin of the genus, as to which we are at this stage of the inquiry quite in the dark.

Referring to the group comprising *Saccocoma*, *Marsupites*, and *Uintacrinus*, he says that the central apical plate may originate in three ways (1896, p. 997):

One may say, if one chooses, that in *Saccocoma* this represents the fused basals and in *Uintacrinus* the fused infrabasals; but in *Marsupites* it must be something else. Or one may say that in each case it is the same element, be it the proximal stem-ossicle (which some erroneously call "centrodorsal") or the distal stem-ossicle (which some, seeking an homology, have called "dorso-central"), or perhaps a new plate altogether, a simple supplementary plate developed to fill up the gap left by the disappearance of the stem. One might argue forever; there is no evidence. The one obvious fact is that such a central plate is found in three different forms, all of which were free-swimming, and unlike all other crinoids in showing absolutely no trace of a stem. It is therefore not safe to ascribe to the central plate any morphological significance or to give it any name other than "centrale."

In 1900 (1900, p. 135) Bather modified his statement in regard to the nature of this plate in *Uintacrinus*.

* * * in *Uintacrinus* and *Marsupites* it represents neither basals nor infrabasals, but may be the proximale, or the supposed distal columnar plate ("dorso-central"), or a new supplementary plate.

Springer on the "centrale."—Springer (1901, p. 22), in discussing the centrale of *Uintacrinus*, quotes the statements made by Bather in his paper on *Uintacrinus*, and seeks (1901, p. 28) to arrive at a more definite conclusion in regard to the origin and homologies of the plate. It will be noticed that he deals only with the suggestions of Bather as presented in his *Uintacrinus* paper and not as subsequently modified in Lankester's Zoology. He says in part (p. 28):

* * * it can not be (1) the fused infrabasals, because it is found here coexistent with them, a distinct element, situated within their circlet. There are thus left the other possibilities, viz: (2) That it is the representative of the proximal or distal stem ossicle; or (3) "a simple supplementary plate developed to fill up the gap left by the disappearance of the stem."

To the second and third hypotheses he objects (p. 28) on the ground—

That the centrale is located within the circlet of infrabasals, and abuts against them by their *inner* faces, instead of by their outer or dorsal sides. It does not envelop or conceal the infrabasals, as the proximal columnal does in pseudo-monocyclic forms; nor the basals and radials, as the representative of the stem in the Comatulæ usually does, although there is an exception to that in the case of certain living species of *Actinometra*, and in many fossil Comatulæ. On the other hand, the orientation of the centrale is precisely as the stem should be; i. e., interradial when the infrabasals are present, and radial when they are not. And the orientation is strongly against the third of the above suppositions. For the gap left by the disappearance of the stem, and to be filled up by stereom, would be the axial canal piercing the base of the calyx at the center of the basal or infrabasal ring. This would be radial in the latter case and interradial in the former. A supplemental plate developed to fill up this space should have the same orientation; but this is just the reverse of what is exhibited by the centrale. It seems to me, therefore, that the argument is decidedly in favor of the view that the centrale is a relic of the stem of the Stalked Crinoids, if not, indeed, of the pedunculate stage of *Untacrinus* itself.

This last statement is explained more at length on page 59, where he implies that the centrale is a modified proximale as in *Millericrinus prattii*, *Actinometra*, and other Comatulæ.

Probable origin of the centrale.—At this point I wish merely to consider the second and third possibilities given by Bather, and the objections raised in regard to them by Springer. Against the hypothesis that the plate represents the proximal or distal stem ossicle, he brings the argument that the centrale lies *within* the circlet of infrabasals, and "abuts against them by their inner faces, instead of by their outer or dorsal sides, etc." This objection I consider insuperable, although Springer, as above quoted, apparently does not, considering such a solution of the problem the most reasonable one. In no case do we know of the proximal columnal taking part in the dorsal cup except as a proximale, fusing with the infrabasals which it overlies. Nor can we readily imagine a proximal columnal, resting on the outer faces of the infrabasals, consolidated into a plate which is squeezed into an opening of the size of the axial canal with which, as a columnal, it was itself perforated.

An obvious argument against this last conception is that the separation of the crown and stem took place very early in the ontogeny of the animal, and that the proximale, now the centrale, enlarged but very slightly or not at all in the subsequent growth of the crinoid. Even at this early stage, however, the proximale would have had to fit into an opening smaller than itself. The cases among *Actinometra* where the cirri are lost, and the centrodorsal by partial resorption

becomes rounded and flush with the adjacent plates (Pl. 6, figs. 9 to 11, and Pl. 5, figs. 10 to 12), rests on an entirely different footing. Here the proximale is probably fused with the infrabasals, and partially with the basals. Again, the centrale of *Uintacrinus* is very thin, and shows no sign of a central perforation in either a dorsal or ventral view. Had there ever been one, there would most certainly have been a decided thickening of the plate, which, even if partially resorbed in the adult, would be indicated in very young specimens. Such, however, is not the case.

Now let us turn to the third hypothesis, which is so improbable on the grounds of orientation. According to Springer, in the passage quoted above, a supplemental plate should conform to the angles of the axial canal, being radial in a dicyclic form and interrarial in a monocyclic individual. This is absolutely at variance with the observed condition of affairs, as is shown on Plate 9, figures 1 and 11.

Carabocrinus, a dicyclic Inadunate from the Ordovician has a decidedly pentalobate axial canal, which is radial as should be the case in a dicyclic form. In a specimen from which the column had been broken, careful cleaning shows that the infrabasals are distinctly invaginated by the axial canal at their lower margins. It has been my good fortune to obtain an adult specimen of *Carabocrinus radiatus* from the Trenton limestone of Canada, which, probably through some accident, completely lost its column during life. That this separation of stem and crown occurred late in the life of the individual, there can be little doubt. The stem-cicatrix on the inner edges of the infrabasals is distinctly marked, and is of considerable size. A comparison of the diameter of the stems of other specimens, with the diameter of the cicatrix in this individual, indicates that the crinoid could not have been a great deal smaller when it became free than it is at present. In this specimen we find a small centrale within the infrabasal circle. In this case there was no possible chance of the proximal columnal becoming transformed into a centrale. The proximal columnal was fully formed, and over twice the diameter of the opening left between the infrabasals. Moreover it lay on the *outer* faces of these plates. Such a columnal could scarcely be imagined by the exercise of ever so much ingenuity to become a comparatively minute plate, lying *within* the infrabasal circle, and abutting against the *inner* faces of these plates.

Granted then that this centrale could not have been formed from the proximal columnal, the question naturally arises as to what it really is. The only possible answer is that it is an entirely new element, functioning as a plug to stop up the axial canal. A hint as to the possible derivation of this plate is given by Carpenter (1884, p. 34). In *Bathycrinus*, *Rhizocrinus*, and *Pentacrinus* there is in the lower inner portion of the dorsal cup a sort of plug formed of

calcareous matter. In these forms, this plug only extends to the tops of the basals, and is of rather loose texture. It shows, however, the tendency of calcareous matter to be deposited in the basal portion of the cup, which, in case of the detachment of the crinoid from its column, could readily be formed into a solid plug. A relatively slight extension of this calcite-depositing tissue would completely fill the axial canal, and form a plate which on the exterior would be flush with the plates of the proximal circlet. Thus it is probable that in the case of *Carabocrinus* at least, the centrale was formed from within, outward.

The most astonishing thing about this plate in *Carabocrinus* is that, contrary to all expectations, it does not form a stellate plug which merely fills up the axial canal, and the angles between the infrabasals, but actually constitutes a pentagonal interradian centrale. The orientation of a central, apical plate, then, if it lies within the proximal circlet of plates, and "abuts against them by their inner faces" is of absolutely no importance. The centrale in all cases conforms to the angles of the adjacent plates and not to the lobes of the axial canal. Another instance of a plate conforming to the surrounding plates has already been given in the case of *Antedon*. Here we find in the early stages that the proximale is pentagonal, and radial in position, its shape being controlled by the basals. Later, when the centrodorsal has overgrown the basals, the shape of the plate is governed by the general contour of the calyx and the presence of cirri. These factors are of course, not at all of the same nature as the one that controls the plate when it lies *within* the proximal circlet. In the latter case it is the absolute lateral contact of the adjacent plates that governs its form.

The centrale of *Uintacrinus*, I take it, was an entirely new element, formed much in the same manner as the plate in *Carabocrinus*. The presence of infrabasals and the centrale in some of the individuals precludes the possibility of its having been formed by the fusion of the infrabasals.

Significance of both mono and dicyclic bases in Uintacrinus.—The presence in *Uintacrinus* of apparently both dicyclic and monocyclic types has been considered as of the utmost importance by Springer and others, as conclusively showing the unimportance of the features upon which Bather has made his main divisions of the Crinoidea. Mr. Springer's views on the subject may best be explained by a quotation from his work on *Uintacrinus* (1901, p. 30):

If the two forms of base represented by text figures 1 and 2 had been found in specimens otherwise separable, they would, under Mr. Bather's arrangement, have been unquestionably referred to different genera, families, orders, and subclasses. Considering the apparent identity of these forms in every other point of structure, coupled with their mode of occurrence and association, I do not see how any such separation can possibly be made in this case. We therefore have apparently to deal with a case

of individual variation, as to this supposed primitive character, within the limits of a species. That is to say, in this species, living in the same locality, having the same environment, floating in the same mass, certain individuals matured to represent one stage of larval development, i. e., with infrabasals, and others in another stage, i. e., with basals only. In short, they are the two supposed distinct types, Monocyclica and Dicyclica, occurring in both young and adult of one and the same species.

Why is not the centrale in the so-called "monocyclic" type of *Uintacrinus*, merely the primitive centrale of the dicyclic type to which the infrabasals have become fused? Springer, in his memoir on *Uintacrinus*, argues against the transmutation of one form into the other on various grounds. His arguments may best be brought under several headings, and so discussed. All page references are to his work on *Uintacrinus* unless otherwise stated.

On page 25 he says: "The differences presented by forms M and D are not correlated with any other characters. They have no apparent relation to size or maturity of the specimens, and therefore could not have been the result of differences in individual growth." Against this assertion I can offer no more convincing proof than Springer's own subsequent statements: "There is no reason, based upon any characters exhibited by these specimens, for any inference as to one being prior in development rather than the other, unless it is the greater prevalence of Form D among the young individuals." This prevalence of Form D in the young, we find to be very striking indeed, and is of the utmost significance. On page 34 we find the relative proportion of Form D among the young and adult specimens to be as follows: "Among specimens measuring under 25 mm. across the calyx, 75 per cent are dicyclic; while among those of maximum size—50 mm. and over—the proportion of dicyclic is about 40 per cent." In the face of these figures, he continues (p. 34): "If there were a tendency to develop by individual growth into either form, then we ought to find practically all the adult specimens belonging to that form; and the same thing would be true if the transition took place during the larval stage."

It is true that we do not have all the adults, or 90 odd per cent of them, "monocyclic," or all the young "dicyclic," nor should we expect it. A change from 25 to 60 per cent, which expresses the change in percentage of "monocyclic" forms in the young and in the adult stage, is rather startling, however. As a matter of fact, the change is slightly less than that just given, based on Springer's figures given below. On page 86 in a table that recapitulates the data bearing on the number of interbrachial plates and the character of the base, we find that out of a total number of 82 individuals measuring less than 25 mm. in diameter, but 20 are "monocyclic." This gives us a percentage of a trifle over 24 per cent—not 23 as given in this table, where the percentage of "dicyclic" specimens is set down as 77 per cent. Among individuals having a width of

calyx of from 61–75 mm., 59 per cent are monocyclic. The high percentage of Form D in the young and the low percentage of the same type among the adult specimens is evidence amounting almost to proof that there is a change in the structure of the base in the ontogeny of the animal.

It may be argued, and this seems to be the attitude assumed by Springer, that if the change from dicyclic to “monocyclic” took place in the ontogeny of certain individuals, the same process should be effective in all cases. It is highly unreasonable to look for the transmutation of one type into the other in the case of each and every crinoid. Such a universal acquisition of this character could only obtain where the tendency had become most thoroughly impressed upon the race through its acquirement by a great number of successive generations. In *Uintacrinus* the tendency toward the fusion of infrabasals with the centrale had its inception at no very remote date. This is clearly shown by the fact that the period of fusion, although variable as to the time of occurrence, in most cases comes rather late in the ontogeny of the animals.

An examination of the tables in Mr. Springer's monograph on pages 78–85 will show even more clearly than the percentages already given how gradually and at what different stages in development the change from one form to the other took place. These facts prove that the fusion of the infrabasals was a comparatively new thing, and as a result was not uniformly acquired by the different individuals. Everywhere we find that certain individuals are more accelerated in development than others. A structure that appears in one *Uintacrinus* when but 25 mm. or less in diameter might well be retarded in another until the animal had attained its maximum growth. Another factor that may be considered is that of sexual difference. It is a matter of common knowledge that one sex is frequently more accelerated in development than the other, and I have been assured by Prof. R. T. Jackson that such is the case among living Echinoderms, at least in some forms. This differential sexual acceleration I would not lay much stress upon for the reason that probably the females so greatly exceeded the males in number that any such difference would but slightly affect the general result. This probable preponderance of the females over the males will be discussed later.

At any rate we can readily conceive that such a fusion of the centrale with the infrabasals, taking place first in the adult crinoids, gradually was pushed back farther and farther in the ontogeny of the animals, and, finally, may have taken place immediately upon the formation of the centrale, following the detachment of the crinoids from their stems. This acceleration in development, resulting in the acquirement of a “monocyclic” base at various stages of growth answers perfectly the objection raised by Springer on page 26 in

regard to the relative size of the centrale. We find in *Uintacrinus* that the centrale varies considerably in size, apparently irrespective of whether it occurs in Form M or D, or of the size of the individual to which it belongs. Apparently, however, the centrale in Form D is "often very small." In some cases where fusion does not take place the centrale increases somewhat in size. There is indeed no good reason why the centrale in *Uintacrinus* should not show variation in size in different individuals. In *Marsupites* we find that the central apical plate, which in the young must have been quite small, became relatively enormous in size. The increase in size of the centrale in *Uintacrinus* is similar in kind, if not in degree, to that shown by *Marsupites*. The variation in size of the centrale in Form D may readily be explained. If the fusion of the infrabasals with the centrale took place early in the life of the individual, a small plate would have been formed of necessity. This might or might not have increased in size during the subsequent growth of the animal, the size being again merely a matter of individual variation. If the infrabasals fused with the centrale later in the life of the crinoid, as in some cases they certainly did, the resultant plate would have been of comparatively large size. This plate might still be added to, making it even larger. It seems to me that the foregoing arguments explain the variations in the size of the centrale in Forms M and D, and the occurrence of both types of structure in young and adult individuals, features upon which Springer lays particular stress on page 34 and elsewhere.

In regard to the possession of the two types of base by *Uintacrinus*, Springer, on page 25, says: "It is not a case where the infrabasals are concealed, or are more or less perfectly or imperfectly developed, or are used with some other element, as in some forms which Bather calls pseudomonocyclic. For here Wachsmuth and Springer's law of alternate arrangement of the elements of the Crinoid skeleton strictly prevails." As I have previously shown, the orientation of the centrale is of little or no importance, being dependent entirely upon the character of the surrounding plates. In Form D the centrale fits into the angles between the infrabasals, and is, therefore, interradial. In Form M the centrale (consisting now of the original centrale, to which the infrabasals have fused) adjusts itself to the angles of the basals, and is, therefore, radial. Springer also uses this argument against the possibility of the fusion of infrabasals and centrale at the bottom of page 30. It is curious to note in this connection, that on page 32 in considering the possibility of a fused condition of centrale and infrabasals he says: "A coalescence or fusion of the infrabasals with the centrale would not be subject to the same objection on the ground of orientation. The resulting plate would be radial, as it should be in a monocyclic form."

Mr. Springer, on page 31, considers that the change from one type to the other might have taken place in one of three ways:

1. The resorption of the infrabasals in Form D.
2. The intercalation of infrabasals in Form M.
3. The coalescence of the infrabasals with the centrale.

Although I do not believe that the change was brought about by the second process, and can accept the first hypothesis only as a partial explanation, either is a *possible* explanation for the facts as we know them. Therefore it is best to consider the arguments for and against both before taking up the discussion of the third, which, as before stated, I believe to be essentially the correct interpretation.

The argument brought against the first two hypotheses by Mr. Springer is that of the orientation of the centrale, which he considers an insuperable difficulty. As shown above, the centrale is dependent as regards its form on the plates surrounding it. To show what a simple matter it would be to change the orientation of the centrale by the intercalation of infrabasals consider first figure 11, Plate 9, a typical Form M, with an unusually large centrale. Here the centrale is pentagonal and radial. Now, at the apices of this pentagon suppose we introduce five minute infrabasals. To allow the introduction of these infrabasals, however small, there is a synchronous resorption of each apex, which becomes more marked with the increase in the size of the infrabasals. We now have a decagon, such as is beautifully shown in figure 3, Plate 9. If the infrabasals continue to grow there will be a corresponding resorption of the centrale along the surfaces in contact with the infrabasals. It is obvious that soon the infrabasals will meet laterally, and the inclosed centrale instead of being a radial pentagon or decagon will be transformed into an inter-radial pentagon, resulting in a form like figure 2, Plate 9. So far as orientation is concerned this hypothesis is perfectly sound. If we reverse the series outlined above we can see how the form of the centrale can be altered from interradial to radial, if we wish to establish the validity of the infrabasal resorption theory. Here, starting with figure 2, Plate 9, let us consider that the centrale gradually enlarges. As it increases in size there is a concomitant resorption of the apical portions of the infrabasals. Before long we reach the decagon stage, represented by figure 3, Plate 9. If this process be continued but a short time longer these minute remnants of the infrabasals would disappear, their places being taken by the enlarged centrale. A very slight straightening of the lines of contact between the centrale and basals would give us a typical Form M, with a radial centrale. That such resorption and mutual readjustment of plates is quite possible will be shown hereafter at some length.

As shown above, Form D *could* be evolved from Form M, providing the requisite infrabasals were supplied. But where could these plates

come from? There are but two possible ways to account for their appearance. In the first place, the plates might have arisen as absolutely new elements in a true monocyclic crinoid. This theory, as hereafter explained, I consider absolutely untenable. In the second place, if *Uintacrinus* were descended from a pseudomonocyclic form the infrabasals which in the ancestral type were practically obsolete, upon the assumption of an eleutherozoic existence, might have begun to appear as important elements of the cup. It is obvious that if we accept the theory of the intercalation of infrabasals we can not tell by which of these two processes the plates were formed.

I can not, however, in any way admit the possibility of the infrabasals representing absolutely new elements in the cup. In the first place, there is no logical reason for their existence. They add not at all to the efficiency of the crinoid, and among the Crinoidea we see little or no aimless variation. The sole possible excuse for their introduction would be the enlargement of the cup. The resultant amount of enlargement is palpably insignificant and could quite as well have been accomplished by the enlargement of the centrale and proximal plates, as in *Marsupites*. Again, the introduction of these new elements would necessarily result in a fundamental change in the nervous system. The change from a dicyclic to a monocyclic type of nervous system I consider quite within the range of possibility, but a reversal of the process offers insuperable difficulties. The essential difference between a dicyclic and a monocyclic crinoid can scarcely be emphasized too strongly. Certain it is that one form can only arise from the other as the result of a long evolutionary process, and it is quite inconceivable that, as would have to be the case in this instance, one type should be a mere mutant of the other.

Against the possibility of the enlargement of the minute infrabasals of a pseudomonocyclic type one can not make so strong a case. The uselessness of the proceeding is perhaps as good an argument in this case as in the preceding. One would certainly expect that with the assumption of a free-swimming existence and the formation of a centrale that the minute plates would fuse with the new element. This would only conform to the general tendency to be observed among nearly all crinoids toward the gradual elimination of the proximal cirlet of plates as distinct elements.

How are we to explain such types of bases as are shown in figures 5, 6, 7, and 8, Plate 9? Obviously figures 5 and 6 may represent individuals in which three and four infrabasals have appeared, respectively. It is not so easy, however, to account for figure 7. Springer describes this specimen as having a double centrale and one infrabasal. We are not told, however, by what process two centrales could be formed. If the centrale represents the rudiment of the ancestral stem, could one individual have been the fortunate

possessor of two columns? Again, if, as I believe, the centrale merely represents a plate to fill up a gap—an entirely new element—why should two plates have been necessary to fill up one small opening? A glance at this figure will show clearly that such an explanation is quite out of the question. There is but one possible explanation of this base and that is a fusion of the plates. If there is fusion here we may expect it elsewhere. Under the discussion of the third hypothesis I shall deal with this coalescence of the plates in some detail. I wish at present merely to point out that we have every reason to believe that fusion among the plates did take place.

If we attempt to explain figures 7, 6, and 5 as cases where one, three, or four infrabasals only have appeared, the question involved is a far greater one than the mere explanation of the apparent vagaries of *Uintacrinus socialis*. It may be stated almost as a law that each of the circlets, composed either of basals or infrabasals, acts as a unit in evolutionary changes; that is to say, if, for instance, the tendency in evolution is toward an elimination of the infrabasals, all are equally affected. The plates finally become of so little importance as to be practically a negligible quantity, thus forming a pseudo-monocyclic type. Again, one or more of the plates of a circlet may not drop out, leaving the remainder to shift for themselves. Naturally certain plates of a circlet may be modified and become larger than the others, as is well shown by the basals of *Eleuthero-crinus*, all five plates being represented. This rule, it seems to me, holds absolutely in regard to the presence or absence of plates. If one plate of a circlet be present, the other four are present, except in purely abnormal individuals. So here in *Uintacrinus* I do not believe it possible for one, three, or four infrabasals to be present and the others absent. Hence, any apparent reduction in number must necessarily be due to fusion. Of course, one may claim that all these specimens cited are abnormal, but as long as the structures observed can be explained as the result of a perfectly normal process, and, indeed, are exactly what we should expect to find, it seems rather unnecessary. As before stated, I believe that the change from Form D to Form M has been brought about by a fusion of the plates. At the same time more or less resorption took place, so these two processes will be discussed together.

On page 32 and following, Springer raises the following objections to the fusion theory other than those already discussed. In the first place, he has never seen a specimen in which the coalescence of infrabasals and centrale would result in the formation of a plate having the outline of the centrale actually found in Form M. The centrale in Form M is pentagonal, whereas the resultant plate he thinks should be stellate. In the following passage which I quote from page 32, the qualifying phrases, which I shall here place in italics, somewhat

spoil the force of the argument. "Among the 268 dicyclic specimens examined by me *I can scarcely point out one* in which the coalescence of the infrabasals and centrale would produce a plate having the same outline as the centrale has, or which would not be entirely distinct in shape from the centrale in *most* of the 275 monocyclic specimens in the collection." These irregularities in the shape of the centrale will be discussed later. At this point let me merely point out that in the case of *Carabocrinus* already cited we have a stellate opening to be filled, but the centrale which is formed is strictly pentagonal and, moreover, interradiial.

It is a notable fact, although one which I believe has never been hitherto pointed out, that a permanent reentrant angle is an unknown quantity in a fully formed crinoid plate. This rule applies with equal force to a composite plate resulting from the complete fusion of two or more primary plates. Indeed, I hold that this rule is equally applicable to all Echinoderms. The forked radial of the Blastoidea will suggest itself to everyone as an exception to the rule. Even in this case, however, the exception may prove more apparent than real.

In the case of fusion among basals and infrabasals in crinoids the resultant reentrant angle formed between any two of the plates tends to fill out and make a straight face. At the same time there is a gradual resorption of the lower edge of the plate resting in the reentrant angle. Within a short time all traces of the reentrant angle disappear and a straight face results. Why this is so it is hard to say, unless it be that a reentrant angle is a source of weakness in a plate and is eliminated as rapidly as possible. A large number of examples of such filling up of reentrant angles might be adduced. An examination of a series of Camerata in which the basals tend to fuse into a solid plate will illustrate this condition admirably. In certain species where fusion has not become effective, or in young individuals, it is to be noted that certain of the radials, and frequently the proximal anal plate, if such be present, rest in reentrant angles formed by the basals. Upon a complete consolidation of the basals a pentagonal or hexagonal plate with straight faces is formed. Such a hexagonal disk as is shown in the genus *Megistocrinus* is here figured (Pl. 9, fig. 12). In other specimens of *Megistocrinus* it may frequently be observed that the anal rests within an angle formed by two of the unfused elements of the tripartite base.

The regular polygonal shape of such basal elements as is to be noted in the Camerata may only be accounted for on the basis of fusion and subsequent filling of reentrant angles. Where before there was a reentrant angle between two plates, after such fusion we find a straight face. This change necessarily requires not only

a filling out of the reentrant angle, but a concomitant resorption of the proximal portion of the plate which rests within the angle. If we take a monocyclic crinoid with a tripartite base we do not say that there can only be three basals present, because there are no signs of sutures or reentrant angles, and we can only see three elements. If such a statement can not be applied here, wherein are we justified in making the same assertion in regard to the proximal circlet of *Uintacrinus*?

On page 33 and elsewhere Springer states that there is no evidence of fusion. Why does not his Plate 2 show practically every step in such a process? On Plate 9 will be found reproduced the important stages figured by him. Figure 7 shows clearly that fusion of one sort or other must have taken place. It is evident that there is a single unfused infrabasal and one plate consisting of two fused infrabasals. It is not necessary at this point to determine the composition of the third plate, although we know that it must be either the centrale alone or the centrale with which the other two infrabasals have fused. The important fact is that there is a tendency toward fusion among these plates just as we found that there was a similar tendency among the plates of the proximal circlet of other crinoids. If there be such a tendency toward consolidation, is it not highly probable that the plates will not only fuse among themselves, but also with the centrale? If so much be granted, it is very easy to explain the various bases figured, which are otherwise so puzzling.

Figure 11 shows the regular "monocyclic" base with the centrale of maximum size. Figures 1 and 2 show the normal dicyclic base. In figure 5 we find that one infrabasal has fused with the centrale. The four other infrabasals are present, three being relatively small, while the other is quite large. In figure 6 we see that two of the infrabasals have fused with the centrale. Figure 7 shows a modification of the process. Here the centrale has fused with two of the infrabasals, the resultant plate probably being represented by the largest plate of the three—that on the upper left-hand side. In addition, two of the infrabasals have fused, forming the plate next in size. A fusion of the centrale and two infrabasals and the remaining unfused infrabasals would most certainly give the form represented in figure 8. A further fusion of these two elements would result in an irregular plate, which would gradually acquire a more symmetrical form by a process of accretion in some parts and resorption in other parts, combined with similar processes acting on the adjacent faces of the basals.

Apparently the coalescence of the infrabasals and centrale took place in no definite order. In figure 7 two infrabasals fused together, while the centrale fused with two others. Another variation is to

be noted in figure 3. Here the infrabasals are greatly diminished in size, while there is a corresponding increase in the size of the centrale. Here there seems to be no possibility of a fusion between the members of the infrabasal circle. In case fusion had taken place subsequent to this stage the infrabasals would have united directly with the centrale. In figure 5 there was a similar reduction in the size of the infrabasals before, or, perhaps, during, the process of fusion. The tendency was toward the elimination of the infrabasals as distinct elements, and whether the result was obtained by the simple fusion of the plates concerned, irrespective of the order in which such fusion took place, or by the partial resorption of the infrabasals and their subsequent coalescence with the centrale, was of little moment.

Springer styles all those apical plates that meet interbasal sutures by more than one angle, "centrales." Thus in figure 8 we find *two* "centrales," and in figure 7 two centrales and one infrabasal. Such types he describes as having a double centrale. As previously stated, Springer does not attempt to explain how two centrales could by any chance have been produced in an individual. He merely states that "all these irregular cases are rare and exceptional, and constitute mere individual variations." Two such plates could certainly not represent a "proximal or distal stem ossicle." If a gap existed to be filled, one plate would have been formed—not two. The only other possible explanation for a "double centrale" is that one of these plates is composed entirely of fused infrabasals, and the other made up of the primitive centrale to which one or more infrabasals have fused.

Springer calls attention to the fact that in the case of figure 6 the centrale is both interradiar and radial. Hence it follows according to the law of Wachsmuth and Springer, which "strictly prevails," that this individual is at one and the same time monocyclic and dicyclic. This is obviously impossible. The specimen *does*, however, combine features typical of forms M and D as shown by *Uintacrinus*. This same plate beautifully illustrates my contention that the shape of the centrale is entirely dependent upon the plates surrounding it. On one side the centrale rests against three infrabasals, and conforms to the angles between these plates. As a result, on that side it is interradiar. On the other side it has fused with the other two infrabasals, and after a process of mutual adjustment between itself and the basals, one complete and two incomplete sides of the pentagon to be have been formed, the inclosed angles conform to the basals and are radial in position.

Inasmuch as Form M in *Uintacrinus* is not truly monocyclic, we may well pass over the last objection of Springer on pages 33 to 34 in regard to the supposed change in orientation of the chambered

organ. This organ would not necessarily be changed in any way. The loss of the stem would doubtless result in a more or less complete coalescence of the lobes of the chambered organ; much as we find in the case of *Actinometra* and *Antedon*. The mere subsequent fusion of the infrabasals with the centrale would probably in no wise affect the organ. Certainly there would be no occasion for a transformation of one form into the other involving "in addition to the change in orientation of the centrale, a revolution of the chambered organ, and an extension or shortening (as the case might be) of the downward prolongation of the axial nerve-cords."

How important a part resorption of the infrabasals has played in the transmutation from one form into the other must always remain a moot question. It is perfectly possible that the change might be effected by this process. If in a specimen like figure 3 the infrabasals become progressively smaller and smaller it is evident that before long they will entirely disappear and their place be taken by the centrale. A very slight resorption of the proximal faces of the infrabasals and a corresponding increase in the size of the centrale would result in a typical centrale of Form M. It would certainly be difficult to prove in advocating this theory that in the final stages of the process the remnants of the infrabasals did not fuse with the centrale. The question is apt to remain an open one indefinitely.

The fusion observed in some specimens, as pointed out above, between the infrabasals themselves and the infrabasals and the centrale certainly shows that there was a tendency toward coalescence. If then we have a well-marked tendency in this direction, and if all the known facts appear to warrant rather than discourage such an assumption, we should feel quite justified in considering the fusion theory the more probable one, with resorption playing a minor or subsidiary part.

On page 35 Springer offers three alternatives to explain the presence of Forms M and D in the one species:

1. That from the eggs of either a monocyclic or dicyclic crinoid both forms were indiscriminately hatched.
2. That they hatched in one form, with a tendency in the larva to develop into the other, which tendency irregularly became effective in some individuals and ineffective in others.
3. That after the larval stage, by some process of addition, subtraction, or consolidation among the hard parts of the test, a dicyclic crinoid was transformed into a monocyclic or *vice versa*.

From the discussion given above we may offer here an explanation compounded in part from the second and third alternatives of Springer.

The larvæ were certainly dicyclic and became free-swimming at an early age. When a crinoid became detached from its stalk, a

calcareous plug was formed to fill up the opening through which the axial canal had formerly passed. The tendency in the development of the animal, so far as the base is concerned, was now toward an elimination of the infrabasal circlet as composed of distinct elements. This took place probably as a result of the consolidation of this newly formed centrale with the surrounding infrabasals. The consolidation "irregularly became effective in some individuals and ineffective in others," dependent, as explained above, upon the fact that some individuals were more accelerated in development than others. This consolidation of the proximal circlet is a tendency to be observed among all crinoids, and especially is it to be noted in free-swimming types such as, for instance, *Agassizocrinus* and some species of *Edriocrinus*. In such recent forms as *Antedon* and *Actinometra* the infrabasals are practically obsolete and fuse very early with the proximale. Even the basals, which to all intents and purposes have now become the proximal circlet, are affected by the same tendency, fusing to form the so-called "rosette." It might well be that if given sufficient time the basals of *Uintacrinus* would in turn be reduced and fused with the centrale. Indeed figure 9 seems to show that such a process had already begun. Here the presence of apparently four basals suggests the fusion of two of the plates, although it is obvious that this condition of the plates may be purely abnormal.

It is evident that Bather's arguments in favor of his classification have yet to be refuted. Whether the change from Form D to Form M or *vice versa* took place by the intercalation of infrabasals on the one hand or their elimination on the other is of little moment so far as this particular question is concerned. If there has been an elimination of the infrabasals by fusion or resorption, the resultant form still remains a dicyclic crinoid, or at most may be styled a "pseudomonocyclic" form. In case the infrabasals have made their appearance in Form M it will be impossible to prove that they do not represent the nearly obsolete plates of an ancestral pseudomonocyclic crinoid. In this case the plates that had come to assume an insignificant part in the makeup of the crinoid were brought back to a state of comparative prominence under the stimulus of changed conditions of life. Against this hypothesis it may be argued that in typical Form M absolutely no trace of infrabasals may be seen. This objection carries little weight, however, as the infrabasals in the ancestral form may well have been present only in the larval stage and have become quite obsolete in the adults. Whatever the process, then, all one has is a change either from pseudomonocyclic to dicyclic, or from dicyclic to *apparently* monocyclic or pseudomonocyclic types.

Probable derivation of Uintacrinus.—Among all known crinoids *Uintacrinus* possibly stands as the form best adapted to meet the

requirements of an eleutherozoic existence. As a result of this high degree of specialization it is difficult, if not impossible, to pick out any specific structure and use it as the basis of comparison with any special group of crinoids in the hope of proving genetic relationship. The structure of the tegmen; the exocyclic mouth; the thinness of the plates of the cup; the large visceral cavity, made possible by the fixation of pinnules and introduction of interbranchials; the length of the arms; the presence of syzygies; all these are modifications for which a free-swimming existence is directly responsible. In order then to arrive at any sort of a satisfactory conclusion in regard to the relationships of *Uintacrinus* we must consider the form stripped of its special modifications. To be sure, with these gone we have little left, but even that fact is of considerable importance.

The exocyclic tegmen illustrates, I believe, an accentuated bilateral symmetry induced by a pelagic existence. The marked regularity in the swimming movements of eleutherozoic types such as to be noted in living *Comatula*, unquestionably tends to bring about a bilateral symmetry on the part of the organisms.¹ Among other Echinoderms, notably the Eleutherozoa, the acquisition of a secondary bilateral symmetry is too well known to warrant extended comment. Nor can the flexible tegmen be taken as positive evidence of relationship with any special group. This, too, is simply an expression of a free-swimming existence—a pliant disk making for greater mobility and consequent arm freedom. The arms themselves again exhibit great specialization, but there is nothing in their structure which might not be independently acquired. The fixation of pinnules, although characteristic particularly of the *Camerata*, nevertheless need not be restricted to that group. In *Calamocrinus* and *Actinometra*, for instance, we find a partial incorporation of the arms and pinnulæ into the calyx, and also in *Dadoerinus*, as pointed out by Bather. In *Uintacrinus* such incorporation was the logical thing. The interbranchial system does not, I think, show marked affinities with any group. Its great irregularity, if anything, rather argues against a close relationship with the *Camerata*.

¹ Mr. A. H. Clark has proposed an interesting hypothesis to explain the exocyclic disk of the *Comatulæ*. According to him, this type of tegmen is evolved as the result of the feeding habits of the crinoids. Mr. Clark says that those forms with exocyclic disks constantly keep their digestive apparatus filled with bottom mud, from which they extract the nutritive material. Such feeding habits necessitate the possession of an unusually long gut, as one finds in animals which feed in this manner. When one considers the limited capacity of the body cavity it is obvious that such an increase in the length of the gut must result in a coiling of that organ. Concomitant with such coiling Mr. Clark maintains that the orientation of the disk changes. Such an explanation is equally applicable to *Uintacrinus*. Mr. Clark holds, though here it is not bottom mud but surface plants as a food supply to which the animal must adapt itself. This explanation seems a possible one in the case of *Actinometra* at least, and is an alternative explanation constantly to be borne in mind.

The feeding habits and food of endocyclic and exocyclic forms should be noted with care. In the case of a number of *Actinometra japonica* the included food of which I have examined, I found no evidence of bottom sediment. The intestine content was composed almost wholly of comminuted animal matter.

Springer seems to favor descent from the Flexibilia. On page 58 he records the tendency among certain Flexibilia to separate from the stem just below the proximale. If the proximale be true to its definition it will always remain, fusing with the proximal elements of the cup. In *Uintacrinus*, as shown above, this condition can not obtain. As long then as only those forms having a persistent proximale are to be referred to the Flexibilia, so long must *Uintacrinus* seek relationship elsewhere. The Camerata as the ancestral stock, as suggested by Jaekel, is a proposition scarcely to be considered seriously. By a process of elimination, then, we have narrowed the field down to the Inadunata, in this agreeing with Bather. To attempt to fix the line of descent any more definitely is, I think, at the present state of our knowledge, somewhat premature.

The stalked Inadunata ancestor should, I think, unlike *Dadoerinus* chosen by Bather, be a distinctly dicyclic form, not pseudomonocyclic. The apparent elimination of the infrabasals in some specimens of *Uintacrinus* is a feature acquired very late in the evolution of the genus. In this connection the possibility of the infrabasals of a pseudomonocyclic form regaining their former importance as elements of the dorsal cup, upon the loss of the stem, is a consideration not to be lost sight of, as pointed out above. In such a case, however, it is very difficult to see why the tendency shown by *Uintacrinus socialis* toward a coalescence of centrale and infrabasals, which is merely an expression of the general trend of all crinoids toward a more or less complete elimination of the plates of the proximal circlet as distinct elements, should show itself so late in the developmental series. One would think that in their almost completely atrophied condition in the pseudomonocyclic form, the infrabasals would at once fuse with the new element, the centrale, rather than remain as minute independent plates. Whatever be the genetic line that evolved *Uintacrinus* it is probable that we shall ultimately come to a type that will serve as a common ancestor for both *Dadoerinus* and *Uintacrinus*. This type again may serve equally well for many of the phyletic lines that flourish in Mesozoic and later times.

Springer (1901, p. 55) objects strongly to the placing of *Uintacrinus* in the Inadunata. In speaking of the relationship of *Uintacrinus* to *Dadoerinus* he says: "In the essentials of structure upon which the great groups of Camerata, Inadunata, and Flexibilia have been distinguished, *Uintacrinus* seems to me far more widely separated from this group than from the others." In regard to its positive relationships he says: "It must be evident that the line of derivation of *Uintacrinus* will have to be considered in connection with the Comatulæ. Whatever its ancestry may have been, it is quite plain that one of its near relatives was *Actinometra*." It is mainly on the evidence of similarity of structure as induced by the mutual possession of

exocyclic disks that this close alliance with *Actinometra* is predicated. These features as elsewhere noted I believe to be purely secondary and induced by an eleutherozoic mode of life. *Actinometra* and *Uintacrinus* I do not believe we may safely hold to be more closely related than as having descended from a common pre-*Dadoocrinus* ancestor.

A. H. Clark (1909 *b.*) in placing *Uintacrinus* systematically, groups the Uintacrinidæ and Marsupitidæ together under the "Comatulida Innatantes." His definition follows:

Comatulida Innatantes: Pelagic comatulids in which the basals are not metamorphosed but form an integral part of the body wall; the infrabasals are not united with the central plate, but usually form part of the body wall; occasionally, through individual variation, they are absent; there is no evidence of attachment at any stage, so that their central apical plate may possibly represent the dorso-central instead of the centro-dorsal of other comatulids. The plates of the calyx, which is very large and more or less globular, are very thin.

Included families: Marsupitidæ; Uintacrinidæ.

This treatment is but slightly better than the time-honored and discarded custom of placing the two genera into one family. It is to be noted that he follows Springer in placing *Uintacrinus* with the Comatulæ. Springer, however, while placing *Uintacrinus* among the Comatulæ, and consequently in his opinion, in the Flexibilia, retains *Marsupites* as a well-defined Inadunate.

Ecology of Uintacrinus.—There can be little doubt but that *Uintacrinus* was a pelagic type. Its extreme modifications to adapt it for such an existence, and above all its lack of prehensile cirri or other organs by means of which it could attach itself to extraneous objects, coupled with the extreme length and flexibility of its arms, are almost conclusive proof that such is the case. Such forms as *Agassizocrinus* and the free *Edriocrinus* which likewise lacked cirri, but which were decidedly not fitted for a pelagic existence, probably rested on the bottom on their comparatively short arms. Indeed, it is probable, as is shown elsewhere, that these forms crawled about a good share of the time, rather than swam about freely.

It is a debatable question whether *Uintacrinus* was as gregarious in its habits as has generally been conceded hitherto. At the present day, it is true, *Antedon* swims about in schools, and *Actinometra* seems to be equally gregarious so far as observations have been made. In the past, *Agassizocrinus* seems to have lived together in great numbers, and the same was true of *Saccocoma*. These forms, however, I do not consider essentially pelagic as I do *Marsupites* and *Uintacrinus*. In European deposits *Uintacrinus* has been found as isolated specimens only. It is when we come to the Niobrara of Kansas that we have to deal with the curious "colonies" of *Uintacrinus*. Springer believes, as do all other writers on the subject, that *Uintacrinus* was gregarious in habit. He says on page 11, "These

crinoids were in detached masses, clinging together and floating in the open sea, entirely separate from other objects. They were actually swarming, very much like a swarm of bees when they leave the hive and settle upon some object—some on the outside and some buried underneath their fellows—all in the utmost confusion.

A. H. Clark (1909*a*, p. 129) devotes some attention to the ecology of *Uintacrinus*, although he suggests nothing essentially new. In one paragraph he arraigns authors as not having the "courage of their convictions" in considering *Uintacrinus* as a pelagic type, as shown by their figuring specimens with the mouth up. I think it has been generally conceded that *Uintacrinus* floated with the arms dependent. Indeed this is so obvious that no one has taken the trouble to point it out hitherto. The figuring of *Uintacrinus* mouth up is not such an evidence of weak faith as it seems to Clark, after all. This is the conventional manner of illustrating crinoids, and is followed out even in the case of the Calceocrinidæ by Bather (1893). A plate of *Uintacrinus* figures with the apical portions up would have to be reversed by the average mortal before becoming intelligible. Clark likewise gives some interesting views relative to the feeding habits of *Uintacrinus*. He considers that—

the closer the individuals lived, the more advantageous it would be for them; for their food probably consisted of minute pelagic organisms which they intercepted with their long feathery arms; these organisms are largely lucifugous, and would tend to collect under the shadow of a mass of crinoids as they are known to do under floating logs and driftwood which, thereby, would be placed in the economically advantageous attitude of attracting to itself without effort its own food supply. The perisome of *Uintacrinus* is black, of such a dense carbonaceous black that it has been preserved without change through the ages which have elapsed since cretaceous times; and, if one of these small lucifugous organisms took refuge under the shadow of a mass of *Uintacrinus*, it would be quite likely to be attracted to the blackest portion of the animals, the disk or ambulacra, whereupon it would soon find its way (or rather be conducted) to the mouth.

Just why the disk is held to be black in the case of the living crinoids it is difficult to say. As described by Springer (1901) the tegmen is black, as carbonized animal tissues are apt to be. It has not hitherto been held as remarkable that carbonized matter should retain its blackness. Furthermore, the advantage of having the food attracted to the disk is not immediately obvious. The hundreds of pinnules borne on the arms are supposed to function as food-gathering organs, and they would not be specially benefited by a black spot an inch or so in diameter, several feet away.

It is inconceivable that the animals could have lived under such crowded conditions as has been predicated by the authors just quoted. For what purpose were the extremely long arms and other very special modifications other than that the animal might have the utmost freedom of movement? Again, how could any but a favored few, and even those in but a very insufficient way, obtain nourishment?

It is probable indeed that this "swarming" was the actual cause of the death of the crinoids, as has been suggested as a possibility by Springer. Setting aside the theory that the crinoids lived in more or less agglomerated masses it seems scarcely possible that they could have lived in freely swimming schools, as do the living Comatulæ. Arguing against the living of any considerable number of *Uintacrinus* in juxtaposition, one needs but to consider their great size. An adult fully expanded would cover an area of 30 or more square feet. Allowing for a reasonable amount of clear water on all sides, say a couple of feet, we would have the individual's space requirements greatly increased. Under these conditions it seems as if it would prove inexpedient for any considerable number of individuals to travel together.

There seems but one plausible explanation to account for the "swarming" of *Uintacrinus* and that has been put forward by Springer. He says: "It is possible that this may have happened during periods of sexual activity." We can easily conceive, under such conditions, of large numbers of *Uintacrinus* gathering together in favorable localities, such as bays or lagoons. Here possibly through the crowding of females about the males¹ a large number of individuals might become inextricably tangled together. Under such circumstances the individuals constituting the core of the mass must inevitably die of suffocation and starvation, though probably the former course may be held as the more efficient inasmuch as the whole incident could have occupied but a short time. Some of the individuals on the outer surface of the mass might be able to clear themselves by a breaking off of their arms, but the majority would be killed. Subsequent to the death of the animals the mass would sink to the bottom, and there form such lenses as we find to-day. On this hypothesis one may understand the absence of isolated specimens in this region. The crinoids came into the shallow waters during periods of sexual activity and afterwards returned to their normal habitat, perhaps far out in the open sea, leaving behind only an occasional mass of their unfortunate fellows.

A glance at a paleogeographic map of the Niobrara sea gives considerable support to the foregoing conclusions. The ancient Gulf of Mexico occupied in a general way the area it now covers, although it was considerably greater in extent. Passing northward into Kansas, however, was a great embayment. In the Gulf itself there was probably a strong Gulf stream much as at the present time. Out in this current, and probably farther out at sea also, the *Uintacrinus* spent the greater part of the year. In the breeding season they entered the

¹ The preponderance of females over males seems to be quite marked in recent forms. Among nearly thirty specimens of *Actinometra japonica* collected at a single locality at one time, there were no males. The females in all cases bore large numbers of nearly ripe ova. At the same locality *Antedon macrodiscus* likewise showed a very marked preponderance of females over males.

comparatively quiet waters of the bays in great numbers, and here, as before described, many lost their lives. The original locality where *Uintacrinus* was found, in the Uinta Mountains of northern Utah, represents another great bay. In both cases it is interesting to note that the crinoids are found in the innermost portions of the embayments where one would scarcely expect to find the conditions for which *Uintacrinus* is so obviously fitted. That the water was very shallow in which the beds containing *Uintacrinus* were deposited is generally conceded.

Another possible explanation of the formation of these masses is a variant of the foregoing. It may be when gathered in these embayments in the breeding season, that the crinoids were thrown together as a result of wind activity. They may even have been driven into the shallows and there been massed and stranded. The agitated chalk sediment of the bottom would quickly cover and serve to preserve the crinoids. Of the two explanations the former seems the more reasonable, inasmuch as the crinoids are as a rule most beautifully preserved and do not show the effects of violent disturbance.

The whole structure of *Uintacrinus* as noted above argues against a littoral habitat. The crinoid is evidently adapted only for life on the high seas, for elsewhere storms might well work havoc with the enormous but delicately constructed organism. The widespread occurrence of the genus again argues against a continuous shallow-water life. Living largely in the Gulf Stream, as they probably did, some followed the current and found a final resting place in the European Chalk. It seems possible that the type evolved in American waters, and here *Uintacrinus* chiefly flourished, a few straggling forms only making their way to the European seas. It is possible, of course, that in Europe the scarcity of the organism is due to the fact that as yet no breeding locality has been found, and that some day masses of *Uintacrinus* similar to those found in America will be discovered in those regions.

A. H. Clark (1909a) gives quite a different version of the breeding habits of *Uintacrinus* than that here suggested. According to him the eggs were laid and fertilized while the animals were moving about in the open sea. His idea can best perhaps be expressed in his own words:

Now a floating colony of *Uintacrinus* during a breeding period would be drifted about, as at other times, by the surface currents, the waves, and the wind, just as the medusæ are; and, consequently, their embryos would fall over a large extent of territory. By the time the larvæ from such embryos as happened to fall upon suitable bottom had begun to grow, the parent colony would have drifted to a very considerable distance, unless, of course, the species was an inhabitant of inclosed bays, which, however, taking into account its enormous range, is quite unlikely; by the time the young were ready to discard their stems and swim away, forming a swarm of their own, the parent colony would be in some remote part of the sea. As the position of the parent colony

over any given area of sea bottom would not be of long duration, the young from the embryos which happened to fall at any given place would naturally be all of approximately the same age, and hence of the same size.

This casual peppering of eggs seems opposed to all that we know of the habits of the Crinoidea, and would furthermore be highly detrimental to the best interests of the organisms. In the first place, fertilization would by no means be assured, and, in the second place, the chances are that the majority of the eggs would fall in an unfavorable environment.

Such an hypothesis fails to explain the colonies of young individuals as it is supposed to do. Were the adult colony to stop at a given spot and discharge a large number of eggs, and subsequently were the eggs to develop and furnish young that acquired freedom at the same time and were imbued with the colonial habit, one might perhaps concede that this explanation explains the conditions as we find them. There are too many difficulties in the way, however.

On the other hand, the swarming of the crinoids in the breeding season certainly forms a plausible solution of the problem. One would expect crinoids of the same age to interbreed, and so we should expect to find any given colony composed of individuals of approximately the same size. There should be at least two or three distinct grades. The first would consist of year-old animals perhaps. The next year the crinoids might be of sufficient size to herd with the adults, although there may be a second-year group as well. A comparison of the size of individuals in different colonies might be used as an approximate index of the rate of growth of the animals.

As to the life history of *Vintacrinus* one can not be certain. It is probable that the eggs were laid in shallow, comparatively current-free water. Here they hatched and the larvæ become attached to the bottom. There seems no question but that a stalked stage was had, although, as will be noted below, exception has been taken to this view. Upon becoming detached from its column the young *Vintacrinus* probably remained in the shallow water of the embayment. It is probable that the first year at least was passed here, the animal not having sufficient swimming powers to reach the open sea. Such embayments could have but feeble currents, and the animals, in order to get from place to place, must have had to rely to a considerable extent on their own activity.

Clark, in the passage quoted above, speaks of the young *Vintacrinus* as discarding their stems. In a paper published at approximately the same time as the one quoted he has this to say: "The crinoids are the only recent fixed echinoderms; but in the fossil crinoids, as Lang pointed out in *Marsupites*, and I independently showed in *Vintacrinus*, there are forms which exhibit no evidence of having been attached; in fact the evidence is quite the other way.

In these forms the centrale may be instead of centro-dorsal really the dorso-central, in which case we should get an interesting homology with the echinoids."

Which paper has the precedence it is hard to say. It is quite evident, however, that in two papers, perhaps in press at the same moment, he reverses himself without in either case referring to the other paper.¹

It is somewhat mystifying when and how Clark "independently showed" that *Uintacrinus* had never been attached. That *Uintacrinus* has no column, so far as known, has been established by the researches of Bather and Springer. The only way for Clark to prove the absence of a column, or its presence for that matter, is to trace the development of the form back until a stem is found, or back so far in the ontogeny of the animal that there is no chance of a column having been present. We shall await this proof with considerable interest.

The other two genera referable to Type II are of considerable interest, but they are so well known that any extended discussion of their structural features is scarcely warranted. There are, however, certain interesting structural deviations from those to be noted in the case of *Uintacrinus*. These deviations form an interesting example of adaptation to the same type of existence by crinoids belonging to fairly unrelated genetic lines. Any conclusions to which we may come relative to the derivation of these two genera are even more nebulous than in the case of *Uintacrinus*.

Marsupites.—In its adaptation to a free-swimming existence *Marsupites* (Pl. 10, fig. 4) differs from *Uintacrinus* in many important regards. The arms are comparatively short and bifurcate many times. The dorsal cup is large, but its size is due simply to the great size of the three circlets of plates and of the centrale. There are no interbranchials, and there is no incorporation of the proximal pinnules in the cup. The tegmen is composed of rather heavy plates, indicating the comparatively recent acquisition of a free-swimming existence.

In regard to this form Bell (1891, p. 210, footnote) has written: "I suppose no morphologist will be bold enough to say whether *Marsupites* or the irregular Blastoids are primarily or secondarily free forms." This seems to be the stand taken by A. H. Clark, at least in regard to *Marsupites*, as elsewhere quoted. It seems to me, rather, that it would be a bold morphologist indeed who has the courage to claim a primary free condition for these forms. Freedom is too easily secured, and symmetry is far too difficult to acquire to warrant such statements.

¹ Since writing the above I have been informed by Mr. Clark verbally that he believes *Uintacrinus* never to have been attached by a column.

Saccocoma.—*Saccocoma* (Pl. 10, figs. 1-3) is chiefly interesting because of its high degree of specialization. This form has well been described by Jaekel (1893). In this form the centrale is minute and may consist either of a new element to which the basals have been fused, or it may consist simply of the fused basals. The minute size of this plate compared with the size of the cup is surprising, inasmuch as in *Marsupites*, the other form the cup of which consists of but few plates, the centrale has been so considerably enlarged. The arms of *Saccocoma* are of great interest. Reference to the figure will show most unusual modifications. The arms are comparatively long and slender and in their distal portions are considerably branched. In their proximal portions the most noticeable feature is the lateral flange-like extensions of the arm ossicles. These are obviously adapted for use in swimming. The comb-like processes of the more distal ossicles probably represent modifications for a similar function. This small form, as has been held by Jaekel, probably swam about in enormous numbers in quiet lagoons. It is quite probable that as opposed to *Uintacrinus* this genus lived in schools as do the Comatulæ.

Abnormally free types—*Carabocrinus*.—Having discussed the members of Type II, mention should be made of those forms which subsequent to a complete loss of the column, evolve similar structures to those had by the three genera above described. This detachment from the column is unquestionably accidental in *Carabocrinus*, while in *Arachnocrinus* it seems that it may be a condition that becomes irregularly effective, though normal. These two genera are of very considerable interest as pointing to the probable derivation of the centrale. The case of *Carabocrinus* has already been described under the discussion of *Uintacrinus*. This is the most perfect example of the formation of a centrale where there is no possibility of the proximal columnal taking part in its formation. The evidence showing that this plate could not be other than an absolutely new skeletal element has already been given.

Arachnocrinus.—The genus *Arachnocrinus* offers us most remarkable and unexpected structures of a similar nature. The genus is an unusual dicyclic Inadunate which lived in the neighborhood of the coral reefs of the Onondaga seas. Apparently a column was possessed by this genus in the majority of cases, although the extraordinarily heavy arms could seemingly not be held other than as resulting from a special modification for an eleutherozoic habit. In the examination of a number of individuals of this genus in the course of the preparation of a memoir on the Devonian Crinoidea of New York State, I was astonished to find that no less than three individuals showed absolutely no trace of column attachment. In each of these specimens a centrale is to be observed. *Arachnocrinus* certainly had no proximale, and it seems evident that here again no other explanation

for its origin may be had other than that it represents an entirely new element. One of these crinoids is of special interest as showing a complete fusion between the centrale and certain of the infrabasals. This fusion quite parallels that to be found in the case of certain *Uintacrinus*.

One may only speculate as to the conditions under which an eleutherozoic habit was assumed by *Arachnocrinus*. It would appear that detachment from the column took place naturally but perhaps not universally. However such may be, we know that the form lived in the comparatively shallow waters about coral reefs where either an excessive shortening of the column or its complete elimination would tend to be induced. Subsequent to its acquisition of freedom it is probable that *Arachnocrinus* crawled about on the bottom rather than swam. The comparatively small size of the theca and the relatively enormous expanse of the massive arms seem to preclude the possibility of active swimming movements on the part of this organism. A full discussion of these remarkable crinoids will be given in a forthcoming work.

Having discussed the features more intimately associated with the different genera referred to this type, and having shown the presence of a centrale in certain normally attached forms, it may be well to recapitulate the evidence relative to the formation of this plate. This seems best as in the discussion of various types such facts have been scattered and used to illustrate specific structures.

Upon the loss of the column by a form in which a persistent proximal columnal is not present or in which specialization has not brought about a fusion of the proximal columnals into a centro-dorsal, we may have the formation within the proximal circle of plates of an entirely new element. Subsequently this element may fuse with the adjacent plates of the cup, but this process is but a secondary one and of no great importance. In other cases, as will be pointed out later, upon the loss of the column the axial canal is closed simply by the increase in the size of the elements of the proximal circle. This shows that the formation of a new plate is not essential. Furthermore it points to the possibility that in the case of *Saccocoma* we need not have had a centrale originally to which the basals fused. Instead the centrale in that form may represent simply the fused basals. At all events the centrale may not be held as of any considerable morphologic significance, and is of no great value in determining relationships.

It is unnecessary to enter upon a discussion of the homologies of the centrale, inasmuch as being an absolutely new element, it is not homologous with any structures in other crinoids. It may be seen that a consideration of it as representing the "dorso-central" or the

entire column of the Crinoidea is quite groundless. Nor may the centrale be compared with the apical plate of the Echinoidea, thereby giving a footing to far-fetched theories of mutual interrelationships.

TYPE 3.

Agassizocrinus.—The sole genus referable to this division is *Agassizocrinus*, which flourished in enormous numbers in the late Mississippian seas. The structure characteristic of this group is the close union and subsequent fusion of the proximal circlet of plates. No centrale was formed, apparently. As elsewhere noted *Saccocoma* may possibly belong in this division, for in that genus the "centrale" may simply represent the fused basals.

The infrabasals in *Agassizocrinus* are large and massive, while the axial canal is comparatively small. Upon detachment from the column a filling of the axial canal probably took place, but the resultant plug must of necessity have been insignificant in size, and may indeed never have reached the surface. At any rate no trace of the plug can be seen externally. A very close union was effected between the infrabasals, and in the majority of cases complete fusion took place in the adult stages. As a rule the fusion of the plates was followed by a secondary deposition of stereom over the entire surface of the infrabasal knob, which effectually obliterates all traces of sutures. In the figure here given (Pl. 10, fig. 5), it is to be noted that the infrabasal sutures are indicated. This is somewhat unusual for the genus. These fused infrabasals are preserved to us in great numbers, certain beds being largely composed of them associated with disarticulated calycal plates.

Agassizocrinus is particularly interesting because of the fact that the acquisition of an eleutherozoic habit is a comparatively new thing, and occurs in a line where such disruption indicates a wide deviation from the normal. In spite of this fact the innovation seems to have been a most successful one, judging from the prolific development of the genus. *Agassizocrinus* appears to have been near the termination of its genetic line, and it is perhaps on this account alone that it has not given rise to a line of eleutherozoic descendants.

As to the habits of *Agassizocrinus* little may positively be said. It seems highly probable that an eleutherozoic existence was maintained from a very early ontogenetic stage, for no trace of a stem cicatrix is to be seen. Considering the very heavy nature of the cup plates and the comparatively massive and short arms it scarcely is to be held that the animal was a free-swimming organism. Rather, I think it should be considered that *Agassizocrinus* for the greater part of the time crawled about on the bottom and was capable of swimming but short distances.

Scytalocrinus.—In connection with the discussion of *Agassizocrinus* should be noted a specimen of *Scytalocrinus* which abnormally exhibits similar structural features to those shown by *Agassizocrinus*. In this specimen the column has been completely lost. Although disruption from the column in this instance may be held to be abnormal, it may well represent the effect of a tendency toward an eleutherozoic habit becoming irregularly effective in this genetic line. *Agassizocrinus* is closely related to *Scytalocrinus* and a condition so universally assumed and maintained by this genus might well appear sporadically elsewhere among related types.

The specimen illustrating this unusual and interesting structure has been described in Troost's recently published manuscript (1909, p. 88) as *Scytalocrinus* (?) *gracilis*. Troost observed that the stem is wanting and that there seems to be no evidence of stem attachment. He therefore referred the specimen to the genus *Agassizocrinus*. Miss Wood, in editing the manuscript, referred the species to *Scytalocrinus*, a genus to which it may well be referred.

In this specimen there is no sign of fusion among the infrabasals nor has a centrale been formed to plug up the axial canal. The closing of this canal has been effected by a growth and close union of the infrabasals themselves. The crinoid probably did not lose its stem when young as Miss Wood supposes. A very definite flattening of the infrabasals marks the former stem cicatrix, and while there has been more or less resorption and solution there is every reason to believe that the column had reached a fair size before the crinoid became detached.

The anal side of the crinoid is badly weathered, and it is somewhat difficult to make out the true nature of the plates. Miss Wood in her notes has pointed out that one of the infrabasals seems smaller than the others and apparently does not reach the center. The infrabasals were undoubtedly nearly equal in size, but owing to weathering one has been nearly eliminated. This shows how difficult it is to judge accurately of the relationship of the other plates on this side. The plates certainly are not "much distorted." The left posterior radial seems abnormally small, and it is possible that the left posterior arm was partially aborted. Not enough remains now to be sure of this, however. The anal interradius seems fairly normal. The primibrachs of the left antero-lateral and right postero-lateral rays are curiously flattened on the sides toward the anal interradius, but this I attribute to weathering.

Miss Wood has suggested that the crinoid lay flat on the bottom. This explanation might well account for the apparent distortion and abortion of the plates and arms of the anal side, but is so opposed to the habits of the Crinoidea that one hesitates to accept it. The conditions as we have them may be accounted for on the basis of

excessive weathering, and such being the case it seems perhaps preferable to explain them on that basis. One would think that the development of the arms of this form is quite sufficient to enable the crinoid to use them as swimming or ambulatory organs and so obviate the necessity of maintaining a purely passive existence.

TYPE 4.

This group has been erected for the reception of two blastoid genera, *Eleutheroocrinus* and *Zygocrinus*, and two cystid genera, *Protocrinus* and *Lichenoides*. This division obviously contains a rather heterogeneous collection of Pelmatozoa, all of which, however, have a similar arrangement of proximal plates as regards the closing of the apical aperture. In each of these genera the axial canal is closed by an increase in the size of the plates composing the proximal circlet, which become closely united but not fused. In this they agree with *Scytalocrinus*, described above, and with certain *Agassizocrinus* in which fusion of the infrabasals has not become effective.

Lichenoides.—*Lichenoides*, which has been described and figured by Barrande (1887) as well as the preservation of the material permits, must have lost its column at a very early stage in its development. As will be seen by reference to Plate 11, figure 11, the proximal circlet of plates is somewhat disarranged, and by a mutual adjustment of the elements the apical opening is closed.

Bather (1900) holds that the theca is "composed of rounded plates of very different size, but semiregular in arrangement. At the base are five to twelve minute plates." It seems to me that the cup is composed of four circlets of plates, with five plates in each range, as in *Macrocystella*, to which this genus appears to be closely related. The apparent irregularity of arrangement is due to a shifting of the plates subsequent to detachment from the column.

The systematic position of this genus is highly problematic. As stated under the discussion of *Macrocystella* above, the forms seem more closely related to the Crinoidea than the Cystidea, and might well be styled "tricyclic" Crinoidea. At all events one finds considerable difficulty in assigning them to the Cystidea.

Protocrinus.—In the genus *Protocrinus* (Pl. 11, figs. 12 and 13) it may be seen that attachment by a column was had until comparatively late in the life of the animal—at least in certain individuals. The specimen given as figure 12 apparently has four plates in the proximal circlet, and there is a well-defined stem-cicatrix. By the well-defined nature of the latter, it is evident that the column was comparatively well differentiated. In figure 13 all traces of stem attachment have disappeared. There has likewise been a fusion between two of the elements of the proximal circlet.

It is probable that in both this and in the preceding forms locomotion was effected by the animals crawling on the bottom. The appendages seem scarcely to be of sufficient size and strength to warrant the conclusion that they could function as efficient swimming organs unless aided by a considerable buoyancy of the theca, which in these cases seems to be wanting.

Eleutheroocrinus and *Zygocrinus* differ from most other eleutherozoic Pelmatozoa either in not being essentially free-swimming organisms or in not crawling along the bottom with the theca raised above the surface. In their manner of life they simulate the Echinoidea among the Eleutherozoa and the Anomalocystidæ among the Pelmatozoa. A free-swimming existence was denied them, indeed, by the lack of proper organs of propulsion. Their slender, comparatively weak pinnules, ranged along the ambulacral areas, were incapable of the sweeping oar-like movements of the long stout crinoid arms. They could do creditable service, however, in pushing the crinoid along the bottom,

Eleutheroocrinus.—*Eleutheroocrinus* (Pl. 10, figs. 6–8) was descended from an essentially *Pentremitidea*-like ancestor. When the blastoid became detached from its column, it naturally lay lengthwise. Two points determined the side which was to lay next the bottom. In the first place the anal opening had to be on the lower side to prevent the excrement from fouling the spiracles and ambulacra. In the second place, as many of the ambulacra were to retain their unimpaired efficiency as possible. There are three possible positions meeting the first requirement; upon the right posterior ambulacrum, the left posterior ambulacrum, and upon the posterior interradius. In order to meet the second requirement, however, the posterior interradius must be eliminated from consideration. With the blastoid resting upon it, two ambulacra would have been rendered practically useless. Of the two positions left, the one with the left posterior ambulacrum resting on the bottom was assumed.

In motion the blastoid—not *Eleutheroocrinus* as yet—progressed backward, as it were. That is, the apical portion formed the forward end. The reasons for this are obvious. If motion were to take place in the opposite direction, the sediment of the bottom would be pushed up over the oral openings. Moreover, the efficiency of the pinnules would probably be lessened.

The modifications in the structure of the blastoid as a result of the assumption of this type of existence are marked, and offer a beautiful instance of adaptation. The aboral end of the theca became sharply pointed, rounding above and flattened below. The left posterior ambulacrum became greatly shortened and widened, coming to lie entirely in the plane of the oral face. Thus we have the

lower portion of the body forming a smooth flattened surface, admirably adapted to sliding along the bottom.

Zygoerinus.—In *Zygoerinus*, from the Carboniferous of England, modifications apparently quite at variance with those to be observed in the case of *Eleutheroerinus* are to be noted. It is difficult in the extreme without an examination of original material to determine the nature and extent of these differences. It would seem, however, in *Zygoerinus*, that upon detachment the animal did not rest lengthwise upon the bottom, but upon the apical portion of the theca. If this be the case it seems highly probable that the ancestral type was subglobose as to form, and perhaps not unlike *Granatoerinus*. Motion in this curious genus seems to have been directed with the aborted ray forward. The genus is certainly a highly specialized and divergent type and if it bears movable spines as described the resemblance to the Echinoidea is considerably enhanced.

General discussion of Group II.—In the members of Group II it is to be noted that the greater portion of the column is lost and in certain cases no remnant of it remains subsequent to detachment. Maintaining an eleutherozoic existence, permanent refixation by cementation has in no case been observed. The loss of the column is even more remarkable than the assumption of a detached existence. The column is a highly differentiated organ and was only acquired after a long period of fixation. That such a highly specialized organ should suddenly be dispensed with is an interesting commentary on the way in which animals discard structures when it is to their advantage to do so. The wide assumption of an eleutherozoic type of life among such extremely variable organisms throughout geologic time further emphasizes the remarkable tendency there has been noted toward the assumption of freedom by the Pelmatozoa.

GROUP III.

The members of Group III as heretofore defined constitute those Crinoidea that do not possess a true jointed column but as a rule are cemented to the bottom by a base of varying composition. This base for purposes of convenience I have styled a peduncle. The bearing that these pedunculate forms have on eleutherozoic conditions as they obtain among the Pelmatozoa may not be immediately obvious. It seems highly probable, however, that these forms represent an effort on the part of the Crinoidea to assume a detached existence, a tendency that has become but partially effective. Furthermore, in one genus at least to which we shall devote most of our attention both an attached and detached existence is maintained, even within a single species. At all events the cause for the assumption of such structures as are possessed by the members of this group

is doubtless of very similar nature to those that have brought about an eleutherozoic habit on the part of other crinoids. It is for this reason that these forms have been introduced in the present paper.

Edriocrinus.—The genus *Edriocrinus* has long been known, although its genetic affinities are but poorly understood. It has a fairly long geologic range, being found from the New Scotland to the Onondaga. Its structure is apparently very simple, as will be seen by reference to Plate 11, figures 1, 2, 9, 14, 15. The cup consists of five radials and an anal plate. The latter is somewhat narrower than the radials but of equal height. This cup rests upon an apparently amorphous base. The arms are short but remarkably broad and stout, indicating adaptation perhaps more to a shallow water habit than to an eleutherozoic existence. The shape of the base and the relation of the thecal plates to it vary considerably. This variation is immediately obvious in a comparison of Plate 11, figures 1 and 9.

Edriocrinus dispansus, new species (Pl. 11, figs. 1 and 2), offers perhaps the most interesting variant from the normal *Edriocrinus* structure. In this species, which occurs in the Linden (Helderbergian) of Big Sandy River, Benton County, Tennessee, the base is greatly expanded. In the specimen here figured the animal is attached to a shell of *Leptæna rhomboidalis*, which it entirely covers and extends beyond. Despite the great expanse of the lower portion of the cup, the diameter of the theca at the arm bases is comparatively small. It is to be noted that the radials and anal are directed inward, rather than vertically or outward, as in the case of most Crinoidea. As a result the radials are considerably broader at the base than at the top. There is no other species of *Edriocrinus* that in any way approaches this form. The holotype of this species is in the United States National Museum. (Cat. No. 27757.)

As going to the opposite extreme from *Edriocrinus dispansus* should be taken *E. pyriformis*. In this species (Pl. 11, fig. 9) the peduncle is comparatively slender and elongate, having more the appearance of a short, fairly stout column. The other species of *Edriocrinus* lie intermediate between this and the preceding species, both structurally and geologically.

Edriocrinus sacculus, from the Oriskany, is a type that offers many interesting features relative to the structure of the genus. It is through the evidence of this form, for instance, that we know anything in regard to the structure of the arms of *Edriocrinus*. This species likewise combines an eleutherozoic and stazoic habit. The species is constantly attached in the young forms, as may be noted in Plate 11, figure 14. The young apparently were often associated in groups or clusters as here indicated. A number of these clusters have been noted where the young are cemented to brachiopod or gastropod shells. In certain individuals it appears that attachment was main-

tained throughout life. In the majority of cases, however, detachment from the bottom took place. Detachment became effective through the resorption of the stalk near its base. This resulted in the freedom of the organism. Detachment in the case of these crinoids apparently occurred at widely different periods in the development of the animals, for attached forms of widely different sizes may be observed. Figure 14, Plate 11, probably represents the approximate size at which detachment normally occurs, for the majority of attached individuals seem to be of about this size or smaller.

Subsequent to detachment *Edriocrinus* perhaps moved from place to place by crawling on its stout arms. The position assumed by the specimen of *E. sacculus* as given on Plate 11, figure 15, is probably the natural one. As here shown *Edriocrinus* is crawling over the surface of a large gastropod. It does not seem possible with the comparatively feeble musculature of this genus and the stout arms that are borne that the animal could have been capable of very effective swimming movements.

The origin of the peduncle as possessed by *Edriocrinus* may not certainly be determined. It seems probable, however, that it consists in part at least of fused columnals. Early in the ontogeny of the animal it may well be that the crinoid became detached from its embryonic stem and swam about freely with but a few columnals attached to the theca. Instead of thereafter maintaining a detached existence the crinoid settled down and became cemented to some object on the bottom. Subsequently a coalescence of the constituent columnals took place, resulting in the formation of such structures as we find.

Edriocrinus has been placed among the Flexibilia largely from the want of a better place to put it. Its apparent lack of pinnules has caused it to be grouped with the Impinnata. It does not seem evident that this grouping is correct, for the genus does not behave as one would expect a member of the Flexibilia to do. The evidence of the lack of pinnules is highly inconclusive. Indeed I think that the use of this character in classification must be attended with considerable caution. There has probably never been a crinoid which might truly be styled impinnate. The pinnulæ may be more in the nature of tentacles perhaps and need not be strengthened by calcified ossicles but they are nevertheless pinnulæ. Upon occasion centers of calcification may appear within these pinnules and ossicles be formed. Even with the formation of definite ossicles it does not necessarily follow that the pinnules would be preserved to us to-day unless there be a very close union between the constituent ossicles and between the pinnulæ and the arm proper. Bather argues for the origin of pinnules from bifurcation of the arm, but I hold that

in all probability the opposite process has obtained. At times, no doubt, arm branches have become reduced in size forming ramules and even ultimately what might be styled pinnules. However, I do not think that this has been the normal process.

As has been elsewhere noted, certain fossil Crinoidea may be held to have led an epi-planktonic existence, being attached to floating wood. *Edriocrinus* may be added to the list of epi-planktonic types. The species involved is probably *E. dispansus*, a fairly young specimen of which has been found attached to the float of a *Scyphocrinus*. The *Edriocrinus* was cemented to the lower surface of the bulb, and inasmuch as these floats are almost invariably found in the rocks with the lower surface down, it seems probable that attachment was had while the *Scyphocrinus* was alive and freely floating.

Cotylederma, *Eudesicrinus*, and *Holopus*.—For comparison with *Edriocrinus* figures are here given of the curious genera *Cotylederma*, *Eudesicrinus*, and *Holopus* (Pl. 11, figs. 3-5, 6-8, 10). It will be noted in all of these forms that the crinoid is cemented to the bottom by a solid calcereous disk. No infrabasals or basals are to be observed. The origin of these forms, as in the case of *Edriocrinus*, is more or less obscure. Likewise the composition of the base by which the crinoid is cemented is a matter of conjecture. It is only I think by tracing the possible derivation of these crinoids that we may get a clue as to the composition of the peduncle. It is not essential in tracing the evolution of these forms that we establish the exact genetic lines. Rather we should attempt to establish the evolution of the structural features that might evolve such a type of base.

Origin of pedunculate type of structure.—The evolution of these forms may perhaps be held to be somewhat as follows: Having a stalked ancestor with a well differentiated proximale, detachment becomes effective immediately beneath this plate. For a time a free-swimming or possibly crawling existence is maintained. Subsequently reattachment takes place. This is accomplished by the cementation of the proximale to some object on the sea bottom. If such be held to be the origin of the peduncle we may consider it to have essentially the composition of a centro-dorsal, barring the lack of cirri.

The reason for refixation in these forms is not altogether clear. As is elsewhere noted there is considerable evidence to prove that alternate periods of freedom and fixation frequently obtain among the Pelmatozoa. In these genera this condition may be expressed in a single period of freedom followed by permanent fixation throughout the subsequent life of the organism. The reason for the lack of maintenance of an eleutherozoic habit may not certainly be stated although there are several possible causes. It may be that the structure of the arms in these genera is not such as to enable them to

function as efficient ambulatory or swimming appendages. There are so many factors indeed that might influence the crinoids that there is small choice between them. The important fact after all is that cementation did take place.

Jaekel (1891) has combined these genera with the *Eugeniocrinidæ*, near which they unquestionably belong. It seems probable furthermore that different though closely related genetic lines may be represented. A tendency becoming effective in one line would be bound to crop out among other related types.

CONCLUSIONS.

In the preceding portion of this paper an attempt has been made rather toward the enumeration of specific instances of detachment of the *Pelmatozoa* and the consequent modifications as shown by certain types than toward the broader features as influencing the class as a whole. It may be well to bring together the more pertinent facts relative to the assumption of an eleutherozoic habit among the *Pelmatozoa* indicating in a broad way the general tendencies to be observed. This will of necessity include a comparative study of the manifestations of an eleutherozoic habit as shown in the various groups and by the different classes of the *Pelmatozoa*. The probable proximal causes for the assumption of this mode of life will also be treated in a general way. It was originally intended to discuss at length the influence of the widespread acquisition of freedom on the symmetry and distribution of the *Pelmatozoa*, but such topics though germane to the subject matter of the present paper may perhaps best be treated independently in separate articles.

A review of the evidence relative to the maintenance of an eleutherozoic habit among the *Pelmatozoa* will show that such a form of life has widely been assumed and maintained among the *Cystidea*, *Blastoidea*, and *Crinoidea* throughout their history. In each class highly specialized types have been evolved, the degree and nature of the specialization being dependent in the main on the structure of the organisms involved. Among the stalked, erect forms detachment from the bottom may be held as an almost universal attribute. At times the period of detachment may be brief and succeeded by a period of fixation. Again, there may be several alternating periods of attachment and freedom. Such may be held to be the normal mode of life of the majority of the stalked *Pelmatozoa*.

It is obvious, I think, that those forms among which a detached existence is largely maintained are to be derived from types whose periods of freedom were of short duration. Whether there ever existed a stalked *Pelmatozoan* that was sedentary from the time of its attachment is a question that must unfortunately be forever open. One might argue that such should of necessity be the case in order to

account for the radial symmetry of the Pelmatozoa. According to the hypothesis of A. H. Clark, which will be discussed at length at some future time, the acquisition of radial symmetry is in no wise dependent upon the type of life led by the ancestral forms. Radial symmetry, according to his views, may be evolved equally as well in eleutherozoic as in statozoic stock. It is impossible to completely accept these views, but it does seem probable that absolute fixation throughout the life of the individual for many generations is not essential.

We may assume that from the very primitive eleutherozoic echinoderm stock there split off a group in which a statozoic condition of life was the prevailing tendency. Within this general stock there probably were strains in which this tendency was more deeply impressed than in others. Be this as it may it seems likely that in the history of the Pelmatozoa there was a period in which a statozoic habit was the prevailing and dominant character. This period lies intermediate between that in which freedom is the expression of non-specialization, and that in which an eleutherozoic existence is the expression of a still higher degree of specialization among types of considerable complexity. It is no doubt largely to this intermediate stage that the Pelmatozoa owe the indelible impress of a statozoic existence as evidenced by orthogenetic tendencies made manifest even to the present day.

Among the Cystidea we find the only eleutherozoic Pelmatozoa that may not be held as having descended from a long line of statozoic ancestors. Even in this class there are but a few of the many-plated types that may be claimed as having evolved from a stock in which fixation had not become effective. These many-plated Cystidea were short-lived and never of commanding importance. With but one exception indeed there seems to have been no line which persisted for any considerable length of time but that was derived from a stock in which a statozoic habit had been deeply ingrained. The exception is that of the Anomalocystidæ, where it would seem that an eleutherozoic habit had been early assumed and constantly maintained. It is probable, however, that even in this line descent was had from Cystidea among which fixation at least became irregularly effective.

Causes for assumption of detached existence.—When the general tendency among the Pelmatozoa seems, superficially at least, to be constantly toward the perfection of organs for purposes of attachment, it is difficult to see the reason for such widespread departure from statozoic conditions. The assumption of an eleutherozoic habit may by no means be held as a reversion, but instead is to be considered as a well-defined progressive tendency. The causes of this deviation from the indicated path are not immediately obvious. It is **probable**

indeed that they are of two sorts, to a certain extent mutually interdependent. In the first place detachment may be forced upon the organisms by stress of physical conditions under which the animals live. In the second place it may be assumed as a character largely benefiting the race.

A discussion of these factors is of no small interest as showing to what extent the disruption of the column is optional and to what extent it is involuntary. There are two possible processes by which detachment may be attained among living Pelmatozoa. In the first place we may have a violent disruption of the column through the agency of some physical force. In the second place we may have voluntary detachment, following partial resorption of the column. Both of these processes have no doubt at times been effective.

Detachment by violent disruption.—In order to make valid the hypothesis of violent disruption of the crinoid column one must first have a physical agent competent to cause such a break. The only plausible explanation would be that of severe wave action. The assumption that crinoids may live at depths at which wave activity might act with considerable intensity is not wholly unwarranted. As has been elsewhere cited, *Isocrinus* has been reported at depths of approximately 20 fathoms. It is said, however, that they live in much shallower water than this even. After heavy storms the shores of certain coasts are said to be strewn with fragments of *Isocrinus*. Carpenter (1884, p. 289) records that after a gale *Isocrinus* of all ages and sizes were cast up on the shores at Barbados. This must indicate a very shallow water habit for *Isocrinus* at that locality. Certainly were we to find the modern representatives of the Crinoidea living at such extremely shallow depths as to be destroyed by wave action and cast up on the shore, we may equally well expect the Paleozoic forms to have lived in water shallow enough to subject them to considerable wave violence.

Involuntary detachment of the crinoids may have been a not uncommon, and consequently an important occurrence in Paleozoic times. As mentioned above, it seems possible that the sea bottom was quite within the range of wave action, at least in cases of violent storms. If this were true we may readily conceive of the crinoids being torn loose from their anchorage and leading an eleutherozoic existence for a time at least, while they were seeking favorable locations for reattachment. The beds of crinoid roots at Waldron may well be an instance of this sort. These were adult specimens and it seems highly improbable that the entire colony would break loose and migrate to another point voluntarily.

Such involuntary detachment may have been especially common in the case of young forms. It seems reasonable to expect that these may have lived in much shallower water than the adults. The case

of the Ordovician crinoids at Kirkfield, Ontario, seems to indicate such a condition of affairs. Here we have the bases of the crinoid columns cemented to an old, hardened and eroded sea bottom. It is obvious that this area had been emerged and upon its sinking the crinoids came in with the gradually advancing sea. The lack of sediment, and the fact that the crinoids are cemented directly to this eroded surface, indicate that the crinoids lived there very shortly after submergence. Submergence in such cases is admittedly a gradual process and of necessity these crinoids must have lived in quite shallow water. It is evident that even moderate wave activity would serve to loosen these crinoids from their points of attachment.

Effect of forcible detachment on the organisms.—It may easily be seen that if the majority of the Pelmatozoa were forcibly detached at different times in their ontogeny, and were they to live under such conditions that they might at any time be torn from the bottom, no complicated organs for the purpose of permanent fixation would tend to be evolved. Rather, the exigencies of such a life would tend to perfect the organism in the way of acquiring structures for temporary attachment, or to cause them totally to abandon all attempts toward permanent fixation. Here, with the exception of those Cystidea where fixation had not yet become wholly effective, we probably see the prime cause for the inception of detached conditions among the Pelmatozoa. Generalizing, one may say with a considerable degree of certainty that a free-swimming or pedunculate form of existence among the Crinoidea is induced by a comparatively shallow water habitat. Although free-swimming crinoids are found at great depths, it is only reasonable to suppose that they have secondarily sought the abyssal zone. The greater number of free-swimming crinoids are to be found either in shallow water or in regions largely affected by strong oceanic currents.

Having to a greater or less extent forcibly been compelled to assume a semidetached existence generation after generation, it is but natural that in certain lines a tendency would be induced toward the more perfect acquisition of such a mode of life as being of considerable benefit to the animals. Such a tendency is apt to make itself most evident among the terminal members of various genetic lines. Here, probably owing to the impaired force of the tendency toward fixation, complete detachment from the column may become effective. This freedom of the animal is further made possible by the possession of structures that are sufficiently perfected as organs of locomotion to enable the echinoderm to maintain a truly eleutherozoic existence.

Advantages of a detached existence.—The ability of a crinoid to move from place to place is obviously of great advantage. Irrespective of the movement of the ciliated larvæ, selective migration of the adults largely makes for the welfare of the Crinoidea. Granting that

such ability was possessed by many of the Crinoidea, as we may well be safe in assuming, there are a number of reasons for such migration. The most obvious reasons, perhaps, are those relating to the betterment of physical conditions and food supply. These two factors are more or less mutually dependent, naturally. In a sea lacking currents, and at approximately the same depth, with uniform conditions of sedimentation there would be little choice in location. Such uniform conditions seldom if ever obtain, however, except in comparatively restricted areas. The contour of the sea bottom, particularly in the shallow epicontinental seas, must have varied somewhat, making certain areas more suitable for the crinoids than others. Far more important, however, are the effects of currents, the presence of which in the Paleozoic seas may be assumed with a considerable degree of assurance. These currents would largely affect the food supply, and the Crinoidea if able to orient themselves in relation to such currents, might obtain optimum food conditions.

It is quite conceivable that the ciliated larvæ may not have settled at a locality entirely favorable to an adult crinoid. Indeed, the spot most suitable for the needs of the very young crinoid might well be far from desirable for the adult. Again, it is quite possible that during even the short life of a crinoid, conditions might so change as to make an originally favorable area less congenial. Moreover, in order to bring about a wider distribution of the Crinoidea, post-larval locomotion would be a factor of very great value. The importance of a wide distribution in contributing to the welfare of a group is at once apparent.

Bearing of detachment on distribution.—The distribution of the Crinoidea is necessarily effected by movement of the animals themselves. The change of location takes place either in the larval or the post-pentacrinoid stages of development. It has been considered hitherto that larval dispersal is the chief factor in controlling distribution. As indicated above we have a great deal of evidence going to prove that an eleutherozoic habit is largely maintained by the adult crinoids. It is here held that this post-larval freedom is of considerable importance in supplementing the activity of the mero-planktonic larvæ. The facts of crinoid distribution, and particularly of their segregation, argues strongly for considerable post-larval shifting among the Crinoidea. These topics, as elsewhere noted, will be discussed at length in a future paper.

Bearing of detachment on struggle for existence.—A prime reason for the maintenance and further perfection of eleutherozoic conditions not only among the Pelmatozoa, but among the Echinoderma in general, is in order to escape the intense struggle for existence that obtains in the crowded colonies of the bottom. The ciliated larvæ are probably of far less importance as effecting distribution among

the Echinoderms than is generally assumed, as is evidenced by the great numbers of pentacrinoïd larvæ that are to be found in immediate proximity to the adults. Indeed, it has frequently been observed that these larvæ are attached to the arms and cirri of the mature crinoids.

Those types that have assumed a pelagic habit, such as *Uintacrinus* and *Marsupites* express the highest degree of specialization known among the Pelmatozoa, in search of easy conditions of existence. Among all the Echinoderma they may be noted as having most nearly reached optimum conditions of life, so far as the struggle for existence is concerned. As has been pointed out by Brooks (1899), pelagic life is the easiest of all types of existence. The life of such epi-plankton as *Pentacrinus* is far less favorable in that many individuals may cling to one bit of floating wood and thus materially cut one another's food supply.

Causes for reattachment of Pelmatozoa.—Despite the advantages of a detached mode of life we have considerable evidence showing that re-fixation frequently becomes effective subsequent to a period of freedom. Indeed, it seems highly probable that seldom if ever has a crinoid passed its entire life rooted to one spot. The reasons for the nonmaintenance of an eleutherozoic habit by many crinoids where disruption of the column has been caused by physical agency, is probably due in large part to the fact that in these organisms the tendency toward fixation is still a potent force. It must be remembered that even in the detached forms no great activity is maintained by the Crinoidea. Carpenter states that among the Comatulæ, for instance, the crinoids do not swim about actively except at the periods of reproduction. Again, it may well be that only those forms maintain an eleutherozoic type of existence which from their structure are capable of effecting a fair degree of movement. This may either be brought about through the acquisition of some buoyant structures or suitable modification of the arms to enable them to function as swimming or ambulatory appendages. In most cases it would seem that the nature of the arms is the determining factor as regards the maintenance of such an existence. Were crinoids to become detached that are but poorly equipped to live as eleutherozoic types, what is more natural than that they should again become affixed?

Evidences of the assumption of a detached existence.—Naturally, the most obvious indication of the maintenance of an eleutherozoic existence by a crinoid, is the lack of a column or pedicle. As has been shown above, however, a number of stalked forms were quite as free in their habits as some of the non-stalked. In such cases one generally finds a tapering stem, usually looped at the end and unprovided with roots or a terminal plate for attachment. A column provided

with cirri throughout the greater part of its length, especially if these be equipped with terminal claws, such as is shown on Plate 4, figure 2, is an equally good indication that the animal is free-swimming for a greater or less part of its existence. Among the prostrate Cystidea and Blastoidea, which crawled along the bottom, an eleutherozoic form of existence is clearly indicated by the marked modifications to be observed in the structure of the theca. These modifications have been discussed at length under such genera as *Eleutheroocrinus*, *Pleurocystis*, and *Anomalocystis*.

Aside from such obvious signs of the maintenance of an eleutherozoic habit there are many more, the significance of which may only be appreciated when considered in the light of structures brought about through such a type of life. Inasmuch as semi-detached conditions so largely obtain among the Pelmatozoa, it is evident that throughout the Grade we have to deal with these modifications. It is only when organs become highly specialized and obviously adapted to eleutherozoic conditions that we feel safe in assigning such an origin to them, however.

The sporadic deviations and the earlier variations from the stazoic stock have characters more or less peculiar to themselves. It should be remembered that these types possessed no long ancestral lines that as Pelmatozoa had assumed a detached existence. As a result, there had come to be no special modifications fitting the forms for such an existence. These earlier types, therefore, are characterized by the absence of special organs such as cirri. Instead, it seems that they as a rule had not yet lost the semi-prehensile columns of their ancestors, and could upon occasion attach themselves by coiling the distal portion of their tapering columns about some stationary object.

Gradually, as an eleutherozoic existence was more universally assumed, and was perpetuated generation after generation, modifications of structure became manifest. Movement probably never was rapid or continuous for any prolonged period of time. As a result, in most forms we may look for but slight modification in the theca of the crinoid. Where modifications became most effective were in the arms and column.

Effect of a detached mode of life on the column.—The modifications which one would expect to find in the case of the column are of a twofold nature. In the first place the length of the column would be affected, and in the second structures capable of balancing and temporarily holding the animals would be perfected. As is well known, crinoid columns are prevailingly short—at times surprisingly so. To attribute this shortness of column to an eleutherozoic habit would be presumptuous, for it is obviously incapable of demonstration. That such a type of life may have been of considerable importance in

bringing about conditions as we know them, or in *preventing* any considerable *increase* in the length of the columns, seems a reasonable supposition, however.

Bather (1900) believes that the assumption of a detached existence by the Pelmatozoa results in a marked abbreviation of the column, drawing this inference from the facts as we know them in the case of *Millericrinus prattii*. It is not evident that this case may be assumed to be typical. An eleutherozoic habit in the majority of cases probably did not result in a marked shortening of the column. Indeed, the longest columns reported are those of the fossil *Pentacrinus* which occurred in types which probably were not attached. The columns of crinoids have at no time been of great length, and it may well be that the widespread maintenance of an eleutherozoic habit as here assumed may have had much to do with keeping the columns within moderate bounds. It is probable only in special cases where other factors enter into the question that we have an appreciable abbreviation of the stems.

A fairly long column would be of considerable advantage to a crinoid whether free or attached. Of course in the case of complete separation of the crown from the column these advantages are more than compensated for by the additional degree of freedom. In the case of stalked forms however, a moderately long stem would serve as ballast either with or without a terminal weight and give the crinoid a certain degree of stability while at rest. The advantage of this is at once apparent. It is apparently necessary for crinoids at times to be stationary. The instances of comatulids dying in a bowl of water wherein there were no pebbles or other objects to which they might attach themselves is well known. Other specimens similarly placed but with objects to which they might attach placed in the bottom of the bowl live for some time. Again, moderately long columns would be of advantage as keeping the crinoids well above the sea bottom. The advantages of this are obvious both to the animals themselves and to the young of the colony. The impossibility of the young finding a foothold in a colony of well grown Comatulæ has well been stated by Clark (1909, *a*).

The formation of prehensile cirri may directly be attributed to the maintenance of an eleutherozoic existence, however. Wherever found, there we may postulate free-living crinoids. It is evident that in the case of purely stazoic forms nothing could be more useless than appendages designed for holding to extraneous objects. In earlier times the cirri were comparatively simple, but so specialized have they since become that isolated cirri of certain *Pentacrinidæ* and comatulids can be distinguished with difficulty. Even the terminal claw has been developed in the stalked forms (Pl. 4, fig. 2). The function of these cirri has been primarily no doubt that of

temporarily anchoring the crinoid. It was suggested by de Loriol (1878, p. 12) that the cirri were used as organs of locomotion, a supposition that may in part be right, as is elsewhere indicated. The development of these cirri even in Paleozoic times is most noteworthy. For example, in *Cordylocrinus*, and particularly in a new Camerate genus from the Hamilton a most extraordinary development of cirri is to be noted. In some cases these cirri reach from well down on the column to considerably above the tips of the arms, the total length being two to three times the total height of the crown. In both of these genera, and particularly in *Cordylocrinus*, the crown is frequently so completely covered by cirri as scarcely to be visible. As has been noted under *Cordylocrinus*, the columns are remarkably short, measuring but a few inches in length, and show no signs of permanent fixation.

In connection with the formation of cirri as induced by an eleutherozoic habit should be recalled the grapnel of *Ancyrocrinus*, the float of *Scyphocrinus*, and the distal knobs of certain Devonian Camerata. The float of *Scyphocrinus* is unique and is a type of modification scarcely to be looked for. The distal excrecences, and the grapnel of *Ancyrocrinus* are obviously for the purpose of balancing the crinoids, as no doubt is the fused distal portion of the *Lepadocrinus* column.

It is a noteworthy fact that among the Crinoidea, especially in the later forms, the stem is frequently lost, or but a remnant of it remains. Among the Cystidea this is never the case. The reason for this is obvious. In the latter group the column has not become so highly differentiated an organ as among the Crinoidea and Blastoidea. It still contained a portion of the visceral mass, in all probability, and could not readily be shed. Again, the stem had not become so highly specialized for purposes of attachment that it could not be modified so as to be made a useful adjunct in the propulsion of the animal.

Effect of a detached mode of life on the arms.—The tendency toward more perfect freedom—that is, toward directed movement—would of necessity find expression in a strengthening of the arms and their more perfect adaptation as swimming organs. Concomitant with such modification and induced by the mechanical influence of the arm-action may be noted a modification of the tegmen, both as to composition and orientation. These features are of indifferent value in many cases, no doubt, owing to the variable degree in which freedom was assumed, probably even within a closely circumscribed group. Under such circumstances the influence of a given type of life, held for short or variable periods, has to contend with cumulative tendencies induced by a diametrically opposed form of life held for the greater part of the lives of the common stock. Moreover,

there are opposed tendencies apparently inherent in the strain, such as the assumption of a heavily plated tegmen by the Camerata, the cause for which may be far to seek and which of necessity may never definitely be determined. The modifications of the arms proper which would be of value in an eleutherozoic existence are on the other hand not incompatible with their functions as organs of purely statazoic forms.

The brachial appendages of the Pelmatozoa subserve two vital functions—the gathering of food and the bearing of sperm or ova. Obviously, the greater the surface area exposed by the arms of a crinoid, the more perfectly will they fulfill their mission. In order adequately to extend this surface area, a musculature of sufficient strength and complexity to spread and close the rami is essential. The arm area is increased chiefly by bifurcation of the rami and by pinnules. Increase of arm area, unless carried to excess, as in certain *Actinometra*, is of positive value in locomotion, as offering a greater surface for catching the water. The modifications of the musculature to adapt it the more perfectly to function as a motor system would be simply an increase in the complexity of the system already possessed. So it may be assumed that while the modifications of the arms tend to be mutually strengthened, the tendencies in the modifications of the vault and theca in general may work at cross purposes in forms having variable statazoic and eleutherozoic ancestry.

Up to a certain limit, as before noted, an increase in the arm area of a crinoid would prove of advantage in perfecting these appendages as swimming organs. A similar result might be even more effectively brought about by the broadening of the rami themselves. Such broadening is to be noted in the genus *Eretmocrinus*, the remarkable paddle-shaped arms of which are so well known. A quite similar broadening of the rami is to be found in *Aorocrinus*, *Coelocrinus*, and *Dorycrinus*, although such structures have apparently not hitherto been noted in the case of these genera. This remarkable broadening of the rami may be explained on other grounds—as, for example, giving greater food-catching area. The same result could be more expeditiously and advantageously attained by a slight lengthening of the pinnulæ, or by bifurcation of the arms such as is common among closely related genera. The beautiful adaptation of these arms to swimming conditions is at once apparent, and it does not seem highly improbable that such was an important part of their functions. Again, we have the hooks on the pinnulæ of *Cactocrinus* (Pl. 5, figs. 4, 5) which hold the pinnulæ together much after the fashion in which the barbs of a feather are joined. So fastened together, the pinnulæ might well have offered a most effective surface for catching the water in swimming.

If we concede a general participation of the Crinoidea in an eleutherozoic existence, it will be well to bear the fact in mind, as affecting the type of arm-branching, the modification of articulations, and the general structure of the arms. We know, for instance, that in at least two species of *Mariacrinus* there is little or no ground for the supposition of an attached existence. May we not then legitimately wonder if the curious arm modifications of the Melocrinidæ, the atrophy of the outer and the hypertrophy and fusion of the inner rami, is not perhaps due to the assumption of an eleutherozoic existence by the stock? We may not expect identical or even similar modifications of arm-structure in different lines, for that is not the way of crinoids. We may expect, and we do find, if we look for them, modifications peculiar to the several lines, but all tending to the solution of the same problem. So it is with other crinoid structures.

Effect of an eleutherozoic existence on the symmetry of the Pelmatozoa.—The assumption of a completely detached form of life by certain Pelmatozoa gives one an excellent chance to study the effect of free movement upon a type whose radial symmetry has been impressed upon it by countless generations of stazoic ancestors. We have been assured by A. H. Clark (1909, p. 685) that radial symmetry does not depend upon a sessile ancestry. The octopus cited as an example to prove this assertion scarcely tends to confirm Clark's statement, however. The amount of modification resultant upon the change from a fixed to a free existence depends entirely upon the type of locomotion adopted. In the case of a crinoid, with its five equal rays, the changes in symmetry are not of great magnitude and probably were brought about but slowly. The exocyclic disks of *Vintacrinus* and *Actinometra* are perhaps directly to be attributed to a free-swimming life. As opposed to the for the most part freely swimming Crinoidea, we have to consider the crawling *Eleutheroacrinus* and *Zygocrinus*. Here the changes, as pointed out in the discussion of the genera, are far reaching in their effect upon the structure of the animal. The amount of modification seems to vary directly as the amount of friction applied to the body of the animal while in motion. The body propelled by its appendages through a uniform medium, suffers little change, but given a drag on the body, as exacted by movement along the bottom, and we have results expressed in no uncertain terms. Naturally, to be effective, movement must take place in a given direction, as far as the orientation of the animal is concerned.

Effect of a detached mode of life on the distribution of the Pelmatozoa.—The almost universal assumption of freedom by the Pelmatozoa can not have other than a most marked effect upon the distribution of the

organisms. Even more important is the bearing such eleutherozoic conditions have on the minor movements of the animals, as evidenced by their segregation. It seems highly probable that the characteristic colonial habit assumed by the Pelmatozoa is due in large part to the selective migration of the echinoderms in their post-larval stages of development. This is a highly important topic and one that will be discussed at length in a subsequent paper.

Types of life led by the eleutherozoic Pelmatozoa.—A comparative study of eleutherozoic Pelmatozoa as regards their mode of life consequent upon the assumption of this form of existence is one of considerable interest. For purposes of convenience we may recognize three groups of eleutherozoic Pelmatozoa—those forms that constantly remain upon the bottom; those that are capable of swimming, but either temporarily attach themselves to the bottom or crawl; and, finally, those forms that are truly pelagic.

All of the stalked Pelmatozoa, with the exception of *Scyphocrinus* and certain *Pentacrinus*, may be held as vagile benthos. Among these benthos an erect position is almost universally maintained. The only known exceptions are to be found among the Cystidea as evidenced by such types as *Pleurocystis* and *Anomalocystis*. Among those forms where the stem has been entirely eliminated or but a few ossicles remain, movement is effected either by swimming or by crawling upon the bottom in an inverted position. Among the swimming types are to be found the most highly specialized eleutherozoic Crinoidea, such as *Uintacrinus*. These may be held as true plankton in their adult stages, inasmuch as they constantly maintain a pelagic existence by virtue of their own swimming movements.

It may safely be assumed that the stalked eleutherozoic Crinoidea spent but a small part of their time in motion. Having reached a favorable spot the natural tendency would be to remain there. It may be argued that under these conditions permanent fixation would become a necessity. This does not follow, however. In the case of cirriferous individuals temporary fixation is no doubt assumed by the clasping of some projection on the sea bottom with the cirri. Those forms with prehensile columns could loop the distal portion of the column about some stationary object. *Ancyrocrinus*, with its grapnel, might anchor almost anywhere. That even such types of fixation were unnecessary seems to be indicated by those columns above mentioned in which the distal extremity is simply rounded off into a knob, and no cirri are present. Such a knob might, indeed, be held as a sort of balancing organ, but when we consider the comparatively small size of the knob, and its lightness, compared with the size and weight of the column, this argument loses its force. It seems probable that the weight of the column alone was sufficient ballast for the crinoid, and that in the comparatively untroubled waters at the sea

bottom a position once assumed would be maintained unless altered by definite swimming movements of the crinoid. Slight adjustments of position might at any time be secured by motion of the arms, or of the cirri, where such were present.

It has been suggested by Carpenter that the comatulids seldom move about to any extent except during the breeding season. Clark (1909 *a*) confines the free-swimming period of multibrachiate comatulids to those stages in which a ten-armed condition obtains. During this stage the young, when observed, are continually swimming about. When the multibrachiate stage is assumed they are incapable of swimming movement. Whether or not this be the case it is hard to tell, but it seems likely that, in these forms at least, the adults are incapable of any considerable activity. This prohibition is obviously dependent upon the structure of the arms. This is of such a nature as to render any considerable motion impossible. It is conceivable, however, that the crinoids may crawl by employing the distal portions of their arms. In the case of adult detached crinoids as a whole there seems no physical disability in most cases rendering the crinoids incapable of using their arms as swimming organs. It seems probable, however, by the time an adult stage is reached that the crinoids will have found a favorable environment and under normal conditions would be content to remain there. Detachment from the bottom then need by no means indicate active swimming movements on the part of the animals involved. Indeed, among the stalked detached forms one may hold that the type of life led is essentially statozoic. As a rule advantage is taken of their freedom probably only during periods of sexual activity.

Eleutherozoic conditions as indicative of progression or degeneracy among the Pelmatozoa.—It should be borne in mind that the tendency toward an eleutherozoic existence among the crinoids is not a reversion, in the sense of indicating a loss of vigor in the stock, and degeneration. The freedom of the crinoid is rather an expression of a higher degree of specialization along perfectly natural lines. The discarding of the stem after a long period of attachment, as I see it, is a sign of strength rather than weakness, as indicating a tendency on the part of the organisms toward the elimination of semiuseless structures for the attainment of a type of life more beneficent to the crinoids. The fact that highly specialized eleutherozoic conditions do not more largely obtain among the Crinoidea is due in no small part to the fact, as has elsewhere been pointed out, that the animals in the main are not fitted for the efficient maintenance of this type of existence.

Among the Cystidea, on the other hand, the majority of the free forms may be considered degenerate. Indeed, lack of fixation among these types may be held as evidence of failure on their part to acquire the statozoic habit toward which they were aiming. Such a case is

that of *Pleurocystis*. Originally descended from a free form, a statozoic existence was acquired, which was maintained long enough to impress a degree of radial symmetry upon the theca, and for the acquisition of a jointed column. In the decadence of the stock a prostrate existence was gradually assumed, and the animals crawled about, dragging an all but useless stem behind them. Such a failure as regards the majority of the Cystidea well illustrates the fate of any major tendency becoming effective in a large body of organisms. When a group of animals tends to assume a decided change in structure and habit of life, the tendency becomes effective in varying degrees among different genetic lines. One or two lines, perhaps, out of the whole group will carry the innovation through successfully. The other members equally affected by the tendency, but incapable of pushing it to a successful issue, form short-lived lines that as a rule show obvious indications of degeneracy.

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EXPLANATION OF PLATES.

PLATE 1.

Aristocystis bohemicus Barrande.

- Fig. 1. Specimen showing base of attachment and a side apparently smoothed and somewhat flattened by contact with some extraneous object. From Barrande, 1887. (Pl. 10, fig. 13.)
2. View of base, enlarged, showing attachment to a gastropod shell which is almost completely overgrown. From Barrande, 1887. (Pl. 10, fig. 16.)
 3. Opposite side of the same specimen showing normal convexity and surface structure. From Barrande, 1887. (Pl. 10, fig. 13.)
 4. Base of another individual showing no sign of attachment. From Barrande, 1887. (Pl. 10, fig. 20.)
 5. Lateral view of a specimen which was completely detached. The smoothing of the plates in the upper right-hand portion of the figure indicates contact with some object, and may point to the maintenance of a prostrate existence. From Barrande, 1887. (Pl. 10, fig. 21.)
 6. Basal view of the same specimen, showing rounded character of base and total absence of signs of attachment. From Barrande, 1887. (Pl. 10, fig. 22.)
 7. Lower portion of theca of an individual which apparently was attached. The smoothing of the plates on one side is quite evident. From Barrande, 1887. (Pl. 10, fig. 29.)
 8. The base of the same specimen, showing basal depression. It is to be noted that the area of attachment is somewhat excentric in position and that the smoothing of the plates may be attributed to contact with the object to which attachment was had. From Barrande, 1887. (Pl. 10, fig. 30.)
 9. View of a very large, incomplete individual. The area of attachment is very large but not sharply defined. It is probable that in this case detachment was had late in the life of the organism. From Barrande, 1887. (Pl. 10, fig. 23.)
 10. Basal view of the same, showing lateral position of the area of attachment. From Barrande, 1887. (Pl. 10, fig. 24.)

Echinosphæra aurantium (Gyllenahl).

11. Lateral view of theca, showing highly excentric location of the minute protuberance that served as the point of attachment. From Jaekel, 1899. (Pl. 8, fig. 5.)

PLATE 2.

Cheirocrinus penniger Eichwald.

- Fig. 1. View of antanal side with ramules restored. From Jaekel, 1899. (Pl. 11, fig. 1.)
2. View of anal side of the same specimen. The slight flattening of the theca and the great development of the anal area are especially to be noted. From Jaekel, 1899. (Pl. 11, fig. 2.)

Erinocystis volborthi Jaekel.

Fig. 3. Basal view of an individual, showing the marked flattening of one side and the carrying outward and backward of the anal opening. From Jaekel, 1899. (Pl. 13, fig. 6a.)

Pleurocystis filitextus Billings.

(See also Plate 3, fig. 3.)

4. Anal (lower) side, somewhat enlarged. Adapted from Jaekel, 1899. (Pl. 12, fig. 5.)

Arachnocystis infaustus (Barrande).

5. A specimen with the stem essentially complete. From Barrande, 1887. (Pl. 25, fig. 7.)
6. A portion of the column enlarged. From Barrande, 1887. (Pl. 25, fig. 8.)

Macrocybella marie Callaway.

7. Reconstruction of crown and stem by Bather. From Bather, 1900. (Text fig. 18, p. 56.)

Echinæncrinus angulosus (Pander).

8. Specimen showing flattening of the lower side of the theca, the posterior location of the anal opening, and the nature of the column. From Jaekel, 1899. (Pl. 13, fig. 18.)

Erinocystis angulata Jaekel.

9. Specimen showing the extreme outward and backward location of the anal opening. From Jaekel, 1899. (Pl. 13, fig. 16a.)

PLATE 3.

Placocystis forbesianus de Koninck.

- Fig. 1. Convex upper (dorsal) surface of theca with a portion of the column. After Bather, 1900. (Text fig. 13, 1, p. 51.)
2. Flattened lower (ventral) surface showing adoral appendages ("spines"). After Bather, 1900. (Text fig. 13, 2, p. 51.)

Pleurocystis filitextus Billings.

(See also Plate 2, fig. 4.)

3. Specimen preserving a portion of the brachioles and an essentially complete column. Original in the collection of the University of Chicago.

Trochocystis bohemicus Barrande.

4. The terminal adoral hinged plate, approximately $\times 2$. From Barrande, 1887. (Pl. 3, fig. 22.)
5. A complete column of this species, approximately $\times 2\frac{1}{2}$. From Barrande, 1887. (Pl. 3, fig. 17.)

Mitrocystis mitra Barrande.

6. Lower (ventral) surface of theca with appended column. From Bather, 1900. (Text fig. 12, 1, p. 50.) After Barrande.
7. Convex upper (dorsal) surface. From Bather, 1900. (Text fig. 12, 2, p. 50.) After Barrande.
8. Inner surface of adoral portion of upper thecal wall, showing longitudinal corrugations on the central terminal plate. From Bather, 1900. (Text fig. 12, 3, p. 50.) After Barrande.

Anomalocystis disparilis Hall.

- Fig. 9. Adoral (anterior) view of theca, showing terminal aperture and sockets for the articulation of the spines. Original in the United States National Museum, catalogue number 33661.
10. Lateral view of the same specimen.
11. Aboral view of the same individual showing deep, socket-like depression for the reception of the stem.

PLATE 4.

Isocrinus maclearanus Wyville Thomson.

- Fig. 1. A complete individual, showing the extreme brevity of the column, approximately $\times 1$. From Carpenter, 1884. (Pl. 16, fig. 1.)

Isocrinus decorus Wyville Thomson.

2. A very young specimen with a practically complete column, approximately $\times 2$. From Carpenter, 1884. (Pl. 35, fig. 1.)

Woodocrinus macrodactylus de Koninck.

3. A complete individual, showing the tapering column with no evidence of structure for permanent fixation, approximately $\times 1$. From Zittel, 1896. (Text fig. 265, p. 159.) After de Koninck.

PLATE 5.

Pentacrinus (Extracrinus) collenoti de Loriol.

- Fig. 1. A portion of the cirrus, enlarged. After de Loriol, 1884-1889. (Pl. 198, fig. 1b.)
2. The distal ossicles of a cirrus, showing the terminal claw. After de Loriol, 1884-1889. (Pl. 198, fig. 1h.)
3. Articular face of a cirrus ossicle. After de Loriol, 1884-1889. (Pl. 196, fig. 1d.)

Cactocrinus proboscidiialis (Hall).

4. Portion of three juxtaposed pinnules enlarged, showing close union effected by overlapping of the lateral processes on adjacent pinnules. After Wachsmuth and Springer, 1897. (Pl. 58, fig. 7c.)
5. A single pinnule ossicle greatly enlarged, showing the nature and relation of the lateral spinous process to the ossicle.

Lepadocrinus gebhardi (Conrad).

6. Portion of the column, showing discrete, articulated ossicles above, and the consolidated, terminal portion below. After Hall, 1859. (Pl. 7, fig. 5.)
7. Terminal fused portion of the column of another individual, showing a pustulose surface. After Hall, 1859. (Pl. 7, fig. 16.)

Brachiocrinus nodosarius Hall.

8. Distal portion of the column, showing its termination in a knob. Above may be noted the points of attachment for two of the lateral cirri. $\times 2$. After Hall, 1859. (Pl. 6, fig. 2a.)

Ancyrocrinus bulbosus Hall.

9. Distal portion of the column showing the grapple, the fused columnals, and above, some of the unaltered columnals. From Bather, 1900. (Text fig. 51, p. 134.) After Hall.

Actinometra paucicirra Bell.

Fig. 10, 11, 12. Specimens showing centro-dorsals from which all cirri have been lost. The variability in outline of the centro-dorsals is interesting, and shows how this character is governed by the contour of the surrounding and underlying plates. After Carpenter, 1888. (Pl. 54, figs. 3, 5, 7.)

Isocrinus wyville-thomsoni Jeffreys.

13. The terminal nodal of a detached individual showing how the columnal has been smoothed and rounded off by a secondary deposit of stereom; approximately $\times 4$. From Carpenter, 1884. (Pl. 22, fig. 27.)

PLATE 6.

Millericrinus prattii (Gray).

- Fig. 1. Individual showing practically resorbed stump of the column of which five columnals have been retained. After Carpenter, 1882. (Pl. 1, fig. 13.)
2. Specimen with a longer column, which shows signs of resorption in its distal portion. After Carpenter, 1882. (Pl. 1, fig. 10.)
3. Individual retaining but three columnals and showing no signs of resorption. After Carpenter, 1882. (Pl. 1, fig. 3.)
4. Basal view of another specimen the column of which is represented by the "proximale" and a single largely resorbed columnal. After Carpenter, 1882. (Pl. 1, fig. 2.)
5. View of the distal face of the "proximale," showing its insertion within the basal circlet. After Carpenter, 1882. (Pl. 1, fig. 22.)
6. The "proximale" and surrounding basals of an individual the column of which has otherwise entirely been lost. The resemblance of this "proximale" to a centrale is apparent. After Carpenter, 1882. (Pl. 1, fig. 6.)

Apiocrinus roissyanus d'Orbigny.

7. Specimen showing supernumerary plates comparable to those found in *Millericrinus prattii* as figured on this plate. After de Loriol, 1882-1884. (Pl. 43, fig. 3a.)

Apiocrinus elegans DeFrance.

8. Specimen showing "intercalated" plates in the theca similar to those noted in *A. roissyanus*, fig. 7. After de Loriol, 1882-1884. (Pl. 34, fig. 4.)

Actinometra nobilis Carpenter.

- 9, 10, 11. Basal views of different specimens showing loss of cirri by the centro-dorsals, and the partial resorption of these organs. After Carpenter, 1888. (Pl. 65, figs. 3, 4, 5.)

PLATE 7.

Millericrinus charpyi de Loriol.

- Fig. 1. A specimen showing the highly differentiated nature of the proximal columnal, to which three of the basals are still attached; approximately $\times 1\frac{1}{2}$. After de Loriol, 1882-1884. (Pl. 100, fig. 1c.)

Millericrinus beaumonti d'Orbigny.

2. View of an individual showing the cup and proximal columnal. To the right and below is a view of the inferior face of the proximal columnal showing the petaloid type of articulation. After de Loriol, 1882-1884. (Pl. 90, figs. 3, 3a.)

Thiollicricinus heberti de Loriol.

Fig. 3. Lateral view of theca, showing great development of the proximal columnal and relative insignificance of the cup; approximately $\times 1\frac{1}{2}$. After de Loriol, 1884-1889. (Pl. 228, fig. 2a.)

Thiollicricinus flexuosus Goldfuss.

4. View of theca and proximal columnal. In both this and the preceding figure it is to be noted that in the cup nothing but the radials appear externally. The appearance of irregularly placed cirri borne by the proximal columnal is likewise of interest; approximately $\times 1\frac{1}{2}$. After de Loriol, 1884-1889. (Pl. 229, fig. 2b.)
5. Cup from below showing character of proximal columnal, and its type of articulation; $\times 2$. After Bather, 1900. (Text fig. 117, 1, p. 195.)

Antedon phalangium (Müller).

6. Very early pentacrinoid stage, $\times 20$. After Carpenter, 1888. (Pl. 14, fig. 1.)

Antedon tuberosa Carpenter.

7. Later pentacrinoid stage than that shown in figure 6; $\times 12$. After Carpenter, 1888. (Pl. 14, fig. 9.)

Antedon multispina Carpenter.

- 8, 9, 10. Successive stages in the development of the centro-dorsal as shown by this species; all $\times 12$. After Carpenter, 1888. (Pl. 14, figs. 5, 6, 7.)

Antedon sarsii Duben and Koren.

- 11, 12. Lateral view of some of the larval columnals of this species, and a view of the articular surface of one of the columnals; much enlarged. After Bather, 1900. (Text fig. 49, 8, 9, p. 132.) After Sars.

PLATE 8.

Antedon laticirra Carpenter.

Fig. 1, 2. Two views of the centro-dorsal of this species showing the irregular arrangement and relatively enormous size of the cirrus sockets; $\times 6$. After Carpenter, 1880a. (Pl. 23, figs. 6b, 6c.)

Antedon (Solanocrinus) scrobiculata Goldfuss.

3. Side view of a specimen showing highly elongate centro-dorsal. After Carpenter, 1880b. (Pl. 10, fig. 14.) From Goldfuss.
4. Inferior aspect of dorsal cup showing petaloid type of articulation. After de Loriol, 1884-1889. (Pl. 214, fig. 3c.)

Pentacrinus (Extracrinus) dargniesi Terquem and Jourdy.

5. Basal view of a specimen from which the stem has been lost. For comparison with figures 4 and 7; approximately $\times 3$. After de Loriol, 1884-1889. (Pl. 210, fig. 1a.)

Antedon incerta Carpenter.

6. A cirrus of this species to show the high degree of specialization acquired by these organs. Note the terminal claw and the spinous processes borne by the ossicles to perfect the appendages as grasping organs.

Antedon depressa d'Orbigny.

- Fig. 7. Basal view of specimen from which the centro-dorsal has been removed; approximately $\times 2$. After de Loriol, 1884-1889. (Pl. 221, fig. 1a.)
 8. Lateral view of cup to which the centro-dorsal is attached; $\times 3$. After De Loriol, 1884-1889. (Pl. 221, fig. 2b.)

PLATE 9.

Uintacrinus socialis Grinnell.

- Fig. 1. Normal base of "Form D" with unusually large centrale. After Springer, 1901. (Pl. 2, fig. 10.)
 2. Normal base of "Form D" with smaller centrale. After Springer, 1901. (Pl. 2, fig. 12.)
 3. Base of "Form D" in which the centrale meets the basals as well as the infrabasals, and is decagonal in outline. The infrabasals are comparatively minute, but of equal size. After Springer, 1901. (Pl. 2, fig. 9.)
 4. Base of "Form D" in which the centrale meets three of the basals. Two of the infrabasals are much smaller than the other three. After Springer, 1901. (Pl. 2, fig. 18.)
 5. A variant of the foregoing in which the centrale has fused with one of the small infrabasals. After Springer, 1901. (Pl. 2, fig. 7.)
 6. A base in which fusion has been carried still further. The centrale has here fused with two of the infrabasals. After Springer, 1901. (Pl. 2, fig. 6.)
 7. A base in which in addition to the centrale becoming fused with two of the infrabasals, fusion has taken place between two of the other infrabasals. After Springer, 1901. (Pl. 2, fig. 5.)
 8. Base in which fusion has taken place probably between the centrale and two of the infrabasals on the one hand, and between the three remaining infrabasals on the other. After Springer, 1901. (Pl. 2, fig. 4.)
 9. A base of "Form M" in which fusion has been effected between two of the basals. After Springer, 1901. (Pl. 2, fig. 14.)
 10. Base of "Form M" showing centrale of nearly minimum size. After Springer, 1901. (Pl. 2, fig. 2.)
 11. Base of "Form M" showing centrale of maximum size. After Springer, 1901. (Pl. 2, fig. 1.)

Megistocrinus rugosus Lyon and Casseday.

12. View of fused basals, surrounded by the radials and proximal anal. It is to be noted that the fused basals form a regular pentagon with straight faces. After Wachsmuth and Springer, 1897. (Pl. 48, fig. 6a.)

PLATE 10.

Saccocoma tenella Goldfuss.

- Fig. 1. Specimen showing cup and structure of arms. R=radial; c=centrale; $\times 7$. From Bather, 1900. (Text fig. 68, 1, p. 155.) After Jaekel.

Saccocoma pectinata Goldfuss.

2. Complete individual to show coiling of the distal portions of the arms; $\times \frac{1}{2}$. From Bather, 1900. (Text fig. 68, 2, p. 155.)
 3. Lateral view of cup and proximal arm ossicles; $\times 2\frac{1}{2}$. R=radial. From Bather, 1900. (Text fig. 68, 3, p. 155.) After Zittel.

Marsupites testudinarius Schlotheim.

Fig. 4. Lateral view of cup. B=basal; c=centrale; IB=infrabasal; R=radial. From Bather, 1900. (Text fig. 104, 1, p. 185).

Agassizocrinus dactyliformis Troost.

5. Complete individual showing cup and arms. The infrabasals are here shown as not completely consolidated. From Meek and Worthen, 1873. (Pl. 21, fig. 7a.) After Roemer.

Eleutheroocrinus casedayi Shumard and Yandell.

6, 7, 8. Upper, lower, and adoral views of a fairly perfect specimen; $\times 2$. From Whiteaves, 1889. (Pl. 14, figs. 5, 5a, 5b.)

PLATE 11.

Edriocrinus dispansus, new species.

Fig. 1. Lateral view.

2. View from above. Original in the collection of the United States National Museum, catalogue number, 27757.

Eudesicrinus mayalis (Deslongchamps) de Loriol.

3, 4, 5. Three greatly enlarged views of this species. The degree of magnification is shown by the small figure to the right and above fig. 3. After de Loriol, 1882-84. (Pl. 29, figs. 1, 1a, 1b, 1c.)

Cotylecrinus docens Deslongchamps.

6, 7, 8. Three views of this species, from below, the side, and above. Attachment is had in this case by growth of the base over a crinoid stem. After de Loriol, 1882-1884. (Pl. 20, figs. 1, 1a, 1b.)

Edriocrinus pyriformis Hall.

9. Side view, showing cup and elongate peduncle. After Hall, 1862. (Text fig. 1, p. 115.)

Holopus rangii d'Orbigny.

10. Complete individual, slightly enlarged. After Carpenter, 1884. (Pl. 2.)

Lichenoides priscus Barrande.

11. Basal view of a specimen showing entire absence of column attachment. After Barrande, 1887. (Pl. 1, fig. 21.)

Protocrinus oviformis Volborth.

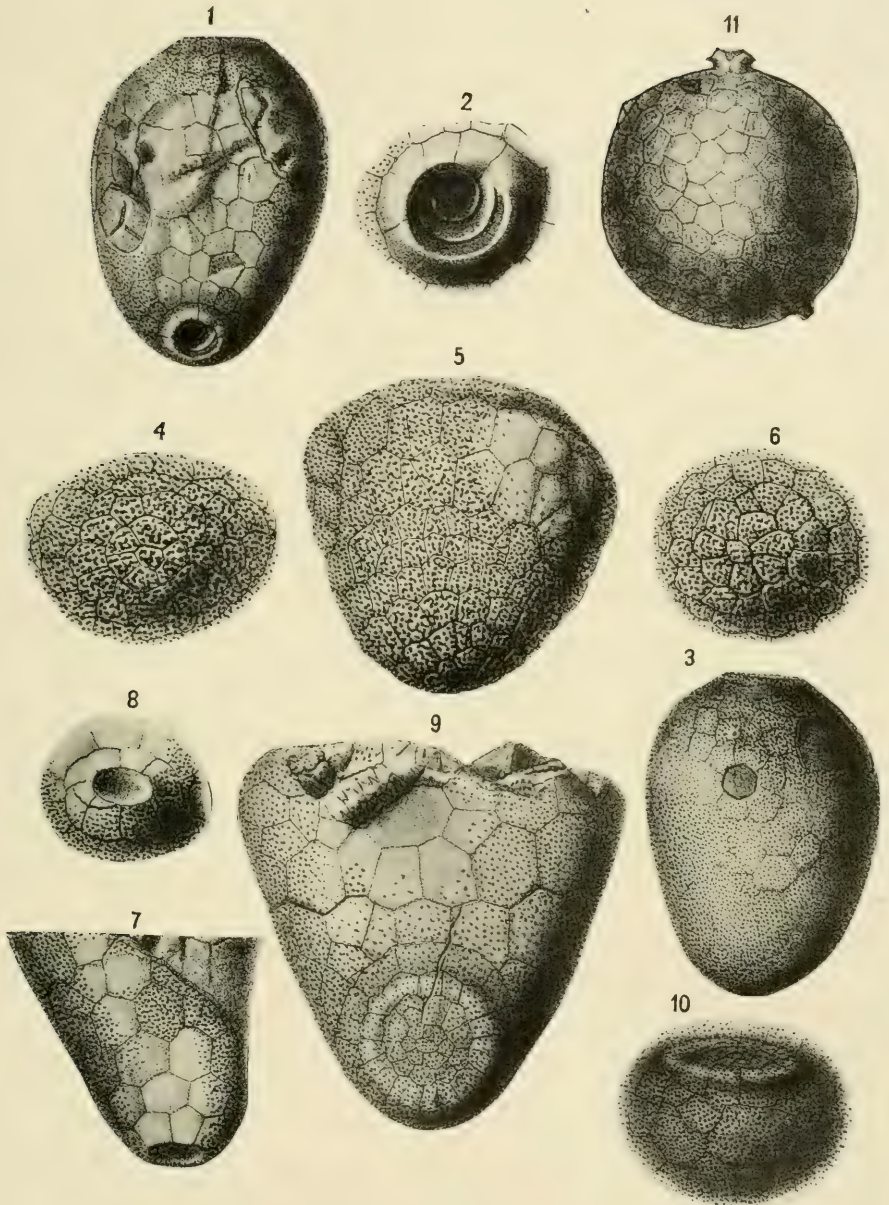
12. Basal view of specimen showing point for attachment of the stem. It is to be noted that the proximal circlet consists of four plates. After Bather, 1900. (Text fig. 45, 2, p. 75.) After Volborth.

13. Basal view of another specimen which shows no signs of stem attachment; the basal circlet consists of but three plates, as a result of the fusion of two of the four plates shown in figure 12. After Bather, 1900. (Text fig. 45, 3, p. 75.) After Volborth.

Edriocrinus sacculus Hall.

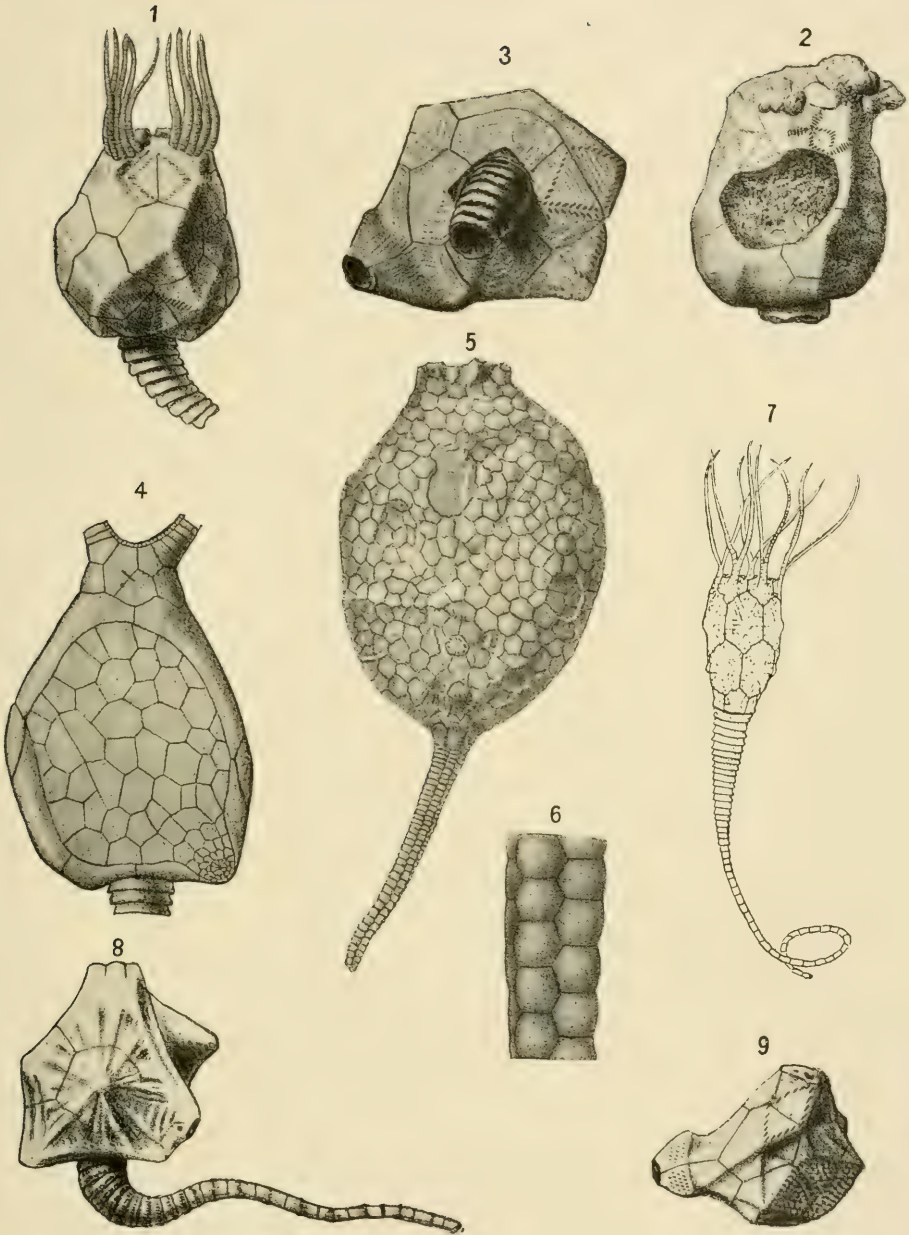
14. A group of young attached individuals. Original in the collection of the United States National Museum, catalogue number, 57504.

15. Adult, free individual, crawling over the surface of a gastropod shell. Original in the collection of the United States National Museum, catalogue number, 57504.



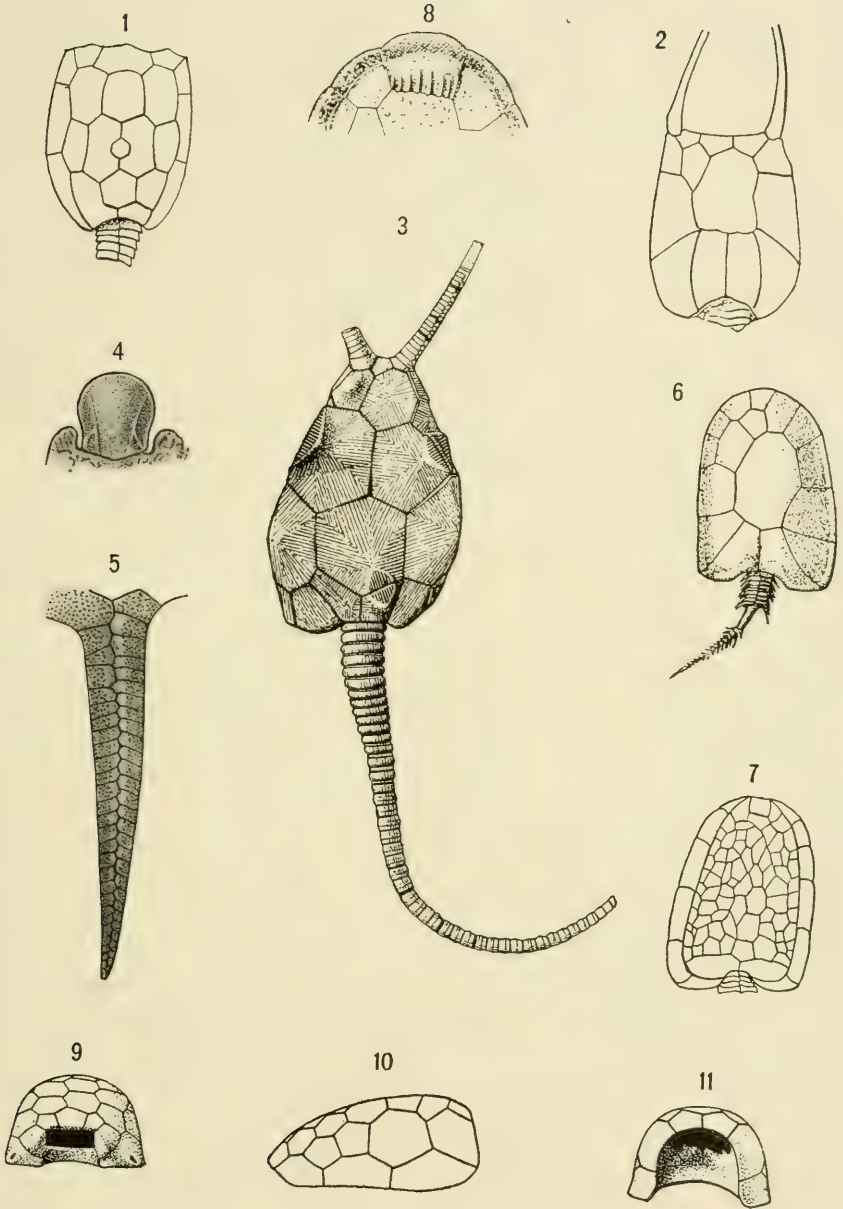
CYSTIDEA OF GROUP I.

FOR EXPLANATION OF PLATE SEE PAGE 131.



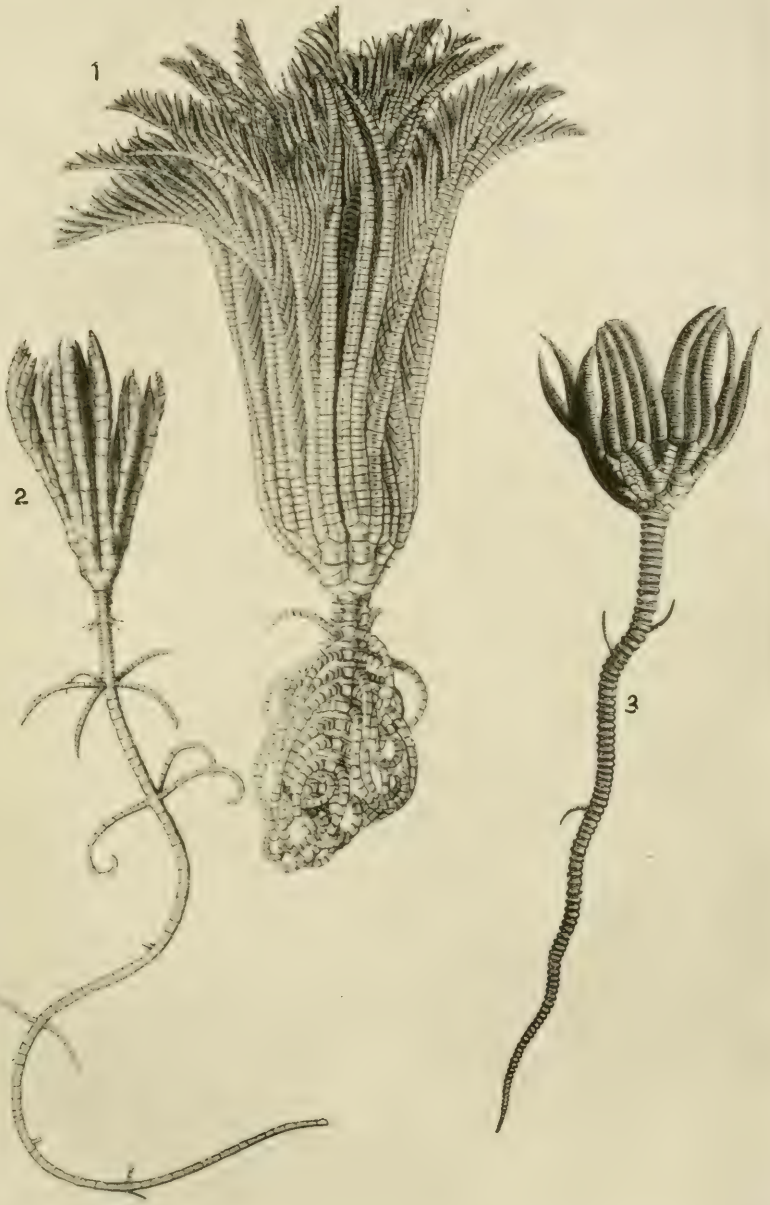
CYSTIDEA OF GROUP I.

FOR EXPLANATION OF PLATE SEE PAGES 131 AND 132.



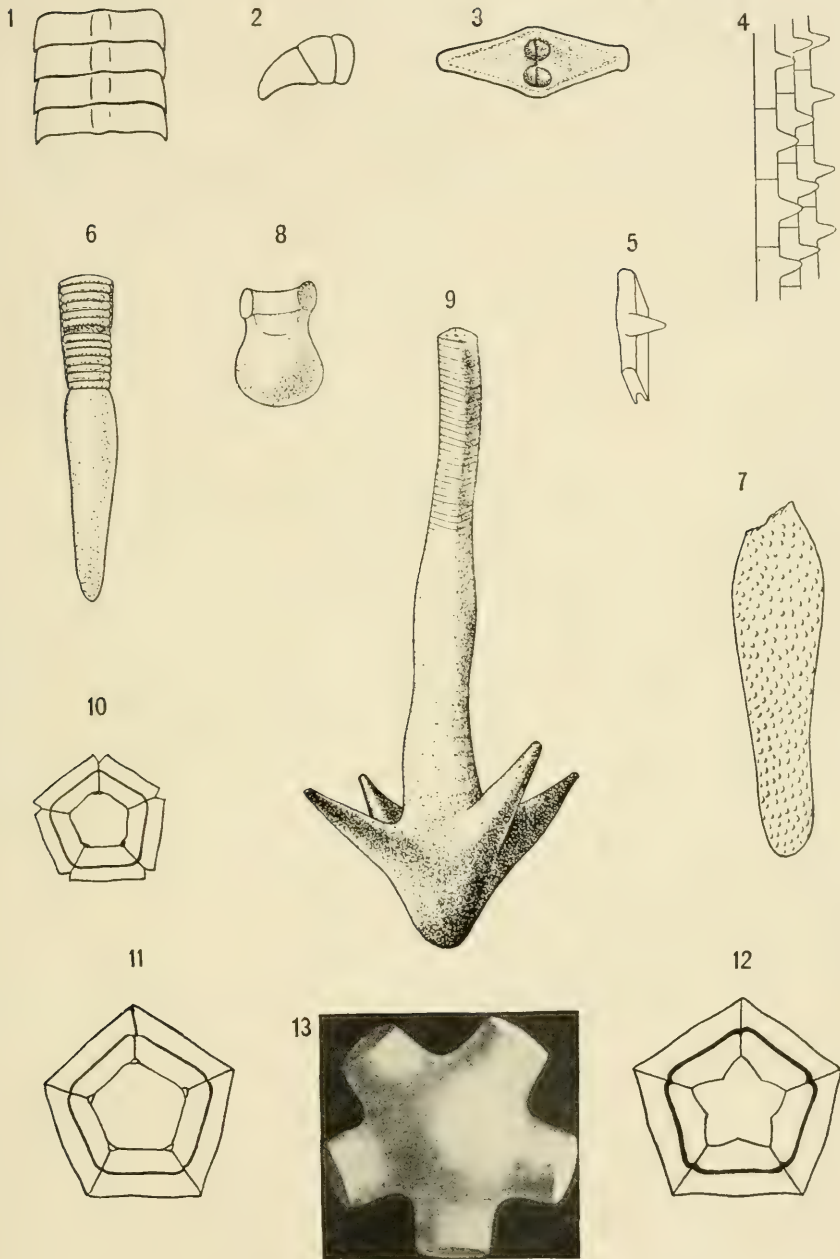
CYSTIDEA OF GROUP I.

FOR EXPLANATION OF PLATE SEE PAGES 132 AND 133.



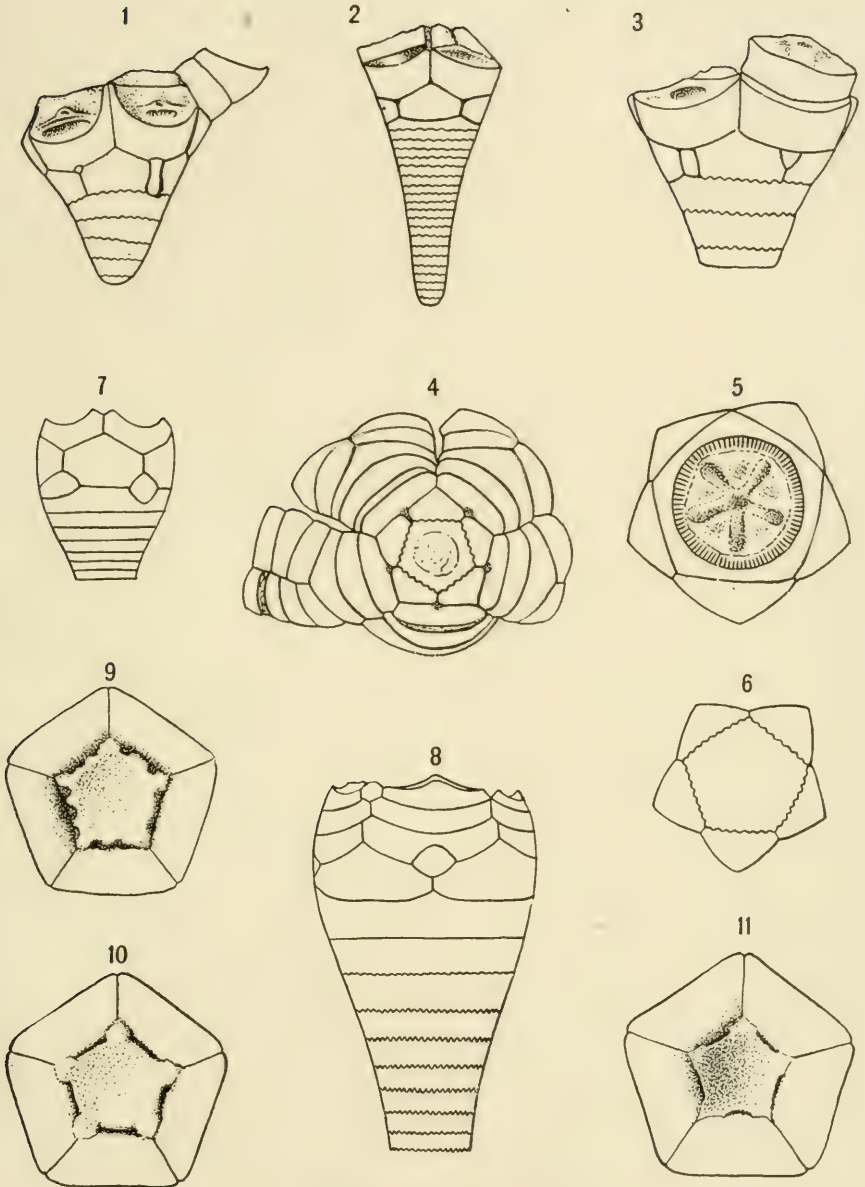
CRINOIDEA OF GROUP I.

FOR EXPLANATION OF PLATE SEE PAGE 133.



CRINOIDEA OF GROUPS I AND II.

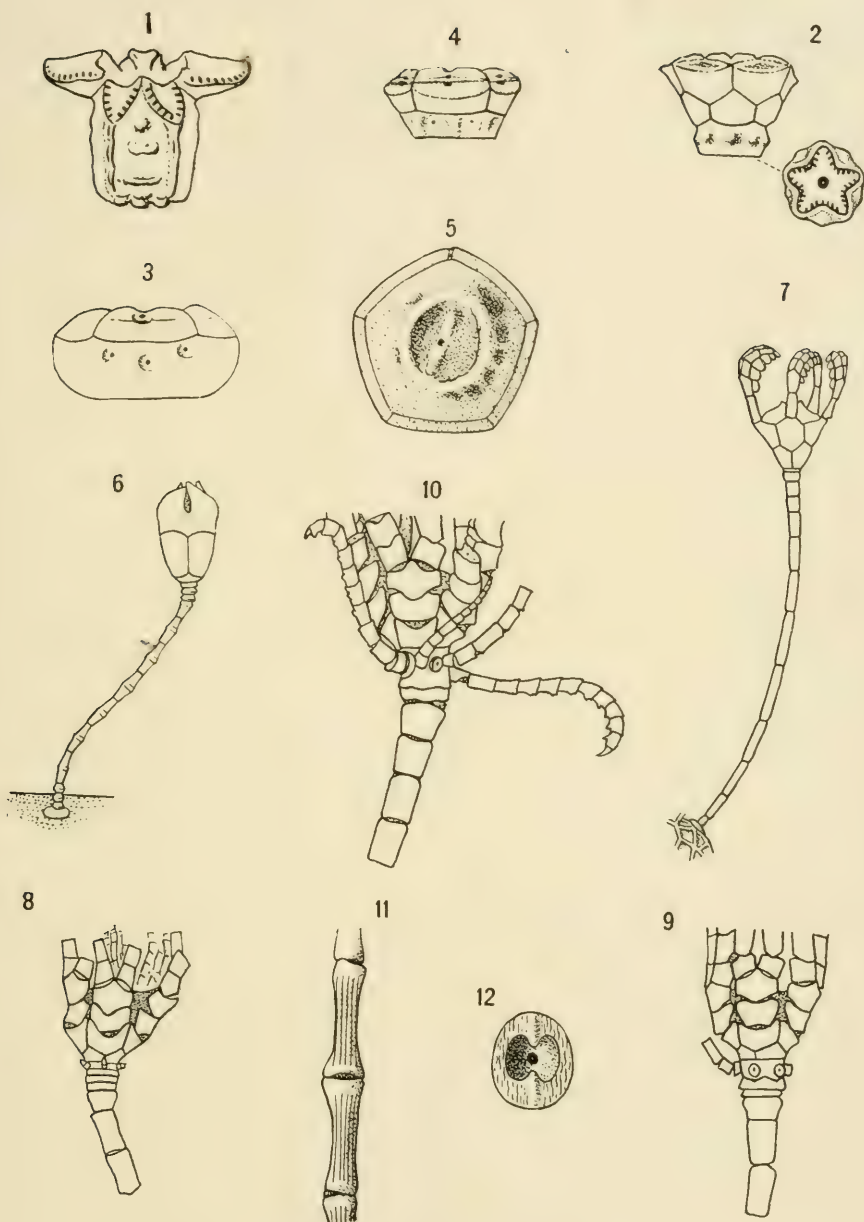
FOR EXPLANATION OF PLATE SEE PAGES 133 AND 134.



CRINOIDEA OF GROUPS I AND II.

FOR EXPLANATION OF PLATE SEE PAGE 134.

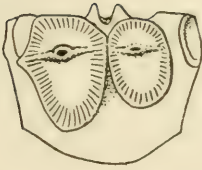




CRINOIDEA OF GROUPS I AND II.

FOR EXPLANATION OF PLATE SEE PAGES 134 AND 135.

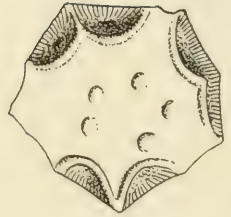
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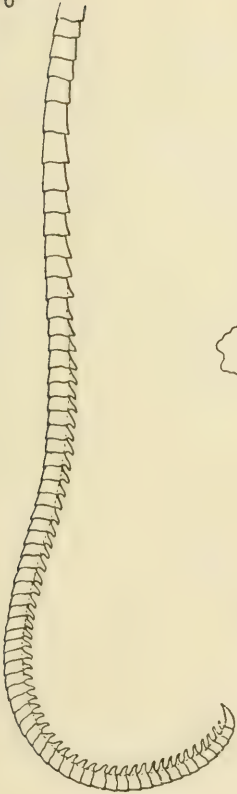
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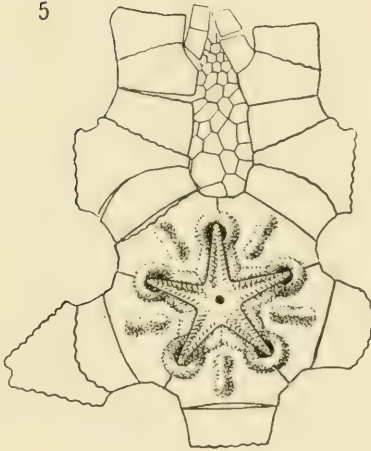
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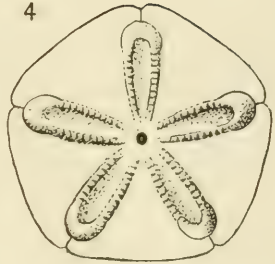
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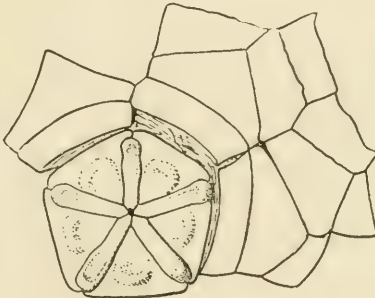
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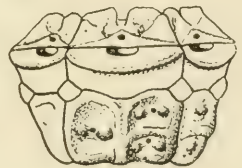
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7

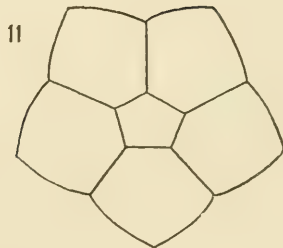
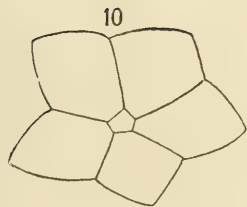
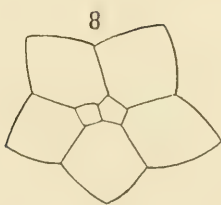
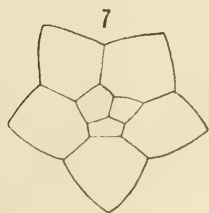
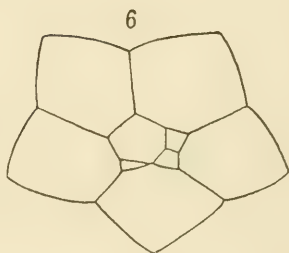
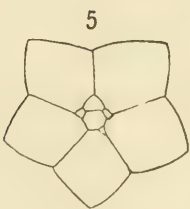
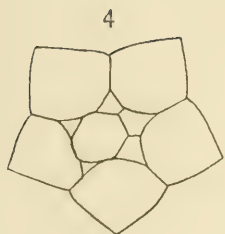
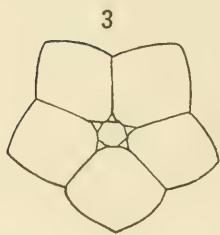
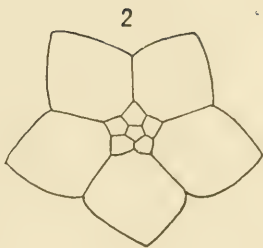
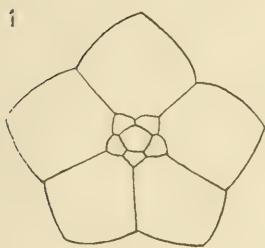


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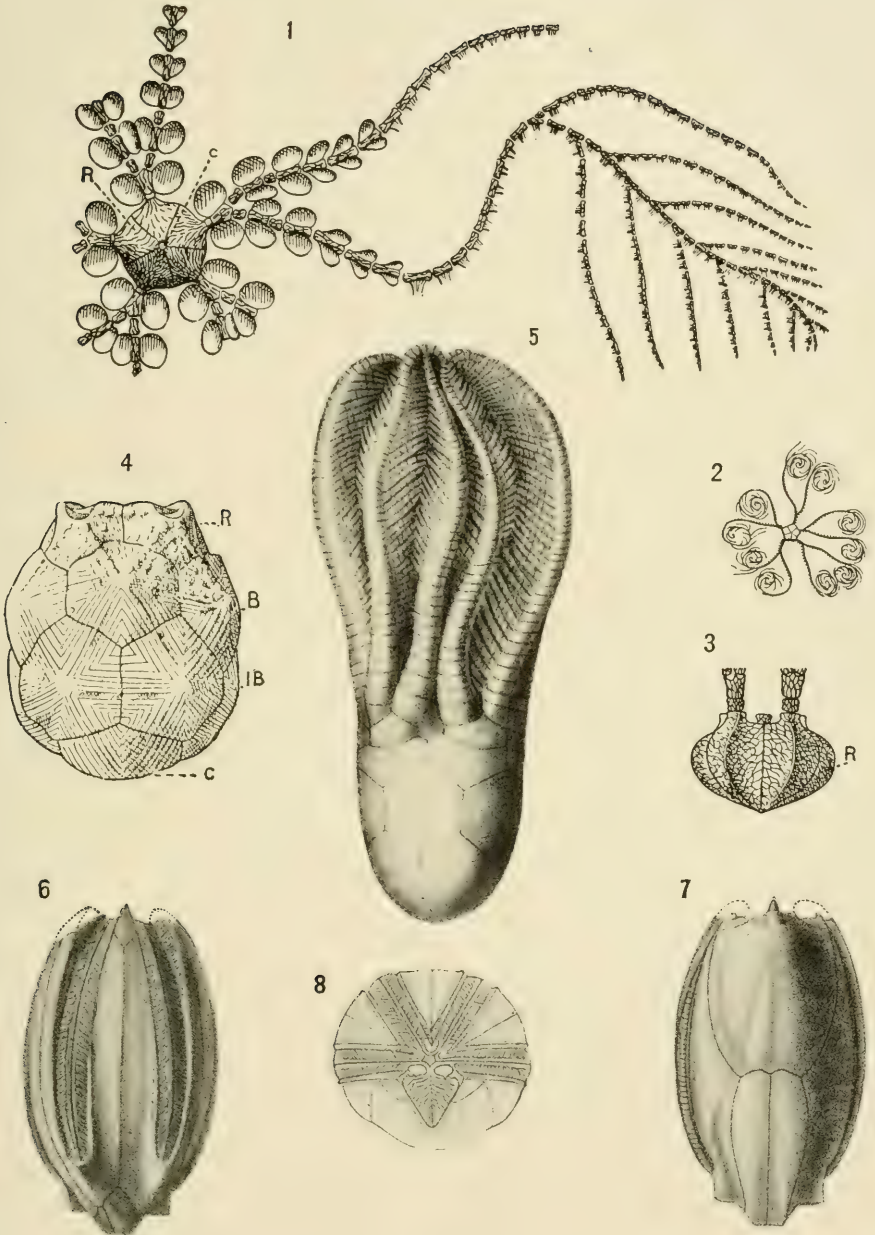
CRINOIDEA OF GROUP II.

FOR EXPLANATION OF PLATE SEE PAGES 135 AND 136.



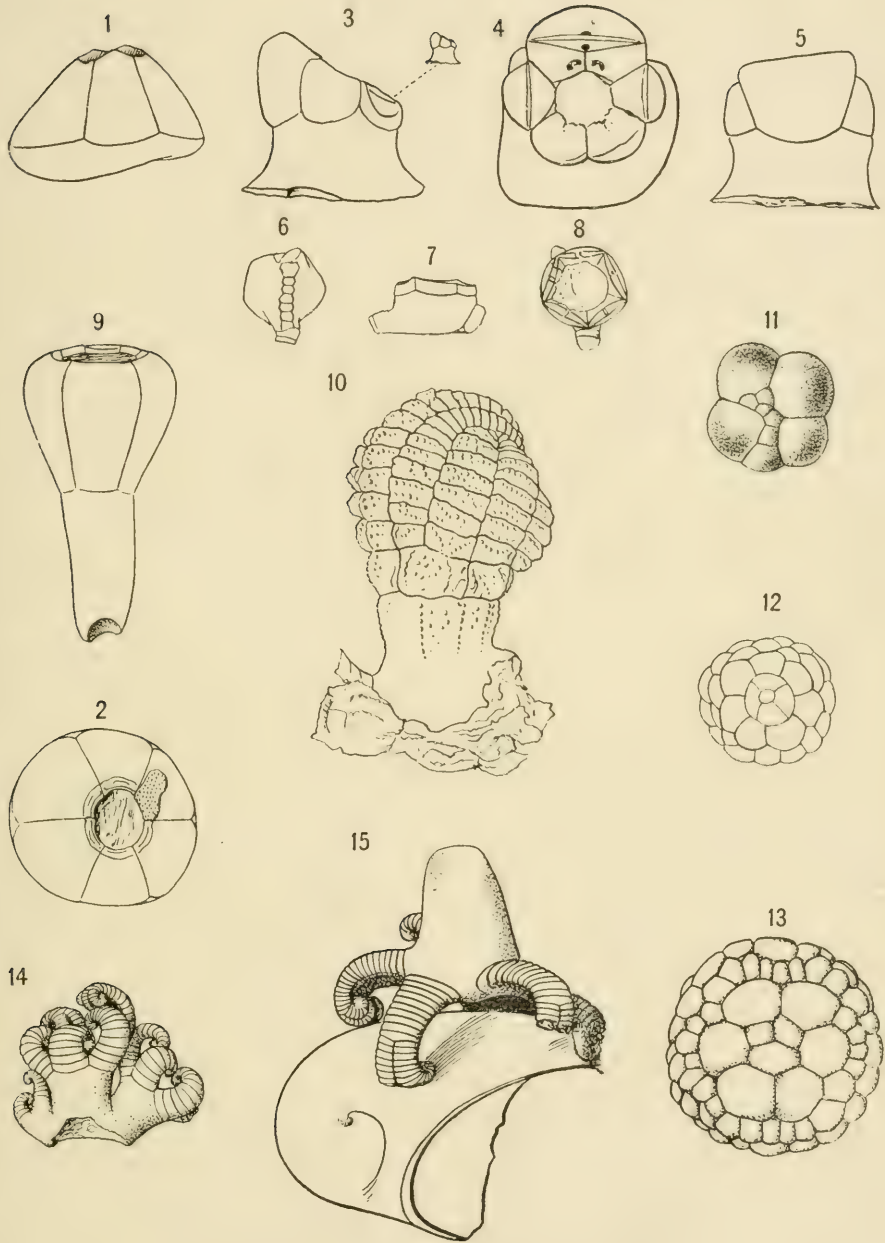
CRINOIDEA OF GROUP II.

FOR EXPLANATION OF PLATE SEE PAGE 136.



CRINOIDEA AND BLASTOIDEA OF GROUP II.

FOR EXPLANATION OF PLATE SEE PAGES 136 AND 137.



CRINOIDEA AND CYSTIDEA OF GROUPS II AND III.

FOR EXPLANATION OF PLATE SEE PAGE 137.

A REVISION OF THE FORMS OF THE LADDER-BACKED WOODPECKER (*DRYOBATES SCALARIS* [WAGLER]).

By HARRY C. OBERHOLSER,
Assistant Ornithologist, Department of Agriculture.

This paper is the outgrowth of an attempt to determine the proper name for the ladder-backed woodpecker of Texas. The investigation has developed some interesting results, which it seems well to publish collectively. The writer is under great obligation to Mr. Ridgway for the use of all the material of this group that he had brought together for his "Birds of North and Middle America," as well as a large number of his measurements. Altogether 560 specimens have been available, comprising the collections of the U. S. National Museum, with that of the Biological Survey; the American Museum of Natural History; the Academy of Natural Sciences of Philadelphia; the Museum of Comparative Zoology at Cambridge, including the Bangs collection; the Carnegie Museum at Pittsburg; and the Field Museum of Chicago.

The ladder-backed woodpeckers, *Dryobates scalaris* (Wagler), range from the southwestern United States, in southern Colorado and southern Utah, to southeastern Mexico and British Honduras, chiefly in the Lower Austral and Tropical zones. They are strictly resident, and are preeminently birds of the chaparral and cactus, rarely frequenting the forest. In a general way the smallest forms inhabit the south and the largest forms the north. The six currently recognized races are here increased to fifteen. The adult females differ from the males in lacking all red on the pileum, black taking its place, and in being of smaller size; otherwise the sexes are identical. There is considerable individual variation in both size and color.

In all measurements, which are in millimeters, it has been the aim to use, as far as possible, only typical specimens, so that the averages and extremes may represent, not the limits of intermediate specimens, but standards for the various forms.

The following key may be of some assistance for purposes of identification, as well as serving for an exposition of salient characters.

KEY TO THE SUBSPECIES OF *DRYOBATES SCALARIS*, BASED ON ADULT MALES.

- a.* Outermost long rectrix (the second) with black spots or bars on whole of both vanes.¹
- b.* Lower surface darker, more smoky.
- c.* Larger (wing usually more than 100 mm.); sides of breast *streaked* with black; black bars on upper parts wider; black postocular and malar stripes wider, the latter reaching bill.
- d.* Somewhat larger (wing averaging 104.4 mm.); lower surface darker; black bars on back broader; postocular stripe wider. . . . *Dryobates scalaris bairdi*.
- d'.* Somewhat smaller (wing averaging 102.4 mm.); lower surface lighter; black bars on back narrower; postocular stripe narrower.
Dryobates scalaris centrophilus.
- c'.* Smaller (wing less than 100 mm.); sides of breast *spotted* with black; black bars on upper parts narrower; black postocular and malar stripes narrower, the latter not reaching bill.
- d.* Larger (wing more than 93 mm.); black bars on basal part of exterior vane of outermost long rectrix (the second) averaging larger, never absent.
Dryobates scalaris scalaris.
- d'.* Smaller (wing usually less than 93 mm.); black bars on basal part of exterior vane of outermost long rectrix (the second) reduced to spots, and averaging smaller, occasionally absent. . . . *Dryobates scalaris ridgwayi.*
- b'.* Lower surface lighter, less smoky.
- c.* Larger (wing usually over 100 mm.; averaging more than 101 mm.).
- d.* Upper parts darker (the white bars narrower, the black bars broader); sides of breast more often streaked; size somewhat larger.
Dryobates scalaris cactophilus.
- d'.* Upper parts lighter (the white bars wider, the black bars narrower); sides of breast less often streaked; size somewhat smaller.
Dryobates scalaris symplectus.
- c'.* Smaller (wing under 100 mm.; averaging less than 98 mm.).
- d.* Postocular and malar stripes wider, the latter always reaching bill; size smaller (wing averaging 89.1 mm.); black bars on back somewhat narrower; primary coverts with somewhat less white; lower parts less heavily spotted.
Dryobates scalaris parvus.
- d'.* Postocular and malar stripes narrower, the latter usually not reaching bill; size larger (wing averaging 96.5); black bars on back somewhat wider; primary coverts with somewhat more white; lower parts more heavily spotted. . . . *Dryobates scalaris percus.*
- a'.* Outermost long rectrix (the second) with black spots or bars wanting on most of basal half of exterior vane.
- b.* Lower surface much darker.
- c.* Larger (wing more than 90 mm.); sides of breast *streaked* with black; primary coverts with more white.
- d.* Back and scapulars darker, the black bars wider, the white bars narrower; size decidedly greater (wing averaging more than 100 mm.); malar stripe not obsolete at base of bill; black bars on tail generally broader; streaks on sides of breast rather wider. . . . *Dryobates scalaris agnus.*
- d'.* Back and scapulars lighter, the black bars narrower, the white bars wider; size decidedly smaller (wing averaging less than 100 mm.); malar stripe nearly always obsolete at base of bill; black bars on tail generally narrower; streaks on sides of breast rather narrower.
Dryobates scalaris sinaloensis.

¹ In *Dryobates scalaris ridgwayi* these are occasionally wanting on proximal portion of outer vane.

- c'. Smaller (wing less than 90 mm.); sides of breast *spotted* with black; primary coverts with less white.....*Dryobates scalaris leucoptilurus*.
- b'. Lower surface much lighter.
- c. Smaller (wing less than 100 mm.); outer webs of primary coverts with very little or no white; postocular stripe rather broader; malar stripe obsolete at base of bill.
- d. Under parts lighter; size decidedly larger (wing not less than 95 mm.); lower surface less heavily spotted with black; black bars on back and tail broader.....*Dryobates scalaris graysoni*.
- d'. Under parts darker; size decidedly smaller (wing less than 95 mm.); lower surface more heavily spotted with black; black bars on back and tail narrower*Dryobates scalaris azelus*.
- c'. Larger (wing not less than 100 mm.); outer webs of primary coverts conspicuously spotted with white; postocular stripe not so broad; malar stripe not obsolete at base of bill.
- d. Decidedly smaller (wing averaging less than 104 mm.); ventral surface lighter; lighter above (the white bars on back averaging wider and more regular, the black bars narrower); black bars on posterior lower parts averaging less heavy.....*Dryobates scalaris lucasanus*.
- d'. Decidedly larger (wing averaging more than 104 mm.); ventral surface darker; darker above (the white bars on back averaging narrower and less regular, the black bars wider); black bars on posterior lower parts averaging somewhat heavier.....*Dryobates scalaris eremicus*.

DRYOBATES SCALARIS SCALARIS (Wagler).

Picus scalaris WAGLER, Isis, 1829, p. 511.

Picus gracilis LESSON, Rev. Zool., 1839, p. 41 (Mexico).

Picus orizabae CASSIN, Proc. Acad. Nat. Sci. Phila., 1863, p. 196 (Jalapa, Vera Cruz, Mexico).

Chars. subsp.—Size medium (wing of male averaging about 96 mm.); white bars of back wider than the black interspaces; exterior webs of three outer pairs of tail-feathers barred throughout with black and white, although the black bars occasionally incomplete basally; outer webs of primary coverts slightly spotted with white; malar stripe more or less obsolete at base of bill; lower surface smoky brownish; sides of breast and body lightly spotted with black.

Description.—Adult male, No. 37432, U.S.N.M.; Orizaba, Vera Cruz, Mexico, January 15, 1864; F. Sumichrast. Crown and nape black, the feathers of the former subterminally dull white, terminally scarlet vermilion, this producing a mottled effect on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; remaining upper parts black, all, excepting the superior tail-coverts, barred with white—these white bars nearly all wider than the black interspaces; tail black, the three external pairs of rectrices, including the dwarfed outermost one, much barred with dull white, except on basal portion of inner webs of the second and third; the fourth pair spotted with white on margin of outer vane; wings black, the remiges spotted conspicuously on both webs with white, these spots forming, on tertials fairly well-defined bars, the

medium and greater coverts heavily, the lesser and primary coverts sparingly, spotted on both webs with white; sides of head and neck light smoky brownish, the superciliary stripe rather more whitish; a postocular and a malar stripe of black, which meet on the side of the neck, the malar stripe, however, more or less obsolete at the base of the bill; nasal tufts and entire inferior surface smoky brownish, paler, even whitish on crissum; sides of breast and body with small spots of black, flanks and crissum with bars of the same color; lining of wing white, with spots of black.

Measurements.—Male ¹: Wing, 95–97 (average, 96.3) mm.; tail, 52.5–55 (53.5); exposed culmen, 19.5–21 (20.2); tarsus, 18; middle toe, 11.5–12 (11.8).

Female: ² Wing, 93–98 (95.1); tail, 49–52.5 (50.1); exposed culmen, 17.5–19.5 (18.5); tarsus, 16–16.5 (16.3); middle toe, 10.5–12 (11.6).

Type-locality. —“Mexico:” i. e., central part of the State of Vera Cruz, Mexico.

Geographical distribution.—Central eastern Mexico: north to Alta Mira, southeastern Tamaulipas; west to Valles, eastern San Luis Potosi; Jico and Orizaba, central western Vera Cruz; south to Cordoba and Orizaba, central western Vera Cruz; east to Carrizal, central eastern Vera Cruz; and Tampico, southeastern Tamaulipas.

Specimens examined from various parts of the range of this form, as above outlined, are very uniform in size. A female from Chalchicomula, Puebla, has the black bars on outer web of outermost long tail-feather much reduced, and in this appears to be aberrant, verging toward *Dryobates scalaris azelus*,³ but its other characters proclaim it the present form. Birds from extreme southeastern Tamaulipas (Alta Mira and Tampico) are somewhat intermediate in color between this race and *Dryobates scalaris symplectus*,⁴ but in general characters are nearer *D. s. scalaris*.

In the original description of *Dryobates scalaris*⁵ the type-locality given is simply “Mexico;” but the measurements there added,⁶ and the subsequent remarks of Malherbe,⁷ who examined the type, evidently refer to the bird of central Vera Cruz, to which we therefore here restrict the name *scalaris*. The *Picus gracilis* of Lesson, poorly described⁸ from “Mexico,” is the same form, as Malherbe’s remarks on the type⁹ clearly indicate. The *Picus orizabae*

¹ Three specimens, from the State of Vera Cruz, Mexico.

² Five specimens, from Vera Cruz and eastern San Luis Potosi, Mexico.

³ See p. 147.

⁴ See p. 155.

⁵ *Picus scalaris* Wagler, Isis, 1829, p. 511.

⁶ Ibid. These, reduced to millimeters, are: Wing, 95.3; tail, 54.9; exposed culmen, 17.5; tarsus, 17.

⁷ Mon. Pictidées, vol. 1, 1861, p. 116, et seq.

⁸ Rev. Zool., 1839, p. 41.

⁹ Mon. Pictidées, vol. 1, 1861, p. 117.

of Cassin,¹ from Jalapa. Vera Cruz, the type of which we have seen, is also a synonym of *Dryobates scalaris scalaris*. Malherbe's *Picus scalaris* var. *d'orizaba*,² commonly cited under *D. s. scalaris*, is merely a vernacular designation, and has therefore no real standing in nomenclature.

Twelve specimens of this form have been examined, from the following localities in Mexico:

San Luis Potosi.—Valles.

Tamaulipas.—Alta Mira; Tampico.

Vera Cruz.—Carrizal; Jico; Mirador; Orizaba.

DRYOBATES SCALARIS RIDGWAYI,³ new subspecies.

Chars. subsp..—Similar to *Dryobates scalaris scalaris*, but much smaller; and the black bars (of *scalaris*) on basal part of exterior web of outermost long rectrix averaging smaller and reduced to spots, sometimes absent.

Description.—Type, adult male, No. 187546, U.S.N.M., Biological Survey collection; Jaltipan, Vera Cruz, Mexico, February 3, 1904; E. W. Nelson and E. A. Goldman. Crown and nape black, the feathers of the former subterminally brownish white, terminally poppy red, this producing a mottled effect on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; rest of upper body surface black, all, except the superior tail-coverts, barred with dull white—these white bars decidedly wider than the black interspaces; tail black, the three exterior pairs of feathers, including the dwarfed outermost one, much barred with brownish white except on basal portion of inner web of second and third, the black interspaces reduced to spots on basal portion of the external web of the outermost long rectrix (the second); the fourth pair of rectrices barred distally with brownish white; wings black, much spotted with white, this forming, on tertials, fairly well-defined bars; sides of head and neck light smoky brownish, the superciliary stripe somewhat paler; a postocular and a malar stripe of black, which meet on the side of the neck, the malar stripe, however, obsolete anteriorly; nasal tufts and whole lower surface smoky brown, paler posteriorly; sides of breast and body with small spots of black; flanks and crissum with bars of the same; lining of wing white, with spots of black.

Measurements.—Male:⁴ Wing, 88–92.5 (average, 90.8) mm.; tail, 45–50.5 (47.8); exposed culmen, 18.5–20.5 (19.1); tarsus, 16–17.5 (16.6); middle toe, 11.5–12 (11.8).

¹ Proc. Acad. Nat. Sci. Phila., 1863, p. 196.

² Mon. Piciées, vol. 3, 1861, pl. 27, fig. 6.

³ Named for Mr. Robert Ridgway, as a slight token of appreciation on many and various courtesies.

⁴ Four specimens, from the State of Vera Cruz, Mexico.

Female:¹ Wing, 86–89.5 (88); tail, 47.5; exposed culmen, 17–19.5 (18); tarsus, 16; middle toe, 11–11.5 (11.3).

Type-locality.—Jaltipan, Vera Cruz, Mexico.

Geographical distribution.—Southeastern Vera Cruz, Mexico: northwest to Tlacotalpam; east to Jaltipan; and south to Pasa Nueva.

This new race may be distinguished from *Dryobates scalaris parvus*, of Yucatan, by its decidedly lighter upper parts—the black bars narrower, the white ones broader; much narrower postocular and malar stripes, the latter not reaching the bill; smaller or absent black markings on outer vane of outermost long rectrix; darker lower surface; and less heavily spotted sides of breast and body. It differs from *Dryobates scalaris bairdi*, of Hidalgo, in being very much smaller; in having the upper parts decidedly lighter, the black bars being narrower; black bars on tail not so wide; black markings on outer web of outermost long rectrix smaller; postocular and malar stripes much narrower, the latter not reaching the bill; lower surface paler, *spotted* instead of streaked, and less heavily thus marked, with black.

Of this race we have seen seven examples, representing the following Mexican localities:

Vera Cruz.—Jaltipan; Tlacotalpam; Pasa Nueva.

DRYOBATES SCALARIS PERCUS, new subspecies.

Chars. subsp.—Similar to *Dryobates scalaris ridgwayi*, but larger; lower surface paler and much more heavily spotted with black; upper parts darker, the white bars much narrower, the black bars wider; postocular and malar stripes somewhat broader; spots of black on white portion of outer vane of outermost long rectrix (the second) averaging larger, inclining sometimes to bars.

Description.—Type, adult male, No. 193906, U.S.N.M., Biological Survey collection; Comitán, Chiapas, Mexico, April 15, 1904; E. W. Nelson and E. A. Goldman. Crown and nape black, the feathers of the former subterminally dull white, terminally poppy red, this producing a mottled effect on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; remainder of upper parts black, all, excepting the superior tail-coverts, barred with white—these white bars narrower than the black interspaces; tail black, the three outer pairs of feathers, including the dwarfed exterior one, much barred with dull white, excepting on basal portion of inner webs of the second and third, the black interspaces on the outer vanes often reduced to spots, particularly on basal part; the fourth pair irregularly and broadly margined with white on outer vanes; wings black, with numerous spots of white, which, on tertials, become fairly well-defined bars; sides of head and neck deep brownish

¹ Three specimens, from the same State.

white; a postocular and a malar stripe of black, which meet on the side of the neck, the malar stripe, however, more or less obsolete at base of bill; nasal tufts and lower surface pale smoky brownish, the chin, sides, flanks, and crissum decidedly whitish; sides and middle of breast and sides of body heavily spotted with black; flanks and crissum barred with the same; lining of wing white, spotted with black.

Measurements.—Male:¹ Wing, 94–99 (average, 96.5) mm.; tail, —; exposed culmen, 17.5–20 (18.8); tarsus, 17; middle toe, 11.5–12.5 (12).

Female:² Wing, 90–94.5 (92.3); tail, —; exposed culmen, 16.5–18 (17.3), tarsus, 16–17 (16.5); middle toe, 11.5–12 (11.8).

Type-locality.—Comitan, Chiapas, Mexico.

Geographical distribution.—Southern Chiapas, Mexico: north to Comitan and Tuxtla Gutierrez, south central Chiapas; east to San Vicente, southeastern Chiapas; and west to Tuxtla Gutierrez.

This form is easily to be separated from *Dryobates scalaris bairdi* by its greatly inferior size; narrower postocular and malar stripes; more restricted black bars on upper parts; lighter lower surface, which is more heavily marked with *spots*—not streaks—of black.

Only four birds examined, from the subjoined Mexican localities:

Chiapas.—Comitan; San Vicente; Tuxtla Gutierrez.

DRYOBATES SCALARIS PARVUS (Cabot).

Picus parvus CABOT, Boston Journ. Nat. Hist., vol. 5, 1845, p. 92.

Picus vagatus CASSIN, Proc. Acad. Nat. Sci. Phila., 1863, p. 196 ("Mexico;" i. e., Yucatan).

Chars. subsp.—Resembling *Dryobates scalaris percus*, but decidedly smaller; postocular and malar stripes wider, the latter always reaching bill; black bars on back rather narrower; primary coverts with somewhat less white; and lower parts less heavily spotted.

Measurements.—Male:³ Wing, 87–92 (average, 89.1) mm.; tail, 46–53.5 (48.4); exposed culmen, 18–20.5 (19.4); tarsus, 15–17 (16.3); middle toe, 11–12.5 (11.5).

Female:⁴ Wing, 86–89.5 (87); tail, 46–49 (47.3); exposed culmen, 16–18 (16.9); tarsus, 15.5–16.5 (15.9); middle toe, 11–12 (11.5).

Type locality.—Ticul, Yucatan, Mexico.

Geographical distribution.—Northern Yucatan, Mexico: north to Progreso, San Felipe, and La Vega; east to Cozumel Island, coast of northeastern Yucatan; south to Chichen Itza, north central Yucatan; west to Merida, northwestern Yucatan.

This well-marked subspecies differs greatly from *Dryobates scalaris bairdi*, for it is much smaller; has paler upper parts, since the black

¹ Two specimens, from the State of Chiapas, Mexico.

² Two specimens, from the same State.

³ Ten specimens, from Yucatan, Mexico.

⁴ Six specimens, from the same State.

bars are decidedly narrower; less broad black tail-bars, on the outermost long rectrix particularly; the lower surface of body much lighter, more heavily marked on breast and sides, *spotted*, instead of streaked, with black. It may be distinguished from *Dryobates scalaris scalaris* by its smaller size, rather darker upper surface, the black bars being somewhat broader, the white bars narrower; wider postocular and malar stripes, the latter extending to the bill; and paler under parts, more heavily spotted with black.

So far as known, this race is confined to northern Yucatan, but its range may be extended by future explorations.

The bird described by Cassin as *Picus vagatus*,¹ from "Mexico," is the same as the Yucatan race. This Mr. Witmer Stone has kindly determined by an examination of the type in the collection of the Philadelphia Academy of Sciences and a comparison with typical examples of *Dryobates scalaris ridgwayi* and *Dryobates scalaris parvus*. Mr. Stone furnishes the following measurements of the type: Wing, 88; tail, 54; exposed culmen, 18; tarsus, 14.5 mm.

Specimens examined, 24, from Mexican localities as under:

Yucatan.—La Vega; Chichen Itza; Progreso; Merida; Temax: San Felipe; Tekanto; west of Tunkas.

DRYOBATES SCALARIS LEUCOPTILURUS, new subspecies.

Chars. subsp.—Like *Dryobates scalaris parvus*, but still smaller; lower surface much darker, but somewhat less heavily spotted; outer webs of second (the first long) pair of rectrices without bars basally; black bars on upper parts rather narrower and more irregular; primary coverts with rather less white on outer webs.

Description.—Type, adult male, No. 25254, Carnegie Museum; Pine Ridge, near Manatee Lagoon, British Honduras; October 26, 1905; Morton E. Peck. Crown and nape black, the feathers of the former subterminally dull white, terminally poppy red, this producing a mottled effect on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; remaining upper parts black, all, excepting the superior tail-coverts, barred with white, these white bars somewhat wider than the black interspaces; tail black, the three outer pairs of feathers, including the dwarfed outermost one, barred with white except on basal portion of inner webs of the second and third, but the outer vanes of the second (the first long pair) and third almost wholly white basally; the fourth pair largely white on distal half of outer vanes; wings black, with numerous spots of white, which, on the tertials and some of the inner long wing-coverts, become fairly well-defined bars; sides of head and neck pale smoky brownish; a broad postocular and a malar stripe of black, which meet on the side of the neck;

¹ Proc. Acad. Nat. Sci. Phila., 1863, p. 196.

nasal tufts and ventral surface of body smoky brown, the chin and crissum paler; sides and middle of breast and sides of body heavily spotted with black; the flanks and crissum barred with the same; lining of wing brownish white, spotted with black; "iris brownish red; bill dark bluish; feet greenish blue."

Measurements.—Male: ¹ Wing, 85–88.5 (average, 86.8) mm.; tail, 43–48.5 (45.8); exposed culmen, 18–19 (18.5); tarsus, 16.5; middle toe, 11.5–12 (11.8).

Female: ² Wing, 84; tail, 44; exposed culmen, 16.5; tarsus, 15; middle toe, 11.5.

Type-locality.—Pine Ridge, near Manatee Lagoon, central eastern British Honduras.

Geographical distribution.—Southeastern British Honduras; north to Manatee Lagoon, central eastern British Honduras; south to Yeacos Lagoon.

This is the most diminutive of all the races of *Dryobates scalaris*, and seems to be very restricted in distribution. The series available is small, but the differences that these birds show, coupled with their isolated habitat, seem to warrant subspecific recognition.

Four examples seen, from the localities below:

British Honduras.—Yeacos Lagoon; Pine Ridge near Manatee Lagoon.

DRYOBATES SCALARIS AZELUS, new subspecies.

Chars. subsp.—Much like *Dryobates scalaris leucoptilurus*, but of decidedly greater size; lower parts lighter: postocular and malar stripes somewhat narrower, the latter not reaching the bill; less black on the outer long tail-feathers, particularly on the exterior webs.

Description.—Type, adult male, No. 185060, U.S.N.M., Biological Survey collection; La Salada, Michoacan, March 19, 1903; E. W. Nelson and E. A. Goldman. Crown and nape black, the feathers of the former subterminally dull white, terminally scarlet vermilion, this producing a mottled effect on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; remaining upper parts black, all, excepting the superior tail-coverts, barred with white—these white bars narrower than the black interspaces; tail black, the three outer pairs of feathers, including the dwarfed outermost one, barred broadly with white, except on basal portion of inner webs of the second and third, but the outer vanes of the second (the first long pair) and third wholly white basally; the fourth pair distally barred with white, and broadly margined on median portion of outer webs with white; wings black, with numerous spots of white (except on primary coverts, alula, and some of the lesser coverts), which, on tertials and some of the inner long upper

¹ Two specimens, from British Honduras.

² One specimen, from the same country.

wing-coverts, become well-defined bars; sides of head and neck deep brownish white; a black postocular and a black malar stripe, which meet on the side of the neck, the malar stripe, however, obsolete anteriorly; nasal tufts and lower surface light smoky brown, the chin, abdomen, flanks, and crissum whitish; sides and middle of breast, and sides of body heavily spotted with black; the flanks and crissum barred with the same; lining of wing brownish white, spotted with black.

Measurements.—Male:¹ Wing, 92 mm.; tail, 48.5; exposed culmen, 18.8; tarsus, 15.5; middle toe, 11.

Type-locality.—La Salada, Michoacan, Mexico.

Geographical distribution.—Southern Mexico: west to La Salada, central western Michoacan; north to Chietla, southwestern Puebla; east to Tlacolula and Oaxaca, west central Oaxaca; south to Sola, southwestern Oaxaca, and Amula, central Guerrero.

This form is superficially much like *Dryobates scalaris sinaloensis*, but differs in its smaller size; spotted instead of streaked breast and sides, these parts more heavily marked; lighter under surface; and somewhat less white on outer webs of primary coverts.

Curiously enough, this new form much more closely resembles *Dryobates scalaris leucoptilurus* from British Honduras, and *Dryobates scalaris sinaloensis*, from Sinaloa, Mexico, than it does any of the geographically adjoining races. Although only the type has been available for examination in this connection, this example is so different from *Dryobates scalaris centrophilus*, from Jalisco,² *Dryobates s. bairdi* from Hidalgo and Mexico, *Dryobates scalaris ridgwayi*, from Vera Cruz, and *Dryobates scalaris percus*, from Chiapas, that it deserves separation. Another specimen, from Chietla, Puebla, was examined by Mr. Ridgway a number of years ago,³ and he is now convinced that it should be referred to this race, an impression borne out by his printed remarks on this bird.⁴ The present species (*Dryobates scalaris*) has been recorded from localities in the States of Guerrero and Oaxaca,⁵ and these States, without much doubt, should be included in the range of this form.

DRYOBATES SCALARIS GRAYSONI (Baird).

Picus scalaris, var. *graysoni* BAIRD, in Baird, Brewer, and Ridgway, Hist. North Amer. Birds, Land Birds, vol. 2, 1874, pp. 501, 517.

Chars. subsp.—Resembling *Dryobates scalaris azelus*, but decidedly larger; under surface paler, and much less heavily spotted, sometimes streaked, with black; postocular and malar stripes wider;

¹ One specimen, the type, from the State of Michoacan, Mexico.

² See p. 157.

³ Proc. U. S. Nat. Mus., vol. 9, 1886, p. 159.

⁴ Ibid.

⁵ Hargitt, Cat. Birds Brit. Mus., vol. 18, 1890, p. 249.

black bars on outer long tail-feathers wider; black bars on upper parts broader.

Measurements.—Male: ¹ Wing, 95–99 (average, 97.7) mm.; tail, 51–57 (54.5); exposed culmen, 20.5–23 (22.1); tarsus, 16.5–18 (17.4); middle toe, 12.5–13.5 (12.9).

Female: ² Wing, 92–98 (95); tail, 49–56 (53.6); exposed culmen, 18.5–20 (19.3); tarsus, 16.5–17.5 (17); middle toe, 11.5–12.5 (12).

Type-locality.—Tres Marias Islands, Tepic, Mexico.

Geographical distribution.—Tres Marias Islands, Tepic, Mexico.

The present race differs from *Dryobates scalaris lucasanus* in smaller size; in having the outer webs of primary coverts usually without white spots, never with large ones; postocular stripe rather broader; malar stripe obsolete, or nearly so, at base of bill; and sides of breast less heavily spotted.

The original citation of this subspecies is sometimes given as ‘Lawrence, Mem. Bost. Soc. Nat. Hist., vol. 2, 1874, p. 294;’ but here only a *nomen nudum* is found.

Of this race we have handled altogether 14 specimens, all from the Tres Marias Islands, Tepic, Mexico, and most of them from Maria Madre Island.

DRYOBATES SCALARIS SINALOENSIS Ridgway.

Dryobates scalaris sinaloensis RIDGWAY, Man. North Amer. Birds, 1887, p. 285.

Chars. subsp.—Similar to *Dryobates scalaris graysoni*, but smaller; lower surface much darker, the sides of the breast always *streaked*, instead of spotted, and more conspicuously thus marked, with black; black bars on upper parts and on tail narrower; postocular stripe rather narrower; outer webs of primary coverts with somewhat more white.

Measurements.—Male: ³ Wing, 94–95 (average, 94.5) mm.; tail, 43.5–53 (48.4); exposed culmen, 19–21.5 (20.3); tarsus, 16.5–17 (16.8); middle toe, 12–13 (12.6).

Female: ⁴ Wing, 93–96 (94.6); tail, 53.5–55.5 (54.5); exposed culmen, 17.5–19 (18.2); tarsus, 16–17 (16.3); middle toe, 11–12.5 (11.8).

Type-locality.—Near Mazatlan, Sinaloa, Mexico.

Geographical distribution.—Southern and central Sinaloa, Mexico: north to Culiacan, central Sinaloa; west to Mazatlan; south to Plomosas; east to Juan Lisiarraga Mountain, southeastern Sinaloa.

Specimens examined, 11, from the subjoined localities in western Mexico:

Sinaloa.—Mazatlan; near Mazatlan; Culiacan; Plomosas; Juan Lisiarraga Mountain.

¹ Nine specimens, from the Tres Marias Islands, Tepic, Mexico.

² Four specimens, from the same islands.

³ Four specimens, from the State of Sinaloa, Mexico.

⁴ Five specimens, from the same State.

DRYOBATES SCALARIS AGNUS, new subspecies.

Chars. subsp..—Like *Dryobates scalaris sinaloensis*, but decidedly larger; back and scapulars darker, the black bars wider, the white bars narrower; malar stripe not obsolete at base of bill, though sometimes obsolescent; black bars on outer tail-feathers usually wider; streaks on sides of breast rather broader.

Description..—Type, adult male, No. 164107, U.S.N.M., Biological Survey collection; Camoa, Rio Mayo, Sonora, November 6, 1898; E. A. Goldman. Crown and nape black, the feathers of the former subterminally dull white, terminally poppy red, this producing a mottled appearance on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; remaining upper parts black, all, excepting the superior tail-coverts, barred with white—these white bars decidedly narrower than the black interspaces; tail black, the three outer pairs of rectrices, including the dwarfed outermost one, barred with white except on basal portion of inner webs of the third pair, but the outer vanes of the second (the first long pair) and third wholly white basally; the fourth pair tipped, and broadly margined on distal two-thirds of outer vanes, with white; wings black, with numerous white spots, which, on the tertials, become fairly well-defined bars; sides of head and neck rather light smoky brown; a broad postocular and a malar stripe of black, which meet on the side of the neck; nasal tufts and lower surface smoky brown, the crissum paler; sides of breast and body with broad streaks of black, the flanks and crissum with bars of the same; lining of wing brownish white, spotted with black.

Measurements..—Male¹: Wing, 100–101.5 (average, 100.8) mm.; tail, 58–59.5 (58.8); exposed culmen, 20–23 (21.5); tarsus, 17; middle toe, 13.

Female:² Wing, 95–98.5 (96.8); tail, 56.5–60.5 (58.5); exposed culmen, 19.5–20 (19.8); tarsus, 16–16.5 (16.3); middle toe, 12.

Type-locality..—Camoá, Rio Mayo, Sonora.

Geographical distribution..—Southern Sonora, Mexico: northwest to Batamotal, southwestern Sonora; and southeast to Camoa, southeastern Sonora.

Of this race four examples have been seen, from the subjoined Mexican localities:

Sonora..—Camoá; Batamotal.

DRYOBATES SCALARIS LUCASANUS (Baird).

Picus lucasanus BAIRD, Proc. Acad. Nat. Sci. Phila., 1859, p. 302 (Xantus MS.)

Chars. subsp..—Resembling *Dryobates scalaris agnus*, but somewhat larger; lower surface much lighter, and the sides of breast spotted, rarely streaked; black bars on upper parts decidedly broader; white

¹ Two specimens, from southern Sonora, Mexico.

² Two specimens, from the same locality.

bars on wings averaging narrower; and spots on outer webs of primary coverts usually much larger.

Measurements.—Male:¹ Wing, 100–105 (average 102) mm.; tail, 60.5–66 (63); exposed culmen, 23.5–25 (24.5); tarsus, 18.5–19.5 (19.1); middle toe, 13–14.5 (14).

Female:² Wing, 95–102 (99.2); tail, 57–69 (63.8); exposed culmen, 19–22 (20.5); tarsus, 17–18 (17.7); middle toe, 12.5–13 (12.8).

Type-locality.—Cape San Lucas, Lower California.

Geographical distribution.—Southern and central Lower California, Mexico: north to Rosarito, north central Lower California; south to Cape San Lucas.

Of this subspecies I have seen 47 examples, representing the localities below:

Lower California.—San Ignacio; Cape San Lucas; La Laguna; Rosarito; Santo Domingo; Miraflores; San Jose del Cabo; Todos Santos; Pescadero (10 miles south of Todos Santos); Santa Anita; El Cajoncito; San Francisco Mountains.

DRYOBATES SCALARIS EREMICUS, new subspecies.

Chars. subsp.—Similar to *Dryobates scalaris lucasanus*, but larger; lower surface darker; upper parts darker, the white bars on back averaging narrower and less regular, the black bars wider; black bars on posterior lower parts averaging somewhat wider.

Description.—Type, adult male, No. 196255, U.S.N.M., Biological Survey collection; San Fernando, Lower California, Mexico, September 4, 1905; E. W. Nelson and E. A. Goldman. Crown and nape black, the feathers of the former subterminally dull white, terminally poppy red, this producing a mottled effect on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; remaining upper parts black, all, excepting the superior tail-coverts, barred with white—these white bars decidedly narrower than the black interspaces; tail black, the three outer pairs of feathers, including the dwarfed outermost one, barred with white, except on basal portion of inner webs of the third pair, but the outer vanes of the second (the first long pair) and third wholly white basally; the fourth pair irregularly barred with white on terminal portion of both webs, and outer vanes broadly margined with white for most of the rest of their length; wings black, with numerous spots of white, which, on tertials and some of the large upper wing-coverts, become fairly well-defined bars; sides of head and neck light smoky brown, the superciliary stripe paler; a broad postocular and a malar stripe of black, which meet on the side of the neck; nasal tufts and under surface light smoky brown; the lower abdomen and crissum decidedly whitish, in rather abrupt contrast; sides of

¹ Ten specimens, from southern Lower California.

² Ten specimens, from the same locality.

breast and body with spots of black, the flanks and crissum with bars of the same; lining of wing white, sparingly spotted with black.

Measurements.—Male:¹ Wing, 104–111 (average, 106.6) mm.; tail, 64–72 (68); exposed culmen, 24–28.5 (26.9); tarsus, 19.5–21 (20.4); middle toe, 13–15 (14).

Female:² Wing, 98.5–104.5 (101.4); tail, 66–67.5 (66.9); exposed culmen, 22.5–25.5 (23.9); tarsus, 17.5–19.5 (18.9); middle toe, 13–14 (13.4).

Type-locality.—San Fernando, Lower California.

Geographical distribution.—North central and northwestern Lower California: north to Nachoguero Valley, northwestern Lower California; northeast to 45 miles east of San Quintin; south to Ubai and Playa Maria Bay, north central Lower California.

Specimens examined, 29, from the places that follow:

Lower California.—Ensenada; Ubai; San Fernando; Rosario; San Simon River, near San Quintin; 45 miles east of San Quintin; San Telmo; Playa Maria; Playa Maria Bay; Rancho Layla; Nachoguero Valley.

DRYOBATES SCALARIS CACTOPHILUS, new subspecies.

Chars. subsp.—Much like *Dryobates scalaris eremicus*, but smaller, particularly the tail and bill; lower surface lighter, laterally almost always *streaked* with black; upper parts lighter—the black bars on back and scapulars narrower; wing-quills with larger spots and broader bars of white; outer long rectrices with exterior webs barred throughout with black; black bars on posterior lower surface narrower.

Description.—Type, adult male, No. 119415, U.S.N.M.; Tucson, Arizona, November 30, 1890; P. L. Jouy. Crown and nape black, the feathers of the former subterminally white, terminally scarlet vermilion, this producing a mottled effect on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; rest of upper surface of body black, all, excepting the superior tail-coverts, barred with white—these white bars rather narrower than the black interspaces; tail black, the three outer pairs of feathers, including the dwarfed outermost one, barred throughout with white, the fourth pair barred with white on terminal portion of inner webs and on all but a small basal part of outer webs; wings black, much spotted with white, this forming, on tertials and longer wing-coverts, fairly well-defined bars; sides of head and neck pale brownish, with a postocular and a malar stripe of black, which meet on the side of the neck; nasal tufts and lower surface dull light smoky brownish, more whitish on lower abdomen and crissum; the sides of breast and body with spots and some streaks of black, the

¹ Ten specimens, from northern Lower California.

² Five specimens, from the same locality.

flanks and crissum with bars of the same; lining of wing white, with spots of black.

Measurements.—Male:¹ Wing, 102–109 (average, 105.1) mm.; tail, 57.5–68 (61.9); exposed culmen, 21.5–24.5 (23.1); tarsus, 18–19.5 (18.9); middle toe, 12.5–14 (13.2).

Female:² Wing, 97–104.5 (100.6); tail, 56–63.5 (59.7); exposed culmen, 17.5–22 (19.6); tarsus, 16–18.5 (17.1); middle toe, 11.5–13 (12.3).

Type-locality.—Tucson, Arizona.

Geographical distribution.—Southwestern United States and northwestern Mexico: west to Guaymas, southwestern Sonora; Cocopah Major Mountains and Gardner's Laguna on Salton River, northeastern Lower California; Vallecito, Riverside, and Hesperia, southwestern California; north to Victorville, southwestern California; eastern base of Charleston Mountains, and Vegas Wash, southern Nevada; Santa Clara, southwestern Utah; Beaverdam, northwestern Arizona; Camp Verde and Holbrook, central Arizona; Glenwood, southwestern New Mexico; Abiquiu, middle northern New Mexico; Corona, central New Mexico; and Santa Rosa, central eastern New Mexico; east to Montoya, Fort Sumner, and the Guadalupe Mountains, eastern New Mexico; Fort Davis and Tornillo Creek, central western Texas; south to the Chisos Mountains, central western Texas; Rio Sestin, northwestern Durango; Nacori, south central Sonora; Guaymas, southwestern Sonora; and Colony (Colorado River), northeastern Lower California.

From *Dryobates scalaris bairdi* this form differs in its much less deeply smoky under surface, sometimes with lateral black spots (always streaks in *D. s. bairdi*); lighter upper parts—the black bars narrower, the white bars broader, the pileum with more white; wider white bars on wings; larger white spots on remiges; and much larger white spots on outer webs of primary coverts. It may be distinguished from *Dryobates scalaris scalaris* by its much greater size; paler lower surface, which has usually streaks on breast and sides, instead of only spots, and these markings of black heavier; broader black bars on upper parts; larger white spots and broader white bars on remiges; wider postocular and malar stripes, the latter extending quite to the base of the bill; and more extensive white spots on the outer webs of the primary coverts.

The birds from northwestern Durango are somewhat smaller and darker than those from Arizona, and verge thus toward *Dryobates scalaris centrophilus*,³ but seem to be nearer the present form. Examples from Nacori and Bacadehuachy, central Sonora, are small and dark, and incline thus toward *Dryobates scalaris agnus*, though

¹ Ten specimens, from Arizona and southern Utah.

² Twenty-two specimens, from Arizona, Sonora, and northeastern Lower California;

³ See p. 157.

in other characters they are like Arizona specimens. In central western Texas the birds are as small as *Dryobates scalaris symplectus*,¹ but in color are just like *D. s. cactophilus*, so, since color is the most reliable distinction between these two forms, these intermediates belong with the latter.

Birds from New Mexico and Chihuahua are likewise slightly smaller than those from Arizona. In northeastern Lower California and in southern California north to Palm Springs and Needles there occur occasional specimens which have no black bars on the outer web of the outermost long rectrix, indicating intergradation with *Dryobates scalaris eremicus*; and the writer himself in times past has identified some of these as *Dryobates scalaris lucasanus* (i. e., *D. s. eremicus*). In the same regions, however, there are also birds with this feather fully barred; and all have the lighter colored upper parts and other characters of *Dryobates scalaris cactophilus*, to which race it is now evident that they belong. This disposition makes it necessary to expunge *Dryobates scalaris lucasanus* (i. e., *Dryobates scalaris eremicus*) from the list of California birds.

Of the present new race, 202 specimens have been seen, from the localities that follow:

Arizona.—Beaverdam; Phoenix; Calabasas; Fort Verde; Tucson; Gila River; Oracle; Buenos Ayres (Pima County); La Osa (Pima County); Santa Cruz River, west of Patagonia Mountains, near the Mexican boundary line; Pinal County; Fort Lowell; Fort Whipple; Sturgis Well, 2 miles west of Poso Verde (Pima County); Lowell; Fort Huachuca; Huachuca Mountains; Warsaw Mills (Pima County); Cochise; Fort Yuma; San Bernardino River at Mexican boundary line; San Bernardino Ranch, Mexican boundary line; Santa Catalina Mountains; San Pedro, 5 miles north of Nogales; Russellville (Cochise County); Colorado River at Monument 204, Mexican boundary line; Fort Buchanan; Camp 122, Kennerly and Möllhausen, on Bill Williams Fork, below mouth of Rio Santa Maria.

California.—Hesperia; Needles; Mountain Spring, near Mexican boundary line (San Diego County); Whitewater; Vallecito; Walters (Riverside County); La Puerta (San Diego County); Palm Springs (25 miles southeast of Banning); Mecca (Riverside County).

New Mexico.—Albuquerque; Organ Mountains; Silver City; Cliff; Santa Rosa; Deming; Abiquiu; Apache; Fort Cummings; San Francisco River; Socorro; Hachita; Lone Mountain; Carrizalillo Spring; Chamberino; Redrock; western side of San Luis Mountains; Los Pinos; Dry Canyon (Otero County); Lake Valley.

¹ See p. 155.

Texas.—Fort Davis; El Paso; Presidio County; Davis Mountains, 20 miles southwest of Toyahvale; Chisos Mountains; Fort Hancock; mouth of Tornillo Creek (near Boquillas); 25 miles south of Alpine.

Utah.—Santa Clara.

Chihuahua.—Colonia Diaz; Colonia Juarez; Casas Grandes; San Diego; Chihuahua City; Boca Grande.

Durango.—Cienega de las Vacas; Rio Sestin; Las Bocas; Rancho Baillon; Rosario.

Lower California.—Gardners Laguna, Salton River; Cocopah Major Mountains; Colony, lower Colorado River; lower Colorado River, above Colony.

Sonora.—Magdalena; Bacadehuachy; Sonoyta, 1 mile south of Nogales; Poso de Luis; Colorado River, below Colonia Diaz; Oputo; Nacori; Guaymas; Santa Cruz.

DRYOBATES SCALARIS SYMPLECTUS, new subspecies.

Chars. subsp.—Resembling *Dryobates scalaris cactophilus*, but male smaller; upper parts lighter, the white bars wider, the black bars narrower, and with more white on pileum; and sides of breast less often streaked (mostly spotted).

Description.—Type, adult male, No. 140730, U.S.N.M., Biological Survey collection; mouth of Nueces River, Texas, November 21, 1891; William Lloyd. Crown and nape black, the feathers of the former subterminally white, terminally scarlet vermilion, this producing a mottled appearance on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; rest of upper surface of body black, all, except superior tail-coverts, broadly barred with white—these white bars broader than the black interspaces; tail black, the three outer pairs of feathers, including the dwarfed outermost one, barred throughout with white; the fourth pair barred terminally on inner vane, and for distal half on outer vane, and spotted on basal part of outer vane, with white; wings black, much spotted with white, this forming, on tertials and some longer wing-coverts, fairly well-defined bars; sides of head and neck brownish white, with a postocular and a malar stripe of black, which meet on the side of the neck; nasal tufts and lower surface dull light brownish, the sides of breast and body with spots of black, the flanks and crissum with bars of the same; lining of wing white, with spots of black.

Measurements.—Male:¹ Wing, 98–107 (average, 102.3) mm.; tail, 53.5–60.5 (56.9); exposed culmen, 20–24 (22.4); tarsus, 16–18.5 (17.7); middle toe, 12–13.5 (12.6).

¹ Eighteen specimens, from Texas, Tamaulipas, and Nuevo Leon.

Female:¹ Wing, 96.5–105 (100.4); tail, 52.5–60.5 (56.9); exposed culmen, 18–21 (20.3); tarsus, 16.5–18.5 (17.3); middle toe, 11–13 (12.1).

Type-locality.—Mouth of Nueces River, Texas.

Geographical distribution.—Middle southern United States and northeastern Mexico: south to Calhoun County, southeastern Texas; Xicotencatl, southern Tamaulipas; and Monterey, central western Nuevo Leon; west to Santa Catarina, central western Nuevo Leon; Sabinas, northeastern Coahuila; Samuels, Fort Lancaster, Grand Falls, Gail, and Tascosa, western Texas; and Saint Charles Canyon, southeastern Colorado; north to Swink, southeastern Colorado; McClellan Creek (Gray County), Vernon, and Gainesville, northern Texas; east to Springfield, southeastern Colorado; Smith County and Houston, eastern Texas; San Fernando de Presas, and Soto la Marina, eastern Tamaulipas.

This new subspecies differs from *Dryobates scalaris bairdi*, from Hidalgo, much as does *Dryobates scalaris cactophilus*, except that it is smaller, and still more extensively white on all the upper parts.

This race reaches its extreme development in Texas; and specimens from central Tamaulipas and central Nuevo Leon are not so light above, showing a tendency toward *Dryobates scalaris bairdi*. They are also somewhat more smoky below. There is, however, no difference in size between examples from Texas and Tamaulipas.

Of this form, 170 specimens have been examined, the following localities being represented:

Colorado.—Saint Charles Canyon (Pueblo County).

Texas.—Mouth of Pecos River; Eagle Pass; Dan Diego; Vernon; Kerrville; Samuels; Seguin; 7 miles west of Camp Verde; Rio Grande City; Cameron County; mouth of Devils River; Blocker's ranch, San Lorenzo Creek (Dimmitt County); Langtry; Del Rio; Colorado; Fort Clark; Brownsville; San Antonio; Laredo; Boerne; Concho County; Eastland; Lomita; Nueces River; Comanche County; Cisco; Corpus Christi; Hidalgo; Brownwood; Dallas; Leon Springs; Mud Creek (Val Verde County); Aransas River; Santa Maria; Bexar County; Kendall County; mouth of Nueces River; Uvalde; Coleman County.

Coahuila.—Sabinas.

Nuevo Leon.—Rodriguez; Santa Catarina; Monterey; San Juan Ranch; Boquillo.

Tamaulipas.—Forlon; Villagran; Soto la Marina; Mier; Camargo; Matamoros; Xicotencatl; Rio del Pilon; Victoria; San Fernando de Presas.

¹ Nineteen specimens, from Texas and Tamaulipas.

DRYOBATES SCALARIS CENTROPHILUS, new subspecies.

Chars. subsp.—Similar to *Dryobates scalaris symplectus*, but bill shorter; lower surface darker, laterally always *streaked* with black; also sides of head and neck more deeply smoky; upper parts much darker, the white bars decidedly narrower, the black ones broader; white bars on wing-quills much narrower, the white spots much smaller, and with less white on pileum; outer webs of primary coverts with much smaller spots of white.

Description.—Type, adult male, No. 155991, U.S.N.M., Biological Survey collection; Ameca, Jalisco, Mexico, March 3, 1897; E. W. Nelson and E. A. Goldman. Crown and nape black, the feathers of the former subterminally white, terminally scarlet vermilion, this producing a mottled effect on the top of the head, but merging into a solid band of red on the occiput and anterior hind neck; rest of upper body surface black, all, except the superior tail-coverts, barred with white—these white bars decidedly narrower than the black interspaces; tail black, the three exterior pairs of feathers, including the dwarfed outermost one, barred throughout with white except on basal portion of inner web of third pair; the fourth pair barred on most of outer vane and on terminal portion of inner vane with white; wings black, much spotted with white, this forming, on tertials and longer wing-coverts, fairly well-defined bars; sides of head and neck pale brownish, with a postocular and a malar stripe of black, which meet on the side of the neck; nasal tufts and entire under parts rather light smoky brown, the lower abdomen and crissum whitish; the sides of breast and body with streaks of black; the flanks and crissum with bars of the same; lining of wing white, with spots of black.

Measurements.—Male:¹ Wing, 100–105 (average, 102.4) mm.; tail, 56–63.5 (57.7); exposed culmen, 19.5–23 (20.9); tarsus, 16.5–17.5 (17.1); middle toe, 11.5–13 (12.3).

Female:² Wing, 97–103.5 (99.6); tail, 54–62.5 (56.9); exposed culmen, 16.5–18 (17.5); tarsus, 16–17 (16.4); middle toe, 10.5–12 (11.4).

Type-locality.—Ameca, Jalisco, Mexico.

Geographical distribution.—Central western Mexico: north to Durango, southern Durango; east to San Juan Capistrano, central western Zacatecas; Bolaños, northern Jalisco; Ocotlan, central eastern Jalisco; and Patamban, northwestern Michoacan; south to Uruapam, northwestern Michoacan; and Sierra Nevada de Colima, southern Jalisco; west to near Mascota, western Jalisco; and Arroyo de Javilan, southern Tepic.

¹ Six specimens, from the Mexican States of Jalisco, Zacatecas, and southern Durango.

² Seven specimens, from the Mexican States of Jalisco and Michoacan.

From *Dryobates scalaris cactophilus* this form may be distinguished by smaller size; more deeply colored ventral surface, with only streaks (no spots) on the sides of the breast; darker upper parts, the white bars slightly narrower, the black ones somewhat broader; and smaller white spots on outer webs of primary coverts. It differs from *Dryobates scalaris sinaloensis* in its much greater dimensions; lighter under surface; entirely black-barred outer web of outermost long rectrix; wider postocular and malar stripes, the latter not obsolete at base of bill; somewhat broader black bars on upper parts; and wider black bars on the tail-feathers. Compared to *Dryobates scalaris azelus*, it is very much larger; has the outer web of outermost long rectrix barred throughout with black; the breast and sides streaked, instead of spotted, but less heavily thus marked; wider postocular and malar stripes, the latter always extending to the base of the bill; somewhat broader black bars above; and somewhat more white on outer webs of primary coverts. It may be separated from *Dryobates scalaris scalaris* by its decidedly greater size; streaked instead of spotted, and more heavily thus marked sides of breast; broader black bars on upper surface; wider postocular and malar stripes, the latter not obsolete at the base of the bill.

Specimens from La Pisagua, Jalisco, are of the same size as the present form, but are more extensively white above, and in this, as well as other respects, appear to be somewhat intermediate between *Dryobates s. centrophilus* and *Dryobates s. azelus*, though nearer, of course, to the former. Birds from Aguas Calientes¹ we have not seen, and they may belong to either *Dryobates scalaris centrophilus* or *Dryobates scalaris bairdi*.

Eighteen examples have been available, from the Mexican localities below:

Durango.—Durango.

Jalisco.—Atemajac (north of Guadalajara); Ocotlan; Ameca; La Pisagua; Las Canoas; Guadalajara.

Michoacan.—Patamban; Uruapam.

Tepic.—Arroyo de Gavilan (near Amatlan).

Zacatecas.—San Juan Capistrano.

DRYOBATES SCALARIS BAIRDI (Malherbe).

Picus bairdi MALHERBE, Mon. Pucidées, vol. 1, 1861, p. 118, pl. 27, figs. 7, 8 (Slater MS.).

Chars. subsp.—Resembling *Dryobates scalaris centrophilus*, but somewhat larger; ventral surface darker; black bars on the back broader; and postocular stripe wider.

Measurements.—Male:² Wing, 102–107.5 (average, 104.4) mm.; tail, 56–62.5 (60.1); exposed culmen, 20–23.5 (22.1); tarsus, 17–18.5 (17.7); middle toe, 12–14 (12.7).

¹ Hargitt, Cat. Birds Brit. Mus., vol. 18, 1890, p. 248.

² Seven specimens, from the Mexican States of Hidalgo, Guanajuato, Coahuila, and San Luis Potosi.

Female:¹ Wing, 97.5–103 (101.7); tail, 57–62 (59.8); exposed culmen, 19.5–20.5 (20); tarsus, 16–17 (16.8); middle toe, 12–13 (12.3).

Type-locality.—"Mexico": i. e., the State of Hidalgo.

Geographical distribution.—Central Mexico: north to Jaral, southern Coahuila; east to La Ventura, southeastern Coahuila; Pachuca, southern Hidalgo; and Chalchicomula, central eastern Puebla; south to Puebla and Atlixco, central western Puebla; and Mexico City, eastern Mexico (State); west to Silao, southwestern Guanajuato; Ahualulco, southwestern San Luis Potosi; and Cedros, northeastern Zacatecas.

The present subspecies may be distinguished from *Dryobates scalaris scalaris* by its much greater size; darker ventral surface, with *streaks*, instead of spots, on breast and sides, and these markings heavier; darker upper surface, the black bars much wider—of about the same width as the white bars—the pileum with less white; and broader postocular and malar stripes, the latter reaching to the bill.

The birds from the Valley of Mexico, although not examined in the present connection, belong doubtless to this form. The *Picus bairdi* of Malherbe,² described from simply "Mexico," is clearly the bird from the State of Hidalgo, as his description, remarks, and plate conclusively show, and to this we therefore restrict the name *bairdi*.

Of this form, 13 examples have been examined, from the localities that follow:

Coahuila.—La Ventura; Carneros; Jaral.

Guanajuato.—Silao.

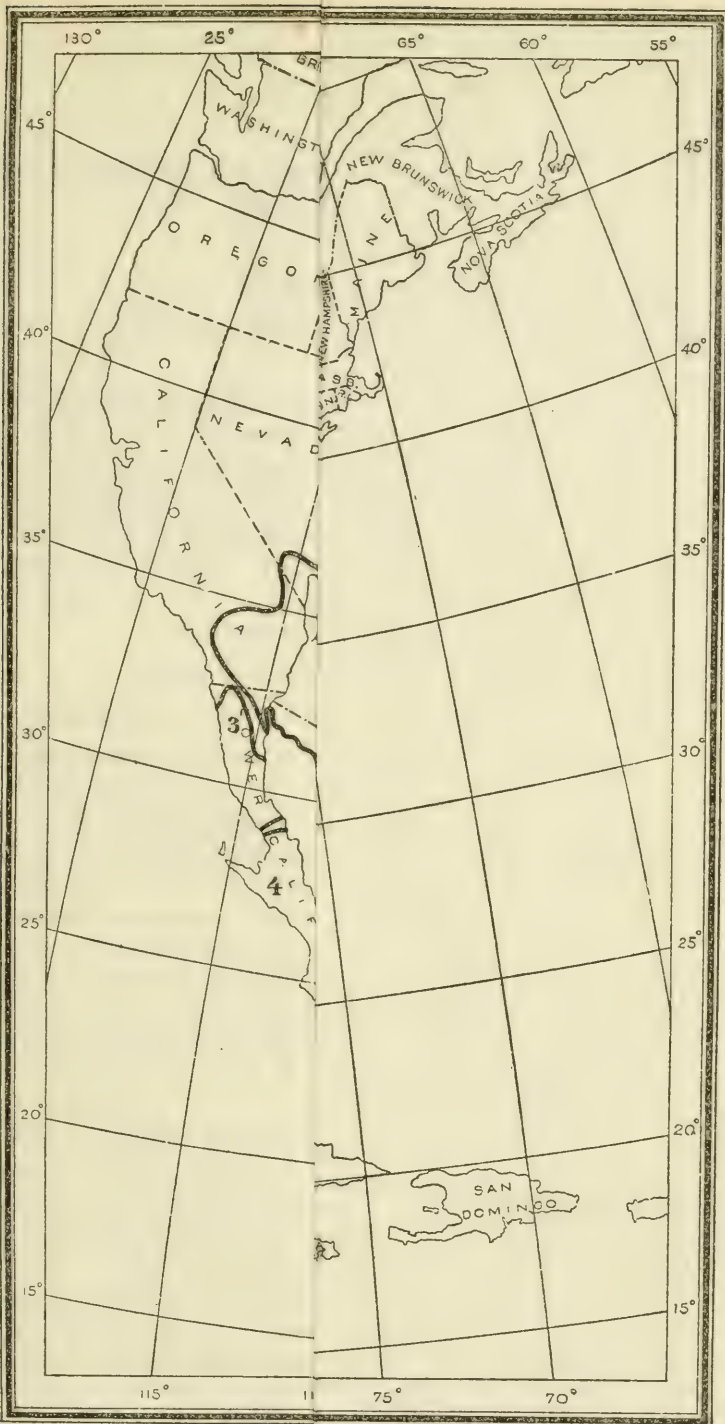
Hidalgo.—Tula; Pachuca.

Puebla.—Chalchicomula; Puente Colorado.

San Luis Potosi.—Hacienda La Parada; Ahualulco.

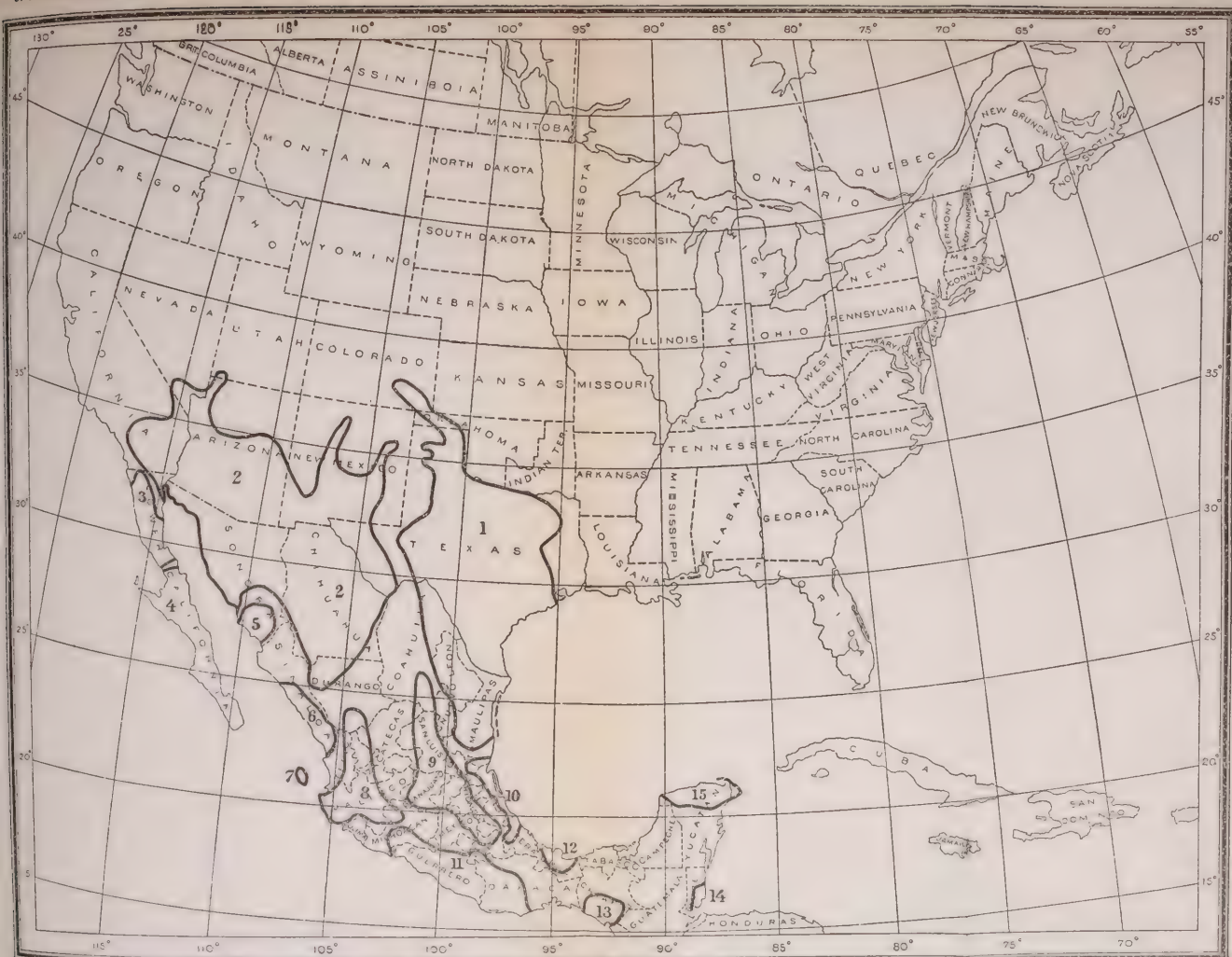
¹ Six specimens, from the States of Hidalgo, Puebla, Coahuila, and San Luis Potosi, Mexico.

² Mon. Picidées, vol. 1, 1861, p. 118, pl. 27, figs. 7, 8.



- 1. *Dryobates scalaris symplectus*
- 2. *Dryobates scalaris cactophilus*
- 3. *Dryobates scalaris eremicus*
- 4. *Dryobates scalaris lucasianus*

- 13. *Dryobates scalaris percus*
- 14. *Dryobates scalaris leucoptilurus*
- 15. *Dryobates scalaris parvus*



RANGES OF THE SUBSPECIES OF DRYOBATES SCALARIS.

1. *Dryobates scalaris symplectus*.
2. *Dryobates scalaris cactophilus*.
3. *Dryobates scalaris eremicus*.
4. *Dryobates scalaris lucasianus*.

5. *Dryobates scalaris argus*.
6. *Dryobates scalaris sinuolensis*.
7. *Dryobates scalaris graysoni*.
8. *Dryobates scalaris centrophilus*.

9. *Dryobates scalaris bairdi*.
10. *Dryobates scalaris scalaris*.
11. *Dryobates scalaris aztecus*.
12. *Dryobates scalaris ridgwayi*.

13. *Dryobates scalaris percus*.
14. *Dryobates scalaris leucopillurus*.
15. *Dryobates scalaris parvus*.

DESCRIPTIONS OF RECENTLY DISCOVERED CLADOCERA FROM NEW ENGLAND.

By ALFRED A. DOOLITTLE,

Of the Central High School, Washington, District of Columbia.

The collections of Entomostraca made by the writer for the United States Bureau of Fisheries in its investigations of the New England lakes contain several Cladoceran forms which seem to be new. This paper describes more fully and with drawings a recently established genus and its type-species and another recently discovered species of a different family, a preliminary diagnosis of which has already appeared.¹

Family LYNCODAPHNIIDÆ.

Genus PAROPHRYOXUS Doolittle.

Parophryoxus DOOLITTLE, Proc. Biol. Soc. Washington, vol. 22, 1909, p. 153.

This genus is erected to include the new species *P. tubulatus* Doolittle, described below.

Female.—Form ellipsoidal; dorsal and ventral margins convergent and produced posteriorly; posterior margin a small fraction of greatest height. Upper or dorsal posterior angle often prominent, but not produced as a spine. Ventral margin sinuate, middle third setiferous. Head viewed laterally, evenly rounded; produced into distinct beak. Cervical sinus present. Fornix well developed, with a horizontal portion running over base of second antenna and eye, and a vertical portion running well toward end of rostrum, resembling *Ophryoxus*. A median keel from tip of rostrum to posterior end of test. Sides of test concave.

Eye moderate; *macula nigra* or ocellus quadrangular, situated in base of rostrum; smaller than eye. First antennæ or antennules attached to apex of rostrum; long, cylindrical; a sensory seta near base of each, and several unequal olfactory setæ distally; otherwise without conspicuous armature. Second antenna with basal segment annulated, and with two setæ and one spine; rami with setæ $\frac{0.0}{0} \frac{0.3}{3}$, spines $\frac{0.1}{0} \frac{0.1}{1}$; setæ and rami about equal, reaching to posterior third. Labrum with anterior and posterior lobes encircling an open-

¹ New Cladocera from New England. Proc. Biol. Soc. Washington, vol. 22, pp. 153-156, July 28, 1909.

ing, the labrum thus appearing fenestrated. Maxillæ with three teeth. Thoracic appendages or legs six, conforming closely to family type. Postabdomen long, tapering, triangular; armature very weak, consisting of a double row of a few tiny spines distally upon upper or posterior border, and laterally of a few fasciculi of spicules. Caudal claw long, slightly curved, with two small spines at base; claw ciliated on both concave and convex borders.

Intestine coiled, hepatic cæca present.

Male.—Form similar to female. First antennæ or antennules each with long sensory seta; second antennæ each with additional seta upon each of the first and second segments of the lower or inner ramus, therefore, setæ $\frac{0.0}{1} \frac{0.3}{13}$, spines $\frac{0.1}{0} \frac{0.1}{0}$. Hook upon first leg. Postabdomen almost smooth; sperm duct terminal.

Though resembling *Ophryoxus* in side view quite remarkably, it is necessary to establish this genus as the following parallel shows.

	<i>Parophryoxus</i> .	<i>Ophryoxus</i> .
General aspect.....	Ellipsoidal.....	Quadrangular.
Head.....	Evenly, convexly rounded.....	Truncated, concave.
Dorsal margin.....	Sloping downward and produced without spine.	Directed upward and with prominent spine.
Ventral margin.....	Sinuate, middle third setigerous.....	Straight, setigerous throughout.
Posterior margin.....	Low, and at end of tubular extension.....	High, no extension of test.
Sides.....	Concave.....	Convex.
Keel.....	On head and body.....	Lacking.
Antennules.....	Almost smooth.....	Heavily bristled.
Antennæ, female.....	Setæ $\frac{0003}{003}$, spines $\frac{0101}{001}$	Setæ $\frac{0003}{113}$, spines $\frac{0101}{001}$.
Labrum.....	Without fleshy organs, fenestrated.....	With fleshy organs, not fenestrated.
First leg.....	Without maxillary process.....	With maxillary process.
Postabdomen.....	Armature obsolescent.....	Armature very strong.
Caudal claw.....	Convex border ciliated.....	Convex border smooth.
Rectal cæca.....	Absent.....	Present.
Opening of sperm duct.....	Terminal.....	Middle of anterior border.

Type-species.—*P. tubulatus* Doolittle.

The name was chosen to indicate its relationship to other Lyncodaphniidæ by Prof. E. A. Birge, to whom also the writer is indebted for calling his attention to the proper place among the Cladocera of specimens of this genus and to important characteristics.

PAROPHRYOXUS TUBULATUS Doolittle.

Plates 13, 14, 15, and 16.

Parophryoxus tubulatus DOOLITTLE, Proc. Biol. Soc. Washington, vol. 22, 1909, p. 153.

Female.—Length 1.15 mm.; height one-half to two-thirds the length. General form, long oval. Upper and lower margins curved nearly symmetrically; however, the middle third of lower margin flattened, sinuate, bearing ciliated setæ, long in the middle part and diminishing rapidly anteriorly and posteriorly. The convergent dorsal and ventral margins and two sides produced to form a rather conspicuous tube posteriorly, the open end of which constitutes the free posterior margin. Posterior margin one-fifth to one-seventh of

greatest height; ciliated. Upper angle sometimes accentuated, especially in immature specimens, but never spined. Width from side to side one-fourth length; suddenly narrowing anteriorly at head, and more gradually posteriorly at the tubular part. Keel low, of uniform height throughout. Upper and lower margins of the concavity of sides thickened to form obvious ridges as seen from the front, and traceable upon the sides of the test in lateral and dorsal views. The opening or gape between the valves ventrally, rhomboidal or lozenge-shaped in anterior two-thirds, with sides of the figure equal, straight; angles well defined. In posterior one-third, that is, in the tubular portion, margins of valves ventrally parallel and nearly touching. Test marked with delicate hexagonal meshes.

Outline of head in side view semicircular; rostrum truncated. The horizontal limb of fornix arising opposite the cervical sinus, curving upward over base of second antenna and eye, then curving downward with slight sinuosity almost to end of rostrum, very similar to the course taken in *Ophryoxus*. Viewed from above, fornix broad with parallel sides; from the front, narrowed. Eye moderate in size, with few facets; *macula nigra* or ocellus nearly as large as eye, in base of rostrum. First antenna or antennule cylindrical, slightly smaller in middle than at ends, the base swollen posteriorly; length ten times average diameter; lateral seta one-fourth distance from base; three of the terminal olfactory setæ long, subequal, about two-thirds length of antennule, and four times the length of the remaining six setæ. Each antennule with two longitudinal rows of seven or more equidistant minute denticles; from side view one row appearing near anterior border, and one row near the posterior border. Second antenna long, basal segment annulated, bearing upon a tubercle at the middle of upper border two delicate setæ with fleshy first joints; distally upon lower border a strong spine. Rami armed typically for females of the genus; rami reaching to end of antennules or to first third of test; setæ equaling the rami, reaching to posterior third of test. The anterior lobe of labrum slender, backwardly curved; the posterior lobe also slender, but anteriorly curved or hooked, almost touching the anterior lobe, thus inclosing an oval space or fenestrum, opposite to the mandibles, of the size and orientation of their grinding surfaces, so that the mandibles oppose each other through the opening. Mandibles without noteworthy features. Maxillæ with basal arm narrowed distally; teeth three, set at an angle of 60° with base, subequal, distal largest, and its convex border sparsely ciliated.

Thoracic appendages or legs, six similar to those of other Lyncodaphniidæ, especially *Ophryoxus gracilis* G. O. Sars, yet differing from *Ophryoxus* and agreeing with all other genera of the family in the absence of the maxillary process upon the first pair. The spines and setæ of the first leg are: upon the protopodite, a cluster

of hairs and two ciliated setæ; upon exopodite, one short and one long seta; anterior or outer branch of endopodite encircled with three rows of short stiff hairs, three strong terminal setæ, one of them two-segmented; the posterior or inner branch of endopodite plainly three-lobed, each lobe bearing, respectively, beginning anteriorly, two short heavy ciliated setæ or spines, three still stronger ciliated spines, and four more delicate two-segmented setæ. The second to fifth legs almost identical with those of *Ophryoxus*, but with the geniculate setæ upon maxillary processes of third, fourth, and fifth very strongly developed. Sixth leg asymmetrical; on lower posterior border a protuberance with two fasciculi of long cilia, ventrally a row of cilia; on anterior border cilia, fine and numerous below, sparse and stronger above.

The postabdomen slender and triangular, the two converging borders irregularly sinuous; about three short spines upon the flexible basal part of the superior or posterior border; anal setæ two, sparsely ciliated; further armature lacking, except for double row distally of about eleven small obsolescent spines, and laterally two or three fasciculi of five to eight delicate cilia each, forming a line approximately parallel to the posterior border. Terminal claw long, nearly or quite half the length of postabdomen, evenly but slightly curved; at base two small subequal teeth, the distal larger; externally at base a row of six small denticles, distal to which the row is continued to the tip with delicate cilia; internally there is a similar row, but with a group of larger cilia instead of denticles; on convex border a row of cilia, distinct at base, but smaller and appressed to the claw toward the tip.

Intestine flexed once upon itself and coiled once in the body; hepatic cæca small; rectum large without cæca.

Male.—Immature males only have been collected. The most advanced specimens are assumed to show most clearly the male structure.

Form, proportion, and general structure essentially as in females of equal development, with the following distinctive details. First antennæ or antennules with conspicuous offset or prominence as in *Bosmina*, on anterior margin, one-fourth distance from base, the angle of which bears a seta reaching well toward end of antennule. The anterior border of antennule distal to offset, with five to eight slight notches or traces of segmentation in youngest specimens. Second antennæ or antennæ proper with seta upon the proximal segment of lower or inner ramus reaching just to or beyond the seta upon the penultimate segment, these two setæ being distinctive for males.

The hook of first thoracic leg strong, slightly curved. The number of obsolescent spines or spicules of posterior or distal border of postabdomen reduced to about three. In some of the most advanced

specimens the end of the postabdomen has withdrawn or shrunken from the exoskeletal sheath, apparently showing the opening of the sperm duct, developing for a molt soon to occur, terminal and dorsal to the caudal claw.

Color light yellow; test and tissues transparent.

Measurements of an egg-bearing specimen taken from Anonymous Pond (Crystal Lake), Maine, United States of America, are:

Length	mm. 1. 14	Antennules, length	mm. 0. 20
Maximum height .....	. 82	Antennules, diameter .....	. 02
Posterior height .....	. 12	Postabdomen, length .....	. 24
Meshes, diameter .....	. 021-. 018	Terminal claw, length .....	. 12
Eye, diameter .....	. 0137	Ocellus, diameter .....	. 0112

Type.—Cat. No. 42781, U.S.N.M.

Type-locality.—Anonymous Pond (Crystal Lake), Maine, September 5, 1908.

Occurrence.—Taken frequently and singly in weedy shallow parts of Umbagog Lake, Maine and New Hampshire, August, 1905; Sebago Lake, Maine, July, August, September, 1906, 1907, 1908; Anonymous Pond, Maine, September, 1908.

Family CHYDORIDÆ Leach (LYNCEIDÆ Baird).

CHYDORUS BICORNUTUS Doolittle.

Plates 17, 18, and 19.

Chydorus bicornutus DOOLITTLE, Proc. Biol. Soc. Washington, vol. 22, 1909, p. 154.

Female.—Length of body 0.50 to 0.62 mm.; height of body five-sixths the length. General form from side view circular oval, somewhat truncated posteriorly, posterior margin sparsely spined. Ventral margin sinuate, with sharp ventral curvature at the middle; setigerous margin turned inward, with short, delicate ciliated setæ interlocking across the ventral opening or gape between the valves. Seen from above, body nearly twice as long as broad, oval, broadest at middle, rounded broadly anteriorly, tapering posteriorly. In front view general form oval, broadest at upper one-fourth, dorsal margin slightly concave on each side. The ventral margins of the valves nearly approximate in posterior one-third, but slightly divergent at posterior one-third and running forward nearly parallel.

The form of the test of the body proper is modified by a most extraordinary exoskeletal development of horns, ridges, and deep rectangular and hexagonal cells, of which the exoskeletal development of *C. faviformis* Birge gives a suggestion. From the middle of each valve of the test there stands out horizontally a large horn, slightly curved posteriorly. This horn varies in length from one-fifth of to a little more than the width of the body. From this obvious

structural feature the species has derived its specific name. From this horn there originate two sets of ridges, one running anteriorly and one dorsally. Taking their origin well toward the tip, one on the upper or dorsal margin of the horn and another on the lower or ventral margin, there run forward two ridges of the first set. The upper one, the superior spinal ridge, continuing across the base of the rostrum merges with other ridges which have a downward course and disappears at the tip of the rostrum. The lower one, the inferior spinal ridge, also passes forward; it diminishes in height and merges with the general level of the honeycomb cells at the upper end of the anterior border of the valve. The space thus bounded by the superior and inferior spinal ridges of each side, the lateral spinal cleft, is free of structures. Similarly there run dorsally from horn to horn two ridges of the second set, the anterior and the posterior interspinal ridges, taking their origins halfway to the tip of the horn, bounding the interspinal cleft, which runs from horn to horn over the back. This cleft also is free from structures and divides the dorsum into anterior and posterior portions. In the middle of the space anteriorly is a clearly defined area, to be called the anterior dorsal area, bounded laterally by high dorsal ridges which converge anteriorly with sharp lateral and apical angles. This area is divided into large cells. The arrangement of these cells usually conforms to the following plan: occupying the anterior angle is a single cell, then four transverse rows of cells with two and three cells in each row alternating; behind the last of these rows is a large pentagonal cell, and between this cell and the anterior interspinal ridge is a row of several smaller cells.

From the antero-lateral angles of the anterior dorsal area just discussed there runs laterally and downward on each side a high ridge, the cervical ridge, to the superior spinal ridge. The lateral space bounded by the two ridges last mentioned, the anterior dorsal area, and the lateral parts of the anterior interspinal ridge is occupied by deep cells; large rectangular cells adjoining the dorsal and cervical ridges, but hexagonal and smaller cells toward the other boundaries.

From the anterior angle of the anterior dorsal area there runs forward in the median line a short occipital ridge which divides right and left into the facial ridges. The facial ridge on each side continues parallel to the cervical ridge and meets the superior spinal ridge at the base of the rostrum, where their identity merges. Between the cervical ridge, on the one hand, and the occipital and facial ridges on the other, there pass parallel partitions dividing the space into long, deep, rectangular cells, some seven or eight in number. Included between the two facial ridges is the facial area. In the center of this is a small deep cell, the ocular cell, immediately behind which is the compound eye. From the ocular cell and from small

cells lateral to it there radiate to the facial ridges a number of partitions further dividing the facial area into long radiating cells, somewhat rectangular in form and corresponding in number to the cells external to the facial ridges. Immediately ventral to the ocular cell there are four cells, behind whose common meeting point is the *macula nigra* or ocellus. To the tip of the rostrum there run the ridges already referred to and a converging series of elongated cells diminishing in height distally.

Each valve of the test supports four prominent ridges below the horn, some especially conspicuous from front and from dorsal view. Those of each side have their origin very near each other at the upper end of the anterior border of the test. Their general direction is parallel to the ventral edge, two of them upon or near the margin, and two a little removed from the margin. They will be called, taking them in order from the margin, the marginal, submarginal, inferior valval, and superior valval ridges. The superior valval ridge standing out at right angles to the test is a very conspicuous object in front view, and also from dorsal view its posterior part, which is seen to end one-fourth from the posterior end of test. The submarginal ridge takes its origin where the inferior spinal ridge is lost among the hexagonal cells at the upper end of the anterior margin of the valve, crosses the origins of the valval ridges, and merges with the marginal ridge midventrally. The inferior valval ridge and the marginal ridge follow the directions already indicated for them, and parallel to those just discussed, and fuse opposite the superior angle of the posterior margin as the margino-valval ridge. At this point it flares outward slightly and running forward on the back joins the posterior interspinal ridge. The space thus inclosed between these united ridges of each side is the posterior dorsal area. Across the anterior end of the area are three large cells. The remaining part of the area is open. The portion of the valves included between the two clefts and the valval ridges is filled with hexagonal cells, larger dorsally and posteriorly and smaller anteriorly. From ridge to adjacent parallel ridge high partitions pass, dividing the intervening space into deep rectangular cells.

Rostrum long, acute, often included between the ridges upon the anterior margins of the valves; the anterior portion of the superior spinal ridge forms a sort of fornix across its base. Eye large; ocellus one-half its diameter, in the base of rostrum. Antennules slender, failing to reach tip of rostrum by about their length; sensory seta in angle upon anterior margin distally; five or more subequal, short, olfactory setæ apically. Antennæ short, not reaching to end of antennules. Rami with setæ $\frac{0}{1}\frac{0}{3}$, with spines $\frac{0}{0}\frac{0}{1}$; one of the distal setæ of lower or inner ramus one-third the length of the remaining. Labrum from side view with short, blunt anterior lobe, and elongated, fingerlike posterior lobe, directed ventro-posteriorly, tipped with

short bristles or cilia; from anterior view labrum with anterior lobe broadly triangular, keeled dorsally, and posterior lobe narrower, sides sinuate but approximately parallel, the tip trilobed, the middle lobe bearing the bristles or cilia. Mandible not distinctive. Maxilla with two teeth, densely bristled; the basal arm broad, its distal boundary and outer tooth forming a continuous semicircular curve.

Legs or thoracic appendages five, conforming strictly to generic type.

Postabdomen broad, length medium; dorsal margin concave beyond anal angle, and broadly rounded at end; proximal half ciliated, distal half with double row of twelve teeth in each row, quite strong for this genus, diminishing slightly distally. Laterally a row of cilia from base of caudal claw to a point near anal angle. Terminal claw strong, slightly curved and crumpled; concave border ciliated to tip; basal spines two, the distal twice the size of the proximal.

Measurements.

	<i>Chydorus bicornutus</i> from Sebago Lake.						
	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Length of body.....	0.400	0.475	0.500	0.520	0.520	0.600	0.620
Length over all.....	.540	.550	.640	.680	.640	.780	.760
Width of body.....	.260	.280	.380	.400	.410	.440	.480
Width over all.....	.900	.550	.740	.520	.600	1.020	.720
Height of body.....	.320	.400	.460	.500	.480	.520	.560
Height over all.....	.440	.500	.560	.660	.600	.720	.730
Length of horn.....	.340	.170	.240	.060	.140	.320	.140
Highest ridge.....	.080	.100	.075	.100	.120	.125	.120
Diameter of largest hexagonal cell.....	.035	.040	.050	.050	.040	.060	.075
Diameter of average hexagonal cell.....	.025	.025	.030	.035	.030	.030	.050
Depth of average cell.....	.020	.040	.070	.040	.030	.060	.040
Length of terminal claw.....	.050	.060	.065	.070	.070	.070	.075
Length of postabdomen from anal setae to claw.....	.165	.....	.140	.235	.190	.250	.245

The variations in proportions are at once apparent; the greatest extremes are in the length of the horn. An analysis of these proportions expressed in percentages of the length shows no significant correlation. On the whole, there are more minimum proportions among the smallest specimens and more of the maximum proportions among the larger specimens. But the totals of the proportion percentages are larger for the smaller individuals and smaller for the larger individuals, with an exception in each group. The 0.60 mm. specimen is the only one not extreme in any of the structures measured; each of the others is extreme, maximum or minimum, in from three to six proportions measured. The variation is dependent upon locality rather than upon age or size. Specimens from one collecting station (mouth of Northwest River) furnished the long-horned specimens; another locality (mouth of Sucker Brook) the short-horned individuals. Specimens from other localities seem to be more average in this particular. Specimens from New Jersey are of the short-horned type.

Eggs, two.

Male.—Unknown.

Color, yellowish.

The honeycomb cells are remarkably free from attached algæ or protozoa or debris, though some of these are observed at times. *C. faviformis* Birge, which occurs associated with the form here described, is often loaded with algæ and protozoa.

Occurrence.—Taken frequently but not in numbers from weedy shallow parts of Umbagog Lake, Maine, and New Hampshire, 1905, July, August; Sebago Lake, Maine, 1906, 1907, 1908, July, August, September; Panther Pond, Maine, 1906, August; Songo River, Maine, 1906, July; Grover Mill Pond, Princeton, New Jersey, 1909, September; 1910, August.

Type.—Cat. No. 42782, U.S.N.M.

Type-locality.—Sebago Lake, Maine, August 19, 1907.

EXPLANATION OF PLATES.

PLATE 13.

- Fig. 1. *Parophryoxus tubulatus*, female from Umbagog Lake, Maine and New Hampshire, August, 1906. Lateral view. $\times 58$.
 2. Do. Rostrum and Antennule. $\times 233$.
 3. Do. Antenna. $\times 233$.
 4. Do. Postabdomen. $\times 233$.

PLATE 14.

- Fig. 1. *Parophryoxus tubulatus*, female from Anonymous Pond, Maine, September, 1908. Lateral view. $\times 58$.
 2. Do. Dorsal view. $\times 58$.
 3. Do. Anterior view. $\times 58$.
 4. Do. First leg. $\times 233$.
 5. Do. Second leg. $\times 233$.
 6. Do. Third leg. $\times 360$.

Lettering: *d*, exopodite; *e*, *e'*, *e''*, endopodite and its branches; *mx*, maxillary process.

PLATE 15.

- Fig. 1. *Parophryoxus tubulatus*, female from Anonymous Pond, Maine, September, 1908. Fourth leg. $\times 360$.
 2. Do. Fifth leg. $\times 360$.
 3. Do. Sixth leg. $\times 360$.
 4. Do. Head, lateral view. $\times 133$.
 5. Do. Maxilla. $\times 400$.
 6. Do. Postabdomen. $\times 133$.

Lettering as under Plate 14.

PLATE 16.

- Fig. 1. *Parophryoxus tubulatus*, marking of shell, female. $\times 633$.
 2. Do. Male from Anonymous Pond, Maine, September, 1908. Lateral view. $\times 94$.
 3. Do. Anterior view. $\times 133$.
 4. Do. Juvenile male. Lateral view. $\times 94$.
 5. Do. End of postabdomen, the shrunken tissues showing position of spermatid. $\times 270$.

PLATE 17.

- Fig. 1. *Chydorus bicornutus*, female from Sebago Lake, Maine, July, 1908. Lateral view, antenna not shown. $\times 127$.
 2. Do. Dorsal view. $\times 127$.

KEY TO LETTERING.

<i>A D A</i> Anterior dorsal area.	<i>L S C</i> Lateral spinal cleft.
<i>A I R</i> Anterior interspinal ridge.	<i>M R</i> Marginal ridge.
<i>B O</i> Body outline.	<i>M V R</i> Margino-valval ridge.
<i>C R</i> Cervical ridge.	<i>O C</i> Ocular cell.
<i>D R</i> Dorsal ridge.	<i>O R</i> Occipital ridge.
<i>F A</i> Facial area.	<i>P D A</i> Posterior dorsal area.
<i>F R</i> Facial ridge.	<i>P I R</i> Posterior interspinal ridge.
<i>H</i> Horn.	<i>S S R</i> Superior spinal ridge.
<i>I C</i> Interspinal cleft.	<i>S R</i> Submarginal ridge.
<i>I S R</i> Inferior spinal ridge.	<i>S V R</i> Superior valval ridge.
<i>I V R</i> Inferior valval ridge.	

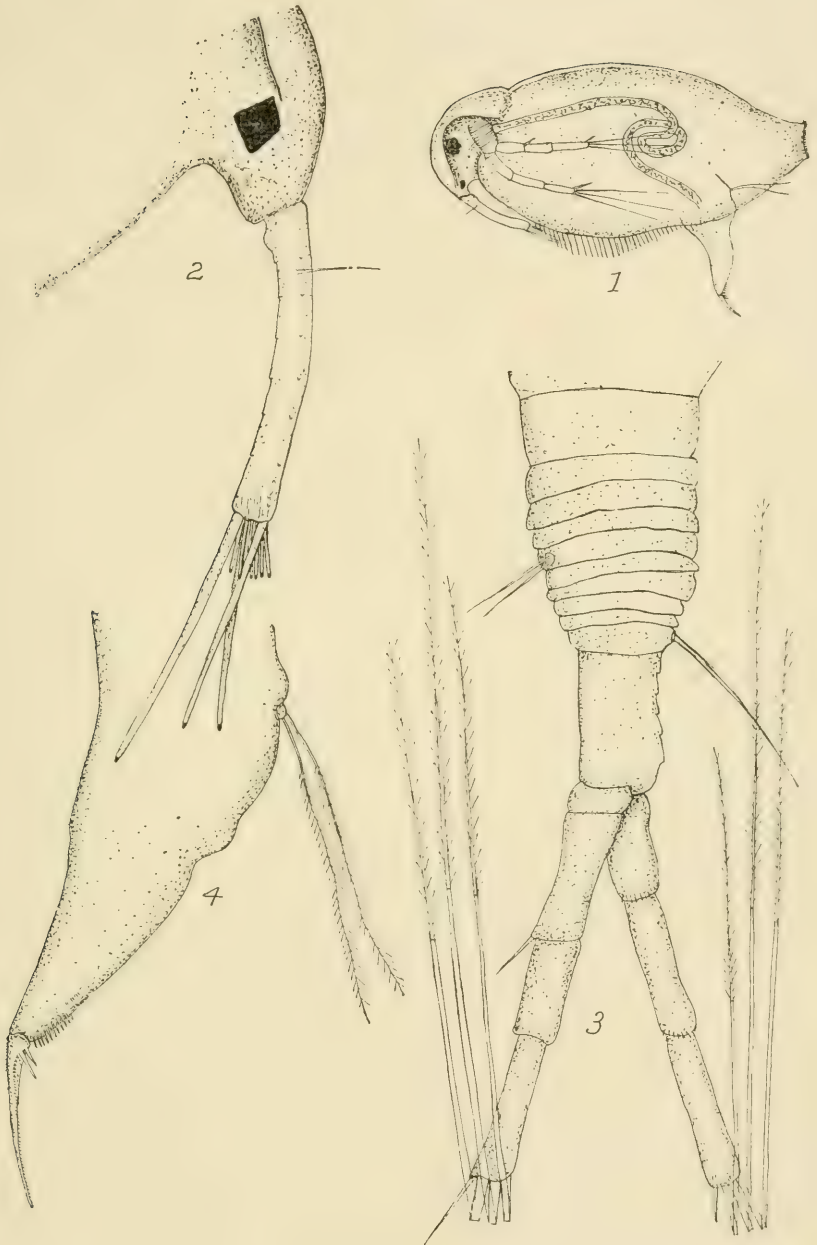
PLATE 18.

- Fig. 1. *Chydorus bicornutus*, female from Sebago Lake, Maine, July, 1908. Anterior view. Lettering as on Plate 17. $\times 127$.
2. Do. Antenna. $\times 233$.
 3. Do. Antennule. $\times 400$.
 4. Do. Lower part of head, lateral view. $\times 233$.
 5. Do. Labrum, anterior view. $\times 233$.
 6. Do. Maxilla. $\times 400$.

PLATE 19.

- Fig. 1. *Chydorus bicornutus*, female from Sebago Lake, Maine, July, 1908. First leg. $\times 400$.
2. Do. Second leg. $\times 400$.
 3. Do. Third leg. $\times 400$.
 4. Do. Fourth leg. $\times 400$.
 5. Do. Fifth leg. $\times 400$.
 6. Do. Postabdomen. $\times 233$.

Lettering: *d*, exopodite; *e*, *e'*, *e''*, endopodite and its branches; *mx*, maxillary process.



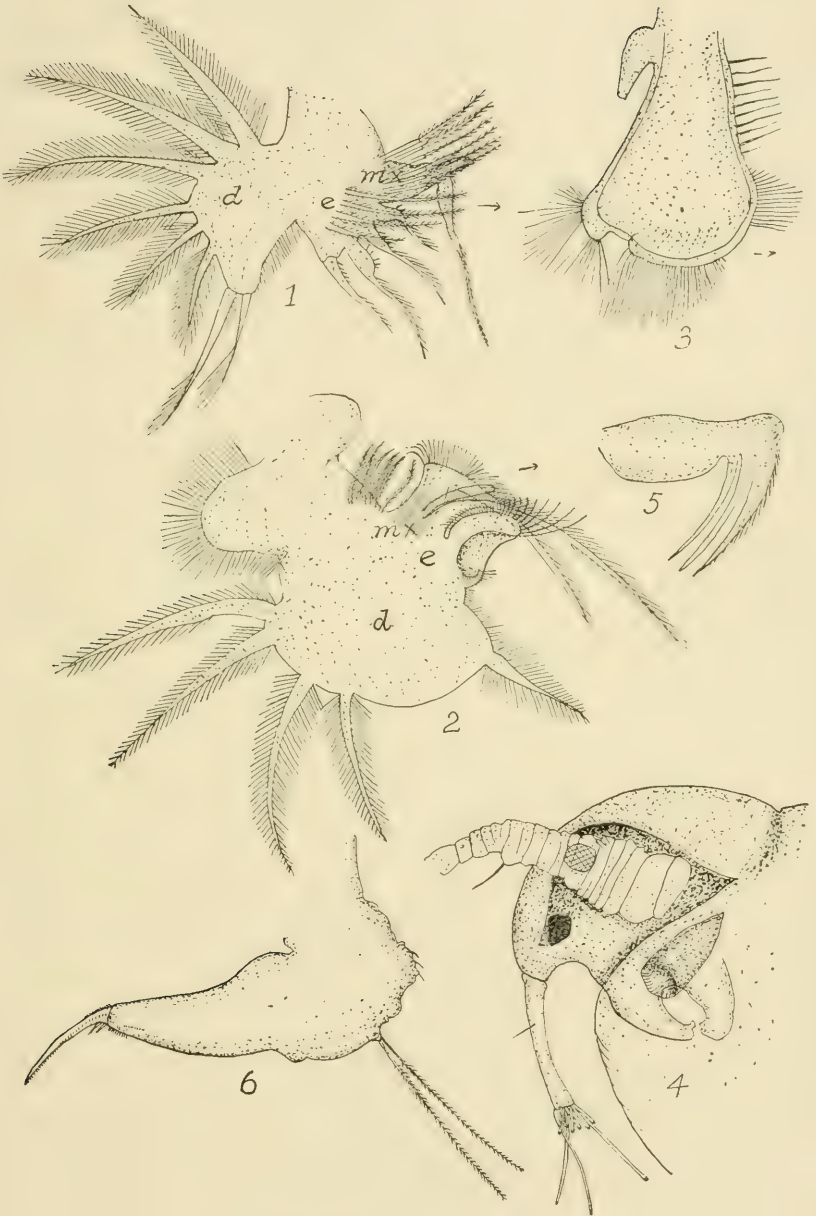
NEW ENGLAND CLADOCERA.

FOR EXPLANATION OF PLATE SEE PAGE 169.



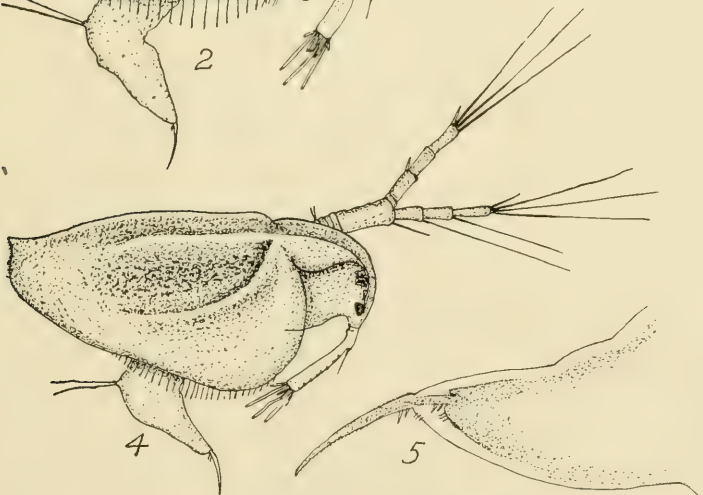
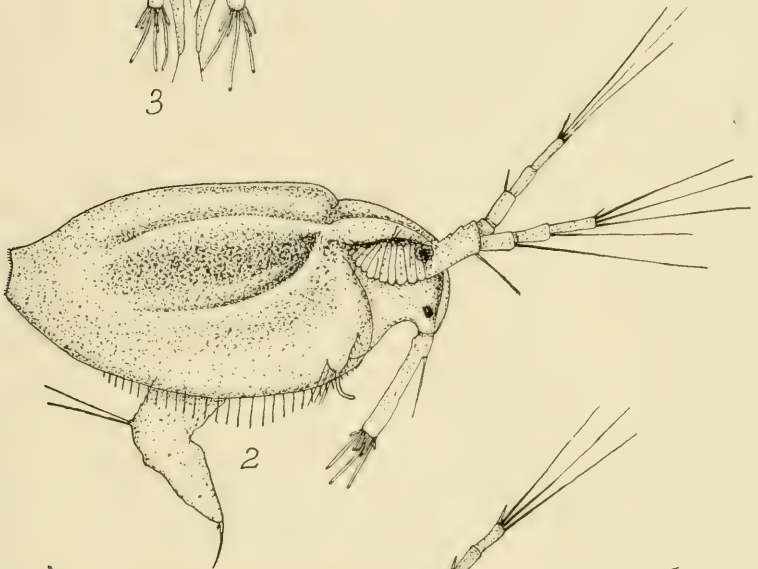
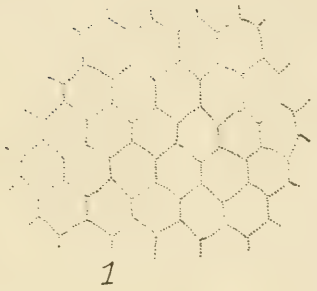
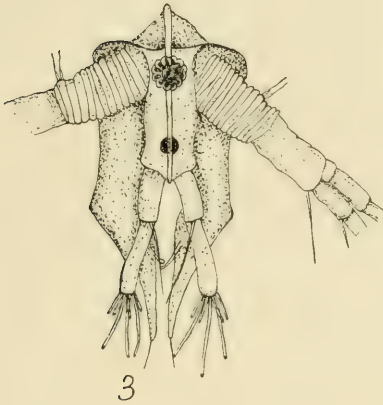
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FOR EXPLANATION OF PLATE SEE PAGE 169.



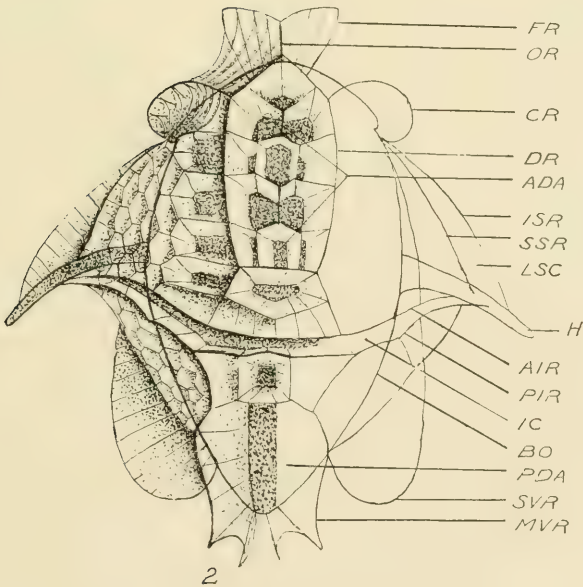
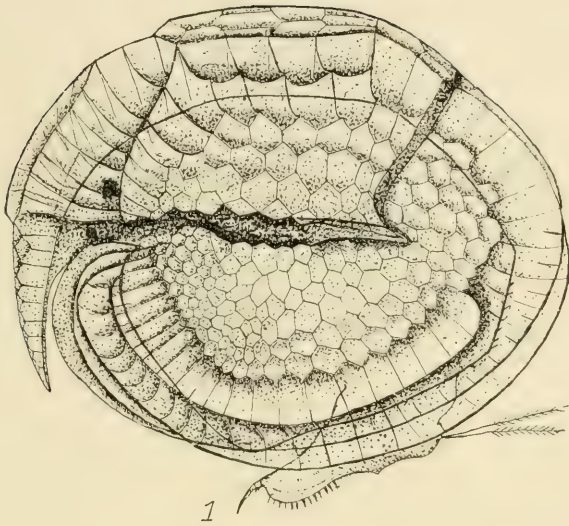
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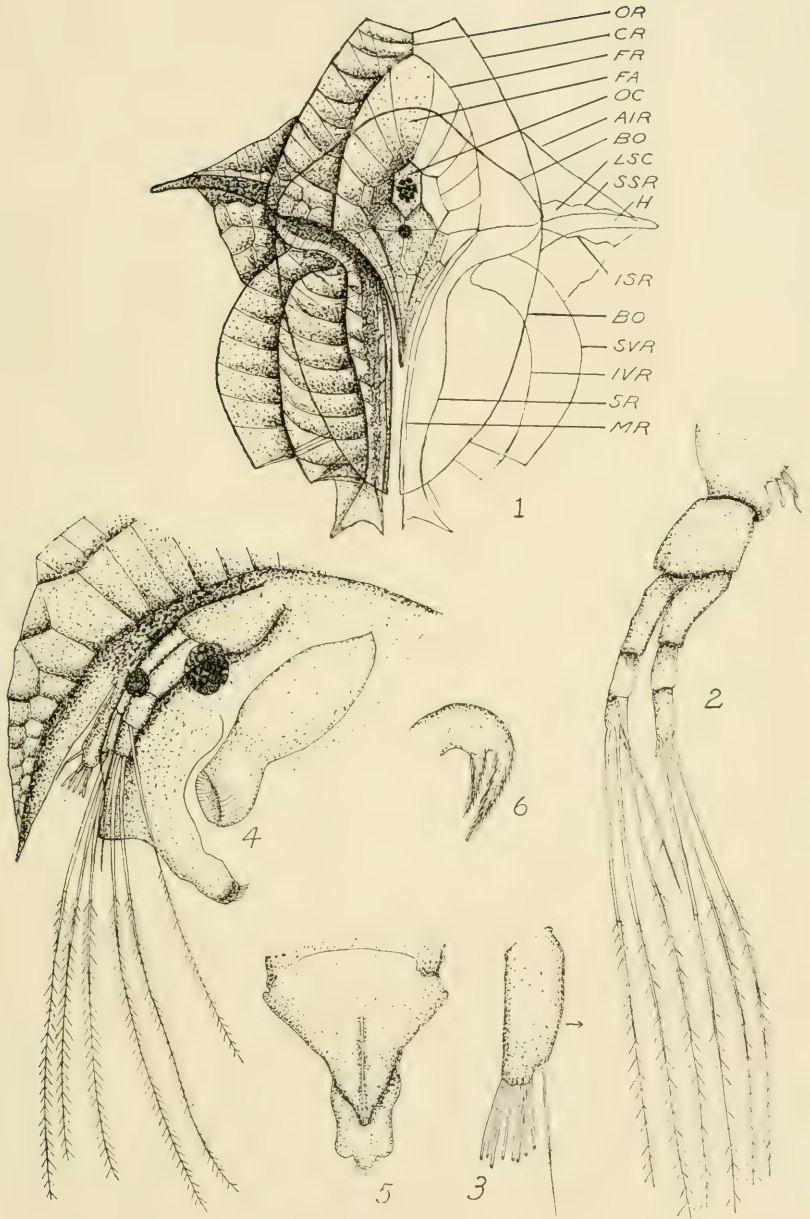
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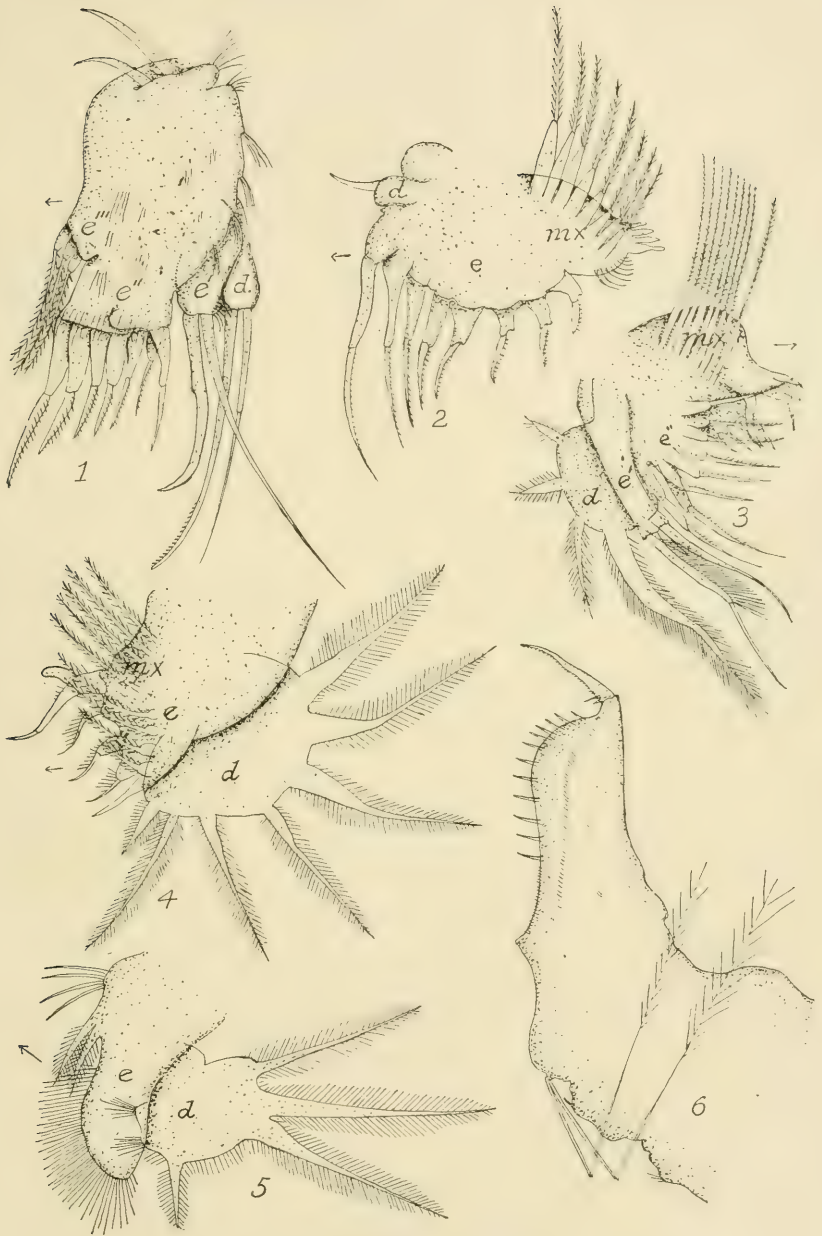
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FOR EXPLANATION OF PLATE SEE PAGES 169 AND 170.



NEW ENGLAND CLADOCERA.

FOR EXPLANATION OF PLATE SEE PAGE 170.



NEW ENGLAND CLADOCERA.

FOR EXPLANATION OF PLATE SEE PAGE 170.

A NEW UNSTALKED CRINOID FROM THE PHILIPPINE ISLANDS.

By AUSTIN HOBART CLARK,

Assistant Curator, Division of Marine Invertebrates, U. S. National Museum.

In a preliminary account of a collection of comatulids from the Philippine Islands I recorded a specimen of *Comaster multifida* as having been taken by the U. S. Bureau of Fisheries steamer *Albatross* near Port Dos Amigos, Tawi Tawi. This specimen fits the available descriptions of *C. multifida* exactly; but recently, during a visit to Paris, I was enabled to examine the type of Müller's species, and I found, much to my surprise, that it is quite a different thing from what I had supposed.

Comaster multifida is very closely related to *C. typica*, but it is a smaller species with a much smaller number of arms; these are about forty in number and show, so far as it is developed, the same scheme of arm division characteristic of *C. typica*.¹ The centrodorsal is not so much reduced as it is in *C. typica*, and usually bears a few cirri.

The *Comaster variabilis* described by Prof. F. J. Bell in 1884 is founded upon specimens both of *C. typica* and of *C. multifida*, the type being one of the former.

In the *Challenger* report Carpenter placed *Comaster multifida* in his "Parvicirra Group," far removed from *C. typica*, which was the type of his "Typica Group;" although I recognized the fact that both *multifida* and *variabilis* belonged in the genus *Comaster*, the wide separation of the forms, and the important structural differences shown by Carpenter, prevented me from detecting their fundamental agreement with *C. typica*, which was at once evident upon examination of the types.

C. multifida was supposed to differ radically from *C. typica* in having the ossicles of the division series united by synarthry instead of by syzygy. It is true that the ossicles of the division series are united by synarthry in *C. multifida*, but I have recently shown that the supposed syzygy which unites these ossicles in *C. typica* is not a syzygy at all, but a peculiarly modified synarthry, possessing many of the characters of a syzygy, a type of articulation for which I suggested the name pseudosyzygy.

¹ This is shown in Professor Döderlein's figure (Denkschr. Ges. Jena, vol. 8, 1898, pl. 36, fig. 4, "*Actinometra belli*") of a young specimen.

The specimen from Tawi Tawi agrees with *C. multifida* in having true synarthries between the ossicles of the outer division series; but it differs markedly in the scheme of arm division, and in its larger and permanent cirri. It is probably most nearly allied to *C. delicata*, but represents a very distinct new species, which may be described as follows:

COMASTER TAVIANA, new species.

Phanogenia carpenteri A. H. CLARK, Proc. U. S. Nat. Mus., vol. 36, 1909, p. 392.

Description.—Centrodorsal discoidal, broad, the polar area flat, 5 mm. in diameter; cirrus sockets arranged in a single crowded, somewhat irregular, marginal row.

Cirri XX–XXII, 16–18, moderately slender, 13 mm. to 15 mm. long; first two segments about twice as broad as long, third slightly longer than broad, fourth—seventh or eighth half again as long as broad, the following gradually decreasing in length, the terminal seven or eight being about one-third again as broad as long; ninth a transition segment, rounded in cross section and with a dull surface like the preceding in the proximal three-fourths, polished like the succeeding in the distal fourth; following the transition segment the segments become rather strongly compressed laterally, so that in a lateral view the cirrus appears to thicken from this point onward; transition and following segments with the distal dorsal edge produced, this production rapidly becoming more sharply rounded, and soon Λ -shaped, the segments at the same time becoming distally more carinate dorsally, so that the later segments are provided with a small but sharp subterminal tubercle; in addition, the segments from the eleventh or twelfth onward have, just before their middle, a second, more rounded median dorsal tubercle, not quite so high as that in the distal portion, presenting, therefore, the same appearance as the cirrus segments of *Oligometra aedeonæ*; opposing spine represented by a small median tubercle arising from the entire dorsal surface of the penultimate segment, the apex usually forming in lateral view slightly more than a right angle, though occasionally more sharp; terminal claw somewhat longer than the penultimate segment, stout basally but becoming more slender distally, moderately curved.

Ends of the basal rays visible as small tubercles in the angles of the calyx; radials only slightly visible in the angles of the calyx, over the ends of the basal rays; IBr₁ very short and broad, more or less (sometimes wholly) concealed by the centrodorsal, just in contact basally but diverging distally; IBr₂ broadly pentagonal, almost triangular, twice as broad as long, or even somewhat broader; IIBr 4 (3+4); IIIBr 2; IVBr 2, but irregular in occurrence; division series free laterally though not widely separated, rounded dorsally, but not especially convex.

Thirty-six arms about 100 mm. long; first brachial short, wedge shaped, almost entirely united interiorly, twice as broad as its interior length or slightly broader; second brachial similar, but slightly larger; third and fourth (syzygial pair) not quite so long as broad; next two brachials oblong, about twice as broad as long, then becoming triangular, about half again as broad as long, after the end of the proximal third of the arm gradually becoming wedge shaped, and in the terminal portion wedge shaped, about as long as broad; fourth and following brachials with strongly produced and finely spinous distal ends. The arm increases gradually in diameter up to the tenth brachial, then tapers away very gradually distally. Syzygies occur between the third and fourth brachials, again usually between the thirteenth and fourteenth, and distally at intervals of four (more rarely five) oblique muscular articulations.

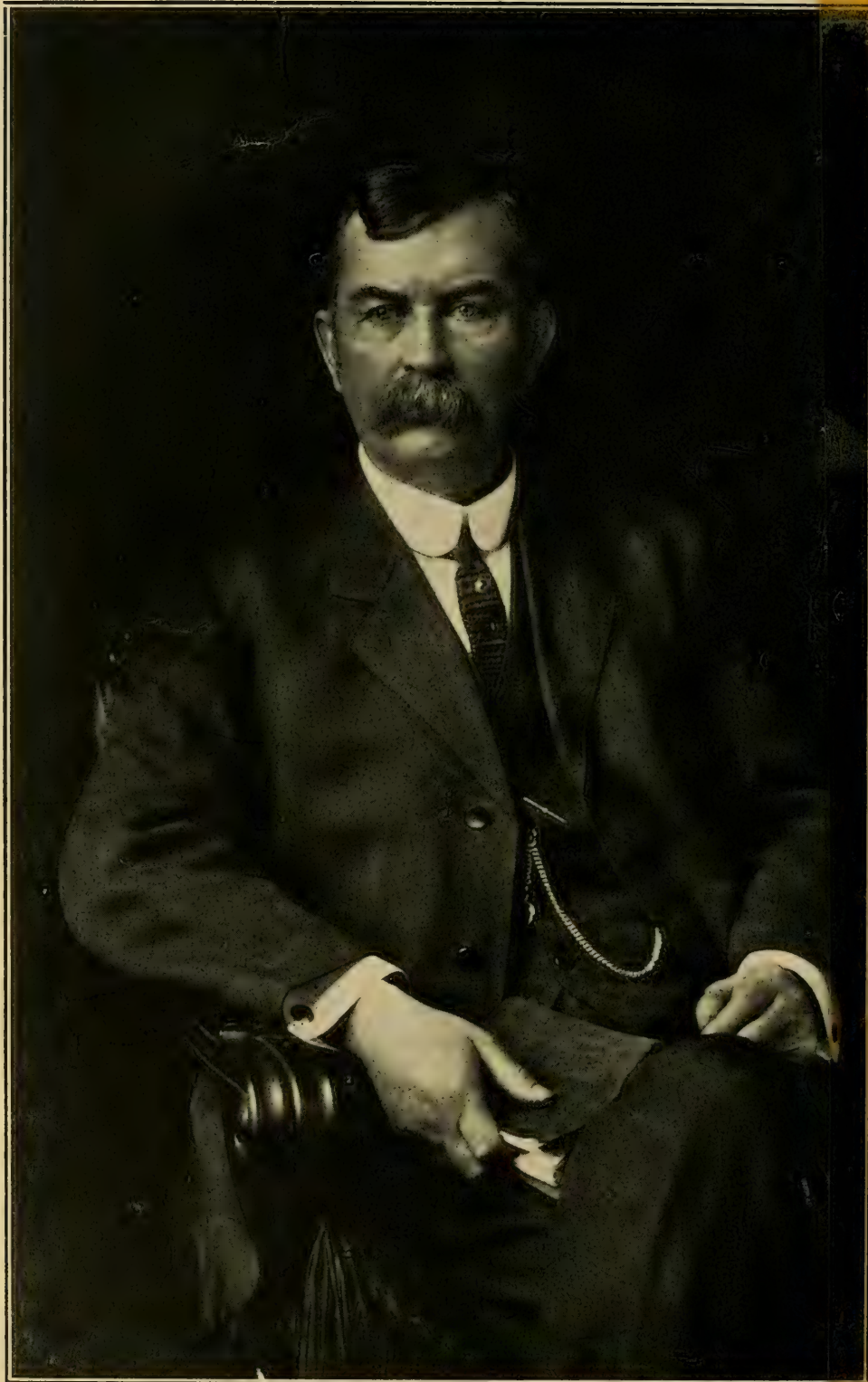
Disk covered with rather coarse papillæ; mouth submarginal, anus subcentral.

P_1 10 mm. long, slender, with thirty-five segments, of which the first is short oblong, about two and one-half times as broad as long, and the following are rhombic, at first nearly twice as broad as long, gradually becoming longer and about as long as broad after the sixth; second and following segments with the corners cut away, this gradually decreasing distally and disappearing entirely after about the twelfth segment; second to tenth or eleventh segments with long single or double spines projecting vertically from the dorsal surface, at first about equal to half the diameter of the joint in height, but slowly decreasing in length distally; terminal comb short, very prominent, rising abruptly, with six or seven teeth which are subequal, triangular, slightly longer than broad, rather strongly recurved, rather longer than the diameter of the segments which bear them, the bases in apposition; P_2 5 mm. long, with twenty segments, resembling P_1 but weaker and more slender; P_3 3.5 mm. long with fifteen segments, resembling P_2 ; P_4 and following pinnules stouter than the preceding, 6 mm. long, with about twenty segments, the first two short, the remainder squarish, becoming longer than broad distally; the distal ends of the segments are spinous and strongly overlapping, and the more proximal segments are usually furnished with more or less prominent dorsal spines in addition; distally the pinnules gradually become shorter and more slender, the distal pinnules being 6 mm. long, very slender, with about twenty segments, the first two short, the third longer than broad, the remainder elongated, with slightly expanded ends, becoming about twice as long as broad distally; terminal combs occur usually on most of the genital pinnules, and at intervals on those in the distal part of the arm.

The color is chrome yellow, the skeleton yellowish white.

Habitat.—Philippine Islands (Tawi Tawi group).

Depth.—49 fathoms.



FRANK SPRINGER

THE CRINOID FAUNA OF THE KNOBSTONE FORMATION.

By FRANK SPRINGER,
of Las Vegas, New Mexico.

In connection with my researches on the fossil Crinoidea I have encountered continual difficulty relative to the stratigraphic position of a number of important species from the Lower Carboniferous described from southern Indiana, Kentucky, and Tennessee, and found in collections made by Troost, Safford, Lyon, Wachsmuth, Pate, Greene, and others. These species in the descriptions and upon the labels in collections have been referred to a horizon where it has seemed to me increasingly more evident they do not belong.

Lyon, writing in 1860 on the "Stratigraphical arrangement of the rocks of Kentucky,"¹ gave a general section of the strata of western Kentucky, which he divided into beds designated from *A* to *X*, in descending order, grouped in two large divisions. The upper of these he called the "Millstone Grit series," including all above the Cavernous (St. Louis) limestone, and the lower the "Sub-Carboniferous series," in which he included the Black slate and the Devonian beds of the Falls of the Ohio. Taking this division above the black slate in ascending order, his beds were: *P*. Sandstones and shales; *O*. Middle limestone; *N*. Cavernous limestone. The last is clearly the St. Louis limestone of the Missouri and Iowa geologists. His "Middle limestones," *O*, he found to contain in the lower part fossiliferous beds equivalent to the Spergen Hill beds of Indiana (Spergen). His "Sandstones and marls," *P*, he says are "frequently distinguished as the Knobstone beds," and he describes them as varying in thickness from two to three hundred feet, the upper part consisting of "alternate beds of muddy sandstone, aluminous shale, and plates of limestone of variable thickness * * * sometimes largely charged with beds of chert, the lower part of beds of aluminous and marly shale, with occasionally thin beds of fine sandstone." He considers the upper part equivalent to the crinoid beds near Scottville, Allen County; the marly lower beds he says are best known in Bullit and Jefferson counties as "Button-mold Knob."

¹Trans. Acad. Sci. St. Louis, vol. 1, pp. 612-621.

Safford, in 1869,¹ divided the Lower Carboniferous of Tennessee into two groups, designated in ascending order as "(8a) Siliceous Group," and "(8b) Mountain limestone." His Mountain limestone included everything between the St. Louis and the Coal Measures, *i. e.*, the Kaskaskia. The Siliceous group he subdivided into two members, the "Upper or Lithostrotion bed," equivalent to the St. Louis limestone of the Missouri geologists, and the "Lower or Protean member," including everything from the St. Louis down to the Black slate. He considered this member as "more especially the equivalent of the Keokuk limestone" (p. 342), but adds that "it contains, however, some Burlington forms." His descriptions and sections show it to be of a variable character, but in a general way to be composed of argillaceous beds, or shales, in the lower part, and more or less siliceous, or cherty, limestones in the upper, with irregular occurrence of limestone bands among the shales and cherts.

The Lower or Protean member of Safford's Lower Carboniferous corresponds to Lyon's bed *P*; and the name "Knobstone," as mentioned by Lyon, has been given to it currently because of its exposure in many of the isolated hills, or "knobs," which form a conspicuous feature of the topography of southern Indiana and northern Kentucky. But it extends over a wide area in Kentucky and Tennessee where the knobs do not occur. In the latter state it has received the name of "Tullahoma formation," and is applied to such well-known localities as Whites Creek Springs, Tenn., and Allen and Metcalfe counties, Ky., at all of which species of undoubted Keokuk type occur. In Indiana the name "Knobstone" is adhered to, as given by Owen in 1859.² In the earlier reports of the State Geological Survey a clear distinction was recognized between the Knobstone shales, with intercalated calcareous layers, the succeeding Burlington, and the Keokuk limestone beds. In the report for 1878 (p. 379) some good sections are given of exposures in Harrison County, which is a westward continuation of the Kentucky knob region, showing over 200 feet of Knobstone shales and sandstones, including at the upper part 8 to 15 feet of thin bands of "red encrinital limestone," and above that, after several different beds of various colored siliceous clays, slates, flints, and cherts of from 30 to 70 feet, heavy Keokuk crinoidal limestone to a thickness of 40 feet or more. An earlier report, 1874 (p. 115-118), recognized the Knobstone as distinct from the Burlington and Keokuk, and treated the part consisting of sandstones and underlying bluish and greenish (New Providence) shales as equivalent to the Chemung, Waverly, and Kinderhook. It says that the "Button-mould wash," so called from the disk-shaped segments of crinoid stems found in it, is but another

¹ Geology of Tennessee, p. 339.

² Report of a Geological Reconnaissance of Indiana Rocks in 1839, p. 21.

name for the greenish marly shale of these beds; and it mentions as among the fossils occurring in these "washes" imperfect specimens of *Cyathocrinus*, *Platycrinus*, *Synbathocrinus*, *Actinocrinus*, and *Forbesiocrinus* (p. 122).

In the Fifteenth Report, 1885-86, on the Geology of Washington County, by Gorby (p. 124), it is very clearly shown that the Burlington beds are represented by certain irregular buff to gray limestones occurring between the shales and sandstones of the Knobstone and other limestones and cherts in which Keokuk species prevail; and he says (p. 132): "The tendency of the evidence leads strongly to the conclusion that these beds of this (Burlington) group separate the Keokuk from the Knobstone throughout the greater portion of Washington and Harrison Counties." In some localities in these counties red or buff limestone layers have yielded undoubted Upper Burlington species; and in Washington County certain buff, geodiferous beds lying very close to the Knobstone shales contain a characteristic Keokuk crinoid fauna, with many species identical with those found at Indian Creek, in Montgomery County.

It may be here remarked that little dependence is to be placed upon color as distinguishing the Burlington and Keokuk beds in the Indiana-Kentucky region; the one may be red and the other blue at one place, and the colors exactly reversed a short distance away; and colors of the same bed often change in short distances. In the Burlington-Keokuk beds of the typical region along the Mississippi River, which was a center of deposition with little disturbance, the coloration is extremely regular and characteristic, and a person whose early collecting was in these localities is apt to attach too much importance to color elsewhere. The southern Indiana region especially was one of many changes, and frequent invasions and recessions of the waters, accompanied by much erosion and replacement during the epoch which the Keokuk-Burlington-Warsaw beds represent; so that their thickness is extremely irregular, and in many places their vertical section is greatly reduced. Thus there may be characteristic Burlington and Keokuk, or Keokuk and Warsaw, fossils at the same exposure from a few feet of strata. There have also been extensive later denudations cutting through several beds of rocks, and redistribution of the material, with its contained fossils, from one area to another, so that those from two or three successive formations may be found together in the same bed of clay. This is clearly stated in the last-mentioned report (p. 135), and is borne out by the experience of every careful collector. For instance, the well-known locality of Spergen Hill, which name is really applied to fossils collected over an area of several square miles covered by a deposit of reddish ferruginous clays, containing the

residuum of decomposed limestones, chiefly the so-called Oolite of the Salem quarries, which form the surface rocks of the region. This clay is very fossiliferous, and specimens from it are found in many collections, in some labeled "Warsaw" and in others "St. Louis." These names mean here the same thing—a bed of foraminiferal limestone and the clay composed of its decomposed remains, characterized by a great abundance of *Pentremites conoideus*, usually called Warsaw by the Indiana geologists and often St. Louis by others. It is immediately underlaid by the Keokuk, which is exposed in some places, as in the railroad cut at Spergen Hill, and from the erosion of which its fossils have also sometimes been mingled in the same red clay and have taken on its color. A few have been obtained directly from the rocks and are of its original bluish-gray color. Therefore, while the great majority of the fossils labeled "Spergen Hill" are doubtless derived from the Spergen beds, it is always possible to find a true Keokuk species among them.

Returning now after this digression to the Knobstone, the later Indiana geologists did not adhere to its distinct separation from the beds above it, as was done by those of 1874–85, but the Geological Survey of that state¹ has extended it so as to definitely include, in the north, the typical Keokuk crinoid beds of Crawfordsville and Indian Creek in Montgomery County.

There being thus included in this formation, in all three of the states mentioned, crinoidal beds yielding species of a true Keokuk fauna correlating strictly with the occurrences at the typical localities in Iowa and Illinois, it came to pass that the entire so-called "Knobstone" of Indiana and Kentucky, and Tullahoma of Tennessee, have been regarded by some geologists as belonging to the Keokuk epoch, and collectors labeled their fossils derived from it indiscriminately as "Keokuk." All the species described by Miller and Gurley from these beds have been referred to the Keokuk; and S. A. Miller went so far as to claim that the Waverly beds at Richfield, Ohio, also belong to the Keokuk; and in the second Appendix to his *North American Geology and Paleontology*, 1897, he referred all the species of crinoids described by Hall from that locality to that horizon. (See also Bull. No. 12, Ill. State Mus., p. 11.)

This prevalent conception of the stratigraphy of these beds has completely ignored the possibility of the prolific Kinderhook and Burlington series being represented in them, somewhere between the Black Slate and the Upper Siliceous limestones of undoubted Keokuk equivalency—and it illustrates how, even in science, people will often go on following the leader without knowing why.

Now, to the systematic student of the crinoids, seeking to find out something of their actual geologic succession and phylogenetic

¹ Twenty-sixth report, for 1901, pp. 263, 272.

relations, it makes considerable difference whether a given species is said to be derived from the Keokuk Limestone or from the lower beds of the Burlington or the Kinderhook, for these stand for the extremes in what is probably the best, and best preserved, line of local crinoid development in all geological history. The Burlington and Keokuk beds represent the acme of crinoidal life, both in variety of form and profusion of individuals, and it was the overwhelmingly predominant faunal feature of those epochs. So profuse is its development that it has been proposed by Wachsmuth and Springer and by Keyes to recognize this by grouping the two formations into a distinct division of the Lower Carboniferous, for which Keyes¹ proposed the name "Augusta," and Williams, before him,² with slightly different limitations, that of "Osage."

Of more importance than this, however, is the fact that faunal considerations have required us to further subdivide it, so as to recognize the upper and lower beds of the Burlington as well marked and distinct horizons. There is a thoroughly well-defined succession in the crinoidal fauna, beginning in the Lower Burlington with a predominance of species characterized by great delicacy of form and beauty of ornamentation, and culminating in the Keokuk with prevalent forms of large size, rough ornamentation, and much exaggeration of structural details, in many cases marking the extinction of the genera. Between these there is a distinctly intermediate condition, represented by the Upper Burlington. The three formations are separated by heavy transition beds of chert, each marking the extinction of most of the species and some of the genera of the bed preceding it, and the inauguration of a rougher habit in the forms which follow. These facts were pointed out long ago by White,³ Wachsmuth and Springer,⁴ and Keyes.⁵ The modifications here indicated do not apply to all the species, some simpler forms of a more generalized type persisting through the beds with little change, while in some there was a distinct retrogression, resulting in ultimate extinction through diminished vitality. But in the specialized and predominant types, like *Camerata*, the process of acceleration and abrupt termination from one bed to another and at the close of the epoch was most striking.

The focus of this profuse development of crinoidal life was the region near and west of the Mississippi River, in Iowa, Illinois, and Missouri. It was a deep and clear water formation, little disturbed by oscillation or other causes, and continuous through a long period, except for the changes produced by the repeated increase in the

¹ Iowa Geological Survey, vol. 1, 1892, p. 61.

² Bull. 80, U. S. Geol. Surv., 1891, p. 109.

³ Journ. Boston Soc. Nat. Hist., vol. 7, 1860, pp. 224-225.

⁴ Proc. Acad. Nat. Sci. Philadelphia, 1878, p. 229.

⁵ Geol. Surv. Iowa, vol. 1, 1893, p. 65.

siliceous content of the water at the end of the subordinate periods. The main beds of each period are formed of remarkably homogeneous limestones, very regularly and evenly stratified, almost entirely composed of the calcareous remains of countless myriads of crinoids, and interrupted only by the siliceous invasions above mentioned, resulting in the deposition of the heavy cherty beds of passage between the different members. It has a total thickness of upward of 200 feet of solid limestones and chert, the latter being one-third or more of the whole. The chert beds are not wholly barren, for thin bands or lenses of limestone are found irregularly throughout them, often filled with remains of crinoids that struggled through under the changed environment. The coloration of the limestone beds is remarkably uniform for each horizon. There is little muddy shale until rather late in the Keokuk, when there were evidently considerable changes of level, with migration into shallower waters to the eastward, resulting in the deposit of the shale beds of the Crawfordsville region in Indiana.

These facts indicate an unusually favorable condition for a succession of life during long periods, and for this reason the Mississippi River region above indicated is taken as the typical one for this formation, with which other occurrences of any of its members should be compared, when considering their faunal or stratigraphic relations. This was not the case with the occurrences in southern Indiana and Kentucky, where, as already pointed out, there must have been frequent changes of level and of chemical constituents, resulting in much irregularity and interruption in the deposition of the strata and variability in their fossil contents. There was evidently a strong migration of Keokuk species to the southward, for there is a more definite assemblage of typical forms in Kentucky and Tennessee than in the central Indiana region.

The boundary between the two Burlington beds is really more sharply marked than that between the Burlington and Keokuk, there being a much more gradual transition of forms between the latter, and the passage beds being more fossiliferous. Between the Lower Burlington and the beds preceding it there is no such definite line of separation.

In White's original section at Burlington¹ the top of the Kinderhook—his bed No. 7—is shown to be an impure limestone, sometimes magnesian, which passes insensibly into the Lower Burlington Limestone. It is thin at that point, but thickens to the northwest to 40 feet of limestone containing the rich fossil beds of LeGrand, in Marshall County; and to the southward it also thickens to upward of 100 feet in Missouri, where it takes the name in part of the Louisiana and in part the Choteau Limestone; and occasional highly fossiliferous beds of shale, like those at Fern Glen, may constitute a

¹ Geology of Iowa, vol. 1, 1870, p. 193.

part of it. While there is some difference in species between this and the beds called Lower Burlington, yet the general type remains the same, and there is no such extinction of genera and of conspicuous species as is found between the later members of the formation. Below this bed are a number of irregular layers, mostly of limestone, some of them oolitic, brecciated, or shaly, and some of sandstone; all of them extremely variable locally and in many places absent; but everywhere at the base of the formation is a great thickness of argillaceous and sandy shales overlying the Black Slate. If the crinoidal content of the formations is to govern, it would probably be more logical and would simplify the geology of the formation if all these beds above the heavy shales and lower sandstones were ranked with the Lower Burlington as one member. Those parts of the formation embraced in the Upper Burlington and Keokuk, representing a period of culmination and extinction, are of relatively restricted extent, while the earlier portion, namely, Lower Burlington-Choteau-Waverly-Kinderhook (in part), is of very wide geographical distribution. It is found on the flank of the Rocky Mountains, in New Mexico and Montana, and the Mountain Limestone of Great Britain and Belgium is substantially its equivalent, containing most of its characteristic genera, and many species scarcely distinguishable, but none of those peculiar to the succeeding members here.

No one acquainted with the fauna of this formation, as disclosed at numerous localities in the typical region above indicated, would ever mistake a set of crinoids from the Lower Burlington for Keokuk, or the opposite. While a few of the more generalized forms, like *Cyathocrinus*, are similar, the characteristic species are widely different, and several important genera have become wholly extinct within the Burlington, *e. g.*, *Megistocrinus*, *Amphoraocrinus*, *Cactocrinus*, *Steganocrinus*, *Telciocrinus*, *Strotocrinus*, the discoid *Platy-crini*, *Metichthyocrinus*, *Mespilocrinus*, *Wachsmuthicrinus*, *Belemnocrinus*, and the blastoid genera *Orophocrinus*, *Schizoblastus*, *Cryptoblastus*, *Orbitremites*, and *Codaster*. On the other hand, the paired arm structure so frequent in the Keokuk—as in *Dizygocrinus*—is known in but one species in the Lower Burlington; the large and rugose *Actinocrini*, *Dorycrini*, and *Agaricocrini* are represented only by a few small and delicate species; and the important genera of the *Flexiblia*, *Onychocrinus* and the so-called *Forbesiocrinus* of the type of *F. wortheni*, etc., not at all. In the typical region there is no trouble whatever in distinguishing these beds by their crinoidal fauna.

But when we come to species described from the southern Indiana-Kentucky-Tennessee region, and the collections made therein by Lyon, Safford, Wachsmuth, Greene, and others, I have been constantly

perplexed by the reference to the Keokuk horizon of many forms, including several genera which had never been seen in that position in the typical region, but which would have seemed perfectly at home in the Lower Burlington. These reputed occurrences seriously interfered with the logical sequence of several specialized genera, whose position was otherwise perfectly clear. After a while I came to suspect that the real trouble lay in the correlation of the Knobstone beds, and I concluded to undertake a reexamination of that region, with a view of determining the actual horizon of its fossils. In this I was encouraged by Doctor Weller of the University of Chicago, who expressed the opinion, based upon his own extensive studies of the Kinderhook, that the Knobstone fauna was more likely to prove Kinderhook than Keokuk.

Accordingly, in 1909, I sent the veteran collector, Frederick Braun, into the field to make a careful and systematic collection from the so-called Knobstone beds from the northern limit of the knobs in Indiana, to and including the famous Button-mould Knob region of Jefferson and Bullit counties, Kentucky, and thence as far south, along the Devono-Carboniferous outcrop, as time would permit. He spent the entire season at this work, covering the ground thoroughly from Washington and Clark counties, Indiana, to Marion County, in central Kentucky. Good specimens of crinoids have always been rare at the Knobs, but Braun was instructed to collect minutely all fragments and detached plates. In this way he accumulated a large quantity of material from the weathered slopes of the talus—the so-called Button-mould washes—and from ravines and fields formed by their erosion. The crinoids are chiefly derived from the disintegration of thin limestone bands interbedded in the argillaceous shales and marls, and are usually highly silicified, often pure flint. It is rarely possible to find them in place, and therefore we can not designate the exact layers from which they came; but it is usually practicable to fix their approximate limits, and to say whether they were derived from the main body of the Knob, or only from siliceous limestones at the upper part of the section.

This material, when assembled, showed clearly—

1. That there were no characteristically Keokuk forms in the débris of the Knobs in southern Indiana, or those of the Button-mould Knob region; but farther south in Marion County, where well-defined heavy beds of siliceous limestone cap the hills, true Keokuk species, such as *Dorycrinus gouldi*, *Actinocrinus jugosus*, *Agaricocrinus americanus*, began to appear, more or less intermingled with the others, but their origin was evident.

2. That the whole fauna, except the last-mentioned occurrences, is of unmistakably Lower Burlington type.

3. That this fauna includes a number of reputed Keokuk species occurring at Whites Creek Springs, Tennessee, where true Keokuk forms are also known to occur; among these the rare "*Ichthyocrinus*" *tiaræformis* of Troost.

As the Whites Creek region was known to present a section from the Niagara to the Warsaw, and to be one of tremendous erosion, it now seemed probable that the equivalent of the Button-mould Knob beds would be found there, although not heretofore recognized, with an intermingling of fossils from the erosion of these and the overlying Keokuk beds, which would account for the confusion of faunas already mentioned. I therefore thought it advisable to have that region carefully searched anew, under the guidance of an experienced geologist. I was so fortunate as to enlist the interest of Dr. R. S. Bassler, of the U. S. National Museum, in the question, and he readily consented to undertake the examination, which he made in company with Mr. Braun, in June, 1910, after first carefully studying the beds at Button-mould Knob and vicinity. My thanks are due to Dr. Richard Rathbun, assistant secretary of the Smithsonian Institution, for kindly granting Doctor Bassler leave of absence from office duties for that purpose.

Doctor Bassler's observations, more fully set forth in his accompanying paper, clearly demonstrated that the Button-mould Knob beds are present at Whites Creek, and fully confirmed the suspicion of the intermingling of their fossils with those of the Keokuk limestones above. His researches have cleared up the complex stratigraphy of that region, and placed the correlation of the Knobstone beds upon a sound basis, as shown in his account, where the geological details are given in full. A series of authentic collections, made at the same time by Mr. Braun, makes possible a close comparison of the Whites Creek fauna with that of the Knobs. In addition to this, I have had the advantage of examining the collection of the Vanderbilt University in Nashville, which was generously placed at my disposal by Prof. L. C. Glenn, of the department of geology of that institution. It includes the original collection of Safford, with others since made by Professor Glenn, and is a useful addition to the other material when interpreted in the light of our present knowledge of the Whites Creek beds.

I may mention also that during Mr. Braun's work of 1909 he made a general collection of other fossils at the Knobs, which I placed in the hands of Doctor Weller, who informs me that he finds them of a decidedly pre-Keokuk type. And in this connection I would also call attention to Weller's paper on the fauna of the Fern Glen formation,¹ from shaly layers immediately underlying limestones referable

¹ Bull. Geol. Soc. America, vol. 20, pp. 265-332.

to the Burlington. These beds are undoubtedly equivalent to some part of the Knobs series, and some of the species occurring there will be referred to in the list which is to follow.

The locality of Whites Creek is an extremely interesting one. It was referred to by Safford in his *Geology of Tennessee*, 1860, page 342, as a good representative of his Lower, or Protean, member of the Lower Carboniferous. He gave a list of the fossils occurring there, of which he said: "Most of the above species occurring outside of Tennessee are Keokuk forms." And from that day to this every fossil collected at Whites Creek above the Niagara beds has been labeled "Keokuk," if the local name, Tullahoma, was not employed. As before stated, the section in the vicinity extends from the Niagara to the Warsaw. According to Bassler's section, a bed of green Kinderhook shale overlies the Black Slate, followed by about 35 feet of rather light gray limestone, which is massive on first exposure, but upon weathering produces material similar to that in the talus of the middle or upper layers in the Knobs. This limestone is highly fossiliferous, and contains numerous crinoid remains. Above it is a heavy bed of siliceous Keokuk Limestone, containing crinoids similar to those of Barren County, Kentucky, and of the typical Keokuk. This weathers to a reddish, or dirty yellow, clay, which imparts its color to objects embedded in it.

The country is rough, with many hills, ridges, or small mountains, separated by numerous ravines and gullies leading to level fields below. Erosion has been great, and the gullies and fields contain the washings from the entire slopes of the ridges and mountains, often deposited in thick and very ancient clay beds. The reddish Keokuk Limestone caps the hills, while the gray limestone overlying the shales is in the slopes below it.

Now, fossils found in place at the top of the hills can be depended upon as Keokuk; they are usually reddish or dirty yellow in color, like the rock containing them, highly siliceous, and often geodized—a frequent occurrence in the Keokuk. Those found in place in the gray limestone are a dirty bluish or gray, sometimes geodized, but more often entirely replaced by silica as solid as flint. But these same fossils, when transported by erosion down the slopes, and buried under soil washed from the beds above, take on a reddish or reddish-brown color; and as the fossils of both beds are highly siliceous, it is impossible to distinguish such specimens with certainty by their physical appearance. Again, the fossils from the upper beds, when long embedded in the clays derived from the gray limestone, or from the shales below it, have lost their reddish color and have come to resemble those of the lower limestone. It is evident, therefore, that specimens found in the washes, gullies, slopes, or fields below the top of the hills may be from either the Keokuk or the gray limestone;

and if below the upper level of the latter, may be from both intermingled. This was the condition in a plowed field where Wachsmuth, over 20 years ago, made one of the best collections ever obtained at Whites Creek, in which the fossils, although evidently mostly from the gray limestone, as we now know, were nearly all of the reddish or yellowish color of the soil. In fact, we not infrequently find a specimen which is partly reddish and partly bluish, from having been buried in partial contact with a clay derived from one or the other of the beds.

Furthermore, in such limestones as these gray beds we may expect small bands or pockets colored with ferric oxide, from which the fossils come out reddish or yellowish. This is quite frequent in the limestones and cherts at Burlington. I would also expect to find the bluish color from the lower beds running up to the Keokuk layers.

Hence we can not depend upon color as a guide to the origin of the specimens, and it should be disregarded altogether in their consideration.

Alloprosallocrinus conicus, for instance, is an unquestioned Keokuk species, and we find it both red and blue; so with *Lobocrinus nashvillae*, and *Agaricocrinus americanus*. On the other hand, species known to occur in the Knobstone layers of Button-mould Knob are found here in both colors—as, for instance, *Metichthyocrinus tiariformis*, *Catillocrinus tennesseensis*, etc. In general, it may be said that the fossils from the lower limestone are usually more solid flint, and less often geodized, while those of the Keokuk beds are more imperfectly silicified, and frequently geodized. Neither is this a reliable criterion, as these differences are sometimes found elsewhere in one and the same bed.

The crinoids of this locality are more frequently found intact than at the Knobs, and we were fortunate in securing a fair series of them from each bed in place; these furnish a firm basis of comparison to begin with. They include the following species:

A. Undoubted Keokuk, from top of hills:

Agaricocrinus americanus.

Agaricocrinus nodulosus.

Lobocrinus nashvillae.

Alloprosallocrinus conicus.

Eretmocrinus ramulosus.

Eretmocrinus praegravis.

Dorycrinus gouldi.

B. Below the Keokuk, in grey limestone:

Eretmocrinus, large arm fragments and parts of calyx—probably

E. yandelli.

Agaricocrinus, small species with 10 arms.

Metichthyocrinus tiaraeformis.

Barycrinus cornutus.

Barycrinus, cf. *rhombiferus*.

Cyathocrinus, small smooth species.

Cyathocrinus, elongate and highly ornamented.

Poteriocrinus, large elongate species.

Catillocrinus tennesseensis.

Halysiocrinus perplexus.

Synbathocrinus robustus.

Every one of list B was found at Button-mould Knob, but not one of list A.

The material obtained by Braun from the Knobs, while abundant in quantity, seemed rather discouraging at first, owing to its fragmentary character. Along with a few complete calices, it consisted mainly of an immense number of loose calyx plates. Many of these, however, were of forms marked by conspicuous and delicate ornamentation, such as occur peculiarly in the lower beds at Burlington; and by patiently assorting them, I found that I could separate a large number of specific forms, in some cases finding enough of the different plates of a form to enable me to reconstruct representative specimens, sufficient for figuring hereafter, in the case of several new species. These, added to what I already had from previous collections, notably the Lyon collection acquired by me some years ago, gave me a total of some 45 species from the Knobs, which can be compared with those of other localities.

With these explanations, necessary for a proper understanding of the relations of this fauna, I will give a list of the species found in the Knobstone beds of various localities, and some known to be from Keokuk beds, lying above those under consideration. To save some needless repetition, I will first give the localities to be referred to:

George Palmer's farm, Clark County, Indiana.

Stone's farm, 9 miles southeast of Borden County, Indiana.

Near Henryville, Clark County, Indiana.

Williams' farm, near Rush Creek, Indiana.

Button-mould Knob, Bullitt County, Kentucky.

Bradbury Knob, Bullitt County, Kentucky.

Jacobs Knob, Bullitt County, Kentucky.

Bells Knob, Marion County, Kentucky.

Bradfordsville, Marion County, Kentucky.

Sallietown, Marion County, Kentucky.

Whites Creek, Davidson County, Tennessee.

Fern Glen, 20 miles west of St. Louis, Missouri.

LIST OF THE KNOBSTONE CRINOIDEA.

GILBERTSOCRINUS Phillips.

G. cf. tenuiradiatus Hall, Lower Burlington, Burlington, Iowa.

This is only a fragment, consisting of part of an interradial appendage, rather delicate, ornamented with small, sharp tubercles on the dorsal side, and, what is most important, having only two rows of covering plates—a true Burlington type, never found in the Keokuk, where all species have four.

Locality.—Button-mould Knob.

ERETMOCRINUS Lyon and Casseday.

1. *E. yandelli* (Shumard). (Trans. Acad. Sci. St. Louis, vol. 1, 1860, p. 76.) Syn. *E. prodigialis* Miller and Gurley. (Bull. No. 7, Illinois State Mus., 1895, p. 39.)

Referred to Keokuk Group by all authors. I have the types in the Lyon collection from Button-mould Knob, and good specimens were found there and in neighboring knobs by Braun. Arm fragments of some large *Eretmocrinus* were found in the same bed. This well-known species was referred by Waeshsmuth and Springer to *Loboecrinus*,¹ to which I do not now agree; in the absence of the arms which have not been found attached, it is difficult to place satisfactorily, but is more probably an *Eretmocrinus*. It has not the projecting basal rim of the genus generally, but this is true also of some Lower Burlington forms, where the genus is represented by several species; and it ranges from the Kinderhook to the Keokuk. This species has not been found except at the Kentucky Knobs. Miller and Gurley described *E. prodigialis* upon a specimen of it from the type locality, unusually mature, and having abnormally a few extra arms. This species has superficially more of a Keokuk aspect than any of the others of the supposed Knobstone fossils. It is very large for the genus, and has a rugose appearance from its highly tumid plates both dorsally and ventrally; but these plates on the ventral side, in well-preserved specimens, are found to be covered with a distinct ornamentation formed by small raised tubercles, such as is not usual in Keokuk forms. A number of specimens have been found, all in the so-called "washes" at Button-mould and adjacent knobs; but none at any true Keokuk locality.

Locality.—Button-mould and Jacobs Knobs, Kentucky; not found at Whites Creek.

2. *E. praegravis* Miller.

3. *E. ramulosus* Hall.

¹ North American Crinoidea Camerata, 1897, p. 441.

These are both large species, from the typical Keokuk or passage beds from the Burlington; they are found in place in the Keokuk beds at the top of the hills at Whites Creek, but are not found at the Knobs.

4. *E. cf. matuta*. A small species occurring in the Lower Burlington; several good specimens at Whites Creek.

LOBOCRINUS Wachsmuth and Springer.

L. nashvillae Hall, is another typical Keokuk and Upper Burlington species, found in the Mississippi River region, and in Barren and Metcalfe counties, Kentucky. It occurs in the Keokuk beds at Whites Creek, where it was found in place, but not at the Knobs in Bullitt County. It is reported from one locality in Marion County, where it probably came from the limestone beds at the top.

L. robustus Wachsmuth and Springer. Described from Whites Creek; found in the upper Keokuk beds, and not found at the Knobs.

DORYCRINUS Roemer.

D. gouldi Hall. Typical Keokuk species of Iowa; is found at Whites Creek, but not at Button-mould Knob.

AGARICOCRINUS Hall.

A. americanus Roemer.

A. nodulosus Meek and Worthen; both typical Keokuk species; are abundant in the Keokuk beds at the top of the hills at Whites Creek but not found at the Knobs. There are fragments of large *Agaricocrinus* at Button-mould, unidentifiable, and a small form, with ten arms, that might be a Burlington or Keokuk species.

MEGISTOCRINUS Owen and Shumard.

Fragments of large stems, clearly belonging to this genus, are found at Button-mould and Bradbury Knobs, but have not been noted at Whites Creek. It is a Devonian genus, becoming extinct with the Burlington.

AMPHORACRINUS Austin.

Spinous tegmen plates belonging to this genus occur at Button-mould and Bradbury Knobs, Whites Creek, and at Fern Glen, Missouri. This is essentially a Choteau-Lower Burlington genus, ending with the latter horizon, where it is represented by two fine species. Species have been described from the Kinderhook of Jersey County, Illinois, the Choteau of Sedalia, Missouri, and the Waverly of Richfield, Ohio; and it occurs at Lake Valley, New Mexico. It is also one of the leading crinoids of the Mountain Limestone of England. It is emphatically a pre-Keokuk genus, and did not so far as known even enter the Upper Burlington.

ACTINOCRINUS Miller.

A. jugosus Hall, or a similar species, occur at Whites Creek, but not found in place. The base and loose plates of the same type were found at the Joe Bell Knob, near Lebanon, Kentucky, associated with *Dorycrinus gouldi*, and probably came from the upper limestone. There are also a few loose plates at Button-mould Knob referable to some species of *Actinocrinus*. The genus ranges from the Lower Burlington to the Keokuk.

CACTOCRINUS Wachsmuth and Springer.

Arm fragments characteristic of this genus, with short, spiny nodes on every third, fourth, and fifth brachial, were found at the Knobs. No trace of this genus has been seen above the Lower Burlington.

Localities.—Button-mould Knob; Stone's Farm; Whites Creek; Fern Glen.

PLATYCRINUS Miller.

Many detached radial plates, and a few basal disks. All are of Lower Burlington types, and not one of them can be positively referred to a Keokuk species or type. Several forms can be distinguished which may be compared with described species as identical or closely allied. My comparison is mainly with species known at Burlington, and not with those described by Miller from the Choteau of Missouri, some of which are probably closer, but of which I have not the specimens at hand.

1. Discoid form, base only; small, thick, with very coarse nodes, elongated toward the corners of the basal pentagon: cf. *P. yandelli* Owen and Shumard, Lower Burlington.

Locality.—Button-mould Knob; Bradbury Knob, Kentucky.

2. Low discoid form, base only; very small with a single prominent node just below each corner of basal pentagon: May be *P. americanus* Hall, or young of *P. yandelli*, both Lower Burlington.

Locality.—Button-mould Knob.

3. Discoid form with very long radials, and facets projecting beyond the limits of the calyx, proximal part of the rays very deep and narrow. It is the form described by S. A. Miller from the Lower Burlington at Sedalia, Missouri, as *P. occidentalis*,¹ which is a good species of this type, and not a synonym, as stated in North American Crinoidea Camerata, page 728.

Locality.—Whites Creek, in place in the gray limestone; it occurs also at Fern Glen, and a form probably identical with it is abundant in the equivalent beds at Lake Valley, New Mexico.

The discoid *Platynerini* are characteristically Lower Burlington, and not Keokuk.

¹ Bull. No. 4, Geol. Surv. Missouri, p 10.

4. Elongate form, with straight sides; very thin plates, perfectly smooth, with small radial facets, deeply indented: *P. planus* Owen and Shumard; Lower Burlington; also found in the Mountain Limestone of Belgium.

Locality.—Button-mould Knob; also Lake Valley, New Mexico.

5. Similar to the last, but with a few small nodes, forming lines from radial facets to middle and corners of plates.

Locality.—Button-mould and Bradbury Knobs, Kentucky.

6. Elongate form, with slightly spreading sides; thin plates, very small facets, but little indented in upper margin of radials; plates evenly curved, but little depressed at the sutures. Very fine nodes or tubercles, sometimes confluent, forming faint lines parallel to margins of plates. One good calyx and detached plates. Is nearer to *P. granosus* de Koninck and Lehon of the Mountain Limestone of Belgium than to any American species, but may be compared with *P. scobina* Meek and Worthen, Lower Burlington.

Locality.—Button-mould Knob.

7. Erect form, not elongate, slightly spreading; small facets, directed upward; fairly thick plates with beveled sutures; rows of moderate sized nodes run from facets to corners of radials: *P. pocilliformis*, Lower Burlington Limestone.

Locality.—Whites Creek; one good calyx.

8. Erect form, large, spreading calyx; thin plates; facets wide and shallow; ornamented with good-sized nodes, thickly distributed without definite arrangement on basals and radials.

Locality.—Button-mould Knob; similar form from Fern Glen, Missouri, and Lake Valley, New Mexico.

9. Elongate form, medium size, with spreading cup and stronger plates than the preceding; ornamented with a few scattered nodes on radials and basals; radial facets wide and shallow: *P. verrucosus* Hall, Lower Burlington, but larger than usual at Burlington.

Locality.—Button-mould Knob.

10. Elongate, calyx moderately spreading; large, with strong plates; radial facets wide; smooth, or slightly marked with obscure ridges: *P. sculptus* Hall, Lower Burlington.

Locality.—Button-mould Knob; Bradbury Knob; and Bell Knob, near Lebanon, Kentucky. This is the only form that might perhaps be referred to a Keokuk species of *Platyerinus* or *Eucladocrinus*. Some plates from Bell Knob are more elongate than those at Button-mould Knob, but similar variations from moderate to quite elongate can be seen among specimens from Burlington labeled as above.

11. Base of a small, smooth species, similar to *P. burlingtonensis* Owen and Shumard, Lower Burlington.

Locality.—Stone's farm, Clark County, Indiana.

A close comparison with actual specimens from the English Lower Carboniferous may show some of the above forms to be indistinguishable from them by the calyx alone. It is interesting to note in passing that the only American *Platycrini* having a long anal tube like *P. laevis* of the English and Irish Mountain Limestone, as figured by Austin, are one from the Lower Burlington and one from the Lower Carboniferous beds in Nevada. The best known and best preserved species of the Burlington and Keokuk have nothing of the kind.

WACHSMUTHICRINUS Springer.

1. *W. spinosulus* (Miller and Gurley). Described as *Ichthyocrinus*, and said by the authors¹ to have been "found in Clark County, Indiana, in what is called the Knobstone, but which we think must be of the age of the Keokuk Group."

Locality.—Several specimens are from Stone's farm, Clark County, Indiana, and Mr. Greene informs me that the type was found by him at the same place.

2. A smooth form, without nodes or spines, undescribed, from the same locality, and also from the Knobstone beds in the neighborhood of Junction City, Kentucky, along the outcrop eastward from Lebanon.

This genus is characteristically Lower Burlington, a single specimen only being known from the upper bed. It occurs also at Fern Glen, Missouri, Lake Valley, New Mexico, and in the Mountain Limestone of England.

MESPILOCRINUS de Koninck and Lehon.

Good specimens of two new species at Button-mould Knob and at Stone's farm; also stem fragments at Fern Glen, Missouri. The genus occurs in the Mountain Limestone of Belgium and England, and in the Lower and (rarely) Upper Burlington Limestone at Burlington, and in the Choteau of Missouri. It is a highly specialized form, and no trace of it has ever been seen in the Keokuk rocks.

METICHTHYOCRINUS Springer.

1. *M. tiaraeformis* (Troost, Hall). Described as *Ichthyocrinus*, and the horizon is stated by Hall, Wachsmuth and Springer, and Miller, simply as the Subcarboniferous. Oral tradition has always assigned it to the Keokuk, and in the republication of Troost's Monograph² the horizon is given as the "Keokuk horizon of the Tullahoma formation." The type is from Whites Creek, of a rather neutral, or dirty yellowish color. I have another almost identical with it; one of a more reddish color; and two of a decided

¹ Bull. Illinois State Mus., No. 5, p. 45.

² Bull. 64, U. S. Nat. Mus., p. 100.

bluish gray, one of which came directly out of the gray limestone of that locality. There is also a very dark, flinty specimen from a knob just south of Louisville.

2. *M. clarkensis* (Miller and Gurley); said by the authors to be from the Keokuk or Warsaw Group, Clark County, Indiana.¹ I have specimens of it from the Knobstone at Stone's farm, and near Henryville, Clark County, Indiana, and I have no doubt that the type came from the same horizon; I also have it from Button-mould Knob.

The genus is well represented in the Lower Burlington by *M. burlingtonensis*, and the species, or a similar one, occurs at Fern Glen, Missouri. Fragmentary specimens from Button-mould Knob might also be referred to it, as it can not be distinguished from *M. clarkensis* by the base alone. Only one doubtful specimen of the genus has been reported from the Upper Burlington, and no indication of it has ever been seen in the typical Keokuk.

TAXOCRINUS Phillips.

A highly ornamented form, of which we have only broken parts of calyx and arms, not resembling any Keokuk species, but nearer to an undescribed species from the Lower Burlington at Burlington.

Locality.—Button-mould Knob; Stone's farm, Clark County, Indiana.

FORBESIOCRINUS de Koninck and Lehon.

Calyx plates similar to those from the Mountain Limestone of Tournai, Belgium, were found at Stone's farm, and Palmer's farm, Clark County, Indiana, and Button-mould Knob, Kentucky; also at Fern Glen, Missouri, and Lake Valley, New Mexico. Recent studies of the type, and some better specimens since found, of de Koninck and Lehon's species, *F. nobilis*,² have shown that this is a good genus, and that the name will stand as proposed by the authors. But the Belgian species belongs to a type quite distinct from all the American species which have been described under this name, with the single exception of Hall's *Forbesiocrinus communis*³ from the Waverly Group at Richfield, Ohio, a horizon equivalent in part to the Knobstone.

F. saffordi (Hall),⁴ the largest species of the genus. The original specimen came from Whites Creek, and is of a preservation much resembling those specimens found in place in the Keokuk beds. I have several specimens of the species from the red clays of the Warsaw horizon at Spergen Hill, Indiana, and there is no doubt that it belongs to the upper, true Keokuk, beds at Whites Creek.

¹ Bull. No. 5, Illinois State Mus., p. 43.

² Rech. Crin. Carb. Belg., 1854, p. 121.

³ Pal. Ohio, vol. 2, p. 169; pl. 12, figs. 4, 5; not fig. 3.

⁴ Suppl. Geol. Iowa, 1860, p. 87.

EURYOCCRINUS Phillips.

This genus was described from the Lower Carboniferous of Yorkshire, England. It has since been recognized in the Devonian of this country, and a well-defined species is now found in the Knobstone beds of Whites Creek and the Knobs of Kentucky and Indiana.

SYNBATHOCRINUS Phillips.

1. *S. robustus* Shumard.¹ Originally described from Button-mould Knob, where the author says it is "rather abundant in the blue marl layers, interstratified with the fine grained sandstone." It is listed as from the Keokuk Group by Worthen,² Wachsmuth and Springer,³ Miller,⁴ and Weller.⁵ It is an abundant and widely distributed species, notable for being, when mature, the largest of the genus. I have it from Palmer's farm, Clark County, Indiana; Button-mould and Bradbury Knobs, and Bradfordsville, Kentucky; and Whites Creek, Tennessee. At Whites Creek we find it in both the reddish and bluish preservation, and in place in the grey Knobstone beds, but not in the Keokuk beds above. Worthen's specimen, figured in Geological Survey of Illinois, vol. 6, plate 29, was from Greene County, Illinois, where Kinderhook, Burlington, and Keokuk are all present, although the Kinderhook is said to be nonfossiliferous. It is possible, however, that it came from the Keokuk beds, and is an unusually large example of *S. swallowi*, which occurs in the Keokuk and Warsaw. *Synbathocrinus* is one of the genera which persists through the crinoidal formation with but little change, and species from the different horizons are often hard to distinguish. It is to be noted, however, that the specimens of this genus occurring at undoubted Keokuk localities in southern Indiana and Kentucky are invariably much smaller than *S. robustus*, and this species has not been found at any locality where the Knobstone beds do not occur. The genus begins in the Devonian, occurs abundantly in the Lower and Upper Burlington of Iowa and Missouri, culminating in the latter, and becoming extinct in the Warsaw. It is found in the Lake Valley beds of New Mexico, and the Mountain Limestone of England; a species is described by Wetherby from the Kinderhook beds at Kings Mountain Tunnel, Kentucky, and one by Hall from the Goniatile Limestone (Kinderhook) of Rockford, Indiana.

Locality.—As above stated.

2. *S. angularis* Miller and Gurley,⁶ is described from Button-mould Knob, as Keokuk. A small form with more angular plates than the last, but found associated with it, and perhaps only its younger stage.

¹ Trans. Acad. Sci. St. Louis, vol. 2, 1866, p. 397.

² Geol. Surv. Illinois, vol. 6, p. 514.

³ Rev. Pal., vol. 3, p. 169.

⁴ North Amer. Geol. and Pal., 1889, p. 285.

⁵ Bull. 153, U. S. Geol. Surv., p. 618.

⁶ Bull. No. 5, Illinois State Mus., p. 42.

Locality.—Button-mould and Bradbury Knobs, Kentucky; and Stone's farm, Indiana.

HALYSIOCRINUS Ulrich.

1. *H. perplexus* (*Cheirocrinus perplexus* Shumard),¹ is described from Button-mould Knob as "in blue calcareous shale, supposed to be of the age of the Keokuk division of the Archimedes Limestone," and listed as of that horizon by Wachsmuth and Springer, Miller, and Weller. A very large, broad-based form, with surface strongly granular or pustulose.

Locality.—Very abundant at the type-locality, and more rare at Bradbury Knob and in Marion County, Kentucky; Whites Creek, Tennessee; Palmer's farm, Clark County, Indiana.

2. A medium-sized, much narrower form occurs at Stone's farm, Clark County, Indiana, perhaps undescribed.

This genus also comes up from the Devonian and is well represented in the Burlington and Keokuk, where it ends. The Knobstone species, especially the large pustulose form, is much nearer to one occurring in the Hamilton of Alpena, Michigan, than it is to the Keokuk forms of Iowa and Indiana.

CATILLOCRINUS Shumard.

C. tennesseae (Troost) Shumard.¹ Troost's type was from Whites Creek, Tennessee, as stated by Shumard, who saw the specimen at Nashville in 1847. The specimens in the Troost collection, mentioned in the publication of his monograph, Bulletin 64, U. S. National Museum, page 25, are said to be from Button-mould Knob. Those from which Shumard made his description were from the latter locality "in blue marls and marly limestones, which I suppose to be of the age of the Keokuk division," and the species is listed from that horizon by Wachsmuth and Springer, Miller, and Weller. I have numerous specimens from both the above localities, and also from Palmer's farm, Clark County, Indiana. It has never been found, to my knowledge, in any typical Keokuk locality in Iowa, Illinois, Missouri, or Kentucky. Gorby² reports it as occurring in the red Warsaw clays on Rush Creek in Williams's farm, 8 miles northwest of Salem, Indiana, associated with numerous "*Pentremites* of various species, and *Batocrinus*, *Alloprosallocrinus*, and several specimens of *Catillocrinus tennesseae* Troost, which are locally known as 'quart cups.' " If actually found so associated, it must have been in some gully where the Warsaw fossils were mixed with Knobstone, which is exposed to a thickness of 50 feet on the same farm. I have good specimens of the genus from the

¹ Trans. St. Louis Acad. Sci., vol. 2, 1866, p. 358.

² Fifteenth Rep. Geol. Indiana, p. 137.

typical Keokuk at Crawfordsville and Indian Creek, and they are much smaller than this, as are also those of the Upper Burlington.

This is the largest species of the genus, and it has been thought that this makes for the Keokuk character of the horizon. But the fact is that the course of this genus was one of degradation and gradual extinction of vitality. It represents a high specialization, which began in the Devonian with *Mycoerinus* of the Eifel and persisted through this genus into the St. Louis, where its last representative, as found at Huntsville, Alabama, is a depauperate form of very diminutive size. Therefore it is perfectly in accord with the facts to consider that the line of development culminated in size with the present species in the marls of the Knobstone, not later than the age of the Lower Burlington.

CYATHOCRINUS Miller.

This is a genus of wide geographical distribution and long life. It is a form of simple organization and generalized type, its calyx consisting of infrabasals, basals, radials, and an anal plate, just as we find in the larva of some *Antedons* to-day. It ranges from the Silurian to the end of the Keokuk. It underwent slight changes with time, and ran its course to extinction without any extravagant development, as is usually the case with the simpler types. Except by the color, and character of the matrix, it is hard to distinguish between a smooth *Cyathocrinus* of the Burlington and one from the Keokuk. About 10 species are recognized from the Silurian, chiefly from Gotland; true *Cyathocrinus* has not been noted in the Devonian, but its acme came in the Lower Carboniferous, from which there have been described species referable to the genus as follows: Mountain Limestone of England, 9; Kinderhook, 1; Choteau, 1; Lower Burlington, 7; Upper Burlington, 6; Keokuk, 18; from which numbers some deduction must be made for synonyms, especially in the Keokuk. The species described and listed from the St. Louis, Maxville Group (=Kaskaskia), and Lower and Upper Coal Measures do not belong to this genus.

Cyathocrinus was evidently a very prominent crinoid in the Knobstone formation, and flourished in profusion in a variety of beautiful forms, most of them highly ornamented; several of them are undescribed. The Lower Burlington described species are mostly small, and a majority of them smooth. The ornamented ones, or some of them, are represented or closely paralleled by species at some of the Knobstone localities. My material from the Knobs consists chiefly of isolated plates; but by separating these into well-defined groups and reconstructing some calices in part, it is sufficient to indicate the existence of at least 8 well-marked species, and to afford a good description of them by which they can be readily identified. Most of these

are represented at Whites Creek, where we find better preserved calices of some of the species.

1. Rather elongate, large, and robust. IBB low; BB large, elongate; RR smaller than BB; radial facets deep, directed outward. Ornamented with low ridges and broad furrows from facets to center of BB and down to IBB, also from center to center of BB, where they meet in a prominent knob. This is of the type of *C. barrisi* of the Lower Burlington, but much stronger and coarser. Much closer to it, however, is *C. kelloggi* White, which is a large species with similar ridges and broad furrows, and tumid basals, and the two forms may well be identical. Doctor White's species is stated in the description¹ to be from the Keokuk Limestone. This must have been a pure *lapsus pennæ*. I have the type-specimen before me, with the original label by Doctor Barris (to whose collection it belonged) showing that it came from Honey Creek, Henderson County, Illinois. The Keokuk is not exposed at that locality, but the Burlington is, quite extensively, chiefly the upper bed, although the section in the vicinity goes down to the Kinderhook. From the appearance of the specimen itself no collector familiar with these rocks would ever mistake it for Keokuk. I have other specimens of it from the Upper Burlington, and that may be safely taken as its horizon. Two English Mountain Limestone species have similar knobs at the center of the basals, but the ridges, if present, are not well shown in the types. A similar ornamentation is found in a Keokuk species which is abundant at Indian Creek, Indiana, and Boonville, Missouri, but the specimens are uniformly small, with a low calyx and concave base.

Locality.—Button-mould, Bradbury, and Bell Knobs, Kentucky; Palmer's farm, Clark County, Indiana; and Whites Creek, Tennessee, from which I have a complete calyx. Plates are so abundant at some of the other localities that I have reconstructed a large calyx from them.

2. Elongate, large, with tall, erect IBB; BB elongate, longer than RR, and not protuberant; RR rather short, radial facets rather shallow, directed outward. Surface highly ornamented with numerous strong, rugose wrinkles or tubercles, tending to become confluent, usually in no definite order. There is considerable variety in size and shape of the tubercles, but all follow the same general plan. It is a very striking and beautiful species. *C. rigidus* White, from the Lower Burlington, has a somewhat similar pustulose surface, but the pustules are well separated, and the calyx is small, low, and rotund. *C. conicus* Phillips, from the Mountain Limestone of England, has a rather similar elongate form, but the type does not show distinct ornamentation. The species may be compared with *C. multibrachiatum* of the Keokuk, which is similarly large and elongate, but usually

¹ Proc. Bost. Soc. Nat. Hist., vol. 9, p. 8.

has only a few scattered tubercles, though some specimens have them considerably like this.

Locality.—Button-mould, and other Knobs in the vicinity, and in Marion County, Kentucky; Palmer's and Stone's farms, Clark County, Indiana; Whites Creek, Tennessee. From the latter I have a very large calyx, supplementing a good reconstructed calyx from the other localities.

3. Elongate, medium size, with high BB apparently much larger than RR, which have deep, narrow facets, not projecting and directed outward; IBB not found, but probably high, as in the last species. Surface very strongly ornamented with sharp, elevated ridges and narrow furrows radiating from the facets and passing three or more parallel to centers of BB, thence to centers of adjoining BB, and down to the IBB. It is superficially similar to species 2, but distinct in form of radial facets and regular arrangement of ornament into ridges; the isolated plates of the two can be separated with certainty at a glance. There is no other American species with which it can be compared; *C. lamellosus* White, from the Upper Burlington, faintly resembles it in its few sharp ridges, but it is short and of a very different type. But it will need very close comparison with a species described by Austin¹ and erroneously referred to *C. geometricus* Goldfuss; it is said in the text to be from South Devon, but I suspect it is Lower Carboniferous.

Locality.—Button-mould and Bradbury Knobs, Kentucky; and Stone's farm, Clark County, Indiana.

4. Elongate, medium size; a delicate species with thin plates. BB elongate, RR large, probably larger than BB, with deep facets not projecting and directed outward; IBB not found. Surface thickly studded with very small granules tending to become confluent and form fine lines at right angles to the sutures; and a very prominent five or six pointed star in the center of BB, composed of strongly elevated sharp ridges running nearly to the edge of the plates, where they thin to fine points and do not pass to adjoining plates; similar ridges radiate from the radial facets, but not reaching the sutures. There is nothing to compare this with, save the last species, of which it may be a modification; but we can never mistake a plate of one for the other on account of the fine, granular surface outside of the ridges in this, whereas in the last the intervening surface is perfectly smooth. We have a reconstructed calyx minus the IBB.

Locality.—Button-mould and Jacob's Knobs, Kentucky; and Palmers, Clark County, Indiana.

5. Rather broadly rotund, medium size; with low IBB; large BB, as wide as long, much larger than RR and not protuberant; RR short and wide, facets rather large and not projecting, facing obliquely

¹ Monog. Rec. and Foss. Crin., p. 61, pl. 7, figs. 5a-c.

upward. Surface very finely and uniformly granulose, the granules sometimes forming fine striæ toward or parallel with the margins of the plates. Comparable in general form with *C. fragilis* of the Lower Burlington, which lacks the granulose surface. A reconstructed calyx.

Locality.—Button-mould Knob, Kentucky.

6. Rotund, medium size, with thick plates. IBB low; BB rather longer than wide, strongly convex and gibbous; RR smaller than BB, with large projecting facets facing outward. Surface finely granulose. Except for the distinct granulose ornamentation, this form may be compared with *C. nodosus* of the Keokuk; also with *C. bursa* and *C. calcaratus* of the English Mountain limestone. It is probably the same species described by Meek and Worthen as *C. saffordi* and by Troost (MS) as *C. pentasphericus*.¹

Locality.—Button-mould and Bradbury Knobs and Newmarket, Kentucky; from the latter two complete calices.

7. Medium sized; elongate, campanulate, narrow at base and abruptly widening at the arm bases owing to the large size of RR, which constitute nearly one-half of the calyx. IBB small, erect; BB about half the size of RR; facets large, facing outward. All plates smooth, BB and RR low convex, without ornament, or with possibly some low obscure pustules on BB only, not on RR. In its turbinate form and smooth surface this can only be compared with *C. choteauensis* of the Missouri Choteau.

Locality.—Only identified at Whites Creek, where a specimen was found in place in the Knobstone beds; but smooth radials probably of the same species are frequent at the Knobs.

8. Similar in general form and proportion of plates to the last; but more strongly campanulate. All plates gibbous, with a few large, rough pustules in the median parts and bordering the facets. It is very similar in form to *C. barydactylus*, from the highest part of the Upper Burlington.

Locality.—Good calices were found at Whites Creek in washes below the Knobstone, but it was not identified at the other localities.

While some of the foregoing species of *Cyathocrinus* are undoubtedly indecisive of the horizon, yet it can not be denied that the entire facies is suggestive of the Lower Burlington in a more luxuriant development than at the typical locality. It is significant that in all the careful collecting made at the true Keokuk localities in Barren, Metcalfe, and Allen counties, Kentucky, by Lyon, Wachsmuth, and Wetherby, not a single specimen of any of these species appears, and that none of them are among the fossils found in place in the Keokuk beds by Bassler and Braun at Whites Creek.

¹ Bull. 64, U. S. Nat. Mus., p. 84, pl. 5, figs. 6, 7, 8.

I have not undertaken to give names to these forms, preferring to wait until proper illustrations can be prepared and closer comparison made with described species; but I have little doubt that most of them are new.

~ BARYCRINUS Meek and Worthen.

This was also a prominent genus in these beds. It ranges from the Lower Burlington to the Warsaw, but has not been recognized in the European Lower Carboniferous. It is a more specialized type than *Cyathocrinus* in its arm structure, and the course of its development through the crinoidal formation was more in accordance with the general rule. The species in the Lower Burlington are relatively small, with delicate ornamentation, while those in the Keokuk are mostly large and coarse, one of them being the largest Inadunate crinoid in the American rocks. Some types persisted through with little change recognizable in the fossils, and some forms from the typical Burlington and Keokuk can scarcely be distinguished from one another except by the color and matrix. This is especially so in forms with a more or less stellate base. Seven species have been described from the two Burlington beds and the Choteau; 21 from the Keokuk, of which at least half are synonyms; 2 from the Warsaw; and 1 said to be from the St. Louis of Jersey County, Illinois, which is doubtless from the Warsaw also. About six species are represented among the isolated plates from the Knobs, some of them by complete calices at Whites Creek, along with some additional species.

1. Medium to small size, low, with broad base. IBB very small and flat; BB about as large as RR; facets very large, rather deep and elliptic, more resembling those of *Cyathocrinus* than usual in this genus. The dorsal surface is traversed by remarkably elevated, sharp, keel-like ridges, connecting the facets laterally and running from them without a break to the center of the basals, thence less conspicuously branching to the infrabasals; these divide the calyx into ten deep and wide pits, somewhat resembling a colony of Lithostrotion corals. Isolated radials of this form can be at once recognized from all others by the four large, sharp ridges projecting like cogs from the rim of the facet, which occupies almost the entire radial. Three good calices and a number of plates were found at Whites Creek showing these characters beautifully. Now this is the very kind of sculpturing, only more pronounced, that is found in a remarkably beautiful specimen from the Lower Burlington that has been for many years in my collection labeled "*B. rhombiferus* Owen and Shumard." It has the arms perfectly preserved, and the same kind of high, knife-like wrinkles extend for their entire length; but on each axillary the wrinkle is produced into a short spine, as is also the case

with another Lower Burlington species, *B. cornutus*. Such peculiar sculpturing has not been found on any *Barycrinus* later than the Lower Burlington, and as shown in these specimens it is doubtless a strong exaggeration of that of *B. rhombiferus*, as described, and usually labeled in collections; this form is beautifully ornamented with fine wrinkles, from which the above more striking characters were perhaps derived, and it has also decidedly shallower and wider radial facets. As the form now described can be recognized without the least doubt, either by the calyx or a single radial, I have thought best to designate it at once as a new species, *Barycrinus asperrimus*.

Locality.—As above stated at Whites Creek. It was not found at the Knobs, but I have plates belonging to it from the equivalent beds at Lake Valley, New Mexico.

2. A species with long, horn-like, irregular, projecting nodes on radials and basals, readily identifiable as *B. cornutus* Owen and Shumard, of the Lower Burlington Limestone. *Barycrini* with stellate base, *i. e.*, with a broad, projecting ridge from infrabasals to basals, giving a star-like effect, are found throughout the Burlington and Keokuk, and several species have been described upon slight modifications of detail in this. In this species the projections on basals and radials are confined to the plates on which they originate, and are often peculiarly contorted nodes, pulled out to all kinds of irregular ends, like a piece of clay when pulled in two. The surface is otherwise smooth. The axillary brachials, where the ramules are given off from the main arms, are produced into spines, which become long and slender toward the distal end of the arms.

Locality.—Calyx plates with the nodes above described, and spiniferous axillary brachials, some with spines half an inch long, are found at Button-mould and neighboring knobs in Kentucky; at Stone's farm, Indiana; Fern Glen, Missouri; and at Lake Valley, New Mexico. Also a completely typical calyx at Whites Creek, Tennessee; this has a radianal, as occasionally occurs in this genus, and the Burlington specimens of this species have either an unusually large anal plate for the genus, or two, with RA sometimes showing only at the interior.

3. A less rugose and smaller protuberance on BB and RR, more distinctly rounded or spiny, gives a form closely related to the last, described by Hall as *B. stellatus*, from the Iowa Keokuk. It is a rather small species, quite abundant at Indian Creek, Indiana, and it has also spiniferous axillary brachials. Both have very wide, shallow radial facets, directed obliquely upward. The two forms are closely related, and doubtless shade into one another; but while the typical *cornutus* has not been found above the Lower Burlington the present one is represented there as well as in the Keokuk.

Locality.—Several good specimens were found at Whites Creek, and at Newmarket, Kentucky; the latter from the Knobstone shales, the former among intermingled fossils, some reddish and some bluish-gray, from both Keokuk and Knobstone, with the probability that most of them came from the latter.

4. Another closely related, rather small form is that of *B. quinquelobus* Meek and Worthen, described from the Warsaw Group of Illinois and found at several localities of the typical Keokuk. With only moderate and often no projections on the radials, the center of the basals is abruptly elevated to a small point; from this a strong ridge, widening and tending to form a shallow grooved depression between the margins, runs to the infrabasals, giving the distinct form of a large, five-pointed star involving the whole basal portion of the calyx. The name "*stellatus*" would have been absolutely appropriate for this. This form of base is best defined in the Keokuk forms, but may be traced from the Lower Burlington, where it is found in *B. rhombiferus*.

Locality.—Good specimens of this are found in the Knobstone shales at Newmarket, Kentucky, and at Whites Creek in a red preservation of uncertain horizon. I have also very characteristic specimens of it from the top of the Keokuk or Warsaw near Colesburg, Hardin County, Kentucky.

5. Another small form, with very small, tumid BB, and extremely large, convex RR, with large, deep facets facing laterally, is somewhat like *B. tumidus* Hall, from the Iowa Keokuk. From the deep radial facets, and the appearance of some arm fragments that may belong to it, it is possible that this and the next form may belong to *Cyathocrinus*. Their low calyx and flat base, unusual in that genus, and the extreme size of the facets, occupying almost the entire plate, lead me to place it here; but it has an erectness, and absence of spreading in the calyx, which are unlike *Barycrinus*. Only the definite association of arms can settle it.

Locality.—There are good specimens from Button-mould Knob—one complete calyx—and several from Whites Creek, in both reddish and bluish preservation, but none found in place.

6. In the last four species the surface is smooth and without ornament. There is another form, in shape and size closely resembling the last, and possibly a *Cyathocrinus*, in which the plates, in addition to being tumid, are surrounded by a number of more or less prominent, small nodes, sometimes tending to arrange themselves in rows from center to center; they fringe the margins of the radial plates like rows of beads, and also the brachials (of which three are in place in a ray of one specimen) all the way around to the ventral furrow.

Aside from the ornament it has some general resemblance to *B. bullatus* of the Keokuk.

Locality.—Separate brachials with the bead-like fringe of nodes are found at the Knobs, and complete calices at Whites Creek.

7. A large, low, wide-spreading species, with finely wrinkled, granulose surface ornament in a variety of forms; the surface of the plates bent into broad, low ridges branching from RR, meeting on BB, and passing down to IBB, with a slight median groove, leaving 10 shallow, lozenge-shaped depressions at the corners where three plates meet. This is the general form and structure of *B. wachsmuthi* of the Lower Burlington, and *B. sculptilis* of the Upper; but it has relatively thinner plates than those species. The surface sculpturing is delicate, and not suggestive of any of the large Keokuk species.

Locality.—Plates of this are common at Button-mould and Bradbury Knobs, Kentucky, and at Stone's and Palmer's farms, Indiana, from which calices have been reconstructed; also at Whites Creek. There is also a large, coarse form, with heavy plates, at the latter locality, probably referable to one of the smooth Keokuk species.

8. Large, low, spreading calyx, with very convex radials and strongly tumid basals, without any connecting ridges, and with perfectly smooth surface; it is a good example of *B. bullatus* Hall, of the Iowa Keokuk.

Locality.—Whites Creek, from slope with mixed fossils, below level of Knobstone.

While, as in *Cyathocrinus*, several of these species are not decisive of horizon, two of them are of distinctly Lower Burlington type, and there are few among the others which might not belong to that formation; so the weight of evidence, upon this genus alone, is in favor of that horizon rather than Keokuk.

POTERIOCRINUS Miller.

The true *Poteriocrinus*, which includes only a few out of the vast number of species described under this name, is represented by at least two species. The genus, beginning in the Devonian, is a strong fossil of the Mountain Limestone of England and Belgium, and in this country ranges from the Lower Burlington to the Keokuk.

1. Large, elongate, with very thin plates which are flexed into deep folds, leaving broad, elevated bands composed of several more or less sharp ridges, passing from the radial facets to one another and to the basals, converging at the middle and passing down to the infrabasals; a pair of such striated bands passes right and left from one basal to another, with fine granulose ornament between. These markings are very conspicuous, and the plates become as thin as paper at the sutures. BB elongate, much larger than RR, which are

short, with small, deep, and narrow crescentic facets, having a transverse ridge. IBB of this species not found, but calyx above them reconstructed from plates which are fairly plentiful at the Knobs, but not observed at Whites Creek. It is of the same type as Hall's "*Cyathocrinus*" *macropleurus*,¹ which has been erroneously referred to *Vasocrinus*. It is a rare species from the Lower Burlington at Burlington, scarcely ever found except as detached plates; it also occurs at Lake Valley, New Mexico. It is hard to say how these plates can be distinguished from those of *P. crassus*, of the European Lower Carboniferous. The same type runs through the Upper Burlington—*P. doris*—into the Keokuk, where it culminates in a very large new species, which I expect shortly to describe.

2. Elongate calyx, with perfectly smooth surface, no ridges or furrows, and very thin plates; represented by the infrabasal circlet attached to proximal column joints, and a few loose basal and radial plates, all from the Knobs. Not known at Burlington, but indistinguishable in the parts preserved from specimens of *P. spissus* from Tournai, Belgium.

3. A very large, low, broadly spreading form, with stronger plates than the preceding; smooth surface, and obscure connecting ridges. RR very wide and larger than BB; facets wide and shallow, with distinct transverse ridge. IBB unknown, and characters taken from isolated basal and radial plates, found at Button-mould Knob. The general aspect is more that of *Barycrinus*; but the very distinct transverse ridge and relatively thin plates seem rather to indicate this genus. Not known at Burlington or elsewhere.

SCAPHIOCRINUS Hall.

There is a fine new species of this genus represented by several calices from Whites Creek, and a nearly complete specimen with arms from some locality in Lincoln County, Kentucky, not far from Junction City. The horizon of either might be Knobstone or Keokuk, and at neither is it positively known. There is an undescribed species somewhat similar to it in the Upper Burlington, and another in the true Keokuk at Indian Creek, Indiana.

There are also some loose smooth plates from Button-mould Knob and Stone's farm which can not be distinguished from similar plates from Tournai, Belgium.

ZEACRINUS Hall.

Z. nodosus Wachsmuth and Springer.² This singular crinoid, having the base of true *Zeacrinus* and the arms of *Scaphiocrinus*, was found by Wachsmuth at Whites Creek in a ravine washed out of

¹Journ. Bost. Soc. Nat. Hist., vol. 7, 1860, p. 295. ²Rev. Pal., vol. 3, p. 243, pl. 6, fig. 9; pl. 9, fig. 3.

clays below the level of any of the fossil-bearing beds. It has always been credited to the Keokuk, and this may be correct. It is similar to *Z. compactilis* Worthen, from Cumberland County, Kentucky, the only known specimen of which is labeled Keokuk. The form of base in these two species is unknown in the Burlington rocks.

STEMMATOCRINUS Trautschold.

S. trautscholdi Wachsmuth and Springer.¹ This remarkable species was described by us from a large series of specimens collected by Wachsmuth at Whites Creek. They were nearly all found in one locality, a plowed field in a valley filled with soil washed from the hills, some distance from the Keokuk exposures. Doctor Bassler and Mr. Braun also found several specimens, but none of them in place; all were in position where it was possible for the loose fossils to have been derived from either horizon. The genus was first observed in the Bergkalk of Moscow, Russia, whose crinoidal fauna closely parallels that of our Kaskaskia; and the only occurrence of it in this country is that of the present species, which has been supposed to be from the Keokuk. It has not been found in Barren County, or other Keokuk localities in Kentucky, or elsewhere; only at Whites Creek until now. I find loose plates of it in the débris of the Knobstone shales at Button-mould Knob, not associated with Keokuk fossils, and I think this establishes a presumption that its true horizon is Knobstone rather than Keokuk. But I state this impression subject to change upon further evidence.

BLASTOIDEA.

The genera and species of this order are usually excellent indices of stratigraphy, being restricted mostly to very definite limits. Although not abundant in these rocks, we are fortunate in finding a few which are of decisive weight.

OROPHOCCRINUS von Seebach.

This genus was short lived, and confined, so far as known, to the Kinderhook and Lower Burlington and their equivalents. In the very rich blastoid fauna of the Upper Burlington it does not occur, unless in the doubtful species, *Pentremites sirius* White, and in the Keokuk not a trace of it has ever been seen at any locality. It is therefore extremely significant that we find at Button-mould Knob the detached forked-plates of a large species of *Orophocrinus* of the same type as the well-known *O. stelliformis* of the Lower Burlington.

¹ Rev. Pal., vol. 3, p. 256.

SCHIZOBLASTUS Etheridge and Carpenter.

This genus is closely related to the one commonly known as *Granatocrinus*, a name which under the laws of priority now gives way to *Orbitremites*, from which it was separated by Etheridge and Carpenter. The two constitute essentially a Choteau-Burlington group, only one small species being from the Keokuk; two species referred to it by some authors from the St. Louis and Kaskaskia respectively probably belong elsewhere. Seven species are recognized from the Mountain Limestone of England, Ireland, and Belgium; and in this country two have been described from the Choteau, five from the Lower Burlington, six from the Upper Burlington, and one, the smallest of the genus, from the Keokuk. Besides these is the well-known and magnificent *Granatocrinus granulatus* of Roemer, by far the largest of either of these genera, which, on account of having ten spiracles instead of five, must be referred to *Schizoblastus*. Its horizon has been involved in a curious lot of guesswork. Roemer, in describing it¹, gave as its localities, on the authority of Troost and Shumard, Shelbyville, Bedford County, Tennessee, and Allen County, Kentucky; and the horizon simply as Kohlenkalk. It is referred to the St. Louis by Etheridge and Carpenter,² by S. A. Miller,³ and by Weller.⁴ Shumard in his Catalogue⁵ referred it to the Kaskaskia; while Troost, who described it in his Monograph, unpublished until lately, said it was from the Devonian.⁶ With all this lucid information in the literature to choose from, the collectors have taken another guess at it. I have specimens of this species obtained in various collections, from Bradfordsville, Sallietown, and other localities in Marion County, Kentucky, Whites Creek and Maury County, Tennessee; and they are without exception labeled Keokuk. Now it is significant that every one of these localities, as well as those given by Troost, Roemer, and Shumard, is in a region where the shales pass up from the Devonian to the Lower Carboniferous Limestone, and where the lower member of Safford's "Siliceous Group"—*i. e.*, the Knobstone—is exposed; and also that no specimen of this species has ever been reported from any typical Keokuk locality. To all this I am now able to contribute one decisive fact—namely, good specimens direct from the Knobstone shales at Stone's farm, Clark County, Indiana, in layers 40 or 50 feet above the Black Slate, and where there is no Keokuk mingled in the débris. Troost's reference to the Devonian undoubtedly meant these same shales, and the conclusion

¹ Monogr. Blastoidea, p. 43.² Cat. Blastoidea, p. 244.³ North Amer. Geol. and Pal., p. 250.⁴ Bull. 153, U. S. Geol. Surv., p. 299.⁵ Trans. St. Louis Acad. Sci. vol. 2, p. 375.⁶ Bull. 64, U. S. Nat. Mus., p. 21.

is inevitable that at all the localities the species comes from the shales now known as Knobstone. This adds another strong confirmation to the correlation of these beds with the Lower Burlington; for the stratigraphic succession of the blastoids is quite peculiar. Certain groups of genera, to which the present one belongs, coming up from *Nucleocrinus* and *Codaster* of the Devonian, became prominent, culminated, and were practically extinguished in the Burlington. Another line, beginning with *Troosticrinus* in the Silurian, continued along moderately until the St. Louis and Kaskaskia, when it culminated in a development of the genus *Pentremites* in extraordinary profusion. In the Keokuk, between these two culminations, the blastoids were relatively rare. In the most prolific localities for crinoids, such as Crawfordsville, Indian Creek, and in Washington and Lawrence counties, Indiana, and in Barren and Metcalfe counties, Kentucky, specimens are scarcely ever found. The abundant occurrences of *Pentremites conoideus* at Spergen Hill, Indiana, and Boonville, Missouri, are from higher beds above the Keokuk—namely, the Warsaw. In the true Keokuk of the Mississippi River and Kentucky region a few straggling specimens of *Metablastus*, and the diminutive *Granatocrinus* already mentioned, are all that are ever found. It would seem, therefore, a needless stretch of the imagination to assign such a species as this to a horizon in which its group is practically extinct, instead of to one where upon every consideration of faunal succession and association it properly belongs.

S. decussatus (Shumard).¹ This species, described from Buttonmould Knob under *Pentremites*, is thought to belong to the above genus. All the specimens are imperfect, and its exact generic characters obscure, but it belongs to this group, and not to *Pentremites* as now restricted. I have some other specimens from the type locality and also from the Knobstone shales at Bradfordsville, Marion County, Kentucky. It occurs also at Fern Glen, Missouri, in shales directly underlying the typical Burlington Limestone, and is figured as a part of that fauna by Weller.²

To show the full force of the foregoing facts, I have arranged in tabular form the genera, and a few decisive species which are found at the Knob localities and Whites Creek, along with their known stratigraphical limits elsewhere.

¹ *Pentremites decussatus*, Trans. St. Louis Acad. Sci., vol. 1 p. 242.

² Bull. Geol. Soc. Amer., vol. 20, p. 288, pl. 11, figs. 28, 29.

Table of genera, and a few species occurring at the Knobstone localities and Whites Creek.

	Choteau - Kinderhook.	Lower Burlington.	Upper Burlington.	Keokuk.	Warsaw.	Mountain Limestone, Europe.	Moscou Bergk.	Knobs, Kentucky and Indiana.	Whites Creek.	
									Mixed.	Keokuk in situ.
<i>Gilbertsocrinus tenuiradiatus</i>		×						×		
<i>Eretmocrinus ramulosus</i>			×	×				0	×	×
<i>Eretmocrinus praegravis</i>				×				0	×	×
<i>Eretmocrinus yandelli</i>			Not found elsewhere.					×	0	0
<i>Dorycrinus gouldi</i>				×				0	×	×
<i>Lobocrinus nashvillae</i>			×	×				0	×	×
<i>Agaricocrinus americanus</i>				×				0	×	×
<i>Agaricocrinus nodulosus</i>				×				0	×	×
<i>Alloprosallocrinus</i>				×				0	×	×
<i>Megistocrinus</i>	×	×	×			×		×		
<i>Amphocrinus</i>	×	×				×		×		
<i>Actinocrinus</i>		×	×	×		×		×		
<i>Cactocrinus</i>		×				×		×		
<i>Platycrinus, discoid</i>	×	×				×		×		
<i>Platycrinus, other</i>	×	×	×	×	×	×		×	×	
<i>Wachsmuthicrinus</i>		×				×		×		
<i>Mespiloerinus</i>	×	×	×			×		×		
<i>Metichthyocrinus</i>		×						×	×	
<i>Forbesiocrinus (nobilis type)</i>	×	×				×		×		
<i>Forbesiocrinus (wortheni type)</i>			×	×				0	×	
<i>Tazocrinus</i>	×	×	×	×		×		×	×	
<i>Euryocrinus</i>						×		×	×	
<i>Synbathocrinus</i>	×	×	×	×		×		×	×	
<i>Halysiocrinus</i>	×	×	×	×		×		×	×	
<i>Catillocrinus</i>					St. L.			×	×	
<i>Cyathocrinus</i>	×	×	×	×		×		×	×	
<i>Barycrinus</i>		×	×	×	×	×		×	×	
<i>Potericrinus</i>		×	×	×		×		×	×	
<i>Scaphiocrinus</i>		×	×	×		×		×	×	
<i>Stemmatocrinus</i>							×	×	×	
<i>Orophocrinus</i>	×	×				×		×	×	
<i>Schizoblastus</i>	×	×	×	×				×	×	

Recapitulating these data, we have:

	Knobs.	Whites Creek.	
		Mixed.	Keokuk in situ.
Genera or particular species occurring—			
Not later than Lower Burlington.....	8	2	
Not later than Upper Burlington.....	2		
Kinderhook or Lower Burlington to Keokuk.....	10	10	
Not earlier than Upper Burlington or Keokuk.....	1	9	7
Others not definitely comparable.....	2	1	
In Mountain Limestone of Britain and Belgium.....	14	8	

These figures tell their own story better than pages of argument, which is that the main fossiliferous beds of the Knobs, and the lower limestone above the Black Slate at Whites Creek, must be placed stratigraphically as equivalent in part or closely related to the Lower Burlington. That some important Lower Burlington species are not found here, or that there may be a slight intermingling of Upper Burlington forms, does not interfere. I think there can be no doubt that the typical region of the crinoidal formation, namely,

western Illinois, eastern Iowa, and Missouri, with its long and quiet deposition of strata, was the chief habitat and center of distribution of the crinoids during that epoch; and that the occurrences in Indiana, Kentucky, and Tennessee represent migrations involving only part of the species, repeatedly interrupted and renewed, as evidenced by the frequent bands of crinoidal limestone with muddy clays and shales between. What name should be attached to these beds would probably be a matter of contention between the geologists of the different States. I am not so much concerned about that, so long as the facts are understood, and willingly leave it to those in authority to settle. But I think I may say with confidence that the name will not be Keokuk.

THE WAVERLYAN PERIOD OF TENNESSEE.

By RAY S. BASSLER,

Curator of Invertebrate Paleontology, U. S. National Museum.

INTRODUCTION.

Of late years much valuable information has been published concerning the lower part of the Subcarboniferous or Mississippian strata of the United States, so that to-day we know their history in considerable detail. Weller's various faunal and stratigraphic studies, relating chiefly to the Kinderhook of Illinois, Iowa, and Missouri, have furnished a foundation for the comparison of these strata in other states. In Ohio, Indiana, and Kentucky the stratigraphic succession is now fairly well known, but the correlations are in some instances doubtful, and the faunas particularly require much more study. In Tennessee a considerable thickness of early Mississippian rocks is present, but here little has been published on their stratigraphy and less on their faunas. The object of the present article is mainly to present a short account of these strata in Tennessee to supplement the paper by Mr. Frank Springer on "The Crinoid Fauna of the Knobstone Formation," published elsewhere in this volume. Mr. Springer has briefly summed up the results of Safford's work upon these rocks, but a more complete account is given below.

THE SILICEOUS GROUP OF TENNESSEE.

The Subcarboniferous rocks of Tennessee were divided by Safford into a lower Siliceous group and an upper Mountain limestone. The latter formation is not discussed in this paper; indeed, the scope of the present article is limited to the lower part of the Siliceous group.

Although the term "siliceous stratum" originated with Doctor Troost and was employed by him in his reports, the first description of these strata is by Safford in an article on "The Silurian Basin of Middle Tennessee, with Notices of the Strata surrounding it,"¹ where he divides the Paleozoic rocks of middle Tennessee underlying the Pentremital limestone into five sections. The fifth section, included

¹ Amer. Journ. Sci., ser. 2, vol. 12, 1851, pp. 352-361.

between the Black slate and Pentremital limestone, was called the Siliceous group. This group was subdivided in ascending order into the Siliceous beds and the Cherty limestone. The lower member, the true Siliceous beds, about 200 feet thick in the northern part of the state, consists of a fine-grained, siliceous, light blue, rather unfossiliferous limestone, which, upon weathering, leaves a light yellow to brown soil strewn with chert fragments. The cherty limestone proper differed "in being a true limestone affording a brick-red soil, in the character of its interbedded [flint] masses and in being much more fossiliferous." A species of *Lithostrotion* (*Lonsdalia canadensis*) was registered as one of the fossils.

In 1856¹ Safford described the same strata under the same name, giving little additional information regarding the rocks.

In his well-known classic work, "Geology of Tennessee," 1869, Safford gives an excellent description of the Siliceous group, dividing it into the "Lower, or Protean bed," and the "Lithostrotion Coral bed." The Lithostrotion bed is characterized everywhere by *L. canadense*, and Safford correlates it with the St. Louis limestone. The lower or Protean member is said to be "in general equivalent to the divisions of the Lower Carboniferous limestone lying below the St. Louis limestone. It is, perhaps, more especially the equivalent of the Keokuk limestone; it contains, however, some Burlington forms." As Mr. Springer has indicated, the fact that most of the Lower Siliceous fossils listed by Safford are Keokuk species outside of Tennessee, has led to the correlation of these beds almost invariably with the Keokuk. This opinion is indicated in the "Table of Geological Equivalents" (by A. Winchell), on page 364 of the "Geology of Tennessee," where the Lower Siliceous is correlated with the Keokuk limestone of Iowa and Missouri, and with the Keokuk and Knobstone of Kentucky, while the Burlington and underlying Subcarboniferous strata are indicated as wanting in Tennessee.

Safford and Killibrew use the term Barren group instead of Protean bed for these strata in 1874 in their "Resources of Tennessee." Later, in their textbook "The Elements of the Geology of Tennessee," published in 1900, they abandon both the names Siliceous group and Barren group, substituting for these, respectively, St. Louis limestone and Tullahoma limestone, and introducing the new term Maury green shale for the basal member of the series in Maury County.

The next work upon the subject, so far as it relates to Tennessee, is by Hayes and Ulrich,² who adopt the names Tullahoma formation and St. Louis limestone, but include and map the Maury green shale with the Chattanooga black shale. In the Tullahoma formation they describe a lower calcareous shale member and state that it is fre-

¹ Geological Resources in the State of Tennessee, First Report, p. 159.

² Columbia Folio, Tennessee. U. S. Geol. Surv., Folio No. 95, 1903.

quently absent. This shale contains undescribed ostracods indicative of early Mississippian age. Above this comes the usual siliceous limestone with few fossils. In their correlation table the Tullahoma is made the equivalent of the Kinderhook, Burlington, and Keokuk of the generalized time scale.

The most recent discussion of these strata is contained in the paper entitled "Types of Sedimentary Overlap," by Dr. A. W. Grabau.¹ The portion of this paper devoted to the Tennessee Subcarboniferous is apparently based upon the literature alone, for this author writes:

The Fort Payne chert is very fossiliferous, and is the "siliceous group" of Safford, which he divided into a lower, or Protean (Lauderdale, McCalley), and upper, or Lithostrotion (Tuscumbia, McCalley). Ulrich makes the Tullahoma of central Tennessee and the Fort Payne of eastern Tennessee equivalent, and correlates both with the Kinderhook and Osage of the Mississippi Valley. There is here an inconsistency, for the upper part of the Fort Payne (Tuscumbia) is clearly of lower Saint Louis age, as shown by the abundance of *Lithostrotion canadense* (= *L. mamillare*).

Taking up these statements in order, it may be said that, aside from dismembered crinoid columns, recognizable fossils in the Fort Payne are exceedingly rare. The Fort Payne is not the equivalent of the Siliceous group of Safford, because it does not contain the St. Louis limestone at its top. There is not an abundance of *Lithostrotion canadense* in the upper part of the Fort Payne. This characteristic St. Louis fossil is found only in the lower beds of the overlying Bangor limestone. Taking for example the McMinnville folio from which Grabau takes some of his statements, one acquainted with the area can easily make out the geological equivalents. Here the Fort Payne chert is described as a cherty limestone and heavy beds of chert, giving rise to a white, siliceous soil, and forming the barrens of the Highland rim. The overlying Bangor limestone has at its base a blue limestone member with nodular chert, weathering into a red, slightly cherty soil. It is in this latter red soil only that the characteristic St. Louis fossils are found.

The Lauderdale and Tuscumbia formations do not fall within the scope of the present paper, and need not be mentioned further, except to state that, as the names are of later date than the formations here discussed, they will in all probability be found to be superfluous.

The above notes include all of the more important references to the Lower or Protean member of the Siliceous group in Tennessee. In the discussion of the geology of neighboring states the terms Siliceous, Tullahoma, and other names have been frequently employed, but they need not be referred to at present, with one exception. This is the Fort Payne chert, a term proposed by Hayes² for practically the same strata in the southern Appalachian Valley. It is

¹ Bull. Geol. Soc. America, vol. 17, 1906, pp. 567-636.

² Idem, vol. 2, 1890, p. 143.

employed by the same author also in the McMinnville folio covering a part of the eastern rim of the Central Basin.

The Fort Payne chert seems to agree exactly with the Tullahoma of Safford and Killibrew, as founded on exposures of the formation in the eastern rim of the Central Basin. However, they used the name Tullahoma also for all the beds between the Maury green shale and the St. Louis limestone along the western edge of the basin, thus including the Kinderhook shale, which is there locally developed beneath the cherty beds. Hayes and Ulrich adopted the term in the latter sense in the Columbia folio. From the foregoing it will be noted that there is no Tennessee term which includes all of the Subcarboniferous rocks, including the Chattanooga shale, forming the subject of the present paper, namely, those underlying the Lithostrotion or St. Louis limestone. Safford's subdivision "Protean member" comes nearer to covering this interval than any other, but this term has no geographical significance. As the St. Louis limestone of Tennessee occasionally contains a Warsaw fauna in its basal layers, the underlying Subcarboniferous rocks will fall into the Mississippian Period, as recently emended by Schuchert.¹ Newberry's Waverly group covers the same interval, and I have used this term in the title of my paper, first, because it has priority, and, second, because it requires no revision of boundaries as is necessitated by Schuchert's proposed restriction of the term Mississippian.

It is true that Newberry was not the author of the term Waverly, but I think it will be conceded that his writings form the most valuable contributions to the literature of the subject. By reference to Weeks's "North American Geologic Formation Names,"² it will be noted that the term Waverly was first applied by Mather, in 1838, to the Subcarboniferous sandstone series in Ohio. Then Owen used the term on two occasions in the early Indiana reports, regarding the Knobstone group of that state as a synonym. The first definite limits to the group were those given by the next writer upon the subject, Newberry, who, in his "Report of Progress of the Ohio Geological Survey for 1869," included the Cuyahoga shale, Berea grit, Bedford shale, and Cleveland shale as members of the Waverly group. In all of Newberry's subsequent works, and, indeed, that of most subsequent writers upon the subject, these same divisions are recognized in the Waverly group, although at times the separate divisions have been designated as Waverly sandstone, Waverly shale, or Waverly black slate. Excluding the Chattanooga shale, the term Waverlyan is employed as a series term by Ulrich³ to include deposits of Kinderhook, Burlington, and Keokuk age.

¹ Paleogeography of North America, Bull. Geol. Soc. Amer., vol. 20, 1910, p. 547.

² Bull. 191, U. S. Geol. Surv., 1902, p. 414.

³ Prof. Paper, U. S. Geol. Surv., No. 36, 1905, p. 24.

THE WAVERLYAN PERIOD.

In the following pages I have included the Chattanooga shale, with its initial deposit, the Hardin sandstone, as a part of the Waverlyan. As mentioned before, Newberry, in all of his works on the Waverly, considered the Cleveland shale as its lowest member. In his Ohio report, published in 1874, he mentioned fish remains and large numbers of conodonts as its most abundant fossils, these being described later in volume 2 of the "Paleontology of Ohio." A thin, impure limestone containing *Syringothyris typa*, *Macrodon hamiltonae*, and other Waverly fossils, inaugurated the Cleveland shale and separated it from the underlying Erie (now Chagrin) shale holding *Spirifer disjunctus* and other Chemung fossils. Accepting Newberry's classification of the Cleveland shale as the basal member of the Waverly, the present stratigraphic divisions of this series in Ohio are as follows:

Divisions of Waverlyan in Ohio.

7. Logan formation, mainly sandstone.
6. Black-Hand formation, sandstones, often coarse and conglomeratic.
5. Cuyahoga formation, clay shales and sandstones.
4. Sunbury formation, fissile black shale.
3. Berea sandstone.
2. Bedford shale, locally with sandstone.
1. Cleveland black shale.

Foerste, in his article on The Bedford Fauna at Indian Fields and Irvine, Kentucky,¹ correlates the Logan formation with the Keokuk by two errors, which, curiously enough, nullify each other and leave the correlation probably correct. His statement is as follows:

In 1888 Mr. E. O. Ulrich, in the fourth volume of the Bulletin of Denison University, identified from the Upper Waverly of Ohio sixteen species of bryozoans which occur also in the Keokuk of Kentucky, Illinois, and Iowa. Of these, eight are found at Kings Mountain, Kentucky, in strata identified by Ulrich as Keokuk, and two other species are closely related to forms found at that locality. From this it is evident that the upper Waverly, now known as the Logan formation, is closely related to the strata exposed at Kings Mountain, and that both are approximately equivalent to the Keokuk of the Mississippi Valley.

However, the bryozoans described by Ulrich were derived from the upper part of the Cuyahoga formation and not from the Logan. Again, the Kings Mountain strata are not of Keokuk age but belong to the typical Knobstone shale.

In an article entitled "The Waverly Formations of East-Central Kentucky,"² Morse and Foerste show that the Bedford and Berea formations thin rapidly southwestward from the Ohio River; in fact,

¹ The Ohio Naturalist, vol. 9, No. 7, May, 1900.

² Journal of Geology, vol. 17, No. 2, 1909.

become so thin that the Sunbury, Bedford, and the underlying black shales seem to become a unit. In Kentucky then, quoting these authors, "The Ohio black shale of the Kentucky reports or the Chattanooga shale of U. S. reports, south of Petersville, is not of Devonian age alone but of Devonian and Carboniferous; that is, is composed of both the Ohio and Sunbury shales, and a thin zone representing the Bedford and Berea."

In the Richmond and other folios of east central Kentucky, the U. S. Geological Survey maps the clay shales and sandstones between the Newman limestone, as identified in this area (St. Louis and Chester), above, and the Chattanooga shale below, as the Waverly formation, giving the Waverly the same limits as in Ohio, save that the lower black shale divisions (Cleveland, Bedford, and Sunbury) with possibly a black shale of Devonian age, are mapped as a unit under the name of Chattanooga shale.

In central Tennessee the Chattanooga black shale with the underlying Hardin sandstone undoubtedly represents the deposits of the first submergence following the Devonian emergence. Whenever present the Hardin sandstone almost invariably contains worn, silicified fossils of Ordovician, Silurian, and Devonian age, and in addition shows specimens of many of the fish teeth and conodonts described from typical Cleveland shale in volume 2 of the "Paleontology of Ohio." This same fauna occurs in the typical Chattanooga shale at many Tennessee localities. At Mount Pleasant, Tennessee, specimens of the conodonts especially are so numerous that some of the layers at the base of the black shale here are composed almost entirely of these fossils alone. At Bakers, Tennessee, as indicated in the Bakers-Ridgetop section presented on a later page, these same conodonts and fish teeth are present in both the basal part of the typical black shale and in the Hardin sandstone member of the Chattanooga. The most southern locality where this fauna has been found is near Huntsville, Alabama, where the basal layers of the Chattanooga are crowded with the same conodonts. Although the division line between the Devonian and Carboniferous in Ohio is still in doubt, as indicated in Professor Prosser's paper "Revised Nomenclature of the Ohio Geological Formations,"¹ it seems to me that there is sufficient evidence published to justify the regarding of the Chattanooga shale of central Tennessee as basal Waverlyan. That this black shale in central Tennessee is correctly correlated with the Chattanooga shale of the Appalachian Valley is another question, but I think such a correlation can be proven.

With the exception of the Rockwood formation of Silurian age, the stratigraphic relations at Chattanooga, Tennessee, the type locality of this shale, are precisely the same as along the eastern rim

¹ Geol. Surv. Ohio, Bull. No. 7, 1905, pp. 2, 17-21.

of the Central Basin. East and northeast of this Chattanooga band of outcrop, a similar black shale, but of undoubted Devonian age, has been mapped as the Chattanooga shale. This shale in central Tennessee will, therefore, according to the present classification, be placed as the first formation of the Waverlyan. The remaining Waverlyan formations of Tennessee form more especially the subject-matter of the present article.

WAVERLYAN SECTIONS IN TENNESSEE.

The usual section of Waverlyan rocks in Tennessee is quite simple. Along the eastern side of the Nashville dome the section given in the McMinnville folio of the U. S. Geological Survey is quite typical. In fact, in a study of hundreds of exposures I have seen little deviation from it. This section, with the formations listed according to present-day nomenclature, is as follows:

Geologic section of Waverlyan, McMinnville folio.

	Feet.
Bangor limestone (of St. Louis and Chester age).....	—————
Waverlyan:	
Fort Payne chert—	
Siliceous limestone with heavy beds of chert at the base.....	150-225
Maury green shale—	
Light blue to green shale holding glauconite locally and usually containing a layer of phosphatic concretions.....	0-2
Chattanooga black shale—	
Carbonaceous fissile shale.....	10-30
Ordovician limestone (usually of Trenton age).....	—————

At a locality near Woodbury in Cannon County, just a few miles west of the McMinnville quadrangle, Safford has recorded the typical Keokuk fossil *Agaricoerinus americanus*.¹ I have examined this and many other similar sections in the Woodbury quadrangle and find that the stratigraphic succession is identical with the McMinnville section given above. The crinoids come from the basal part of the Fort Payne chert, and as the lowest layers of the overlying Bangor limestone contain *Lonsdalia canadense*, the whole of the Fort Payne chert falls within the Keokuk of the general time scale. The Chattanooga black shale and the Maury green shale afforded no fossils, but lithologically they are identical with the formations so named in the following sections. Tullahoma, the type-locality of the Tullahoma chert formation of Safford and Killibrew, is but a few miles to the south. Here essentially the same section is presented and the Tullahoma formation at its type-locality is, from all the evidence so far as known, likewise of Keokuk age. The Fort Payne chert at its type-locality in northern Alabama does not include the St. Louis at its top nor does it contain the Kinderhook shales at its base. It is, therefore, the same as the Tullahoma, and the latter term is discarded in favor of the former on the ground of priority.

¹ Geology of Tennessee, 1869, p. 342.

As previously stated, Safford and Killibrew and Hayes and Ulrich referred to the Tullahoma certain underlying shales which are locally developed along the northern and western sides of the dome. As these shales represent a distinct group—the Kinderhook—the new name Ridgetop shale is here proposed. An excellent development of the Ridgetop shale is seen in the section about to be described, from which the name is taken.

Geologic section along Louisville and Nashville Railroad, from Bakers to Ridgetop, Tenn.

Tennessean:

St. Louis limestone—

	Feet.
Massive gray to blue limestone weathering into the characteristic angular, rather solid chert and red soil, with an occasional specimen of <i>Lonsdalia canadense</i> (top of hill)	—

Waverlyan:

Fort Payne chert (Keokuk)—

Massive to thin bedded, dark gray and drab, siliceous, practically unfossiliferous limestone weathering into a yellow, barren soil full of small plates of chert. These layers rest unconformably upon the underlying shales.	100+
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Ridgetop shale (Kinderhook)—

(i) Light blue to green clay shale holding numerous ostracods and bryozoans.	15-20
(h) Arenaceous shales with bands of porous chert, yielding silicified fossils.	2
(g) Light blue to green shale with same fossils as second bed above.	36
(f) Unfossiliferous blue shales passing upward into light blue and green shales of bed above	4
(e) Thin bedded argillaceous limestone and compact dark shales with numerous fossils	5
(d) Dark, compact clay shale with few fossils	15
(c) Fine grained argillaceous sandstone weathering red and forming a conspicuous line in the section.	1
(b) Light blue to green unfossiliferous shale.	20
(a) Sandy, unfossiliferous chert	1

Maury green shale—

Unfossiliferous green shale	1-2
Green shale containing phosphatic nodules	½-1½

Chattanooga shale—

Carbonaceous black fissile shale containing numerous Cleveland shale conodonts and fish teeth in the lower beds	30
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Hardin sandstone member—

Iron stained conglomeritic sandstone composed mainly of chert and fragments of silicified fossils from older formations, resting upon the eroded top of the underlying Louisville limestone. Fish teeth and conodonts of Cleveland shale age are associated with the fossils of greater age	0-2 in.
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Silurian-Niagaran:

Louisville (Bledsoe) limestone—

Massive, dolomitic, unfossiliferous limestone	0-17
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Waldron (Newsom) shale	—
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The town of Ridgetop is situated upon the lower part of the St. Louis limestone. Between the top of the ridge and the railroad

station the full thickness of the usual Fort Payne is shown, while along the railroad near the station the uppermost beds of the Ridgetop shales are encountered. The latter are abundantly fossiliferous and contain besides numerous bryozoans and ostracods of known Kinderhook age, specimens of the species long ago described and listed by Prof. A. Winchell as of Marshall or Kinderhook age.¹ This fauna is not discussed in detail here, since it requires much more study before it can be listed and employed in exact correlation with Kinderhook formations in the Mississippi Valley.

The Maury green shale and the Chattanooga shale, with its Hardin sandstone member, show no unusual features in this section, and need no lengthy description. The Hardin sandstone is simply the physical representation of the unconformable relations of the Chattanooga shale, as evidenced by its conglomeritic nature. The Maury green shale is likewise conglomeritic. A similar phosphatic green shale almost invariably follows the Chattanooga shale at many localities.

In many sections the Maury green shale is succeeded by light blue to green shales bearing the Kinderhook fauna mentioned by Winchell, but in the present section the lowest beds assigned to this shale division are sandy, fossiliferous cherts holding practically the same fauna as the more typical clayey layers above. The main portion of the shale, however, is as described frequently by Safford, a light blue to green fossiliferous clayey fetid shale. Bryozoa form the most abundant fossils of this shale, but none of them has been named. The ostracods likewise are unnamed, with one exception, *Ctenobolbina loculata* Ulrich, which is known also from the yellow clay beds at the base of the Louisiana limestone in Missouri. The other classes of fossils were studied by Winchell, who recognized among them numerous Kinderhook species. His list of species, published in the "Geology of Tennessee" (pp. 441-446), follows:

Spirifera hirta? White and Whitfield.

Rhynchonella sageriana Winchell.

Chonetes multicosta Winchell.

Chonetes pulchella? Winchell.

Producta concentrica Hall.

Chonetes fischeri Norwood and Pratten.

Zaphrentis ida? Winchell.

Conularia byblis White.

Leda bellistriata? Stevens.

Solen scalpriformis Winchell.

Discina saffordi Winchell.

Pleurotomaria hickmanensis Winchell.

Phillipsia tennesseensis Winchell.

¹ Safford's Geology of Tennessee, 1869, pp. 442-446.

In another publication Winchell refers to these Kinderhook shale beds as the Hickman shale, but the term was never defined and has since been employed for a formation of Eocene age.

The arenaceous shales and porous cherts forming a band two feet or less in thickness in the upper part of the Ridgetop shale are abundantly fossiliferous and contain species which, considered alone, would be regarded as indubitably Devonian. Among these are a *Striatopora*, and a *Michelinia* of Devonian affinities, but the presence of well-developed species of *Palaeacis*, *Productus*, and *Agaricocrinus* is sufficient evidence for the post-Devonian age of the fauna.

The Fort Payne chert and St. Louis limestone following the Ridgetop shale in this section are typical for Tennessee, and need no further description than that given in the section.

WHITES CREEK SPRINGS SECTION.

This is undoubtedly the most interesting and important Waverlyan section of Tennessee, first, because it affords a clue to the unsettled points in the stratigraphy of the Central Basin, and second on account of the rather numerous fossils afforded by these rocks, which, in most other localities contain few specimens. The section also throws a somewhat unexpected light upon the equivalence of the different beds of the Waverlyan with those of the upper Mississippi Valley. The Springs emerge from the base of the Chattanooga shale and obtain their chalybeate and other properties from the shale and its contained minerals. Excellent exposures showing practically every inch of the formations listed are to be seen in the road northward to the top of the hill or on the ridge to the east.

Geologic section, Whites Creek Springs, 12 miles north of Nashville, Tennessee.

Waverlyan:

Fort Payne chert—

Massive dark gray siliceous and argillaceous limestone weathering into light yellow to brown platy chert. Fossils as a rule uncommon, crinoidal remains being most often observed. <i>Agaricocrinus americanus</i> , <i>A. nodulosus</i> , <i>Dorycrinus gouldi</i> , and <i>Lobocrinus nashvillae</i> are the most abundant crinoids.....	Feet. 100±
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New Providence formation—

Coarsely crystalline white to gray crinoidal limestone in layers 12 to 18 inches thick, separated by thin green to blue shale bands. Upon weathering these limestones and shales break up, forming glades covered with crinoidal remains.....	35
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Ridgetop shale—

Light blue to green fossiliferous clay shales, with bryozoans and ostracods most abundant fossils.....	40
Layers of decomposed chert.....	0-1

Maury green shale—

Green shales containing phosphatic concretions.....	6 in. ±
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Chattanooga shale—

Black bituminous fissile shale.....	35
Hardin sandstone member.....	0-2 in.

Silurian limestone.

In this section the Hardin sandstone, Chattanooga shale, and Maury green shale present their usual characters, differing only in thickness from the same strata elsewhere. The Ridgetop shale has decreased in thickness, although the bed of decomposed, sandy chert is still present at its base. The Kinderhook fauna described under the Ridgetop section is present here throughout this shale.

Succeeding the Ridgetop shale, instead of the usual siliceous limestone of the Fort Payne is a formation of a coarsely crystalline, rather massive crinoidal limestone, with bands of green and blue shale. Both the shale and limestone are highly fossiliferous. Frequently the crinoidal fragments and other fossils are loosely cemented together by a greenish shale, which, upon weathering, leaves the ground strewn with an abundance of specimens. The lithology and general method of preservation is exactly the same as in the Knobstone of Indiana and Kentucky, except that in Tennessee the limestone predominates, while in the more northern areas the shale is much more conspicuous. The fossils likewise are identical so far as they have been collected and identified. Among the bryozoans, *Rhombopora incrassata* Ulrich, the most abundant and characteristic bryozoan of the Knobstone, or, as it should now be called, the New Providence shales, is likewise very common here. *Fenestella regalis*, *Cystodictya pustulosa*, and *Ptilopora cylindracea* of Ulrich, and other bryozoans known from the Knobstone, are also present. The brachiopod *Rhipidomella michelinia* L'Eveille, and *Chonetes illinoisensis* Norwood and Pratten, are as abundant as in the Kentucky strata. The fauna, including the echinoderms which Mr. Springer has identified specifically, is as follows:

Fauna of the New Providence formation, Whites Creek Springs, Tenn.

- Favosites valmeyerensis* Weller.
- Beaumontia americana* Weller.
- Zaphrentis cliffordana* Edwards and Haime.
- Amplexus rugosus* Weller.
- Amplexus brevis* Weller.
- Cladoconus americana* Weller.
- Monilopora crassa* (McCoy).
- Rhipidomella michelinia* L'Eveille.
- Chonetes illinoisensis* Worthen.
- Spirifer vernonensis* Swallow.
- Lasiocladia hindei* Ulrich.
- Rhombopora incrassata* Ulrich.
- Cystodictya pustulosa* Ulrich.
- Fenestella regalis* Ulrich.
- Ptilopora cylindracea* Ulrich.
- Metichthyocrinus tiaraeformis* (Troost).
- Barycrinus cornutus* (Owen and Shumard).

- Catillocrinus tennesseensis* Troost.
Halysiocrinus perplexus (Shumard).
Synbathocrinus robustus Shumard.
Schizoblastus decussatus (Shumard).

Practically every one of the above species has been found in the New Providence shales in the Ohio Valley near Louisville. Mr. Springer's notes indicate many more echinoderms which are common to these Kentucky shales and the Whites Creek Springs bed immediately under discussion. A more complete study of the other fossils will no doubt greatly increase the number of identical species. It therefore seems to me that the equivalence of the New Providence shale and the Tennessee strata under consideration can not be doubted. Not only are the faunas practically identical, but, as mentioned above, the lithological characters of the beds in the two areas are essentially similar. As these Tennessee strata are undoubtedly only the southern extension of the New Providence (Knobstone) shale, it seems desirable to use the same name for them in preference to coining a new term.

The Fort Payne chert in the Whites Creek Springs section differs but little from the beds elsewhere recognized in Tennessee under the names Fort Payne and Tullahoma. For reasons stated before, the latter name is discarded in favor of the former. Fossils, with the exception of crinoids, are extremely rare and the crinoids are by no means common. All of the crinoids from this horizon are of undoubted Keokuk forms, as evidenced by Mr. Springer's list which follows:

Crinoids of the Fort Payne chert, Whites Creek Springs, Tenn.

- Agaricocrinus americanus* Roemer.
Agaricocrinus nodulosus Meek and Worthen.
Lobocrinus nashvillae Hall.
Alloprosallocrinus conicus Casseday and Lyon.
Eretmocrinus ramulosus (Hall).
Eretmocrinus praeegravis Miller.
Dorycrinus gouldi (Hall).

The hills in the vicinity of Whites Creek Springs do not rise high enough to show the St. Louis limestone.

EMBAYMENT DEVELOPMENT OF NEW PROVIDENCE FORMATION IN TENNESSEE.

Sections with the same stratigraphic units as at Whites Creek, and each developed to practically the same thickness, are exposed in the creek valleys just east and west of Whites Creek; but farther away, say 8 or 10 miles west and southwest along the line of outcrops, the New Providence shale division is entirely absent, having pinched out in the intervening space. Going east and northeast

from Whites Creek toward Ridgetop, the same thing happens. At Union Hill, 4 miles east of the Whites Creek section, the New Providence division and the Fort Payne chert are both splendidly exposed, but the former is here much reduced in thickness. A few miles farther east the New Providence disappears entirely, as shown in the Ridgetop section. The Whites Creek area, therefore, seems to have been the site of an embayment of the Nashville Island in New Providence times. Considering the location of the area and the lithologic and faunal similarity of these deposits to those of the same age in the vicinity of Louisville, Kentucky, it seems probable that the latter were laid down in the northern part and those at Whites Creek near the southern end of a trough paralleling the Cincinnati axis. So far as known, the New Providence did not extend to the east of this axis. Similar embayments of Richmond and Niagaran times have been described by Hayes and Ulrich.¹ One of their embayments terminates in the northeastern corner of the Columbia sheet, and it is possible that detailed mapping will show the New Providence formation of the Whites Creek area, which is less than 25 miles to the north, to have been deposited in a continuation of the same trough. If true, we have a good example of the permanence of these embayments. The extent of the submergence of this trough varied at least in Richmond and Niagaran times, for the older deposits stretched some miles farther south than did the Niagaran invasion. From evidence here presented and elsewhere in hand it appears that deposition was still more restricted in Waverlyan transgressions. Thus, with each transgression the extent of each subsequent invasion was progressively less, until, in New Providence time, the submerged area extended only a few miles south of Whites Creek Springs. As brought out by Hayes and Ulrich, even the Chattanooga shows evidence of earlier deposition confined to these embayments, with the later Chattanooga spreading far and wide over their borders. Following this New Providence time of greatest restriction, at least of these embayments, the long and general submergence of the Fort Payne sets in, doubtless covering the whole dome.

The development of these shales and limestones in the Whites Creek area has a noticeable effect upon the present topography. In areas where the siliceous Fort Payne rests upon the soft Ridgetop shale or upon the Chattanooga shale, the descent from the Highland rim to the Central Basin is usually very steep. The intercalation of a loosely cemented fragmental, fossiliferous limestone in the Whites Creek area causes a bench to be developed in this otherwise steep descent, so that from a study of the topography one is almost able to determine the outline of the area containing the New Providence.

¹ Columbia Folio, U. S. Geol. Surv., Folio No. 95, 1903.

Proceeding south along the west side of the Nashville dome, the Fort Payne chert rests either upon the Ridgetop shale or upon some lower formation. I am aware of no instance in which the New Providence formation forms a part of the section. However, it is possible that more field work will show deposits in embayments similar to the one at Whites Creek, along the west and south sides of the dome. Safford mentions crinoidal limestone in the lower part of his Siliceous Group at several localities in addition to Whites Creek, and these possibly may prove to be of New Providence age.

CORRELATION.

In the accompanying correlation table I have endeavored to arrange the Waverlyan and early Tennessean formations according to the available facts. As Schuchert, in his "Paleogeography of North America,"¹ has presented a more comprehensive table covering the Waverlyan, or, as he terms it, the Mississippic, I need only call attention to the points in which my own table differs. In the column devoted to the general time units it will be noted that the Kinderhookian does not include the early Waverlyan black shales, and that these are placed as a part of an unnamed series. The Kinderhook never did include these shales, and it would be an unwarranted extension of the series term to make it embrace them. Moreover, these black shales represent a definite time period of pre-Kinderhookian and post-Devonian age, and distinct diastrophic history. In the same column the Glen Park is placed, not below, but above the Louisiana, a position which I determined some years ago in sections at Hamburg, Illinois. The placing of the New Providence under the Burlington at the base of the Osagian is a provisional arrangement, since the close relations to the Lower Burlington are appreciated, and the possibility of their partial equivalence is recognized. A correlation which is made, however, without reserve, is the exact equivalence of the New Providence and the Fern Glen formations. Weller, in his *Kinderhook Faunal Studies*² writes as follows:

Although our knowledge of this basal Knobstone fauna is incomplete, the evidence available seems to indicate that a reasonably close correlation between it and the Fern Glen fauna can be made.

Mr. Springer's study of the echinoderms strengthens this view, and the occurrence of numerous other Fern Glen fossils in the Tennessee strata here termed New Providence, is thought to establish the correctness of this correlation. The reasons for the adoption and correlation of the other formational names under discussion have been stated in the preceding remarks.

¹ Bull. Geol. Soc. Amer., vol. 20, 1910, p. 548.

² The Fauna of the Fern Glen Formation, Bull. Geol. Soc. America, vol. 20, 1909, pp. 265-332.

Correlation table of Waverlyan and early Tennessean formations.

Tennessean.		Waverlyan.					
Series.	General time units.	Ohio Basin east of Cincinnati axis.	East Tennessee.	North Tennessee.	West side of Nashville dome.	Ohio Basin (Indiana and Kentucky).	Mississippi Valley South of St. Louis.
Merramecian.	St. Louis.	(Undifferentiated formations.)	Bangor (lower part).	St. Louis.	St. Louis.	St. Louis (Mitchell in part).	St. Louis.
	Spergen.			Warsaw.	Warsaw.	Spergen.	Spergen.
	Warsaw.					?	Warsaw.
Osagian.	Keokuk.	Logan.	Fort Payne.	Fort Payne (Tullahoma).	Fort Payne (Tullahoma).	Harrodsburg.	Boone.
	Upper Burlington.	Black Hand.				Riverside.	
	Lower Burlington.	Cuyahoga (Upper).		New Providence.		New Providence.	Fern Glen.
Kinderhookian.	Chouteau.	Cuyahoga (Middle).					Bushberg.
	Hannibal.	Cuyahoga (Lower).					Glen Park.
	Glen Park.						
Chattanooga.	Louisiana.			Ridgetop.	Ridgetop.	Rockford.	
		Sunbury.					
		Berea.	Chattanooga.	Mauzy member.	Chattanooga.	New Albany (part).	Chattanooga.
	Bedford.		Black shale member.				
	Cleveland.		Hardin member.				

CONCLUSIONS.

To sum up, it is believed that the paleontologic and stratigraphic data presented in the preceding pages warrant the following conclusions:

I. The Waverlyan section in Tennessee, in its most complete development, contains formations of the three series of the general time scale, comprising (1) the Chattanooga black shale with its initial deposit, the Hardin sandstone, and a succeeding green shale with phosphatic nodules, the Maury green shale; (2) an overlying shale here named the Ridgetop, which is referred to the lower part of the Kinderhook; and (3) the Osage formations consisting of (*a*) crinoidal limestone and intercalated green shales equivalent to the New Providence shale of Kentucky and the Fern Glen of Missouri, and (*b*) the Fort Payne chert, a light blue siliceous limestone of Keokuk age.

II. The Chattanooga black shale is a wide-spread, overlapping formation on both sides of the Nashville dome. The Kinderhook Ridgetop shale is apparently restricted to the northern and western flanks of the dome, where, however, it is well developed and usually present in sections. The New Providence has a more local distribution, in fact, it seems to occupy old embayments of the dome. Finally the Fort Payne chert has as great a distribution as the Chattanooga shale.

III. Instead of a single fauna of Keokuk age, two distinct faunas can now be recognized in the classic Whites Creek Springs crinoid locality. One of these, the lower fauna, is identical with that of the New Providence shale, while the other contains only Keokuk species.

IV. The upper Cuyahoga shale, New Providence shale, and the formation in Tennessee here referred to the latter, and the typical Fern Glen of Missouri, contain essentially the same fauna, which, on account of its intimate relation to the fauna of the lower Burlington, causes the reference of these deposits to the Osage instead of the Kinderhook. The stratigraphic relations of the New Providence to the preceding Kinderhook formations are also much less conformable than to the succeeding typical Burlington limestone. There is thus a good diastrophic reason for regarding it as the basal member of the Osage and not as the top of the Kinderhook.

NAMES APPLIED TO BEES OF THE GENUS *NOMADA*, FOUND IN NORTH AMERICA.¹

By T. D. A. COCKERELL,
Of the University of Colorado, Boulder.

Having recently had occasion to classify a large number of *Nomada* for the United States National Museum, I have thought it useful to present for publication a list of the names applied to the American species of this genus. The need for such a list is evident, none having appeared since that of Cresson, published in 1887, which included only 73 names.

All the names are cited in alphabetical order, followed by the name of the author and date of publication. Whenever known, the type-locality is given, and also the name of the collector of the type. References are also made to all the principal synoptic tables, which are enumerated below, and referred to by number in the list.

SUBGENERA AND SECTIONS.

Gnathias ROBERTSON, 1903. Species with an inner tooth on the mandibles; includes *N. cuneata*, *ovata*, *bella*, *washingtoni*, *grayi*, *rhodomelas*, etc.

Cephen ROBERTSON, 1903. Scape of male normal; front coxæ of female with long pubescent spines.

Type.—*N. texana*; also includes *fervida*, etc.

Centrias ROBERTSON, 1903. Scape of male robust; front coxæ of female with long pubescent spines.

Type.—*N. erigeronis*.

Phor ROBERTSON, 1903.

Type.—*N. integra*. Also includes *N. subgracilis*.

Heminomada COCKERELL, 1902.

Type.—*N. obliterata*.

Micronomada COCKERELL and ATKINS, 1902. Species of the type of *N. modesta*.

Xanthidium ROBERTSON, 1903. Species of the type of *N. luteola*; includes *N. civilis*, *citrina*, *dentariæ*, etc.

Holonomada ROBERTSON, 1903. *N. superba* and its allies; includes *N. edwardsii*, *vinnula*, *vincta*, *affabilis*, etc.

¹ The asterisk (*) indicates that the species is in the collection of the United States National Museum. Specimens sent to the Museum by Prof. T. D. A. Cockerell labeled as cotypes are considered as paratypes, as Professor Cockerell uses the word "cotype" in the sense that the Museum uses the word "paratype." Of the 273 names in this list, representatives of 112 are in the Museum collection. The Museum collection contains types of 44 of the species and paratypes of 7 additional ones. The catalogue number of the type or paratype, when in the United States National Museum, has been added after the other information.—S. A. ROHWER.

Nomadula COCKERELL, 1903.

Type.—*N. articulata* (*americana* auctt.). Antennæ of male peculiar. Includes also *N. martinella*, *scita*, *scitiformis*, *erythrochroa*, and *sophiarum*.

Melanomada COCKERELL, 1903.

Type.—*N. grindeliæ*. Male entirely black, female with red abdomen.

I can not distinguish *Cephen* from *Micronomada*.

TABLES.

- (1) Cockerell, Bull. 94, Colo. Agric. Exp. Sta., pp. 70-75. (Dated December, 1904, but published early in February, 1905: Species of Rocky Mountains.)
- (2) Cockerell, Bull. 94, Colo. Agric. Exp. Sta., p. 82. (Allies of *N. pallidella*.)
- (3) Cockerell, Bull. 94, Colo. Agric. Exp. Sta., p. 84. (Allies of *N. coloradensis*.)
- (4) Cockerell, Proc. Acad. Nat. Sci. Phila., 1903, pp. 559-561. (Species of California.)
- (5) Cockerell, Proc. Acad. Nat. Sci. Phila., 1903, pp. 580-582. (*Xanthidium* and *Holonomada*.)
- (6) Cockerell, Proc. Acad. Nat. Sci. Phila., 1903, p. 589. (Red species.)
- (7) Cockerell, Proc. Acad. Nat. Sci. Phila., 1903, p. 591. (*Centrias* and *Nomadula*.)
- (8) Cockerell, Proc. Acad. Nat. Sci. Phila., 1903, p. 593.
- (9) Cockerell, Proc. Acad. Nat. Sci. Phila., 1903, pp. 594-596. (*Gnathias*.)
- (10) Cockerell, Proc. Acad. Nat. Sci. Phila., 1903, pp. 608-610. (*Micronomada* and *Centrias*.)
- (11) Cockerell, Univ. of Colorado Studies, vol. 4 (1907), pp. 247-248.
- (12) Robertson, Canadian Entomologist, June, 1903, pp. 173-179.

LIST OF SPECIES.

- * *accepta* CRESSON, 1878. "Colorado, Kansas (Snow, male, Morrison, female)." Tab. 1.
- adducta* CRESSON, 1878. Colorado (Morrison). Tab. 1.
- * *affabilis* CRESSON, 1878. "New York; Illinois." Tab. 5, 12.
- * *affabilis dallasensis* COCKERELL, 1911. Dallas, Texas (Crawford and Pratt). Subg. *Holonomada*.
- Type*.—Cat. No. 13434, U.S.N.M.
- agynia* COCKERELL, 1905. Golden, Colorado, July (Gillette). Tab. 1.
- * *albofasciata* SMITH, 1879. Canada. Tab. 1, 9.
- Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 312. Subg. *Gnathias*.
- Distribution in U. S.; Proc. Acad. Nat. Sci. Phila., 1903, p. 602.
- alpha* COCKERELL, 1905. Fort Collins, Colorado, May 20 (Bishopp). Tab. 1.
- * *americana* KIRBY, 1837. Hudson Bay.
- Confusion as to identity. See Trans. Amer. Ent. Soc., vol. 31, p. 310.
- amoena* CRESSON, 1863. Rock Island, Illinois.
- Viereck reports that the type is not in Philadelphia.
- * *angalarum* COCKERELL, 1903. Los Angeles County, California (Coquillett). Tab. 4.
- Type*.—Cat. No. 13158, U.S.N.M.
- annulata* SMITH, 1854. "North America" (Murchison).
- Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 311.
- antonita* COCKERELL, 1909. Antonito, Colorado.
- * *aquilarum* COCKERELL, 1903. South Fork of Eagle Creek, New Mexico (Townsend). Tab. 1.
- Visits *Erigeron* in August.
- Type*.—Cat. No. 13183, U.S.N.M.
- * *arizonica* COCKERELL, 1911. Arizona (Carl F. Baker). Subgen. *Xanthidium*.
- Type*.—Cat. No. 14024, U.S.N.M.
- armata* HERRICH-SCHAEFFER, 1839. Europe.
- Nova Scotia. Female with head and thorax black; anterior margin of clypeus ferruginous; thorax marked with ferruginous; abdomen ferruginous, base black, second segment with an oval yellow spot on each side. Labrum of male armed with a sharp tooth in the middle.

**armatella* COCKERELL, 1903. Canada. Tab. 3.

Type.—Cat. No. 13174, U.S.N.M.

**articulata* SMITH, 1854. "North America" (Doubleday). Tab. 12. (As *Centrias americanus*.)

Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 312.

This has been erroneously known as *N. americana*.

**ashmeadi* COCKERELL, 1903. Los Angeles County, California (Coquillett). Tab. 4.

Type.—Cat. No. 13173, U.S.N.M.

**astori* COCKERELL, 1903. Corvallis, Oregon, May and June (Cordley). Tab. 6.

Possibly a variety of *N. ultima*.

**atrofrontata* COCKERELL, 1903. S. California. Tab. 4.

Allied to *N. ultima*.

**atecorum* COCKERELL, 1903. Amecameca, Mexico, September (Barrett).

Female about 11 mm.; black with bright yellow markings; tegulae bright ferruginous; legs black and red.

**banksi* COCKERELL, 1907. Glencarlyn, Virginia, October (N. Banks).

**belfragei* CRESSON, 1878. Texas (G. W. Belfrage).

**belfragei xanthogaster* COCKERELL, 1911. Texas (G. W. Belfrage).

Type.—Cat. No. 13427, U.S.N.M.

**bella* CRESSON, 1863. Massachusetts; Connecticut. Tab. 1, 6, 9. Subg. *Gnathias*.

Distribution; Proc. Acad. Nat. Sci. Phila., 1903, p. 601.

**bella callura* COCKERELL, 1911. West Cliff, Colorado (Cockerell). Subg. *Gnathias*.

Type.—Cat. No. 13437, U.S.N.M.

**bethunei* COCKERELL, 1903. Canada. Tab. 3.

Table contrasting *bethunei* with *armatella*; Proc. Acad. Nat. Sci. Phila., 1903, p. 607.

Type.—Cat. No. 13159, U.S.N.M.

**beulahensis* COCKERELL, 1903. Beulah, New Mexico, August (Cockerell). Tab. 1.

Allied to *N. interruptella*.

**bifurcata* COCKERELL, 1903. S. California. Tab. 4.

Allied to *N. sayi*.

**bisignata* SAY, 1824.

Robertson (1898) stated that this could not be identified, as he knew three species agreeing with Say's description.

**borealis* ZETTERSTEDT, 1838. Europe.

Description of specimen from Nova Scotia; Trans. Amer. Ent. Soc., vol. 31, p. 311.

**californiæ* COCKERELL, 1903. S. California. Tab. 4.

Allied to *N. erythræa*.

**carolinæ* COCKERELL, 1903. North Carolina. Tab. 9.

Very close to *N. cuneata*.

**ceanothi* COCKERELL, 1907. Glencarlyn, Virginia (N. Banks).

Allied to *N. florilega*. Visits *Ceanothus* in June.

**citrina* CRESSON, 1878. California (Henry Edwards). Tab. 5.

**citrina rufula* COCKERELL, 1903. Grangeville, Idaho. Tab. 5.

**civilis* CRESSON, 1878. Colorado (Ridings, Morrison). Tab. 1, 5.

Female; Entomologist, 1909, p. 93.

**civilis spokaneensis* COCKERELL, 1910. Spokane, Washington (W. M. Mann). Subg.

Xanthidium.

**clarkii* COCKERELL, 1903. Corvallis, Oregon, April 6 (Cordley). Tab. 6.

**collinsiana* COCKERELL, 1905. Fort Collins, Colorado (S. A. Johnson). Tab. 1, 11.

**coloradella* COCKERELL, 1905. Fort Collins, Colorado. Tab. 1.

**coloradensis* COCKERELL, 1903. Montrose, Colorado (Gillette). Tab. 1, 3.

Male, and history of type; Bull. 94, Colo. Agric. Exp. Sta., p. 84.

**coquilletti* COCKERELL, 1903. Santa Clara County, California (Coquillett). Tab. 4.

Resembles *N. modocorum*.

Type.—Cat. No. 13186, U.S.N.M.

cordleyi COCKERELL, 1903. Corvallis, Oregon (Cordley).

Male 7 mm.; abdomen subclavate.

cornelliana COCKERELL, 1908. Ithaca, New York (N. Banks).

A *Gnathias* allied to *N. physura*.

corvallisensis COCKERELL, 1903. Corvallis, Oregon, May 24 (Cordley). Tab. 6.

**crassula* COCKERELL, 1903. Louisiana. Tab. 10.

Resembles *N. modesta*.

Type.—Cat. No. 13171, U.S.N.M.

**crawfordi* COCKERELL, 1905. Virginia Dale, Colorado (Bishopp). Tab. 1.

Male; Bull. Amer. Mus. Nat. Hist., vol. 22 (1906), p. 438.

**cressonii* ROBERTSON, 1893. Illinois (Robertson). Tab. 12.

cressonii trevoriana COCKERELL, 1905. Olympia, Washington State (Kincaid).

No subdiscal cuneate spot on fourth abdominal segment.

**crotchii* CRESSON, 1878. Fort Tejon, California (Crotch).

crotchii nigrior COCKERELL, 1903. S. California. Tab. 4.

**crucis* COCKERELL, 1903. Las Cruces, New Mexico, August (Townsend). Tab. 1, 8, 10.

Closely allied to *N. neomexicana*.

Female; Entomologist, 1907, p. 265.

crudelis CRESSON, 1878. Georgia (Morrison).

"This and *grandis* are our largest species" (Cresson, 1878).

cubensis CRESSON, 1865. Cuba (Gundlach).

**cuneata* ROBERTSON, 1903. Illinois. Tab. 1, 9, 12.

Distribution; Proc. Acad. Nat. Sci. Phila., 1903, pp. 601-602.

cuneata decemnotata ROBERTSON, 1903. Illinois. Tab. 12.

**cuneata octonotata* ROBERTSON, 1903. Illinois. Tab. 12.

**cuneata quadrisignata* ROBERTSON, 1903. Illinois. Tab. 12.

cuneata sexnotata ROBERTSON, 1903. Illinois. Tab. 12.

**custeriana* Cockerell, 1911. West Cliff, Colorado (T. D. A. Cockerell). Subgen. *Gnathias*.

Type.—Cat. No. 14023, U.S.N.M.

**cymbalariae* COCKERELL, 1906. Near Lake George, Colorado, June 18 (Rohwer).

Probable male (close to *illinoiensis*); Entomologist, Dec., 1907, p. 268.

**dacotana* COCKERELL, 1903. Brookings, South Dakota. Tab. 1, 10, 11.

Also in Colorado and Montana.

davidsoni COCKERELL, 1903. S. California. Tab. 4.

decempunctata COCKERELL, 1903. S. California. Tab. 4.

**dentariæ* ROBERTSON, 1903. Illinois (Robertson). Tab. 5, 12.

**denticulata* ROBERTSON, 1902. Illinois (Robertson). Tab. 12.

Formerly confused with *N. articulata*.

depressa CRESSON, 1863. Maine.

Female with a depression on fifth dorsal abdominal segment.

Table of species allied to *depressa*; Ent. News, July, 1908, p. 323.

depressicauda COCKERELL, 1908. Falls Church, Virginia (N. Banks).

Group of *N. depressa*.

dilucida CRESSON, 1878. Colorado (Morrison). Tab. 1.

ednæ COCKERELL, 1907. Boulder, Colorado, April 10 (Edna Baker).

Superficially much like *N. ornithica*.

**edwardsii* CRESSON, 1878. California (Henry Edwards). Tab. 4, 5.

Resembles *N. superba*.

edwardsii australior COCKERELL, 1903. Los Angeles County, California (Coquillett).

Tab. 4.

**electa* CRESSON, 1863. Illinois; Connecticut.

Female with sides of face, clypeus, labrum, mandibles, posterior orbits, and a minute spot on each side of ocelli, ferruginous tinged with yellowish; abdomen yellow-banded above, beneath piceous, immaculate. Male with clypeus, etc., yellow.

electella COCKERELL, 1903. Georgia.

Anterior coxæ of female spined.

**elegantula* COCKERELL, 1903. Los Angeles County, California. Tab. 4.

Also occurs at Lewiston, Idaho.

Type.—Cat. No. 13180, U.S.N.M.

elrodi COCKERELL, 1903. Montana. Tab. 1, 5.

Also in Nebraska.

erigeronis ROBERTSON, 1897. Illinois (Robertson). Tab. 7, 10, 12.

West to Nebraska. See Proc. Acad. Nat. Sci. Phila., 1903, p. 588.

**erythræa* DALLA TORRE, 1896. Tab. 4.

**erythrochroa* COCKERELL, 1903. Pasco, Washington, May 25 (Kincaid).

An orange-ferruginous species.

Type.—Cat. No. 13165, U.S.N.M.

**excellens* COCKERELL, 1903. S. California. Tab. 4.

Variety from Nevada; Proc. Acad. Nat. Sci. Phila., 1903, p. 588.

excurrens COCKERELL, 1903. Southern California. Tab. 4.

Very close to *N. hemphilli*.

fervida SMITH, 1854. "St. John's Bluff, East Florida; Georgia (E. Doubleday)."

Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 310.

festiva CRESSON, 1863. New Jersey.

Resembles *N. modesta*; abdomen with yellow bands.

flammigera COCKERELL, 1906. North Yakima, Washington, May 15 (E. Jenne).

Female with head and thorax red, with black markings and no yellow; abdomen with a round cream-colored spot on each side of second segment; mandibles simple.

flaviceps CRESSON, 1865. Cuba (Gundlach).

flavipes PROVANCHER, 1888. Los Angeles, California.

Appears to be near *N. formula*.

florilega LOVELL and COCKERELL, 1905.

Female about 8 mm.; allied to *N. sayi*, but larger and darker, the metathorax entirely black.

Visits *Aralia* and *Spiræa*.

fontis COCKERELL, 1910. Steamboat Springs, Colorado (Cockerell). Subg. *Nomada* s. str.

**formula* VIERECK, 1903. San Pedro, California (Cockerell). Tab. 4, 8, 10.

Male; Cockerell, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 658.

fowleri COCKERELL, 1903. Corvallis, Oregon, April 15 (Cordley).

Female black and ferruginous; the only yellow about the insect is a small patch at extreme lower corners of face.

fragilis CRESSON, 1878. Colorado (Ridings, Morrison). Tab. 1, 8, 11.

**frieseana* COCKERELL, 1904. Prospect Lake, Colorado Springs, Colorado, May 22 (T. and W. Cockerell).

Resembles *N. rubicunda*.

**garciana* COCKERELL, 1907. Mesilla Park, New Mexico, May 1 (Cockerell).

Possibly a subspecies of *N. snowi*.

gibbosa VIERECK, 1905. Oregon.

Thorax almost entirely black, including scutellum; abdomen with yellow spots; a little yellow at lower corners of face.

gillettei COCKERELL, 1905. Golden, Colorado, July 3 (Gillette). Tab. 1.

**gracilis* CRESSON, 1863. Massachusetts.

Notes on type; Entomologist, 1907, p. 98.

grænicheri COCKERELL, 1905.

A *Xanthidium* looking like *N. modesta*; visits *Helianthus* in August.

grandis CRESSON, 1875. Colorado (H. C. Yarrow). Tab. 1.

- grayi* COCKERELL, 1903. Corvallis, Oregon, May 7 (Cordley). Tab. 6, 9.
- **grayi eastonensis* COCKERELL, 1903. Easton, Washington. Tab. 9.
Type.—Cat. No. 13163, U.S.N.M.
- **grindelix* COCKERELL, 1903. Lincoln, Nebraska, Sept. 2 (Crawford). Tab. 1.
Male black; female with red abdomen.
- gutierrezii* COCKERELL, 1896. Mesilla Park, New Mexico (Cockerell). Tab. 1.
Type.—Cat. No. 5322, U.S.N.M.
- heiligbrodtii* CRESSON, 1878. Texas (L. Heiligbrodt). Tab. 10.
Allied to *N. modesta*.
- **heleniella* COCKERELL, 1911. Victoria, Texas (J. C. Crawford). Subg. *Melanomada*.
Type.—Cat. No. 13431, U.S.N.M.
- hemphilli* COCKERELL, 1903. S. California. Tab. 4.
- hesperia* COCKERELL, 1903. S. California. Tab. 4.
- hoodiana* COCKERELL, 1903. Mount Hood, Oregon.
- illinoensis* ROBERTSON, 1900. Illinois (Robertson). Tab. 12.
Was confused with *N. sayi*; abdomen of female nearly always 5- or 6-spotted.
- imbricata* SMITH, 1854. "United States."
Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 310.
- **incerta* CRESSON, 1863. "Conn., N. J., Pa., Md., Ills."
Female abdomen ferruginous, immaculate.
Same as *N. articulata*.
- infantula* COCKERELL, 1907. Great Falls, Virginia, May 22 (N. Banks).
A very small species, about 5 mm. long.
- integerrima* DALLA TORRE, 1896.
Apex of male abdomen entire.
- integra* ROBERTSON, 1893. Illinois (Robertson). Tab. 12. (*Phor integer*).
Name preoccupied; = *integerrima*.
- intercepta* SMITH, 1879. Vancouver Island.
Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 312.
- interrupta* FOWLER, 1899. Berkeley, California (H. O. Woodworth).
Name preoccupied; = *interruptella*.
- interruptella* FOWLER, 1902.
- itamera* COCKERELL, 1910. Pullman, Washington (W. M. Mann). Subg. *Nomada*
s. str.
- jenei* COCKERELL, 1906. N. Yakima, Washington, Sept. 26 (E. Jenne).
Although the anterior coxæ are not spined, they have minute red tubercles.
Probably nearest to *N. pascoensis*, which is quite differently colored.
- jocularis* CRESSON, 1879. Nevada (Morrison).
- kincaidiana* COCKERELL, 1903. Washington.
- krugii* CRESSON, 1878. Porto Rico (Leopold Krug).
- lamarensis* COCKERELL, 1905. Lamar, Colorado. (E. D. Ball). Tab. 1.
- **latifrons* COCKERELL, 1903. Santa Cruz Mountains, California. Tab. 4.
Variety from Nevada; Proc. Acad. Nat. Sci. Phila., 1903, p. 588.
Type.—Cat. No. 13155, U.S.N.M.
- **lehighensis* COCKERELL, 1903. Lehigh Gap, Pennsylvania. (Viereck).
Paratype.—Cat. No. 13831, U.S.N.M.
- **lepida* CRESSON, 1863. Pikes Peak, Colorado; Rock Island, Illinois. Tab. 1, 9, 11.
Subgenus *Gnathias*.
New description; Proc. Acad. Nat. Sci. Phila., 1903, p. 596.
- **levisi* COCKERELL, 1903. Corvallis, Oregon, May and June (Cordley). Tab. 6.
Paratype.—Cat. No. 13188, U.S.N.M.
- **libata* CRESSON, 1878. Colorado (Ridings). Tab. 1.
For characters see Cockerell, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 648.
- limata* CRESSON, 1878. Mexico (Sumichrast).
Resembles the Cuban *N. tibialis*. Also in Texas.

- lippia* COCKERELL, 1903. La Cueva, Organ Mountains, New Mexico (Townsend).
Tab. 1, 8, 10.
Visits *Lippia* in September.
- lippia sublippia* COCKERELL, 1907. Las Cruces, New Mexico, Sept. 15 (Cockerell).
Male with clypeus black; no supraclypeal mark; lateral face-marks narrower above.
- **louisiana* COCKERELL, 1903. Louisiana. Tab. 9.
Allied to *N. cuneata*.
Type.—Cat. No. 13166, U.S.N.M.
- **luteola* OLIVIER, 1811. Carolina. Tab. 5, 12.
- **luteola bishoppi* COCKERELL, 1911. Dallas, Texas (Bishopp). Subg. *Xanthidium*.
Type.—Cat. No. 13435, U.S.N.M.
- **luteoloides* ROBERTSON, 1895. Illinois (Robertson). Tab. 5, 12.
Allied to *N. luteola*.
- luteopicta* COCKERELL, 1905. Palisades, Colorado (Gillette). Tab. 1.
- **maculata* CRESSON, 1863. Connecticut.
Female of *N. bella*.
- magnifica* COCKERELL, 1903. Colorado. Tab. 1.
Perhaps a variety of *N. grandis*.
- malonella* COCKERELL, 1910. Wawawai, Wash. (W. M. Mann). Subg. *Nomada* s. str.
- malonina* COCKERELL, 1910. Wawawai, Wash. (W. M. Mann). Subg. *Nomada* s. str.
- **marginella* COCKERELL, 1903. S. California. Tab. 4.
- **martinella* COCKERELL, 1903. Mesilla Park, New Mexico, April (Cockerell). Tab. 1,
10, 11.
Male; Bull. 94, Colorado Agric. Exper. Sta., p. 76. Also in Colorado.
Type.—Cat. No. 13156, U.S.N.M.
- melliventris* CRESSON, 1878. California (Henry Edwards).
- **mera* COCKERELL, 1908. Salina, Colorado (W. P. Cockerell).
Allied to *N. cressonii*; a variety occurs in New Jersey.
- mexicana* CRESSON, 1878. Mexico (Sumichrast).
- mirimula* COCKERELL, 1908. Falls Church, Virginia (N. Banks).
Resembles *N. modesta*.
- miniata* SMITH, 1854. Georgia.
Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 311.
- **mittelli* COCKERELL, 1911. Victoria, Texas (J. D. Mitchell). Subg. *Micronomada*.
Type.—Cat. No. 13433, U.S.N.M.
- **modesta* CRESSON, 1863. Maine; Rock Island, Illinois. Tab. 10.
- modesta rivertonensis* COCKERELL, 1903. Riverton, New Jersey (Viereck). Tab. 10.
- modocorum* COCKERELL, 1903. Corvallis, Oregon (Cordley).
- montezumia* SMITH, 1879. Orizaba, Mexico.
Notes on type; Trans. Am. Ent. Soc., vol. 31, p. 312.
- **morrisoni* CRESSON, 1878. Colorado (H. K. Morrison). Tab. 1, 5.
- **morrisoni flagellaris* COCKERELL, 1903. Colorado (Morrison). Tab. 1, 5.
Type.—Cat. No. 13172, U.S.N.M.
- mundo* CRESSON, 1878. Colorado (Ridings). Tab. 1.
Female with clypeus and tegulae ferruginous.
- mutans* COCKERELL, 1910. Pullman, Washington (W. M. Mann). Subg. *Holonomada*.
- **neomexicana* COCKERELL, 1903. Deming, New Mexico, July (Cockerell). Tab. 1,
8, 10.
Perhaps a subspecies of *texana*.
Type.—Cat. No. 13157, U.S.N.M.
- nigrocincta* SMITH, 1879. Arctic America. Tab. 6.
Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 311.

obliqua FOWLER, 1899. Berkeley, California (H. O. Woodworth).

Name preoccupied; = *obliquella*.

obliquella FOWLER, 1902.

**obliterata* CRESSON, 1863. District of Columbia. Tab. 1, 12. (*Heminomada obliterata*.)

obscura FOWLER, 1899. Berkeley, California (Fowler).

Name preoccupied; = *obscuraella*.

obscuraella FOWLER, 1902.

opposita CRESSON, 1878. California (Henry Edwards).

orcusella COCKERELL, 1910. Orcas Island, Washington (W. M. Mann). Subg. *Nomada* s. str.

**oregonica* COCKERELL, 1903. Corvallis, Oregon, April to June (Cordley). Tab. 4, 6.

Ranges to S. California. Similar to *N. sayi*.

Paratype.—Cat. No. 13191, U.S.N.M.

ornithica COCKERELL, 1906. Boulder, Colorado (W. P. Cockerell). Tab. 11.

**osborni* COCKERELL, 1911. Tucson, Arizona (H. Osborn). Subgen. *Nomada* s. str.

Type.—Cat. No. 14025, U.S.N.M.

ovata ROBERTSON, 1903. Illinois (Robertson). Tab. 9, 12.

ovata binotata ROBERTSON, 1903. Illinois. Tab. 12.

ovata octomaculata ROBERTSON, 1903. Illinois. Tab. 12.

ovata plena ROBERTSON, 1903. Illinois. Tab. 12.

ovata quadrimaculata ROBERTSON, 1903. Illinois. Tab. 12.

ovata sexmaculata ROBERTSON, 1903. Illinois. Tab. 12.

ovata unicolor ROBERTSON, 1903. Illinois. Tab. 12.

pacata CRESSON, 1878. Colorado (Ridings).

Same as *N. accepta*. See Ann. Mag. Nat. Hist., Oct., 1903. p. 447.

packardella COCKERELL, 1906. Boulder, Colorado, June 11 (W. P. Cockerell). Tab. 11.

Allied to *N. nigrocincta*.

pallidella COCKERELL, 1905. Montrose, Colorado (Gillette). Tab. 1, 2

parata CRESSON, 1878. Colorado (Ridings). Tab. 1.

Allied to *N. libata*, but tegulae polished, with a few scattered punctures (in *libata* coarsely sculptured and opaque).

**parva* ROBERTSON, 1900. Illinois (Robertson). Tab. 12.

Confused with *N. sayi*; female abdomen 8-spotted.

**pascoensis* COCKERELL, 1903. Pasco, Washington State, May 25 (Kincaid). Tab. 4, 5.

A variety occurs in Los Angeles County, California.

Type.—Cat. No. 13187, U.S.N.M.

**pecosensis* COCKERELL, 1903. Pecos, New Mexico, June 26 (W. P. Cockerell). Tab. 1, 5.

Described as a variety of *N. xanthophila*.

Type.—Cat. No. 13185, U.S.N.M.

pennigera COCKERELL, 1894. Mesilla Valley, New Mexico. Tab. 1.

**perbella* VIERECK, 1905. Corvallis, Oregon (Cordley). Subg. *Gnathias*.

Closely related to *N. bella*. Also in British Columbia.

Paratype.—Cat. No. 13330, U.S.N.M.

pervincta COCKERELL, 1905. Colorado. Tab. 1.

**pervincta* COCKERELL, var. B. COCKERELL, 1911. Colorado.

pervincta semirufula COCKERELL, 1905. Colorado. Tab. 1.

**perplexa* CRESSON, 1863. "Mass., Conn., Pa., Del." Tab. 9. Subgenus *Gnathias*.

perplexans COCKERELL, 1910. Pullman, Washington (W. M. Mann). Subg. *Gnathias*.

physura COCKERELL, 1903. Nevada. Tab. 9.

**pilosula* CRESSON, 1878. New York.

Belongs to the genus *Viereckella*.

Plummers Island, Maryland, July 5, 1909 (J. C. Crawford).

**placida* CRESSON, 1863. Pennsylvania. Tab. 12.

**placitensis* COCKERELL, 1903. Placita, New Mexico, May (Cockerell). Tab. 1.

Female about 10 mm.

Type.—Cat. No. 13176, U.S.N.M.

provancheri DALLA TORRE, 1896.

proxima CRESSON, 1863. Maine.

Allied to *N. vicina*.

pseudops COCKERELL, 1905. Milwaukee, Wisconsin (Graenicher).

Female about 9 mm.; red, with black and yellow markings. Looks much like *N. coloradensis*.

pulchella SMITH, 1854. "North America."

**pulsatillæ* COCKERELL, 1906. Boulder, Colorado, April 20 (Cockerell). Tab. 11.

Female red and black, with no yellow anywhere.

punctata = *provancheri* DALLA TORRE.

A Canadian species has been cited as *punctata* Fabricius, but there is no species of this name described by Fabricius; *N. punctata* Lepeletier is Algerian. Provancher says the scutellum has a spine on each side. Dalla Torre renames this *provancheri*.

putnami CRESSON, 1876. Spring Lake, Utah (J. D. Putnam). Tab. 10.

**pygmæa* CRESSON, 1863. Connecticut.

Male with clypeus, a spot above it, labrum, mandibles, and face narrowly on each side of clypeus, yellow; orbits ferruginous. Viereck examined Cresson's type and found mandibles simple.

rhodalis COCKERELL, 1903. Nevada. Tab. 9.

rhodomelas COCKERELL, 1903. Corvallis, Oregon (Cordley). Tab. 9.

**rhodosoma* COCKERELL, 1903. Santa Cruz Mountains, California. Tab. 4.

Close to *N. erythræa*.

Type.—Cat. No. 13167, U.S.N.M.

**rhodosoma rhodosomella* COCKERELL, 1903. Colorado (Morrison).

Type.—Cat. No. 13161, U.S.N.M.

rhodotricha COCKERELL, 1903. S. California. Tab. 4.

Thorax with bright ferruginous hair.

rhodoxantha COCKERELL, 1905. Colorado.

ridingsii CRESSON, 1878. Colorado (J. Ridings). Tab. 1, 10.

Allied to *N. putnami*.

**rivalis* CRESSON, 1878. California (H. Edwards, Behrens). Tab. 5.

For characters see Cockerell, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 651.

robertsonella COCKERELL, 1903. Nevada.

Resembles *N. erythræa*.

**rohweri* COCKERELL, 1906. Near Lake George, Colorado, June 18 (Rohwer).

Allied to *N. snowi*.

rubicunda OLIVER, 1811. Carolina. Tab. 10.

rubra PROVANCHER, 1888. Los Angeles, California.

Name preoccupied; = *erythræa*.

rubrella COCKERELL, 1905. Fort Collins, Colorado (Mrs. Laura Titus). Tab. 1.

Subgenus *Gnathias*.

**rubrica* PROVANCHER, 1896. Los Angeles, California (Coquillett). Tab. 4.

Variety: Proc. Acad. Nat. Sci. Phila., 1903, p. 570.

**ruficornis* LINNÆUS, 1758. Europe.

Supposed *ruficornis* in Maryland; Proc. Acad. Nat. Sci. Phila., 1903, p. 614.

**ruidosensis* COCKERELL, 1903. Ruidoso Creek, New Mexico (Wootton). Tab. 1.

Variation: Bull. Amer. Mus. Nat. Hist., vol. 22 (1906), p. 438. Also in Colorado.

Type.—Cat. No. 13175, U.S.N.M.

salicis ROBERTSON, 1900. Illinois (Robertson). Tab. 2, 12.

**sanctæcruis* COCKERELL, 1903. Santa Cruz Mountains, California. Tab. 4, 5.

Type.—Cat. No. 13179, U.S.N.M.

**sayi* ROBERTSON, 1893. Illinois. Tab. 1, 12.

New description: Canad. Ent., 1900, p. 293.

Distribution: Proc. Acad. Nat. Sci. Phila., 1903, p. 605.

- **schwarzi* COCKERELL, 1903. Veta Pass, Colorado, June 28. Tab. 1, 9. Subg. *Gnathias*.
Allied to *N. bella* and *cuneata*.
Type.—Cat. No. 13164, U.S.N.M.
- **schwarzi contractula* COCKERELL, 1903. Beulah, New Mexico (Cockerell). Tab. 1, 9.
Subg. *Gnathias*.
Type.—Cat. No. 13134, U.S.N.M.
- **scita* CRESSON, 1878. Colorado (Morrison). Tab. 7, 8, 10.
Related to *N. articulata*.
- **scitiformis* COCKERELL, 1903. Corvallis, Oregon, June (Cordley). Tab. 7, 10.
Paratype.—Cat. No. 13160, U.S.N.M.
- **semiscita* COCKERELL, 1904. Prospect Lake, Colorado Springs, Colorado, May 22 (T. and W. Cockerell).
Allied to *N. scitiformis*.
- **semisnavis* COCKERELL, 1910. Wawawi, Washington (W. M. Mann). Subg. *Micro-nomada*.
Female: Cockerell, Proc. U. S. Nat. Mus., vol. 39, 1911, p. 658. Also in California
- **sidæfloris* COCKERELL, 1898. Mesilla, New Mexico (Cockerell). Tab. 1.
Described as a variety of *N. pennigera*.
Type.—Cat. No. 5821, U.S.N.M.
- simplex* ROBERTSON, 1902. Illinois. Tab. 2, 12.
In 1897 Robertson recorded this as the female of *N. bella*.
- skinneri* COCKERELL, 1908. Lehigh Gap, Pennsylvania, June 30 (Viereck).
Group of *N. depressa*.
- **snowii* CRESSON, 1878. Colorado (F. H. Snow, Morrison). Tab. 1, 10.
Female with clypeus ferruginous, lateral face-marks white.
- **sophiarum* COCKERELL, 1903. Mesilla Park, New Mexico, April 16 (Cockerell).
Tab. 1, 8, 10.
Type.—Cat. No. 13182, U.S.N.M.
- sphærogaster* COCKERELL, 1903. Riverton, New Jersey, April (Viereck).
- **suavis* CRESSON, 1878. "California (*Behrens*); Oregon (H. Edwards)." Tab. 8.
- **subaccepta* COCKERELL, 1907. Florissant, Colorado (Rohwer). Subg. *Gnathias*.
In Tab. 1 runs to *N. vicinialis*, but differs (male) by its smaller size, base of metathorax with distinct though delicate longitudinal ridges, absence of yellow on first abdominal segment, etc.
Paratype.—Cat. No. 13667, U.S.N.M.
- **subangusta* COCKERELL, 1903. S. California. Tab. 4.
Type.—Cat. No. 13163, U.S.N.M.
- subgracilis* COCKERELL, 1903. California. Tab. 4.
Belongs to subgenus *Phor*.
- subrutila* LOVELL and COCKERELL, 1905. Maine (Lovell). Tab. 11.
Also in Colorado. See Ann. and Mag. Nat. Hist., July, 1906, p. 69.
- **subsimitis* COCKERELL, 1903. Los Angeles County, California, Feb. (Coquillett).
Tab. 4.
Perhaps a subspecies of *N. civilis*.
Type.—Cat. No. 13178, U.S.N.M.
- **subvicinialis* COCKERELL, 1903. S. California. Tab. 4.
Type.—Cat. No. 13169, U.S.N.M.
- suda* CRESSON, 1879. Nevada (Morrison).
- sulphurata* SMITH, 1854. Georgia. Tab. 5.
Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 311.
- **superba* CRESSON, 1863. Pike's Peak, Colorado. Tab. 1, 12.
- **taraxacella* COCKERELL, 1903. Placita, New Mexico (Cockerell). Tab. 1.
Allied to *N. ultima*.

- **texana* CRESSON, 1872. Texas (Belfrage; Boll.) Tab. 10.
 Type.—Cat. No. 1762, U.S.N.M.
- tibialis* CRESSON, 1865. Cuba (Poey).
- tiftonensis* COCKERELL, 1903. Tifton, Georgia. Tab. 10.
 Allied to *N. modesta*.
- **tintinnabulum* COCKERELL, 1903. Santa Cruz Mountains, California. Tab. 4.
 Type.—Cat. No. 13177, U.S.N.M.
- torrida* SMITH, 1854. Georgia.
 Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 310.
- truttarum* COCKERELL, 1909. Trout Spring, Gallinas Canyon, New Mexico, May (Cockerell).
 In Tab. 1 runs to *N. vicinalis*, from which it (male) differs by the large lateral face-marks, first abdominal segment without yellow, etc.
- uhleri* COCKERELL, 1905. Fort Collins, Colorado (Titus). Tab. 1.
- ultima* COCKERELL, 1903. Corvallis, Oregon (Cordley). Tab. 6.
 Also in California, at Palo Alto.
- ultimella* COCKERELL, 1903. S. California. Tab. 4.
 Similar to *N. erythræa* and *N. ultima*.
- undulaticornis* COCKERELL, 1906. Boulder, Colorado, April 20 (W. P. Cockerell).
 Male in Tab. 1 runs to 62, but runs out because of the rather smaller size and red on scutellum.
- **valida* SMITH, 1854. Nova Scotia.
 Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 310.
- vallesina* COCKERELL, 1906. Las Valles, New Mexico, April 20 (Cockerell).
 Female 8½ mm.; head, thorax, and legs bright ferruginous, without yellow, except that the postscutellum is a sort of dull orange (black at extreme sides), but there are black markings; abdomen with broad lemon-yellow bands. Visits wild plum.
- **vegana* COCKERELL, 1903. Las Vegas, New Mexico (A. Garlick). Tab. 1, 8, 10.
 Very close to *N. modesta*; clypeus of female ferruginous.
- vegana nitescens* COCKERELL, 1905. Fort Collins, Colorado (Titus). Tab. 1.
- **verecunda* CRESSON, 1879. Nevada (Morrison). Tab. 8.
 "Easily recognized by the black annulus on posterior tibiae and immaculate meta-thorax" (Cresson).
- vespiformis* FÖRSTER, 1771. "North America; Europe."
 A species not recognized by modern writers.
- **vexator* COCKERELL, 1909. Troublesome, Colorado, June (Rohwer).
 Paratype.—Cat. No. 12285, U.S.N.M.
- viburni* ROBERTSON, 1897. Illinois (Robertson).
 Only two submarginal cells.
 Same as *N. obliterata*.
- **vicina* CRESSON, 1863. "Connecticut; New York."
- vicinalis* CRESSON, 1878. Colorado (Morrison). Tab. 1, 3.
 Related to *N. civilis*.
- vicinalis aldrichi* COCKERELL, 1910. Moscow, Idaho.
- vicinalis infrarubens* COCKERELL, 1905. Corvallis, Oregon (Cordley). Tab. 3.
- **victrix* COCKERELL, 1911. Victoria, Texas (A. J. Leister). Has only two submarginal cells.
 Type.—Cat. No. 13436, U.S.N.M.
- **vierecki* COCKERELL, 1903. Juarez, Mexico, May 12 (Cockerell). Tab. 1, 8, 10.
 Also in Mesilla Valley, New Mexico.
 Type.—Cat. No. 13162, U.S.N.M.
- **vineta* SAY, 1837. Indiana (Say). Tab. 1, 5, 12.
- vinnula* CRESSON, 1879. Nevada (Morrison).

viticollis CRESSON, 1878. Mexico (Sumichrast).

Female mesothorax black, with four longitudinal yellow lines.

volatilis SMITH, 1879. Canada.

Notes on type; Trans. Amer. Ent. Soc., vol. 31, p. 312. Subg. *Gnathias*.

washingtoni COCKERELL, 1903. Washington State. Tab. 9.

* *wheeleri* COCKERELL, 1903. Texas (Belfrage). Tab. 10.

Type.—Cat. No. 13170, U.S.N.M.

* *wheeleri engelmanniæ* COCKERELL, 1911. Dallas, Texas (W. S. Pierce).

Also in Kansas.

Type.—Cat. No. 13432, U.S.N.M.

wootonella COCKERELL, 1909. Mesilla Park, New Mexico (Cockerell).

Visits *Sophia* in April. Allied to *N. sayi*.

* *xantholepis* COCKERELL, 1911. Los Pinos, Colorado (Carl F. Baker).

Type.—Cat. No. 14022, U.S.N.M.

xanthophila COCKERELL, 1900. Las Vegas, New Mexico (W. Porter). Tab. 1.

Resembles *N. superba*.

xanthura COCKERELL, 1908. Sea Cliff, Long Island, New York (N. Banks).

Allied to *N. denticulata*.

* *zebrata* CRESSON, 1878. "Colorado; Kansas (Ridings)." Tab. 1, 5.

"The male of this species is readily distinguished by the short dilated scape" (Cresson).

ADDITIONAL NOTES ON BEES OF THE GENUS *NOMADA*.

[The material discussed below is in the U. S. National Museum.]

SPECIES FROM COLORADO.

NOMADA (*XANTHIDIUM*) *PERIVINCTA* Cockerell, var. *b*.

Female.—Length fully 11 mm.; first abdominal segment broad; mandibles yellow, piceous at apex; clypeus all yellow; posterior orbital margins largely yellow; third and fourth antennal joints the same light red, third much shorter than fourth; black disk of mesothorax with two broad red bands; scutellum strongly bilobed; patch on lower part of pleura all red; legs with much yellow, the general effect being yellow flushed with red, the hind femora and tibiæ largely black behind; tegulæ yellow, suffused with red posteriorly; apices of first four abdominal segments with reddish-black bands; first ventral segment red, with a trilobed yellow mark; bases of third to fifth segments rufopiceous; third s. m. very broad below, greatly narrowed above; b. n. going a little basad of t. m. Differs from *N. sulphurata* Smith by having third antennal joint the same color as fourth; stripes on disk of mesothorax red and broad (yellow and narrow in *sulphurata*); and the greater amount of yellow on abdomen. Differs from *N. citrina* Cresson by the absence of black on the anterior and middle legs (though the middle tibiæ have a fuscous patch behind), and the large amount of red on legs; the square face; etc.

One from the Baker collection, labeled "Colo. 2075." *N. perivincta* was based on a single specimen in the collection of the Colorado Agricultural College, simply marked "Colorado." Another specimen in the same collection, also marked "Colorado," differed so much that

it was described as a variety *semirufula*. The present insect represents another variety, more approaching *N. sulphurata*, but it does not seem worth while to give it a special name. It seems that *sulphurata* of the Eastern States, *perivincta* of the Rocky Mountains, and *citrina* of the California region are very closely allied, and possibly only subspecifically distinct. They are all confusingly variable.

NOMADA ACCEPTA Cresson.

A male in Baker's collection labeled "Colo. 1160" was marked *accepta* by Baker, but someone crossed this out. It differs from Cresson's description of male *accepta* as follows: Upper half of labrum and base of mandibles broadly, cream-color; tubercles with a large cream-colored spot; pleural patch red with a large transverse cream-colored mark. I possess only the female of *N. accepta*, but after careful comparisons I feel assured that the male is correctly referred to it, the various differences noted being due to variation. In my table of Rocky Mountain *Nomada*¹ this runs to the same place as the female. The mesothorax and metathorax are entirely black.

NOMADA (MICRONOMADA) VEGANA Cockerell.

Six from the Baker collection from Colorado, with numbers 1591, 2325, 2096, 2098, 1081.

NOMADA CIVILIS Cresson.

A male from West Cliff, Colorado (Cockerell); marked *fragilis* by Ashmead, and recorded as such.²

NOMADA FRAGILIS Cresson.

Several males from Fort Collins, Colorado, 1905, collector unknown; one from Baker, labeled "Colo. 2212."

NOMADA (NOMADULA) ARTICULATA DACOTANA Cockerell.

Males; Colorado (Baker 2076); Denver, Colorado, May 23, 1898 (collector not given).

NOMADA (NOMADULA) MARTINELLA Cockerell.

Male: Berkeley, Colorado, May 18, 1898 (collector unknown).

NOMADA (NOMADULA) FRIESEANA Cockerell.

Male.—Length 10 mm.; superficially like *N. articulata dacotana*, with the same red, yellow-banded abdomen, but the light band on first segment with a spot on each side, and the apical plate entire; it is easily distinguished by the antennæ, which are thick, with the fourth joint much shorter, the fifth with a prominent sharp spine; the tegulæ

¹Bull. 94, Colorado Agric. Exper. Station.

²Trans. Amer. Ent. Soc., vol. 20, p. 339.

are yellow. Compared with *N. semiscita* this is larger and more robust, with the ground-color of the first three abdominal segments bright ferruginous, the postscutellum yellow or orange, and very obscure light spots on the axillæ and near the posterior corners of the scutellum. The first r. n. joins the second s. m. in the middle, and the eyes are olive-green. Venter of abdomen clear ferruginous, sparingly marked with yellowish; lateral face-marks rather irregular, but gradually narrowing above, to end in a line which nearly reaches the top of the eye; hind femora blackened behind, but in front only at base.

Berkeley, Colorado, June 10, 1897 (collector unknown). I was about to describe this as new, but on close comparison with *N. frieseana* female, I am convinced that it is the hitherto unknown male of that species.

NOMADA TEXANA Cresson.

Two females: Colorado (Baker 2095). The yellow markings are paler than usual.

NOMADA TARAXACELLA Cockerell.

Four females: Colorado (Baker 2075). One is quite normal, except that the face is broad; the other three lack the yellow markings at the sides of the abdomen, and the lower corners of the face, though a little pallid, are scarcely yellow. After careful comparison, I am convinced that they are all one species. Eight males, also with Baker's No. 2075, are, I think, certainly to be associated with them. These males, however, can not be easily separated from *N. modocorum* Cockerell. *N. taraxacella* was originally described as a subspecies of *N. ultima* Cockerell. The types of *N. ultima* and *modocorum* both came from Corvallis, Oregon, and I now believe they are the sexes of one species. The Rocky Mountain *taraxacella* is readily separable in the female, but the male is like that of *modocorum*, except that the hair on inner side of hind basitarsus is pale fulvous, and the third antennal joint is relatively shorter. The yellow bands along sides of face may be swollen at the upper end. The scutellum varies as follows: (1) All black, (2) with two minute red spots, (3) with two large red spots, slightly confluent, (4) with two small yellow spots.

Two female *taraxacella* are labeled "Colo. 2179," from the Baker collection.

NOMADA SAYI Robertson.

Females: Colorado (Baker 1893); Westcliffe, Colorado, at flowers of *Erigeron radicans*, May 24, 1889 (T. D. A., Cockerell, 34). The last was reported in the Wet Mountain Valley list as *N. americana* var. *valida*. These are best distinguished from *N. taraxacella* by the smooth shining abdomen, without the satiny, almost purplish

luster of *taraxacella*, and the longer third antennal joint. The Rocky Mountain *sayi* is not quite typical; it may prove to grade into the Pacific coast *N. oregonica* Cockerell.

NOMADA MERA Cockerell.

Two females (Baker 2075 and 2212) and one male (Baker 2075) from Colorado. The male, which has not been described, has the following characters: Length about 8 mm.; head and thorax with much white silky hair; clypeus, supraclypeal mark (broader than long), lateral face-marks (filling space between clypeus and eye, except a dark stripe along sides of upper part of clypeus, narrowing above antennæ, and passing into a red band which reaches top of eye), labrum, mandibles (except the ferruginous apical part), and front of the thick scape, all *pale yellow*; flagellum bright ferruginous, the basal half black above; third antennal joint about half as long as fourth; mesothorax dark red with a broad median black band, and black lateral margins; scutellum nearly all bright red; sides of metathorax with much white hair; metathorax all black; pleura with a small obscure red spot; tubercles yellowish red; upper border of prothorax red; tegulæ light yellowish testaceous; legs bright ferruginous, without yellow; hind femora strongly blackened beneath; hind basitarsus with a dark streak; abdomen colored and marked practically as in female; apical plate strongly notched. In Robertson's table¹ this runs nearest to *N. cressonii* Robertson. The female is easily separated from *N. cymbalariae* Cockerell by the abundant white hair at the sides of the metathorax.

Female *N. mera* was also taken at Boulder Falls, Boulder County, Colorado, May 23, 1908 (Hite).

NOMADA CRAWFORDI Cockerell.

Berkeley, Colorado, female, June 10, 1897 (collector unknown). In 1907 Mr. S. A. Rohwer took this species at flowers of *Antennaria microphylla*, Florissant, Colorado, June 15, two males; and at flowers of *Drymocallis fissa*, Topaz Butte, Colorado, June 23.

NOMADA XANTHOLEPIS, new species.

Male.—Length $11\frac{1}{2}$ mm. or rather more, anterior wing nearly 9 mm.; black and yellow, the legs red and yellow, pubescence a rather sordid white; head broad, facial quadrangle broader than long; eyes pale greenish-gray; labrum, mandibles except apex, sides of face, clypeus and nearly square supraclypeal mark, all bright yellow; a small dark spot on each side of clypeus, contiguous with a round spot beyond the suture; a black band along each side of supraclypeal mark and upper part of clypeus, the broad lateral areas otherwise all yellow,

¹Canadian Entomologist, June, 1903.

the yellow ending in a point, away from the orbit, a short distance above the antennæ; lower half of posterior orbital margins broadly yellow; scape thick, very broadly yellow in front; flagellum long (reaching postscutellum) and thick but normal, black above except at apex, broadly bright ferruginous beneath; third antennal joint much shorter than fourth; mesothorax black, densely and coarsely punctured; metathorax all black; upper border of prothorax, tubercles and coarsely punctured tegulæ, bright yellow; scutellum bigibbous, with two very large contiguous round patches, ferruginous suffused with yellow; postscutellum with a short band of the same color; pleura with a broad angular (rather L-shaped) yellow patch in front, a reddish-yellow spot near the middle of the upper part, and a small spot near the lower end posteriorly; legs red marked with yellow, and with the anterior tibiæ in front, and the outer side of the hind basitarsi, all yellow; wings strongly yellowish, dusky at apex; b. n. a little basad of t. m.; second s. m. broad below, receiving first r. n. about middle; stigma and nervures clear ferruginous; abdomen broad, bright yellow, basal half of first segment black, and a triangular red lobe projecting from the black in the middle, reaching the middle of the yellow band; hind margins of segments reddish subhyaline, and extreme bases black; apical plate large, shallowly emarginate; venter yellow, only the basal part darkened.

Habitat.—Los Pinos, Colorado, at flowers of *Erigeron*, May 22, 1899 (Carl F. Baker).

Type.—Cat. No. 14022, U.S.N.M.

In my table of Rocky Mountain *Nomada* this runs to 47, differing from *N. superba* by the notched apical plate. The following table brings out its relationships with the species running to the same point in the 1903 table:

Large and robust; metathorax with an obtuse projecting angle on each side; postscutellum all black; hind margins of abdominal segments black (male).

superba Cresson.

Smaller; metathorax without such angles..... 2

2. Outer nervures dark fuscous; first r. n. joining second s. m. far beyond middle; scutellum with large yellow spots; postscutellum with a yellow band; hind margins of first four abdominal segments black (female)..... *mimula* Cockerell.

Outer nervures ferruginous or light brown: first r. n. usually joining second s. m. about middle (beyond in *crawfordi*) 3

3. Legs red, strongly marked with yellow; postscutellum with a light mark; lateral face-marks very broad above..... *xantholepis* Cockerell.

Legs red, not or hardly at all marked with yellow; postscutellum all black 4

4. Lateral face-marks broad above..... *crawfordi* Cockerell.

Lateral face-marks narrow above..... *ednæ* Cockerell.

N. xantholepis is a typical member of the subgenus *Xanthidium* Robertson. Superficially, it looks very much like *N. civilis* Cresson. In the table¹ it runs out next to *N. sanctæcrucis* Cockerell.

¹ Proc. Acad. Nat. Sci. Phila., 1903, p. 580.

NOMADA (*GNATHIAS*) *BELLA* Cresson.

Females: Bear Creek, Colorado, July 7, 1897 (collector unknown); Colorado (Baker 884).

NOMADA (*GNATHIAS*) *CUSTERIANA*, new species.

Male.—Length a little over 6 mm.; head and thorax black, rugosopunctate, with long white hair, dense and silvery on face; head transversely oval; eyes pale greenish-grey, their distance below at least as great as the length of an eye; mandibles ferruginous, strongly bidentate at end; the linear malar space also ferruginous, but tegument of labrum, clypeus, and all the rest of head entirely black; antennæ reaching base of metathorax; scape black; flagellum bright ferruginous, the upper surface black above and flattish on the basal half, on the apical half not quite so dark, though strongly infuscated; third antennal joint much shorter than fourth, fourth about as long as last; thorax entirely black; tegulæ large, punctured, rufopiceous; stigma and nervures ferruginous; b. n. going only a very little basad of t. m. (unusual venation for a *Gnathias*); second s. m. broad, receiving first r. n. about middle; third s. m. extremely broad, but narrowed to about a fifth of its length above; legs black basally, with the knees broadly, the tibiæ and tarsi chestnut red; anterior and middle tibiæ with a dusky suffused patch on outer side; abdomen dark red. The first segment black at base, the black gradually melting into the red; segments 2 to 6 with cream-colored bands, on 2 very broad, interrupted by red in middle, on 3 narrower, also interrupted by red, on 4 with a linear median interruption, but a very broad one on each side, on 5 and 6 continuous in the middle, but failing laterally; apical plate long, notched; venter chestnut red, nude, except for a large apical tuft of hair.

Habitat.—West Cliff, Colorado (T. D. A. Cockerell). Labeled by Doctor Ashmead *Nomada pacata* Cresson, a species to which it is not allied, although the markings of the abdomen are very like those of *pacata*. Among the small species of *Gnathias* it will be readily known by its wholly dark face and the venation.

Type.—Cat. No. 14023, U.S.N.M.

In the Transactions of the American Entomological Society,¹ *N. parata* Cresson is recorded from West Cliff, but not *pacata*. I am practically certain that *N. custeriana* is one of the specimens captured May 19, 1889, of which I have a note that the size was small and the thorax black. This was determined at the time by Doctor Ashmead as *N. parata*, and was the basis of the record just cited.

The specimens labeled "West Cliff, Col." in the U. S. National Museum, from the Ashmead collection, are all of my collecting, though this is not stated on the labels. So far as the aculeate Hymen-

¹ Vol. 20, p. 339.

optera are concerned, I fear the Wet Mountain Valley list in the Transactions of the American Entomological Society¹ must be considered very unreliable, but the records can be checked with the specimens in the National Museum.

SPECIES FROM ARIZONA.

NOMADA TEXANA Cresson.

Eight males and three females from the Baker collection, labeled Arizona, with Nos. 2122 and 2123.

NOMADA (XANTHIDIUM) ARIZONICA, new species.

Male.—Length 9 mm. or rather more; yellow, black, and red, with scanty white pubescence; eyes pale green; facial quadrangle about square; face below antennæ all lemon yellow, except that it is slightly suffused with red above, and there is a dusky band down each side of supraclypeal area and halfway down margin of clypeus; lateral face-marks ending broadly but suffusedly a little above level of antennæ; a pale red posterior orbital band, extending over top of eye, its lowermost part changing to yellow; labrum yellow; mandibles yellow at base, red in middle, dark at apex; scape stout, bright yellow, with a black band behind; flagellum blackened above, except the first joint, beneath clear ferruginous, with the last three joints dusky; third antennal joint hardly over half length of fourth; mesothorax densely rugosopunctate, black with red lateral suffusion and sublateral bands, the axillæ also red; scutellum and postscutellum bright yellow; upper border of prothorax and tubercles yellow; pleura with a very broad yellow band, having an upward broad extension in front; above and below this band it is red, but black just below the wings; metathorax broadly black in middle, with a broad red band on each side, invading inclosure, and having on its lower part a large yellow spot; tegulæ bright ferruginous; wings clear hyaline, dusky at apex and in marginal cell; stigma ferruginous, nervures rather light brown; b. n. meeting t. m.; first r. n. joining second s. m. a little beyond middle; third s. m. very broad below; legs bright ferruginous, with the apical half of anterior femora below, their tibiæ in front, spots on coxæ and trochanters, middle and hind femora at apex, yellow, hind femora and tibiæ strongly blackened behind; outer side of hind tibiæ tuberculate; abdomen not very broad, bright yellow with the hind margins of the segments reddish, and the extreme bases, as far as the fifth, black; the base of the second is black margined with red, and with a yellow streak on each side at extreme base; first segment conspicuously narrower than second, red at extreme base, then with a broad black band, edged posteriorly with red, then with an irregular but not broken yellow band, with a posterior subdorsal red emargination on each side, the broad hind margin of the segment dusky, very

finely pubescent; apical plate strongly notched; venter yellow, with broad black bands at bases of second and fourth segments.

Habitat.—Arizona, from the Baker collection, with No. 1856.

Type.—Cat. No. 14024, U.S.N.M.

Distinguished among male *Xanthidium* by the red markings on the mesothorax. In the table of Rocky Mountain species it runs to *N. perivincta* Cockerell, the male of which is unknown, but from analogy with other species it is practically certain that it is not the male of *perivincta*. There is evident relationship with *N. clrodi* Cockerell, but that species differs by the broader face, black postscutellum, etc.

NOMADA OSBORNI, new species.

Male.—Length about 6 mm.; head and thorax black, quite densely clothed with entirely white hair; mesothorax with large strong punctures, the shining surface between them conspicuous on the disk; scutellum very flat; eyes pale olive-green; facial quadrangle longer than broad; face densely covered with white hair; mandibles simple, yellow with the apical part ferruginous; broad band beneath eyes, labrum, lower half of clypeus (with an upwardly directed angle in middle), and narrow lateral face-marks (ending in a very sharp point at about level of antennæ), all *yellow*; scape not much swollen, broadly yellow in front; flagellum bright ferruginous, nearly the basal half infuscated above; third antennal joint conspicuously shorter than fourth; tubercles and a small mark on lower part of pleura, almost hidden by hair, yellow, thorax otherwise black; tegulæ pale yellowish with a darker spot; wings a little smoky, darker at apex; stigma dark ferruginous, nervures fuscous; b. n. going just basad of t. m.; second s. m. receiving first r. n. in middle; third s. m. nearly as broad above as second; anterior legs light ferruginous, the tibiæ dark behind, and yellowish apically in front; middle and hind legs darker, strongly infuscated behind, the knees and apices of tibiæ yellow; hind tibiæ with much white hair behind; abdomen long and tapering, broadest at second segment, bright chestnut red, with very obscure small yellowish spots at sides of second and third segments; a broad yellow band on sixth segment, not reaching sides; first segment dark at base, and dusky on apical margin; broad apical margins of segments very thinly clothed with white hair; apical plate notched; venter red, the first segment with a cordiform black mark, at the end of which is a patch of white hair; apical ventral tuft of white hair small.

Habitat.—Tucson, Arizona (H. Osborn).

Type.—Cat. No. 14025, U.S.N.M.

A *Nomada* s. str., related to *N. vexator* Cockerell, but smaller, with differently colored tegulæ, the darker abdomen with much less yellow, etc. In the table of Rocky Mountain *Nomada* it runs to 66, and goes with *N. vexator* in a new division. The dorsum of thorax shining between the punctures, and the flattened scutellum, are highly distinctive.

NOTES ON SOME FISHES OF THE GENUS *AMIA*, FAMILY
OF CHEILODIPTERIDÆ, WITH DESCRIPTIONS OF FOUR
NEW SPECIES FROM THE PHILIPPINE ISLANDS.

By LEWIS RADCLIFFE,

Scientific Assistant, U. S. Bureau of Fisheries.

In identifying the large series of Cheilodipteridæ collected by the U. S. Bureau of Fisheries steamer *Albatross* on the Philippine expedition, it was found that much confusion had resulted from the remarkable similarity in color pattern, fin formulæ, scaling, and comparative measurements of some species of *Amia*. In the present paper a small group of striped forms most in need of revision is dealt with.

The measurements herein used represent the ratio between length of part described and the standard length from tip of snout to end of last caudal vertebra, with the exception of eye, snout, maxillary, interorbital, fins, and least depth of caudal peduncle, which are expressed in ratio to head measured from tip of snout to posterior edge of opercle (not including opercular flap). The length of caudal peduncle is measured between the verticals drawn at base of last anal ray and at end of last vertebra. Even when the last dorsal and anal rays are cleft to base they are still counted as single rays. The scale formula indicates the number of scales in a transverse row from insertion of dorsal downward and backward to and including lateral line, and from origin of anal upward and forward to lateral line; and the number of transverse rows above the lateral line, between upper angle of opercle and end of last caudal vertebra.

KEY TO CERTAIN STRIPED SPECIES OF *AMIA* HEREIN DESCRIBED.

- a*¹. Body with three to five broad reddish brown or slaty black stripes on each side and one along the middle of the back.
- b*¹. Dorsal spines 6.
- c*¹. Body deep, compressed, 2.25 to 2.50; eye large, 2.2 to 2.4; dorsal vi-1,9; anal ii,9; five broad lateral stripes, the three upper extending to base of caudal; a short bar from upper part of eye, backward, thence upward, merging into first stripe and ending on tenth scale of lateral line.....*compressa*.

- b*². Dorsal spines 7 (dorsal VII-1,9; anal II,8).
- d*¹. Eye small, equal to snout, 3.50; body deep; five stripes, the second merging into the third on straight portion of lateral line; fourth and fifth indistinct, the former crossing side above base of pectoral. *fasciata*.
- d*². Eye large, less than 3.50 in head, longer than snout; body relatively slender.
- e*¹. Stripes wider than light colored interspaces, the three upper very dark colored, two of them converging to meet the median stripe at base of caudal. *aroubiensis*.
- e*². Lateral stripes equal to or narrower than interspaces, not connivent at base of caudal.
- f*¹. Scales strong, ctenoid, serrations in more than one row, 25 scales in lateral line to end of last caudal vertebra; soft dorsal and anal with black bands at base, margin sinuous. Shore fishes of moderate size with well developed stripes of reddish or olive brown.
- g*¹. Body compressed, its breadth behind opercle more than 2.1 in depth; lateral stripes narrower than light colored interspaces; no short bar behind eye.
- h*¹. Stripes dark, two of them converging to meet middle one near tip of median caudal rays; caudal blotch absent; first lateral stripe separated from its fellow near tip of snout by a median white line; pectoral base black or very dark brown; a distinct black bar near base of soft dorsal and anal; maxillary short, 1.80-1.96. *novemfasciata*.
- h*². Stripes light, not connivent near tips of caudal rays; caudal blotch distinct; first stripe united with its fellow near tip of snout; pectoral base not noticeably darker; black line near base of soft dorsal and anal, narrow, indistinct, basal portion of rays white; maxillary of moderate length, 1.75-1.79. *angustata*.
- g*². Body robust, its breadth behind opercle 1.9-2 in depth; stripes of varying width but approximately equal to interspaces, not connivent on caudal; a short stripe across upper fourth of eye, below lateral line to middle of side, usually uniting with stripe below it; first lateral stripe united with its fellow near tip of snout; third stripe crosses upper pectoral base. *robusta*.
- f*². Scales thin, weakly ctenoid, serrations on apical margin in a single row or absent, 23 scales in lateral line to end of last caudal vertebra; soft dorsal and anal without black basal bands, margins rounded. Fishes of small size, variable in form and coloration, commonly occurring in the deeper waters. *versicolor*.
- a*². Body with numerous (18 to 20 in adult) narrow olive green stripes, alternate stripes broader and darker; stripes in reduced number in young, similar to *A. robusta* except that they are narrower and the first does not unite with its fellow near tip of snout. *multilineata*.

AMIA COMPRESSA Smith and Radcliffe, new species.

Plates 20 and 21.

Dorsal VI-1,9; anal II,9; scales 3 + 6—25.

General form subovate, compressed; head 2.98, short, deep; body short, deep, strongly compressed, dorsal and ventral surfaces symmetrical, depth 2.45; caudal peduncle deep, strongly compressed, depth 1.64, length 1.27; eye 2.31, very large, its diameter much greater than length of snout; snout 3.93, short and blunt; mouth

moderate, oblique, lower jaw slightly projecting; maxillary 1.89, extending to vertical from posterior border of pupil; nostrils small, widely separated; interorbital 3.60, broad, nearly flat, a slight depression on either side of median ridge; margin of preopercle strongly serrate; intramarginal preopercular crest, subopercle, interopercle and orbital bones smooth or with traces of a few weak denticulations; scapula toothed; teeth villiform, in bands on jaws, vomer and palatines; tongue narrow, rounded, free, marginal portion thin; peritoneum silvery white.

Scales large, regular, of quite uniform size, deeper than long, basal margin truncate, apical margin rounded; basal radial folds rather numerous, about 15; denticulated area on apical margin rather narrow.

Origin of dorsal slightly posterior to vertical to base of pectoral, spines of moderate size; first spine short 2.55 in the second, which is longest and strongest, 1.82; origin of soft dorsal slightly anterior to origin of anal, distal margin slightly concave, first ray longest, 1.20; caudal forked, shortened outer rays pungent, spinelike; second anal spine much longer than the first, 2.12; first ray longest, 1.48; margin of fin concave; ventrals reaching to behind vent, 1.64, distal margin rounded, their base slightly in advance of vertical from pectoral base; pectoral long, narrow, reaching base of second anal spine, 1.19.

Color in alcohol: Ground color dusky silvery white with brownish shades dorsally and dusky points ventrally; five broad dark reddish brown stripes on sides and one along the middle of the back; the latter extends from nape to origin of dorsal where it divides, reuniting behind soft dorsal and ending at base of caudal, under dorsals and on caudal peduncle it is broken up into a series of blotches, one to each scale, becoming indistinct posteriorly; the first lateral stripe unites with its fellow on middle of snout and extends backward over eye, above lateral line to base of caudal; a short bar or stripe crosses upper part of eye and extends backward four scales from opercle, bends sharply upward to lateral line, its upper margin merging into the first stripe and ends or merges into the first stripe on tenth scale of lateral line; the second stripe joins its fellow on tip of snout, extends backward through middle of eye, along middle of side to base of caudal peduncle; two short bars posterior to this, above and below lateral line and a blotch just below and behind first stripe; the third unites with its fellow on tip of mandible and extends along lower margin of eye to upper pectoral base, then breaks beginning again on side above pectoral and extending to base of caudal; the fourth, narrower, extends from axil of pectoral to last anal ray; the fifth, very narrow, extends from above base of ventrals to above middle of anal; a slight duskiness, indicating

traces of a sixth, below this; head dusky brown (in adults the stripes on anterior part of head merge into the brown and are practically indiscernable; in the young they are very distinct); spinous dorsal dusky brown; soft dorsal dusky, a dark brown bar near base to tip of last ray; caudal dusky, outer rays dusky brown; anal similar to soft dorsal; ventrals dusky; pectoral hyaline.

Color in life of a specimen 8 cm. in length from Tataan, Simaluc Island: Alternate dark red brown and silvery stripes on body; fins reddish brown; first dorsal dusky anteriorly; second with an indistinct blackish bar at base; anal with a similar bar but distinct; snout and lower portion of head blackish.

Color in life of a specimen 8.5 cm. in length from Port Uson, west of Pinas Island: Body crossed by longitudinal brown stripes, approaching vermilion below; first stripe extending along base of dorsal composed of a row of spots, interspaces olive; lower interspaces between stripes pearly; throat blackish; breast pink; front of dorsal spines with golden shades; soft dorsal rays pink, a dusky bar at base, turning upward on vertical edge; caudal pink, edges dusky; pectoral pink; iris with sapphire reflections.

Color in alcohol of a specimen 3.4 cm. in length from Balalo Bay, Palawan Island: Median dorsal stripe ending at base of last dorsal ray; three lateral stripes fading out on middle of caudal peduncle; first stripe united with its fellow on middle of snout; short bar behind eye indistinct, not continued upward to first stripe; second stripe united with its fellow on tip of snout, passing backward through middle of eye; the third encircles tip of lower jaw, touches lower margin of eye and passes backward through base of pectoral; other stripes not apparent; a large black area on caudal peduncle at base of caudal; a narrow brown bar near base of soft dorsal and anal; outer caudal rays brown.

This species is easily recognized by its short head, large eye, deep, strongly compressed body, the number of dorsal spines and anal rays, and distinctive coloration.

The collection contains over 200 specimens from about 45 different localities ranging from Port Matalvi on west coast of Luzon and Quinalasag Island on the east coast, southward throughout the Philippine Archipelago to Borneo and the Moluccas. The largest example is 10.7 cm. in length.

Type.—Cat. No. 68398, U.S.N.M., 10.2 cm. in length, from Bisucay Island, Cuyos Group, taken with dynamite April 9, 1909. The figure is of an example 7.2 cm. in length from Tataan Pass, Tawi Tawi Group.

AMIA FASCIATA (White).

Plates 21 and 22.

Mullus fasciatus WHITE, Journal of a Voyage to New South Wales, 1790, p. 268, fig. 1; Port Jackson.

Apogon fasciatus GÜNTHER, Catalogue of Fishes, vol. 1, p. 241, 1859 (part)—MACLEAY, Descriptive Catalogue of Australian Fishes, vol. 1, 1881, pp. 43–44.—TENISON-WOODS, Fish and Fisheries of New South Wales, p. 14, 1882.—STEAD, Fishes of Australia, 1906, p. 96, 107.

Following is White's original description of this species:¹

Mullus fasciatus. *Mullus subflavescens fasciis longitudinalis fuscis*. Pale yellow Mullet with longitudinal brown bands. Length about five inches; scales large.

William Macleay² wrongly places *Amia fasciata* of Bleeker in the synonymy of this species and gives the following description of specimens from type locality:

D. 7. 1/8. A. 2/8. L. lat. 28.

Height nearly half of the length without tail; space between the eyes much smaller than the diameter of the orbit and much channelled; tail slightly emarginate. Colour brownish-red with five longitudinal black bands on each side, the first close to the back, the second from above the eye to the upper margin of the tail, the third along the middle of the side and extending nearly to the extremity of the tail, the fourth from below the eye to the inferior margin of the tail, the fifth along the belly and more or less indistinct; there is also a black bar at the base of the soft dorsal and anal fins.

Port Jackson and Northern Coast. Length five inches.

This is the most common Port Jackson species and is without doubt the true *A. fasciatus*, White, but I doubt its identity with *A. aroubiensis*, Hombr. and Jacquin., *A. endekataenia*, Bleek., and even with the *A. fasciatus*, Günth., Journ. Mus. Godeff., Fish. Sudsee, Heft I., tab. 20 A. B.

Stead³ says of the soldier fish:

It is a pretty little species with large eyes and rough scales and is very prettily striped along the body—whence its name of "soldier." It is common on the New South Wales Coast—particularly at Port Jackson—and probably occurs on portions of the Victorian and Queensland coasts; though it has not so far been recorded from these places. The original specimens were taken from Port Jackson, and are described in White's "Voyage to New South Wales" before referred to.

Description of a gravid female in the United States National Museum, 10.2 cm. in length, from Port Jackson, New South Wales, from Mr. D. G. Stead:

Dorsal VII-1,9; anal II,8; scales 3 + 6—25.

General form subovate, compressed; head long, 2.58; body deep, dorsal and ventral surfaces symmetrical, depth 2.53; caudal peduncle relatively short, depth, 2.52, length 1.50; eye small, 3.50; snout, 3.50, long, pointed, as long as eye; mouth of moderate size, oblique, lower jaw slightly projecting; maxillary 1.97, not reaching vertical from posterior border of pupil; interorbital 4.20, broad, flattened,

¹ Journal of a Voyage to New South Wales, 1790, p. 268, fig. 1.

² Descriptive Catalogue of Australian Fishes, vol. 1, 1881, pp. 43–44.

³ Fishes of Australia, 1906, p. 107.

slightly channeled; preopercular margin serrate; intramarginal preopercular crest and orbital bones smooth; bands of villiform teeth on jaws, vomer, and palatines, those on vomer somewhat blunter than the others; peritoneum dusky silvery; scales normal, subrectangular.

Dorsal spines weak, the third longest, 2.52; soft dorsal, 1.91, distal margin obliquely truncate; caudal emarginate; anal 2.34, low; ventrals, 1.68, short, tips reaching vent; pectoral 1.57, short.

Color in alcohol: Ground color dusky brownish yellow (much discolored), with five dark brown lateral stripes and one along the middle of the back from nuchal region to base of last dorsal ray; the first lateral stripe appears to join its fellow near tip of snout, extends backward over eye to upper margin of caudal; the second crosses upper fourth of eye, backward along lower half of scales of curved portion of lateral line, merging into the third on straight portion; the third, widest, passes around tip of snout, through middle of eye to tips of median caudal rays; the fourth from middle of maxillary, under eye, above base of pectoral to inferior margin of caudal, very indistinct behind pectoral; faint traces of a fifth along side of belly to posterior base of anal; spinuous dorsal dusky; soft dorsal with a narrow dusky bar near base to tip of last ray; a similar bar on anal, crossing middle of sixth and seventh rays to tip of eighth; basal portion of rays of soft dorsal and anal whitish; first ventral ray light, others dusky black; pectorals dusky, base iridescent; tip of mandible blackish.

This species is apparently the only one of the group occurring on the coast of New South Wales and is distinct from the other striped forms herein described. It is characterized by the small eye, long snout, deep body, and marked coloration. White's figure was evidently made from a much faded specimen. That portion of the stripes not shown in his sketch is least distinct in the example at hand.

AMIA AROUBIENSIS (Hombron and Jacquinot).

Plate 22.

Apogon aroubiensis HOMBRON and JACQUINOT, D'Urville's Voyage au Pole Sud, Poissons, 1853, p. 31, pl. 1, fig. 1; Aroub in Malaysia.

Apogon fasciatus, GÜNTHER, Fische der Südsee, 1873, p. 19, pl. 20, fig. A (part).

Amia aroubiensis, JORDAN and SEALE, Fishes of Samoa, Bulletin Bureau of Fisheries, vol. 25, 1905, pp. 241-2, fig. 35, 1906.

Dorsal VII-I,9; anal II,8; scales 3+6—25.

General form subovate, compressed; head 2.65; depth 2.73; caudal peduncle slender, depth 2.18, length 1.34; eye 2.57, large; snout 3.94, short, pointed; mouth of moderate size, oblique; maxillary 1.76, long, reaching a little beyond vertical from posterior border of pupil; interorbital 5.14, narrow, flattened, rugose; margin of preopercle

serrate; intramarginal preopercular crest and orbital bones smooth or with very weak serrations; teeth small, villiform; peritoneum silvery white; scales large, subcircular, regular in arrangement.

Dorsal spines slender, third longest, 1.76; soft dorsal somewhat higher 1.54, distal margin rounded; caudal forked; anal similar to soft dorsal, depth 1.75; ventrals 1.61; pectoral 1.37, long.

Color in alcohol: Ground color silvery white, four broad, dark reddish-brown stripes on sides and one along the middle of the back, stripes much wider than light-colored interspaces; the median dorsal stripe extends from between eyes to posterior base of soft dorsal, margined anteriorly by a silvery white line on each side which unite and extend to near tip of snout, separating the first lateral stripe from its fellow at this point, the latter extends over eye to upper base of caudal peduncle, then bends sharply downward uniting with the second on base of caudal; the second separated from first and third on head by white lines joins its fellow on tip of snout and extends through middle of eye to base of caudal ending in a very dark brown area; the third extends from lower margin of eye to inferior base of caudal peduncle, then bends sharply upward to second; the fourth, lighter in color, extends along side of belly to base of anal; fins yellowish white; a black bar along base of soft dorsal to tip of last ray; a similar bar on anal; middle rays of caudal in this specimen with a slight trace of duskiness. This description is of an individual 6.1 cm. in length from Tutu Bay, Jolo.

This species is found throughout the Philippine Archipelago, the collections containing about 125 examples from 50 localities in the Philippines and Celebes. These do not differ from individuals from Apia, Samoa. It closely resembles *A. novemfasciata*, differing in having the stripes broader and not extended beyond base of caudal; the curvature of dorsal surface is greater, giving the fish a slightly deeper appearance; the eye is relatively larger, and the snout is shorter.

AMIA NOVEMFASCIATA (Cuvier and Valenciennes).

Plate 23.

Apogon fasciatus QUOY and GAIMARD, Voyage de l'Uranie, 1824, p. 344; Guam.

Apogon fasciatus,¹ PETERS, Monatsberichte der Königlichen Preussischen Akademie der Wissenschaften zu Berlin, 1868, p. 256; Luzon, Samar—GÜNTHER, Fische der Südsee, 1873, p. 19, pl. 20, fig. B—BLEEKER, Atlas, 1873-76, vol. 7, p. 87, (part), pl. 326, Percoidei pl. 48, fig. 4, 1876-77—DAY, Fishes of India, p. 69, 1878-88 (part).

Apogon novemfasciatus CUVIER and VALENCIENNES, Histoire Naturelle des Poissons, vol. 2, 1828, p. 154; Timor and Guam.

Amia novemfasciata JORDAN and SEALE, Fishes of Samoa, Bulletin Bureau of Fisheries, vol. 25 (1905), pp. 242-3, fig. 36, 1906 (not fig. 37)—JORDAN and SEALE, Fishes from Negros, Proc. U. S. National Museum, vol. 28, 1905, p. 777—JORDAN and RICHARDSON, Fishes from Islands of Philippine Archipelago, Bulletin Bureau of Fisheries, vol. 27 (1907), p. 254, 1908; Calayan, Cuyo, Ticao.

¹Confused with *Mullus fasciatus* White.

Dorsal VII-1,9; anal II,8; scales 3+6—25.

General form oblong, compressed; head 2.68, regular in outline; body slender, curvature of dorsal and ventral surfaces similar, depth, 2.86; caudal peduncle strongly compressed, depth 2.03, length, 1.37; eye 2.93, small; snout 3.73, pointed; mouth large, oblique; maxillary 1.82, long, not reaching vertical from posterior border of orbit; interorbital 5.12, flattened; margin of preopercle armed with weak serrations; intramarginal preopercular crest and orbital bones smooth or with traces of weak serrations; well-developed villiform teeth on jaws, vomer and palatines; peritoneum silvery white; scales regular.

Dorsal spines slender, third longest, 1.80; height of soft dorsal 1.64, its distal margin nearly truncate, becoming concave posteriorly; caudal forked; anal similar to soft dorsal, 1.78; ventrals 1.58; pectoral 1.46.

Color in alcohol: Ground color silvery white with three dark reddish brown stripes on sides and one along middle of back, width about two-thirds that of interspaces; median dorsal stripe extends from interorbital, dividing at nape, along base of dorsals, uniting again behind dorsals and extending as a narrow line to base of caudal; the first lateral stripe separated from its fellow by a median white line, near tip of snout, extends over eye to upper base of caudal, bends downward to meet the second near tip of median caudal rays; the second margined above and below on side of snout by white lines, encircles snout, passes through middle of eye to tips of median caudal rays; the third from middle of maxillary along lower margin of eye, through lower pectoral base, following curvature of belly to base of caudal, then bends upward to meeting place of first and second; a fourth, quite distinct on head, from tip of mandible to near base of ventrals, very indistinct on breast; two white lines on ventral surface of head; spinous dorsal hyaline, tips of membranes posteriorly black; a black bar margined above and below with white near base of soft dorsal to tips of last rays, remainder of fin hyaline; caudal rays whitish, membranes hyaline except portions crossed by connivent stripes; anal similar to soft dorsal; paired fins hyaline; base and lower axil of pectoral black, very characteristic of the species. This description is of an example 7 cm. in length from tide pools at Gubat Bay, Luzon.

There are 25 examples in the collection from the coasts of Luzon to the Celebes. These have been compared with specimens from Apia, Samoa, in the reserve series of the United States Bureau of Fisheries and with examples from the Fiji Islands in the United States National Museum. The slender, compressed form, trim appearance, narrow stripes connivent near tip of caudal, and black pectoral base are characteristic of this species.

In the original description of the species, Cuvier and Valenciennes mention as types two specimens, one from Timor and the other from

Guam, the latter apparently Quoy and Gaimard's type of *A. fasciatus*; both seem to be this species, and as the name *fasciatus* is preoccupied the present name holds. Bleeker¹ wrongly credits this species to Doctor Gill, and Day² evidently has copied from Bleeker.

AMIA ANGUSTATA Smith and Radcliffe, new species.

Dorsal VII-1,9; anal II,8; scales 3+6—25.

General form oblong, compressed; head 2.68, conic; body compressed, slender, dorsal and ventral outline arched from tip of snout to caudal peduncle, depth 2.95; breadth of body behind opercle 2.18 in depth; caudal peduncle strongly compressed, rather deep, depth 2.12, length 1.40; eye 2.75, large, prominent; snout 3.85, short, depressed, pointed; mouth large, oblique, jaws subequal; maxillary

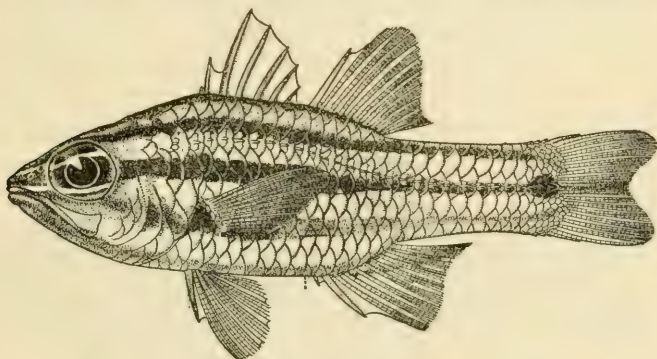


FIG. 1.—*AMIA ANGUSTATA*. (From the type. Natural size.)

1.79, extending slightly beyond vertical from posterior border of pupil; interorbital 5.31, narrow, with a slight median ridge; margin of preopercle denticulated; intramarginal preopercular crest and orbital bones with weak denticulations; well-developed villiform teeth on jaws, vomer, and palatines; peritoneum silvery white; scales large, firm, somewhat longer than broad; 28 pores in lateral line.

Dorsal spines slender, the first 5.55 in the second, second 2.20 in third, the third longest, 2; soft dorsal high, 1.66; caudal forked; anal 1.85, distal margin sinuous; ventrals 1.85, short; pectoral 1.39, long.

Color in alcohol: General color yellowish white with three light brown stripes on the side and one along the middle of the back, these are narrower than light-colored interspaces; median dorsal stripe extends from between eyes to occiput, where it divides, reuniting and ending behind last dorsal ray; first lateral stripe joins its fellow near tip of snout and passes over eye to base of caudal, slightly decurved at

¹ Atlas, vol. 7, p. 87.

² Fishes of India, p. 69.

end; the second unites with its fellow at tip of snout and extends through center of eye to base of caudal, ending in a round black blotch about the size of pupil; a third from middle of maxillary, beneath eye, through lower pectoral base to inferior base of caudal, very indistinct posteriorly; obscure brown dots along lower part of maxillary to base of anal; fins hyaline, spines and rays whitish, base of soft dorsal and anal white with dusky above, indicating presence of dark bar as in related species; dorsal stripe on head margined with a white line which becomes median at anterior end of stripe, extending forward to first lateral stripe; a white line crosses upper third of eye, extends forward on snout as a margin to first lateral stripe, a similar line through lower part of eye, margining second stripe around tip of snout.

A specimen 7 cm. in length from Sipadan Island, Borneo, has the following measurements: Head 2.72; depth 3.11; depth of caudal peduncle 2.10, length 1.43; eye 2.50; snout 4.17; maxillary 1.75; interorbital 5.71; third dorsal spine 1.81; height soft dorsal 1.45; depth of anal 1.60; ventral 1.74; pectoral 1.40; a narrow black line composed of a series of spots on membranes between rays near base of soft dorsal and anal.

From *A. novemfasciata* this species differs in having the maxillary slightly longer, the eye more prominent, body relatively longer, the ratio of depth to length being less, first stripe not separated from its fellow near tip of snout, the lateral stripes not connivent on caudal, base of dorsal not markedly darker, and bars on soft dorsal and anal less distinct. From *A. robusta* it differs in the slenderer, more compressed body, larger eye, narrower interorbital, shorter dorsal spines, shorter ventrals, narrower stripes, and absence of short stripe behind eye.

Type.—Cat. No. 68399, U.S.N.M., 8.5 cm. in length, from Malapina Island, east of Zamboanga.

AMIA ROBUSTA Smith and Radcliffe, new species.

Plate 24.

Amia fasciata, EVERMANN and SEALE, Fishes of the Philippine Islands, Bulletin Bureau of Fisheries, vol. 26 (1906), p. 72, 1907; Bacon.

Dorsal VII-I,9; anal II,8; scales 3 + 6—25.

General form fusiform; head 2.68, conic, robust; body robust, dorsal and ventral surface arched from tip of snout to caudal peduncle, depth 2.63, breadth behind opercle 1.90 in depth; caudal peduncle tapering, compressed, depth 2.15, length 1.47; eye 2.84, moderate; snout 3.85, rounded, not depressed; mouth large, oblique, upper jaw projecting slightly; maxillary 1.85, extending a little beyond vertical from posterior border of pupil; nostrils small, dis-

tinged, well separated, the anterior provided with a raised flap; interorbital 4.55, rather broad, nearly flat; preopercular margin serrate; intramarginal preopercular crest weakly serrate, the serrations least distinct at angle and on lower border; orbital bones smooth or with slight traces of serrations; small, regular, villiform teeth on jaws, vomer and palatines; peritoneum silvery white; scales regular, firm, ctenoid, somewhat deeper than long; 27 pores in lateral line.

Dorsal spines strong, first 2.38 in second, 5.55 in third, second 1.94 in third, third longest and strongest, 1.72; soft dorsal somewhat higher, 1.61, its distal margin obliquely truncate; caudal forked, lobes rounded; anal 1.92, its distal margin sinuous; ventrals 1.51, not reaching base of anal, their base a little in front of base of pectoral; pectoral 1.39.

Color in alcohol: Ground color yellowish bronze with iridescent reflections; four stripes on side and one along middle of back, light

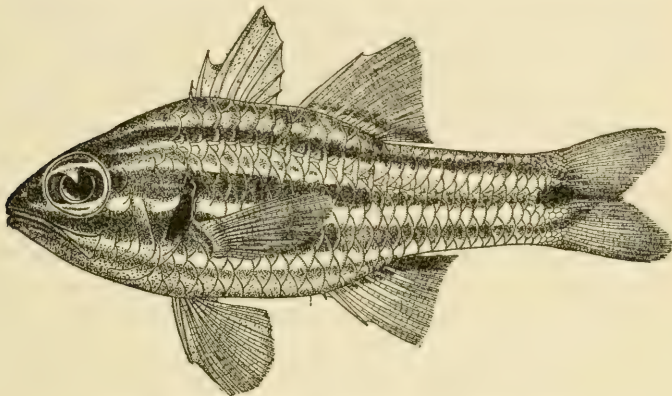


FIG. 2.—*AMIA ROBUSTA*. (From the type. Natural size.)

reddish brown in color, varying in width, but approximately equal to interspaces; the median dorsal stripe begins above anterior margin of eye, divides on nape, following row of scales along base of dorsals, uniting behind soft dorsal, continues to base of caudal; from front of dorsal posteriorly it is broken up into a series of blotches, one on each scale; the first lateral stripe, narrower than the others, joins its fellow near tip of snout, in this respect differing from *aroubiensis* and *novemfasciata*, extends backward over eye, touching upper half of anterior scales of lateral line, decurved near base of caudal, the coloration rapidly fading out on rays; a short stripe of lighter color crosses upper fourth of eye, below pores of lateral line to eleventh scale, where it is decurved and merges into second stripe; the latter encircling snout, passes through middle of eye to base of caudal, enlarging into a darker colored blotch at this point, a dusky shade along caudal to tips of median rays; the third from middle of maxillary, along lower border

of eye, through and above base of pectoral, always parallel with second to base of caudal, curved upward toward second, similar to the first; a fourth from tip of mandible to posterior base of anal; head dusky brown, with an iridescent sheen in places; lateral stripes not nearly so distinct anteriorly as in smaller examples; two silvery lines cross eye forming a margin to second stripe to tip of opercle; opercle brown and iridescent, an irregular dark brown or blackish area above pectoral base; anterior dorsal spines with a silvery sheen, membranes and posterior spines dusky; soft dorsal dusky, a brownish bar along base to tips of posterior rays; caudal dusky, outer and median rays with a brownish tinge; anal similar to soft dorsal; ventrals dusky with traces of a silvery sheen, especially on the spine; pectorals hyaline, axil brownish black, base brownish.

Color in life: Body pearl gray with three broad olive-green stripes along side, another less distinct, along middle of back and base of dorsal and a fifth below base of pectoral; head with yellowish shades; lower portion of opercle with a dusky blotch (while specimen was being described, this was invaded by a silvery white spot about size of pupil); ground colors on cheeks and under pectoral becoming somewhat silvery; first dorsal with greenish yellow shades on anterior membranes; spines silvery white in front; posterior portion of fin purplish; second dorsal washed with orange distally; a dark olive-green bar from base of spine to tips of last rays; caudal somewhat pink; anal pale vermilion, a reddish brown bar from base of spines to tips of posterior rays; edge of fin somewhat dusky; ventral similar to anal but paler, tip dusky; pectoral pale pink; iris dark green.

Small examples in alcohol have the spot at base of caudal more distinct, larger, often black in color; the second and third stripes are broadest, broader than interspaces, parallel, the third not following the curvature of belly as in related species; base of pectoral not darker than rest of stripe; first lateral stripe joins its fellow near tip of snout; traces of a short stripe behind upper third of eye in all save one or two of smallest examples.

The collection contains about 150 specimens from eleven localities in the Philippines and Celebes, principally from the southeastern coast of Luzon. The characteristic coloration, the greater breadth of body, and the more rounded appearance of dorsal surface of head and body are diagnostic of the species.

Jordan and Seale¹ list this species as a color variation of *A. novemfasciata* with the following note: "A third specimen from the same locality has a deeper body, the black stripes more olive, none below level of pectoral; no black bar across axil; a blackish spot on lower part of opercle; fins dull red; both dorsals and anal with an oblique black crossband; stripes on caudal less distinctly converging, the

¹ Fishes of Samoa, p. 243, fig. 37.

outer margin black; first dorsal all black. These specimens differ rather markedly from the ordinary ones and may represent a distinct species, but except in color we find no tangible characters." In the reserve series of the United States Bureau of Fisheries, among the specimens of *A. novemfasciata*, taken by these authors, are a number of examples of this species. These agree with specimens from the Philippines, and their figure, 37, is undoubtedly from a fish of this species; it lacks the short bar behind eye.

The specimen in the reserve series of the United States Bureau of Fisheries identified as *A. fasciata*, Evermann and Seale¹ from Bacon, Philippine Islands, is also this species.

Some of the *Albatross* examples from Canimo Island taken June 15, 1909, and those from Apia are females with eggs in an advanced stage of development. An examination of a number of examples of this species and of *A. novemfasciata* shows both sexes present in each case.

The relative proportions of parts of body of *A. aroubiensis*, *novemfasciata*, *angustata*, and *robusta* are so close that the ordinary comparative measurements when used alone are of little diagnostic value, yet the form of body and differences in coloration are so marked that these species can be separated with comparative ease.

Type.—Cat. No. 68400, U.S.N.M., 8.7 cm. in length, from Jolo Reefs, taken with dynamite.

AMIA VERSICOLOR Smith and Radcliffe, new species.

Dorsal VII-1,9; anal II,8; scales 3+6-23.

General form subovate, compressed; head 2.46, large; body short, deep, depth 2.50; caudal peduncle short slender, depth 3.05, length 2.10; eye 2.90, small; snout 4.06, short, rounded; mouth large, very oblique, jaws subequal; tongue large, thick, with a peculiar pointed, constricted tip; maxillary 1.63, scarcely reaching vertical from posterior border of orbit; nostrils well developed; interorbital 3.40, rather broad, convex; margin of preopercle serrate; intramarginal preopercular crest smooth or with weak serrations; orbital bones smooth; small villiform teeth on jaws, vomer and palatines; peritoneum dusky silvery; scales large, suborbicular, with a marginal row of long slender denticulations; some of the scales have only a few denticulations or none at all, cycloid-like.

Dorsal spines weak, third longest, 2.15; soft dorsal 1.80, margin rounded; caudal rather deeply forked; anal similar to soft dorsal, 2.45; ventrals 1.75, short; pectoral 1.75, broad rounded, short.

Color in alcohol: Ground color dusky silvery; three narrow, slaty black lateral stripes and one along the middle of the back from nape to base of caudal; the first lateral stripe unites with its fellow near

¹ Fishes of the Philippine Islands, 1907, p. 72.

tip of snout, extends over eye to posterior base of second dorsal; the second from near tip of snout through middle of eye to base of caudal; the third from middle of maxillary, below eye, through base of pectoral to base of caudal, parallel with contour of ventral surface, narrowest on caudal peduncle; traces of a fourth from throat to base of ventrals, uniting as a median ventral stripe to base of anal; a broad band of silver forms lower margin to third; spinous dorsal dusky slate, other fins hyaline; constricted tip of tongue white, rest of tongue silver plated.

Color in life of two specimens from Usada Island near Jolo: General color seal brown, over silvery, with reddish shades under this; vertical fins vermilion; paired fins similar but very pale. When first taken from the water these examples were black as in deep-sea fishes—paling later, the reds appearing.

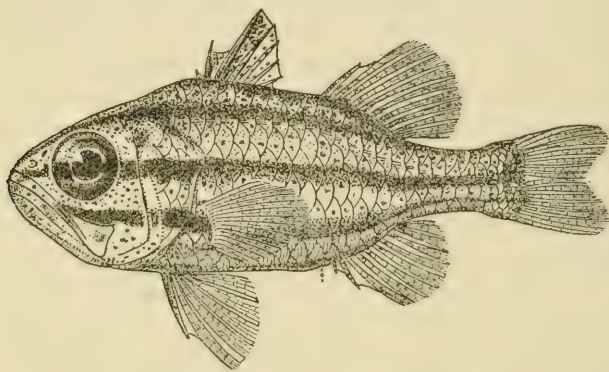


FIG. 3.—*AMIA VERSICOLOR*. (From the type. Twice natural size.)

This interesting little species is subject to a remarkable variation in color and form. Most of the specimens taken with seine at Cataingan Bay, Masbate, are like the type in coloration, the others, together with specimens taken with dynamite at Usada and Pangasinan Islands, are silvery black without or with only slight traces of stripes, others taken with the dredge in deep water are silvery white, the stripes in some very distinct, these shading into forms in which the striping is less and less marked, finally disappearing entirely, especially those taken with seine at Canmahala Bay, Luzon. The silver plating on tongue and the broad silvery band from throat to inferior caudal base are present in all. In form they range from the robust little fish with a very large head to an elongate, spindle-shaped form as in Canmahala Bay examples; these may represent a distinct species, but the gradations from one form to the other are so close that it has seemed best not to separate them.

Following is description of one of slender form from Canmahala Bay, Luzon, length 4.4 cm.:

Dorsal VII-1,9; anal II,8; scales 3+6-23.

Body slender, fusiform; head 2.76; depth 2.92; depth caudal peduncle 2.45, length 1.81; eye 3.02; snout 3.62; maxillary 1.72; interorbital 3.35; pectoral 1.70; ventral 1.70; light brown with silvery reflections; ventral silver stripe margined above with a narrow black line; first dorsal dusky, other fins hyaline; opercular bones silvery; tongue silver plated.

Specimens from Cataingan Bay, the largest being 3.9 cm. in length, had spawned and many males were carrying eggs and apparently fry in mouth. As these had practically all been washed out into preservative it is impossible to determine the conditions in individual cases. Comparison with eggs and young from mouth of *Albatross* examples of *Amia atradorsata* from Chatham Island, Galapagos Islands, shows that the fry are farther advanced in the Philippine species and were free from egg capsule at time of capture. The condition of the young of *Amia atradorsata* indicates that they may have been freed by the shock resulting from placing them in alcohol.

There are 110 specimens in the collection from numerous shore stations between Luzon and the most remote southern parts of the Philippine Archipelago—Sibutu Island and North Balabac Strait; and from various dredging stations at depths of 10 to 169 fathoms.

Type.—Cat. No. 68401, U.S.N.M., 3.9 cm. in length, from Cataingan Bay, Masbate.

AMIA MULTILINEATA Bleeker.

Plate 25.

Apogon multitanicus, BLEEKER, Contribution to ichthyology of Sumbawa, Journal Indian Archipelago and Eastern Asia, vol. 2, 1848; Verhandelingen Bataviaasch Genootschap van Kunsten en Wetenschappen, vol 22, Percoiden, 1849, p. 28.—GÜNTHER, Catalogue of Fishes, vol. 1, 1859, p. 242, (not of Ehrenberg).

Amia multitanata, BLEEKER, Atlas, vol. 7, p. 319, Percidæ, pl. 41, fig. 1, 1873-76.

Amia multilineata BLEEKER, Atlas, vol. 7, pp. 83-84, 1873-76.

Dorsal VII-1,9; anal II,8; scales 3 + 6—25.

General form oblong, compressed; head 2.87, conic; body robust, dorsal and ventral outline symmetrical; depth 2.66; caudal peduncle elongate, compressed, depth 2.02, length 1.39; eye 2.59; snout 3.55, short, pointed; mouth moderate, oblique, jaws subequal; maxillary 2, reaching vertical from posterior border of pupil; interorbital 5, flat; preopercular margin finely serrate; intramarginal preopercular crest and orbital bones smooth or with a few very weak serrations; villiform teeth on jaws, vomer and palatines; peritoneum silvery white; scales regular.

Dorsal spines long and slender, third longest and strongest, 1.65; soft dorsal higher, 1.28, its distal margin slightly rounded, nearly truncate; caudal forked; anal similar to soft dorsal, 1.54; ventral 1.52; pectoral 1.54.

Color in alcohol: Ground color dull silvery gray with about 18 narrow longitudinal olive brown stripes, those on head indistinct, alternate stripes narrower; a distinct silvery line from tip of snout through lower third of eye, across opercle to above base of pectoral, a second from lower margin of eye to lower base of pectoral; a fine silvery line from eye above posterior nostril meeting its fellow near tip of snout; a median line from this point backward to between eyes where it divides and fades out; fins dusky hyaline; a dusky brown bar at base of soft dorsal and anal to tips of posterior rays. This description is of a specimen 8.2 cm. in length from Jolo Reefs, taken with dynamite.

Color in life of an example 6.6 cm. in length from Tataan Bay: Ground color olive gray with many narrow dark-green olive stripes, these irregularly alternately narrower and wider; the median stripe ends in a blotch at base of caudal; head yellowish green; pearl gray through lower edge of eye across snout and posterior part of head; a similar stripe under eye, through angle of preopercle; posterior and lower parts of head with bronzy and green shades; third and posterior membranes of spinous dorsal yellowish, spines lilac, tips of first four or five scarlet; soft fins orange; pectoral very pale; caudal membranes in fork of fin citron yellow; anal with a dusky bar at base posteriorly; iris dark.

Color in life of an example 7.6 cm. in length from Great Tobe Island: Ground pearly gray with numerous olive stripes; side of head olivaceous with white stripe through lower eye from snout to edge of opercle; a similar stripe along upper maxillary to base of pectoral; pale stripes on top of head and snout; fins very pale scarlet or orange; brownish bar across base of second dorsal and anal, other fins unmarked.

In smaller examples, there are fewer stripes, the narrow alternate stripes being the first to disappear. In an example 2.3 cm. in length from Great Tobe Island there are three distinct lateral stripes and one along the middle of the back, these are arranged very much as in the young of *A. robusta* except that the first lateral stripe does not unite with its fellow near tip of snout and there is no distinct caudal blotch; very indistinct traces of narrow lines between lateral stripes. The marked similarity in color of the young to some of foregoing species make them difficult to identify, especially where bands and markings on head are not distinct. *Lepidamia noordzieki* (Bleeker) resembles this species in coloration, but is easily identified by the smaller scales.

The collection contains about 25 examples from the Philippines and Celebes.

EXPLANATION OF PLATES.

PLATE 20.

Amia compressa Smith and Radcliffe, new species.

From photograph. Illustrating changes in color pattern at different stages of growth. Upper figure, a fish 4.8 cm. long, from Romblon, Philippine Islands; middle figure, a fish 7.4 cm. long, from same locality; lower figure, a fish 9.5 cm. long, from Biri Channel, east coast of Luzon, Philippine Islands.

PLATE 21.

Upper figure, *Amia compressa* Smith and Radcliffe, new species.

From photograph of a colored drawing of a fish 7.2 cm. long, from Tataan Pass, Tawi Tawi Group, Philippine Islands.

Lower figure, *Amia fasciata* (White).

Copied from White's Journal of a Voyage to New South Wales, p. 268, fig. 1.

PLATE 22.

Upper figure, *Amia aroubiensis* (Hombron and Jacquinot).

From photograph of a fish 6.5 cm. long, from Kayoa Island, west of Gillolo, Dutch East Indies.

Lower figure, *Amia fasciata* (White).

From photograph of a fish 10.2 cm. long, from Port Jackson, New South Wales.

PLATE 23.

Amia novemfasciata (Cuvier and Valenciennes).

From photograph. Illustrating changes in color pattern. Upper figure, a fish 2.6 cm. long from Basa Reef, Gulf of Boni, Celebes; middle figure, a fish 4.8 cm. long, from Sablayan, Mindoro, Philippine Islands; lower figure, a fish 7.8 cm. long, from Gubat Bay, Luzon, Philippine Islands.

PLATE 24.

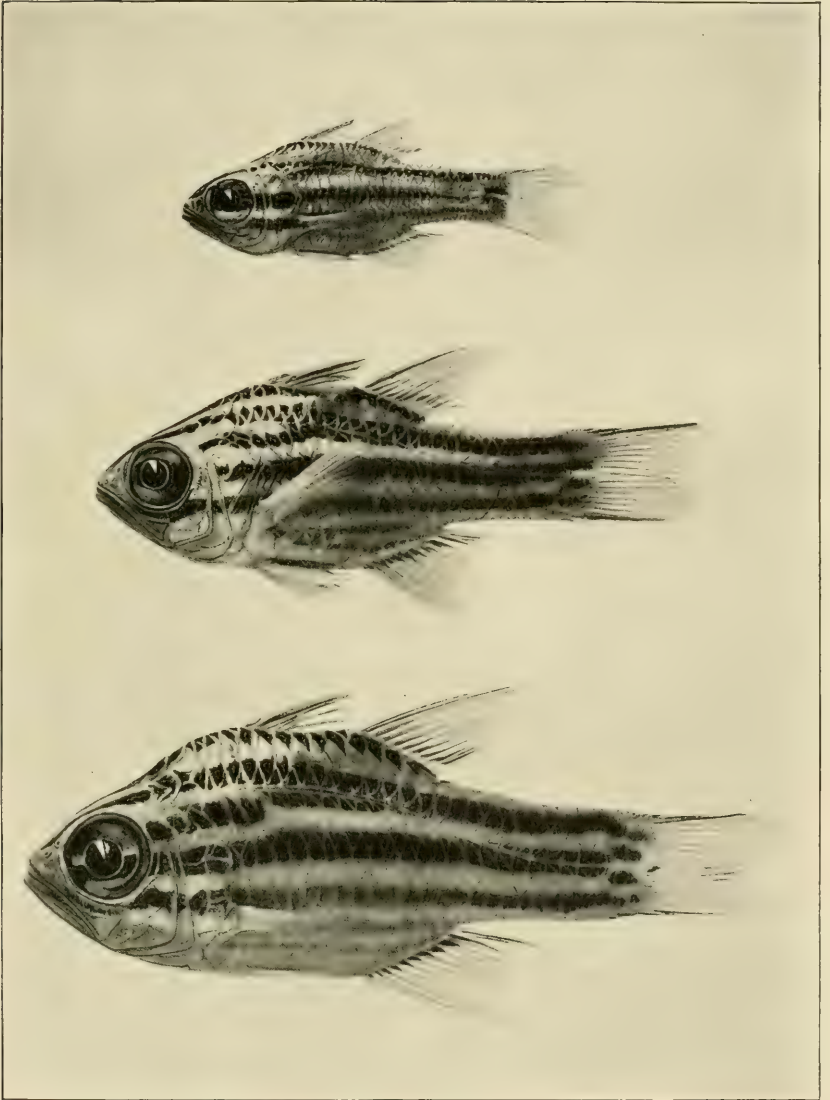
Amia robusta Smith and Radcliffe, new species.

From photograph. Illustrating the characteristic color pattern and the differences in color and form from *A. novemfasciata* at same stages of development. Upper figure, a fish 6.4 cm. long, from Canimo Island near Daet, Philippine Island; middle figure, a fish 4.3 cm. long, from Sablayan, Mindoro, Philippine Islands; lower figure, a fish 2.7 cm. long, from Canimo Island near Daet, Philippine Islands.

PLATE 25.

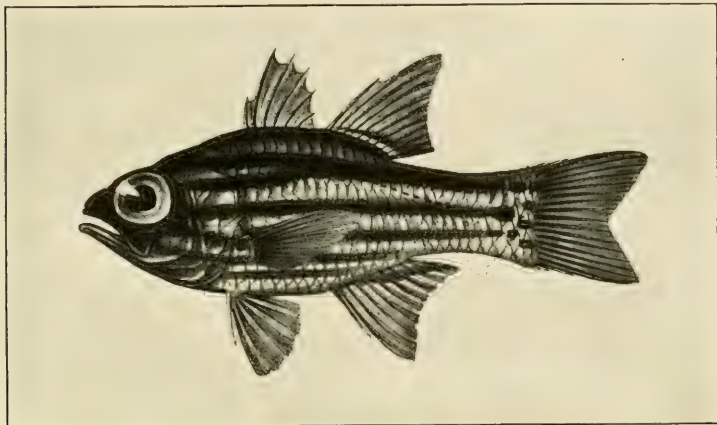
Amia multilineata Bleeker.

From photograph. Illustrating the remarkable changes in color pattern at different ages and the marked resemblance of the young to the young of *A. novemfasciata* and *A. robusta*. Fishes respectively 2.2, 3.9, 4.6, and 7.3 cm. long, from Great Toba Island, Celebes.



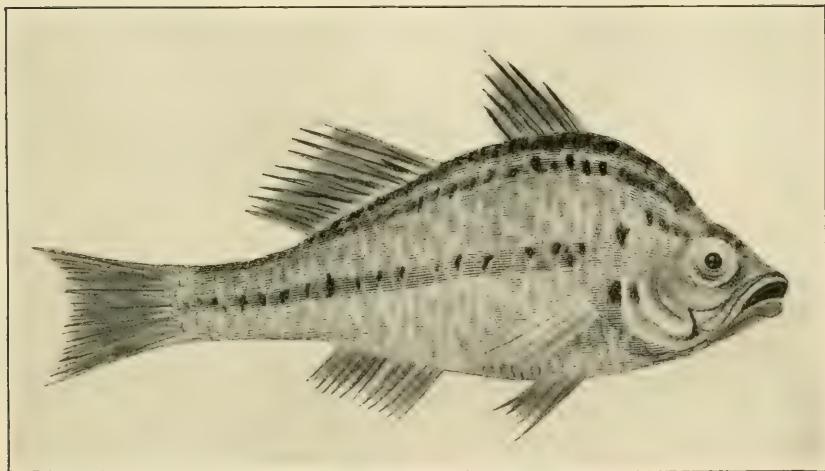
AMIA COMPRESSA.

FOR EXPLANATION OF PLATE SEE PAGE 261.



AMIA COMPRESSA.

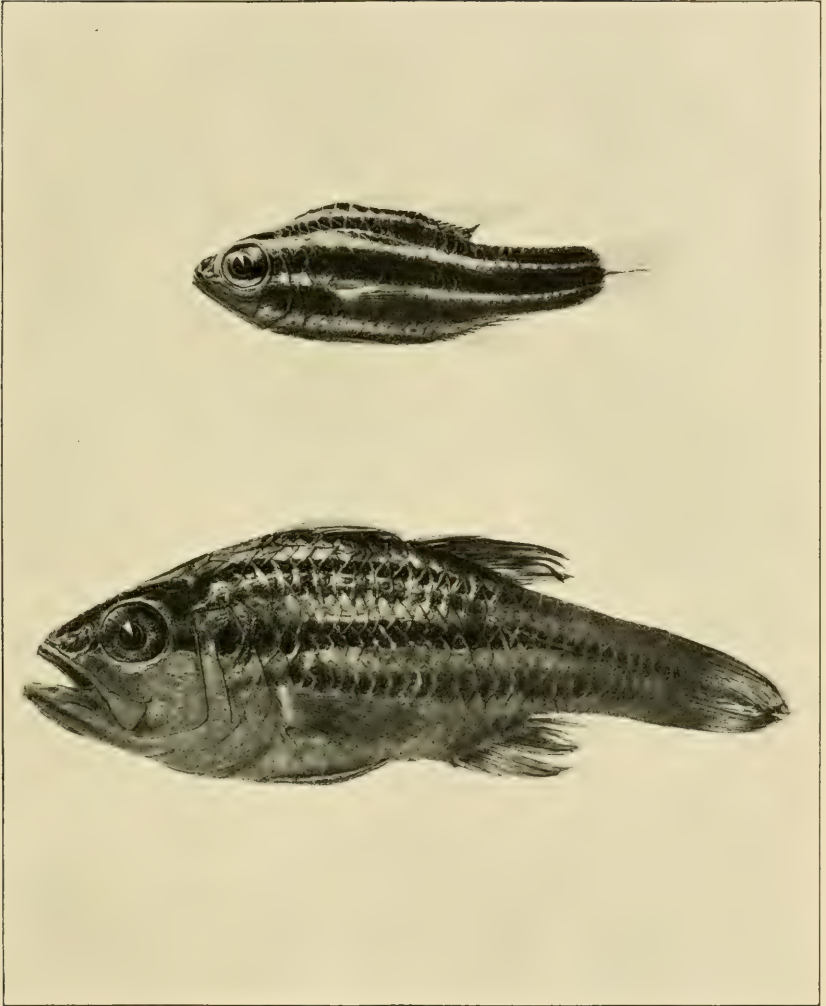
FOR EXPLANATION OF PLATE SEE PAGE 261.



AMIA FASCIATA. AFTER WHITE.

FOR EXPLANATION OF PLATE SEE PAGE 261.



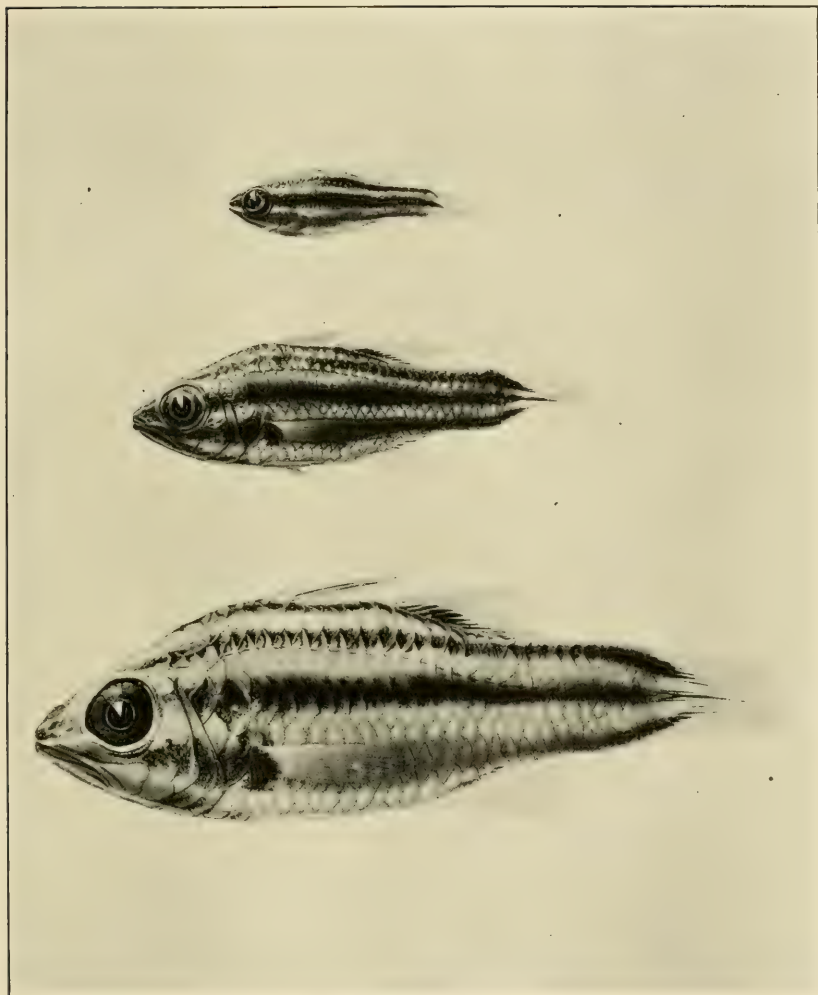


AMIA AROUBIENSIS. UPPER FIGURE.

AMIA FASCIATA. LOWER FIGURE.

FOR EXPLANATION OF PLATE SEE PAGE 261.

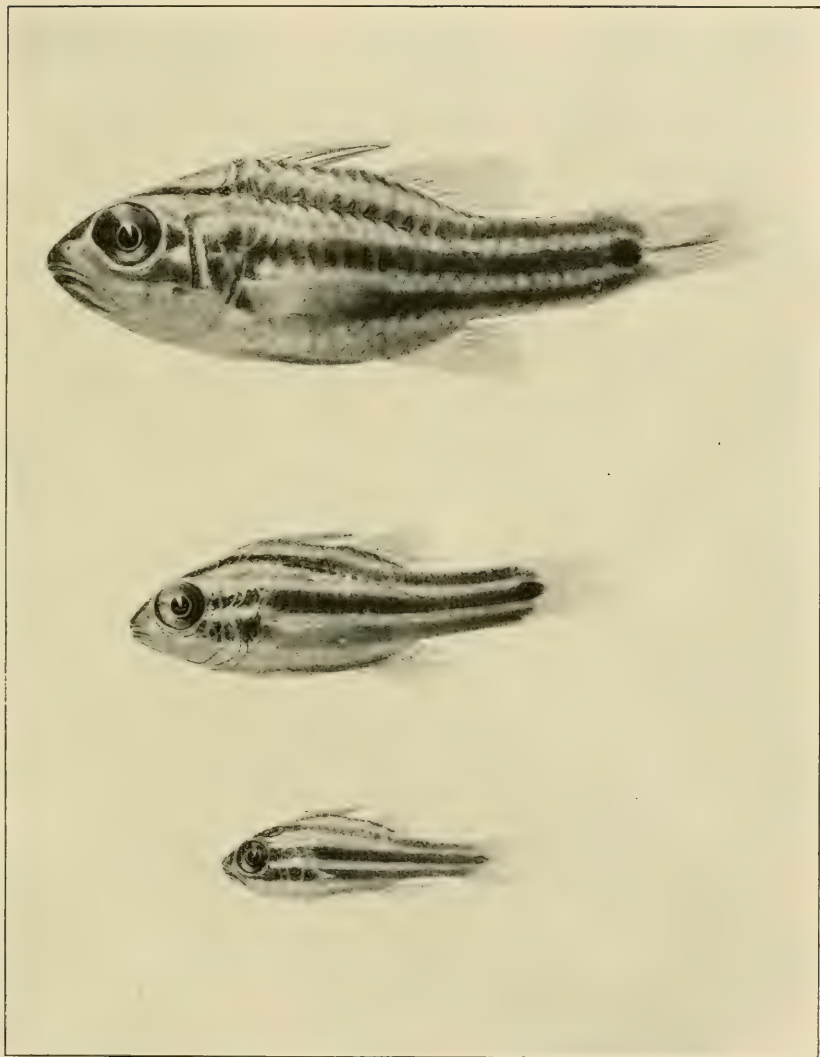




AMIA NOVEMFASCIATA.

FOR EXPLANATION OF PLATE SEE PAGE 261.

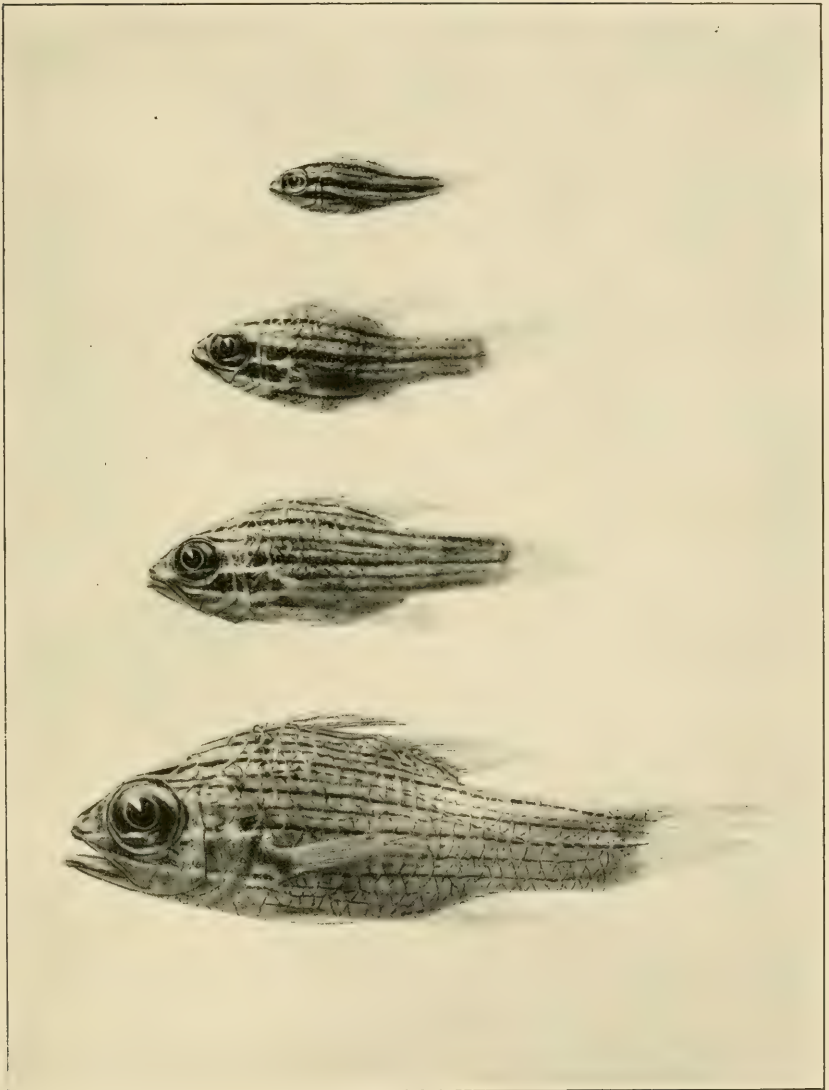




AMIA ROBUSTA.

FOR EXPLANATION OF PLATE SEE PAGE 261.





AMIA MULTILINEATA.

FOR EXPLANATION OF PLATE SEE PAGE 261.

THE WEST AMERICAN MOLLUSKS OF THE GENUS AMPHITHALAMUS.

By PAUL BARTSCH,

Assistant Curator, Division of Mollusks, U. S. National Museum.

The genus *Amphithalamus* was established by Dr. P. P. Carpenter in 1865¹ for *Amphithalamus inclusus* Carpenter. Watson's name *Scrobs*² is a synonym of it. In 1866 Carpenter described another species, *Amphithalamus lacunatus* Carpenter.³

To these I now add a third, *Amphithalamus tenuis*, also from California.

Of these three, *A. inclusus* Carpenter has a peripheral cord; *A. tenuis* Bartsch, a faint raised line only; *A. inclusus* Carpenter is broadly conic; *A. tenuis* Bartsch, elongate ovate. In *A. lacunatus* Carpenter there is no peripheral cord.

AMPHITHALAMUS LACUNATUS Carpenter.

Amphithalamus lacunatus CARPENTER, Proc. California Acad. Nat. Sci., vol. 3, 1866, p. 218.

Shell minute, broadly conic, milk-white. Nuclear whorls one and one-half, well rounded, marked by about 15 slender, equal and equally spaced, spiral threads and numerous, very fine, axial threads, lending the surface a very minutely pitted appearance. Post-nuclear whorls feebly shouldered at the summit, slightly rounded, marked by incremental lines only. Suture well impressed. Periphery of the last whorl inflated, rounded. Base moderately long, slightly rounded, with a narrow umbilical chink. Aperture incomplete (outer lip fractured); inner lip curved, appressed; parietal wall covered with a thick callus.

Doctor Carpenter's type (Cat. No. 15564, U.S.N.M.) has two post-nuclear whorls and measures: Length 1.5mm., diameter 1.1 mm. It comes from shell washings at San Pedro, California.

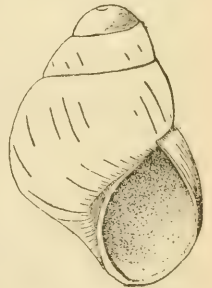


FIG. 1.—AMPHITHALAMUS LACUNATUS CARPENTER.

¹ Ann. Mag. Nat. Hist., ser. 3., vol. 15, p. 181.

² Challenger Report, 1886, p. 611.

³ Proc. California Acad. Nat. Sci., vol. 3, 1866, p. 218.

AMPHITHALAMUS INCLUSUS Carpenter.

Amphithalamus inclusus CARPENTER, Ann. Mag. Nat. Hist., ser. 3, vol. 15, 1865, p. 181.

Shell elongate-ovate, purplish brown with the nuclear whorls yellowish white. Nuclear whorls about one and one-half, well-rounded, marked by about 15 slender, equal and equally spaced, spiral threads and numerous, very fine, axial threads, lending the surface a very minutely-pitted appearance. Post-nuclear whorls subtabulatedly shouldered at the summit, well rounded on the middle, marked by fine lines of growth only. Suture well impressed. Periphery of the last whorl marked by a rather broad, low, rounded, spiral thread, which is separated from the space posterior to it by a narrow, shallow, spiral sulcus. Anteriorly, this cord passes, without demarcation, into the general surface of the moderately long and gently rounded base. Base broadly umbilicated, having a rather broad, low, spiral cord a little posterior to the insertion of the columella. Aperture oval, very oblique, reenforced within by an inner peristome which, in the anterior portion of the outer lip, fuses with it, while the columellar portion and the parietal portion stand at a considerable distance from the columella and the parietal wall, being connected with these by a concave bridge of shelly matter; columella moderately long and stout.

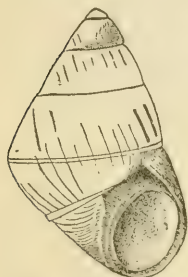


FIG. 2.—AMPHITHALAMUS INCLUSUS CARPENTER.

Doctor Carpenter's cotypes, three specimens (Cat. No. 15573, U.S.N.M.), come from San Diego, California. The largest of these has two and one-half post-nuclear whorls, and measures: Length 1.4 mm., diameter 0.9 mm. Cat. No. 105464, U.S.N.M., contains two specimens, also from San Diego, and Cat. No. 213540, U.S.N.M., contains one, from Catalina Island, California.

AMPHITHALAMUS TENUIS, new species.

Shell elongate-ovate, dark greenish horn-color, with the columella and the aperture yellowish white, excepting the dark edge of the peristome. Nuclear whorls one and one-half, well rounded, marked by about 15 slender, equal and equally spaced, spiral threads and numerous, very fine, axial threads, lending the surface a very minutely-pitted appearance. Post-nuclear whorls very narrowly subtabulatedly shouldered at the summit, well rounded, smooth excepting fine, incremental lines. Suture moderately impressed. Periphery of the last whorl well rounded. Base long, well rounded, bearing a low, broad, spiral cord on its middle, which bounds the posterior termination of the white area. Aperture oval, very oblique; peris-

tome double, the inner fusing with the anterior portion of the outer lip, while posteriorly it is distinct and at a considerable distance from the columella and the parietal wall; the space between the columella, parietal wall and the inner peristome is bridged over by a concave band of shelly matter.

The type (Cat. No. 213541, U.S.N.M.) has two and a half post-nuclear whorls and measures: Length 1.1 mm., diameter 0.7 mm. It and another specimen, entered under the same catalogue number, were taken from sea moss at La Jolla, California, by Mr. F. W. Kelsey, in whose collection there are nine additional specimens from the same locality. Another specimen (Cat. No. 32374, U.S.N.M.) comes from Monterey, California, while seventeen more (Cat. No. 186026, U.S.N.M.) were taken from mossy rocks at low tide at San Diego, California.



FIG. 3.—AMPHITHALAMUS TENUIS
BARTSCH.

DESCRIPTIONS OF NEW HYMENOPTERA. No. 3.

By J. C. CRAWFORD,

Assistant Curator, Division of Insects, U. S. National Museum.

Most of the species described in this paper were received for determination through the Bureau of Entomology, United States Department of Agriculture, and are of economic importance. The figures made to illustrate certain details were all drawn with the aid of the camera lucida. Comparative measurements were made with an eye-piece micrometer used in the Zeiss binocular microscope.

Superfamily APOIDEA.

HALICTUS SANSONI, new species.

Female.—Length about 7 mm. Belongs to the group with no obsolescent wing veins and hair bands on the apical margins of the abdominal segments. Black, the mesonotum with a greenish luster; face above insertion of antennæ closely punctured and finely lineolated; below the antennæ the punctures sparser; clypeus, supraclypeal area, and sides of face below, smooth, polished and with a few scattered punctures; facial quadrangle subquadrate, the clypeus distinctly produced; mesoscutum and scutellum, smooth, shiny, the punctures small, separated from each other by more than the width of a puncture; metanotum closely, finely rugoso-punctate and tomentose; propodeum finely rugulose and minutely reticulate, the rugulæ reaching the apex of the propodeum only medially; truncation not surrounded by a salient carina; wings hyaline, veins and stigma honey colored; second submarginal cell narrowed anteriorly, receiving the first recurrent vein much before apex; third submarginal almost twice as long as the second, narrowed one-half anteriorly; legs dark brown, the pubescence yellowish-white, that on the inner side of hind tarsi more yellowish; inner spur of hind tibiæ with about six short teeth; abdomen brownish, with very slight metallic luster, polished, and finely, sparsely punctured; beyond the second segment, the abdomen very finely transversely rugosely-lineolate; hair bands white, those on segments one and two interrupted medially (worn?).

Habitat.—Banff, Alberta, Canada.

Type.—Cat. No. 13753, U.S.N.M.

One specimen sent by Mr. N. B. Sanson, curator of the Rocky Mountains Park Museum, with the additional information that the specimen was taken on the "Anthracite Road, altitude 4,700 ft., on June 17, 1908."

Named in honor of Mr. Sanson.

Owing to the sparse punctures of the mesoscutum, as well as other characters, this species does not at all resemble the species of the *provancheri* group, nor is it at all similar to any of the species without any green on them.

Superfamily PROCTOTRYPOIDEA.

Family SCELIONIDÆ.

SCELIO PULCHELLUS, new species.

Female.—Length about 3.75 mm. Black, scape, pedicel and first two or three joints of antennæ (the rest missing), and legs, including coxæ, fulvous, the coxæ somewhat darker; head smooth, polished, with a few scattered, fine punctures; occipital foraminal depression margined, semicircularly striate; pronotum, mesocutum and scutellum, coarsely reticulately rugose, a transverse area on middle lobe mesocutum between anterior ends of parapsidal furrows with a few large shallow scattered punctures; parapsidal furrows apparent; parapsidal areas smooth, with large shallow punctures; propodeum reticulate, at apex with two large smooth spots; mesopleuræ horizontally striate, metapleuræ reticulate; wings, except bases, dusky; segments one and two of abdomen longitudinally striate, segment two depressed at base; segment three finely reticulate, segment four with similar sculpture at base, the apex and lateral margins smooth; following segments hardly sculptured, ventral segments one and two longitudinally striate, segment three with an area on each side of middle, punctured, segment four with similar smaller area.

Habitat.—Lake Cowal, New South Wales.

One specimen bred from eggs of the "small plague locust" (which Mr. A. N. Caudell says is the common name of *Chortoicetes pusilla* Walker), and sent by Mr. W. W. Froggatt under his number 96.

Type.—Cat. No. 13968, U.S.N.M.

The sparse punctures of the head separate this species from the species of this genus described from Australia.

SCELIO FROGGATTI, new species.

Female.—Length 5 mm. Black, legs including coxæ fulvous; face, cheeks, rear of head and thorax coarsely reticulately rugose; antennal fossa hardly depressed, smooth for two-thirds the length of the scape; lower part of face with striæ converging toward mouth parts; lateral ocelli about one-half their own width from eyes; head deeply excavated behind, the occipital foraminal depression margined; antennæ

dark brown; first joint of funicle conical, about as long as pedicel; following joints transverse; parapsidal furrows obliterated by the coarseness of the sculpture; propodeum longitudinally rugose; lateral hind angles of propodeum produced; inflexed sides of pronotum coarsely reticulately rugose, but not as coarse as dorsum; mesopleuræ coarsely punctured; metapleuræ reticulately rugose; wings, except the hyaline bases, dusky; abdomen strongly longitudinally rugulose, narrow apical margins of the segments smooth; segment two strongly depressed at base; venter more finely longitudinally rugose, the rugæ failing medially and apically.

Male.—Unknown.

Habitat.—Childers, Queensland.

Type.—Cat. No. 13967, U.S.N.M.

Two specimens bred from the eggs of the "Plague locust" (which Mr. Caudell says is the common name of *Chortoicetes terminifera* Walker), by Mr. W. W. Froggatt and sent by him under his number 95.

Named in honor of the sender.

SCELIO FULGIDUS, new species.

Female.—Length about 3.5 mm. Head and thorax black, abdomen dark brown, legs fulvous, the coxæ somewhat darker in color; scape, pedicel and basal joints of funicle, fulvous; apical joints of antennæ brown; head smooth, polished, with a few scattered, small punctures, sides of face below with a few striæ converging toward mouth parts; occipital foraminal depression margined, vertically striate; dorsum of pronotum coarsely rugose laterad; parapsidal furrows apparent, consisting of a row of large pits; parapsidal areas with a few very large scattered punctures; anterior half of median lobe similarly sculptured, the posterior half with close large punctures, the medial punctures smaller than those laterad; scutellum with large punctures separated from each other by about half the width of a puncture; propodeum closely, coarsely, irregularly punctured, the punctures laterad resembling thimble-like punctures; posterior half of mesopleuræ longitudinally striate, the anterior half smooth, with a few punctures; metapleuræ with sculpture like the propodeum; wings dusky with hyaline bases; abdomen finely longitudinally striate, the apical margins of the segments smooth; segment five with a median area which is not striate; venter longitudinally striate with the middle of the segments smooth.

Habitat.—New South Wales.

Three specimens sent by Mr. W. W. Froggatt, during 1900 under number 60 with the additional record "parasitic in the eggs of *Pachytylus australis*."

Type.—Cat. No. 13969, U.S.N.M.

Separated at once from the preceding by the striæ on the face, and the sparsely punctured mesonotum.

TELENOMUS DALMANI (Ratzeburg) Mayr.

The collections of the United States National Museum contain specimens of this species reared from the eggs of *Orgyia antiqua* in England by Miss A. Taylor and also others from Holland from the same host. There is also a series from Ottawa, Canada, from the same host, which are entirely identical with the European specimens. The species described as *T. fiskei* by Brues is undoubtedly this species.

TELENOMUS ABNORMIS, new species.

Female.—Length 0.75 mm. Belongs to the group having the antennæ with only ten segments; black, the legs, including coxæ and antennæ, except club, testaceous; club of antennæ 4-jointed (fig. 1); pedicel slightly longer than first joint of funicle; lower part of face finely reticulated; along inner margin of eyes a single row of punctures; above insertion of antennæ a smooth space; ocellar area finely reticulated; mesonotum finely closely punctured, appearing almost granular; scutellum smooth, polished, with a few punctures around the edge, metanotum rugose; first segment of abdomen strongly striate for almost the whole length; striæ on segment two longer than first segment of abdomen; segment two at base pitted between the striæ; second segment about as long as wide.

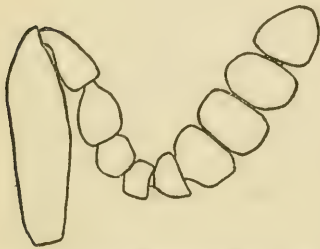


FIG. 1.—TELENOMUS ABNORMIS. OUTLINE OF ANTENNA OF FEMALE.

Male.—Length 0.75 mm. Similar to the female, the sculpture of the face and thorax stronger; joints of flagellum except first one, subquadrate.

Habitat.—Deli, Sumatra.

Many specimens reared from lepidopterous eggs (said by Dr. H. G. Dyar to be Liparidæ or Notodontidæ) by Dr. L. P. de Bussy and sent under his number 3.

Type.—Cat. No. 13879, U.S.N.M.

T. dalmani (Ratzeburg) Mayr, which in the female has 10 jointed antennæ, is larger, has the pedicel and first joint of funicle more elongated, the latter slightly longer than the pedicel, and the club of antennæ distinctly five-jointed in the female; in the male the second and third joints of the funicle are elongate.

DISSOLCUS TETARTUS, new species.

Female.—Length 0.75 mm. Black, the first abdominal segment red; the legs, including most of coxæ, and antennæ, except club, flavous; first joint of funicle about as long as pedicel; the second shorter, the third quadrate, the fourth transverse; cheeks and face below eyes vertically striate; face with a carina on each side that

follows inner orbits of eyes but below continues to mouth; another carina at each side of antennal fossa, these also continuing to mouth parts; space between these two sets of carinæ coarsely punctured; mesoscutum strongly reticulated with impressed lines, appearing scaly; scutellum finely rugose; apical margin of scutellum and metathorax at base each with a row of pits separated by strong carinæ; base of scutellum, especially laterally, and lateral margin of lateral lobes of mesoscutum with a row of similar pits; first abdominal segment striate at base; second, except laterally where it is smooth, striate almost to apex.

Male.—Unknown.

Habitat.—Medan, Deli, Sumatra.

Type.—Cat. No. 13880, U.S.N.M.

Sixteen specimens reared from eggs of an unknown host by Dr. L. P. de Bussy.

Superfamily CHALCIDOIDEA.

Family CHALCIDIDÆ.

HALTICHELLA STOKESI, new species.

Female.—Length 5 mm. Black, lower margins of abdominal segments reddish-brown; tegulæ and legs, including coxæ, red; head closely, coarsely punctured; facial excavation bounded by a carina which includes anterior ocellus; carina at top of antennal fossa situated just in front of anterior ocellus; pronotum sculptured about as head; mesonotum with somewhat finer punctures, separated by about a puncture width; scutellum with an apical emarginate plate; propodeum with lateral angles produced; mesopleuræ longitudinally rugose, posterior part of mesopleuræ, metapleuræ, and sternum umbilicately rugoso-punctate; wings with a small infuscated spot covering marginal vein and extending about half way across wing; apicad of this a slightly smaller discal spot; postmarginal vein longer than marginal; abdomen smooth, polished, the apical segments finely reticulately lineolated.

Male.—Length 4 mm. Similar to the female, punctures of mesothorax closer; wings hyaline; front legs black, intermediate legs brownish black, posterior tibiæ with basal two-thirds fuscous; all tarsi slightly lighter than their tibiæ.

Habitat.—Glen Innes, New South Wales.

Type.—Cat. No. 13971, U.S.N.M.

One of each sex sent by Mr. Froggatt under his number 107 with the additional record "in codlin moth, 2-3-09, W. S. Stokes."

Named in honor of the collector.

Of the species of this genus described from Australia by Walker, *fabricator*, *indignator*, and *internata* are said to have the scutellum

unarmed and *proxenus*, described from a male, has black legs; *dexius*, a male, has red legs; *eracon* has black legs; *nyssa* has a red abdomen and the legs partly black; *indignator* has the legs partly black; *H. bicolor* Ashmead has the abdomen entirely red.

CHALCIS COMP SILURÆ, new species.

Female.—Length about 4.25 mm. Black, the tegulæ and the legs in part, yellow; head and thorax coarsely, umbilicately punctured; carina at front of malar space dividing before reaching eye, one branch running up anterior orbits the other directed backward; there is also a branch running to eye; malar space weakly sculptured; depressed apical margin of scutellum emarginate; lateral projections on propodeum obsolete; wings subhyaline; front and intermediate legs beyond middle of femora, a large spot at apices of hind femora, hind tibiæ, except bases and a median black annulus, and hind tarsi entirely, yellowish; hind coxæ without a tubercle; hind femora on inner side distinctly, finely, closely punctured and without a tubercle on inner side near base; lower margin of hind femora with a large triangular tooth near middle and between it and the apex eight or nine smaller ones.

Male.—Length about 4 mm. Similar to the female, except in secondary sexual characters.

Type-locality.—Wisconsin.

Other locality: Massachusetts.

Types reared from tachinid puparia from Pine Tussock moth at the Gipsy Moth Laboratory at Melrose Highlands, Massachusetts, and recorded under their number 4623 Bb (female) and 4628 D (male).

Seven paratopotypes with the same record are recorded under numbers 4610a, 4650 Ta, 4651 Ta (one each); 4655 T (four).

Five paratypes under numbers 4355 A, 4338 E, 493, 1280 ai, from Massachusetts were reared from puparia of *Compsilura concinnata*.

Type.—Cat. No. 13802, U.S.N.M.

This species has the malar carina and the markings of the hind legs about as in *paraplesia* and *minuta* but the absence of the tubercle on the hind femora and the distinct close punctures of the inner side of the hind femora readily separates them. The males are harder to separate from the males of the other species but the absence of the lateral projections on the propodeum added to the other characters is satisfactory.

CHALCIS THRACIS, new species.

Male.—Length 5 mm. Black; tegulæ, knees, bases and apices of front and middle tibiæ, a line on front of anterior tibiæ, spot at apex of hind femora, a spot on outer side near base of hind tibiæ and one at apex and all tarsi, yellow; carina at front of malar space dividing

before reaching eye, one branch directed backward, the other weaker, running up inner orbits to join a few vertical rugæ which extend to summit of eye; face below insertion of antennæ finely rugoso-punctate; above, coarsely, reticulately, umbilicately punctured; pronotum and mesonotum coarsely, closely, umbilicately punctured, the walls between the punctures flattened and finely lineolate; disk of lateral lobes of mesoscutum toward rear with a space in which the punctures are subobsolete; propodeum without lateral angular projections; wings glassy hyaline; hind femora closely minutely punctured on outer side, the punctures coarser and closer along upper edge; inner side of hind femora distinctly, finely punctured and without a tubercle on lower margin near base.

Female.—Unknown.

Habitat.—Manila, Philippine Islands.

Three specimens reared from the pupæ of *Erionota thrac* Linnaeus, D. B. Mackie, collector.

Type.—Cat. No. 13870, U.S.N.M.

Received through the Bureau of Entomology, United States Department of Agriculture, from Mr. C. M. Conner, of the Philippine Bureau of Agriculture.

Family EURYTOMIDÆ.

EURYTOMA NESIOTES, new name.

This is proposed to replace *E. fulvipes* Crawford, 1910, not of Fitch.

EURYTOMA PYRRHOCERUS, new species.

Female.—Length 4 mm. Black, the antennæ fulvous, the club and pedicel fuscous; face with coarse irregular umbilicate punctures; clypeus medially smooth; first joint of funicle almost twice as long as pedicel, following joints of funicle successively shorter, the last slightly longer than wide; the back of head, pronotum, and mesonotum with crowded umbilicate punctures; pronotum about twice as wide as long; posterior face of propodeum with thimble-like punctures and medially a vertical row of irregular, shallow pits bounded laterally by two quite regular rugæ; sides of propodeum coarsely irregularly rugose; prepectus almost smooth; mesopleuræ, except the anterior margin, horizontally striate, with punctures between the striæ; metapleuræ coarsely rugose; marginal and postmarginal veins subequal in length, the stigmal shorter; coxæ black, trochanters fulvous; femora black, the tips and extreme bases and a line on front of anterior ones, fulvous; tibiæ fulvous, the tips, together with the tarsi, whitish; abdomen elongate, polished, the sides of the segments punctured; segments 1-3 subequal, 4 slightly longer than 3.

Male.—Unknown.

Habitat.—Glen Innes, New South Wales.

Two specimens sent by Mr. W. W. Froggatt under his number 107 with the additional record "in codlin moth, W. S. Stokes."

Type.—Cat. No. 13970, U.S.N.M.

In addition to the fulvous antennæ this species is separated from some of the other forms by the following characters:

The enlarged stigmal knob distinguishes *E. eucalypti* Ashmead; *E. binotata* has a whitish spot on each side of the pronotum, the legs lighter color and the propodeum rugose; *E. australiensis* has the propodeum rugose and the fourth segment of the abdomen fully as long as segments 1-3 combined.

BEPHRATA CUBENSIS Ashmead.

Mr. Patricio Cardin has sent to the Bureau of Entomology, United States Department of Agriculture, from Santiago de la Vegas, Cuba, two females of this species, with the record that they were reared from seeds of *Anona* species.

This record, together with the one for the following species, constitute, so far as is known to the author, the first rearing records for this genus and add the genus to the list of those which are phytophagous.

BEPHRATA PARAGUAYENSIS, new species.

Female.—Length about 5 mm. Entirely reddish-testaceous; scape and pedicel testaceous, rest of antennæ brown; first joint of funicle twice as long as pedicel and two-thirds as long as scape; the joints of the funicle gradually decreasing in length (see fig. 2); club slightly longer than joint one of funicle; head and notum of thorax coarsely, closely, umbilicately punctured; the punctures, except on disk of

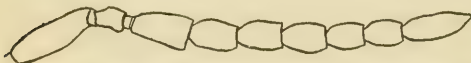


FIG. 2.—*BEPHRATA PARAGUAYENSIS*. OUTLINE OF ANTENNA OF FEMALE.

scutellum, separated only by a narrow wall; space between punctures when more than a thin wall, finely lineolated; propodeum and metapleuræ reticulately umbilicately punctured; mesopleuræ longitudinally striate; wings dusky; petiole short; abdomen about as long as head and thorax combined.

Male.—Length about 4 mm. Similar to the female, but the petiole longer, the dorsum of thorax with black on the disk, the first joint of the funicle almost as long as the scape, the following joint successively slightly shorter, the club hardly longer than the last.

Habitat.—Paraguay.

Reared from seeds of *Anona* species received at the United States Department of Agriculture.

Type.—Cat. No. 13801, U.S.N.M.

Family PERILAMPIDÆ.

PERILAMPUS NESIOTES, new species.

Female.—Length 4 mm. Above black, with bluish reflections in places, the face bluish or greenish, the pleuræ more bluish than the dorsum, the legs blue; face smooth; facial excavation with a carina on each side near eyes, extending downward to about middle of eyes; anterior ocellus at the head of this depression; rear of head circularly striate; mesonotum closely, coarsely punctured; inner edges of lateral lobes of mesoscutum with a broad smooth area; wings hyaline; tarsi whitish.

One specimen reared from a *Prodenia* larva at Medan, Deli, Sumatra, by Doctor de Bussy.

Type.—Cat. No. 13875, U.S.N.M.

Family ENCYRTIDÆ.

Subfamily EUPELMINÆ.

Genus LECANIOBIUS Ashmead.

Zalophothrix CRAWFORD.

The front femora in the type species of this genus are distinctly swollen, and the genus will not therefore run where it was placed by Doctor Ashmead in his tables. On this account the genus was overlooked by me and *Z. mirum* Crawford is *L. cockerelli* Ashmead.

Subfamily ENCYRTINÆ.

Tribe ENCYRTINI.

SOPHENCYRTUS, new genus.

Mandibles at apex apparently blunt, almost edentate, antennæ inserted on the middle of the face, elongate, the scape over twice as long as the distance from insertion of antennæ to anterior ocellus; pedicel short, slightly longer than wide; one ring-joint; funicle 6-jointed, first joint of funicle as long as distance from insertion of antennæ to anterior ocellus, joints 3-6 subequal, 2 shorter; club showing only one joint; viewed in profile, the thorax above greatly rounded, especially the scutellum; axillæ meeting medially; propodeum elongate; marginal vein thickened, as long as postmarginal or stigmal (see fig. 3); anterior wings with two infuscated areas; wings with marginal fringes; hind tibiæ with two apical spurs, one very small.

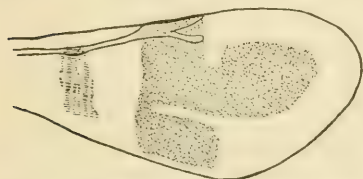


FIG. 3.—SOPHENCYRTUS TOWNSENDI. WING OF FEMALE. SHADING TO SHOW INFUSCATION.

The mandibles in the only specimen are partially covered by the labrum and the dentition is hard to see. The general aspect of the

insect seems to place the species in the Encyrtini rather than in any other group. The shading in the figure of the wing is intended only to give an idea of the general shape of the infuscated areas.

Type of the genus.—*S. townsendi* Crawford.

SOPHENCYRTUS TOWNSENDI, new species.

Female.—Length 2.25 mm. Brownish black; antennæ light brown; head broader than thorax, thin antero-posteriorly, excavated behind, the vertex carinated medially and laterally sharply angulated; lateral ocelli touching carinated edge; head about one-third broader than high; face finely lineolate, above insertion of antennæ becoming indistinct; mesoscutum anteriorly finely transversely lineolated, posteriorly smooth; dorsal part of axillæ finely, deeply, closely punctured, the oblique part smooth; scutellum basally with fine, deep, crowded punctures, rest of scutellum, except smooth apical portion, semicircularly striate, so that from above the scutellum appears more conical than it really is; propodeum and pleuræ smooth; legs brown, knees, apices of tibiæ, and the tarsi lighter; wings, except infuscated spots, hyaline; abdomen smooth, polished.

Male.—Unknown.

Habitat.—Piura, Peru.

Type.—Cat. No. 13869, U.S.N.M.

Described from one specimen received through the Bureau of Entomology from Prof. C. H. T. Townsend, who reared it from the abdomen of an adult *Stenomacra*, sp. and sent it under his number 10010°3a.

Professor Townsend, in a letter to Dr. L. O. Howard, says regarding this species:

This parasite exactly counterfeits the small black ants that make their nests in mesquite trunks and are always running up and down the trunks among the *Stenomacras*, but never molesting the latter. The parasite in life holds its black-barred wings tightly appressed to body, so that they are quite invisible. Even with a lens I thought the parasite was wingless. After death the wing muscles relaxed, and I was surprised to note the wings at the first glance with the lens. The form of the body and the color are both quite like the ant, but I could see by its movements in life that it was not an ant, and that with the naked eye. It jumps when disturbed.

Tribe MIRINI.

LEUROCERUS, new genus.

Belongs to the series in which the female has greatly dilated and flattened foliaceous antennæ; front prominent and with fine thimble-like punctures interspersed with larger ones; antennæ with 6-jointed funicle, the joints of the club fused (fig. 4); facial impression bounded by an angulation but not carinated; lateral ocelli touching eyes and nearer to each other than to the anterior ocellus; axillæ not touching medially; scutellum without an apical tuft of hairs; wings fuscous,

with a short, narrow, hyaline streak directed backward from just apical of the end of the postmarginal vein and reaching a little caudad of the end of the stigmal vein; marginal vein punctiform, stigmal longer than the postmarginal (fig. 5).

In Doctor Ashmead's classification of the tribe¹ this genus would run to *Zarhopalus*, a genus which does not have the foliaceous antennæ and which has the postmarginal and stigmal veins greatly elongated, the lateral ocelli distinct from the margin of the eye and nearer to the anterior ocellus than to each other.

In general appearance this genus most resembles *Cerapterocer* and *Eusemion*, two genera which have the club of the antennæ segmented and the marginal vein elongate, in addition to the characters given in the above description. The genus is of especial interest, since the genera it most resembles are parasites of scale insects.

Type of the genus.—*L. ovivorus* Crawford.

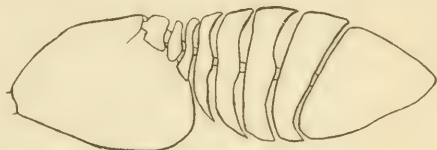


FIG. 4.—LEUROCERUS OVIVORUS. OUTLINE OF ANTENNA OF FEMALE.

LEUROCERUS OVIVORUS, new species.

Female.—Length about 1.5 mm. Head and thorax above, varying shades of bluish and purple; abdomen, antennæ, and pleuræ deep brown; facial impression except antennal prominence very finely punctured, the punctures almost thimble-like; vertex at rear carinated; cheeks and sides of face below finely rugulose; pronotum finely transversely rugulose, mesonotum with fine shallow thimble-like punctures, those on the mesoscutum so shallow that they appear almost as reticulations; tegulæ large, brown, sculptured almost as the mesoscutum; legs dark brown, tibiæ lighter, tips of tibiæ and the tarsi entirely, whitish-testaceous.

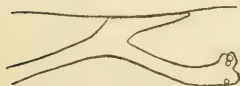


FIG. 5.—LEUROCERUS OVIVORUS. DETAIL OF WING OF FEMALE SHOWING VENATION.

Male.—Unknown.

Habitat.—Medan, Deli, Sumatra.

Type.—Cat. No. 13877, U.S.N.M.

Ten females reared from the eggs of an unknown butterfly and sent by Doctor de Bussy under number 7.

OOENCYRTUS PAPILIONIS Ashmead.

Two specimens of this were received from the Philippine Bureau of Agriculture, reared from the eggs of *Erionota thrax* Linnæus, collected at Manila, Philippine Islands, by Mr. D. B. Mackie.

¹ Memoirs Carnegie Museum, vol. 1, 1904, No. 4, p. 298 et seq.

Family PTEROMALIDÆ.

AGIOMMATUS, new genus.

Belongs to the tribe Sphegigasterini as defined by Doctor Ashmead; mandibles large, strongly 4-toothed; eyes strongly converging above; antennæ inserted on the middle of the face, 13-jointed, with 3 ring joints, very similar in the two sexes; lateral ocelli hardly their own width from eyes; cheeks below broad, at rear sharply angulated; head strongly excavated behind, the vertex thin; parapsidal furrow incomplete; abdomen petiolated, petiole slightly shorter than the hind coxæ; anterior coxæ with a distinct spine in front; propodeal spiracles elongate; propodeum with a strong median and a transverse carina which touches the caudal ends of the lateral

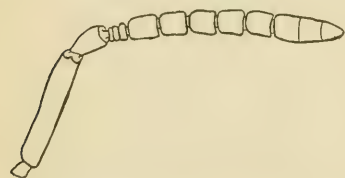


FIG 6.—AGIOMMATUSSUMATRAENSIS. OUTLINE OF ANTENNA OF FEMALE.

fold forming a depressed area; propodeum with a neck; marginal vein long, slightly thickened, postmarginal about two-thirds as long as marginal, stigmal shorter; prepectus with a small obscure triangle above; hind tibiæ with one spur; segments 1-3 of abdomen short, segment 4 longer than all other segments together.

The convergent eyes and spine on the front coxæ readily distinguish this genus.

Type of the genus.—*A. sumatraensis* Crawford.

AGIOMMATUS SUMATRAENSIS, new species.

Female.—Length about 2.25 mm. Head and thorax blue green, abdomen brown; legs whitish, the coxæ more testaceous; antennæ light brown, the scape and pedicel whitish; face finely rugulose reticulated; median lobe of mesoscutum, scutellum and most of mesopleuræ with thimble-like punctures; lateral lobes of mesoscutum and axillæ finely reticulated; sculpture of propodeum between spiracles similar to that on scutellum but much finer; neck of propodeum with a few fine lines.

Male.—Length about 2.10 mm. Similar to the female except in secondary sexual characters.

Habitat.—Medan, Deli, Sumatra.

Type.—Cat. No. 13878, U.S.N.M.

Seven specimens reared by Doctor de Bussy from eggs which Doctor Dyar says are probably noctuid.

Family EULOPHIDÆ.

Subfamily TETRASTICHINÆ.

TETRASTICHUS ECHTHRUS, new species.

Female.—Length about 2.25 mm. Green, the antennæ brown with the scape and pedicel testaceous; coxæ green, the anterior ones partly brown; legs whitish-testaceous; all trochanters brown; anterior femora except tips, brown; intermediate femora basally suffused with brown, hind femora outwardly brown on the basal two-thirds; face finely lineolate, above antennæ with scattered large punctures; clypeus with a median depression; from below insertion of each antennæ a shallow depression runs toward the median depression of clypeus making a V; joints of funicle elongate, the first over twice as long as the pedicel; pronotum with thimble-like punctures, these coarser on the inflexed sides; mesonotum very finely longitudinally lineolate, the lines on the axillæ more irregular; median furrow of mesoscutum very apparent; metanotum finely rugulose; propodeum with a median carina and lateral folds, the area between them finely rugulose, almost resembling thimble-like punctures; lateral folds broadened at rear to form a triangular area which has thimble-like punctures; laterad of the lateral folds the sculpture much finer; just back of the metapleuræ the surface finely lineolated; prepectus and metapleuræ with thimble-like punctures; hind coxæ caudad strongly rugose; wings hyaline, veins honey-color; abdomen basally smooth, apically reticulately lineolated with impressed lines.

Male.—Length 2 mm. Very similar to the female except in secondary sexual characters.

Habitat.—Deli, Sumatra.

Seven specimens sent by Doctor de Bussy and probably a hyperparasite of *Apanteles* (*Protapanteles*) species.

Type.—Cat. No. 13876, U.S.N.M.

Subfamily ELACHERTINÆ.

Genus EUPLECTRUS Westwood.

In my table of the species from Japan¹ the names *fukaii* and *kuwanæ* should be transposed, as may readily be seen from the description of the species.

EUPLECTRUS BUSSYI, new species.

Female.—Length about 2.25 mm. Black, the abdomen with a large basal whitish spot; venter largely whitish; scape whitish, the rest of the antennæ light brownish; first joint of funicle distinctly longer than the second joint or the pedicel; joints 2-4 of funicle

¹ Proc. U. S. Nat. Mus., vol. 39, p. 620.

almost subquadrate, the second about as long as the pedicel; face above insertion of antennæ very finely lineolated; dorsum of pronotum smooth, polished, the anterior truncation finely lineolated; median lobe of mesonotum coarsely rugose, lateral lobes finely reticulated; axillæ smooth; scutellum more coarsely rugose than the mesoscutum, propodeum twice as long as the metanotum, with a median carina dividing anteriorly to form the usual medial lip; hind coxæ black, the front and middle ones deep brown; hind femora largely black, rest of legs reddish testaceous; basal joint of hind tarsi about twice as long as the second; longer spur of hind tibiæ reaching slightly beyond apex of second tarsal joint.

Male.—Length about 1.75 mm. Similar to the female, the sculpture of the face a little stronger.

Type-locality.—Medan, Deli, Sumatra.

Nine specimens, reared from an unknown lepidopterous larva by Dr. L. P. de Bussy, after whom the species is named.

Type.—Cat. No. 13871, U.S.N.M.

The coarse sculpture of the scutellum distinguishes this species from any other known from the Oriental region.

EUPLECTRUS MEDANENSIS, new species.

Female.—Length about 1.5 mm. Black, the clypeal area whitish, abdomen brown, with a large basal testaceous spot; venter largely testaceous; antennæ brown, the scape and pedicel testaceous; first joint of funicle slightly longer than the pedicel; following joints slightly longer than wide, subequal, about as long as the pedicel; face indistinctly lineolated; mesoscutum finely rugose, axillæ and scutellum finely reticulated with impressed lines; propodeum with the usual median carina and anterior medial lip; legs including coxæ, testaceous; longer spur of hind tibiæ reaching slightly beyond apex of second tarsal joint; first joint of hind tarsi almost twice as long as second.

Male.—Length about 1.25 mm. Similar to the female; the antennæ entirely yellowish, the scape somewhat dilated in front; legs yellowish.

Habitat.—Medan, Deli, Sumatra.

Type.—Cat. No. 13872, U.S.N.M.

Many specimens reared by Doctor de Bussy from an unknown lepidopterous host.

This species is related to *E. fukavi*, Crawford, which, however, has the first joint of the funicle fully one and one-half times as long as the pedicel, the second joint of the hind tarsi almost as long as the first, the sculpture of the mesoscutum much coarser and is larger and more robust.

EUPLECTRUS INSULANUS, new species.

Female.—Length about 2 mm. Black, the clypeal area black; abdomen brown, with a large basal testaceous spot; the legs, including coxæ, scape of antennæ, and pedicel, testaceous; rest of antennæ brown; first joint of funicle distinctly longer than pedicel, succeeding joints of funicle elongate, the fourth as long as the pedicel; face above insertion of antennæ, finely indistinctly lineolate; pronotum above finely reticulated; mesoscutum finely rugose; axillæ and scutellum smooth; propodeum with the usual median carina and anterior medial lip; longer spur of hind tibiæ reaching apex of second joint of tarsi; first joint of hind tarsi slightly longer than the second.

Male.—Length about 1.75 mm. Very similar to the female, the scape strongly dilated in front.

Habitat.—Medan, Deli, Sumatra.

Type.—Cat. No. 13873, U.S.N.M.

Seventeen specimens reared by Doctor de Bussy from an unknown lepidopterous host. This species resembles *E. ceylonensis* Howard, which has the first joint of the hind tarsi much longer than the second.

EUPLECTRUS AGARISTÆ, new species.

Female.—Length about 2.25 mm. Black, the abdomen largely reddish-testaceous; the clypeal region whitish, the legs, including coxæ, reddish-testaceous; antennæ testaceous, becoming darker toward tips; first joint of funicle distinctly longer than pedicel; following joints decreasing in length, the fourth about equal in length to pedicel; mesoscutum with a median longitudinal carina, rather finely rugose, the rugæ more or less transverse, the parapsidal area more finely sculptured than the median lobe; axillæ much more finely striate; scutellum finely indistinctly lineolately reticulated, the lines more or less longitudinal; wings slightly yellowish, the veins honey colored; first joint of hind tarsi slightly longer than second; abdomen reddish-testaceous margined all around with dark brown.

Male.—Unknown.

Habitat.—Sydney, New South Wales.

Four specimens sent by Mr. W. W. Froggatt, under number 99, with the additional data, "reared from the larvæ of *Agarista glycinæ*."

Type.—Cat. No. 13972, U.S.N.M.

This is related to *E. fukaii* Crawford and *E. medanensis* Crawford, but differs from both by the distinct median carina of the mesoscutum.

Genus ELACHERTUS Spinola.

ELACHERTUS EUPLECTRIFORMIS, new species.

Female.—Length about 1.4 mm. Translucent yellowish-testaceous, the abdomen suffused with brown, the antennæ beyond the pedicel brown; eyes in dried specimens red; first joint of funicle about one and one-half times as long as the pedicel, following joints elongate, the fourth as long as the pedicel; all sculpture obscure due to the semitransparent chitin; face above antennæ finely lineolate; mesoscutum and scutellum finely rugose; propodeum with an anterior median lip, as in the species of the genus *Euplectrus*, back of this two carinæ forming an inverted V; first joint of hind tarsi slightly longer than second; the single spur on the hind tibiæ long, reaching about to middle of second joint of tarsi.

Male.—Length about 1.15 mm. Similar to the female.

Habitat.—Medan, Deli, Sumatra.

Type.—Cat. No. 13874, U.S.N.M.

Fifteen specimens reared by Doctor de Bussy from an unknown lepidopterous host, and sent under his number 6.

DESCRIPTION OF A NEW AMPHISBÆNOID LIZARD FROM PERU.

By LEONHARD STEJNEGER.

Curator, Division of Reptiles, U. S. National Museum.

Mr. C. H. T. Townsend has recently presented to the U. S. National Museum a specimen of *Amphisbæna*, which he suspected to be undescribed. Upon examination I find that his suspicion was well founded, and I therefore take great pleasure in naming it for him. It was found near his house in Piura, northwestern Peru.

AMPHISBÆNA TOWNSENDI, new species.

Diagnosis.—Nasals forming a suture on the snout; 4 preanal pores; 2 prefrontals, distinct from nasals and labials; suture between nasals about one-half that between prefrontals; temporals small; ocular in contact with second and third upper labials; no lateral line; 44 segments in a ring on the middle of the body; 276 rings on the body.

Habitat.—Peru.

Type.—Cat. No. 47087, U.S.N.M.; Piura, Peru, March 14, 1911; C. H. T. Townsend, collector.

Description of type specimen.—Rostral small, the portion visible from above very short; nasals forming a suture, about one-half as long as that between the prefrontals, slightly shorter than the suture between the frontals; prefrontals large, the suture between them much longer than that between the frontals; frontals moderate, about half the size of the prefrontals; ocular moderate, about the same size as the third supralabial; 2 postoculars; temporals small; no occipitals; 3 supralabials of equal length, second and third in contact with ocular; mental followed by a small median postmental; behind the second lower labial a medium-sized malar shield; behind the postmental and between the malars, 3 transverse rows of scales, consisting, respectively, of 4, 5, and 6 scales; 276 rings on the body, 25 on the tail; 44 segments in a ring around the body, the segments longer than broad and slightly narrower on back than on abdomen; no trace of a lateral line; anal shields, 6; preanal pores, 4. Color

(in alcohol) above, dark purplish brown, the color of the back descending on the sides as irregular scattered spots; sides and underside pale. According to Mr. Townsend's note the living specimen had a distinct lavender pink tinge on forward half, especially about head.

Dimensions.

	<i>mm.</i>
Tip of snout to vent.....	206
Tail.....	21
Diameter of body.....	5

Remarks.—Cope, in 1875,¹ described an *Amphisbæna occidentalis* collected by Prof. James Orton in the valley of Jequetepeque, Peru, but as he neither gave the number of body rings nor of segments contained in a ring nor stated whether a lateral line was present or not, the status of this name has always been dubious. Thinking that it might possibly be the species described in the present paper, I asked Mr. Witmer Stone to furnish the missing data from the type in the Philadelphia Academy. This he has very kindly done. He found 179 rings from corner of mouth to anus and 20 from anus to tip of tail, a ring on the middle of the body containing 45 segments, 19 above the lateral lines and 26 below. It is consequently evident that Townsend's *Amphisbæna* is a totally different animal. *A. occidentalis*, on the other hand, appears to represent the form which Doctor Peracca has indicated as intermediate between *A. darwini* and *A. camura* having from 44 to 60 segments in a body ring, while the former has 28 to 40 and the latter 74 to 84 such rings.²

¹ Journ. Acad. Nat. Sci. Philadelphia, (2) vol. 8, p. 176.

² Peracca, Bol^{l.} Mus. Zool. Torino, vol. 10, no. 195, Feb. 6, 1895, p. 10.

DESCRIPTIONS OF THREE NEW BATRACHIANS FROM
COSTA RICA AND PANAMA.

By LEONHARD STEJNEGER,

Curator, Division of Reptiles and Batrachians, United States National Museum.

Among the specimens in a small collection of reptiles and batrachians recently made by Mr. A. H. Jennings on the Upper Pequini River, Republic of Panama, there is a large, conspicuously colored, and otherwise remarkable tree toad, which has been generously presented to the United States National Museum. A scarcely less remarkable tree toad of another genus, and characterized by the erect spikes surrounding the crown of its head, was simultaneously presented to our Museum by Mr. A. Alfaro, of the National Museum of Costa Rica, together with a less conspicuous, though not less interesting, new species of salamander. The last two species were collected in the valley of the Orosi, Costa Rica, by Mr. C. Picado, for whom I have named the salamander.

SPELERPES PICADOI, new species.

Diagnosis.—Legs short, not meeting on sides by the length of the hind leg; fingers and toes well developed, slightly webbed; palatine teeth well separated from parasphenoid patch, not extending exteriorly beyond the choanæ; 13 costal grooves; body elongate; tail cylindrical; color brown.

Habitat.—Costa Rica.

Type.—Cat. No. 48280, U.S.N.M.; La Estrella, southeast of Cartago, Costa Rica; C. Picado, collector.

Description of type-specimen.—Palatine teeth in two arched, continuous series, not extending outward beyond the choanæ, and well separated from the parasphenoid teeth which form a single patch; head wider than body, truncate; snout short; corner of mouth under the posterior edge of eye; nostrils large, rounded; body elongate, measuring four times the distance from snout to gular fold, and more than three times the distance between axilla and groin; legs short, not meeting on sides by the length of the hind leg; fingers and toes well developed, slightly webbed; tail cylindrical, longer than head and body; skin very smooth; a distinct gular fold; 13 costal grooves.

Color (in alcohol) above dark brown, with a pale irregular band extending from behind the eye backward over the shoulder along the sides to the groin, and another similar one, but fainter, from the occiput on each side of the back, disappearing on the anterior third of the tail; underside paler; palms and soles still more so.

Dimensions.

	<i>mm.</i>
Total length.....	66
Snout to vent.....	31
Tail.....	35
Snout to gular fold.....	6
Width of head.....	4
Between axilla and groin.....	20
Fore legs.....	5
Hind legs.....	6

HYLA CERATOPHRYS, new species.

Diagnosis.—Derm of head involved in the cranial ossification; outer fingers webbed at the base; head broader than long; choanæ very large, subtriangular; vomerine teeth between the choanæ; posterior border of casque not raised; outer edge of upper eyelid produced into a large triangular “horn.”

Habitat.—Panama.

Type.—Cat. No. 47705, U.S.N.M.; upper Pequini River, Republic of Panama, March 29, 1909; A. H. Jennings, collector.

Description of type-specimen.—Tongue subcircular, entire, and scarcely free behind; vomerine teeth in two long, slightly oblique series between the choanæ; choanæ large, subtriangular, longer in an anteroposterior direction than in the transverse direction; head large, considerably broader than long; derm of head involved in the cranial ossification; posterior edge of casque nearly straight, not raised; distance between nostril and eye nearly equals diameter of latter; loreal region concave; canthus rostralis sharp, slightly raised; interorbital space broader than upper eyelid without the “horn,” concave; superciliary edge of upper eyelid produced into a large triangular, pointed flap which overhangs the eye like a “horn;” tympanum distinct, longest diameter about one-half the diameter of the eye; no projecting rudiment of pollex; toes two-thirds webbed; disks of fingers nearly as large as tympanum, of toes slightly smaller; articular tubercles moderately developed; inner metatarsal tubercle slightly developed, no outer; no tarsal fold; the hind leg being carried forward along the body, the tibio-tarsal articulation extends forward beyond the tip of the snout by about one-third the length of the tibia; top of head finely granular, of back nearly smooth, the latter with about nine transverse, narrow lines of glandular tubercles; underside strongly granular, including throat, but not chin, which is nearly smooth; a glandular fold extending along the outer edge of the

supraocular hornlike appendage and continued backward over the tympanum along the sides to some distance beyond the axilla. Color (in alcohol) above dark olive buff with numerous narrow transverse lines of purplish brown, every other of which coincides with the transverse glandular ridges; a similar line across the head from tip of one "horn" to the other; legs cross-lined like the back, the purplish brown bands widening on the inner aspect of the thigh and tibia and narrowly bordered with pale yellowish; between the eye and edge of lip a strikingly distinct, large, triangular, yellowish white spot preceded by a similar one of dark purplish brown in strong contrast; on the sides, from the ear backward, indications of a wide purplish brown band fading out toward the groin; anal region dark purplish brown with a sharply defined, yellowish white, narrow line above; thighs uniform purplish brown, underneath with a few irregular whitish spots on the buttocks; rest of underside pale brownish.

Dimensions.

	<i>mm.</i>
Tip of snout to vent.....	74
Tip of snout to posterior edge of tympanum.....	25
Greatest width of head.....	29
Fore legs from axilla.....	49
Hind legs from vent to heel.....	88
Hind legs from vent to tip of longest toe.....	143
Tibia.....	47

Remarks.—This striking novelty, whose hornlike flap over the eye bears a strong resemblance to a similar structure in the Asiatic genus *Megophrys* as well as in the South American genus *Ceratophrys*, does not seem to be closely related to any of the known Central-American Hylas.

GASTROTHECA CORONATA, new species.

Diagnosis.—Derm of head completely involved in the cranial ossification; outline of casque behind gently concave, the edge studded with high, conical, erect, bony spines; a similar series of spines above tympanum; supraorbital crest tubercular; canthus rostralis granular; vomerine teeth on a level with the posterior edge of the choanæ; tympanum circular, nearly as large as the eye; fingers free; toes one-third webbed.

Habitat.—Costa Rica.

Type.—Cat. No. 48279, U.S.N.M.; Palomo, Valle de Orosi, Cartago, Costa Rica; altitude, 1,200 meters above the sea; April, 1911; C. Picado, collector.

Description of type-specimen.—Adult male. Tongue subcircular, entire, and scarcely free behind; vomerine teeth in two straight series on a level with the posterior edge of the choanæ; head moderate, scarcely wider than long; dermat of head completely involved in the cranial ossification, forming a bony casque; outline of casque behind gently concave, the edge studded with high, conical, erect, bony spines; a similar series of spines above tympanum; supraorbital crest

tubercular; canthus rostralis raised, granular; snout rounded, slightly longer than the diameter of the orbit; crown and loreal region concave; interorbital space much wider than upper eyelid; tympanum circular, very distinct, nearly as large as the diameter of the eye; fingers free; toes one-third webbed; disks large, about three-fourths diameter of tympanum; subarticular tubercles moderate; inner metatarsal tubercle prominent, no outer; a distinct tarsal fold; heels overlapping; hind limb, being carried forward along the body, reaches anterior angle of the eye; skin coarsely granular above, more distinctly so on the abdomen and underside of thigh; throat and chest smooth. Color (in alcohol) above dark bluish slate; on the sides and in the groin, several large, vertical, dark spots, narrowly edged with whitish; hind limbs with transverse bands of dark color similarly edged with whitish; underside paler than back.

Dimensions.

	mm.
Tip of snout to vent.....	60
Tip of snout to posterior edge of tympanum.....	21
Tip of snout to posterior edge of casque on the median line.....	18
Width of head.....	22
Fore leg from axilla.....	41
Hind leg from vent.....	93
Tibia.....	31

Remarks.—The species here described is probably the same as the young specimen from Carillo, Costa Rica, described and figured by Guenther in the *Biologia Centrali-Americana*¹ as *Nototrema oviferum*, and possibly also with the Mexican specimen from Cordova in British Museum, described by Boulenger² under the same name. I feel confident, however, that none of these belong to the true *Gastrotheca ovifera* of Weinland,³ from Venezuela. In the latter the casque is inclosed behind by a “tuberculous wall” of bone, the outline of which forms a wide median extension backward and two deep sinuses laterally; the vomerine teeth are between the choanæ, and the fingers and toes are much more extensively webbed. Moreover, the color pattern is essentially different.

The genus *Gastrotheca* was established by Fitzinger in 1843,⁴ who specifically designated *Hyla marsupiata* Duméril and Bibron as the type. Fifteen years afterwards Dr. Guenther⁵ thought himself “justified in not accepting his name,” because from its supposed Greek derivation “Fitzinger appears to have believed in the existence of a pouch on the belly,” and he accordingly changed it into *Nototrema*. This, of course, is in contravention of all zoological codes of nomenclature, and Fitzinger’s name has to be restored.

¹ Biol. Centr.-Amer., Rept. Batr., 1901, p. 288, pl. 74, fig. A.

² Cat. Batr. Sal. Brit. Mus., 1882, p. 418.

³ Weinland, in Mueller’s Arch. Anat. Physiol., 1854, p. 473, pl. 17.

⁴ Syst. Rept., p. 30.

⁵ Cat. Batr. Sal. Brit. Mus., 1858, p. 115.

THE WEST AMERICAN MOLLUSKS OF THE GENUS NODULUS

By PAUL BARTSCH

Assistant Curator, Division of Mollusks, U. S. National Museum.

The known members of this genus were formerly referred to *Onoba*. That group, however, has feeble axial ribs as well as spiral sculpture. In *Nodulus* we find a very characteristic oblique aperture; axial ribs are never present and spiral sculpture, if at all present, is reduced to exceedingly fine striations.

Doctor Dall, in a paper on Mollusks of Bering Sea and vicinity,¹ was the first to report members of this group from the West Coast of America. In this publication he described and figured *Onoba saxatilis* Möller, *Onoba cerinella* Dall, and *Onoba aleutica* Dall. The first I now rename *Nodulus kyskensis*, since an abundance of *saxatilis* for comparison force me to declare the Alaskan form distinct. *Onoba aleutica* Dall ranges nearer the West American species of *Cingula*, to which it is now referred.

The only other *Nodulus* described from the West Coast is *Nodulus asser* Bartsch, published in the *Nautilus*² for 1910, also from Alaska.

A fourth species, *Nodulus kelseyi*, is now added from Coronado Island, California.

NODULUS CERINELLUS Dall.

Onoba cerinella DALL, Proc. U. S. Nat. Mus., vol. 9, 1886, p. 307, pl. 4, fig. 12.

Shell small, thin, light yellow. The nucleus consists of a single turn, which is smooth and scarcely differentiated from the succeeding whorls. Post-nuclear whorls high between the sutures, moderately rounded, appressed at the summit, marked by fine incremental lines only. Suture well constricted. Periphery of the last whorl and the rather long base gently

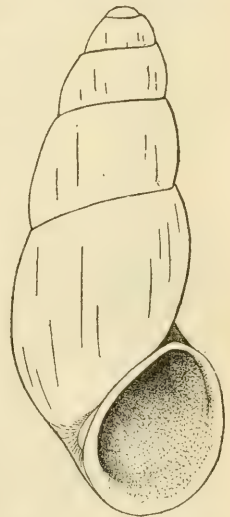


FIG. 1.—NODULUS CERINELLUS.

¹ Proc. U. S. Nat. Mus., vol. 9, 1886, pp. 306-7.

² Nautilus, vol. 23, No. 11, p. 138, pl. 11, fig. 9.

rounded. Aperture very oblique, large, broadly oval; posterior angle obtuse; outer lip thin; columella very oblique, slightly curved, inner lip partly reflected over the base; parietal wall covered with a thick callus, which is free at the edge and renders the peritreme complete.

The type (Cat. No. 213453, U.S.N.M.) has four and one-half post-nuclear whorls and measures: Length 2.9 mm., diameter 1.3 mm. It was collected at Atka Island, Alaska.

Specimens examined.

Cat. No.	Locality.	Number of specimens.
213453 (figured type).....	Atka Island, Alaska.....	1
213454.....	Outer Beach, Kyska Island, Alaska.....	1
213455.....	Constantine Harbor (beach), Amchitka Island, Alaska.....	1
161103.....	Kyska Island, Alaska.....	18

NODULUS ASSER Bartsch.

Onoba asser BARTSCH, Nautilus, vol. 23, 1910, No. 11, p. 138, pl. 11, fig. 9.

Shell elongate-conic, bluish white, semitranslucent. Nuclear whorls one and one-tenth, smooth, a little less elevated than the succeeding turns. Post-nuclear whorls very high between the sutures, overhanging, moderately rounded, appressed at the summit. The preceding whorl shines through the summit of the succeeding turn and gives this the appearance of having a double suture. Sutures well impressed. Periphery of the last whorl well rounded. Base moderately prolonged, well rounded. Entire surface of spire and base marked by closely placed, exceedingly fine, microscopic, spiral striations. Aperture very broadly ovate; posterior angle obtuse; outer lip thin; peritreme complete.



FIG. 2.—NODULUS ASSER.

The type (Cat. No. 208434, U.S.N.M.) was collected by Dr. Fred Baker at Port Graham, Alaska. It has four and a half whorls and measures: Length 2.2 mm., diameter 0.9 mm. This species is nearest related to *Onoba cerinella* Dall, from which it is distinguished by its lesser size and more delicate structure.

NODULUS KELSEYI, new species.

Shell small, very slender, cylindro-conic, translucent, white. Nuclear whorls two, strongly rounded, smooth. Post-nuclear whorls rather high between the sutures, well rounded, very narrowly shouldered at the summit and lightly constricted a little anterior to the summit, marked by fine lines of growth and exceedingly fine, spiral striations. Suture moderately constricted. Periphery of the last whorl and the long



FIG. 3.—NODULUS KELSEYI.

base gently rounded, marked like the spire. Aperture very oblique, subcircular; posterior angle obtuse; outer lip reflected at the edge; inner lip moderately long, reflected; parietal wall covered with a thick callus, which is also reflected, but free at the edge, thus giving the entire aperture a dished appearance.

The type (Cat. No. 111369, U.S.N.M.) comes from Coronado Island, San Diego, California. It has 5 post-nuclear whorls and measures: Length 1.9 mm., diameter of the penultimate whorl 0.6 mm.

Named for Prof. F. W. Kelsey, of San Diego, California.

NODULUS KYSKENSIS, new species.

Shell elongate-ovate, thin, translucent, yellow. Nuclear whorls one and one-quarter, smooth, well rounded, scarcely differentiated from the succeeding turns. Post-nuclear whorls appressed at the summit, with a somewhat concavely sloping shoulder which extends over the posterior third between the sutures. Entire surface marked by numerous fine lines of growth only, surface apparently covered with a thin epidermis which has the finely cracked appearance frequently seen on a surface covered with varnish. Suture strongly constricted. Periphery and the rather short base of the last whorl well rounded. Aperture very large, very broadly oval, decidedly oblique; posterior angle obtuse; outer lip slightly expanded; inner lip decidedly curved and reflected; parietal wall covered with a thick callus which is disjunct at the edge and renders the peritreme complete.

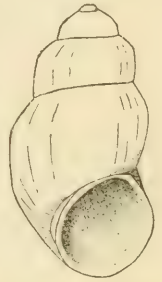


FIG. 4.—*NODULUS*
KYSKENSIS.

The type (Cat. No. 161105, U.S.N.M.) has four post-nuclear whorls and measures: Length 2.3 mm., diameter 1.1 mm. It was collected at Kyska Harbor, Aleutian Islands, Alaska, by Doctor Dall. Seventeen additional specimens, also entered as Cat. No. 161105, U.S.N.M., were collected on the beach and on sponges at low water mark by Doctor Dall on the same island. Four more (Cat. No. 213457, U.S.N.M.) come from Atka Island, Alaska.

This shell has been referred to by various authors as *Rissoa saxatilis* Möller. It differs from that form in having the whorls slopingly shouldered near the summit and in lacking the fine spiral striations.



DESCRIPTIONS OF ONE NEW GENUS AND THREE NEW
SPECIES OF ICHNEUMON FLIES.

By H. L. VIERECK,

Of the Bureau of Entomology, Department of Agriculture, Washington, D. C.

This paper is based upon material determined for the above Bureau. The material involved is now to be found in the collections of the United States National Museum, from which institution these proceedings issue.

CŒLOIDES BRUNNERI, new species.

Female.—Length 4 mm.; compared with *Cœloides pectinator* Say, which it closely resembles. This species may be distinguished by the almost straight suture between the second and third dorsal segments, the shallow furrow along the lateral edge of the second dorsal segment and the reddish head.

Male.—Length 3 mm.; very as in the female.

Type.—Cat. No. 14156, U.S.N.M., female and male.

Type-locality.—Columbia Falls, Montana. On authority of Dr. A. D. Hopkins this species was reared from *Dendroctonus pseudo sugæ* under Hopk. No. 8563, May 23, 1911. Upon the suggestion of Doctor Hopkins this species is named after Mr. J. Brunner, who reared the specimens concerned in drawing up the above description.

A series of specimens show some latitude in length. The smallest male being approximately 1.5 mm., the smallest female 3 mm. long in a series of five females and five males.

Genus MEGARHOGAS Szepligeti.

Megarhogas SZEPLIGETI, Gen. Ins., fasc. 22, p. 83. Two species originally included.

Type.—*Megarhogas longipes* Szepligeti by present designation.

As represented by the following species the malar line in this genus is apparently a little shorter than the width of the mandibles at base; looked at from the side the eye is at least twice as wide as the average width of the cheeks; propodeal spiracles round, recurrent vein received by the first submarginal cell.

MEGARHOGAS THERETRÆ, new species.

Female.—Length 7.5 mm.; compared with the original description of the genotype of this genus the present species differs as follows: Head sculptured, stramineous, region between the antennæ black, antennæ brownish, longer than the body; dorsulum almost polished, its lobes mostly brownish, otherwise stramineous, the posterior half with a median longitudinal furrow; propodeum not keeled, mostly punctate; radius in hind-wings not bisinuate; abdomen dorsally without a median keel except for an ill-defined one at base of first segment, second segment approximately two-thirds the length of the first, third segment without circumscribed anterior lateral corners; thorax and its appendages and the abdomen mostly stramineous to yellowish, wings brownish with a rather washed-out appearance in the radial cell and in the membranous area below the second sub-marginal cell.

Male.—Notably differs from the female in having the second and third joints of the maxillary palpi present, in the dry specimens, as apparently collapsed sacules of rather cuneiform outline with the angles rounded off, thus contrasting greatly with the simple palpi in the female; in most other particulars there is an apparently complete similarity to the female.

Type.—Cat. No. 14157, U.S.N.M., female and male.

Type-locality.—Medan, Deli, Sumatra, where on authority of Doctor de Bussey this species was reared from the larvæ of the moth *Theretra celerio* Linnæus.

Among twenty-two paratopotypes selected from over two hundred specimens there is a noticeable variation in color and size, some of the female paratopotypes being rather suffused with brownish above, whilst in the male paratopotypes there is a tendency toward a fading out of the tegument and a coincident decrease in length, one specimen being only 4 mm. long.

ZALEPTOPYGUS, new genus.

Related to *Leptopygus* (Foerster) Thomson, from which it may be readily distinguished by the apex of the propodeum overlapping the upper face of the hind coxæ to a point at or beyond the middle of the same, by a break in the occipital carina such as is found in *Cremastus* Gravenhorst and by the greatest diameter of the lateral ocelli in the male being as great or nearly as great as the ocellocular line or greater than the same as is the case in (Porizon) *Z. orbitalis* Cresson. The affinities of this genus in the head, etc., are with *Cremastus* Gravenhorst Foerster, when we ignore the venation as described in Foerster's classification. But still greater is the affinity with *Pristomerus* Holmgren when we ignore the armature or lack of armature of the hind femora, the venation, and the head. In brief, then, in the more

satisfactory characters found in the thorax the affinities are with *Cremastus*, *Pristomercus*, and *Leptopygus*. With reference to the propodeum the closest relationship is with *Leptopygus* as represented by the genotype of *Leptopygus* or *Leptopygus harpurus* (Gravenhorst).

Type.—*Zaleptopygus obereæ*, new species.

ZALEPTOPYGUS OBEREÆ, new species.

Female.—Length 11.5 mm.; sheaths of the ovipositor 4 mm. long; bears a close resemblance to *Zaleptopygus orbitalis* Cresson from which it may be distinguished by the areola being virtually as long as the petiolarea, in the thorax which is apparently twice as long as high, in the almost quadrate lower division of the metapleuræ; also not as brightly ornamented as in *Z. orbitalis* Cresson, although the ornamentation follows a similar pattern, and in the darker appendages, the wings being distinctly brownish and not almost whitish as in *Zaleptopygus orbitalis* Cresson.

Male.—Length 10.5 mm.; very similar to the female but with a yellow spot on the face and with the scape partly yellow beneath.

Type.—Cat. No. 13798, U.S.N.M.

Type-locality.—Chicago, Illinois.

“Parasite of *Oberca tripunctata*” according to Mr. A. A. Girault, from whom the species was received.

A NEW FOSSIL ALLIGATOR FROM THE HELL CREEK BEDS OF MONTANA.

By CHARLES W. GILMORE,

Assistant Curator of Fossil Reptiles, U. S. National Museum.

The specimen described below belongs to the vertebrate paleontological collection of the American Museum of Natural History, New York, and it is through the generosity of Dr. H. F. Osborn and Mr. Barnum Brown, of that institution, that I now have the privilege of describing it.

This specimen represents a true though primitive member of the Alligatoridæ, as is abundantly shown by the general proportion of the skull, especially in the shortness and flatness of the broadly rounded muzzle and the nonconstriction at the maxillo-premaxillary union, the reception of the anterior teeth in pits of the upper jaw, the lower teeth biting within the upper, and the divergent lateral borders of the anterior ends of the palatines.

In North America three genera, *Diplocynodon*, *Alligator*, and *Bottosaurus*, have been included under the family Alligatoridæ.

From *Diplocynodon* the present form is to be separated at once by the nonconstriction of the snout at the maxillo-premaxillary suture and the uniform size of the premaxillary teeth.

The abbreviated facial region, the posterior extension of the nasal bones, and differences in the dentition distinguish it from *Alligator*.

On account of the lack of homologous parts for comparison, the separation of this specimen from *Bottosaurus* is somewhat more difficult, though their distinctness appears to be indicated.

In Leidy's description¹ of the type specimen of *Bottosaurus harlani* he says: "The fragment of the dental bone is about 15 inches in length, and in this extent contains the remains of 11 alveoli, which, perhaps, comprise the whole number except three or four." In the Montana skull the total length of the dental series is 8 inches and contains alveoli for 19 teeth. Still further Leidy says the alveoli "appear to indicate a succession of teeth related to one another in size nearly as in the *Crocodile* and *Alligator*." The succession of

¹ Smithsonian Contributions to Knowledge, vol. 14, 1865, p. 13.

teeth in the present form, as will be shown later, is not like that of the *Crocodile* and *Alligator*, and, when considered with the great disparity in the proportional extent of the dental series, appears to justify their generic separation. On that account the new generic name *Brachychampsa* is proposed for its reception. Under this genus I would include the species *Bottosaurus perrugosus* Cope from the Arapahoe beds of eastern Colorado, which Cope provisionally assigned¹ to the New Jersey genus *Bottosaurus*.

The type of this species cannot now be located, but in the original description is said to consist of a "fragmentary dentary, vertebræ, and pieces of the skull." Cope says: "There is a slight difference in the sizes of the alveoli, but not such as is usual in Tertiary crocodiles." In view of the character of the dentition shown by this newly discovered specimen, "the slight differences, etc.," noted above appear especially significant when taken into consideration with the similarity of their geological occurrence.

The classification of this form may be best expressed by the following:

Order.—Crocodylia.

Suborder.—Eusuchia.

Family.—Alligatoridæ.

Genus.—*Brachychampsa*.

Species.—*Brachychampsa montana*.

The genus *Brachychampsa* will now include the two species *B. montana*, *B. (Bottosaurus) perrugosa* (Cope).

BRACHYCHAMPSEA, new genus.

The characters of this genus are included in the description that follows of *Brachychampsa montana*, the type-species.

BRACHYCHAMPSEA MONTANA, new species.

Plates 26 and 27.

Type.—The anterior two-thirds of the skull, accompanied by detached fragments of the posterior portion. Cat. No. 5032, Amer. Mus. Nat. Hist. Collected by Barnum Brown.

Type-locality.—Twenty-five miles southeast of Lismas, Dawson County, Mont.

Horizon.—Upper sandstone, "Hell Creek Beds," Lance formation, Upper Cretaceous.

Description.—The type-specimen is a short, broad-snouted skull, the length from the level of the front border of the orbits being only 7 mm. greater than the width at the same point. Excepting a few detached fragments, the posterior portion of the skull behind the orbits is missing (Pl. 26). The remaining part is fairly complete

¹ Bull. Geol. and Geog. Survey of Terr., vol. 1, 1874-5, p. 27.

and undistorted. The upper surface of the preorbital region is flat and without crests or ridges; the muzzle is evenly but broadly rounded; the nasal aperture is large and pear-shaped in outline. In the absence of a roof-like covering formed by the premaxillaries over the anterior part of the external nares, *Brachychampsa* differs from all known alligators, both recent and extinct. On account of the damaged condition of the anterior extremities of the nasal bones it can not be determined whether they extended forward into the nasal opening. The facial processes of the premaxillaries extend posteriorly to the level of the alveolus for the fifth maxillary tooth. The nasal bones are comparatively slender and extend posteriorly to the level of the anterior borders of the orbits. In recent alligators these bones terminate well in front of the orbital line. The maxillaries are broad, flattened above, and much compressed vertically. The jugals are heavy, with roughly sculptured surfaces. The interorbital surface is flat and not concave as in many crocodiles and alligators. The orbital openings are everted as in the alligators and some crocodiles and are confluent with the lateral vacuities. The sculpturing of the facial surface of the bones is more strongly marked in the neighborhood of the orbits than it is anteriorly.

In the palatal view (Pl. 27), where the bones have not suffered mutilation, all of the sutures are plainly indicated. Latero-inferiorly the maxillo-premaxillary suture passes obliquely backward and inward on the palate. The damaged condition of the palate just back of the anterior palatine vacuity renders uncertain the posterior extent of the premaxillaries. In the recent alligators this suture extends nearly straight across on a level with the second maxillary tooth, while in this form it extends posteriorly at least as far as the level of the fourth maxillary tooth.

Each of the broad maxillaries has alveoli for 14 teeth, and each of the premaxillaries for 5. The palatines, of which only the anterior portions are present, unite with the maxillæ by an almost straight transverse suture on a level with the eleventh maxillary tooth. The lateral borders of the anterior ends of the palatines are divergent, as in all alligators, instead of parallel or convergent as in all true crocodiles. On the left side of the palate enough of the boundary of the posterior palatine vacuity remains to indicate that it was subround instead of elongate as in most members of this group. The preserved borders of the anterior palatine vacuity show it to have been of large size and probably pear-shaped in outline.

The pits on the palatal surface of the premaxillary for the reception of the anterior teeth of the lower jaw are broad and exceedingly shallow.

A detached fragment of the pterygoid shows the processes to have been blunt and stout.

Measurements of skull of Brachychampsa montana. Type-specimen.

	mm.
Distance from anterior angle of orbits to tip of snout.....	164
Width of skull at anterior angle of the orbits.....	157
Width of skull at maxillo-premaxillary suture.....	105
Greatest width of nasal opening.....	44
Greatest longitudinal length of premaxillary.....	80
Least width of interorbital bar.....	26
Greatest width of nasals.....	32
Greatest width of anterior palatine processes.....	45
Greatest width of anterior palatine vacuity.....	33
Distance from anterior end of palatine vacuity to tip of snout.....	24
Length of alveolar border of maxillary.....	135
Length of alveolar border of premaxillary.....	65

Teeth.—The dental formula of the upper jaw consists of 5 premaxillary and 14 maxillary teeth, the total number (38) being the same as found in the upper mandible of many modern alligators. Judging from the size of the alveoli, all of the premaxillary teeth appear to have been of approximately the same size. The teeth still present in the skull are: the bases of three premaxillary teeth, and the third, fourth, fifth, sixth, seventh, ninth, eleventh, and twelfth maxillary teeth on the right side; the roots of the third, fifth, sixth, and seventh, with the tenth and eleventh teeth intact, in the left maxillary. The first three maxillary teeth were relatively small and evidently of about equal size. The fourth is slightly larger than the third; the fifth is larger than the fourth and is the most robust tooth of the anterior dental series; the sixth tooth is slightly smaller than the fifth; the seventh, eighth, ninth, and tenth were quite small, being the weakest of those in the upper mandible; the eleventh and twelfth were robust, and, judging from the size of the alveoli for the thirteenth and fourteenth, all of these teeth were of approximately the same size.

The anterior teeth of the maxillary series although somewhat compressed transversely are acutely pointed, and while the fifth is as long as the eleventh and twelfth the anterior posterior extent of the tooth is only a little over half that of the latter. The relative dimensions are well shown in the table of measurements of the teeth given below.

The posterior teeth of *Brachychampsa montana* resemble most nearly those figured by Leidy¹ as *Bottosaurus harlani* from the Cretaceous of New Jersey.¹

The crowns of the posterior teeth are somewhat compressed laterally, mammiliform, with outer and inner surfaces separated by a somewhat obscure carinæ which extends from the subacute apex to the base of the corrugated surface as shown in figure 1. The upper

¹ Smithsonian Contributions to Knowledge, vol. 18, pl. 18, figs. 11-14.

surface is corrugated with depressions radiating from the apex but the base of the enameled surface is smooth. The upper part of the tooth is separated from the gibbous root by a slight constriction at the base of the enamel.

In the collection of the U. S. National Museum there is a large number of detached teeth from the "Ceratops beds" of Converse County, Wyoming, which can not be distinguished from those in the specimen under discussion. With them are other teeth which from their minute size and other differences appear to indicate the presence in those beds of one or more undescribed species, but the material is too meager upon which to base a determination. Many of these scattered teeth showed wear on their internal surfaces, thus substantiating the evidence of the *Alligatoroid* nature of the bite as shown by the worn posterior teeth of the type-specimen.

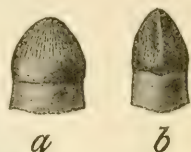


FIG 1.—TWELFTH MAXILLARY TOOTH OF BRACHYCHAMPSA MONTANA. NATURAL SIZE. a, LATERAL VIEW; b, POSTERIOR VIEW. TYPE-SPECIMEN.

Principal measurements of maxillary teeth of Brachychampsia montana. Type-specimen.

Number of tooth....	Third.	Fourth.	Fifth.	Sixth.	Seventh.	Ninth.	Tenth.	Eleventh.	Twelfth.
Length.....	mm. 9	mm. 10	mm. 12	mm. 9	mm. 7	mm. 5	mm. 6.5	mm. 12	mm. 11
Extent antero-posteriorly.....	6.5	7	8	7	6	5	6	12	12

EXPLANATION OF PLATES.

PLATE 26.

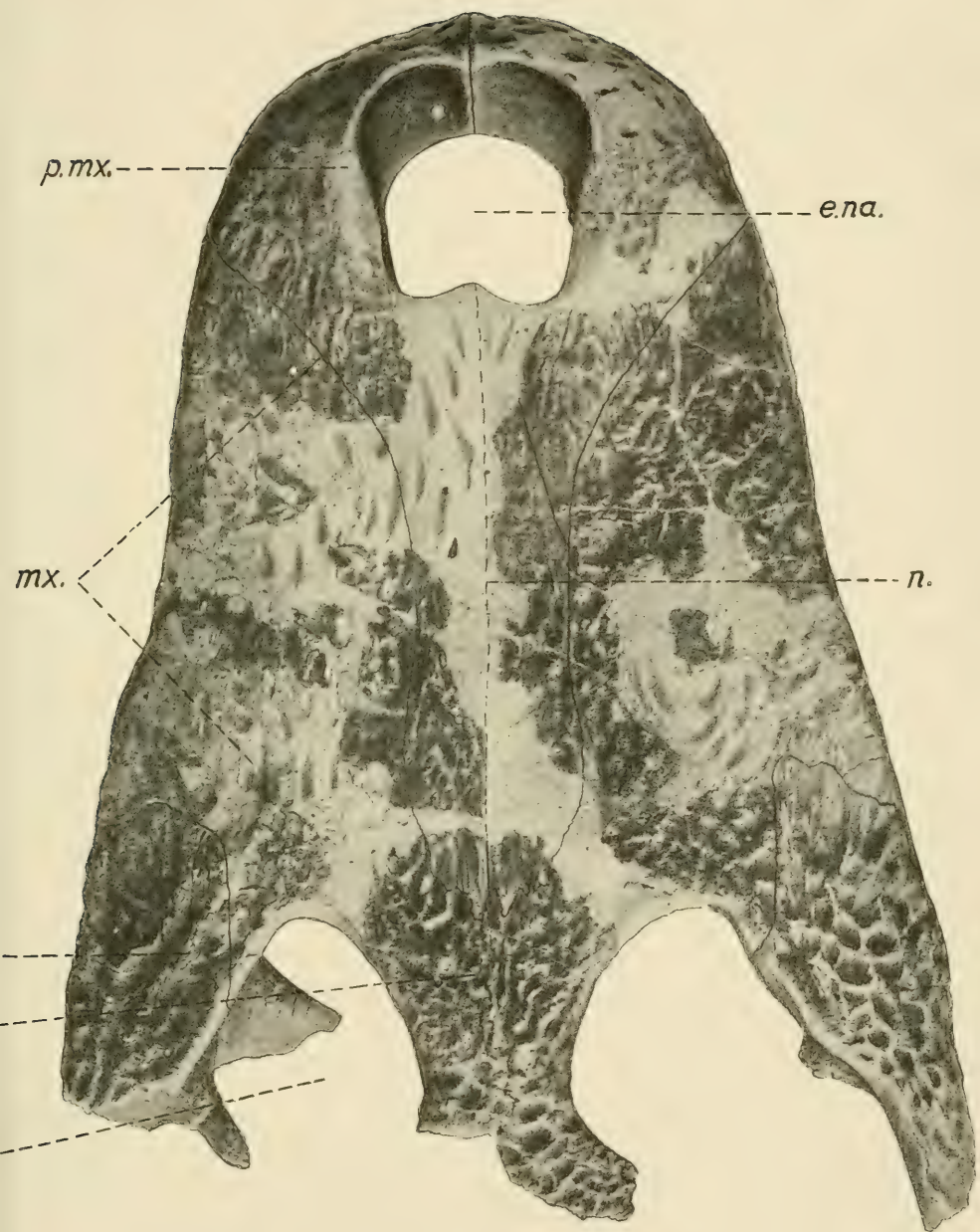
Skull of *Brachychamposa montana*. Cat. No. 5032. Amer. Mus. Nat. Hist. Type-specimen. Superior view of the anterior part of the skull. Natural size.

e. na., external nares; *fr.*, frontal; *ju.*, jugal; *mx.*, maxillary; *n.*, nasal; *o.*, orbit; *p. mx.*, premaxillary.

PLATE 27.

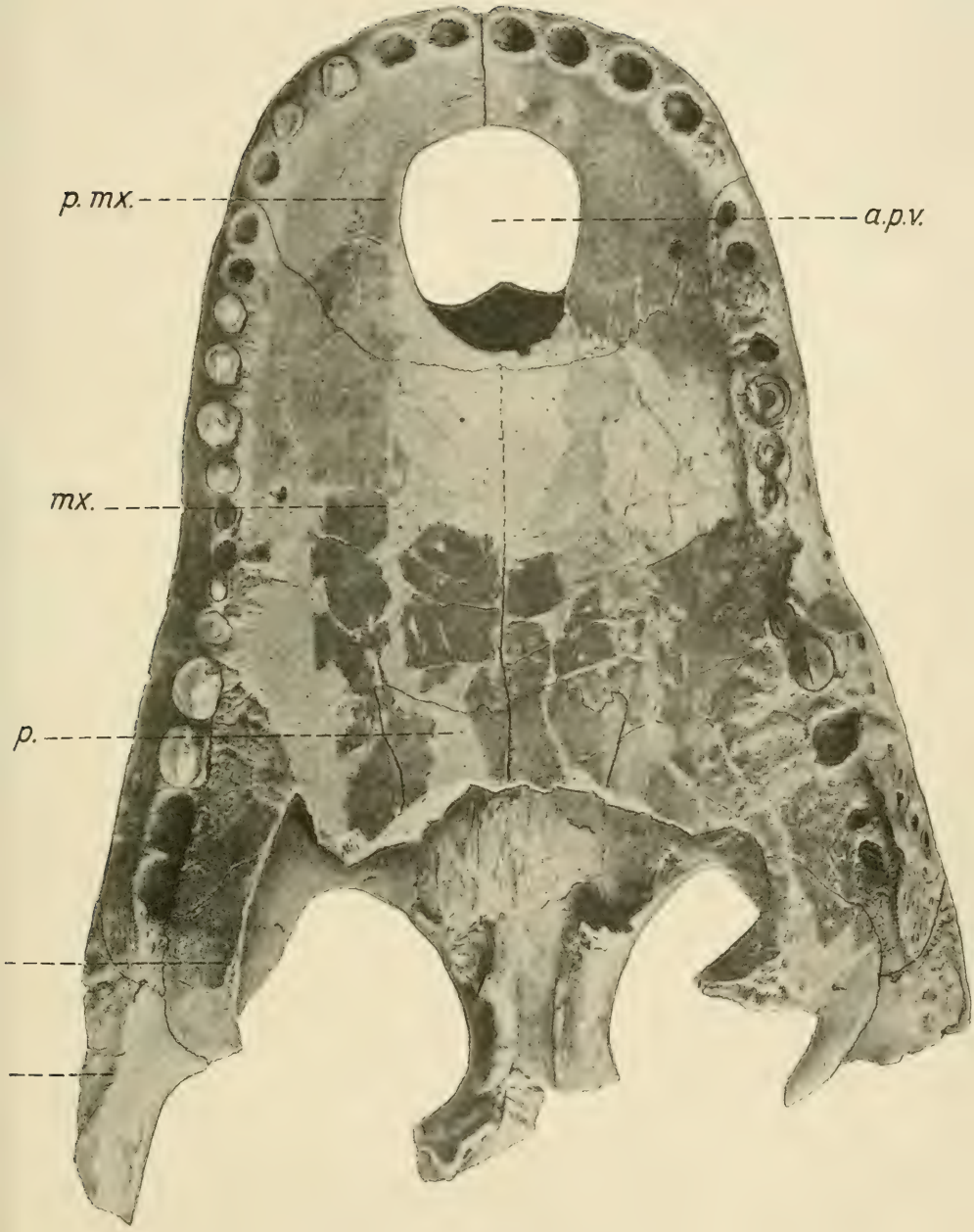
Skull of *Brachychamposa montana*. Cat. No. 5032. Amer. Mus. Nat. Hist. Type-specimen. Inferior view of the anterior part of the skull. Natural size.

a. p. v., anterior palatine vacuity; *ju.*, jugal; *mx.*, maxillary; *p.*, palatines; *p. mx.*, premaxillary; *t. p.*, transpalatines.



ANTERIOR PART OF SKULL OF BRACHYCHAMPSA MONTANA.

FOR EXPLANATION OF PLATE SEE PAGE 302.



ANTERIOR PART OF SKULL OF BRACHYCHAMPSA MONTANA. PALATE VIEW.

FOR EXPLANATION OF PLATE SEE PAGE 302

NEW MARINE MOLLUSKS FROM BERMUDA.

By PAUL BARTSCH,

Assistant Curator, Division of Mollusks, U. S. National Museum.

Some time ago the United States National Museum received a lot of mollusks for determination from Mr. Arthur Haycock, collected by him at Bermuda. Among these were quite a number of new species, which were described by Dr. William H. Dall and the present writer in the Proceedings of the U. S. National Museum, vol. 40, pp. 277 to 288, pl. 35, May, 1911. Since then several other lots have been examined, and among these the following new forms were found:

CERITHIOPSIS HERO, new species.

Plate 28, fig. 1.

Shell large, elongate-conic, chestnut brown, nuclear whorls at least 3, well rounded, smooth, scarcely increasing in size, forming a cylindrical apex; post-nuclear whorls moderately rounded, ornamented with 3 strong spiral cords, and quite regular somewhat retractive axial ribs. Of the axial ribs, 16 occur upon the first and second; 18 upon the third; 20 upon the fourth; 22 upon the fifth to ninth; 24 upon the tenth, and 26 upon the penultimate turn. The intersections of the axial ribs and the spiral cords form strong tubercles, of which those on the cord at the summit are somewhat elongated and well rounded, while those on the median and supra-sutural cords are truncated posteriorly, sloping gently anteriorly. Sutures strongly channeled. Periphery of the last whorl marked by a channel as broad as that which separates the supra sutural from the median spiral cord. This channel is crossed by the continuation of the axial ribs, which terminate at the posterior border of the flattened spiral cord, that bounds the sulcus anteriorly. Base slightly concave, marked by a very feeble spiral cord at the insertion of the columella. Entire surface of spire and base marked with numerous very fine lines of growth, and exceedingly fine spiral striations. Aperture irregularly oval, strongly channeled anteriorly and feebly so at the posterior angle; outer lip rendered decidedly sinuous by the spiral cords; columella very stout, somewhat curved, and partly covered by the reflected inner lip; parietal wall covered with a thick callus.

Seven specimens of this species, collected by Mr. Arthur Haycock, at Bermuda, are before us. Two of these may be considered cotypes. One of these, which has lost part of the nucleus, has 12 post-nuclear whorls, and measures: length, 7.6 mm., diameter 2 mm. The other has a complete nucleus and 8 post-nuclear whorls, and measures: length, 5 mm. and diameter 1.5 mm. The remaining five are young individuals. The smaller cotype and two of the young specimens form Catalogue No. 226450 of the United States National Museum collection.

CERITHIOPSIS CYNTHIA, new species.

Plate 28, fig. 5.

Shell small, elongate-conic, chestnut brown, excepting the early nuclear whorls, which are white. Nuclear whorls a little more than 4, well rounded, smooth, forming a mucronated apex. Post-nuclear whorls moderately rounded, marked by 3 strong spiral cords, and strongly retractive axial ribs. Of these, 16 occur upon the first; 18 upon the second to fifth, and 20 upon the sixth and the penultimate turn. The intersections of the spiral cords and the axial ribs form strong tubercles, which are truncated posteriorly and slope gently anteriorly; while the spaces inclosed between them appear as strongly impressed rounded pits. Sutures moderately constricted. Periphery of the last whorl marked by a sulcus as wide as that which separates the supra sutural from the median cord and like this crossed by the continuations of the axial ribs. Base marked with a strong, broad, rounded spiral cord, adjoining the peripheral sulcus, which is rendered feebly tuberculated by the continuations of the axial ribs. Anterior to this cord there is a strong spiral sulcus which equals the subsutural cord in width. Entire surface of spire and base marked by numerous very fine lines of growth, and exceedingly fine spiral striations. Aperture irregularly oval, strongly channeled anteriorly, feebly so posteriorly; outer lip thin, showing the external sculpture within, rendered sinuous at the edge by the external sculpture; columella very stout, twisted, and somewhat curved; inner lip reflected over the columella; parietal wall glazed with a thin callus.

The type and seven specimens (Cat. No. 226449, U.S.N.M.) were collected by Mr. Arthur Haycock in Bermuda. The type, a perfect specimen, has seven and one-half post-nuclear whorls, and measures: length 3.9 mm. and diameter 1.1 mm.

CERITHIOPSIS IONTHA, new species.

Plate 28, fig. 3.

Shell very minute, elongate-conic, golden brown, excepting the apex, which is white. Nuclear whorls 2, well rounded, smooth. Post-nuclear whorls well rounded, marked by 3 strong spiral cords,

and slightly retractive axial ribs, of the latter 18 occur upon the first; 20 upon the second and third, and 24 upon the fourth and penultimate turn. The intersections of the axial ribs and spiral cords form strong tubercles, of which those on the cord at the summit and those on the median cord are truncated both anteriorly and posteriorly, while those on the supra-sutural cord are truncated posteriorly, sloping gently anteriorly. The spaces inclosed between the axial ribs and spiral cords are strongly impressed squarish pits. Sutures strongly constricted. Periphery of the last whorl marked by a sulcus as wide as that which separates the supra sutural from the median cord. The sulcus is crossed by the feeble continuations of the axial ribs. Base moderately rounded, marked by a broad, low spiral cord, which limits the peripheral sulcus posteriorly, and a second tumid low spiral cord at the insertion of the columella. Entire surface of spire and base marked by numerous fine lines of growth, and exceedingly fine spiral striations. Aperture irregularly oval, strongly channeled anteriorly, feebly posteriorly; outer lip thin, somewhat patulous, rendered wavy by the external sculpture; columella stout and somewhat curved; inner lip reflected over the columella; parietal wall covered with a thick callus.

Three specimens of this species were collected by Mr. Arthur Haycock in Bermuda. These may be considered cotypes. The specimen figured has a little more than five post-nuclear whorls, and measures: 2.1 mm. in length and 0.9 mm. in diameter. One of the three is Cat. No. 226451, U.S.N.M. The other two are in the Bermuda Museum.

TRIPHORIS BERMUDENSIS, new species.

Plate 28, figs. 2 and 4.

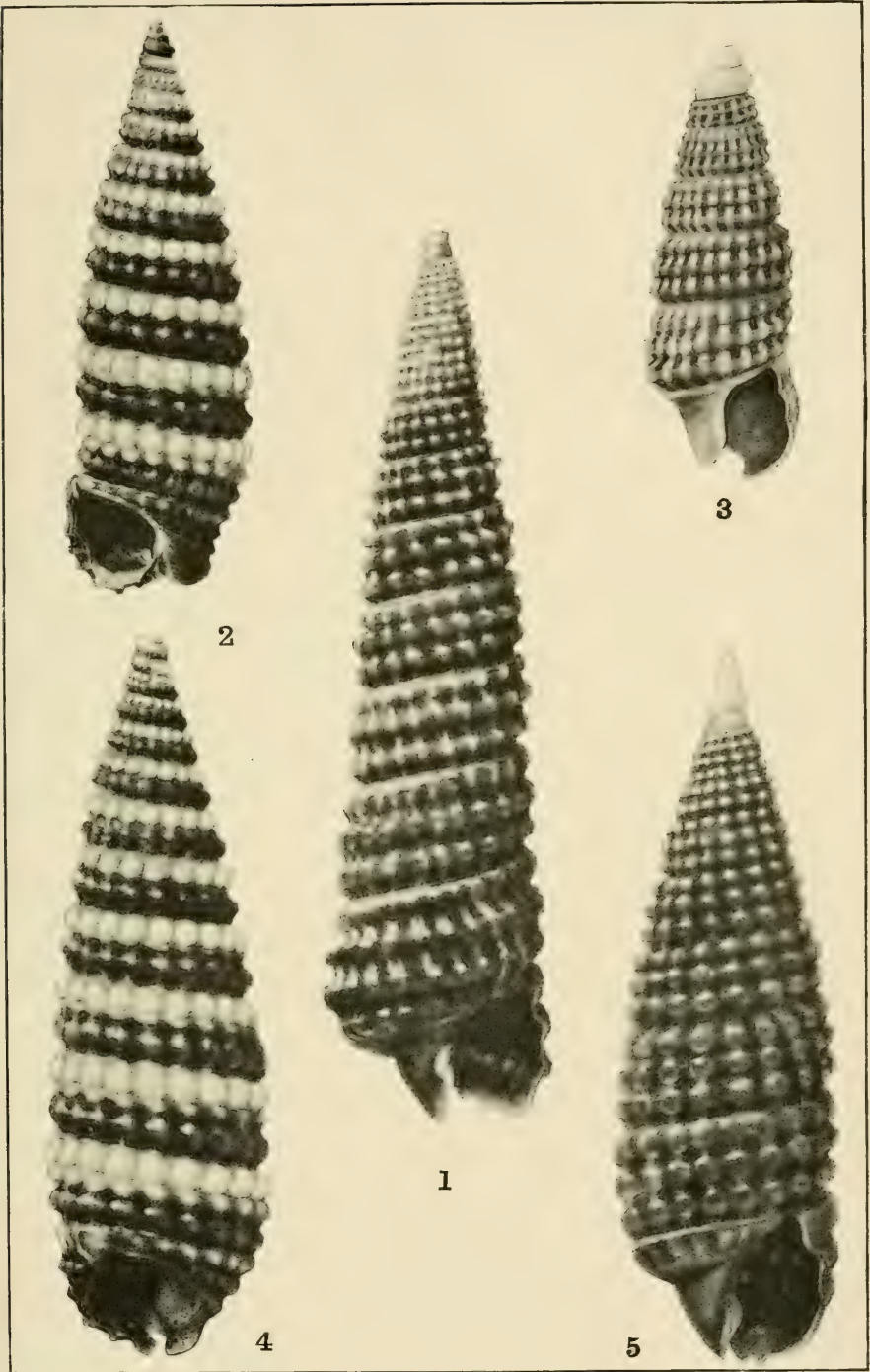
Shell elongate-conic, marked by alternate spiral bands of white and brown. Nuclear whorls moderately rounded, forming a conic apex, the first turn smooth, the second marked by a raised spiral thread which is a little nearer the suture than the summit. On the third whorl a second spiral thread is present, between the first and the summit, being a little nearer to the neighboring thread than the summit. In addition to these spiral threads the last two nuclear whorls are marked by 28 slender, very regular, threadlike axial ribs, which equal the spiral threads in strength. Post-nuclear whorls moderately rounded, the early ones marked with two strong tuberculated spiral cords, one of which is at the summit, and the other a little posterior to the suture. On the later turns a third slender tuberculated spiral cord makes its appearance between the other two, being a little nearer to the cord at the summit than to the supra-sutural cord. In addition to the spiral sculpture the post-nuclear whorls are marked by strong axial ribs, of which 16 occur upon the first; 18 upon the second to fifth; 20 upon the sixth to eighth; and 22 upon

the remaining whorls. The intersections of the spiral cords and the axial ribs form strong tubercles, of which those at the summit are well rounded, while those of the supra-sutural spiral cord are somewhat truncated posteriorly. The spiral cord at the summit is white, while the supra-sutural and median cords are brown. Periphery of the last whorl marked by a tuberculated spiral cord, which is as strong as its posterior neighbor, from which it is separated by a sulcus as wide as that which separates the supra sutural from the median spiral cord. Base moderately rounded, marked by two broad spiral cords, of which the posterior is feebly tuberculated. The entire base is light brown, the peripheral cord being of a little lighter shade of brown than the base. Entire surface of the spire and base marked by numerous very fine lines of growth and spiral striations. Aperture irregular, decidedly channeled anteriorly and posteriorly; outer lip produced into a clawlike element anteriorly; columella very stout and twisted; inner lip adnate to the base of the shell; parietal wall covered with a thick callus, which joins the inner lip with the outer at the posterior angle of the aperture rendering the peritreme complete.

Nine specimens of this species (Cat. No. 226452, U.S.N.M.) were collected by Mr. Arthur Haycock at Bermuda. One of these, a perfect individual, has 10 post-nuclear whorls, and measures: length 4.9 mm., diameter 1.5 mm. Another having 11 post-nuclear whorls measures: length 6.1 mm., diameter 2 mm.

EXPLANATION OF PLATE 28.

- FIG. 1. *Cerithiopsis hero* Bartsch, p. 303; cotype; long. 7.6 mm.
2. *Triphoris bermudensis* Bartsch, p. 305; cotype; long. 4.9 mm.
3. *Cerithiopsis iontha* Bartsch, p. 304; cotype; long. 2.1 mm.
4. *Triphoris bermudensis* Bartsch, p. 305; cotype; long. 6.1 mm.
5. *Cerithiopsis cynthia* Bartsch, p. 304; type; long. 3.9 mm.



NEW BERMUDA MOLLUSKS.

FOR EXPLANATION OF PLATE SEE PAGE 306



A REVISION OF THE FOSSIL FERNS FROM THE POTOMAC GROUP WHICH HAVE BEEN REFERRED TO THE GENERA CLADOPHLEBIS AND THYRSOPTERIS.

By EDWARD W. BERRY,
Of the Johns Hopkins University, Baltimore.

The present paper is the fourth and last of a series of revisions of the more important genera of fossil plants from the Potomac group in Maryland and Virginia.¹ The following genera have been discussed in previous numbers of the Proceedings: *Nageiopsis*, *Acrostichopteris*, *Taeniopteris*, *Nilsonia*, *Sapindopsis*, *Sequoia*, *Athrotaxopsis*, *Sphenolepis*, *Abietites*, *Pinus*, *Cephalotaxopsis*, *Brachyphyllum*, and *Widringtonites*.

With the appearance of the present communication all of the larger genera including those most in need of revision will have been treated. The remainder of the flora, numbering about one hundred species, will be fully described and illustrated in a Monograph of the Lower Cretaceous which will appear under the auspices of the Maryland Geological Survey.

The fern genus *Cladophlebis*, which is discussed in the first part of this paper, is an important cosmopolitan type in the Lower Cretaceous, a type which is an undiminished survival from the older Mesozoic. A large number of species have been described, both in this country and elsewhere. These ferns are abundant and important elements in the Potomac flora. The remains represent for the most part species of considerable size. The usual difficulties in dealing with fossil fragments of large and somewhat variable (in time and space) fronds have resulted in the previous description of many more species than the evidence warranted, a result equally confusing to both the botanist and the geologist.

The numerous species of *Thyrsopteris* recorded in the literature from the Maryland-Virginia area are treated in the second part of

¹The previous papers are: (1) A revision of the fossil plants of the genus *Nageiopsis* of Fontaine, Proc. U. S. Nat. Mus., vol. 38, 1910, pp. 185-195. (2) A revision of the fossil plants of the genera *Acrostichopteris*, *Taeniopteris*, *Nilsonia*, and *Sapindopsis* from the Potomac group, Proc. U. S. Nat. Mus., vol. 38, 1910, pp. 625-644. (3) A revision of several genera of Gymnospermous plants from the Potomac group in Maryland and Virginia, Proc. U. S. Nat. Mus., vol. 41, 1911, pp. 289-318.

the paper in a markedly different manner from what has previously been customary and are considered as representing the polypodiaceous genus *Onychiopsis* of Yokoyama.

THE GENUS CLADOPHLEBIS.

The genus *Cladophlebis* is essentially a form-genus which is restricted at the present time to include only certain fern remains of Mesozoic age, although this type of frond is practically identical with those of some Paleozoic genera, as for example *Pecopteris*, and it can also be closely matched by a variety of Tertiary and living ferns.

Cladophlebis was proposed by Brongniart in 1849¹ for those species which formed the section *Pecopteris neuropteroides* in his "Histoire des végétaux fossiles" which he regarded as transitional between *Pecopteris* and *Neuropteris*. Certain of their characters were mentioned but no formal diagnosis was attempted. Saporta was perhaps the first to define the genus with precision.²

Schimper in 1874 gives a somewhat amplified diagnosis.³ Later this author⁴ abandons *Cladophlebis* in the belief that the fertile specimens described by Heer justify the reference of these forms to the modern genus *Asplenium*.

The most recent diagnosis is that by Seward, which may appropriately be quoted for the American Cretaceous forms:

Fronds pinnately divided, pinnæ spreading, lobes or pinnules attached by the entire base or slightly auriculate, acuminate, or obtuse, occasionally dentate, especially at the apex, not rarely subfalcately curved upwards, midrib strong at base, and towards the summit dissolving into branches, secondary veins given off at a more or less acute angle, dichotomous a little above the base, and repeatedly dichotomous.⁵

Much difference of opinion has prevailed regarding the unity and the systematic position of the genus, Saporta⁶ having long ago pointed out that Brongniart's species had nothing in common with those of the Mesozoic and that the Liassic and Oolitic forms, those which the former author was discussing, give evidence of common characters. At the present time there is still lacking evidence from such fructified remains as have been discovered of close relationship between all of the various species of *Cladophlebis*. Thus Heer discovered in the Siberian Jurassic, fragments of the *Cladophlebis whitbyensis* type with soral characters which he compared with those of the subgenus *Diplazium* of *Asplenium*⁷ and Schenk has figured fertile pinnules of the same type in the case of the allied *Asplenites*

¹ Tableau, p. 25.

² Saporta, Pal. France, ser. 2, Végétaux, Plantes Jurass., vol. 1, 1873, pp. 298, 299.

³ Schimper, Pal. Végét., vol. 3, 1874, p. 503.

⁴ Schimper in Zittel's Handbuch der Palaeontologie, Abth. I, 1890, pp. 99, 100.

⁵ Seward, Wealden Flora, pt. 1, 1894, p. 88.

⁶ Saporta, Pal. France, ser. 2, Végétaux, Plantes Jurass., vol. 4, 1888, p. 357.

⁷ Heer, Flora foss. Arct., vol. 4, 1877, p. 38, pl. 21, figs. 3, 4.

rosserti.¹ Certain specimens of the Jurassic species *Cladophlebis lobifolia* show that the sporangia in this species were apparently borne in semicircular pocket-like depressions on the edges of the fertile segments² while the fructifications of *Cladophlebis denticulata* are in the form of narrow oblong sori parallel with the secondary veins and are compared by Seward³ with the modern forms *Asplenium lugubre* and *Phegopteris decussata*.

In his latest utterance on this subject Professor Seward says that "there are fairly good grounds for the assertion that some at least of the fronds described under this name are those of Osmundaceæ."⁴

Zeiller has recently described a species from the Wealden of Peru which he considers identical with, or very close to, *Cladophlebis browniana* in which the sporangia are biseriate, oval, and annulate as in the Schizaeaceæ. These are said to be very like those of the Jurassic genus *Klukia* of Raciborski.⁵

In the Potomac flora⁶ we find that 14 so-called species of *Aspidium* Swartz (*Dryopteris* Adanson), mostly fertile fronds, were described by Fontaine in 1890. These showed mostly large elliptical or reniform sori in rows on each side of the midvein and located generally on the distal branch of a furcate vein and usually wanting in the apical part of the pinnule. These were compared by this author with modern species of *Aspidium*, *Cystopteris*, *Polystichum*, and *Didymochlaena*. The preservation is not of the best, the matrix being coarse, and Fontaine's figures are largely idealized. It has seemed remarkable that the fronds of *Dryopteris* in the Potomac beds were almost always fertile, while those of *Cladophlebis*, in intimate association with them, were invariably sterile.

By careful comparison it has been possible to correlate the fertile specimens described as *Dryopteris* with the sterile *Cladophlebis* fronds of the same species in five of the types which are represented in the Potomac flora by sterile and fertile fronds, and the presumption is strong, although unverified, that the remaining *Dryopteris* forms represent fertile fronds of *Cladophlebis*. While the foregoing facts are not in unison in regard to the systematic position of *Cladophlebis*, they all point to the inclusion of the following American species in the family Polypodiaceæ or in what represented this family in Lower Cretaceous times, and cast doubt upon Raciborski's suggestion that *Cladophlebis denticulata* and other species of the same genus were the sterile fronds of osmundaceous ferns. It is quite possible that ferns of more than one subfamily of the Polypodiaceæ, or indeed of other families, are

¹ Schenk, *Flora Foss.*, Grenz. Keup. Lias, 1867, p. 51, pl. 7, figs. 7, 7a.

² Seward, *Jurassic Flora*, pt. 1, 1900, p. 23.

³ *Idem*, p. 141.

⁴ Seward, *Fossil Plants*, vol. 2, 1910, p. 345.

⁵ Zeiller, *Comptes Rendus*, vol. 150, 1910, p. 1483.

⁶ Fontaine, *Monogr. U. S. Geol. Surv.*, vol. 15, 1890, pp. 93-104.

included among the various described species of *Cladophlebis*. It need but be remembered how many unrelated modern ferns have fronds of the *Cladophlebis* type, as for example certain species of *Alsophila*, *Asplenium*, *Cyathea*, *Dryopteris*, *Gleichenia*, *Onoclea*, *Osmunda*, *Pteris*, *Polypodium*, etc., to cast doubt upon the botanical affinity of *Cladophlebis* species unless these are attested by a considerable body of evidence. It is believed, however, that the Potomac species are all to be included in the subfamily Aspidiæ, or as it is more properly known, Dryopteridæ; and because of this, and also because their actual identity with the modern genus *Dryopteris* or in fact with any of the modern genera in this subfamily is extremely questionable, it has seemed wiser to use the more general name *Cladophlebis* instead of using *Dryopteris* where the sterile and fertile fronds have been correlated.

A large number of species of *Cladophlebis* have been described, two species, according to Arber, occurring in the Permo-Carboniferous of India. The genus appears in force in the Keuper and Rhaetic with more than a dozen recorded species. Over a score are recorded during the Jurassic, certain types such as *Cladophlebis denticulata* apparently becoming world wide in their distribution. For the Lower Cretaceous Saporta has founded a large number of species based upon Portuguese material and Fontaine has instituted a still larger number of American species. From the Potomac beds of Maryland and Virginia the latter author recorded 23 different species besides several varieties of *Cladophlebis*, altogether losing sight of variations and changes due to age or to position of the fossils with regard to the frond as a whole, as well as changes due to the direct action of the environment. These species were often based upon such insufficient material that it becomes almost impossible to deal with them with any degree of assurance. In considering all of the more representative material, and including with it all of the forms recorded from Maryland, we have a total of 8 species, and these 8 species include remains which were the basis for 23 of Fontaine's species and varieties of *Cladophlebis*, 6 of his species of *Dryopteris* and 9 of his species of *Pecopteris*.

CLADOPHLEBIS ALBERTSII (Dunker) Brongniart.

Neuropteris albertsii DUNKER, Monogr. Norddeutsch. Wealdenbildung, 1846, p. 8, pl. 7, figs. 6, 6a.

Alethopteris albertsii SCHIMPER, Pal. Végét., vol. 1, 1869, p. 570.

Pecopteris whitbiensis TRAUTSCHOLD, Nouv. Mém. Soc. Nat. Moscou, vol. 13, 1870, p. 27, pl. 19, fig. 2.

Pteris ? albertsii HEER, Flora foss. Arct., vol. 6, Abth. 2, 1882, p. 29, pl. 16, figs. 5, 6; pl. 28, figs. 1-3; pl. 46, figs. 22-24.

Pteris albertini VELENOVSKY, Abh. k. böhm. Ges. Wiss., vol. 2, 1888, p. 15, pl. 4, figs. 6-10 (not fig. 5).

Cladophlebis albertsii BRONGNIART, Tableau, 1849, p. 107.—SEWARD, Wealden Flora, pt. 1, 1894, p. 91, pl. 8.

Cladophlebis inclinata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 76, pl. 10, figs. 3, 4; pl. 20, fig. 8.

Cladophlebis denticulata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 71, pl. 4, fig. 2; pl. 7, fig. 7 (not Nathorst).

Cladophlebis, sp., FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 77, pl. 10, figs. 5, 8; pl. 20, fig. 7.

Cladophlebis pachyphylla FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 80, pl. 25, fig. 9.

Cladophlebis, sp., FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 77, pl. 15, fig. 6; pl. 19, fig. 3.

Aspidium angustipinnatum FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 98, pl. 16, figs. 1, 3, 8; pl. 17, fig. 1; pl. 19, fig. 10.

Dryopteris angustipinnata KNOWLTON, Bull. 152, U. S. Geol. Surv., 1898.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 540, 544, 548, pl. 114, fig. 6.

Aspidium oerstedii ? FONTAINE, Monogr. 15, U. S. Geol. Surv., 1890, p. 99, pl. 19, fig. 4 (not Heer).

Dryopteris oerstedii ? KNOWLTON, Bull. 152, U. S. Geol. Surv., 1898, p. 92.

Description.—A large amount of material has been referred to this species since Dunker's day, so that his diagnosis may be considerably amplified. In general these forms show the following characters:

Fronds large, bipinnate or tripinnate. Rachis stout. Pinnae linear lanceolate, alternate to subopposite, becoming pinnatifid distally. Pinnules usually attached by their whole base, which is slightly expanded, contiguous but usually separated to the base, lanceolate, slightly falcate, acuminate. Margin usually entire, more rarely somewhat dentate in the apical portion. Venation of the usual *Cladophlebis* type. Fertile fronds have the rachis more slender than in the sterile fronds. The sori are borne on a distal branch of a furcate vein, as in other Potomac species of *Cladophlebis*, and form a row on either side of the midvein of the pinnules, which are otherwise indistinguishable from the sterile pinnules, though inclined to be straighter.

This species has been made to include a large amount of material from various horizons and localities which in the first instance was described as various species of *Neuropteris*, *Alethopteris*, *Pecopteris*, *Pteris*, etc. It is not at all certain that the result may not be a composite species made up of several distinct species with indistinguishable vegetative characters, and it would not be difficult to select still other forms from various parts of the world which could scarcely be separated from the foregoing.

Cladophlebis albertsii was not recognized as such in Professor Fontaine's Potomac studies, but it is obvious that the forms described as *Cladophlebis inclinata* and *Cladophlebis denticulata* (this was described as a new species and is decidedly different from Brongnart's species of the same name which Nathorst has referred to *Cladophlebis*) and as *Aspidium angustipinnatum* are identical with

each other and with those ferns in the European Wealden which are referred to *Cladophlebis albertsii*. The additional fragments of Potomac ferns which are referred to this species are not common and are equally unimportant botanically and stratigraphically. The two *Cladophlebis*, sp., Fontaine are clearly enough referable to this species. *Cladophlebis pachyphylla* is considered as an anomalous pinna, with thicker, more remote pinnules, which are contracted at the base. It was founded on a single fragment from Fredericksburg, Virginia, and if not an example of this species is simply a distal aberrant pinna of one of the other described species from that locality. The specimen which was the basis for the presence of *Aspidium oerstedii* Heer in this flora is the merest fragment without significance in any way.

The fertile pinnæ of *Cladophlebis albertsii* agree with those of *Cladophlebis parva* and other Potomac species in the general character, form and arrangement of the sori, the nature of the material precluding any more detailed information on this point. The sori appear to be confined to the basal part of the proximal pinnules. The present species is closely related to the contemporaneous form *Cladophlebis virginensis* Fontaine.

It is common in the Wealden of England and Germany and probably in homotaxial beds in Austria and Russia. It has been recorded from the Cenomanian of Bohemia and from the Atane beds of Greenland, but both of these determinations may be considered as very doubtful. In this country it is definitely known only from the Potomac group. It has been recorded from the Patapsco formation at Vinegar Hill, Maryland, but the single specimen is referred by the writer to *Cladophlebis virginensis* which is abundant at this locality.

Occurrence.—PATUXENT FORMATION: Potomac Run, Telegraph Station (Lorton), Dutch Gap, Trents Reach, Fredericksburg, Virginia. ARUNDEL FORMATION: Arlington, Hanover, Bay View, Maryland.

Collections.—United States National Museum, Goucher College.

CLADOPHLEBIS BROWNIANA (Dunker) Seward.

Pecopteris browniana DUNKER, Monogr. Norddeutsch. Wealdenbildung, 1846, p. 5, pl. 8, fig. 7.—FONTAINE, Monogr. U. S. Geol. Survey, vol. 15, 1890, p. 88, pl. 22, figs. 10, 11; pl. 23, figs. 2-7; pl. 26, figs. 3, 13; Proc. U. S. Nat. Mus., vol. 15, 1892, p. 492.—DAWSON, Trans. Roy. Soc. Can., vol. 10, sec. 4, 1893, p. 84, fig. 3.—YOKOYAMA, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 218, pl. 24, figs. 2, 3; pl. 27, figs. 1-5.

Althopteris reichiana ETTINGSHAUSEN, Abh. k. k. geol. Reichs., vol. 1, Abth. 3, 1852, p. 17.

Althopteris browniana SCHIMPER, Pal. Végét., vol. 3, 1874, p. 502.

Cladophlebis browniana SEWARD, Wealden Flora. pt. 1, 1894, p. 99, pl. 7, fig. 4.—Ann. S. Afr. Mus., vol. 4, 1903, p. 10, pl. 2, figs. 1-4, 6.—KNOWLTON, Smiths. Misc. Coll., vol. 4, pt. 1, 1907, p. 108, pl. 11, fig. 1.—KNOWLTON, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 386.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 272, 510, 517, 538, 544, 547, 557, 572.

- Pecopteris* cf. *Browniana* NATHORST, Denkschr. k. Akad. Wiss. Wien, vol. 57, 1890, p. 53, pl. 5, fig. 5.
- Cladophlebis inaequiloba* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 80, pl. 25, fig. 8.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 510.
- Cladophlebis petiolata* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 80, pl. 22, fig. 8.
- Cladophlebis oblongifolia* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 74 (part), pl. 7, fig. 5 (not figs. 3, 4 which are referred to *Cladophlebis virginensis* Fontaine).
- Cladophlebis crenata* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 75, pl. 9, figs. 7-9; pl. 10, figs. 1, 2; pl. 13, figs. 1-3; pl. 19, fig. 7; pl. 20, fig. 6.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 547.
- Cladophlebis alata* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 77, pl. 19, fig. 5.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 229, 480, 510, 544, 557, pl. 65, figs. 17-21.
- Cladophlebis inclinata* FONTAINE, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.
- Cladophlebis*, sp., FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 78, pl. 19, fig. 2.
- Pecopteris strictinervis* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 84, pl. 13, figs. 6-8; pl. 19, fig. 9; pl. 20, fig. 3; pl. 22, fig. 13; pl. 170, figs. 5, 6.
- Pecopteris ovatotodentata* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 85, pl. 15, fig. 8; pl. 22, fig. 12; pl. 23, fig. 1.
- Pecopteris microdonta* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 85, pl. 19, fig. 8; pl. 20, figs. 5, 11.
- Pecopteris virginensis* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 82, pl. 8, figs. 1-7; pl. 9, figs. 1-6; pl. 24, fig. 2; pl. 169, fig. 3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 480, 538, 552, pl. 116, figs. 3, 4.
- Pecopteris constricta* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 86, pl. 20, figs. 1, 2, 4.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 519.
- Pecopteris socialis* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 87, pl. 21, fig. 7 (not Heer, 1882).
- Pecopteris angustipennis* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 87, pl. 21, fig. 10.
- Pecopteris* cf. *virginensis* YOKOYAMA, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 220, pl. 24, fig. 1.

Description.—The American material which the writer refers to this species is much more abundant than that from abroad, and the following diagnosis may be attempted:

Fronde bipinnate or tripinnate. Pinnæ elongate, linear in outline.¹ Pinnules approximate, variable in outline, usually obtuse and becoming united distad to form a pinnatifid pinna, which is then constricted and slightly decurrent at the base. Venation of the *Cladophlebis* type not well seen in the smaller pinnules because of their coriaceous texture.

This is another cosmopolitan species of *Cladophlebis* which may be composite in nature and which, as commonly preserved in frag-

¹ The single form which Fontaine identified with this species has pinnæ which shorten rapidly, giving the frond a deltoid form, and may be properly referable to the allied species *Cladophlebis ungeri*.

mentary specimens, is distinguishable with difficulty from its congeners. It is especially close to *Cladophlebis albertsii* and *Cladophlebis ungeri*. It is recorded from the uppermost Jurassic and lowermost Cretaceous in Portugal, from the Neocomian of Japan, and from the Wealden of England, Germany, and Austria. In America it has been reported from the Shasta through the Horsetown and in the base of the Chico formation on the Pacific coast, and from the Kootenai formation of Montana and British Columbia.

It is well scattered and abundant in the Potomac group, occurring in all three of the formations, but represented for the most part by incomplete specimens showing slight variations, which were made the basis for many species of Professor Fontaine. Material from the Patapsco formation of Maryland shows indistinct oval sori in a single row on either side of the midvein. These are of the type found associated with a number of other American species of *Cladophlebis*.

Professor Zeiller¹ has recently reported fertile fronds of *Pecopteris browniana*, or of a very similar species, from the Wealden of Peru. These are not figured, but are described as having biseriate, oval, annulate sporangia as in the modern family Schizaeaceæ and very like those of the Jurassic genus *Klukia* of Raciborski, thus apparently somewhat different from those of the American representatives of the present species. Fragments from the Neocomian of Japan, showing oval sori, are referred to this species by Yokoyama.²

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Alum Rock, Telegraph Station (Lorton), Potomac Run, Virginia; New Reservoir, Ivy City, District of Columbia; Broad Creek (?), Maryland. ARUNDEL FORMATION: Arlington, Hanover, Howard Brown Estate, Maryland. PATAPSCO FORMATION: Brooke and vicinity, Chinkapin Hollow, Virginia; Federal Hill (Baltimore), Vinegar Hill, Maryland.

Collections.—United States National Museum, Johns Hopkins University, Goucher College.

CLADOPHLEBIS CONSTRICTA Fontaine, emended.

- Cladophlebis constricta* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 68, pl. 2, fig. 11; pl. 3, fig. 2; pl. 6, figs. 5, 6, 8-14; pl. 21, figs. 9, 13; pl. 169, fig. 2.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 280, 297, 504, 528, 547, pl. 77, fig. 26.—PENHALLOW, Summ. Geol. Surv. Can., 1904 (1905), p. 9.—KNOWLTON, Smiths. Misc. Coll., vol. 4, pt. 1, 1907, p. 109.
- Cladophlebis latifolia* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 69, pl. 3, fig. 1; pl. 6, fig. 4.
- Cladophlebis virginianensis* FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 512, pl. 111, fig. 7.

¹ Zeiller, Comptes Rendus, vol. 150, 1910, p. 1488.

² Yokoyama, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 220.

Description.—Fronde large, bipinnate or tripinnate. Principal rachis rather slender. Pinnæ remote, shortening rapidly distad. Proximad they are pinnatifid, changing first into pinnules with undulate margins and then into those with entire margins in passing toward the apex of the frond. Pinnules elliptical in outline, constricted at the base, which is rounded or subauriculate. Venation of the usual *Cladophlebis* type.

This species has been identified at a number of localities in Maryland and Virginia, but it is not common at any of these. Outside this area it has been reported from the Kootenai of Montana, and very similar forms occur in the Kome beds of Greenland, as, for example, those which Heer described as *Pecopteris arctica*,¹ *Pecopteris andersoniana*,² and *Pecopteris hyperborea*.³ Abroad the species described by Schenk⁴ from the German Wealden as *Alethopteris cycadina* is very close to the American species, as Fontaine has already pointed out.

Cladophlebis constricta exhibits considerable variation in the degree of remoteness and outline of the pinnules, and may possibly include more than one species, the fact that certain of these aberrant forms come from the low horizon at Fredericksburg while all of the other occurrences are from Patapsco outcrops lends some credence to this suggestion. The species has been reported by Penhallow from the Kootenai in Canada, but this determination can not be accepted with certainty.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Virginia. PATAPSCO FORMATION: Hell Hole (?), Brooke, Deep Bottom, Virginia; Federal Hill (Baltimore), Vinegar Hill, Fort Foote (?), Maryland.

Collections.—United States National Museum.

CLADOPHLEBIS DISTANS Fontaine, emended.

Cladophlebis distans FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 77, pl. 13, figs. 4, 5.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 280, 572.

Dryopteris fredericksburgensis KNOWLTON, Bull. 152, U. S. Geol. Surv., 1898, p. 92.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 280, 512, 538, 548, pl. 112, fig. 2.

Aspidium fredericksburgense FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 94, pl. 11, figs. 1-6; pl. 12, figs. 1-6; pl. 16, fig. 9; pl. 19, figs. 6, 7.—PENHALLOW, Trans. Roy. Soc. Can., sec. 3, vol. 1; sec. iv, 1908, p. 307.

Description.—Fronde large and coarse, bipinnate or tripinnate. Rachis very stout and rigid. Pinnæ of the ultimate order mostly alternate, rarely opposite or subopposite, with rigid and proportionally rather slender rachises, very long, linear. Pinnules alternate,

¹ Heer, Flora foss. Arct., vol. 1, 1868, p. 80, pl. 1, fig. 13; pl. 43, fig. 5.

² Idem., vol. 3, Abth. 2, 1874, p. 41, pl. 3, fig. 7b.

³ Idem., vol. 1, 1868, p. 81, pl. 44, fig. 4.

⁴ Palaeont., vol. 19, 1871, p. 218, pl. 31, fig. 2.

oblong or ovate, obtuse, slightly falcate, and usually with a somewhat rounded and slightly constricted base, separate, more or less remote, in some specimens those of the lower pinnæ with crenate margins, those of the upper ones entire, passing in the middle part of the frond through pinnules with undulate margins. Leaf-substance thick and leathery. Midvein of the usual *Cladophlebis* type, that is, strong at base and dissolving into branches at the summit; lateral nerves of the crenate and undulate pinnules in groups in each tooth, composed of a midvein which sends off alternate simple branches, or else of forked veins with one of the branches forking again; those of the pinnules with entire margins usually once forked, all quite distinct; fertile specimens rare. Sori very large, elliptical or reniform in shape, and distributed in two rows, one on each side of the midvein, attached to the summit of the upper branch of a furcate nerve.

This species is quite generally distributed throughout the Potomac formations, although there is but one recorded occurrence from the Arundel formation. It is abundant in the Patuxent formation at Fredericksburg and outside the Maryland-Virginia area it has been recorded from the Kootenai formation of Montana and British Columbia and the Shasta of the Pacific coast province.

The sterile and fertile pinnæ are closely similar in outline and venation, the former being much more abundantly represented than the latter. They are both very similar to those of *Cladophlebis parva* Fontaine and may be compared with a number of European and Kome species of *Cladophlebis*, *Alethopteris*, *Pecopteris*, etc.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Telegraph Station (Lorton), Virginia; Broad Creek, Maryland. ARUNDEL FORMATION: Arlington, Maryland. PATAPSCO FORMATION: Chinkapin Hollow, Virginia.

Collections.—United States National Museum.

CLADOPHLEBIS PARVA Fontaine, emended.

Cladophlebis parva FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 73, pl. 4, fig. 7; pl. 6, figs. 1-3.—FONTAINE, in Ward, 19th Ann. Rep. U. S. Geol. Surv., pt. 2, 1899, p. 657, pl. 160, fig. 18; Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 225, 280, 510, 538, pl. 65, figs. 5-8.—KNOWLTON, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 386.

Cladophlebis inclinata FONTAINE, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.—FONTAINE, in Stanton, Bull. 133, U. S. Geol. Surv., 1896, p. 15.

Cladophlebis, sp., FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 81, pl. 26, fig. 15.

Aspidium heterophyllum FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 96, pl. 14, figs. 1-5; pl. 15, figs. 1-5.—FONTAINE, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.—FONTAINE, in Stanton, Bull. 133, U. S. Geol. Surv., 1896, p. 15.

Dryopteris heterophylla KNOWLTON, Bull. 152, U. S. Geol. Surv., 1898, p. 92.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 483, 550, pl. 115, figs. 7, 8.

Description.—Fronds large, bipinnate or tripinnate. Rachis very stout. Pinnæ linear-lanceolate, becoming somewhat falcate in outline distad, and passing from alternate to subopposite. Pinnules relatively wide, falcate, acuminate in the sterile forms but obtuse in the fertile, variable in size according to their position. The distal pinnules which represent the reduced pinnæ lower down on the frond are larger and relatively more slender than the pinnules of the lateral pinnæ, which are almost as wide as they are long, and falcate. Between the two orders there is every gradation on each frond through pinnatifid pinnæ to simple pinnule-like forms. Margins entire or slightly crenate, especially in the fertile pinnules, which are wider than the sterile. Lateral veins usually but once forked, sometimes simple. Texture coriaceous. Sori large, reniform in outline, in three or four pairs on either side of the midvein at the end of a distal branch of a furcate vein. The structure or arrangement of the sporangia can not be made out but the spores are preserved in abundance. They are small, ranging from 0.083 mm to 0.05 mm in diameter, with very thick walls, the outer surface covered with fine granulations not visible with magnifications of 200 diameters or less. The tetrad scars are very distinct. In form as well as size these spores are variable. The smaller, possibly immature, spores are trigonal in outline, while the larger are more nearly spherical.

This is a large and handsome species and is represented in the collections by material of both the sterile and fertile fronds. It ranges from the bottom to the top of the Potomac deposits, and outside the Maryland-Virginia area is recorded from the Shasta beds of the Pacific coast, the Kootenai of Montana, and the Lakota formation of the Black Hills. There are a number of European Wealden species which are similar to *Cladophlebis parva*, but it is believed to be quite distinct from its contemporaries, although small fragments of almost any of the species of *Cladophlebis* are likely to be confused.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Cockpit Point, Potomac Run, Virginia. ARUNDEL FORMATION: Arlington (?), Maryland. PATAPSCO FORMATION: Vinegar Hill, Maryland.

Collections.—United States National Museum, Goucher College.

CLADOPHLEBIS ROTUNDATA Fontaine, emended.

- Cladophlebis rotundata* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 78, pl. 20, figs. 9, 10.—(?) PENHALLOW, Summ. Geol. Surv. Can. 1904 (1905), p. 9.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 491, 510.
Cladophlebis brevipennis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 81, pl. 36, fig. 1.

Description.—In 1890 Fontaine describes this species as follows:

Frond bipinnate or tripinnate, arborescent(?); principal rachis stout, rounded, and prominent; pinnæ short, with a strong rigid rachis; ultimate pinnæ, from the lower.

part of the frond, with alternate, short, broadly ovate, very obtuse, round-lobed pinnules, those of the upper part of the frond having the lowest pinnules distinct and more or less round-lobed, and toward the summit with pinnules passing through such forms as rotundate, subrhombic, and decurrent to entire and rounded, the latter having the tips round-lobed and very obtuse; nerves varying according to the position and shape of the pinnules, those of the round-lobed pinnules and of the pinnæ reduced to pinnules flabellately diverging in each lobe, the branches being either forked or simple. The nerves of the subrhombic pinnules have a midnerve, which sends off alternately on each side forked or simple branches. All the nerves are very strongly marked and stout. The leaf-substance is thick and leathery.

The foregoing description was written for *Cladophlebis rotundata*, but it requires no alteration to include the rare fragments which were named *Cladophlebis brevipennis*, as the material on which the two were founded is identical; in fact, the description of the latter was practically a paraphrase of the former.

This species, while founded upon rather scant remains, is well characterized by the strong venation and the breadth of the short ovate pinnules. It may possibly represent *Cladophlebis constricta* Fontaine, as it closely resembles the form of the latter species which Professor Fontaine named *Cladophlebis latifolia*. It has been recorded by Penhallow from Yukon Territory in Canada, but the identification is very doubtful.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Virginia. PATAPSCO FORMATION: Mount Vernon, Chinkapin Hollow, Virginia.

Collections.—United States National Museum.

CLADOPHLEBIS UNGERI (Dunker) Ward.

- Pecopteris ungeri* DUNKER, Monogr. Norddeutsch. Wealdenbildung, 1846, p. 6, pl. 9, fig. 10.
- Pecopteris polymorpha* DUNKER, Monogr. Norddeutsch. Wealdenbildung, 1846, p. 6, pl. 7, fig. 5 (not Brongniart).
- Pecopteris dunkeri* SCHIMPER, Pal. Veget., vol. 1, 1869, p. 539.
- Pecopteris exiliformis* GEYLER, Palaeont., vol. 24, 1877, p. 226, pl. 30, fig. 1.
- Aspidium dunkeri* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 101, pl. 22, figs. 9, 9a, 9b; pl. 25, figs. 11, 12; pl. 26, figs. 2, 8, 9, 18; pl. 54, figs. 3, 9.—FONTAINE, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.—FONTAINE, in Stanton, Bull. 133, U. S. Geol. Surv., 1896, p. 15.
- Cladophlebis dunkeri* SEWARD, Wealden Flora, pt. 1, 1894, p. 100, pl. 7, fig. 3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 510, 538.
- Pecopteris exilis* YOKOYAMA, Journ. Coll. Sci. Japan, vol. 3, 1890, p. 35, pl. 1, figs. 8-10.
- Aspidium parvifolium* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 100, pl. 21, fig. 6; pl. 24, fig. 8; pl. 25, fig. 10; pl. 26, figs. 1, 14, 16, 17.
- Dryopteris parvifolia* KNOWLTON, Bull. 92, U. S. Geol. Surv., 1898, p. 92.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 486 (not p. 541, pl. 114, fig. 7).
- Pecopteris geyleriana* NATHORST, Denkschr. k. Akad. Wiss. Wien, vol. 57, 1890, p. 48, pl. 4, figs. 2-6.—YOKOYAMA, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 219, pl. 21, fig. 12; pl. 23, figs. 1, 1a; pl. 38, fig. 5.

Pecopteris, sp., NATHORST, Denkschr. k. Akad. Wiss. Wien, vol. 57, 1890, p. 48, pl. 4, figs. 2-6.

Cladophlebis ungeri WARD in Fontaine, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 228, 510, 538, pl. 65, figs. 15, 16.—KNOWLTON, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 386.

Pecopteris brevipennis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 86, pl. 21, figs. 1-3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 510.

Pecopteris pachyphylla FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 88, pl. 26, figs. 4, 5.

Description.—A satisfactory diagnosis is the one written by Professor Fontaine for his *Aspidium Dunkeri* which will answer not only for that material but for all of the other supposed species founded by Fontaine upon various fragments of *Cladophlebis ungeri*. It is as follows:

Fronde bipinnate or tripinnate, arborescent; principal rachis stout and rigid; ultimate pinnae alternate, short, linear-lanceolate; pinnules alternate or subopposite, short, closely placed, narrowed at the base, cut more or less deeply into lobes or teeth which are ovate or oblong, obtuse or subacute, very small, those of the fertile portions of the frond standing nearly perpendicular to the rachis and having in each lobe or pinnule a simple lateral nerve which bears a sorus on its summit, those of the sterile and more common portions more obliquely placed, mostly subacute, with nerves in each lobe that fork simply in the upper ones, and in the lower ones are composed of a midnerve with alternate simple branches; leaf-substance thick; sori very minute, club-shaped or elliptical, visible distinctly only with the help of a lens, and present only in the pinnules of the lower part of the pinnae, and mostly found on the lobes toward the base of these.

This species was described by Dunker in 1846 from the Wealden of Northern Germany as *Pecopteris ungeri* and *Pecopteris polymorpha*. Schimper in 1869 renamed the latter *Pecopteris dunkeri* for the reason that the specific name *polymorpha* had been used by Brongniart in 1828. Schenk two years later, with Dunker's original specimens before him, announced that Dunker's *ungeri* and *polymorpha* were synonymous. He did not, however, restore Dunker's name nor has Seward done so in his discussion (1894) of this species in the "Wealden Flora." In accordance with the prevailing system of nomenclature Dunker's original name must be used for this species, and this proposal was made by Ward in 1906. Seward in 1894 referred the species to the genus *Cladophlebis* and while the American material available in the present treatment of this species is not as complete as might be desired it furnishes some evidence regarding the fertile fronds of still another species of *Cladophlebis*. The character of the fertile material is rather vague and while it is clearly congeneric with a number of other of Fontaine's species of *Aspidium*, it is hardly sufficient evidence of their relationship with that modern genus.

The present species is close to *Cladophlebis browniana* and is apparently a cosmopolitan Lower Cretaceous type since indistinguishable material occurs not only in the English and Continental Wealden

deposits (Belgium, Germany, Austria), but in the Neocomian of Portugal and Japan, and in the Uitenhage series of South Africa. Material obtained from Japan shows obscure fruiting fragments in which the pinnæ are narrowed, and there is apparently a single sorus to each pinnule.¹ The species is also reported from the Albian of Portugal by Saporta. In America it is not rare in the Potomac beds and rather doubtful remains are referred to this species from the Shasta beds of California. It is probably represented in the Kootenai formation of Montana by *Dryopteris montanense* (Fontaine) Knowlton.² Professor Seward in a recent paper³ expresses his belief that this species is identical with *Cladophlebis browniana*, such differences as are observable being merely individual and not specific. This may be the case as the two are certainly closely allied. There is, however, serious danger in uniting under a single specific name fern fronds from all quarters of the globe which resemble each other, unless the evidence of their identity is very strong.

Occurrence.—PATUXENT FORMATION: Woodbridge, Fredericksburg, Dutch Gap, Telegraph Station (Lorton), Virginia. PATAPSCO FORMATION: Chinkapin Hollow, Virginia.

Collections.—United States National Museum.

CLADOPHLEBIS VIRGINIENSIS Fontaine, emended.

- Cladophlebis virginiensis* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 70, pl. 3, figs. 3-8; pl. 4, figs. 1, 3-6 (not Fontaine, 1906).
- Cladophlebis falcata* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 72, pl. 4, fig. 8; pl. 5, figs. 1-6; pl. 6, fig. 7; pl. 7, figs. 1, 2.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 227, 280, 511, 548, pl. 65, figs. 12-14; pl. 111, fig. 6.—KNOWLTON, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 386.
- Cladophlebis acuta* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 74, pl. 5, fig. 7; pl. 7, fig. 6; pl. 10, figs. 6, 7; pl. 11, figs. 7, 8; pl. 166, fig. 5.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 538, pl. 114, figs. 3, 4.
- Thinnfeldia variabilis* FONTAINE, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. 5, 1894, p. 450.—FONTAINE, in Stanton, Bull. 133, U. S. Geol. Surv., 1896, p. 15.
- Cladophlebis acuta angustifolia* FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 539, pl. 114, fig. 5.
- Asplenium distans* DAWSON, Trans. Roy. Soc. Can., vol. 3, sec. 4, 1886, p. 5, pl. 3, fig. 7 (not Heer).
- Thinnfeldia montanensis* FONTAINE, in Weed and Pirsson, 18th Ann. Rept. U. S. Geol. Surv., 1896-97 (1898), pt. 3, p. 481.
- Cladophlebis falcata montanensis* FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 291, pl. 71, figs. 14-20.
- Cladophlebis oblongifolia* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 74 (part), pl. 7, figs. 3, 4 (not fig. 5, which is referred to *C. browniana*).

¹ Nathorst, Denkschr. k. Akad. Wiss. Wien, vol. 57, 1890, pl. 4, figs. 3-5; of these fig. 3 is referred to *Weichselia mantelli* by Seward, 1894.

² Fontaine, Proc. U. S. Nat. Mus., vol. 15, 1892, p. 490, pl. 82, figs. 1-3; pl. 83, figs. 2-3a.

³ Seward, Ann. S. Afr. Mus., vol. 4, 1903, p. 10.

Description.—Fronde large, bi- or tripinnate. Rachis stout and rigid. Ultimate pinnæ long, rather remote, alternate to subopposite. Pinnules ovate to lanceolate and subfalcate in outline, sometimes obtusely pointed mostly separate to the base, attached by their whole base which is more or less widened. Venation of the type usual in this genus. Margins usually entire, sometimes crenulate to subdentate becoming entire distad. Texture coriaceous. The degree of separateness of the pinnules as well as their relative length and breadth and their more or less falcate form are characters dependent upon the age of the frond or the position of the pinnules on the frond, long narrow almost straight proximal pinnules passing gradually into more or less short, broad and falcate distal pinnules.

This species is not very different from the widespread type of *Cladophlebis* commonly referred to the species *albertsii* of Brongniart. It exhibits considerable variation from specimen to specimen, but these variations show so many gradations and are so readily explained when the position of the various fossil fragments upon the frond is taken into consideration that any segregation of them is entirely unwarranted. In general the pinnules are larger and relatively much wider than in *Cladophlebis albertsii*.

The present species is very common at certain localities both in the Patuxent and Arundel formations, and although it apparently survives during the deposition of the Patapsco formation it is less common. Outside of the Maryland-Virginia area remains of this species have been reported from the Shasta beds of California and from the Kootenai of Montana and British Columbia. Seward¹ refers the bulk of Fontaine's figures of *Cladophlebis virginensis* Fontaine to *Todites williamsoni* (Brongniart), a widespread older Jurassic species, but this reference has no justification. *Cladophlebis nathorsti* Yokoyama² from the Neocomian of Japan is very close to the present Potomac species.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Potomac Run, Virginia. ARUNDEL FORMATION: Arlington, Maryland. PATAPSCO FORMATION: Vinegar Hill, Maryland; Chinkapin Hollow, Virginia.

Collections.—United States National Museum, Goucher College.

THE GENUS ONYCHIOPSIS.

Yokoyama characterized the genus *Onychiopsis* as follows: "Fertile segments different from the sterile. Sori terminal, linear, on each side of the midrib, parallel with the margin, involucrate; the involucre of each side confluent over the midrib."³ It was based on a

¹ Seward, Fossil Plants, vol. 2, 1910, p. 340.

² Yokoyama, Journ. Coll. Sci. Japan, vol. 7, 1895, p. 220, pl. 28, figs. 3, 4, 10, 11.

³ Idem., vol. 3, 1890, p. 26.

Japanese Upper Jurassic or Neocomian species originally described by Geyley as *Thyrsopteris elongata* and founded upon sterile pinnules. The discovery of fertile pinnules by Yokoyama led to the erection of the present genus which is very close to the modern genus *Onychium* Kaulfuss, which is made a subgenus of *Cryptogramme* R. Brown by Diels in Engler and Prantl's *Natürlichen Pflanzenfamilien* (1899), although there seems to be but slight warrant for Diel's treatment.

Seward in working over the abundant Wealden material in the British Museum found that the widespread species which usually went by the name of *Sphenopteris mantelli* Brongniart was congeneric with Yokoyama's species mentioned above, and he therefore re-described Brongniart's species as *Onychiopsis mantelli*, redefining the genus in the following terms:¹

Fronde tripinnate, main rachis slender, may be winged, pinnæ alternate, approximate, lanceolate. Pinnules narrow, lanceolate, acute, alternate, the larger ones serrate, and gradually passing into pinnules with narrow ultimate segments. Fertile pinnæ with alternate elliptical pinnules which differ in shape from the sterile pinnules and have the sporangia on the lower surface, giving them the appearance of raised elliptical bodies.

The most abundant and characteristic ferns of the Potomac group were referred by Professor Fontaine to *Thyrsopteris* Kuntze, an existing monotypic genus of the family Cyatheaceæ inhabiting the island of Juan Fernandez. Of these some 40 species, so called, were described. They were all based on sterile fronds or parts of fronds, often extremely small and inadequate fragments. Professor Fontaine, after quoting Heer's diagnosis of *Thyrsopteris*² writes:

This description, given by Heer for the genus *Thyrsopteris*, so far as the portion pertaining to the sterile frond is concerned, agrees well with a large number of species in the Potomac flora. These I place provisionally in the genus *Thyrsopteris*, on account of the great resemblance that the shape of the pinnules, the lobing, and the nervation show to the sterile forms of various species determined to be *Thyrsopteris* by their fructification. As, however, no fructification is found in the Potomac species, the placing of these plants in the genus must be regarded as provisional. It is quite possible that some of them belong to *Aspidium* and *Dicksonia*.

It should be noted that a number of the species of *Thyrsopteris* described in the following pages show a good many features similar to those of *Sphenopteris mantelli*, as described by Schenk and Heer (p. 120).

Professor Fontaine does identify *Sphenopteris mantelli* from one locality in the Potomac belt, that at Federal Hill, Baltimore, and in discussing its bearing upon the age of the deposits he says:

Now in the Potomac flora not only is *S. mantelli* present in beds which show plants of the most recent facies existing in the formation, but there is a very important group of ferns which, although placed in the genus *Thyrsopteris*, have nearly the nervation and foliage typified in *S. mantelli*. The great development in the Potomac of ferns of the general type of *S. mantelli* gives strong evidence of Wealden or somewhat later age. A somewhat later age than Wealden is indicated, perhaps, as most of the species

¹ *Flora foss. Arct.*, vol. 4, pt. 2, 1877, p. 28.

² Seward, *Wealden Flora*, pt. 1, 1894, p. 40.

are somewhat modified, so as to depart more or less from the typical *S. mantelli*, and to assume the facies of *Thyrsopteris*. The other species of *Sphenopteris* give little help in fixing the age of the Potomac strata (p. 338).

Thus while the most prominent fern element in the Potomac group belongs to a different genus and different family, its resemblance to the *Sphenopteris mantelli* type is so pronounced that it furnishes an argument for the nearly homotaxial age of the containing deposits, surely a curious logic. In his latest work this author identifies a species of *Onychiopsis* from three localities in Virginia and Maryland (Hell Hole, New Reservoir, and Fort Foote).

Again in discussing *Thyrsopteris* at the end of his Potomac flora (1890) he writes:

It is true that, as no fructification has been found on these ferns, they may be incorrectly placed in the genus *Thyrsopteris*. Still, the very great development in the Potomac flora of ferns with a foliage and nervation so characteristic of the later Jurassic and Lower Cretaceous can not be without significance.

A number of these Thyrsopterids have the same type of foliage as the Wealden ferns, *Sphenopteris mantelli* Brongn.; *S. goepperti* Dunker; *S. cordai* Schenk; *S. plurinervia* Heer; and *S. gomesiana* Heer, as well as the Urganian plants *Asplenium dicksonianum* Heer; *A. nauck hoffianum* Heer, and various *Dicksonias*, such as *D. johnstrupi* Heer. It is a significant fact that this type of foliage, so common toward the close of the Jurassic and in the oldest Cretaceous, is the most abundant single type in the Potomac strata also. Such a general prevalence of a type is more significant of geological relationship than the identification of a few species common to two formations. It is not worth while to examine in detail the affinities of the different species. Most of them are new and unique. One or two have some resemblance to Oolitic species, while a greater number may be grouped as belonging to the two Wealden types *S. mantelli* and *S. goepperti*.

It will be seen from these lengthy quotations how uncertain the author of these 40 species of *Thyrsopteris* was as to their real botanical affinity, and when the student turns from the text and figures to the actual specimens, the strictures of Professor Seward¹ are found to be abundantly justified. There are 26 species described from a single clay lens at Fredericksburg, Virginia. If the reader will pause to ask himself where in the history of the earth or in the living flora 26 species of a single genus of ferns can be found in a single circumscribed clay lens, or growing in a single circumscribed area, grave doubt as to their validity at once arises; and even if we predicate their having been gathered together by a river system it must needs have been a remarkable river system to have gathered all of these ferns with over 50 other species of ferns and 50 species of gymnosperms, in all 160 different species, and to have deposited them in one quiet pool where clay was forming, a pool not over 15 feet in diameter as preserved and only 4 feet thick, the recognizable remains practically all coming from the basal 3 to 5 inches.

¹ Wealden Flora, pt. 2, 1894, p. 56.

With the large amount of material at his disposal the writer finds it altogether impossible to differentiate the 40 species described by Professor Fontaine from the Potomac group. There are two main types, the narrow pinnule type, that identified in some of the Baltimore specimens as *Sphenopteris mantelli* by Fontaine and including some of the forms described as new species of *Thyrsopteris*, and the broader type exemplified by the foreign *Sphenopteris goepperti*. It is to the latter that a large number of the Potomac forms belong. Three additional species which include the balance of the *Thyrsopteris* forms are characterized. In perusing the synonym of the species which follow, the question is likely to arise in the mind of the reader whether or not the process of ignoring minor differences has not been carried too far, so that it is needful to point out the reasons which have led to the present treatment. The main reason is, of course, that it was found impossible to fix upon any characters of specific value that would hold good for material other than the individual specimen upon which they were based. That the author of these species could not tell them one from the other is quite obvious in looking over the material which passed through his hands, specimens identical in all particulars at one time receiving one name and on a subsequent occasion another, even counterparts of the same specimen being, in at least one instance, identified as distinct species.

These ferns were of large size with tripinnate fronds, so that it is easy to see how one or two species with slight individual variations in form could, when broken up into fragments and fossilized in a matrix for the most part of very arenaceous clay, form the basis for numerous species. The pinnæ from the base of the frond will differ more or less from those higher up and the basal pinnules of the individual pinnæ will differ decidedly from the distal ones. It is possible in the more complete Potomac specimens to trace these variations and so get a number of Fontaine's types on a single specimen so that it seems wiser to consider the bulk of the forms as exemplifying slight variations, due largely to position, rather than to allow them specific or even varietal rank. The published drawings of these forms, especially the enlarged pinnules showing detail, are for the most part inaccurate and idealized to such an extent that even the experts in the National Museum often find it impossible to decide which specimens represent Professor Fontaine's drawings.

With regard to our taking up the genus *Onychiopsis* of the Polypodiaceæ rather than *Thyrsopteris* of the Cyatheaceæ it may be said that while *Thyrsopteris* as a form-genus may not be open to any great degree to criticism, it implies a relationship with the existing species which the evidence does not substantiate so that the best modern usage refers the older type of this sort to the genus *Coniopteris* Brongniart and the later ones to this genus *Onychiopsis*. It is quite possible

that the modern genus *Thyrsopteris* was a prominent Jurassic and older Cretaceous type, there being many parallel cases, as, for example, that of the gymnospermous genus *Ginkgo*. Some of the evidence is at least sufficient to prove that forms so named are referable to the family Cyatheaceæ, so that in considering the Potomac forms we have to decide whether the fact that the Jurassic forms like *Thyrsopteris maackiana* and *Thyrsopteris murrayana* of Heer are members of the Cyatheaceæ, shall be given greater or less weight than the fact that the same type of sterile frond very abundant in the Lower Cretaceous, from England to Japan, should have fertile pinnules like those of the genus *Onychium* of the Polypodiaceæ. It is true that only sterile pinnules are known from the Potomac deposits, but the fertile parts have been found associated and in organic connection with these identical sterile pinnules in nearly homotaxial beds in California, Japan, England, Belgium (?), Bohemia, and Portugal. The writer prefers to believe that the latter evidence is entitled to the greater weight. The modern genus *Onychium* has several widely distributed, chiefly tropical, species of Japan, China, India, Persia, Abyssinia, and the East and West Indies. In this connection attention should be called to the fertile specimens described by Professor Fontaine, from Fredericksburg, as *Aspleniopteris*, since the latter, which is referred to the Aspleniæ, is very similar to the fertile pinnæ of a specimen of *Onychiopsis goepperti* from Japan, kindly communicated by Professor Yokoyama.

ONYCHIOPSIS GOEPPERTI (Schenk) Berry.

- Sphenopteris goepperti* SCHENK (part), Palaeont., vol. 19, 1871, p. 209 (7), pl. 30 (4) figs. 2, 2a (not figs. 3-5 or pl. 35 (9) fig. 2).—SAPORTA, Flora Foss. Portugal, 1894, pp. 71, 123, 159, pl. 18, fig. 6; pl. 33, fig. 8; pl. 29, fig. 6.
- Thyrsopteris elongata* GEYLER, Palaeont., vol. 24, 1877, p. 221.—SCHENK in Richthofen's China, vol. 4, 1883, p. 263, pl. 54, fig. 1.
- Dicksonia elongata* YOKOYAMA, Bull. Geol. Soc. Japan, vol. 1, No. 1, 1886, p. 5.
- Onychiopsis elongata* YOKOYAMA, Journ. Coll. Sci. Japan, vol. 3, 1890, p. 27, pl. 2, figs. 1-3; pl. 3, fig. 6d; pl. 12, figs. 9, 10.—(?) SEWARD, Wealden Flora, pt. 1, 1894, p. 55, pl. 2, fig. 2.
- Thyrsopteris rarineris* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 123, pl. 26, figs. 6, 7; pl. 43, figs. 4-6; pl. 44, figs. 1, 2, 5; pl. 49, fig. 2; pl. 169, figs. 6, 7.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 225, 484, 491, 514, 517, 518, 521, 528, 548, pl. 65, figs. 2-4; pl. 113, figs. 2, 3.
- Thyrsopteris alata* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 124, pl. 36, fig. 3.
- Thyrsopteris meckiana angustiloba* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 126, pl. 38, figs. 5-7, 9; pl. 43, fig. 8; pl. 44, fig. 3; pl. 47, fig. 4; pl. 48, fig. 1; pl. 54, figs. 2, 11; pl. 55, fig. 1; pl. 56, figs. 1-3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 557.
- Thyrsopteris angustiloba* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 134, pl. 48, figs. 3-5; pl. 55, fig. 3.
- Thyrsopteris densifolia* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 129, pl. 39, fig. 3; pl. 40, figs. 2-5; pl. 51, fig. 5.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 484, 511, 517.

- Thyrsopteris decurrens* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 130, pl. 43, fig. 7; pl. 46, figs. 2, 4; pl. 49, figs. 5-7.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 484, 491, 511, 525, pl. 111, fig. 11.
- Thyrsopteris virginica* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 120, pl. 24, fig. 1.
- Thyrsopteris pachyrachis* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 132, pl. 46, figs. 3, 5; pl. 47, figs. 1, 2; pl. 49, fig. 1.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 487, 538, 557.
- Thyrsopteris elliptica* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 133, pl. 24, fig. 3; pl. 46, fig. 1; pl. 50, figs. 6, 9; pl. 51, figs. 4, 6, 7; pl. 54, fig. 6; pl. 55, fig. 4; pl. 56, figs. 6, 7; pl. 57, fig. 6; pl. 58, fig. 2.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 3, 1898, p. 482; pt. 2, 1898, p. 482.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 290, 484, 514, 517, 528, 557, pl. 71, figs. 12, 13.—KNOWLTON, Smiths. Misc. Coll., vol. 4, pt. 1, 1907, p. 110.
- Thyrsopteris distans* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 134, pl. 47, fig. 3; pl. 54, fig. 8.
- Thyrsopteris pinnatifida* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 136, pl. 51, fig. 2; pl. 54, figs. 4, 5, 7; pl. 57, fig. 7.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1890, p. 658, pl. 161, figs. 1, 2.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 511.
- Thyrsopteris varians* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 137, pl. 52, figs. 2-4; pl. 53, figs. 1-3; pl. 54, fig. 10; pl. 57, fig. 2.
- Thyrsopteris rhombifolia* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 138, pl. 52, fig. 5; pl. 54, fig. 1.
- Thyrsopteris bella* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 139, pl. 53, fig. 5; pl. 55, figs. 6, 7; pl. 56, figs. 2, 5; pl. 57, figs. 1, 5; pl. 58, fig. 4.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 491, 511.
- Thyrsopteris microloba* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 140, pl. 57, fig. 4.
- Thyrsopteris microloba alata* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 140, pl. 55, fig. 5; pl. 58, fig. 1.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 281.
- Thyrsopteris inæquipinnata* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 142, pl. 57, figs. 3, 8.
- Thyrsopteris rhombiloba* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 144, pl. 89, fig. 7; pl. 60, fig. 8.

Description.—Yokoyama, in 1890, described this species as follows:

Frond slender, bi-tripinnated; sterile pinnae alternate or rarely opposite, elongated, their length rapidly increasing toward the lower part of the frond; pinnules alternate, acutely directed forward, lanceolate or linearly lanceolate, entire or lobed, or even pinnately parted; lobes or partitions acute at apex and acutely directed forward just like the pinnules themselves. Venation obsolete, secondary veins simple, each going into a lobe. Fertile pinnules elongated, with a linear terminal sorus on both sides of the midrib.

A very large number of Fontaine's species of *Thyrsopteris* fall within the limits of this species. There is, to be sure, some variation in the relative length and breadth of the pinnules, but the material shows every gradation of form, it being possible to select individual pinnules from a single frond fragment which exemplify several of the supposed types. On the whole the pinnules are somewhat more robust

than in the foreign material, and the rachis is inclined to be stouter and may or may not be winged.

This is an exceedingly common form in the Potomac from the oldest to the youngest stratum and it has also been recorded from the Kootenai of Montana at Great Falls, Geysers, etc., and possibly some of Dawson's identifications of *Asplenium dicksonianum* Heer from the Canadian Kootenai should also be referred to this species. It also occurs in the Lakota formation of the Black Hills. Abroad it is rather rare in the English and German Wealden, but its geological distribution in the Lower Cretaceous of Portugal rivals that of eastern America since it comprises considerable material from the Valanginian, Urgonian, and Albian terranes. With regard to its occurrence in the Mesozoic of eastern Asia, Yokoyama writes¹ that it is the "chief and characteristic fossil of the Japanese flora, being found in all of the fossil localities."

That this or *Onychiopsis psilotoides*, or both, occur in the Kome beds of western Greenland seems probable, and several of Heer's species of *Asplenium*, notably *Asplenium dicksonianum* Heer,² suggest themselves for comparison. While the writer has not ventured to include any of them in the synonymy of this species, they certainly are very close to this type in appearance. The English occurrence of this species is questioned in the foregoing synonymy since Professor Seward³ considers the Wealden material as identical with that of *Onychiopsis psilotoides*. This may be true of the Wealden material referred to, but it can hardly apply to that from America and Asia, as the writer will show under the discussion of *Onychiopsis psilotoides*.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Trents Reach, Cockpit Point, Dutch Gap, near Potomac Run, Colchester Road (Pohick Creek?), Virginia; New Reservoir, Ivy City, District of Columbia. ARUNDEL FORMATION: Langdon, District of Columbia, Arlington (?), Maryland. PATAPSCO FORMATION: Federal Hill (Baltimore), Fort Foote, Vinegar Hill, Maryland; near Brooke, White House Bluff, Mount Vernon, Chinkapin Hollow, Virginia.

Collections.—United States National Museum, Goucher College.

ONYCHIOPSIS NERVOSA (Fontaine).

Thyrsopteris nervosa FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 122, pl. 25, figs. 4, 5, 16; pl. 37, figs. 2, 4; pl. 39, fig. 5; pl. 40, fig. 6.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 511, 517, 519, 521, 528, 548, 571.

Thyrsopteris meekiana FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 125, pl. 38, figs. 2-4, 8; pl. 50, figs. 7, 8; pl. 51, fig. 3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 519, 565; pl. 119, fig. 1.

¹ Yokoyama, Journ. Coll. Sci. Japan, vol. 3, 1890, p. 27.

² Flora foss. Arct., vol. 3, Abth. 2, 1874, p. 31, pl. 1, figs. 1-5; idem, vol. 6, Abth. 2, 1882, pp. 3, 33, pl. 2, fig. 2; pl. 32, figs. 1-8.

³ Seward, Ann. S. Afr. Mus., vol. 4, 1903, p. 7.

Thyrsopteris crassinervis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 130, pl. 41, figs. 1-3.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 658, pl. 161, figs. 3, 4.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 513, 528, pl. 112, figs. 5, 6.

Thyrsopteris pecopteroides FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 135, pl. 51, fig. 1.—FONTAINE, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 661, pl. 161, figs. 16-19.

Adiantites parvifolius FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 558, pl. 117, fig. 1.

Thyrsopteris heteroloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 139, pl. 53, fig. 4.

Thyrsopteris obtusiloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 143, pl. 58, figs. 7, 10.

Description.—Frond bipinnate or tripinnate. Principal rachis mediumly stout, somewhat flexuous, sometimes winged in the upper part. Pinnæ alternate or subopposite, ovate to ovate-lanceolate in outline, becoming entire apically, the pinnules passing into dentate teeth while the ultimate pinnæ become dentate pinnules. This character renders distal fragments quite different in appearance from the normal form of this species and quite like *Cladophlebis*. In some individuals the pinnæ lower down on the frond assume this form, constituting the supposed species *Thyrsopteris crassinervis* of Professor Fontaine and well shown in the specimens from Chinkapin Hollow and from near Glymont. Every gradation is shown, however, between this type and the usual type of pinnæ made up of alternate, very oblique, decurrent pinnules, usually rather deeply cut into subrhombic basal lobes, which become ovate or elliptical lobes and finally teeth in passing distad. Base contracted, subpetiolate. Veins numerous and slender but very distinct, branching obliquely, flabellate, repeatedly forked, subparallel. Texture coriaceous.

While the fragments of the fronds of this species are all small, the plant which bore them must have been of considerable dimensions. Representative material is readily distinguished from the other species of *Onychiopsis* recognized, but small fragments are liable to confusion with *Onychiopsis brevifolia*; in fact, Professor Fontaine founded no less than six nominal species upon such fragments, all of which are believed by the writer to represent slight variations of a single species.

It is widely distributed throughout the Potomac group, but not common at any outcrop. Outside this area it has been reported from the Lakota formation of the Black Hills. Practically identical remains from the Lower Cretaceous of Portugal are described by Saporta as various species of *Sphenopteris*.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Potomac Run, Virginia; New Reservoir, Ivy City, District of Columbia; Springfield, Maryland. ARUNDEL FORMATION: Langdon (frequent), District of Columbia. PATAPSCO FORMATION: Chinkapin Hol-

low, Virginia; Fort Foote, near Glymont, Vinegar Hill (?), Federal Hill (Baltimore), Maryland.

Collection.—United States National Museum, Maryland Academy of Science, Goucher College.

ONYCHIOPSIS BREVIFOLIA (Fontaine).

Thrysopteris brevifolia FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 121, pl. 24, figs. 5, 10.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 660, pl. 161, figs. 10–15.

Thrysopteris dentata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 121, pl. 24, figs. 4, 6, 7, 9; pl. 25, figs. 1, 2.

Thrysopteris pachyphylla FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 135, pl. 50, fig. 3.

Thrysopteris nana FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 141, pl. 56, figs. 4, 8.

Thrysopteris heterophylla FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 142, pl. 58, fig. 3.

Thrysopteris sphenopteroides FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 143, pl. 58, fig. 6.

Thrysopteris squarrosa FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 143, pl. 59, fig. 3.

Thrysopteris retusa FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 144, pl. 59, fig. 10.

Description.—Frond small, bipinnate or tripinnate. Rachises rather slender, often winged. Pinnæ alternate to subopposite, relatively long and narrow, divided below, pinnatifid distad. Pinnules much narrowed at the base, decurrent, obliquely toothed or divided, the extent depending upon their position on the frond, triangular ovate to lanceolate in outline. Veins somewhat flabellate, once or twice forked or simple. Texture coriaceous.

This species is not common in the Potomac and is confined to the basal beds in the Virginia area, although it has also been reported from the Lakota formation in the Black Hills region and from the Kootenai formation of Montana. It is represented in the Virginia area by quite a large number of mostly fragmentary specimens showing slight variations in the character of the pinnule lobes or teeth which were made the basis for distinguishing eight species by Prof. Fontaine. It is possible that more than one type is included in the species as defined by the writer, the nature of the material rendering certainty out of the question; but if the test of the validity of a species be the possibility of its being recognized a second time by either the original author or other students it must be admitted that these eight so-called species are not good species.

Onchiopsis brevifolia differs from *Onchiopsis goepperti* and *psilotoides* principally in the smaller fronds, less robust pinnules, which are also less ascending, and in the much less elongate character of the pinnæ and especially the pinnules. It is a much smaller and less robust form than *Onchiopsis latiloba*, from which it is readily distinguished, but approaches somewhat close to *Onchiopsis nervosa*.

The latter species is on the whole a larger form with less elongate and more triangular pinnæ, and the pinnules have more entire margins, the lobes or teeth being rounded and not angular. The veins are also more numerous.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Potomac Run, Telegraph Station (Lorton), Virginia.

Collections.—United States National Museum.

ONYCHIOPSIS PSILOTOIDES (Stokes and Webb) Ward.

- Hymenopteris psilotoides* STOKES and WEBB, Trans. Geol. Soc. London, ser. 2, vol. 1, 1824, p. 424, pl. 46, fig. 7; pl. 47, fig. 2.
- Sphenopteris mantelli* BRONGNIART, in Mantell, Illus. of the Geol. of Sussex (rev. ed.), 1827, p. 55, pl. 1, figs. 3a, b; pl. 3, figs. 6, 7; pl. 3A, fig. 2.—SCHENK, Palaeont., vol. 19, 1871, p. 208, pl. 23, fig. 1-8; pl. 4, fig. 6 (?); vol. 23, 1875, p. 158, pl. 28, fig. 12.—HEER, Contr. Flora Foss. Portugal, 1881, p. 12, pl. 11, figs. 1-5; pl. 12, figs. 2b, 2bb.—FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 91, pl. 1, figs. 1, 2.—SAPORTA, Flora foss. Portugal, 1894, pp. 72, 124, 157, pl. 15, figs. 8-12; pl. 18, fig. 5; pl. 23, figs. 1, 2, 8; pl. 28, fig. 2; pl. 29, fig. 1; pl. 30, figs. 9, 10; pl. 31, figs. 1, 2.
- Onychiopsis mantelli* SEWARD, Wealden Flora, pt. 1, 1894, p. 41, figs. 4, 5 on p. 50; fig. 6 on p. 52, pl. 2, fig. 1; pl. 13, figs. 1-4; Flora Weald. de Bernissart, 1900, p. 15, pl. 1, figs. 17-19; pl. 2, figs. 20, 21; Ann. S. Afr. Mus., vol. 4, 1903, p. 5, pl. 1; pl. 5, fig. 1.
- Thyrsopteris insignis* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 127, pl. 39, fig. 4; pl. 40, fig. 1; pl. 41, fig. 6; pl. 43, figs. 1, 2, 4; pl. 53, figs. 1, 3.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 521.
- Thyrsopteris insignis angustipennis* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 128, pl. 43, fig. 2.
- Thyrsopteris angustifolia* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 131, pl. 44, fig. 4; pl. 45, fig. 3; pl. 48, fig. 2; pl. 49, figs. 3, 4; pl. 55, fig. 2; pl. 58, fig. 8.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 516.
- Thyrsopteris microphylla* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 151, pl. 45, figs. 1, 2, 4, 5.
- Thyrsopteris rarineris* FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 123, pl. 26, figs. 6, 7; pl. 43, figs. 4-6; pl. 44, figs. 1, 2, 5; pl. 49, fig. 2; pl. 169, figs. 6, 7.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 225, 484, 491, 514, 517, 518, 519, 521, 528, 548, 558, pl. 65, figs. 2-4; pl. 113, figs. 2, 3.
- Thyrsopteris dentifolia* FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 660, pl. 161, figs. 6-9.
- Onychiopsis psilotoides* WARD, in Fontaine, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, p. 155 (name only).—FONTAINE, in Ward, Monogr., U. S. Geol. Surv., vol. 48, 1906, pp. 506, 518, 528, pl. 111, fig. 4; pl. 113, fig. 1.—KNOWLTON, in Diller, Bull. Geol. Soc. Amer., vol. 19, 1908, p. 380.

Description.—The following description was given by Seward in 1894:

Fronde tripinnate, ovate lanceolate, rachis winged and prominent; pinnæ lanceolate, alternate, approximate, given off from the main rachis at an acute angle. Pinnules alternate, narrow, lanceolate acuminate, uninerved, of nervation type *Coeopterides* (Luerssen, in Rabenhorst's *Krypt. Fl.*, vol. 3, p. 11); the larger ones serrate and gradually passing into pinnæ with narrow ultimate segments. Fructification in the form of sessile or shortly stalked linear ovate segments with rugose surfaces, and terminating usually in a very short awn-like apical prolongation.

This species is not nearly so common in the Potomac as is *Onychiopsis gapperti*, although it appears to have a wider range and be more common abroad. It occurs at all horizons in the Potomac, however, a vertical range which is paralleled by its range from the Valanginian through the Urgonian into the Albian of Portugal. Elsewhere in Europe it has been found in the Wealden of England, Belgium, and Germany, the Neocomian near Quedlinburg, Saxony, and in the Urgonian of Austria. Forms which are identical, according to Seward,¹ are found in the Uintenhage series of South Africa. In this country outside of the Potomac it is found in the Kootenai at Great Falls, Montana, in the Shasta beds of California, and in the Lakota formation of the Black Hills.

The forms identified as this species from the supposed Jurassic near Cape Lisburne, Alaska, have been shown by Knowlton to be forms of *Dicksonia*. Saprota in his treatment of the Portuguese forms leaves them in the genus *Sphenopteris* but thinks that they are more closely related to certain modern species of *Davallia* than to *Onychium*. His figures, however, do not bring this out with any degree of certainty. Professor Seward, in discussing specimens from South Africa,¹ unites with this species the Japanese Jurassic and Cretaceous forms designated as *Thyrsopteris elongata* Geyler and *Onychiopsis elongata* Yokoyama. The reason for the proposed change is the discovery in the English Wealden of more extensive material which showed the *psilotoides* type of pinnule apically and the *elongata* type of pinnule proximally. It is quite possible that the remains from the English Wealden are all one species, but it certainly does not follow that the synonymy follows such a disposition. The American remains identified with the *elongata* type show that the forms with broader segments are not basal portions of fronds with the distal characters of *psilotoides*, although there is in most ferns more or less diminution in size upward. Through the kindness of Professor Yokoyama the writer has received specimens of *O. elongata* from the Jurassic of Kaga, Japan, and these are certainly specifically distinct, especially in the fertile pinnæ, from the English forms of *psilotoides*. They are, therefore, included in the present discussion under *O. goepperti*, which is retained as a distinct species.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Trents Reach, near Potomac Run, Virginia; New Reservoir, Sixteenth Street, District of Columbia. ARUNDEL FORMATION: Langdon, District of Columbia. Bay View, Maryland. PATAPSCO FORMATION: Federal Hill (Baltimore), Stump Neck, near Wellhams, Maryland: Near Brooke, Hell Hole, Virginia.

Collections.—United States National Museum.

¹ Seward, Ann. S. Afr. Mus., vol. 4, 1903, p. 5.

ONYCHIOPSIS LATILOBA (Fontaine).

Sphenopteris latiloba FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 90, pl. 35, figs. 3-5; pl. 36, figs. 4-9; pl. 37, fig. 1.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 281, 479, 491, 511, 534, 557.

Thyrsopteris brevipennis FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 124, pl. 34, fig. 3; pl. 36, fig. 2; pl. 37, figs. 3, 9; pl. 38, fig. 1; pl. 41, fig. 4.—FONTAINE, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2, 1899, p. 662, pl. 162, fig. 1a.

Thyrsopteris divaricata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 125; pl. 37, figs. 5-8; pl. 70, fig. 1.—FONTAINE, in Ward, Monogr. U. S. Geol. Surv., vol. 48, 1906, pp. 504, 511, 517, 521.

Thyrsopteris crenata FONTAINE, Monogr. U. S. Geol. Surv., vol. 15, 1890, p. 127, pl. 39, figs. 1, 2.

Description.—Frond large tripinnate; principal rachis very stout sometimes winged. Leaf-substance thin but coriaceous. Primary pinnæ opposite or subopposite with a stout, rigid, rachis, which is often somewhat flexuous; ultimate pinnæ remotely placed, very short, decurrent, passing toward the summit of the principal pinnæ or of the frond through lobed pinnules into entire ones. Pinnules somewhat remotely placed, cuneate at base, those in the lower part of the frond cut more or less deeply into oblong acute to obtuse lobes, passing toward the tips of the ultimate pinnæ into lobed pinnules like those of the upper part of the frond, and at the tips into ovate or oblong lobes and teeth. In the upper part of the frond they are elliptical, three lobed, or entire. All the pinnules and segments are broad. The ultimate pinnæ and the pinnules of the lower part of the frond usually terminate in three lobed segments or in broad elliptical pinnules. The veins are copiously branched, diverging flabellately into the lobes and teeth, and are very distinct and strong, although not coarse.

This is a fine, large species, probably arborescent, and quite distinct from the other species of *Onychiopsis*. It is common throughout the Potomac but rather less abundant in the Patapsco formation than in the older beds. It has been recorded from the Lakota formation in the Black Hills area and from the Kootenai formation in both Montana and British Columbia. There is some variation exhibited by the various forms referred by the writer to this species, and some of the smaller ultimate pinnæ are readily confused with other species of *Onychiopsis*.

Occurrence.—PATUXENT FORMATION: Fredericksburg, Dutch Gap, Telegraph Station (Lorton), Virginia; New Reservoir (?), District of Columbia. ARUNDEL FORMATION: Langdon (?), District of Columbia; Bewley estate (?), Bay View (common), Maryland. PATAPSCO FORMATION: Deep Bottom, Mount Vernon, Hell Hole (?), Chinkapin Hollow (?), Virginia; Federal Hill (Baltimore), Maryland.

Collections.—United States National Museum, Johns Hopkins University, Goucher College.

THE RECENT AND FOSSIL MOLLUSKS OF THE GENUS ALVANIA FROM THE WEST COAST OF AMERICA.

By PAUL BARTSCH,

Assistant Curator, Division of Mollusks, U. S. National Museum.

Dr. P. P. Carpenter was the first to record members of the genus *Alvania* from the west coast of America. In his Catalogue of Mazatlan Shells¹ we find *?Alvania cœurrata*, *Alvania effusa*, and *Alvania tumida* described as new. In the same work occurs *?Rissoa lirata* Carpenter, which is now placed in the genus *Alvania*.

In the following year Doctor Carpenter's Report on the Present State of our Knowledge with Regard to the Mollusca of the West Coast of America was published.² In this he refers the species described by Prof. C. B. Adams³ as *Cingula (?) inconspicua*, *C. (?) terebellum*, and *C. (?) turrita* doubtfully to *Alvania*. This decision he changed in 1863,⁴ when he referred all three to the Pyramidellidæ. They are all *Odostomias*.

The next to contribute to our knowledge of *Alvania* was O. A. L. Mörch, who described *Alvania perlata* from the west coast of Central America.⁵

This was followed four years later by *Rissoa* now *Alvania albolirata* Carpenter⁶ and *Diala electrina* Carpenter,⁷ which is also an *Alvania*.

In volume 14 of the same publication, also printed in 1864, *Alvania reticulata* Carpenter and *Alvania filosa* Carpenter will be found described on page 429.

The following year Weinkauff rechristened Carpenter's *Alvania reticulata* *Alvania carpenteri*, *A. reticulata* Carpenter being preoccupied by *Turbo (=Alvania) reticulatus* Montagu. The same year Doctor Carpenter published *Rissoa compacta*,⁸ which is also an *Alvania*.

¹ Pages 359-360, 1856.

² Rep. Brit. Ass. Adv. Sci. for 1856, published in 1857.

³ Ann. Lyc. Nat. Hist. N. Y., vol. 5, 1852, pp. 405-406.

⁴ Proc. Zool. Soc. London, 1863, pp. 353-354.

⁵ Mal. Blätt., vol. 7, 1860, p. 68.

⁶ Ann. Mag. Nat. Hist., ser. 3, vol. 13, 1864, p. 477.

⁷ Idem, p. 478.

⁸ Proc. Acad. Nat. Sci. Phila., 1865, p. 62.

In 1866 Doctor Carpenter added *Rissoa* (= *Alvania*) *acutilirata*,¹ which has been generally considered a synonym of *Alvania compacta* Carpenter, but is in reality quite distinct.

Six years later Doctor Dall described *Alvania purpurea*,² and in 1886 he added the following new forms from Alaska:³ *Alvania castanea* Möller, var. *alaskana*, *Alvania castanella*, and *Alvania aurivillii*.

The following year Professor Keep gave a terse diagnosis⁴ of *Alvania æquisculpta*, which was later redescribed as *Alvania grippiana* Dall.

For the next 21 years no additions were made. In 1908 Doctor Dall published *Rissoa* (*Alvania*) *grippiana*,⁵ and last year the present writer described *Alvania bakeri* from Alaskan waters.⁶

A careful examination of the many bottom samples collected on the west coast by the United States Bureau of Fisheries steamer *Albatross* has added a number of new and interesting forms, some of which come from a considerable depth, while the careful and painstaking collecting by many private collectors has brought to light other new forms from the littoral zone, all of which are here described.

Only two species are known as fossils, and as fossils only, from the west coast of California. These are *Alvania pedroana* and *fossilis*, and come from Sand Rock at San Pedro, California.

KEY TO THE GENUS ALVANIA.

Spiral sculpture much stronger than the axial.

Axial sculpture reduced to incremental lines or mere raised threads, which are developed best between the spiral keels or cords.

Spiral sculpture consisting of strong keels.

Spiral keels between the sutures, 6.....*castanella*, p. 336.

Spiral keels between the sutures, 3.

Adult shell more than 4 mm. long.....*aurivillii*, p. 336.

Adult shell less than 2 mm. long.....*bakeri*, p. 337.

Spiral sculpture consisting of well-rounded cords.....*albolirata*, p. 338.

Axial sculpture consisting of broad, subobsolete ribs.....*lirata*, p. 338.

Spiral sculpture not stronger than the axial.

Junction of axial ribs and spiral cords not nodulose.

Sutures channeled.

Shell large and robust; adult more than 2.75 mm.

long.

Penultimate whorl with about 22 axial ribs.....*trachisma*, p. 339.

Penultimate whorl with about 34 axial ribs.....*californica*, p. 340.

Shell small and delicate; adult less than 2.25 mm.

long.

Whorls strongly rounded.....*carpenteri*, p. 341.

Whorls almost flattened.....*pedroana*, p. 341.

¹ Proc. Cal. Acad. Nat. Sci., vol. 3, 1866, p. 217.

² Amer. Journ. Conch., vol. 7, 1872, p. 116.

³ Proc. U. S. Nat. Mus., vol. 9, pp. 307-308.

⁴ Keep's West Coast Shells, 1887, p. 65.

⁵ Nautilus, vol. 21, 1908, p. 136.

⁶ Idem, vol. 23, 1910, p. 137.

Sutures not channeled.

Sutures strongly constricted.

Spiral cords between the sutures on the penultimate whorl, 12.....*filosa*, p. 342.

Spiral cords between the sutures on the penultimate whorl, 5.....*alaskana*, p. 343.

Spiral cords between the sutures on the penultimate whorl, 4.....*montereyensis*, p. 343.

Spiral cords between the sutures on the penultimate whorl, 3.....*excurvata*, p. 344.

Sutures not strongly constricted.

Spiral cords between the sutures more than 10 on the last whorl.

Shell ovate.....*profundicola*, p. 345.

Shell elongate-conic.....*hoodensis*, p. 345.

Spiral cords between the sutures less than 7 on the last whorl.

Shell elongate-conic.....*electrina*, p. 346.

Shell ovate.

Base with 4 spiral cords.....*perlata*, p. 347.

Base with more than 4 spiral cords.

Spiral cords between the sutures, 4.

Axial ribs on the last whorl,

20.....*galapagensis*, p. 347.

Axial ribs on the last whorl,

14.....*nemo*, p. 348.

Spiral cords between the sutures more than 4.

Body whorl inflated.

Whorls strongly rounded.....*rosana*, p. 349.

Whorls almost flattened.....*fossilis*, p. 349.

Body whorl not inflated.

Axial ribs on last whorl

about 45.....*iliuliukensis*, p. 350.

Axial ribs on last whorl

about 30.....*compacta*, p. 351.

Axial ribs on last whorl

about 20.....*acutilirata*, p. 352.

Junction of axial ribs and spiral cords nodulose.

Sutures channeled.

Spiral cords between the sutures, 2.

Basal cords, 3.....*cosmia*, p. 352.

Basal cords, 4.....*purpurea*, p. 353.

Spiral cords between the sutures more than 2.

Spiral cords between the sutures, 3.

Cord at the summit equal to the other two in strength.....*halia*, p. 354.

Cord at the summit not equal to the other two in strength.....*ima*, p. 355.

Spiral cords between the sutures more than 3.

Spiral cords between the sutures, 6, or more.

Spiral cords between the sutures equal.....*clarionensis*, p. 356

Spiral cords between the sutures unequal.....*lara*, p. 357.

Sutures not channeled.

Shell elongate-conic.

Spiral cords between the sutures, 5.....*effusa*, p. 358.

Spiral cords between the sutures, 3.....*æquisculpta*, p. 358.

Shell not elongate-conic.

Shell broadly ovate.

Basal cords, 2.....*almo*, p. 359.

Basal cords, 4.....*oldroydæ*, p. 360.

Shell subglobose.....*tumida*, p. 361.

ALVANIA CASTANELLA Dall.

Plate 29, fig. 1.

Alvania castanella DALL, Proc. U. S. Nat. Mus., vol. 9, 1886, p. 307, pl. 3, fig. 5.

Shell elongate-ovate, thin, yellowish-white. Nuclear whorls about one and three-quarters, well rounded, smooth. Post-nuclear whorls strongly, slopingly shouldered at the summit, well rounded, marked between the sutures by six spiral keels, the first of which adjoins the strongly channeled suture, while the second marks the angle of the shoulder; the remaining four growing gradually and successively weaker and a little closer spaced. In addition to the spiral sculpture, the whorls are marked by numerous very fine, incremental lines. Suture quite strongly constricted. Periphery of the last whorl well rounded. Base moderately long, well rounded, very narrowly umbilicated, marked by six equal and equally spaced, spiral keels. Aperture semicircular; posterior angle obtuse; outer lip thin, showing the external sculpture within; inner lip thin, strongly curved and slightly revolute; parietal wall covered with a moderately thick callus, which renders the peritreme complete; operculum thin, horny.

The type (Cat. No. 213677, U.S.N.M.) and another specimen were collected by Doctor Dall at Atka Island, Alaska. The type has four post-nuclear whorls and measures: Length 2.4 mm., diameter 1.3 mm. Cat. No. 213678, U.S.N.M., contains 9 specimens taken from sponges on the beach, at low water, at Kyska Harbor, Aleutian Islands, Alaska.

ALVANIA AURIVILLII Dall.

Plate 29, fig. 5.

Alvania aurivillii DALL, Proc. U. S. Nat. Mus., vol. 9, 1886, p. 308, pl. 4, fig. 8.

Shell elongate-conic, thin, light yellow. Nuclear whorls one and one-half, strongly rounded, smooth. Post-nuclear whorls rounded, shouldered at the summit, marked by two strong, spiral keels, between the sutures, on the first two turns; the first keel being on the middle and the second a little posterior to the suture; the space between the summit and the first keel slopes regularly. Beginning with the third whorl a third keel appears, and the space between the sutures is here divided into four parts, of which the one at the summit is a little broader than the rest. On the last turn the peripheral keel

is completely shown in the suture, and a slender, spiral thread appears immediately below the summit. The spaces between the keels are about four times as wide as the keels. Suture quite strongly constricted. Periphery of the last whorl marked by a strong, spiral keel which is a trifle nearer to the first keel posterior to it than that is to its neighbor. Base moderately long, well rounded, narrowly umbilicated, marked by three equal and almost equally spaced spiral keels. In addition to the spiral sculpture, the whorls are marked by numerous, very slender, raised, axial threads which are best developed in the broad spaces between the spiral keels. Aperture subcircular, slightly expanded anteriorly; posterior angle obtuse; outer lip thin, showing the external sculpture within; inner lip strongly curved, somewhat reflected; parietal wall covered with a thick callus which joins the posterior angle to the columella and renders the peritreme complete; operculum thin, corneous.

The type (Cat. No. 213680, U.S.N.M.) and four other specimens were collected at Adakh Island, Alaska. The type has five post-nuclear whorls and measures: Length 4.2 mm., diameter 2 mm.

Specimens examined.

Catalogue No.	Locality.	Number of specimens.
161077.....	Kyska Harbor, Aleutian Islands, Alaska.....	1
213681.....	Pass, Kyska Harbor, Aleutians, Alaska (10 fathoms, rocky bottom).....	1
195372.....	Kyska Harbor, Aleutians, Alaska.....	1
161100.....	do.....	19
161092.....	Amchitka Island, Aleutians, Alaska.....	5
213683.....	Constantine Harbor, Amchitka Island, Aleutians, Alaska.....	2
213682.....	Amchitka Island, Aleutians, Alaska (low water).....	1
213680.....	Adakh Island, Alaska (1=type).....	5

***ALVANIA BAKERI* Bartsch.**

Plate 29, fig. 2.

Alvania bakeri BARTSCH, Nautilus, vol. 23, 1910, No. 11, p. 137, pl. 11, fig. 8.

Shell minute, bluish-white. Nuclear whorls one and one-third, forming a moderately elevated spire. Upper half of the well-rounded nuclear whorls marked by about ten very fine, closely spaced, spiral striations; lower half marked by numerous, closely spaced, depressed, elongate granules, each of which has the long axis decidedly protractively slanted, which lends to this part of the turn a finely blistered appearance. Post-nuclear whorls a little more than two, well rounded, separated by a strongly constricted suture, marked by three strong, rounded, spiral keels, of which the strongest is a little anterior to the posterior third between the sutures, while the anterior of the other two, which are of equal strength, is at the periphery and the third halfway between them. In addition to these keels, the whorls

are marked by fine, incised, spiral lines between the keels, which are best developed on the well-rounded shoulder, between the summit of the whorls and the strong keel below it. Base of the last whorl slightly protracted, well rounded, marked by two broad, depressed, spiral cords, of which the basal one, which is a little anterior to the middle, is the broader. In addition to these there are numerous, exceedingly fine, spiral striations. The axial sculpture of the entire spire and base consists of very fine, incremental lines only. Aperture very broadly ovate, almost circular; peritreme continuous; outer lip thick within, beveled at the margin to form a sharp edge, which is rendered slightly sinuous by the external spiral sculpture; inner lip strong and strongly curved; parietal wall of the aperture appressed to the preceding whorl.

The type (Cat. 208445, U.S.N.M.) was collected by Dr. Fred Baker at Port Graham, Alaska; it measures: Length 1.4 mm., diameter 1.2 mm.

ALVANIA ALBOLIRATA Carpenter.

Plate 29, fig. 6.

Rissoa albolirata CARPENTER, Ann. Mag. Nat. Hist., ser. 3, vol. 13, 1864, p. 76.

Shell elongate-conic, rather thick, yellowish white. Nuclear whorls two and one-half, well-rounded, smooth. Post-nuclear whorls marked by low, rounded, subequal, spiral keels, excepting the one at the summit, which is considerably wider than the rest. Of these keels, 6 occur upon the first, 9 upon the second, and 12 upon the penultimate turn. Summit of the whorls appressed. Sutures very poorly defined. Periphery of the last whorl well rounded. Base somewhat produced, well rounded, marked by 9 subequal and subequally spaced, spiral cords. In addition to the above sculpture, the entire surface of the spire and base is marked by exceedingly fine, incremental lines which are best seen on the spaces between the spiral keels. Aperture decidedly oblique, broadly oval; outer lip decidedly expanded anteriorly, reenforced with a thick callus; inner lip very oblique, slightly reflected over and appressed to the base; parietal wall covered with a thick callus.

The type (Cat. No. 16216, U.S.N.M.) comes from Cape San Lucas, Lower California. It has four post-nuclear whorls and measures: Length 3 mm., diameter 1.3 mm.

ALVANIA LIRATA Carpenter.

Plate 29, fig. 3.

?*Rissoa lirata* CARPENTER, Cat. Maz. Shells, 1856, p. 358.

Shell elongate-ovate; early whorls light brown, later ones milk white. Nuclear whorls two, small, well rounded, smooth. Post-nuclear whorls marked by feebly developed, broad, axial ribs, of

which 16 occur upon the second and third and 18 upon the penultimate turn. These ribs are best shown immediately posterior to the deeply channeled suture, where they appear as a cord of slender tubercles. The main sculpture of the shell consists of fine, spiral lirations, of which 6 occur between the summit and the tubercles on the first turn and 10 upon the second. The space between the tubercles and the suture seems to be marked by a single, spiral liration only. On the last whorl the tubercles are altogether obsolete and the surface of this whorl is marked by 12 subequal and subequally spaced spiral cords, of which the 3 near the summit are the weakest. The spaces between these cords are narrower than the cords. Suture very strongly and deeply channeled. Periphery of the last whorl marked by an impressed groove, which bears a slender, spiral cord in its middle. Base somewhat produced, scarcely rounded, marked by eight equal and equally spaced, spiral cords. Aperture very oblique, rather large, oval; posterior angle acute; outer lip decidedly thickened immediately behind the thin edge; inner lip stout, curved, reflected over, and appressed to the base; parietal wall covered with a thick callus which joins the posterior angle of the aperture with the columella and renders the peritreme complete.

The specimen described and figured is one of ten (Cat. No. 208500, U.S.N.M.), which come from the Gulf of California. It has four post-nuclear whorls and measures: Length 2.8 mm., diameter 1.3 mm. Cat. No. 16207, U.S.N.M., contains one specimen from Cape San Lucas, Lower California, and Cat. No. 32368, U.S.N.M., contains two from the Gulf of California.

ALVANIA TRACHISMA, new species.

Plate 29, fig. 7.

Shell elongate-ovate, yellowish white. (Nuclear whorls decolated.) Post-nuclear whorls slightly rounded, marked by slender, well rounded, almost vertical, axial ribs, of which 26 occur upon the first and second and 22 upon the third and the penultimate turn. These axial ribs are about one-third as wide as the spaces that separate them and extend prominently from the summit of the whorls, where they terminate in rounded cusps, to the umbilical area. In addition to the axial sculpture, the whorls are marked by spiral cords, of which 3 occur between the sutures on the first and second whorls, 5 on the third, and 6 on the penultimate turn. The spiral cords pass over the axial ribs as cords. The spaces inclosed between the axial ribs and the spiral cords are elongate oval pits, having their long axes parallel with the spiral sculpture. Suture broad and very deeply channeled. Periphery of the last whorl marked by a sulcus a little wider than those occurring on the spire, crossed by the

continuations of the axial ribs. Base moderately produced, slightly concave in the middle, marked by six equal and almost equally spaced spiral cords and the continuations of the axial ribs. Aperture oblique, moderately large, oval; posterior angle acute; outer lip very thick, reenforced immediately behind the edge by a strong varix, showing about 10 internal lirations within the aperture; inner lip very stout, curved, and reflected over and appressed to base; parietal wall covered with a thick callus which completes the peristome.

The type (Cat. No. 213684, U.S.N.M.) has 5 post-nuclear whorls and measures: Length 3.3 mm., diameter 1.9 mm. It comes from Monterey, California.

ALVANIA CALIFORNICA, new species.

Plate 29, fig. 9.

Shell elongate-ovate, the spire posterior to the periphery of the last whorl forming a perfect cone, yellowish white. Nuclear whorls two and one-half, well rounded, smooth, separated by a moderately constricted suture. Post-nuclear whorls moderately well rounded, marked by slender, rounded, slightly protractive, axial ribs, of which 26 occur upon the first and 34 upon the second and the penultimate turn. These axial ribs extend quite prominently from the summit of the whorls, where they form slender cusps, to the periphery of the whorls, becoming evanescent immediately anterior to the periphery. In addition to the axial ribs, the whorls are marked by spiral cords about as strong as the axial ribs. Of these two occur upon the first volution, where they divide the space between the sutures into three equal parts; on the second there are four, while upon the penultimate turn there are six. Suture strongly channeled. Periphery of the last whorl marked by a sulcus as wide as the one which separates the two cords posterior to it. Base moderately long, well rounded, marked by six almost equally spaced, spiral cords, which grow successively stronger from the periphery to the umbilical area. In addition to these spiral cords, there are feeble extensions of the axial ribs occurring in the space between the first and second sulcus anterior to the periphery. Aperture very broadly oval; posterior angle obtuse; outer lip very thick, reenforced immediately behind the edge by a strong varix, showing about 10 lirations within; inner lip stout, curved, strongly reflected over and appressed to the base; parietal wall covered with a thick callus, which completes the peristome.

The type and 10 other specimens (Cat. No. 56347, U.S.N.M.) come from Monterey, California. The type has $3\frac{1}{2}$ post-nuclear whorls and measures: Length 2.5 mm., diameter 1.4 mm.

ALVANIA CARPENTERI Weinkauff.

Plate 29, fig. 8.

Rissoa carpenteri WEINKAUFF, Conch. Cab., p. 192, 1885=*Alvania reticulata* CARPENTER, Ann. Mag. Nat. Hist., ser. 3, vol. 14, 1865, p. 429. Not *Rissoa* (= *Alvania*) *reticulata* Montagu, 1808.

Shell small, elongate ovate, yellowish white. Nuclear whorls one and one-half, smooth, well rounded. Post-nuclear whorls well rounded; the first two slightly, slopingly shouldered at the summit, marked by slender, axial ribs, of which 24 occur upon the first, 32 upon the second, and 34 upon the penultimate turn. In addition to the axial ribs, the whorls are marked by spiral cords which equal the ribs in strength; of these cords, 4 occur upon the first and second turns, the space between the summit and the first cord is considerably wider than that between any of the cords and forms a sloping shoulder. On the penultimate whorl, this space is marked by two additional cords, one of which is at the summit and the other is halfway between this and the next cord. The spaces inclosed between the axial ribs and the spiral cords are elongated pits, which have their long axes parallel to the spiral sculpture in all cases except the median, where the pits are squarish. Suture strongly channeled. Periphery of the last whorl marked by a spiral sulcus equal to the one separating the first and second suprapерipheral cords. Base moderately long, well rounded, not attenuated anteriorly, marked by 6 equal and equally spaced, spiral cords and very feeble continuations of the axial ribs, which here appear as very slender threads. Aperture broadly oval; posterior angle obtuse; outer lip thin, showing the external sculpture within; inner lip very strongly curved and slightly reflected; parietal wall covered with a moderately strong callus, which renders the peritreme complete.

The type (Cat. No. 17728, U.S.N.M.) was collected by J. G. Swan at Neah Bay, Washington. It has three post-nuclear whorls and measures: Length, 2 mm., diameter, 1.1 mm.

ALVANIA PEDROANA, new species.

Plate 29, fig. 4.

Shell elongate-ovate, milk white. Nuclear whorls two, well rounded, smooth. Post-nuclear whorls almost flattened, marked by rather strong, vertical, axial ribs, of which 22 occur upon the first and second, and 25 upon the penultimate turn. In addition to the axial ribs, the whorls are marked by spiral cords which almost equal the axial ribs in strength. Of these cords, 5 occur between the sutures on all the whorls, the first being at the summit. The summit of the

last whorl falls anterior to the peripheral cord on the penultimate whorl, displaying the peripheral cord completely in the suture. The spaces inclosed between the spiral cords and the axial ribs are elongated, oval pits about as wide as the spiral cords. Suture strongly and deeply channeled. Periphery of the last whorl marked by a spiral cord, which is separated from the first supraperipheral cord by a channel as wide as that separating the supraperipheral cord from its posterior neighbor. The axial ribs terminate at the posterior edge of the peripheral cord. Base moderately long, slightly produced anteriorly, almost flattened, marked by 8 equal and equally spaced, spiral cords, which are a little broader than the channels that separate them. Aperture oval; posterior angle obtuse; outer lip thick within, thin at edge; inner lip strong, curved, reflected over and appressed to the base; parietal wall covered with a thick callus, which renders the peritreme complete.

The type and another specimen (Cat. No. 213685, U.S.N.M.) are fossils and come from sand rock, San Pedro, California. The type has $3\frac{1}{2}$ post-nuclear whorls and measures: Length, 2.2 mm., diameter 1.2 mm.

ALVANIA FILOSA Carpenter.

Plate 30, fig. 7.

Alvania filosa CARPENTER, Ann. Mag. Nat. Hist., ser. 3, vol. 15, 1865, p. 28.

Shell elongate-conic, thin, translucent, yellowish white. Nuclear whorls one and one-half, well rounded, smooth. Post-nuclear whorls well rounded, roundly shouldered at the summit, marked by slender, feebly developed, sinuous, axial riblets. In addition to these riblets, the whorls are marked by equal and equally spaced, spiral cords which are equal to the riblets in strength. Of these cords, 10 occur between the sutures on the antepenultimate, and 12 on the penultimate turn. The spaces inclosed between the spiral cords and the axial ribs are shallow, impressed, squarish pits. Suture strongly constricted. Periphery and the rather short base of the last whorl well rounded; the latter very narrowly umbilicated, marked by eight equal and equally spaced, spiral cords, which are a little wider than the spaces that separate them. The sulci between the spiral cords on the base are crossed by the feeble extensions of the axial riblets. Aperture broadly oval; posterior angle obtuse; outer lip thin, showing the external sculpture within; inner lip moderately stout, curved and reflected, the posterior half appressed to the base; parietal wall covered with a thick callus, rendering the peritreme complete.

Doctor Carpenter's type (Cat. No. 36632, U.S.N.M.) was collected by J. G. Swan at Neah Bay, Washington. It has 4 post-nuclear whorls and measures: Length 3.5 mm., diameter 1.7 mm. This shell suffered an injury shortly after passing the nepionic stage and it is quite possible that the multifilations which characterize this form

may be a pathologic expression due to the injury received. I am unable to refer it positively to any of the known species and therefore retain it in its present position.

ALVANIA ALASKANA Dall.

Plate 30, fig. 1.

Alvania castanea MÖLLER, var. *alaskana* DALL, Proc. U. S. Nat. Mus., vol. 9, 1886, p. 307, pl. 4, fig. 9.

Shell very elongate-ovate, white. Nuclear whorls one and one-half, strongly rounded, very finely papillose. Post-nuclear whorls strongly rounded, appressed at the summit, marked by fairly strong, spiral cords, of which three occur upon the first whorl, so arranged that the first below the summit marks the anterior termination of the posterior third between the sutures; the other two divide the space anterior to this into equal parts. The spaces separating these cords are a little narrower than the cords. On the second whorl an additional cord makes its appearance halfway between the summit and the first spiral cord on the preceding whorl, thus dividing the space between the sutures into five equal portions. The penultimate whorl has the same spiral sculpture as its predecessor, but in addition this whorl shows the peripheral spiral cord a little posterior to the suture. In addition to these spiral cords, the whorls are marked by numerous very fine, spiral striations, which are apparent on the cords and in the grooves that separate them. The axial sculpture is reduced to very feeble riblets, which are closely spaced and rather irregularly distributed. Suture very strongly constricted. Periphery of the last whorl well rounded. Base rather short, umbilicated, marked by six low, rounded, spiral cords which are situated on the posterior two-thirds of the base and numerous fine, closely spaced, spiral striations. Aperture subcircular; posterior angle obtuse; outer lip thin, showing the external sculpture within; inner lip slender, curved, reflected, but free from the base; parietal wall covered with a thick callus which renders the peritreme complete.

Cat. No. 213686, U.S.N.M., contains the two cotypes collected by Doctor Dall at Nunivak Island, Alaska. One of these has $3\frac{1}{2}$ post-nuclear whorls and measures: Length 2.9 mm., diameter 1.5 mm., the other has the same number of post-nuclear turns but has lost the nucleus and measures: Length 2.8 mm., diameter 1.5 mm. I have figured the last specimen.

ALVANIA MONTEREYENSIS, new species.

Plate 30, fig. 2.

Shell elongate-conic, yellowish white. Nuclear whorls $1\frac{1}{3}$, well rounded, marked by about 8 very slender, spiral striations, of which the 3 near the summit are weaker than the rest. Post-nuclear whorls

well rounded, marked between the sutures by 4 strong, narrow spiral cords, which divide the space between the sutures into 5 almost equal parts, that between the summit and the first cord being a little wider than the rest. In addition to the spiral cords, the whorls are marked by slender axial riblets, which are about as strong as the spiral cords. Of these riblets, about 24 occur upon the first and second, and about 26 upon the penultimate, turn. The spaces inclosed between the spiral cords and the axial riblets are elongated pits, having their long axes parallel with the spiral sculpture. In addition to the above sculpture, the entire surface of the shell is marked by numerous very fine, closely spaced spiral striations. Suture strongly constricted. Periphery of the last whorl marked by a sulcus as wide as that which separates the first suprapерipheral cord from its posterior neighbor. Base moderately long, scarcely produced anteriorly, well rounded, marked by seven spiral cords, which grow successively weaker and closer spaced from the periphery to the umbilical region. Aperture moderately large, broadly oval; posterior angle obtuse; outer lip thin, showing the external sculpture within; inner lip slender, curved, and reflected, the posterior edge touching the body whorl; parietal wall covered with a moderately thick callus, which renders the peritreme complete.

The type (Cat. No. 160114, U.S.N.M.) comes from Monterey, California. It has $3\frac{1}{2}$ post-nuclear whorls, and measures: Length, 2.3 mm., diameter 1.1 mm. Cat. No. 213679, U.S.N.M., contains a specimen from Sitka Harbor, Alaska; Cat. No. 46174, U.S.N.M., contains three from Monterey, California; Cat. No. 126719, U.S.N.M., contains two, also from Monterey; and Cat. No. 219742, U.S.N.M., six from Pacific Grove.

ALVANIA EXCURVATA Carpenter.

Plate 30, fig. 6.

?*Alvania excurvata* CARPENTER, Cat. Maz. Shells, 1856, p. 359.

Shell elongate-conic, brownish gray. Nuclear whorls 2, smooth. Post-nuclear whorls well rounded, marked by slender, axial ribs, of which about 16 occur upon the first, 18 upon the second, 20 upon the third and fourth, and 30 upon the penultimate turn. In addition to the axial ribs, the whorls are marked by slender spiral cords, of which 2 occur upon the first and second, 3 upon the third and fourth, and 5 upon the penultimate turn between the sutures. The spaces inclosed between the cords and ribs are squarish pits. Suture strongly constricted. Periphery of the last whorl well rounded. Base moderately long, scarcely attenuated, well rounded, marked by the feeble continuations of the axial ribs and three spiral cords. Aperture oval; outer lip thin; inner lip strongly curved and slightly

reflected; parietal wall covered with a thick callus, which renders the peritreme complete.

Doctor Carpenter's specimens were taken from *Chama* and *Spondylus*, at Mazatlan. The type, which has 6 post-nuclear whorls, and is in the Liverpool Collection of the British Museum, measures: Length, 2.8 mm., diameter 0.95 mm.

ALVANIA PROFUNDICOLA, new species.

Plate 30, fig. 5.

Shell ovate, yellowish white, nucleus yellow. Nuclear whorls 3, showing 8 fine spiral lirations, which are about half as wide as the spaces that separate them. The spiral sulci between the lirations are crossed by quite regular, very slender axial threads, lending the surface of the nucleus a finely reticulated appearance. Post-nuclear whorls well rounded, weakly shouldered at the summit, marked by rather strong, very regular, curved axial ribs, of which 25 occur upon the first, 26 upon the second, and 32 upon the penultimate turn. Intercostal spaces about three times as wide as the ribs, crossed by fine spiral striations, of which the first below the summit is stronger than the rest and passes over the ribs, constricting them so as to form a series of crenulations at the suture. Anterior to this line the spiral striations are usually much enfeebled. On the last whorl there are about 12 of these lines between the periphery and the summit. Suture strongly constricted. Periphery of the last whorl well rounded. Base well rounded, decidedly attenuated anteriorly, marked by the feeble continuations of the axial ribs, which become evanescent on the middle of the base, and seven subequal and subequally spaced spiral lirations. Aperture subcircular; posterior angle obtuse; outer lip thin at the edge, reenforced immediately behind the edge by a thick varix; inner lip slender, decidedly curved, and reflected over and appressed to the base; parietal wall covered with a thick callus, which renders the peritreme complete.

The type and 24 other specimens (Cat. No. 207606, U.S.N.M.) were dredged by the United States Bureau of Fisheries steamer *Albatross* at station 2808, in 634 fathoms, on coral sand bottom, bottom temperature 39.9°, near the Galapagos Islands. The type has 4 post-nuclear whorls, and measures: Length 3.2 mm., diameter 1.7 mm.

ALVANIA HOODENSIS, new species.

Plate 30, fig. 3.

Shell small, elongate-conic, white. Nuclear whorls a little more than 1, sufficiently eroded to make the question of sculpture doubtful. Post-nuclear whorls slopingly shouldered at the summit, marked by obsolete, rounded, rather broad, vertical axial ribs of which about 20 occur upon the second and 24 upon the third and the penultimate

turn. In addition to the axial sculpture, the post-nuclear whorls bear quite regular, rounded spiral cords, of which 3 occur upon the first whorl between the sutures, 4 upon the second, 8 upon the third—where the primary 4 seem to have undergone bifurcation—and about 14 upon the penultimate turn. The spiral cords are superimposed upon the axial ribs. The spaces inclosed between the spiral cords and axial ribs are very elongated narrow pits, having their long axes parallel with the spiral sculpture. The sloping shoulder on the whorls extends from the appressed summit to the anterior limit of the posterior fourth of the whorls between the sutures. Suture moderately constricted. Periphery of the last whorl well rounded. Base moderately long, slightly produced anteriorly, marked by 9 equal and equally spaced spiral cords, which are considerably wider than the spaces that separate them. Aperture irregularly oval; outer lip slightly thickened behind the edge, rendered sinuous at the edge by the external sculpture; inner lip decidedly curved and slightly reflected over and partly appressed to the base; parietal wall covered with a moderately thick callus.

The type and two other specimens (Cat. No. 213687, U.S.N.M.) were dredged by the United States Bureau of Fisheries steamer *Albatross* at station 2813, off Hood Island, Galapagos Islands, in 40 fathoms, on coral sand bottom, bottom temperature 81°. The type has 5 post-nuclear whorls, and measures: Length 2.5 mm., diameter 1.1 mm.

ALVANIA ELECTRINA Carpenter.

Plate 30, fig. 4.

?*Diala electrina* CARPENTER, Ann. Mag. Nat. Hist., ser. 3, vol. 3, 1864, p. 478.

Shell elongate-conic, golden brown. Nuclear whorls two and one-quarter, well rounded, smooth. Post-nuclear whorls faintly shouldered at the summit, well rounded, marked by low, poorly developed, rounded, almost vertical, axial ribs which are very poorly expressed on the first turn, but slightly better on the remaining ones. Of these ribs, 18 occur upon the second, and 22 upon the penultimate turn. In addition to the axial ribs, the whorls are marked by low, spiral cords which increase in width successively from the summit to the periphery. Of these cords, 5 occur between the sutures on the second and on the penultimate turn. The spiral cords pass regularly over the axial ribs. The spaces inclosed between the spiral cords and axial ribs are narrow, elongated pits, having their long axes parallel to the spiral sculpture. Suture weakly impressed. Periphery of the last whorl well rounded. Base moderately long, evenly and well rounded, marked by three low, broad, rounded, spiral cords which are separated by narrow, incised lines. Aperture oblique, ovate; posterior angle almost acute; outer lip rather thick; inner lip short, strongly curved, reflected over and appressed to

the base; parietal wall covered with a thick callus which renders the peritreme complete.

Doctor Carpenter's type (Cat. No. 12217, U.S.N.M.) comes from Cape San Lucas, Lower California. It has 4 post-nuclear whorls and measures: Length 2.7 mm., diameter 1.1 mm.

ALVANIA PERLATA Mörch.

Alvania perlata MÖRCH, Mal. Blätt., vol. 7, 1868, p. 68.

Shell small, solid, elongate-ovate, marked by a peripheral chestnut band which is apparent upon all the whorls of the spire. Nuclear whorls smooth. Postnuclear whorls marked between the sutures by four spiral cords, the spaces between which are not crossed by the continuations of the axial ribs. Aperture small, subcircular; outer lip somewhat constricted and expanded anteriorly.

Mörch's type, which is in the Copenhagen Museum, came from Central America. It has 6 post-nuclear whorls and measures; length 2.8 mm., diameter 1.5 mm.

ALVANIA GALAPAGENSIS, new species.

Plate 30, fig. 9.

Shell ovate, yellowish white. Nuclear whorls at least two (having their surface eroded in all our specimens). Post-nuclear whorls flattened in the middle, marked by rather slender, irregularly slanting axial ribs, of which 18 occur upon the second and third, and 20 upon the penultimate turn. The ribs are less than one-third as wide as the spaces that separate them. In addition to the axial ribs, the whorls are marked by poorly developed, spiral cords, of which 3 occur upon the second and third, the first being at the summit and the second marking the termination of the anterior third between the sutures, while the third is halfway between this and the suture. The intersections of the axial ribs and spiral cords form the merest indications of nodules, while the spaces inclosed between them are squarish pits on the second and third whorls, and also between the first and second cords on the penultimate whorl. The space between the second and third cords on the penultimate whorl is divided by a slender, spiral thread which renders the pits elongate, with their long axes parallel to the spiral sculpture. Suture slightly constricted, showing the posterior edge of the first basal cord. Periphery of the last whorl marked by a sulcus as wide as that separating the first and second spiral cords between the sutures and, like it, crossed by the feeble continuations of the axial ribs, which terminate at its posterior border. Base produced anteriorly, slightly rounded, with a faint suggestion of concavity in its middle, marked by six spiral cords, which grow successively weaker and closer spaced from the periphery to the umbilical region. Aperture subcircular; outer lip very thick,

reenforced immediately behind the edge by a strong varix; inner lip short, very stout, reflected over the attenuated base; parietal wall covered with a thick callus, which renders the peritreme complete.

The type and two other specimens (Cat. No. 207590, U.S.N.M.) were dredged by the United States Bureau of Fisheries steamer *Albatross* at station 2808, near the Galapagos Islands, in 634 fathoms on coral sand bottom, with a bottom temperature of 39.9°. The type has 4 post-nuclear whorls and measures: Length 3.3 mm., diameter 1.9 mm.

ALVANIA NEMO, new species.

Plate 30, fig. 8.

Shell ovate, white. Nuclear whorls two and one-half, marked by two very strong, spiral keels which are separated by a sulcus as broad as the keels. Post-nuclear whorls well rounded, marked by low, rounded, slightly retractive, axial ribs, 14 of which occur upon all the turns. In addition to the axial sculpture, the whorls are marked by a low, poorly developed, rounded, spiral cord at the summit, and two considerably stronger cords—separated by a narrow channel—a little anterior to the middle of the whorl. On the penultimate whorl a slender, spiral cord appears, halfway between the one at the summit and the first one below it. The spaces inclosed between the spiral cords and axial ribs are squarish pits at the summit on all the whorls except the penultimate and last, where an intercalated spiral cord renders them oblong. The spaces between the two strong, spiral cords and the axial ribs are very long, narrow pits, having their long axes parallel to the spiral sculpture, while the spaces inclosed between the last spiral cord, the suture, and the axial ribs are also squarish in form. Suture moderately constricted. Periphery of the last whorl marked by a broad sulcus, which is bounded anteriorly by a strong spiral cord. This sulcus is crossed by the continuations of the axial ribs which terminate at the posterior edge of the basal spiral cord. Base produced anteriorly, very slightly rounded, marked by eight low, poorly developed, flattened spiral cords, of which the one immediately below the periphery is the strongest. Aperture broadly oval; posterior angle obtuse; outer lip very thick, reenforced immediately behind the edge by a strong varix; inner lip very oblique, curved, reflected over, and appressed to the base; parietal wall covered with a thick callus, rendering the peristome complete.

The type and three other specimens (Cat. No. 195011, U.S.N.M.) were dredged by the United States Bureau of Fisheries steamer *Albatross* at station 2813, in 40 fathoms, on coral sand bottom; bottom temperature 81°, off the Galapagos Islands. The type has 4 post-nuclear whorls and measures: Length 2.6 mm., diameter 1.2 mm.

ALVANIA ROSANA, new species.

Plate 31, fig. 6.

Shell broadly ovate, yellowish white. Nuclear whorls two and one-half, smooth, well rounded. Post-nuclear whorls well rounded, marked by narrow, well-rounded, somewhat sinuous, almost vertical, axial ribs which are about one-third as wide as the spaces that separate them. Of these ribs 24 occur upon the second and the penultimate turn. In addition to the axial sculpture the whorls are marked by low, rounded, equal and equally spaced spiral cords, which are a little weaker than the axial ribs. Of these cords 6 occur between the sutures on the second turn and 7 on the penultimate turn, the first being at the summit. These spiral cords are a little narrower than the spaces that separate them. Suture moderately constricted. Periphery of the last whorl inflated, marked by a sulcus which is as wide as the spaces that separate the cords on the psire and, like them, crossed by the continuations of the axial ribs, which terminate at the posterior border of the first basal keel. Base strongly rounded, narrowly umbilicated, very slightly attenuated anteriorly, marked by eight equal and equally spaced spiral cords which are about as wide as the spaces that separate them. Aperture broadly oval; posterior angle obtuse; outer lip thick, reinforced immediately behind the edge by a moderately thick callus; inner lip strongly curved and somewhat reflected over and partly appressed to the base; parietal wall covered with a moderately thick callus.

The type and 72 specimens (Cat. No. 213688, U.S.N.M.) were dredged by the United States Bureau of Fisheries steamer *Albatross* at station 2901 in 48 fathoms, off Santa Rosa Island, California, on mud bottom, bottom temperature 55°. The type has three post-nuclear whorls and measures: Length 2.6 mm., diameter 1.5 mm. Cat. No. 213689, U.S.N.M., contains 45 specimens dredged by the United States Bureau of Fisheries steamer *Albatross* at station 2902 in 53 fathoms, off Santa Rosa Island, California, on mud bottom, bottom temperature 45°. Cat. No. 23762, U.S.N.M., contains one specimen dredged in 30 fathoms off Catalina Island, California, and Cat. No. 46169, U.S.N.M., contains one which was also dredged in 30 fathoms off Catalina Island, California.

ALVANIA FOSSILIS, new species.

Plate 31, fig. 8.

Shell broadly ovate, white. Nuclear whorls at least two, having their surface eroded. Post-nuclear whorls almost flattened, marked by rather strong, protractive, axial ribs, of which 24 occur upon all the whorls. These ribs are about one and one-half times as wide as the spaces that separate them and terminate at the posterior edge

of the first basal cord. In addition to the axial ribs the whorls are marked by low spiral cords, almost equaling the axial ribs in strength. Of these cords there are 5 between the sutures on the first whorl and 6 on the last one. The spaces between these cords are about one-fourth as wide as the cords. Suture poorly marked, scarcely at all impressed. Periphery of the last whorl marked by a sulcus a little wider than the spaces that separate the cords on the spire, crossed by the continuations of the axial ribs. Base somewhat inflated, well rounded, marked by eight ill-defined spiral cords, which are separated by shallow impressed lines. Aperture oval; posterior angle obtuse (outer lip fractured); inner lip strong, strongly curved, and slightly reflected over and appressed to the base; parietal wall covered with a strong callus.

The type (Cat. No. 213691, U.S.N.M.) is a fossil and comes from sand rock, San Pedro, California. It has $2\frac{1}{2}$ post-nuclear whorls and measures: Length 2 mm., diameter 1.2 mm.

ALVANIA ILIULIUKENSIS, new species.

Plate 31, fig. 2.

Shell ovate, light purplish brown. Nuclear whorls two (surface eroded). Post-nuclear whorls well rounded, appressed at the summit, marked by slender, protractively curved axial riblets, of which 24 occur upon the first, 36 upon the second, and about 45 upon the last turn. These riblets are almost as wide as the spaces that separate them. In addition to the axial ribs the whorls are marked by low spiral cords which equal the axial ribs in strength. Of these cords 6 occur upon the first and 7 upon the second and the penultimate turn, between the sutures. The spaces inclosed between the axial ribs and spiral cords are small, squarish pits. Suture moderately constricted. Periphery of the last whorl marked by a sulcus equal to those occurring between the spiral cords on the spire. Base strongly rounded, somewhat inflated, marked by 8 equal and equally spaced, somewhat flattened, low spiral cords which equal the sulci between them in width. In addition the base is marked by very fine lines of growth which extend over the cords and interspaces. Aperture broadly ovate; posterior angle obtuse; outer lip thin, with a very faint varix immediately behind its edge; inner lip moderately strong, strongly curved and reflected over and appressed to the base; parietal wall covered with a thin callus.

The type and 7 other specimens (Cat. No. 213690, U.S.N.M.) were dredged by the United States Bureau of Fisheries steamer *Albatross* at station 3333 in 19 fathoms, off Iliuliuk Harbor, Alaska, bottom temperature 43.9° . The type has $3\frac{1}{2}$ post-nuclear whorls and measures: Length 3 mm., diameter 1.7 mm. Cat. No. 208750, U.S.N.M., contains a specimen dredged by Doctor Dall in 15-75 fathoms off Belkoffski, Alaska.

ALVANIA COMPACTA Carpenter.

Plate 31, fig. 7.

Rissoa compacta CARPENTER, Proc. Acad. Nat. Sci. Phila., 1865, p. 62.

Shell ovate, light chestnut brown. Nuclear whorls two and one-quarter, well rounded, smooth. Post-nuclear whorls well rounded, slightly shouldered at the summit, marked by poorly developed, slightly protractive, axial ribs, of which 24 occur upon the first and second and 30 upon the penultimate whorl. In addition to these axial ribs the whorls are marked by equal and equally spaced spiral cords, which are almost equal to the axial ribs in strength and of which 6 occur upon the first and 7 upon the second and the penultimate turn between the sutures. The first of these spiral cords is at the summit, which it renders feebly crenulate. The spaces inclosed between the axial ribs and spiral cords are rectangular pits, just a trifle longer than broad, their long axes corresponding to the spiral sculpture. In addition to the above sculpture the entire surface of the spire is marked by exceedingly fine, closely spaced spiral striations and axial lines of growth. Suture moderately impressed. Periphery of the last whorl marked by a sulcus as wide as those which separate the spiral cords on the spire. Base strongly rounded, feebly produced anteriorly, marked by nine equal and equally spaced somewhat flattened spiral cords, which are about as wide as the spaces that separate them, and the fine sculpture noted for the spire. Aperture broadly ovate; posterior angle obtuse; outer lip thin, showing the external sculpture within; inner lip strongly curved, slightly reflected over and appressed to the base; parietal wall covered with a thick callus.

The specimen described and figured is a perfect individual (Cat. No. 204018, U.S.N.M.) and was collected in Bear Bay, Peril Strait, Baranoff Island, Alaska. It has 4 post-nuclear whorls and measures: Length 3 mm., diameter 1.7 mm. Doctor Carpenter's cotypes, four specimens (Cat. N. 4338, U.N.S.M.), come from Puget Sound, Washington. None of these is as perfect as the specimen described and figured.

Specimens examined.

Catalogue No.	Locality.	Number of specimens.
160992.....	Port Etches, Alaska.....	1
206308.....	Virgin Bay, Prince William Sound, Alaska.....	3
204018 (figured).....	Bear Bay, Peril Strait, Baranoff Island, Alaska.....	1
204040.....	Windfall Harbor, Alaska.....	2
107442.....	Cumshewa Inlet, Queen Charlotte Island, Alaska (10-15 fathoms).....	3
213692.....	Saturnia Island, British Columbia (in crop of Harelda).....	17
203959.....	Saturnia Island, British Columbia (in duck crop).....	1
126650.....	Victoria, Vancouver Island, British Columbia.....	9
211610.....	Barkley Sound, Vancouver Island, British Columbia.....	160
15518.....	Neah Bay, Washington.....	7
4338 (cotypes).....	Puget Sound, Washington.....	4

ALVANIA ACUTILIRATA Carpenter.

Plate 31, fig. 3.

Rissoa acutilirata CARPENTER, Proc. Cal. Acad. Sci., vol. 3, 1866, p. 217.

Shell small, ovate, yellowish white, with the base of the columella and the posterior angle of the aperture purplish chestnut brown. Nuclear whorls two and one-half, small, strongly rounded, smooth. Post-nuclear whorls very feebly shouldered at the summit, marked by regular, slender, slightly protractive, axial ribs, which are about half as wide as the spaces that separate them. Of these ribs 24 occur upon the first, 22 upon the second, and 20 upon the penultimate turn. In addition to the axial ribs, the whorls are marked by slender spiral cords which are a little more than half as strong as the axial ribs, and about half as wide as the spaces that separate them. Of these cords, 6 occur between the sutures on the first, and 7 on the second and the penultimate turn. The spaces inclosed between the axial ribs and the spiral cords are elongated pits, having their long axes parallel to the spiral sculpture. Suture well impressed. Periphery of the last whorl marked by a well-rounded, spiral cord, at the posterior edge of which the axial ribs terminate. Base well rounded, feebly produced anteriorly, marked by 8 spiral cords, which grow successively weaker and more closely spaced from the periphery to the umbilical region. Aperture broadly oval; posterior angle acute; outer lip rather thin at the edge, thinner within, showing the external sculpture within; inner lip moderately stout, strongly curved and reflected over and appressed to the base; parietal wall covered with a thick callus, rendering the peritreme complete.

The specimen described and figured (Cat. No. 153072, U.S.N.M.) comes from San Diego Bay, California. It has 3 post-nuclear whorls and measures: Length 2.3 mm., diameter 1.2 mm.

Specimens examined.

Catalogue No.	Locality.	Number of specimens.
195335.....	Monterey, California.....	1
213693.....	San Pedro, California.....	30
152195.....	Do.....	1
129005.....	San Diego, California.....	7
153072 (figured).....	San Diego Bay, California (drift).....	1
213694.....	United States Bureau of Fisheries station 2932, Los Coronados Island, California (20 fathoms, 58°, gray sand and broken shell bottom).	4
198958.....	Todos Santos Bay, Lower California.....	1

ALVANIA COSMIA, new species.

Plate 31, fig. 4.

Shell small, elongate-ovate, white, semitranslucent. Nuclear whorls one and one-half, marked by four, moderately strong, spiral lirations which are separated by strongly impressed lines. Post-

nuclear whorls appressed at the summit, strongly, slopingly shouldered, the shoulder extending from the summit to the anterior termination of the posterior third between the sutures, marked by two strong nodulose, spiral keels, of which the first is situated on the angle of the shoulder, while the second is about as far posterior to the suture as the first is anterior to the summit. In addition to these spiral keels, the whorls are marked by moderately strong, axial ribs which become enfeebled on the shoulder and anterior to the second keel. Of these ribs, 16 occur upon the first and second, and 18 upon the penultimate turn. The spaces inclosed between the spiral keels and axial ribs are large, deeply impressed, squarish pits, while their junctions form cusplike tubercles. Suture strongly channeled. Periphery of the last whorl marked by a strong, sublamellar, spiral keel. Base moderately long, marked by three spiral keels, which grow successively weaker and closer spaced from the periphery to the umbilical area. The broad spaces between the spiral keels are marked by slender, axial lines of growth. Aperture broadly ovate; posterior angle obtuse; outer lip reenforced immediately behind the edge by a strong varix, transparent, showing the external sculpture within; inner lip rather stout, decidedly curved, and strongly reflected over and appressed to the base; parietal wall covered with a thick callus which renders the peritreme complete.

The type (Cat. No. 213698, U.S.N.M.) comes from San Pedro, California. It has $3\frac{1}{2}$ post-nuclear whorls and measures: Length 2.2 mm., diameter 1.2 mm. Cat. No. 162661, U.S.N.M., contains one specimen from La Jolla, California, and Cat. No. 162664, U.S.N.M., contains one from San Martin Island, Lower California.

ALVANIA PURPUREA Dall.

Plate 31, fig. 1.

Alvania purpurea DALL, Amer. Journ. Conch., vol. 7, 1872, pp. 116-17.

Shell elongate-ovate, light yellow. Nuclear whorls one and one-half, well rounded, very finely papillose. Post-nuclear whorls appressed at the summit, strongly, slopingly shouldered, marked by lamellar, slightly retractive, axial ribs, of which 18 occur upon the first and second, and 20 upon the penultimate turn. In addition to these axial ribs, the whorls are marked between the sutures by two spiral lamellæ which divide the space between the sutures into two almost equal portions, the one at the summit being a little narrower than the other. The junctions of the axial and spiral sculpture form spiral cusps, while the spaces inclosed between them are broadly rectangular pits, having their long axes parallel with the axial sculpture. The spaces inclosed between the summit, the first spiral lamella, and the axial ribs are rhomboidal, while those between the second spiral lamella, the suture, and the axial ribs are very broadly rhomboidal.

The sloping shoulder extends from the summit to the first spiral lamella. Suture strongly channeled. Periphery of the last whorl marked by a spiral cord, to which the axial ribs extend. Base moderately produced, well rounded, marked by three strong, sublamellar, subequal, spiral cords which divide the base into four equal parts. These cords are about one-fourth as wide as the concave spaces that separate them, which are marked by fine incremental lines only. Aperture broadly, regularly oval, slightly effuse anteriorly; posterior angle obtuse; outer lip thin at the edge, thicker within; inner lip strongly curved and reflected over, and appressed to the base; parietal wall covered with a thick callus, rendering the peritreme complete.

The specimen described and figured (Cat. No. 152193, U.S.N.M.) is a little more perfect than Doctor Dall's cotypes. It has almost 4 post-nuclear whorls and measures: Length 2.6 mm., diameter 1.4 mm.

Specimens examined.

Catalogue No.	Locality.	Number of specimens.
56416 (cotypes).....	Monterey, California.....	2
46173.....	Do.....	1
152193 (figured).....	San Pedro, California.....	3
129005.....	San Pedro and San Diego, California.....	3
134856.....	San Diego, California (on kelp root).....	6
105468.....	San Diego, California.....	12
213695.....	United States Bureau of Fisheries station 2932, Los Coronados Island, California (20 fathoms, 58°, gray sand and broken shell).	1
162665.....	San Martin Island, Lower California.....	1

ALVANIA HALIA, new species.

Plate 31, fig. 5.

Shell elongate-conic, white. Nuclear whorls one and one-half, well rounded apparently with several spiral lirations, which are ill-defined on the somewhat eroded surface of our shells. Post-nuclear whorls shouldered at the summit, ornamented by strong, axial ribs, of which 14 occur upon the second, 16 upon the third, and 20 upon the penultimate turn. These ribs extend strongly from the summit of the whorls to the suture. In addition to the axial ribs, the whorls are marked by three spiral cords which are about half as wide as the spaces that separate them. The first of these cords is at the angle of the shoulder near the summit, the second on the middle of the whorl, while the third is immediately above the deeply channeled suture. The intersections of the axial ribs and spiral cords form strong tubercles, while the spaces inclosed between them are deeply impressed, squarish pits. Periphery of the last whorl marked by a sulcus which is almost as wide as that separating the supraperipheral from the median cord and, like it, is crossed by the continuations of the axial

ribs. Base attenuated anteriorly, marked by five strong, spiral cords which are almost equal. The spaces separating these cords are a little narrower than the cords and are crossed by axial lines of growth. Aperture very oblique, ovate; posterior angle obtuse; outer lip very much thickened by an external varix; inner lip very stout, very strongly curved, reflected over, and appressed to the base; parietal wall covered with a thick callus which renders the peritreme complete.

The type has 4 post-nuclear whorls and measures: Length 2.4 mm., diameter 1.1 mm. It and 16 other specimens (Cat. No. 195009, U.S.N.M.) were dredged by the United States Bureau of Fisheries steamer *Albatross* at station 2813 in 40 fathoms, on coral sand bottom, bottom temperature 81°, off Galapagos Islands.

ALVANIA IMA, new species.

Plate 32, fig. 8.

Shell elongate-ovate, white excepting a broad, yellow band which encircles the periphery and shows above the suture on all the turns. Nuclear whorls at least two, smooth. Post-nuclear whorls narrowly, slopingly shouldered at the summit, marked by strong, protractive, axial ribs, of which 14 occur upon the first, 18 upon the second, and 20 upon the penultimate turn. In addition to the axial ribs, the whorls are marked between the sutures by three spiral cords, of which the first—which is quite slender—is at the summit; the second, which is very broad, being double the width of the next, is on the middle of the whorl; while the third, which is a little stronger than the first, forms the posterior border of the deeply channeled suture. The space separating the first cord from the median one is about as wide as the median cord, while that which separates the median from the third is equal to the third cord. The intersections of the axial ribs and spiral cords form tubercles which are small and rounded on the first cord; on the second they are truncated posteriorly, sloping gently anteriorly, somewhat flattened and enlarged; on the third they are somewhat flattened, truncated posteriorly and gently rounded anteriorly. The weak cord at the summit and the broad space immediately below it give to the whorls a constricted appearance at this point. Periphery of the last whorl marked by a deep sulcus across which the axial ribs do not extend. Base well rounded, produced anteriorly, marked by five spiral cords, which grow successively weaker from the periphery to the columella. Aperture very oblique; posterior angle obtuse; outer lip thin at the edge, reenforced immediately behind the edge by a strong varix; inner lip stout, strongly curved, and reflected over, and appressed to the base.

The type and two other specimens (Cat. No. 213697, U.S.N.M.) were dredged by the United States Bureau of Fisheries steamer

Albatross at station 2813 in 40 fathoms, on coral sand bottom, bottom temperature 81°, Galapagos Islands. The type has 4 post-nuclear whorls and measures: Length 2 mm., diameter 1.2 mm.

ALVANIA CLARIONENSIS, new species.

Plate 32, fig. 4.

Shell very elongate-ovate, milk white. Nuclear whorls one and one-third, well rounded, smooth. Post-nuclear whorls strongly, concavely shouldered at the summit on all but the last turn, where the summit is rounded. Beginning with the posterior termination of the anterior fourth between the sutures, the shell slopes suddenly toward the suture, forming a strong angle at the widest portion of each whorl. In addition to the above, the whorls are marked by strong, decidedly protractive, axial ribs which are about one-fourth as wide as the spaces that separate them. Of these ribs, 14 occur upon the first, 16 upon the second, 18 upon the third and the penultimate turn. In addition to the axial sculpture, the whorls are marked by slender, spiral lirations of which the one at the suprasutural angle is the strongest, the rest being equal. Of these cords, only the one marking the suprasutural angle is present on the first turn, while on the second a slender cord bounds the channeled summit and a few feeble lirations are indicated between this and the strong suprasutural cord; on the third turn five spiral lirations are apparent between the summit and the suprasutural cord. The space between the suprasutural cord and the suture appears to be devoid of sculpture on the first three whorls; on the penultimate whorl the supraperipheral angle and the shoulder at the summit are lost, and the six spiral cords which appear between the summit and the periphery are about half as wide as the spaces that separate them, being equal and equally spaced and much stronger than on the preceding turn. Here, too, the first two basal cords become apparent in the suture. All the junctions of the spiral cords and axial ribs are feebly tuberculated, excepting those formed by the suprasutural cord and the ribs; these are strongly tuberculated on the first three whorls. On the last whorl the spiral cords appear superimposed upon the axial ribs. Suture decidedly channeled. Periphery of the last whorl marked by a broad sulcus which bears two raised, spiral threads. The first basal cord being considerably more elevated than the sulcus, lends the anterior edge of the base an angular aspect. Base decidedly produced, weakly rounded, marked by eight equal and equally spaced spiral cords, which are about one-third as wide as the spaces that separate them. Aperture very oblique, effuse anteriorly; posterior angle obtuse; outer lip thin at the edge, reenforced immediately behind the edge by a very strong varix; inner lip very stout, reflected over and appressed to the base;

parietal wall covered with a thick callus which renders the peristome complete.

The type (Cat. No. 127373, U.S.N.M.) was dredged by the United States Bureau of Fisheries steamer *Albatross* off Clarion Island, Mexico, in one of the five hauls—2991 to 2995, the depths of which ranged from 31 to 460 fathoms. It has $4\frac{1}{2}$ post-nuclear whorls and measures: Length 2.9 mm., diameter 1.3 mm.

ALVANIA LARA, new species.

Plate 32, fig. 6.

Shell elongate-ovate, white. Nuclear whorls decollated, excepting the last quarter turn, which is smooth. Post-nuclear whorls shouldered at the summit, marked by lamellar spiral keels, of which three occur between the sutures on the first turn. Of these, the suprasutural one is decidedly the strongest and gives a very strongly pronounced angle to the whorls. The keel immediately below the summit is next in strength, while the one between them—which is nearer the suprasutural one than the one at the summit—is but feebly expressed. On the second whorl an additional spiral cord makes its appearance at the summit, while the two anterior to it gain considerably in strength and become equal; the suprasutural one remains strong and an additional slender cord makes its appearance halfway between the strong suprasutural cord and the suture. On the penultimate whorl the cord at the summit has increased in size to equal the cord adjacent to it, and a slender thread appears in the space which separated the second cord from the third on the preceding turn. The strong cord on the preceding turn becomes considerably enfeebled and the space between this and the suture is crossed by two rounded, slender, spiral cords. In addition to the spiral sculpture, which exceeds the axial sculpture in strength, the whorls are marked by rather strong, almost vertical, axial ribs, of which 14 occur upon the first and second, and 16 upon the penultimate turn. The intersections of the spiral cords and axial ribs form compressed tubercles, having their long axes parallel to the spiral sculpture. Suture strongly channeled. Periphery of the last whorl decidedly channeled, the posterior edge of the base being suddenly truncated at the channeled suture, which makes the peripheral sulcus appear as a triangular notch in profile. Base moderately long, attenuated anteriorly, marked by eight spiral cords, the posterior of which is the strongest and is followed by three very slender threads which in turn are succeeded by two strong and two low feeble cords. Aperture oblique, oval; posterior angle obtuse; outer lip thin at the edge, reenforced immediately behind the edge by a strong varix; inner lip oblique, stout, curved and somewhat reflected over, and appressed to the base; parietal wall covered by a moderately thick callus.

The type (Cat. No. 195010, U.S.N.M.) was dredged by the United States Bureau of Fisheries steamer *Albatross* at station 2813, in 40 fathoms, on coral sand bottom, bottom temperature 81°, off Galapagos Islands. It has almost 4 post-nuclear whorls and measures: Length 2.5 mm., diameter 1.3 mm.

ALVANIA EFFUSA Carpenter.

Plate 32, fig. 5.

Alvania effusa CARPENTER, Cat. Maz. Shells, 1856, p. 359.

Shell elongate-conic. Nuclear whorls two, smooth, well rounded. Post-nuclear whorls well rounded, marked by strongly developed narrow, almost vertical, axial ribs of which 14 occur upon the first, 16 upon the second to fourth, and 22 upon the penultimate turn. In addition to the axial ribs, the whorls are marked by spiral cords, of which two appear upon the first whorl, dividing this into three equal spaces, three upon the second, four upon the third, five upon the fourth, and seven upon the penultimate turn, between the sutures. The junctions of the axial ribs and spiral cords form strong cusps, while the spaces inclosed between them are rectangular pits, having their long axes parallel with the spiral sculpture. Suture strongly channeled. Periphery of the last whorl marked by a spiral sulcus, which is about as wide as the sulci occurring between the cords on the last turn of the spire. Base produced anteriorly, moderately rounded, marked by the feeble continuations of the axial riblets and five spiral cords. Aperture oval; posterior angle obtuse; outer lip rendered sinuous by the external sculpture; inner lip strong, curved, slightly reflected over, and appressed to the base; parietal wall covered with a thick callus which renders the peritreme complete.

The unique type of this species, contained on Tablet 1710, Liverpool Collection, British Museum, was taken from *Spondylus* at Mazatlan. It has six post-nuclear whorls and measures: Length 2.9 mm., diameter 1.5 mm.

ALVANIA ÆQUISCULPTA Keep.

Plate 32, fig. 7.

Alvania æquisculpta KEEP, West Coast Shells, 1887, p. 65=*Rissoa* (*Alvania*) *grippiana* DALL, Nautilus, vol. 21, No. 12, 1908, p. 136.

Shell very elongate-conic, light yellow. Nuclear whorls two, moderately well rounded, marked by six spiral threads, which are about as wide as the spaces that separate them, and numerous slender, closely spaced, axial threads, which are about one-fourth as strong as the spiral threads between which they occur, giving the entire surface a finely reticulated appearance. Post-nuclear whorls appressed at the summit, with a sloping shoulder which extends

over the posterior fourth between the sutures, marked by strong, slightly retractive, axial ribs which are about one-fourth as wide as the spaces that separate them. Of these ribs, 14 occur upon the first, 16 upon the second, and 18 upon the penultimate turn. In addition to the axial ribs, the whorls are marked between the sutures by three strong, spiral cords which are almost as strong as the ribs and divide the spaces between the sutures into four almost equal portions. The intersections of the spiral cords and the axial ribs form strong tubercles, while the spaces inclosed between them are well impressed, rectangular pits, having their long axes parallel with the spiral sculpture. Suture strongly constricted. Periphery of the last whorl marked by a spiral sulcus equal to that which separates the supraproperipheral spiral cord from its posterior neighbor and, like it, is crossed by the continuations of the axial ribs, which extend over the first two basal spiral cords and render them tuberculate. Base well rounded, rather short, produced anteriorly, marked by three strong, sublamellar, spiral cords which are about one-third as wide as the spaces that separate them. Aperture very oblique, twisted, ovate; posterior angle obtuse; outer lip thickened at the edge within the lip, reenforced behind the edge by a strong varix, inner lip very stout, strongly curved, and appressed to the base; parietal wall covered with a very thick callus, which renders the peritreme complete.

Professor Keep's cotypes were collected on mossy rocks at low tide at San Diego, California. One of these, the specimen figured, is Cat. No. 219564, U.S.N.M. This has 4 post-nuclear whorls and measures: Length 3.2 mm., diameter 1.8 mm.

Specimens examined.

Catalogue No.	Locality.	Number of specimens.
56752.....	Catalina Island, California.....	1
23749.....	Santa Barba Island, California.....	1
126624.....	San Pedro, California.....	4
56369.....	San Diego, California.....	20
153073.....	San Diego Bay, California (drift).....	1
213696.....	United States Bureau of Fisheries station 2932, Los Coronados Island, California (20 fathoms, 58°, gray sand and broken shell).....	4
46171.....	Todos Santos Bay, Lower California.....	42
46172.....	do.....	4
56353.....	do.....	8

ALVANIA ALMO, new species.

Plate 32, fig. 1.

Shell minute, broadly ovate, yellowish white. Nuclear whorls one and one-half, well rounded, smooth. Post-nuclear whorls somewhat inflated, slopingly shouldered at the summit, marked by very slender, almost vertical, axial ribs, of which 18 occur upon the first, and 20

upon the penultimate turn. In addition to the axial sculpture, the whorls are marked between the sutures by two spiral cords equaling the ribs in strength. Of these, the first is a little posterior to the middle of the whorls, bounding the sloping shoulder, while the second is halfway between it and the suture. The intersections of the axial ribs and spiral cords form slender tubercles, while the spaces inclosed between them are well impressed, squarish pits. The spaces inclosed between the first spiral cord and the summit and the axial ribs are rhomboidal areas, having their long axes parallel to the axial sculpture, while the spaces inclosed between the second spiral cord and the axial ribs and the suture are squarish pits. Suture moderately constricted. Periphery of the last whorl marked by a spiral sulcus, which is crossed by the continuations of the axial ribs. Base narrowly umbilicated—the umbilical chink being bounded by a tumid area—moderately long, well rounded, slightly produced anteriorly, marked on the posterior half by two spiral cords equaling those between the sutures. Aperture almost circular; outer lip very thick all around, reenforced by a strong varix; inner lip very stout, partly reflected over, and appressed to the base; parietal wall covered with a very thick callus which renders the peritreme complete.

The type (Cat. No. 23749*a*, U.S.N.M.) comes from Santa Barbara Island, California. It has three post-nuclear whorls and measures: Length 1.5 mm., diameter 1 mm.

ALVANIA OLDROYDÆ, new species.

Plate 32, fig. 3.

Shell minute, broadly ovate, yellowish white. Nuclear whorls one and one-half, well rounded, smooth. Post-nuclear whorls inflated, weakly shouldered on the posterior fourth between the sutures, marked by numerous slender rather closely spaced well rounded slightly protractive axial ribs, of which 20 occur upon the first, 24 upon the second, and 28 upon the penultimate whorl. In addition to the axial sculpture, the whorls are marked by slender spiral threads which are almost equal to the axial ribs. Of these threads, three occur upon the first and second whorl, dividing the space between the sutures into four almost equal portions, the space at the summit being a little wider than the rest; the first spiral thread marks the termination of the sloping shoulder. On the penultimate whorl an additional spiral cord makes its appearance in the space immediately below the summit, a little nearer to the summit than the first spiral cord on the previous whorl. The intersections of the axial ribs and the spiral cords form slender rounded tubercles. The spaces inclosed between the three cords on the early whorls and the same on the last turn are squarish pits, while the spaces between the summit and the first spiral cord and the axial ribs on the first two turns are rectangular pits, having their long axes parallel

with the axial sculpture. On the last whorl an additional spiral cord renders the pits between this cord and the next spiral cord and the axial ribs also squarish. Suture strongly constricted. Periphery of the last whorl marked by a sulcus as wide as that separating the suprasutural cord from the one adjacent to it anteriorly. Base well rounded, strongly umbilicated, marked by four equal and almost equally spaced spiral cords, which are as strong as those occurring between the sutures and the feeble continuations of the axial ribs. Aperture subcircular; outer lip thickened all around by a very thick varix; inner lip stout, decidedly curved, somewhat reflected over and appressed to the base; parietal wall covered with a very thick callus, which renders the peritreme complete.

The type and another specimen (Cat. No. 213699, U.S.N.M.) come from San Pedro, California. The type has three post-nuclear whorls, and measures: Length 1.6 mm., diameter 1.05 mm. Cat. No. 152193*a*, U.S.N.M., contains one specimen from San Pedro, California; and Cat. No. 226454, U.S.N.M., two from 3 fathoms, off South Coronado Island. Ten more from the same locality are in Doctor Baker's collection.

Named for Mrs. T. S. Oldroyd.

ALVANIA TUMIDA Carpenter.

Plate 32, fig. 2.

Alvania tumida CARPENTER, Cat. Maz. Shells, 1856, p. 360.

Shell minute, subglobose, chestnut brown excepting the columella and the edge of the outer lip, which are light yellow. Nuclear whorls one and one-third, well rounded, very minutely papillose. Post-nuclear whorls inflated, slopingly shouldered at the summit, well rounded, ornamented with slender, almost vertical, axial riblets, of which 24 occur upon the first and 30 upon the penultimate turn. In addition to the axial riblets, the whorls are marked by four spiral cords, of which the first, which is at the summit, is very feeble; the remaining three, which equal the axial ribs in strength, divide the space between the sutures into four equal parts. The spaces inclosed between the axial riblets and the spiral cords are squarish pits, while their junctions are very feebly, roundly tuberculate. Suture moderately constricted. Periphery of the last whorl marked by a slender spiral thread, equaling those between the sutures in strength. The space between it and the suprasutural cord is crossed by the continuations of the axial riblets. Base narrowly umbilicated, well rounded, slightly inflated, marked by two spiral cords which equal the peripheral one. The spaces between the cords are about four times as wide as the cords and are crossed by the continuations of the axial riblets. The umbilical chink is bordered by a narrow tumid area. Aperture subcircular; outer lip thick at the edge, reenforced by a varix; inner lip decidedly curved, somewhat reflected over, and

appressed to the base; parietal wall covered with a thick callus, which renders the peritreme complete.

The specimen described and figured (Cat. No. 16206, U.S.N.M.) comes from Cape San Lucas, Lower California. It has $2\frac{1}{2}$ post-nuclear whorls, and measures: Length 1.2 mm., diameter 0.7 mm. The type and another specimen are on Tablet 1711, Liverpool Collection, British Museum. They were taken off *Spondylus*, Mazatlan.

EXPLANATION OF PLATES.

PLATE 29.

- Fig. 1. *Alvania castanella* Dall; Type; length 2.4 mm.; p. 336.
 2. *Alvania bakeri* Bartsch; Type; length 1.4 mm.; p. 337.
 3. *Alvania lirata* Carpenter; length 2.8 mm.; p. 338.
 4. *Alvania pedroana* Bartsch; Type; length 2.2 mm.; p. 341.
 5. *Alvania aurivillii* Dall; Type; length 4.2 mm.; p. 336.
 6. *Alvania albolirata* Carpenter; Type; length 3 mm.; p. 338.
 7. *Alvania trachisma* Bartsch; Type; length 3.3 mm.; p. 339.
 8. *Alvania carpenteri* Weinkauff; Type; length 2 mm.; p. 341.
 9. *Alvania californica* Bartsch; Type; length 2.5 mm.; p. 340.

PLATE 30.

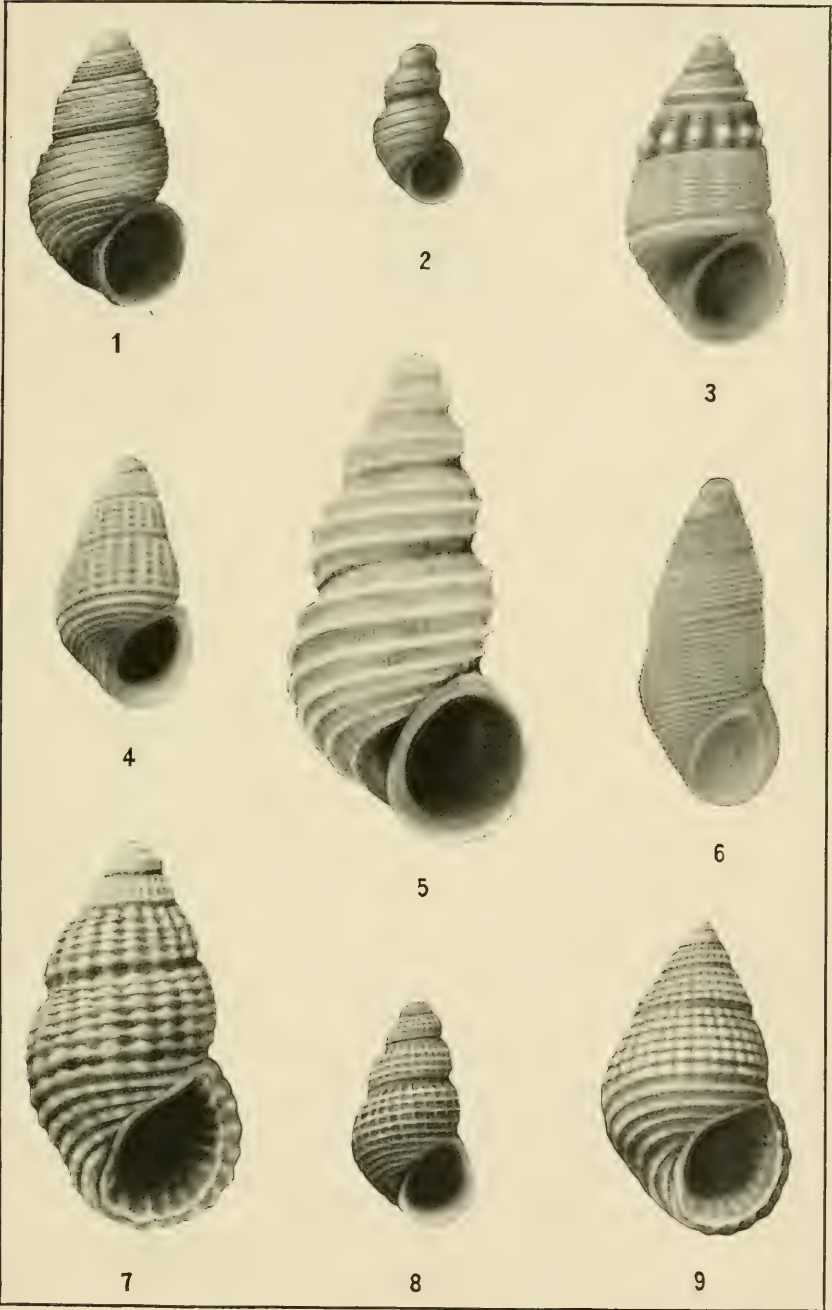
- Fig. 1. *Alvania alaskana* Dall; Type; length 2.9 mm.; p. 343.
 2. *Alvania montereyensis* Bartsch; Type; length 2.3 mm.; p. 343.
 3. *Alvania hoodensis* Bartsch; Type; length 2.5 mm.; p. 345.
 4. *Alvania electrina* Carpenter; Type; length 2.7 mm.; p. 346.
 5. *Alvania profundicola* Bartsch; Type; length 3.2 mm.; p. 345.
 6. *Alvania excurvata* Carpenter; Type; length 2.8 mm.; p. 344.
 After a camera lucida sketch by Doctor Carpenter.
 7. *Alvania filosa* Carpenter; Type; length 3.5 mm.; p. 342.
 8. *Alvania nemo* Bartsch; Type; length 2.6 mm.; p. 348.
 9. *Alvania galapagensis* Bartsch; Type; length 3.3 mm.; p. 347.

PLATE 31.

- Fig. 1. *Alvania purpurea* Dall; length 2.6 mm.; p. 353.
 2. *Alvania iliuliukensis* Bartsch; Type; length 3 mm.; p. 350.
 3. *Alvania acutilirata* Carpenter; Type; length 2.3 mm.; p. 352.
 4. *Alvania cosmia* Bartsch; Type; length 2.2 mm.; p. 352.
 5. *Alvania halia* Bartsch; Type; length 2.4 mm.; p. 354.
 6. *Alvanis rosana* Bartsch; Type; length 2.6 mm.; p. 349.
 7. *Alvania compacta* Carpenter; Type; length 3 mm.; p. 351.
 8. *Alvania fossilis* Bartsch; Type; length 2 mm.; p. 349.

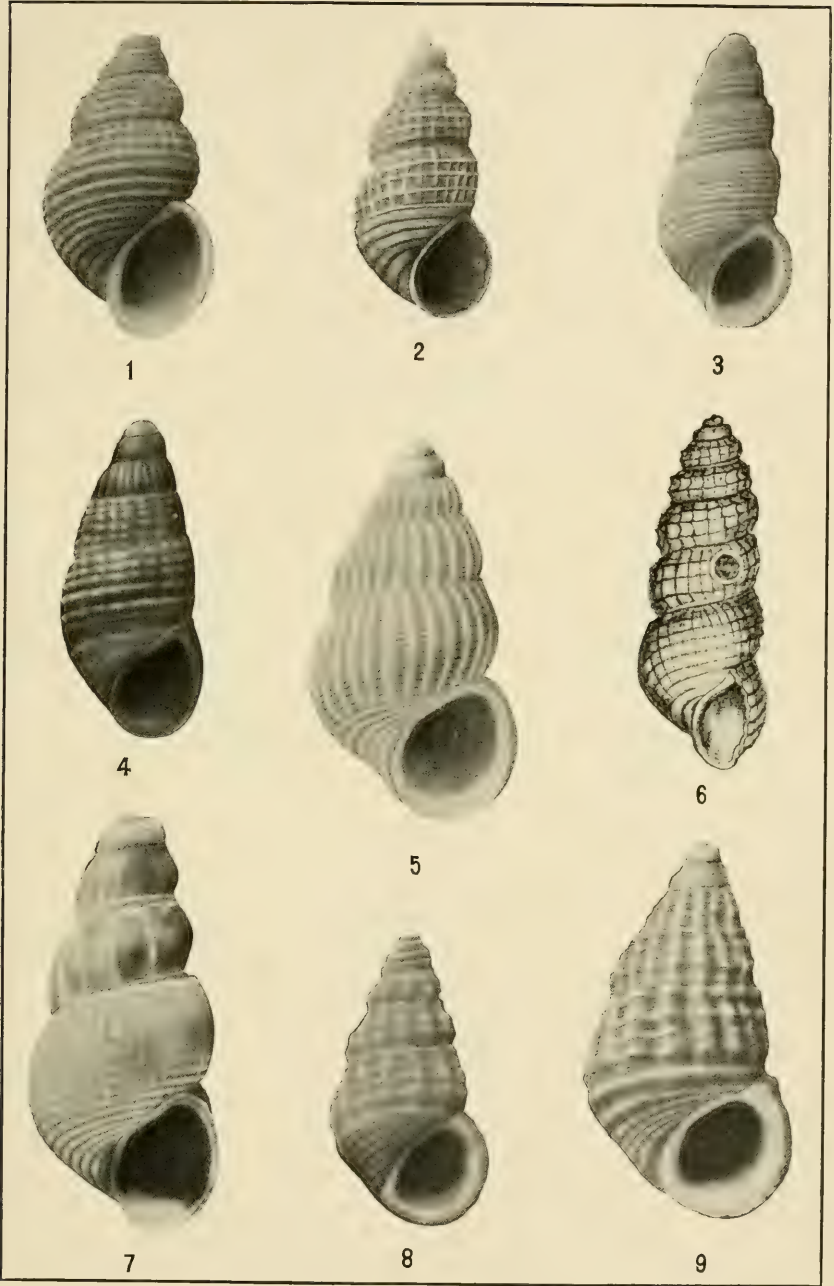
PLATE 32.

- Fig. 1. *Alvania almo* Bartsch; Type; length 1.5 mm.; p. 359.
 2. *Alvania tumida* Carpenter; length 1.2 mm.; p. 361.
 3. *Alvania oldroydæ* Bartsch; Type; length 1.6 mm.; p. 360.
 4. *Alvania clarionensis* Bartsch; Type; length 2.9 mm.; p. 356.
 5. *Alvania effusa* Carpenter; Type; length 2.9 mm.; p. 358.
 After a camera lucida sketch by Doctor Carpenter.
 6. *Alvania lara* Bartsch; Type; length 2.5 mm.; p. 357.
 7. *Alvania æquisculpta* Keep; Type; length 3.2 mm.; p. 358.
 8. *Alvania ima* Bartsch; Type; length 2 mm.; p. 355.



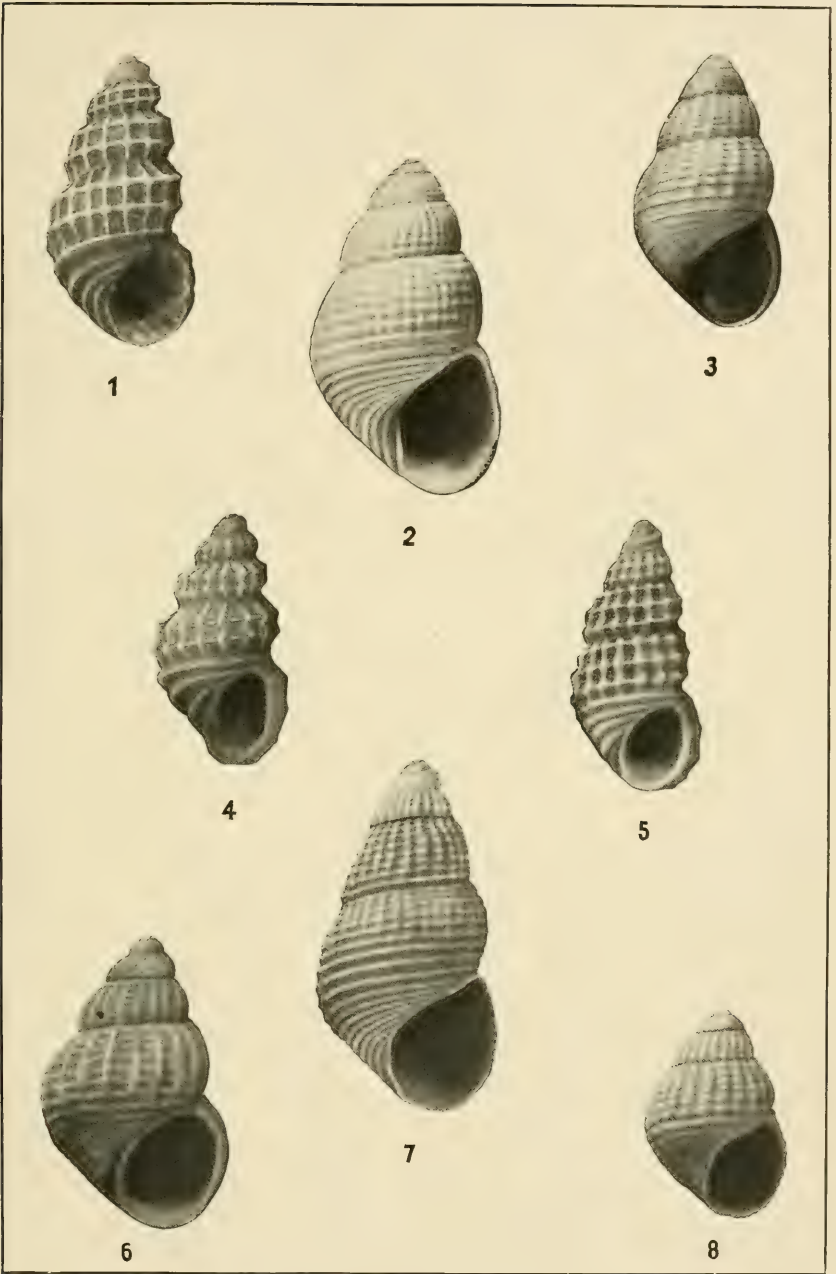
WEST AMERICAN ALVANIA.

FOR EXPLANATION OF PLATE SEE PAGE 362.



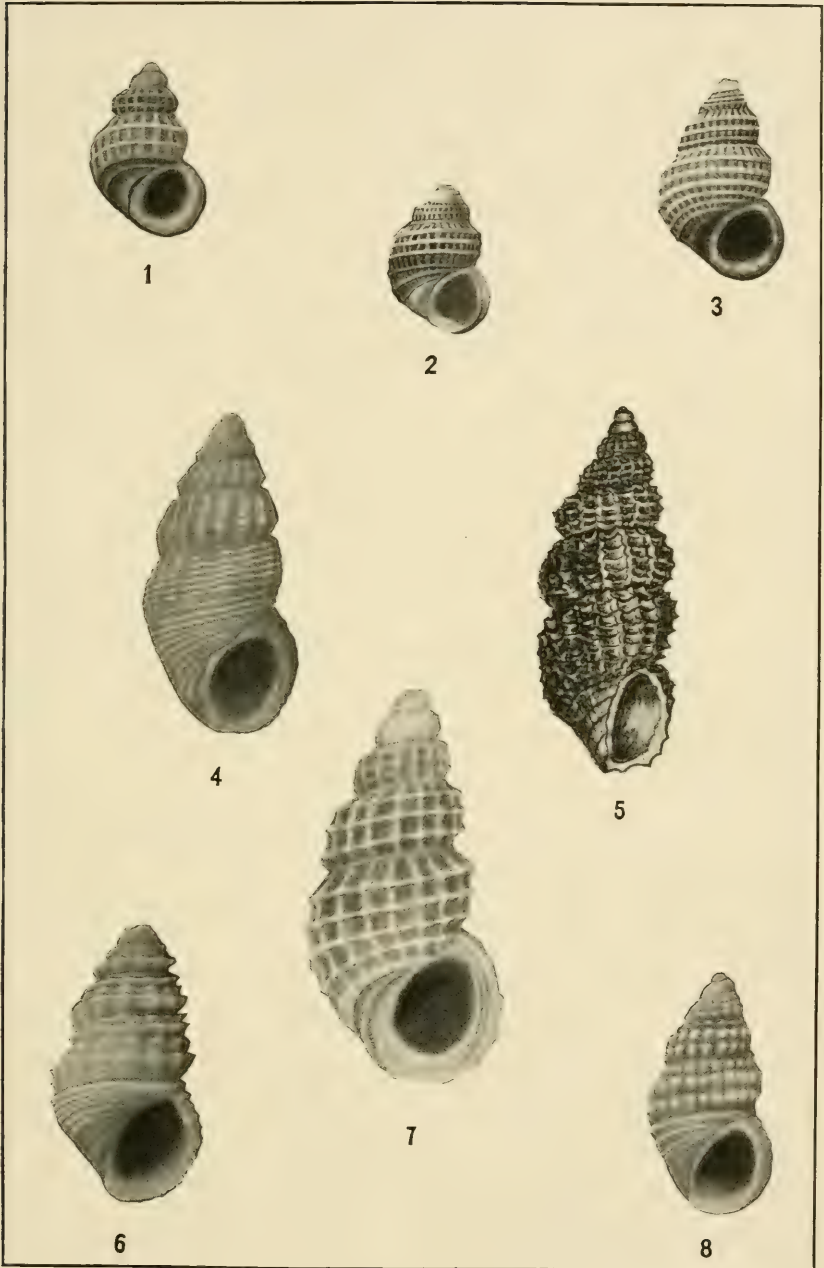
WEST AMERICAN ALVANIA.

FOR EXPLANATION OF PLATE SEE PAGE 362.



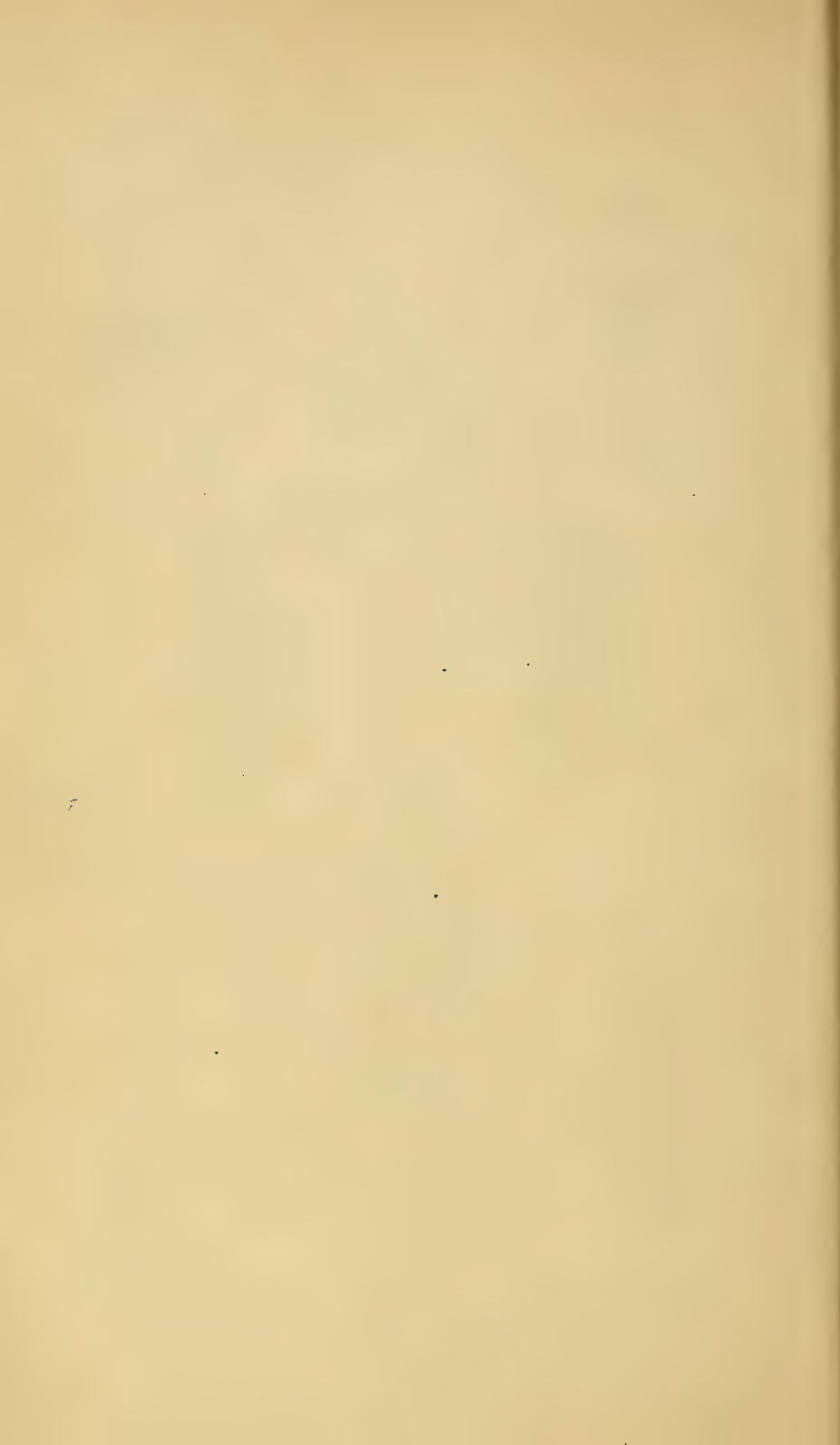
WEST AMERICAN ALVANIA.

FOR EXPLANATION OF PLATE SEE PAGE 362.



WEST AMERICAN ALVANIA.

FOR EXPLANATION OF PLATE SEE PAGE 362.



TWO NEW SPECIES OF PARASITIC NEMATODES.

By BRAYTON HOWARD RANSOM,

Assistant Custodian, Helminthological Collections, United States National Museum.

Since Looss (1905) established the genus *Trichostrongylus* to include the species *T. retortiformis* (type), *T. instabilis*, *T. vitrinus*, and *T. probolurus*, several other species have been added from time to time by various authors. Including the two species described in the present paper, the complete list, with hosts and geographic distribution, is as follows:

T. retortiformis (Zeder, 1800) Looss, 1905; rabbits; Europe.

T. instabilis (Railliet, 1893) Looss, 1905; man, baboon, ruminants; Africa, Europe, Japan, United States, (?) India. (This and the next following species are perhaps identical.)

T. colubriformis (Giles, 1892) Ransom, 1911; sheep; India.

T. vitrinus Looss, 1905; man, ruminants; Europe, Africa, United States.

T. probolurus (Railliet, 1896) Looss, 1905; man, ruminants; Africa, Europe, United States.

T. extenuatus (Railliet, 1898) Ransom, 1907; ruminants; Europe, United States, Australia.

T. capricola Ransom, 1907; ruminants; United States.

T. axei (Cobbold, 1879) Railliet and Henry, 1909; horse, ass; Europe.

T. falculatus Ransom, 1911; goat; Portuguese East Africa.

T. calcaratus Ransom, 1911; rabbit; United States.

T. pergracilis (Cobbold, 1873) Shipley, 1908; grouse; Europe.

T. tenuis (Eberth, 1861) Railliet and Henry, 1909; geese; Europe.

Strongylus quadriradiatus Stevenson, 1904, and *Strongylus nodularis* Rudolphi, 1809, which Shipley (1909) has placed in *Trichostrongylus*, are widely different from the type and should be excluded from this genus.

Family STRONGYLIDÆ Cobbold, 1864.

Subfamily TRICHOSTRONGYLINÆ Leiper, 1908.

Genus TRICHOSTRONGYLUS Looss, 1903.

For generic diagnosis, see Looss (1905) or Ransom (1911, p. 86).

TRICHOSTRONGYLUS FALCULATUS, new species.

Specific diagnosis.—*Trichostrongylus*: Male 4.6 mm. long by 80 μ in maximum thickness (at base of bursa). Latero-ventral (*l. v.*, fig. 1) and externo-lateral rays (*e. l.*, fig. 1) of bursa about equal in width, wider than any of the other rays. Medio-lateral ray (*m. l.*, fig. 1) about two-thirds the width of the latero-ventral or the externo-lateral ray. Posterolateral ray (*p. l.*, fig. 1) slightly narrower than the medio-lateral ray, curves dorsally in its distal portion away from the latter. Externodorsal (*e. d.*, fig. 1) and ventro-ventral (*v. v.*, fig. 1) rays narrower than any of the other paired rays. Ventro-ventral ray straight. Externodorsal ray curved dorsally in its distal portion, its tip a considerable distance from the middle of the dorsal ray, but nearer to the tip of the

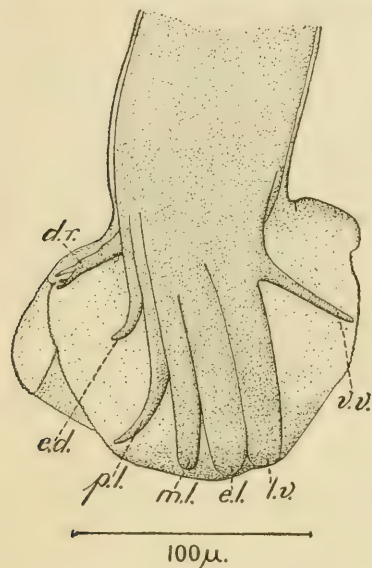


FIG. 1.—TRICHOSTRONGYLUS FALCULATUS. BURSA OF MALE VIEWED FROM RIGHT SIDE. *d. r.*, DORSAL RAY; *e. d.*, EXTERNO-DORSAL RAY; *e. l.*, EXTERNO-LATERAL RAY; *l. v.*, LATERO-VENTRAL RAY; *m. l.*, MEDIO-LATERAL RAY; *p. l.*, POSTERO-LATERAL RAY; *v. v.*, VENTRO-VENTRAL RAY.

postero-lateral ray. Dorsal ray (*d. r.*, fig. 1) bifurcated distally, each branch having a bipartite tip. Spicules (fig. 2) similar in shape and size, 100 μ long, brown in color. An angular projection from the ventral side of each spicule about 60 μ from the anterior end. The terminal portion thus marked off tapers gradually to a point, and is slightly curved ventralward, so that it forms a falciform process 40 μ long. Gubernaculum (fig. 2) similar in color to the spicules, bent almost at a right angle, with the convexity dorsal; distance between the anterior and posterior ends, 50 μ .



FIG. 2.—TRICHOSTRONGYLUS FALCULATUS. SPICULE AND GUBERNACULUM VIEWED FROM RIGHT SIDE.

Female.—Unknown.

Host.—Goat (*Capra hircus*).

Location.—Alimentary tract.

Locality collected.—Pesene, South Africa.

Type-specimens.—Bureau of Animal Industry Helminthological collection, Cat. No. 15980, U.S.N.M., collected August 9, 1908, by C. W. Howard.

About a dozen specimens of males of this species were present among some nematodes labeled as collected from a goat which had been sent by Mr. Howard to the Bureau of Animal Industry, United States Department of Agriculture, for identification. A careful search was made for females, but none could be found. The other nematodes were *Trichostrongylus instabilis*, *Oesophagostomum columbianum*, *Hæmonchus contortus*, *Strongyloides papillosus*, *Gaigeria pachyscelis*, and *Bunostomum trigonocephalum*.

The other known species of *Trichostrongylus* occurring in ruminants are *T. colubriformis*, *T. instabilis* (possibly identical with the preceding), *T. vitrinus*, *T. probolurus*, *T. extenuatus*, and *T. capricola*. *T. falculatus* is readily distinguished from all of these except *T. extenuatus* by the small size of the spicules, *T. falculatus* and *T. extenuatus* being the only species having spicules less than 125 μ in length. Apart from differences which they present in the shape of the spicules, these two species are distinctly different however in that the spicules of *T. falculatus* are equal in size; whereas the spicules of *T. extenuatus* are unequal, the left spicule being considerably longer than the right. The shape of the gubernaculum of *T. falculatus* is another feature marking this species, as none of the other species has a gubernaculum bent in the same manner.

TRICHOSTRONGYLUS CALCARATUS, new species.

Specific diagnosis.—*Trichostrongylus*: Male, 4.7 to 6.6 mm. long. Maximum thickness 100 to 130 μ (at base of bursa). Lateral lobes of

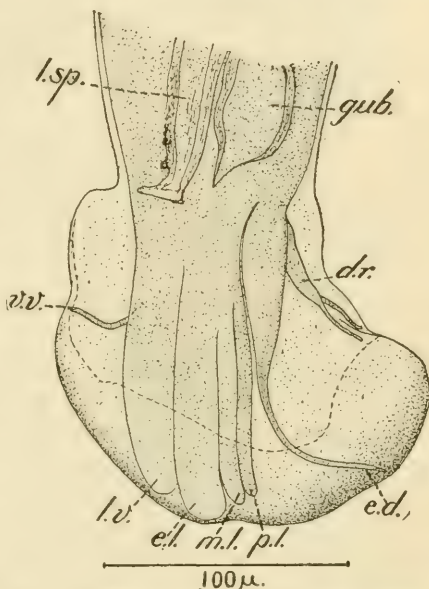


FIG. 3.—TRICHOSTRONGYLUS CALCARATUS. BURSA OF MALE VIEWED FROM LEFT SIDE. *d.r.*, DORSAL RAY; *e.d.*, EXTERNO-DORSAL RAY; *e.l.*, EXTERNO-LATERAL RAY; *gub.*, PORTION OF GUBERNACULUM; *l.sp.*, PORTION OF LEFT SPICULE; *l.v.*, LATERO-VENTRAL RAY; *m.l.*, MEDIO-LATERAL RAY; *p.l.*, POSTERO-LATERAL RAY; *v.v.*, VENTRO-VENTRAL RAY.

bursa, in preserved specimens, tightly curled inward so that it is impossible to spread the bursa out flat. Latero-ventral (*l. v.*, fig. 3) and externo-lateral (*e. l.*, fig. 3) rays closely approximated to one another, about equal in thickness, the former slightly the thicker, each much thicker than the other rays. Ex-

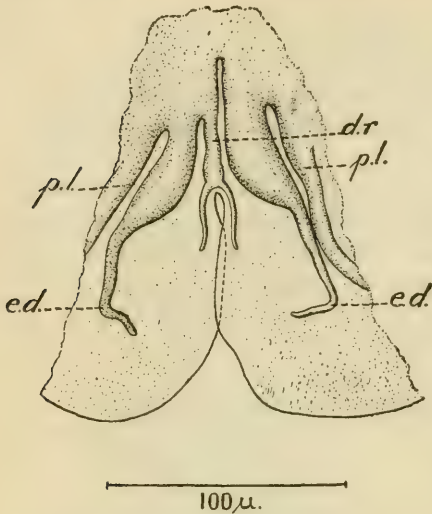


FIG. 4.—*TRICHOSTRONGYLUS CALCARATUS*. PORTION OF BURSA SHOWING ORIGIN OF DORSAL RAY. *d. r.*, DORSAL RAY; *e. d.*, EXTERNO-DORSAL RAY; *p. l.*, PORTION OF POSTERO-LATERAL RAY.

terno-dorsal ray (*e. d.*, figs. 3, 4) long, curving dorsalward in its distal portion; proximally it is thick, distally very slender. Ventro-ventral ray (*v. v.*, fig. 3) slender, of about the same thickness as the distal portion of the externo-dorsal ray. Posterolateral (*p. l.*, figs. 3, 4) and medio-lateral (*m. l.*, fig. 3) rays of about equal thickness, the latter slightly the thicker, less than half as thick as the externo-lateral ray, closely approximated except at their tips, where they diverge slightly, the postero-lateral ray dorsalward and the medio-lateral ray ventralward. Medio-lateral ray closely approximated to the latero-ventral ray. Dorsal ray (*d. r.*, figs. 3, 4) unites at its base with the base of the right externo-dorsal ray; bifurcated distally. The dorsal lobe of the bursa is not distinct from the lateral lobes, and is deeply emarginate between the distal branches of the dorsal ray (fig. 4). Distal branches of the dorsal ray are very slender, with simple unbranched tips. Spicules (fig. 5) 175 to 190 μ long, nearly equal in length but somewhat different in shape, dark brown in color, slightly curved ventralward with truncate tips and without the ventral angular projection typical of *Trichostrongylus*. Tip of left spicule with a large beaklike process or spur projecting ventrally, and a small

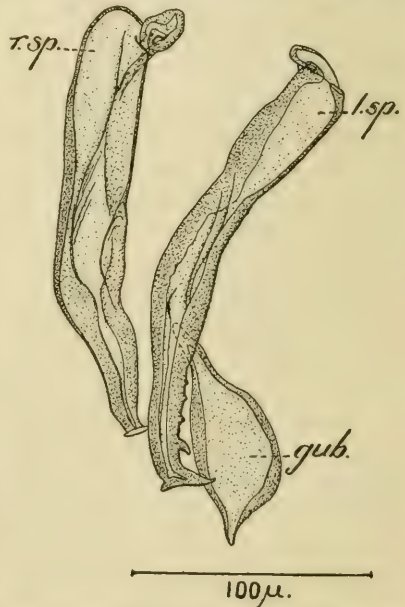


FIG. 5.—*TRICHOSTRONGYLUS CALCARATUS*. SPICULES AND GUBERNACULUM. *gub.*, GUBERNACULUM; *l. sp.*, LEFT SPICULE; *r. sp.*, RIGHT SPICULE.

spur projecting dorsally. Anterior of the ventral beak a small hook, and in front of the latter a series of two or three small projections, the ventral surface of the distal portion of the spicules for a distance of about $50\ \mu$, thus having a hooked, barbed, and roughened appearance. The ventral surface of the right spicule is smooth. Tip of the right spicule smaller than that of the left, with a small flattened caplike enlargement projecting dorsally and ventrally as very small pointed processes, and laterally as a very small ridge. Gubernaculum (fig. 5) about $100\ \mu \times 35\ \mu$ in length and breadth respectively, similar in color to the spicules, with an oval body and a short pointed process posteriorly and a longer process anteriorly.

Female, 5.8 to 7 mm. long by 90 to $120\ \mu$ in diameter at the vulva. Anus 65 to $90\ \mu$ from the tip of the tail. Posterior end of the body (fig. 6) is commonly rather abruptly though slightly diminished in size a short distance in front of the anus, then tapers gradually to the tip of the tail, or beginning some distance in front of the anus may taper gradually to the tip. Tail straight.

Vulva (fig. 7) $850\ \mu$ to 1 mm. from the tip of the tail, elongated diagonally, 50 to $60\ \mu$ long with inconspicuous lips. Combined length of muscular portions of the ovijectors 450 to $560\ \mu$. Eggs 60 to $70\ \mu$ long by 30 to $36\ \mu$ wide, in 8 to 32 celled stage when deposited.

Host.—Rabbit (*Lepus sylvaticus*).

Location.—Small intestine.

Locality collected.—Bowie, Maryland.

Type-specimens.—Bureau of Animal Industry Helminthological collection, Cat. No. 15968, U.S.N.M., collected May 31, 1911.

This nematode has been found almost constantly present in wild rabbits in the vicinity of Bowie, Maryland. The only other known species parasitic in rabbits with which it is likely to be confused is *Trichostrongylus retortæformis*, and from this it may readily be distinguished by the wide differences

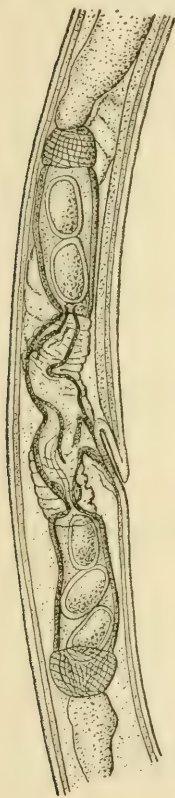


FIG. 7.—TRICHOSTRONGYLUS CALCARATUS. REGION OF VULVA OF FEMALE VIEWED FROM RIGHT SIDE.



FIG. 6.—TRICHOSTRONGYLUS CALCARATUS. POSTERIOR END OF BODY OF FEMALE VIEWED FROM LEFT SIDE.

in the bursa and spicules of the male, and by the size of the eggs and position of the vulva of the female, the eggs of *T. retortæformis* measuring above 75 μ in length, and the vulva being from 1.75 to 2 mm. from the tip of the tail.

It is perhaps questionable whether *T. calcaratus* should be included in the genus *Trichostrongylus* in view of the rather aberrant characters of the dorsal ray of the bursa, and of the spicules. The asymmetrical origin of the dorsal ray and the termination of its branches in undivided tips are atypical, as also is the shape of the distal portion of the spicules. For the present, however, it seems better to look upon this nematode as an aberrant species of *Trichostrongylus* rather than as the single representative of a separate closely related genus.

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THE AMERICAN SPECIES OF SPHYRADIUM WITH AN INQUIRY AS TO THEIR GENERIC RELATIONSHIPS.

By G. DALLAS HANNA,

Of the United States Bureau of Fisheries, Washington, D. C.

Land snails belonging to the genus *Sphyradium* are found in those parts of Europe, Asia, and North America generally designated as Holarctic. One species extends into the Neotropical realm, and two forms which, by the shell, apparently belong to the genus, are found in the Hawaiian Islands.

As the shell is distinctly Pupillid in character the group was originally included in the family Pupillidæ (or Pupidæ), but when the jaw and radula became such factors in the classification of the land snails, the genus was removed from this family and of late years it has been placed along with *Punctum* in a subfamily of the Endodontidæ, one of the divisions of the *Aulacopoda*.

Some live animals of *Sphyradium edentulum* (*Vertigo simplex* Gould, of Binney and others), were recently received from Caribou, Maine, collected by Mr. O. O. Nylander. A study of this material in considerable detail has revealed the fact that the form, by lacking pedal grooves, does not belong to the *Aulacopoda* and all the other anatomical characters other than those of the jaw and radula show that it is closely allied to the genus *Vertigo* of the family Pupillidæ.

The genus was removed from the Pupillidæ by Sterki¹ upon the structure of the radula. The jaw is by Sterki stated to be composed of numerous separate plates loosely joined together in a arcuated series. This is the condition of the jaw in *Punctum* and for this reason the two genera have been placed together in the Endodontidæ. According to Lehman,² however, the jaw is constructed of a single piece and the radula is but slightly different from what is found in *Vertigo*, 12—1—12, teeth in a transverse row. Different investigators seem to have obtained different results in their work on these

¹ Sterki, *Nautilus*, vol. 10, 1896, p. 75.

² Lehman, *Lebenden Schnecken und Muscheln der umgegend Stettin und in Pommern*, 1873, p. 142, pl. 14, fig. 49.

organs.¹ When the rest of the anatomy is considered, however, it is seen that the genus can not belong to other than the Pupillidæ and in this family it is closely related to *Vertigo*.

Genus SPHYRADIUM Charpentier.

Shell brown, translucent, cylindrical or subconical. Spire elevated and apex obtusely pointed. Axis minutely perforate. Aperture basal, semi-circular and without teeth. Peristome thin and acute, its plane radial from the axis, not reflected or thickened within with callus. No indentation in the upper palatal wall.

Animal without a lower pair of tentacles and foot without pedal grooves.

Kidney lying parallel to the rectum and with the urethra leading direct from the anterior end to the mantle margin. The granular matter of the kidney is not arranged in a series of longitudinal filaments as in most of the other Pupillidæ.

Penis with the vas deferens attached at the apex; flagella absent. Hermaphroditic gland composed of a single mass of granules. No demarcation between the oviduct and vagina.

The genus is closely related to *Vertigo*, from which it differs in having no teeth in the aperture of the shell, and the peristome thin and without a callus deposit. Also the surface of the foot is covered with a network of incised lines which are not found in any of the species of *Vertigo* examined by the writer. It is allied to this genus by the animal lacking a lower pair of tentacles and by the vas deferens being attached to the apex of the penis, not down on its side as in *Bifidaria* or *Pupoides*.

In America there are three species of *Sphyradium*. One of these has thus far been found only as a fossil and another is almost extinct.

Key to the American species.

- a. Shell more than 5 mm. in height.....*hasta*.
 a¹. Shell less than 3.50 mm. in height.
 b. Shell long and slender; whorls seven to eight.....*alticolum*.
 b¹. Shell shorter and more conical; whorls five to six.....*edentulum*.

SPHYRADIUM HASTA, new species.

Shell more than 5 mm. in height, long and cylindrical. Light brown in color and glossy. Spire greatly elevated but obtusely pointed on the apex. Whorls 8½ to 9, rather flattened on the face and the last subangulated around the periphery. The last six

¹ NOTE BY WILLIAM H. DALL.—Mr. Olaf O. Nylander of Caribou, Maine, having kindly furnished some fresh material, with the help of Miss Mary Breen the jaw and radula of *S. edentulum* from that locality were isolated, and prove the correctness of Doctor Sterki's observations. The jaw is narrow antero-posteriorly, arcuate, and composed of about 16 rhomboidal overlapping plates. A high magnification is required to bring out these features. The cusps of the teeth on the mature part of the radula were blackish instead of horn color, which is very unusual in the Pulmonata.

whorls are of about equal diameter; the first three increase rapidly. Lines of growth faint and oblique; apex smooth and white. Aperture somewhat angulated at the base of the columella. Peristome thin and acute, forming a regular curve without an indentation in the upper palatal region such as is present in most of the *Vertigos*. The aperture is very slightly thickened with callus on the inside of the peristome in the basal region. Peristome not reflected and with no callus crest back of the aperture. Teeth and lamellæ entirely absent from the aperture. Umbilicus with a very small perforation.

Length, 5.81 mm.; diameter, 2.03 mm.

This species differs from all others of *Sphyradium* by its much greater size and the relatively smaller aperture.

Type.—Cat. No. 214302, U.S.N.M., from the Pleistocene of Long Island, Phillips County, Kansas. The specimens of this species were collected by Mr. Edward C. Johnston and the writer in the autumn of 1910. They occur in deposits of sandy, green marl of undoubted Pleistocene age. With them were large numbers of other Pupillidæ, as well as other land snails. The entire fauna of the beds is foreign to the region at the present time, but is allied to the present day Canadian fauna. From this it is supposed that the animals lived just before or during the Glacial epoch.

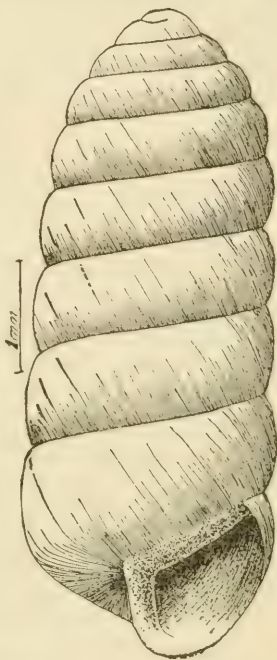


FIG. 1.—SPHYRADIUM HASTA HANNA, TYPE, CAT. NO. 214302, U.S.N.M. DRAWN BY G. D. HANNA.

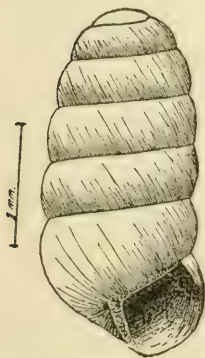


FIG. 2.—SPHYRADIUM ALTICOLUM INGERSOLL. DRAWN BY G. D. HANNA.

SPHYRADIUM ALTICOLUM Ingersoll.

Pupilla alticola INGERSOLL, U. S. Geol. Surv. of the Terr., Bull. 1, No. 2, ser. 2, p. 128 (1874); Eighth Ann. Rep. Hayden Surv., 1874, p. 391.

Pupa alticola (Ingersoll) BINNEY, Man. Amer. Land Shells, 1885, p. 174, fig. 166.

Shell between 2.50 mm. and 3.50 mm. in height, long and cylindrical. Light brown in color with the apex much lighter, sometimes white. Spire elevated and with the apex obtusely pointed. Whorls 7 to 8, well rounded on the face and with the sutures well impressed. The last whorl in adult shells is of greater diameter than the one preceding it, while the next three above it are of about equal size;

this expansion of the last whorl makes the shell slightly unsymmetrical. Peristome thin and acute, without callus, thickenings or indentations in the palatal wall. Lines of growth weak and oblique; apex smooth. Aperture larger in proportion to the shell than in either *S. hasta* or *S. edentulum*; entirely without teeth or lamellæ. The umbilicus is very slightly perforate.

Height.	Diameter.
3.33	1.74
2.81	1.11
2.70	1.14

This species is found at various places as a fossil in the Pleistocene and Loess deposits of the Mississippi Valley.¹ It is also found in several States of the Rocky Mountain region at the present time; i. e., in Utah, Colorado, and Wyoming.

Its abundance in the Pleistocene beds of Long Island, Phillips County, Kansas, shows that at one time this was a very common shell. Many specimens were found there in 1910 by Mr. Johnston and the writer. They were associated with *S. hasta* and other Pupilidæ which are at the present time apparently extinct.

This species can not be confused with any other United States land mollusk. The much greater height of the shell and the greater number of whorls shows it at once to be distinct from *S. edentulum*.

SPHYRADIUM EDENTULUM Draparnaud.

Pupa edentula DRAPARNAUD, Hist. Moll., 1805, p. 52, pl. 3, figs. 28, 29.

Pupa simplex GOULD, Bost. Journ. Nat. Hist., vol. 3, 1840, p. 403, pl. 3, fig. 21.

Vertigo simplex (Gould) BINNEY, Man. Amer. Land Shells, 1885, p. 191, fig 195.

Shell, smaller than either of the two preceding species, not more than 2 mm. in height; translucent brown in color, the apex not lighter than the body of the shell in live specimens. Outline conical rather than cylindrical; apex obtuse. Whorls four to five, well rounded on the face and with the sutures well impressed. Lines of growth very faint and oblique. Shell not spoiled in symmetry by the last whorl increasing in size unproportionately. Aperture well rounded and proportionately not so large as in *S. alticum*; entirely without teeth or lamellæ. Peristome thin and acute, without callous thickenings or indentations. Umbilicus minutely perforate.

Height, 1.60 mm.; diameter, 0.80 mm.

The shell does not vary appreciably in size. It is a resident in that part of North America designated by the United States Biological Survey² as Transition and Canadian. It is also a resident of the northern parts of Europe and Asia.

¹ Pilsbry, Nautilus, vol. 11, 1898, p. 142.

² U. S. Biological Survey. Fourth Provisional Zone Map of North America, by C. Hart Merriam, Vernon Bailey, E. W. Nelson, and E. A. Preble, 1910.

Animal (fig. 3), with a rather short oval foot. Color dark about the head region, lighter posteriorly and on the sole of the foot. Lower tentacles absent. Foot without pedal grooves or traces of such structures. Surface of body covered with a network of incised lines, the meshes of which are very large. This network is absent in at least some of the *Vertigos*, but is present in all of the *Bijidaria* and *Pupoides* which the writer has had the opportunity to examine.

The breathing pore is situated at the upper right-hand angle of the mantle and with the anus immediately to the right. There are no black markings on the mantle or lung wall.

Kidney, a long, slender, granular walled pouch attached to the outer wall of the pallial cavity and with the posterior end lying against the anterior end of the albumen gland. The glandular matter of the kidney is not arranged in longitudinal filaments or folds as in most of the other Pupillids, but is evenly distributed over the entire inner surface. There is in the anterior end an indication of transverse bars which are more noticeable on the upper part of the urethra. The urethra leads directly from the anterior end of the kidney to the excretory pore, which is situated as in the other Pupillidæ. It opens into the anterior end of the pallial cavity, immediately posterior to the breathing pore. The size of the urethra and rectum is about the same and the two are separated by a considerable distance.

The salivary glands are united in one, but have a pair of ducts leading to the buccal mass, and passing beneath the cerebral nerve commissure and through the nerve collar.

The genitalia (fig. 4) are distinctly Pupillid in character. Hermaphroditic gland, composed of a single mass of grape-like granules as in *Vertigo*. In the Endodontidæ, where *Sphyradium* has heretofore been placed, this gland is composed of many individual bunches of elongated tubules, the bunches arranged in a diminishing series toward the apex. The gland of *S. edentulum* is embedded in the anterior end of the liver, which is light brown in color. Hermaphroditic duct slightly swollen in its lower half, but not convoluted in any part. It discharges into the oviduct at the junction of the latter with the albumen gland.

The albumen gland is very large and massive, white and transparent, and on the posterior end there are a few scattering specks of black pigment. These are on the outer surface of the gland only. The oviduct is large at the posterior end and gradually diminishes in size



FIG. 3.—ANIMAL OF SPHYRADIUM EDENTULUM DRAPARNAUD WITH THE SHELL REMOVED, SHOWING THE KIDNEY. DRAWN BY G. D. HANNA.



FIG. 4.—GENITALIA OF SPHYRADIUM EDENTULUM DRAPARNAUD. SPEC. NO. 142, OF THE WRITER'S COLLECTION OF ALCOHOLICS. MUCH MAGNIFIED. DRAWN BY G. D. HANNA.

anteriorly, passing imperceptibly into the vagina. It contains no folds or pouches, nor is there upon it such a shell gland (prostate) as is found in the Endodontidæ. The vagina is a wide tube, free of convolutions, and it opens to the exterior at the base of the right eye-stalk.

Spermatheca, small and globular with a slender duct almost as long as the oviduct and vagina. It discharges into the vagina near the lower end of the latter. There is no point of demarcation between vagina and oviduct, but for purposes of study and comparison in the Orthurethra it is convenient to call that part of the duct below where the vas deferens leads away, vagina, and that which is above, oviduct.

The penis is very small in comparison to the size of the other organs. This, however, is characteristic of the Pupillidæ. It is not attached to the vagina as usual in this family, and therefore there is no atrium; instead it opens to the exterior, on the vaginal lip. The penis is very slender at the point of exit, but enlarges gradually toward the upper end, where it is half the diameter of the vagina. The vas deferens leads from the center of the female organs, the junction of the vagina and oviduct, to the apex of the penis. The retractor muscle is attached to the vas deferens a little way down from the apex of the penis and also to the floor of the pallial cavity. Above the attachment of the vas deferens there is no continuation of the penis as in *Bifidaria* and no long flagella-like appendage as in *Pupoides*. In *S. edentulum* the condition is nearer what is found in some of the *Vertigos* as *V. ovata*.

The genitalia are most closely related to the *Vertigos* of any group of the Pupillidæ, thus bearing out the resemblance of the shells.

The jaw, radula, and genital organs of the European *S. edentulum* have been described and figured by R. Lehman.¹ His figures are not very good, but they show that the genitalia of the animal he had were very different from those of the form now under consideration. As he describes and figures these organs there is one long flagellum on the penis and two short thread-like ones. The larger one has a bulb-like enlargement on the outer end. He also says the oviduct is pouched and folded, and his figure shows a distinct demarcation between the oviduct and vagina. If the species he had was *S. edentulum* and if his dissections are correct, then the American form is specifically if not also generically distinct from the European, and the name, *S. simplex* Gould, will apply to our snail.

However, until modern methods of dissection are used on the European form, it is perhaps best to continue to refer the American snail to *S. edentulum*.

¹ Lehman, Lebenden Schnecken, etc., p. 142, pl. 14, fig. 49.

NEW SAWFLIES IN THE COLLECTIONS OF THE UNITED STATES NATIONAL MUSEUM.

By S. A. ROHWER,

Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

It is believed that the following species are congeneric with the genotypes as defined in the two papers by the author dealing with the subject of genotypes.¹ In the making of descriptions a Carl Zeiss binocular and Carl Zeiss hand lens were used. The figures are from camera lucida sketches. The following new species do not exhaust the collections of the United States National Museum, and some other papers dealing with genera not treated in this paper will be submitted later. While some of the descriptions are apparently brief, they will, it is believed, suffice to determine the species in question with certainty. Certain new species in this paper have been described by comparison with an old species. If the reader has a species, differing from the old species in characters not mentioned in the comparison between the old and new species, it may be considered different from the new species. To redescribe characters common to many species is of no value in a description.

This paper is a contribution from the Division of Forest Insects of the Bureau of Entomology of the United States Department of Agriculture.

Genus ACANTHOLYDA Costa.

ACANTHOLYDA (ACANTHOLYDA) PINI, new species.

Related to *atripes* (Cresson), but may be distinguished by the paler legs, the black and pale abdomen, and non-yellowish wings.

Female.—Length 13 mm. Head with rather large, separate punctures; lateral supra-clypeal area smooth, shining impunctate; clypeus shining, with widely separate punctures, the anterior margin not quite straight; antennæ 35-jointed, the apical joints small, third joint longer than four, but not as long as four plus five; middle fovea represented only by a line; no ocellar basin; all the furrows of the head wanting; the middle area of the mesonotum with dis-

¹ The Genotypes of the Sawflies and Woodwasps, or the Superfamily Tenthredinoidea, Bull. Tech. Ser. No. 20, pt. 2, U. S. Dep. Agr., Bur. Ent., pp. i-vi and 69-109, March 4, 1911.

Additions and corrections to "The Genotypes of the Sawflies and Woodwasps, or the Superfamily Tenthredinoidea," Ent. News, vol. 22, pp. 218-219, May, 1911.

tinct punctures; third cubital cell subequal with the second on the radius; transverse radius interstitial with second transverse cubitus; abdomen normal. Black, mandibles (apicies piceous), clypeus, posterior orbits, most of face below ocelli, three lines on vertex, tegulæ, line on pronotum, posterior part of anterior lobe scutellum, and lines connecting these two spots, most of episternum, venter, sides of dorsum, all the legs beneath yellowish. Wings dusky hyaline, venation pale brown.

District of Columbia. One female from beating on pine, April 26, 1903, collected by A. D. Hopkins.

Type.—Cat. No. 13983, U.S.N.M.

Genus DERECYTRA Smith.

DERECYTRA VARIIPENNIS, new species.

Perhaps more closely related to *D. pictipennis* than any other species, but it is not that species.

Male.—Length 14 mm. Anterior margin of the clypeus with a median tooth; mandibles short, robust, with large separate punctures; inner orbits striate; produced area of the front, depressed above medianly, shining, laterally irregularly striate; head behind the supraorbital line shining, impunctate; postocellar area nearly wanting not parted; fourth antennal joint longer than the third or fifth; middle lobe of mesonotum and lateral part of the lateral lobes transversely striate; anterior part of lateral lobes rather closely, distinctly punctured; scutellum rather coarsely, irregularly sculptured; mesoepisternum above striato-punctate, below and with the mesosternum punctate; second cubital cell much longer than the third; hypopygidium with the apical margin truncate, in the middle slightly emarginate. Rufo-piceous; antennæ black; posterior femora and apical dorsal segments darker. Wings brownish black, with a yellowish spot in the area surrounding the stigma.

San Bernardino, Paraguay. One male collected by K. Fiebrig.

Type.—Cat. No. 13984, U.S.N.M.

Genus HAPLOSTEGUS Konow.

HAPLOSTEGUS MEXICANUS, new species.

Black, except the mesonotum and scutellum which is rufous; wings brown, venation black.

Male.—Length 4 mm. Clypeus very small, apex truncate; a rather distinct transverse suture above the clypeus; antennal furrows distinct, continuous; middle fovea rather large, oval in outline, the sides sloping, extending laterally; anterior ocellus in an indistinct depression; postocellar furrow poorly defined; postocellar line but little longer than the ocellocipital line; antennæ gradually

thickening apically, the first two joints subequal, the third longer than the fourth, the apical one longer than the preceding one, the apex pointed; scutellum obtusely pointed posteriorly; tarsal claws long and simple; hypopygidium with large punctures, the apex narrowed, obtusely rounded. Black, mesonotum and scutellum dark red; wings brown, venation black.

Cordoba, Mexico. One male collected on December 6, by F. Knab.
Type.—Cat. No. 13985, U.S.N.M.

CONOCOXA, new genus.

Rather small, robust species with a habitus very like *Acordulocera* Say; head nearly as wide as the thorax, rectangular when seen from above; eyes at the side of the head, large, their inner margins parallel; malar space present but narrow; antennæ inserted close to the clypeus, simple, seven-jointed, pedicel subequal in length with the scape, third joint much longer than fourth; clypeus small and not separated by a supraclypeal suture; labrum rather large; lateral ocelli slightly above the supraorbital line; thorax like *Acordulocera*; claws long simple; four anterior legs simple; posterior coxæ and femora much enlarged, especially in the male where they remind one of *Chalis*; in the male the posterior trochanters are armed with a spine; tibiæ without a superapical spur; venation differs from *Acordulocera* as follows: Costa uniform in thickness; first transverse cubitus only partly wanting; anal vein straight with a stump (A²) projecting forward so that an incomplete petiolate anal cell is present; hind wings rather broader than in *Acordulocera*; third anal vein of hind wings present; abdomen similar to *Acordulocera*.

Genotype.—*Conocoxa chalicipoda* Rohwer.

CONOCOXA CHALICIPODA, new species.

Head and thorax black; abdomen partly ferruginous.

Female.—Length 4 mm. Clypeus obtusely rounded anteriorly; antennal fovea elongate; middle fovea deep, circular, small; anterior ocellus in a small diamond-shaped basin; antennal furrows complete; postocellar furrow present, well defined; postocellar line equal to the ocellorbital line; stigma very large, not twice as long as broad; sheath large, obtusely rounded at the apex. Black: abdomen except basal dorsal segments and apex of sheath ferruginous; legs ferruginous, base of coxæ, four anterior femora above, posterior tibiæ above and apical joints of tarsi black. Wings slightly dusky, hyaline; venation pale brown, stigma and costa pallid.

Male.—Length 5 mm. Middle fovea elongate; postocellar furrow and ocellar basin not as strong as in female; posterior coxæ tuberculate beneath; posterior trochanters with a long curved prong

extending backward; hind tarsi rather dilated toward the apex; hypopygidium broadly rounded at the apex; four anterior legs brown; apex of posterior coxæ, trochanters, femora except a black line above ferruginous, the rest of the posterior legs black. Except where mentioned the characters given for the female agree with the male.

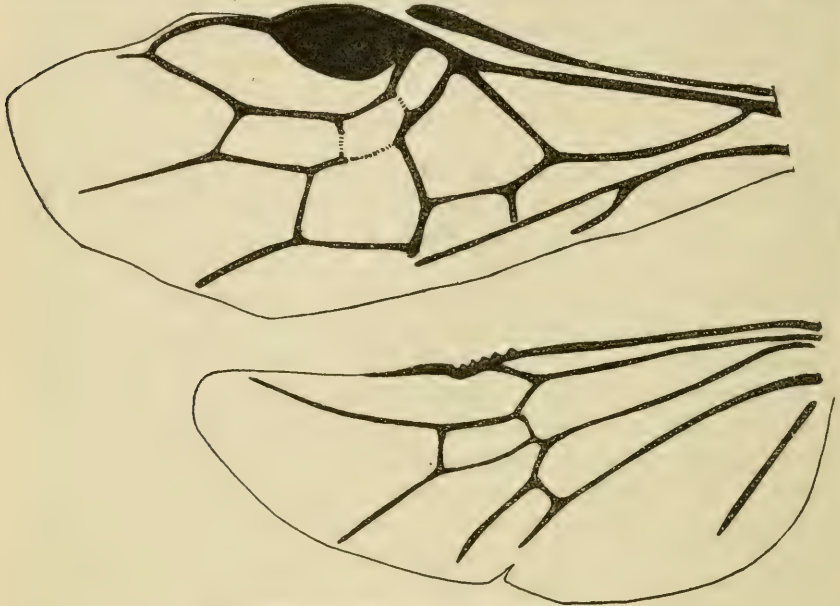


FIG. 1.—WINGS OF *CONOCOXA CHALICIPODA* ROHWER.

Chubut, Patagonia. A male and a female collected by W. F. H. Rosenberg.

Type.—Cat. No. 13986, U.S.N.M.

NITHULEA, new genus.

Very like *Conocoxa* Rohwer and agrees with the description of that genus except in the following points: Malar space broader; antennæ six-jointed, the third joint as long as the fourth and fifth combined, sixth subclavate; antennæ inserted nearly the width of the scape above the clypeus; caudad end of the scutellum rather sharply triangular; posterior coxæ elongate, but the femora normal, second transverse cubitus wanting; the cubital venation reminding one of *Ewura* Newman.

Genotype.—*Nithulea nigrata* Rohwer.

NITHULEA NIGRATA, new species.

Entirely black; wings dusky hyaline, venation brown, stigma paler.

Female.—Length 3.5 mm. Clypeus broadly rounded on the anterior margin; antennal foveæ not sharply defined, striato-granular;

middle fovea wanting; a U-shaped depressed area in the middle of the face below the crest; antennal furrows complete, well defined; area around the anterior ocellus hardly depressed; postocellar furrow deep; postocellar line a very little shorter than the ocellorbital line; third antennal joint curved; head dulled with fine scratches; stigma broad, rounded on the lower margin; sheath rather broad and robust. Entirely black; wings dusky hyaline; venation brown, stigma pale brown.



FIG. 2.—RADIAL VENATION OF NITHULEA NIGRATA ROHWER.

Chubut, Patagonia. One female collected by W. F. H. Rosenberg.
Type.—Cat. No. 13987, U.S.N.M.

Genus LOBOCERAS Kirby.

LOBOCERAS TRIMACULATUM, new species.

Apparently more closely related to some of the Brazilian species, *Loboceras trinotatus* Konow, etc., than any of the Central American forms, but does not agree with any of these. In color it is more like *Loboceras varicone* Cameron than the other described species from Central America.

Female.—Length 8.5 mm.; length of anterior wing 8 mm. Labrum nearly as long as wide, rounded at the apex; clypeus nearly truncate; ocellar basin open below and extending to the open middle fovea, making a broad, shallow facial fovea; antennal furrow not complete; posterior orbits not as broad as in *L. mexicanum* Kirby; postocellar area well defined, the lateral furrows not reaching the posterior margin of the head; third antennal joint distinctly longer than the fourth, but not as long as four plus five; scutellum margined laterally and not depressed in the apical middle; second cubital cell, much broader above than below, receiving the first recurrent slightly beyond the middle; second recurrent slightly beyond the second transverse cubitus; legs normal; sheath well concealed, truncate at the apex. Luteous; head, except pallid labrum, clypeus, supra-clypeal area, scape, mandibles (apices piceous), and antennæ black; a brownish spot on each lobe of mesonotum; intermediate tarsi and the posterior tibiæ and tarsi black. Wings yellowish hyaline, beyond the stigma dusky hyaline; venation to apex of stigma yellowish, in the dusky part of the wing brownish.

Piedros Negras, Costa Rica. One female collected by Schild and Burgdorf.

Type.—Cat. No. 13988, U.S.N.M.

Genus HEMIDIANEURA Kirby.

HEMIDIANEURA ALBOCOXA, new species.

Related to *H. tenebrica* Konow from Surinam, but has black tegulæ, partly pale clypeus, and the antennal furrows are not punctiform.

Female.—Length 8.5 mm. Labrum punctured, depressed in the apical middle; clypeus truncate; supraclypeal area convex; below the antennæ the head is punctured, above shining; antennal furrows extending to the vertex; middle fovea subcircular in outline, joining the ocellar basin; postocellar furrow distinctly present; lateral ocelli slightly anterior to the supraorbital line; pedecellum a little wider than long; flagellum rather slender; third cubital cell about twice as long on the radius as on the cubitus; second recurrent vein, interstitial with the second transverse cubitus; both in the fore and hind wings there is a spurious branch to the median extending nearly to the anal vein; stigma broadest at the base; sheath rather slender, straight above, sharply pointed, the lower margin oblique. Black: mesonotum except anterior part of middle lobe, scutellum, and a spot beneath wings red; most of clypeus, spot at base of costa, legs to basal third of tibiæ yellowish-white. Wings dark brownish-black; venation black.

Male.—Length 7 mm. Agrees with the female except for the sexual differences. Hypopygidium gently rounded apically, about twice as wide as long; genitalia stipes rather broad, gently rounded apically.

San Bernardino, Paraguay. Two males and seven females, numbered 2175a and 2175. Presented to the United States National Museum by K. Fiebrig.

Type.—Cat. No. 13989, U.S.N.M.

Genus ATOMACERA Say.

ATOMACERA DECEPTA, new species.

Related to *desmodii* Dyar, but the sheath is obtusely pointed at the apex, not obliquely truncate, and the scutellum is black. From *debilis* Say it differs in the poorly defined ocellar basin. *Ruficollis* Norton is very different in the sharply defined middle fovea.

Female.—Length 4.5 mm. Clypeus and labrum gently arcuately emarginate; supraclypeal foveæ distinct, punctiform; ocellar basin indistinct almost wanting, poorly defined above the ocellus; postocellar furrow wanting; postocellar line slightly shorter than the ocellorbital line; third cubital cell wider on the radius than on the cubitus, about three times as wide at apex as at base; sheath narrow, nearly parallel sided, at the apex obtusely pointed. Black; pronotum broadly, tegulæ and mesonotum except a large spot on anterior lobe rufo-testaceous; wings brownish, venation brown.

New York. One female.

Type.—Cat. No. 13990, U.S.N.M.

Genus CALOPTILIA Ashmead.

CALOPTILIA PICEOTERGA, new species.

Differs from *C. immunda* (Konow) in the black posterior tibiæ, and other characters.

Male.—Length 7 mm. Labrum depressed, the basal portion punctured; clypeus arcuately emarginate; middle carina strong; middle fovea elongate triangular, separated from the ocellar basin by a transverse ridge; ocellar basin pentagonal, not quite closed above; postocellar area poorly defined on all sides; impressed in the middle; antennæ rather slender, extending beyond the basal plates, curved apically; stigma rounded on the lower margin; third cubital cell longer than the apical width, and receiving the second recurrent near the base; hypopygidium about one third longer than wide, narrowing apically, obtusely rounded; genitalia stipes broader above apically. Black and obscure testaceous; head, antennæ, mesonotum, scutellum, apex of abdomen, anterior tarsi and the four posterior tibiæ and tarsi black; palpi meso and meta-pluræ, mesosternum, anterior coxæ and tibiæ, dorsal abdominal segments piceous; rest of the insect obscure testaceous; wings dusky hyaline; venation black.

Cordoba, Vera Cruz, Mexico. One male collected by F. Knab on January 29, 1908.

Type.—Cat. No. 13991, U.S.N.M.

CALOPTILIA NUBECULOSA ROSENBERGI, new variety.

Differs from *Caloptila nubeculosa* (Konow) as follows:

Ocellar basin pointed behind the median ocellus, not truncate; postocellar furrow absent, not present; mesonotum not marked with black; venation testaceous, not dark brown; wings mostly yellowish, not dusky; only apical dorsal segment black; face pale in the middle to level of antennæ. Female, length 8 mm.

Chawchamayo, Peru. One female from W. T. H. Rosenberg.

Type.—Cat. No. 13992, U.S.N.M.

Genus ACORDULECERA Say.

ACORDULECERA KNABI, new species.

In general color belongs to the group of black species with pale legs, but differs from the descriptions of all of these.

Female.—Length 3.5 mm. Antennal furrows nearly complete but not sharply defined; middle fovea transverse, shallow, rather large; a shallow depression above the middle fovea; ocellar basin rather small, bounded by low rounded walls; postocellar area wanting; third antennal joint nearly as long as four plus five; postocellar line nearly twice as long as the ocellocular line; stigma hardly twice as long as wide, rounded on the lower margin; sheath robust, broadly rounded apically; saw with cross rays, teeth small and rounded.

Black, not densely pilose; mandibles piceous; scape, pedicellum, legs below coxæ yellowish-pallid. Wings dusky hyaline, venation dark brown.

Male.—What seems to be the male (from the same locality) differs from the female in the rather longer antennæ, the third joint not half again as long as the fourth, middle fovea larger, wings somewhat clearer. Hypopygium truncate apically.

Cordoba, Vera Cruz, Mexico. One female collected June 14, and one male collected January 31, 1888, by Frederick Knab, for whom it is named.

Type.—Cat. No. 14020, U.S.N.M.

Genus LYCAOTA Konow.

Due to the great color antigney in this genus the males and females have in some cases been described as different species.

LYCAOTA SODALIS (Cresson).

Selandria sodalis CRESSON, Trans. Amer. Ent. Soc., vol. 8, 1880, p. 44, female.

Lycaota fusca ROHWER, Can. Ent., vol. 40, 1908, p. 108, male.

A common species in parts of Colorado.

LYCAOTA SPISSIPES (Cresson).

Selandria (Hoplocampa) spissipes CRESSON, Trans. Amer. Ent. Soc., vol. 8, 1880, p. 14, female.

Selandria (Hoplocampa) lenis CRESSON, Trans. Amer. Ent. Soc., vol. 8, 1880, p. 14, male.

This little species may be easily known in the female by the broad sheath which is truncate apically and broadly emarginate below. F. Knab collected two females and a male at Oxbow, Saskatchewan during the summer of 1907.

LYCAOTA SPISSIPES BRUNNEUS, new variety.

Female.—Length 6.5 mm. Differs from typical *spissipes* in the pale mesopectus, mesoscutum, orbits and two basal joints of antennæ.

Montana. Two females.

Type.—Cat. No. 13838, U.S.N.M.

LYCAOTA COLORADENSIS, new species.

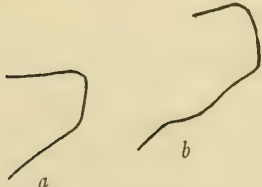


FIG. 3.—SHEATHS OF LYCAOTA. *a*, OF COLORADENSIS ROHWER, *b*, OF SPISSIPES (CRESSON).

Female.—Length 5.5 mm. Supraclyapel foveæ large, connected with the smaller antennal foveæ; supraclypeal area flat; frontal crest very strongly broken; middle fovea well defined, more distinctly so below, not sharply separated from the ocellar basin; ocellar basin not closed below, defined laterally by fine ridges; postocellar area convex, defined laterally by a puncti-

form fovea; postocellar furrow curved anteriorly; antennæ nearly filiform, the third joint a little longer than the fourth; stigma rounded below; sheath as in figure. Black; clypeus, labrum, mandibles (apices piceous), pronotum, tegulæ, mesoprescutum, sides of mesoscutum, mesoepisternum, apical two abdominal segments, legs below middle of coxæ rufo-ferruginous; wings hyaline slightly yellowish; venation yellowish-brown, darker basally.

The clypeus is normally black.

Colorado. Five females from the C. F. Baker collection.

Type.—Cat. No. 13839, U.S.N.M. *

Related to *spissipes* (Cresson), but may be distinguished by the shape of the sheath and somewhat different conformation of the head.

CRATEROCERCUS, new genus.

Belongs near *Hemichroa* Stephens, but has the antennæ shorter and stouter; the malar space wanting; the eyes longer; the head and thorax punctured; and the second recurrent vein usually received by the third cubital cell. Also much like *Mesoneura* Hartig, which belongs to the same tribe, in body characters, but differs in the robust cerci, position of lateral ocelli, and contracted anal cell.

Clypeus deeply emarginate; eyes elongate, reniform; malar space very narrow, wanting; head large, broader than high; ocelli in a low triangle, the lateral ones nearly touching the supraorbital line; antennæ robust, rather short, pedicellum short, much wider than long, third and fourth joints subequal; head and thorax dull, punctured or granular; thorax similar to *Hemichroa*; legs as in *Hemichroa*; tarsal claws cleft; second recurrent vein usually received by the third cubital cell, or sometimes interstitial with the second transverse cubitus; last ventral plate produced in the middle; sheath robust; cerci very short, robust; hypopygidium very elongate; no prodecentia.

Genotype.—*Hemichroa phytophagica* Dyar.

Hemichroa albidovariata Norton and *Hemichroa fraternalis* Norton also belong to this genus.

Genus MARLATTIA Ashmead.

MARLATTIA ERYTHROTHORAX, new species.

Head and abdomen black; thorax and legs reddish.

Female.—Length 4.5 mm. Clypeus arcuately emarginate, lobes broad rounded; supraclypeal suture strong; supraclypeal area triangular in outline, slightly convex; antennal foveæ not large; middle fovea elongate and connected with the poorly defined ocellar depression; postocellar line subequal with the ocellorbital line; lateral ocelli much above the supraorbital line; postocellar area much wider

than the cephal-caudal length, poorly defined; head and thorax closely punctured; stigma but little more than twice as long as wide, a little broader at base, apex oblique; third cubital cell not much longer than broad; cerci hardly tapering; sheath broad, apex more or less rounded. Black: pro- and meso-thorax, legs, except extreme base of posterior coxæ, cerci, apical dorsal segment reddish, thorax darker; wings dusky hyaline, iridescent, venation pale brown.

Jacksonville, Florida. One female from the Ashmead collection.

Type.—Cat. No. 13993, U.S.N.M.

Genus PLATYCAMPUS Schiödte.

PLATYCAMPUS JUNIPERI, new species.

Readily separated from the other species by the black head. The Nearctic species have been referred previously to *Camponiscus* Newman.

Female.—Length 6 mm. Head broad, much broader than high; clypeus nearly truncate; antennal foveæ poorly defined; supraclypeal area convex; middle fovea shallow, triangular; ocellar basin almost wanting; postocellar area defined but not sharply so; postocellar line slightly longer than the ocellorbital line; antennæ strongly tapering, the third and fourth joints subequal; stigma broad, rounded on the lower margin, broadest at the base; third cubital cell but little wider at the apex; the second recurrent interstitial with the second transverse cubitus; upper and lower discal cell in the hind wings equal on the outer margin; claws stout, with an erect inner tooth; sheath broad, apex truncate, the lower margin oblique; cerci moderate. Reddish-yellow; head, antennæ, spots on the lateral lobes of mesonotum, metanotum, pectus, legs and sheath black; labrum, palpi and four anterior tibiæ and tarsi brownish. Wings hyaline, iridescent; venation dark brown, apex of stigma lighter.

Los Vegas, Hot Springs, New Mexico. Bred from *Juniperus*, adult emerging April 7, 1902.

Type.—Cat. No. 13994, U.S.N.M.

Genus PTERONIDEA Rohwer.

PTERONIDEA WINNANÆ, new species.

A distinct species falling nearer *P. dubius* (Marlatt) in Marlatt's Revision to North American Nematinae, but is remarkably distinct from that species.

Male.—Length 5.5 mm. Clypeus distinctly angularly emarginate, lobes broad, rounded; antennal foveæ poorly defined; middle fovea narrow, elongate, open above; frontal crest slightly broken; ocellar basin well defined laterally, almost open below; postocellar area poorly defined; postocellar furrow wanting; postocellar line longer

than the ocellorbital line; antennæ strongly tapering, the third and fourth joints subequal; stigma rather elongate, rounded below, broadest near the base; third cubital cell very small, nearly quadrate; proclivitia a little longer than wide, broadly rounded at the apex; hypopygidium narrow, elongate, apex obtusely pointed. Black: head, except a large spot from the crest to occiput not reaching orbits, prothorax, tegulæ, upper part of mesoepisternum, metapleuræ, venter and legs, except the posterior tarsi, yellowish-white; antennæ all black. Wings hyaline, iridescent; venation dark brown.

Plummer's Island, Maryland, September 1, 1907. One male collected by A. D. Hopkins on *Salix*. Under the Bureau of Entomology number "Hopk.U.S.6495."

Type.—Cat. No. 13997, U.S.N.M.

Genus PACHYNEMATUS Konow.

PACHYNEMATUS ALASKENSIS, new species.

Pachynematus ocreatus KINCAID, Proc. Wash. Acad. Sci., vol. 2, 1900, p. 347.

Very like *P. ocreatus* (Harrington), but the frontal crest is broken; the postocellar area is not strongly convex, and is not wider at the occiput; the third cubital cell is fully one-third longer than the third transverse cubitus on the radius; and the tergum is marked with piceous.

Female.—Length 9 mm. Head expanding behind eyes; labrum broadly rounded apically, granular; clypeus broadly, arcuately emarginate, lobes rather pointed; supraclypeal area triangular in outline, somewhat convex; middle fovea large, triangular, open above where it breaks through the low crest; ocellar basin with the lateral walls rounded; postocellar area well defined on all sides, not strongly convex, not broadening posteriorly; antennæ long, the third joint a little shorter than fourth; stigma large, angular at base, tapering to apex; abdomen as *ocreatus*. Reddish-yellow; antennæ, interocellar area, lateral lobes of mesonotum laterally, metanotum, and large spots on basal segments of tergum black or black piceous. Wings hyaline, iridescent; venation pale brown, stigma yellowish.

Sitka, Alaska. Three females collected April 16, by T. Kincaid while on the Harriman Expedition.

Type.—Cat. No. 13995, U.S.N.M.

PACHYNEMATUS PICEÆ, new species.

May be separated from *P. ocreatus* (Harrington), its near ally, by the small, deep, nearly circular middle fovea; in *ocreatus* the middle fovea is large and triangular.

Female.—Length 9 mm. Head expanded behind the eyes; labrum shining, depressed apically; clypeus subarcuately emarginate, lobes

broad, obtuse; supraclypeal area shining, convex, triangular in outline; middle fovea small, deep, circular, extending over the antennæ; crest very poorly defined, antennal furrows continuous; ocellar basin with the lateral walls rather sharp; postocellar furrow wanting; postocellar area rather strongly convex, the lateral furrows curved, broadening posteriorly; antennæ slender, the third joint a little shorter than fourth; stigma broad, angulate near base, tapering to apex; third cubital cell not a third longer on the radius than the length of the third transverse cubitus; abdomen as in *ocreatus*. Reddish-yellow; antennæ, interocellar area, and on lateral lobes black or piceous; pronotum and tegulæ pallid; venation dark brown, stigma and costa yellowish.

The mesonotum in some specimens is all piceous.

Male.—What seems to be the male, as it bears the same label, shows remarkable antigeny. Length 7.5 mm. Head not strongly expanded behind the eyes; head as in female except the frontal crest which is broken, and the indistinctly present postocellar furrow; stigma not as angular as in female; procendia twice as long as wide, truncate; hypopygidium very long and narrowing apically where it is truncate; genitalia stipes large, long, exceeding the hypopygidium. Black; clypeus, mandibles (apices piceous), face beneath antennæ, posterior orbits narrowly below, tegulæ, angles of pronotum, and coxæ beneath pallid; legs below trochanters, except the posterior tibiæ and tarsi, abdomen except basal plates, apical dorsal segment, hypopygidium and genitalia reddish. Wings hyaline, iridescent; venation and stigma dark brown.

Grand Island, Michigan. Reared from larvæ collected on spruce, July 28, 1907, by A. D. Hopkins.

Type.—Cat. No. 13996, U.S.N.M.

SELANDRIDEA, new genus.

Belong to the Selandrinæ as defined by Doctor MacGillivray. In Konow's classification it runs to *Selandria*. From *Selandria* in the restricted sense it may be separated by the broad malar space, the eyes not or scarcely converging to the mandibles, the head being twice as broad as high, and the costa and subcosta being connected by chitin.

Genotype.—*Selandridea vanduzeei* Rohwer.

Selandria decorata Cresson should be placed here, and it may be that the European *Tenthredo flavescens* Klug will belong here.

Table of species.

Pleuræ largely pale; lateral ocelli in the supraorbital line.....	<i>vanduzeei</i> .
Pleuræ black; lateral ocelli well behind the supraorbital line.....	<i>decorata</i> .

SELANDRIDEA VANDUZEEI, new species.

Male.—Length 7 mm. Clypeus shallowly arcuately, emarginate, the lobes broad, rounded; supraclypeal foveæ deep, connected with the antennal foveæ; middle fovea large, subquadrate; ocellar basin large, well defined, triangular in outline; antennal furrows nearly complete; postocellar area well defined; the lateral ocelli on the supraorbital line; antennæ very robust, the third joint one-fourth longer than the fourth; the third cubital cell a little longer than the second; the transverse radius received in about the middle of the cell, the transverse median well beyond the middle; the lanceolate cell of the hind wings sessile; hypopygidium shallowly emarginate apically. Reddish-brown; flagellum, head (except the clypeus, labrum and mandibles), mesonotum, metanotum, mesopectus, and bases of the hind coxæ black; wings hyaline, iridescent, slightly yellowish; the costa and stigma black, venation testaceous.

Female.—Length 7.5 mm. Differs from the above description of the male in the parted postocellar area, and the lower part of the mesopleuræ being black. Sheath slender, straight above, apex broadly rounded.

Buffalo, New York. A male and female collected by M. C. Van Duzee, for whom the species is named, June 4, 1910. Also four males from Canada without definite data.

Type.—Cat. No. 13998, U.S.N.M.

Genus NESOSELANDRIA Rohwer.

NESOSELANDRIA RUFONOTA, new species.

Apparently related to *Selandria crassa* Cameron and *Selandria ruficollis* Norton, but does not agree with the descriptions of either of these.

Male.—Length 5 mm. Supraclypeal foveæ wanting; antennal foveæ hardly defined; supraclypeal area subconvex; middle fovea very poorly defined, transverse, walls rounded; lateral foveæ small, punctiform; postocellar area hardly defined, lateral furrows punctiform; postocellar line subequal with the ocelloccipital and ocellocular lines; stigma short, about two and one-half times as long as greatest width, subangulate below; transverse radius a little beyond the middle of cell; hypopygidium long, narrow, broadly rounded apically. Black; clypeus, labrum, legs (except the infuscate posterior tibiæ and tarsi) brownish-white; pronotum, tegulæ, first perapteron and mesoscutum rufous. Wings uniformly brownish; venation black.

Acapulco, Mexico. One male collected July 29, by F. Knab.

Type.—Cat. No. 13999, U.S.N.M.

Genus ANEUGMENUS Hartig.

ANEUGMENUS FLAVIPES FLAVIPES (Norton.).

This subspecies occurs from Canada to Georgia and west to Michigan. The wings vary from hyaline to the basal portion being strongly infusate.

ANEUGMENUS FLAVIPES OCCIDENTALIS, new subspecies.

Female.—Differs from the typical form in the poorly defined ocellar basin, the lateral walls being present above, but the lower wall is wanting. The antennæ are somewhat shorter. Wings hyaline.

Colorado. One female.

Type.—Cat. No. 13939, U.S.N.M.

ANEUGMENUS FLAVITARSIS, new species.

This and the following new species may be separated from *flavipes* (Norton) by the lateral walls of the ocellar basin being subparallel, touching the inner margins of the ocelli, the basin being open above. (In *flavipes* the basin is triangular, the lateral walls meeting above and between the ocelli.)

Female.—Length 5.5 mm. Antennal foveæ and supraclypeal foveæ confluent, the latter hardly defined; supraclypeal area convex; lateral foveæ a little above the level of the middle fovea, subcircular in outline; middle fovea transverse, curved, well defined; postocellar line subequal with the ocellocular; postocellar area convex, sharply bounded laterally; flagellum wanting; stigma broadly rounded. Black shining; labrum, posterior angles of pronotum, tegulæ, and legs below bases of coxæ pale yellow; apex of clypeus brownish; wings strongly fuscous at base, venation dark brown paler apically.

Florida. One female collected on "Palm."

Type.—Cat. No. 13941, U.S.N.M.

ANEUGMENUS NIGRITARSIS, new species.

Female.—Length 5 mm. Differs from *flavitarsis* by having the middle fovea irregularly circular, and the tarsi (apices of posterior tibiæ) black. Antennæ pilose, tapering, third joint distinctly longer than the fourth.

Male.—Length 5 mm. Very like the female. Hypopygidium broadly rounded apical.

San Rafael, Jicoltepec, Mexico. Female and two males.

Type.—Cat. No. 13940, U.S.N.M.

ANEUGMENUS DIVERSICOLOR, new species.

Easily known from the other species by the second to sixth abdominal segments being ferruginous.

Male.—Length 5.5 mm. Antennal and supraclypeal foveæ shallow and very poorly defined; supraclypeal area flat; middle fovea transverse, not sharply defined; lateral foveæ well defined punctiform; ocellar basin of the type of *flavipes*, but poorly defined

and with the rounded lower wall broken; postocellar area convex, bounded laterally by punctiform foveæ; postocellar line longer than the ocellocipital but shorter than the ocellocular; antennæ subpilose robust, not tapering, third joint longer than the fourth; stigma rounded beneath, truncate apically; claws with a small basal tooth; hypopygidium broadly subangulate apically. Black; clypeus, labrum, palpi, and anterior tibiæ and tarsi white; tegulæ, legs except most of posterior tibiæ and tarsi, abdominal segments two to six ferruginous. Wings dusky hyaline, iridescent; venation dark brown.

Mexico. One male from the C. F. Baker collection.

Type.—Cat. No. 13942, U.S.N.M.

Genus **STROMBOCEROS** Konow.

Stromboceros KONOW, Wien. Ent. Zeit., vol. 4, 1885, pp. 19 and 20.

Waldheimia KIRBY, List Hym. Brit. Mus., vol. 1, 1882, p. 326 (not Brullé).

Waldheimia ASHMEAD, Can. Ent., vol. 30, 1898, p. 307 (not Brullé).

Brullé¹ in describing the genus *Waldheimia* named the genotype *Tenthredo brazilensis* Lepeletier. The type of *Tenthredo brazilensis* Lepeletier seems to have been lost, at least it is not in the Museum of Paris, but Konow² places as a synonym of Lepeletier's species his *Monophadnus alveatus*, which should stand as a proxytype of *Tenthredo brazilensis* Lepeletier. This makes the genus fall in Konow's *Blennocampides* and not near *Strongylogaster*, as Ashmead and Kirby have it. Ashmead and Kirby probably followed the figure of *Waldheimia orbignyana* Brulle³ which belongs in *Stromboceros sensu lato*riore.

Stromboceros Konow may be divided into a number of species groups. The following are in the material in the Museum:

Key to Subgenera.

Hind basitarsis much shorter than the following joints; (clypeus truncate).

Eustromboceros Rohwer.

Hind basitarsis subequal with or longer than the following joints..... 1

1. Clypeus distinctly emarginate.....*Stromboceros* Konow.

Clypeus truncate or nearly.....*Stromboceridea* Rohwer.

Subgenus **STROMBOCEROS**, *Sensu Strictiore*.

STROMBOCEROS (STROMBOCEROS) BARRETTI, new species.

Female.—Length 6.5 mm. Clypeus with a V-shaped emargination lobes broad, obtuse apically; supraclypeal foveæ connected with the antennal foveæ which are large and extend a little above the lower border of the ocellar basin where they are bounded by a transverse carina; antennal furrows nearly complete above the foveæ; middle fovea oval, well defined; ocellar basin sharply defined, large, V-shaped,

¹ Hist. Nat. Insects Hym., vol. 4, 1846, p. 665.

³ Pl. 46, figs. 8, 8a, 8b, Hist. Nat. Insects Hym.

² Zeit. Hym. u. Dipt., vol. 4, 1904, p. 242.

but entirely inclosed; postocellar furrow wanting; postocellar area transverse sharply bounded laterally; postocellar line subequal with the ocellocipital line but much shorter than the ocellocular line; antennæ pilose, tapering, third joint distinctly longer than the fourth, pedicellum much longer than broad; stigma angled near the base, strongly tapering; transverse radius in apical third of cell; third cubital cell shorter than the second, much broader apically; transverse median in about the middle of the cell; lanceolate cell of the hind wings sessile; hind basitarsis slightly longer than the following; claws with a large basal tooth, at some angles appearing cleft; sheath obliquely rounded apically. Rufo-ferruginous; antennæ, head (except pallid palpi), pro-pleuræ and sternum, meso- and meta-pleuræ and sternum, posterior tibiæ and tarsi black; intermediate tarsi brownish; wings dusky hyaline, venation dark brown.

Tacubaya, Mexico. One female collected by O. W. Barrett for whom the species is named. Doctor Ashmead's manuscript name is used for this species.

Type.—Cat. No. 14000, U.S.N.M.

STROMBOCERIDIA, new subgenus.

Genotype.—*Stromboceros* (*Stromboceridea*) *pilosulus* Rohwer.

The following species all have the pedicellum much longer than broad.

STROMBOCEROS (STROMBOCERIDEA) PILOSULUS, new species.

Female.—Length 8 mm. Clypeus convex, apex nearly truncate; supraclypeal area flat; supraclypeal foveæ very shallow connected with the antennal foveæ which are small; middle fovea shallow subquadrate, with a glabrous spot in the center; lateral foveæ punctiform a little above the level of the middle fovea; antennal furrows incomplete present at intervals; ocellar basin with sharp ridges laterally which meet above, open below; a small fovea in front of the anterior ocellus; postocellar area subquadrate, sharply defined laterally; postocellar line shorter than the ocellocipital and ocellocular lines; front below the ocelli roughened; eyes nearly parallel; antennæ subpilose, robust, apical joints flattened, tapering, third joint nearly as long as the fourth and fifth, pedicellum much longer than broad; stigma tapering; transverse radius near apex of cell; transverse median but little beyond the middle; lanceolate cell of the hind wings sessile; hind basitarsis slightly longer than the following; claws cleft, the inner tooth shorter. Black; clypeus, labrum, first two antennal joints, base of third, prothorax, tegulæ, legs (except most of hind femora and apex of hind tibiæ) pale yellow; sides of mesoprescutum, scutellum, upper part of mesoepisternum, three basal abdominal segments reddish-yellow; wings yellowish-hyaline; costa and stigma reddish, rest of the venation dark brown; front, clypeus, thorax and legs with yellowish pile.

Cordoba, Mexico. One female collected June 14, 1905, by F. Knab.
Type.—Cat. No. 14001, U.S.N.M.

STROMBOCEROS (STROMBOCERIDEA) PLESIUS, new species.

Related to *Stromboceros maculipennis* (Cameron), which belongs to the same group, but the mesoprescutum is margined with a cream colored band, and the antennæ are not as strongly spinose beneath.

Female.—Length 10 mm. Clypeus truncate, lateral angles rounded; supraclypeal foveæ very small, punctiform; antennal foveæ wanting as are also the antennal furrows; middle fovea hardly defined, large and shallow; lateral foveæ small, punctiform; ocellar basin wanting; postocellar line much shorter than the ocellocapital or ocellocular line; postocellar area transverse, well defined laterally; eyes nearly parallel; antennæ pilose, long tapering, third joint but very little longer than fourth, pedicellum much longer than broad; stigma nearly parallel sided, sharply, obliquely truncate; venation as *maculipennis*; lanceolate cell of hind wings sessile; hind basitarsis subequal with the following joints; claws cleft; sheath narrow obtusely rounded. Creamish-yellow; flagellum, head above middle of eyes, middle of mesoprescutum, mesoscutum, scutellum, mesosternum, mesoepimeron, apical three abdominal segments, apical four joints of intermediate tarsi, apex of posterior tibiæ and their tarsi *black*. Wings black with a broad yellow band in the middle, venation the color of wings.

Santa Rosa, Mexico. One female collected by William Schaus.

Type.—Cat. No. 14002, U.S.N.M.

STROMBOCEROS (STROMBOCERIDEA) URICHI, new species.

Male.—Length 7.5 mm. Clypeus broadly rounded; supraclypeal area flat; supraclypeal foveæ small punctiform; antennal foveæ very shallow, poorly defined; antennal furrow nearly complete, but not sharply defined; middle and lateral foveæ punctiform, the latter above the former and much better defined; ocellar basin small, just around the ocellus; postocellar furrow wanting; postocellar line subequal with the ocellocapital line, much shorter than the ocellocular line; postocellar area transverse; pedicellum much longer than broad, rest of the antennæ wanting; stigma rounded below, truncate apically; transverse radius in apical third; third and second cubital cells subequal; transverse median somewhat beyond the middle; lanceolate cell of the hind wings sessile; hind basitarsis subequal with the following joints; claws with an erect inner tooth; hypopygidium narrow, broadly rounded apically. Pale yellowish; pedicellum, posterior orbits and head above the middle of the eyes, mesoscutum, intermediate tarsi, most of the posterior tibiæ, their tarsi black; apex of the abdomen brownish; wings hyaline, slightly brownish apically; venation pale brown; stigma yellowish.

Trinidad, West Indies. One male collected by F. W. Ulrich, July, 1899. Doctor Ashmead's manuscript name is used for this species. Named for the collector.

Type.—Cat. No. 14003, U.S.N.M.

STROMBOCEROS (STROMBOCERIDEA) PALLIDICORNIS, new species.

Apical joints of antennæ, thorax and abdomen marked with yellow.

Female.—Length 6 mm. Clypeus gently, arcuately emarginate; middle and frontal foveæ small, shallow, subcircular in outline; antennal furrows very poorly defined, incomplete; ocellar basin large, extending almost to the bases of antennæ, walls rounded, stronger below; postocellar line distinctly shorter than the ocellocular line and but little shorter than the ocellocipital line; antennæ slender, pilose, wanting beyond the sixth joint, third and fourth joints subequal; stigma angulate near base, tapering to the apex; second cubital cell slightly longer than the third; transverse median vein slightly beyond the middle of cell; tibiæ and tarsi pilose; calcaria short and stout; sheath slender, straight above, obliquely truncate at apex, gradually broadening basally. Black and yellow; the following parts black; head (except clypeus, labrum, mandibles apicies of later piceous), third and base of fourth antennal joints, propleuræ, middle of mesoprescutum, mesoscutum, meso- and metapleuræ and sternum (except a large spot on mesoepisternum), posterior legs below trochanters (except apicies of femora), spot on apical dorsal segments and sheath black; wings dusky hyaline; venation black. Intermediate tarsi are sometimes dusky.

Medan, Sumatra. Six females collected by L. B. du Bussey.

Type.—Cat. No. 14004, U.S.N.M.

EUSTROMBOCEROS, new subgenus.

Genotype.—*Stromboceros (Eustromboceros) melanopterus* Rohwer.

* PEDICELLUM WIDER THAN LONG.

STROMBOCEROS (EUSTROMBOCEROS) MELANOPTERUS, new species.

Rufo-ferruginous marked with black; hind tibiæ and tarsi black.

Female.—Length, 8.5 mm. Clypeus truncate; supraclypeal foveæ deep, circular; antennal foveæ poorly defined below, V-shaped above; ocellar basin bounded by line-like carina which extends between the bases of antennæ, making the basin diamond shape; antennal furrows wanting; a depressed area outside each lateral ocellus; postocellar furrow angular; postocellar area transverse; postocellar line shorter than the ocellocipital and much shorter than the ocellocular; antennæ subpilose, stout, filiform, third joint but little longer than the fourth pedicellum, much broader than long; stigma hardly tapering, apex obliquely truncate; transverse radius but a little distance beyond middle of cell; transverse median less than its length from apex of cell; lanceolate cell of hind wings sessile; hind basitarsis subequal with

length of two following joints. Rufo-ferruginous; antennæ, head (except clypeus, labrum, and base mandibles), spots on mesoscutum and mesoprescutum, mesosternum, sheath, intermediate tarsi, posterior tibiæ and tarsi black; wings black.

Federal District of Mexico. One female from Guillermo Gandara.
Type.—Cat. No. 14005, U.S.N.M.

STROMBOCEROS (EUSTROMBOCEROS) XANTHOGASTER, new species.

Male.—Length 8 mm. May be the male of *S. melanopterus* but differs in the following color characters: Thorax (except the pronotum) and basal plates black. Hypopygidium broadly rounded apically, tipped with black.

Federal District of Mexico. One male from Guillermo Gandara.
Type.—Cat. No. 14006, U.S.N.M.

STROMBOCEROS (EUSTROMBOCEROS) GANDARAI, new species.

Wings black, head black.

Male.—Length 8.5 mm. Clypeus truncate; supraclypeal foveæ deep, punctiform; antennal foveæ shallow, not well defined; supraclypeal area nearly flat; lateral foveæ punctiform, a little above the level of the middle fovea; middle fovea transverse oval well defined; antennal furrows wanting; ocellar basin large, rectangular, not sharply defined above; postocellar area transverse, sharply defined laterally; postocellar line longer than the ocellocipital but shorter than the ocellular lines; eyes strongly converging to the clypeus; antennæ subpilose, filiform, the third and fourth joints subequal, pedicellum wider than long; stigma strongly tapering; transverse radius but little beyond the middle of cell; third cubital cell longer than the fourth; cubitus with a spurious vein near the base; transverse median less than its length from middle; lanceolate cell of the hind wings sessile; hind basitarsis much shorter than the following joints; hypopygidium short, broadly rounded apically. Black; pronotum, small lateral spots of anterior part of mesoprescutum, tegulæ, first perapteron, upper part of mesoepimeron, posterior face of mesoscutum, dorsal abdominal segments three to six, rosy red (perhaps due to potassium cyanide), four anterior tibiæ and apical part of femora beneath, posterior knees pale yellowish; wings black.

Federal District of Mexico. One male from Guillermo Gandara, entomologist of Estacion Agricola Central, for whom the species is named.

Type.—Cat. No. 14007, U.S.N.M.

** PEDICELLUM MUCH LONGER THAN WIDE.

STROMBOCEROS (EUSTROMBOCEROS) LEUCOSTOMUS, new species.

Superficially like *Stromboceros* (olim *Selandria*) *curialis* (Cresson), but that species has the third joint of the antennæ longer than four plus five, and the hind basitarsis as long as the following joints.

Female.—Length 8.5 mm. Clypeus rather shallowly arcuately emarginate anteriorly, basally transversely convex; antennal and supraclypeal foveæ confluent; middle fovea large, subquadrate, well defined; lateral foveæ sharply defined, confluent with the large antennal foveæ below, above the level of the middle fovea; ocellar basin triangular in outline, better defined above; frontal crest well defined; antennal furrows complete to the crest from the occiput; postocellar furrow curved anteriorly; postocellar line shorter than the ocellocipital or ocellocular; postocellar area subquadrate; antennæ pilose, short, tapering beyond middle, third joint longer than the fourth and fifth; stigma tapering; transverse radius in apical fourth of cell; transverse median much beyond the middle; lanceolate cell of the hind wings sessile; hind basitarsis much shorter than the following. Black; clypeus, labrum, apical joints of palpi, narrow posterior margin of pronotum, tegulæ, four anterior femora beneath, apices of coxæ, trochanters, bases of posterior femora, tibiæ except apices (the band is incomplete on the four anterior ones) and anterior tarsi white. Wings dusky hyaline, iridescent; venation black.

Federal District of Mexico. One female from Guillermo Grandara of Estacion Agricola Central.

Type.—Cat. No. 14008, U.S.N.M.

Genus STRONGYLOGASTER Dahlbom.

STRONGYLOGASTER TUBERCULICEPS, new species.

Readily distinguished from *Strongylogaster tacitus* Norton by the strongly parted postocellar area, shining ocellar and frontal areas and the better defined ocellar basin.

Female.—Length 7 mm. Clypeus angulately emarginate, lobes broad, triangular, surface very coarsely sculptured; supraclypeal foveæ large, circular in outline; supraclypeal area subconvex, smooth shining; antennal foveæ large sharply defined, and subangulate above; antennal furrows complete from the foveæ, deeper at the postocellar area; middle fovea small, oval in outline; ocellar basin shining, well defined laterally, triangular in outline; postocellar furrow poorly defined; postocellar line shorter than either the ocellocipital or ocellocular; postocellar area strongly convex, parted in the middle which makes it appear bituberculate; first and second flagellar joints subequal; head shining, with irregularly scattered, distinct punctures; mesonotum shining, practically impunctate; third cubital cell much longer than the second receiving the transverse radius near apical third; transverse median somewhat beyond the middle; sheath obtusely rounded apically. Black; anterior tibiæ

brownish beneath; abdomen except apex of sheath rufoferruginous. Wings and venation black.

Tampa, Florida. One female collected April 28.

Type.—Cat. No. 14009, U.S.N.M.

STRONGYLOGASTER MELANOGASTER, new species.

Differs from *Strongylogaster uncus* Norton in the black abdomen, and more broadly truncate hypopygidium.

Male.—Length 7 mm. Clypeus with a rather narrow arcuate emargination, lobes broad obtusely pointed; supraclypeal area strongly convex; supraclypeal foveæ deep, circular in outline; antennæ foveæ narrow, elongate, sharply defined; antennal furrows present, but poorly defined from foveæ, nearly complete subpunctiform at postocellar area; middle fovea rather large, circular in outline; ocellar basin subtriangular, shining, poorly defined; postocellar furrow present; postocellar line slightly longer than the ocellocipital but shorter than the ocellocular; postocellar area shining, transverse, not parted; third and fourth antennal joints subequal; front very closely punctured, occiput very sparsely so; pronotum punctured; mesothorax shining, nearly impunctate; third cubital cell much longer than the second, receiving the transverse radius near apical third; transverse median beyond the middle; hypopygidium broadly truncate. Black; mesoepimeron, mesoprescutum and scutum, rufous; tip of clypeus and anterior tibiæ beneath brownish. Wings and venation black.

Jacksonville, Florida, two males; St. Nicholas, Florida, four males. All from the Ashmead collection.

Type.—Cat. No. 14010, U.S.N.M.

Genus HEMITAXONUS Ashmead.

Epitaxonus MacGILLIVRAY, Can. Ent., vol. 40, 1908, p. 365.

The characters offered by Rohwer¹ to separate *Epitaxonus* from *Hemitaxonus* are not even of specific value. In a bred series of *Hemitaxonus dubitatus* the relative length of the third cubital cell and the appendiculation of the hind radial cell varies considerably. The other characters are of but little value, the relative difference between the length of the joints of maxillary palpi and hind tibiæ is not great enough to be of any value.

HEMITAXONUS DUBITATUS var. **AMICUS** (Norton).

Taxonus albidopictus DYAR, Journ. New York Ent. Soc., vol. 5, 1897, p. 20.

Hemitaxonus albidopictus ROHWER, Proc. U. S. Nat. Mus., vol. 38, 1910, No. 1739, p. 204.

The specimens in Doctor Dyar's collection labeled *Taxonus albidopictus*, which were reared from the larvæ described in the above

¹ Can. Ent., vol. 42, 1910, p. 50.

reference, are typical specimens of *amicus* (Norton), agreeing exactly with the type. Doctor Dyar writes that, "The larvæ of these two species [*dubitatus* and *amicus*] of *Taxonus* can not be certainly distinguished." The adults offer only varietal differences, if that. Norton, in the original description, suggested that *amicus* would only be a variety of *dubitatus*.

HEMITAXONUS ALBIDOPICTUS (Norton).

Taxonus albidopictus NORTON, Trans. Amer. Ent. Soc., vol. 2, 1868, p. 213, No. 6.
Hemitaxonus rufopectus ROHWER, Proc. U. S. Nat. Mus., vol. 38, No. 1738, 1910, p. 204.

There can be no doubt about this synonymy.

Genus SCOLIONEURA Konow.

SCOLIONEURA LUTEOPICTA, new species.

May be separated from *S. populi* Marlatt by the following comparison:

<i>Scolioneura populi</i> Marlatt.	<i>Scolioneura luteopicta</i> Rohwer.
FEMALE.	FEMALE.
1. Middle fovea somewhat pyriform, broader below.	1. Middle fovea smaller, rectangular in outline.
2. Antennal furrows without a distinct punctiform fovea below the level of ocelli.	2. Antennal furrows with a distinct punctiform fovea below the level of ocelli.
3. Ocellar basin rather well defined.	3. Ocellar basin hardly defined.
4. Postocellar area not parted.	4. Postocellar area parted by a faint median furrow.
5. Apical antennal joint rounded at the apex, subequal with the preceding.	5. Apical antennal joint tapering and distinctly longer than preceding.
6. Antennal furrows black.	6. Antennal furrows pale, except the punctiform fovea.
MALE.	MALE.
7. Pectus black.	7. Pectus pale.

Brookings, South Dakota. Two males and one female bred from cottonwood (*Populus*) June 20, 1892.

Type.—Cat. No. 14011, U.S.N.M.

Genus EMPRIA Lepeletier.

EMPRIA SCHWARZI, new species.

Related to *Empria maculata* (Norton), but may be known from that species by the black clypeus, darker venation, depressed area in the top of inner orbits, and more shining dorsulum. The black clypeus, dark venation, annulated posterior legs, and robust truncate sheath are characters to help distinguish this species.

Female.—Length, 7 mm. Labrum rounded on the anterior margin; clypeus emarginate, with a small inner tooth, a poorly defined carina, the surface coarsely granular, antennal fovea large, extending much above the insertion of the antennæ; a low hump between the antennæ; middle fovea small, well defined; antennal furrows nearly complete; V-shaped depressions below and above the anterior ocellus; postocellar line present; the area near the top of the inner orbits somewhat depressed; head rather coarsely granular below the supraorbital line, shining above it; antennæ very like *maculata*; dorsulum shining; stigma broadest at the base, tapering to the apex; first transverse cubitus wanting; sheath robust, truncate; saw dark, with strong, sharp teeth pointing toward the base near the apex, the base without teeth, the upper part not dentate, rather irregular. Black; labrum, apical palpi joints; four anterior legs below femora and the trochanters, basal half of posterior tibiæ and post-basitarsis, yellowish-white; the usual abdominal spots greenish-white; wings clear hyaline, venation black; eyes in life dark-iridescent green.

Plummer's Island, Potomac River, Maryland. One female collected by E. A. Schwarz.

Type.—Cat. No. 14012, U.S.N.M.

Genus AMETASTEGIA A. Costa.

Taxonus (subgenus) ROHWER, Proc. U. S. Nat. Mus., vol. 39, No. 1777, 1910, p. 111.

Aomodictium ASHMEAD, Can. Ent., vol. 30, 1898, p. 309.

Taxonus (Mac Gillivray) VIERECK, New Jersey State Mus., (1909) 1910, p. 582 (part).

The incorrect remarks about the type of the genus *Taxonus*¹ when corrected does not make *Ametastegia* a synonym of *Taxonus*, but leaves it the first name available for the subgenus *Taxonus* as defined by Rohwer.² The genus *Aomodictium* Ashmead was founded on a male of *Strongylogaster abnormis* Provancher, which belongs to *Ametastegia*. *Aomodictium* Ashmead is, therefore, a synonym of the older genus *Ametastegia* A. Costa. The hind basitarsis is shorter than the following joints. Those who hold that a genus is without standing until it has a species placed in it will accredit the genus *Aomodictium* to the present paper.

EMPHYTINA, new subgenus.

Genotype.—*Emphytina pulchella* Rohwer.

Separated from *Ametastegia* Costa (s. s.) by somewhat different habitus and loss of the first transverse cubitus. The species belong-

¹ See Proc. U. S. Nat. Mus., vol. 39, No. 1777, p. 111; Bull. Tech. Ser. No. 20, pt. 2, U. S. Dep. Agr., Bur. Ent., 1911, p. 90.

² Proc. U. S. Nat. Mus., vol. 39, 1910, p. 111.

EMPHYTINA VIRGINICA, new species.

Female.—Length 6 mm. Clypeus broadly arcuate, lobes broad, obtuse; supraclypeal area convex; supraclypeal and antennal foveæ confluent; middle fovea wanting; antennal furrows wanting; ocellar area raised, ocellar basin wanting; postocellar area not defined; postocellar line shorter than the ocellocipital; ocellocipital line and ocellocular line subequal; antennal joint three longer than four, antennæ pilose; stigma broad, rounded below; sheath as in figure 5. Black; clypeus, labrum, palpi, tegulæ, posterior margin of pronotum, lower part of mesoepisternum, mesosternum, legs and venter white; dorsal segments in the middle rufoferruginous (narrowed laterally).

Wings hyaline iridescent; venation dark brown.

Dixie Landing, Virginia. One female. Collected May 27 by C. L. Marlatt.

Type.—Cat. No. 13978, U.S.N.M.

EMPHYTINA PALLIDSCAPA, new species.

Female.—Length 5 mm. Like *virginica*, except as follows: Clypeus subsquarely emarginate, lobes obtuse; postocellar area faintly defined all the way around; stigma broader at base; sheath as in figure 6; scape white; venation pale brown; dorsal spots smaller.

Male.—Length 4.5 mm. Sufficiently like the female to be easily associated with it; postocellar area not defined, hypopygidium broadly rounded.

Washington, District of Columbia (?). Described from a number of males and females recorded under Bureau of Entomology number 3329. The following note for February, 1884, made by Mr. A. Koebele

is of interest: "Found under bark of black birch (*Betula nigra*), near ground, large numbers of saw-fly larvæ which had hibernated; some of them seem to be parasitized." Microgasterine and Chalcid parasites later issued from some of these larvæ.

Type.—Cat. No. 13979, U.S.N.M.

EMPHYTINA STRAMINEIPES (Cresson).

The following notes from the type may be worth while: Postocellar area hardly defined laterally; middle foveæ and ocellar basin wanting; clypeus subsquarely emarginate, lobes obtuse; sheath differing from *virginica* in being more oblique below.

EMPHYTINA PLESIA, new name.

Emphytus leucostomus ROHWER, Journ. New York Ent. Soc., vol. 16, 1908, p. 110; not Costa, Rend. Acc. Sci. Gis. Napoli, 1890, p. 172.

"Once a homonym always a homonym." This is close to *aperta* (Norton).

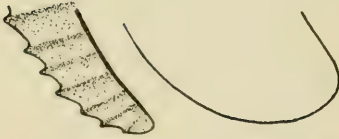


FIG. 7.—APEX OF THE SHEATH AND THE LOWER GONAPOPHYSES OF AMETASTEGIA (EMPHYTINA) CANADENSIS (KIRBY). DRAWING FROM A SPECIMEN BRED BY DR. H. G. DYAR AND RECORDED IN THE CANADIAN ENTOMOLOGIST, VOL. 26, 1894, P. 185. LARVA ON VIOLA TRICOLOR LINNÆUS



FIG. 8.—APEX OF THE SHEATH AND SAW OF AMETASTEGIA (EMPHYTINA) CANADENSIS (KIRBY). FROM A SPECIMEN BRED IN WASHINGTON, D. C., FROM LARVÆ FEEDING ON VIOLETS, THE LARVÆ WERE COLLECTED AT POUGHKEEPSIE, NEW YORK.

EMPHYTINA CANADENSIS (Kirby).

The accompanying figures show variation in the saw and sheath of this species. In other respects the specimens are practically the same.



FIG. 9.—APEX OF THE SHEATH AND SAW OF AMETASTEGIA (EMPHYTINA) APERTA (NORTON). THIS SPECIMEN WAS NOT COMPARED WITH THE TYPE, BUT AGREES WITH A SERIES WHICH IS SUPPOSED TO BE THIS SPECIES IN THE COLLECTION OF THE MUSEUM.

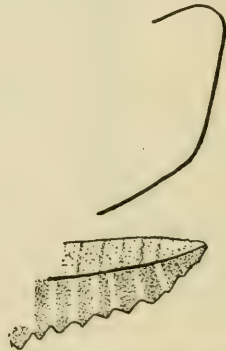


FIG. 10.—APEX OF THE SAW AND SHEATH OF AMETASTEGIA (EMPHYTINA) INORNATA (SAY). DRAWING OF A SPECIMEN WHICH AGREES EXACTLY WITH A PROXYTYPE MADE BY ROHWER IN THE MUSEUM COLLECTION.

Genus PSEUDOSIOBLA Ashmead.

Pseudosiobla Ashmead will probably be classed as subgenus of *Siobla* Cameron, separated from it by the shorter pedicellum and only one (in some cases none) discal cell in the hind wings—in *Sioble* there are two. *Siobla* Kirby¹ is a composite group.

Key to North American species.

- Females..... 1
 Males..... 3
1. Sheath sharply truncate, subparallel-sided; second cubital cell not much shorter than the second; clypeus white.....*cephalanthi* Rohwer.
 Sheath rounded below, not subparallel-sided; second cubital cell distinctly shorter than the second; clypeus mostly black..... 2
 2. Stigma tapering, not truncate apically; posterior orbits closely punctured.....*excavata* (Norton).
 Stigma rounded below, truncate apically; posterior orbits and occiput sparsely punctured.....*robusta* (Kirby).
 3. Stigma tapering, not truncate apically (clypeus mostly black; posterior orbits closely punctured).....*excavata* (Norton).
 Stigma rounded below, truncate apically..... 4
 4. Clypeus black; third antennal joint subequal with the fourth and fifth.
floridana (Provancher).
 Clypeus yellow; third antennal joint distinctly shorter than the fourth and fifth.....*cephalanthi* Rohwer.

PSEUDOSIOBLA ROBUSTA (Kirby).

This species was originally described from Georgia. In the National Museum collection is a female from Texas (Belfrage collection), which agrees exactly with Kirby's description and manuscript notes from the type.

PSEUDOSIOBLA FLORIDANA (Provancher).

Type.—Cat. No. 13965, U.S.N.M.

Dr. A. D. Mac Gillavray² gives this as a synonym of *robusta* (Kirby). It is perhaps better to keep them separate for the present, as *floridana* has the posterior orbits closely punctured; the basal dorsal segments finely aciculate (in *robusta* only the base of the second is aciculate); and the wings are darker.

In the associated males and females this antigeny does not occur. The stigmal and cubital venation is as in *robusta*.



FIG. 11.—THE STIGMAL VENATION AND SHEATH OF PSEUDOSIOBLA ROBUSTA (KIRBY).

¹ List Hym. Brit. Mus., vol. 1, p. 250, etc.

² Can. Ent., vol. 40, 1903, p. 366.

PSEUDOSIOBLA EXCAVATA (Norton).

A homotype (det. Rohwer) of this species came from Lake Forest, Illinois, and is labeled "button bush." It is no doubt one of the lot collected by Doctor Needham.¹ Specimens of this species are also from Canada, and Long Island. The figure is of the homotype.



FIG. 12.—THE STIGMAL VENATION AND SHEATH OF PSEUDOSIOBLA EXCAVATA (NORTON).

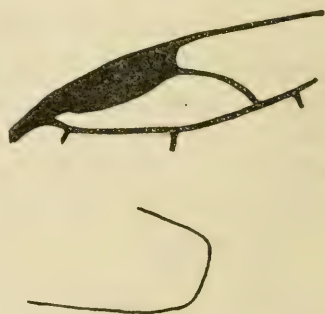


FIG. 13.—THE STIGMAL VENATION AND SHEATH OF PSEUDOSIOBLA CEPHALANTHI ROHWER.

PSEUDOSIOBLA CEPHALANTHI, new species.

Unknown larva 5 c DYAR, Can. Ent., vol. 27, 1895, p. 339.

Siobla excavata DYAR, Journ. New York Ent. Soc., vol. 5, 1897, p. 190.

Pseudosiobla excavata HOWARD, Insect Book, 1904, pl. 13, fig. 7.

Female.—Length 10 mm. Clypeus with a slight median arcuation; antennal furrows complete but not strong; antennal foveæ poorly defined; postocellar line slightly shorter than the ocelloccipital line and much shorter than the ocellocular; head nearly uniformly, coarsely

punctured; third antennal joint subequal with the fourth and fifth; propodeum granular; second and third dorsal segments aciculato-granular, the following very finely granular; hind basitarsis curved. Black; clypeus, labrum, posterior margin of pronotum, spot or side of pronotum, spot on tegulæ, propodeum, trochanters, basal two-thirds of four hind tibiæ whitish; two basal joints of antennæ, anterior tibiæ and tarsi yellow; apex of four posterior tibiæ and their tarsi, and second dorsal segment rufous; dorsal abdominal segments piceous; wings dusky hyaline, venation dark brown (black basally) base of stigma yellow.

Male.—Length 10 mm. Similar to female. Abdomen not piceous; third antennal joint distinctly shorter than the fourth and fifth; hypopygidium sharply rounded apically.

Near New York City, New York. Three females and seven males bred from larvæ on *Cephalanthus occidentalis* (button bush) by H. G. Dyar and described as *Siobla excavata*.²

Type.—Cat. No. 13966, U.S.N.M.

¹ Psyche, vol. 10, 1903, p. 27.

² Journ. New York Ent. Soc., vol. 5, 1897, p. 190.

Genus TAXONUS Hartig.

Subgenus PARASIOBLA Ashmead.

TAXONUS (PARASIOBLA) RUFOCINCTUS VIRGINICUS, new variety.

Differs from the typical *rufocinctus* (according to a proxytype in the American Entomological Society collection made by Rohwer in June, 1909) in having the abdomen beyond the basal plates entirely rufous. This variation occurs with the typical form in Virginia, but as exhibited by many individuals from Mr. Nathan Banks' collection is more abundant than the typical form. In some few specimens the apical dorsal segments are slightly brownish. Males and females.

Great Falls, Glencarlyn, and Falls Church, Virginia; Ithaca, New York. Collected by N. Banks. Dixie Land, Virginia, collected by C. L. Marlatt.

Type.—Cat. No. 13840, U.S.N.M.

Paratype in collection of Mr. Banks.

Genus DIMORPHOPTERYX Ashmead.

Key to species.

- Mesoprescutum rufous; basal plates pale.....*abnormis* Rohwer.
- Mesoprescutum black; basal plates black..... 1
- 1. Apical four abdominal segments black; (mandibles, antennæ, clypeus and labrum black).....*melanognathus* Rohwer.
- Abdomen beyond basal plates pale, sheath black..... 2
- 2. Females (scutellum yellow)..... 3
- Males (scutellum black)..... 5
- 3. Antennæ black.....*pinguis virginica* Rohwer.
- Antennæ pale..... 4
- 4. Ocellar basin with well defined lateral walls which extend to the bases of antennæ; clypeus subangulate emarginate.....*pinguis pinguis* (Norton).
- Ocellar basin with the lower lateral walls not sharply defined and reaching the bases of the antennæ as rounded ridges; clypeus subsquarely emarginate.
- pinguis errans* Rohwer.
- 5. Antennæ black; ocellar basin with rounded walls; fifth to eighth joints of antennæ beneath with an apical projection.....*pinguis errans* Rohwer.
- Antennæ brown; walls of ocellar basin well defined; fifth to eighth antennal joints without projection beneath.....*pinguis virginica* Rohwer.

DIMORPHOPTERYX PINGUIS (Norton).

The type of Norton's *pinguis* is not in the collection of the American Entomological Society, and appears to be lost. A specimen which agrees with the original description and with specimens which were supposed to be determined by Norton is taken as the proxytype.¹ Dr. H. G. Dyar has bred what was considered to be this species from birch, linden, sugar plum (*Amelanchier canadensis*), maple, and

¹ The word "proxytype" is used to designate a specimen chosen (and labeled as proxytype) as the type by a subsequent author when the real type has been destroyed or lost.

black oak. It is impossible to determine if these are all *pinguis* as here restricted. The male is not in the collection of the United States National Museum.

DIMORPHOPTERYX PINGUIS ERRANS, new variety.

Parasiobla rufocinctus HOWARD, Insect Book, 1904, pl. 14, fig. 26.

Besides the characters given in the above table this variety may be separated by the anterior margin of the clypeus being pale.

Two females and two males from the collection of Dr. H. G. Dyar. One of the females from Bellport, New York, June 12.

Type.—Cat. No. 13843, U.S.N.M.

DIMORPHOPTERYX PINGUIS VIRGINICA, new variety.

Female.—Falls Church, Virginia, June 28; female, Washington, District of Columbia, June 22; male, Glencarlyn, Virginia, June 28. All collected by N. Banks.

Type.—Cat. No. 13842, U. S.N.M.

DIMORPHOPTERYX MELANOGNATHUS Rohwer.

Dimorphopteryx melanognathus ROHWER, Proc. U. S. Nat. Mus., vol. 39, No. 1739, 1910, p. 205.

Known from the unique female type.

DIMORPHOPTERYX ABNORMIS, new species.

Very distinct in color, strongly punctured mesoscutum, elevated scutellum.

Female.—Length 6 mm. Labrum broadly rounded apically; clypeus sparsely punctured, shallowly emarginate apically, lobes hardly defined; head as in *pinguis*, except the rounded walls of the ocellar basin; antennæ typical not nodose at apex beneath; mesoscutum and prescutum with rather close well defined punctures; mesoepisternum very coarsely punctato-reticulate; scutellum closely, strongly punctured, elevated; venation normal except that the transverse radius is entirely wanting; sheath obtusely pointed apically. Black; clypeus, labrum, mandibles (apices piceous), tegulæ, legs (apices of posterior femora black) and entire abdomen rufo-ferruginous (parts of legs somewhat paler); antennæ, mesoprescutum, and posterior margin of pronotum rufous; scutellum yellow; wings hyaline, venation pale brown.

Male.—Length 6 mm. Differs from the female in the rufous scutellum and upper part of mesoepisternum; hypopygidium obtusely rounded.

A female paratype shows that the mesoepisternum may be rufous in the female.

Ottawa, Canada. Two females and one male bred from larvæ on cultivated plum in 1900.

Type.—Cat. No. 13841, U.S.N.M.

The complete loss of the transverse radius in all the specimens may indicate an abnormal development or if constant in a large series together with the elevated scutellum might constitute characters for a subgenus.

Genus ALLANTUS Panzer.

Emphytus KLUG.

The genus *Allantus*, a monobasic genus, was established by Panzer in 1801¹ and has *Tenthredo* (*Allantus*) *togata* Panzer as the type. It therefore replaces *Emphytus* Klug. 1813. *Allantus* Auctorum equals *Tenthredo* Linnæus.²

Key to Nearctic and other species of *Allantus*.

- Posterior femora red or reddish..... 1
 Posterior femora black..... 2
 1. Four anterior femora pale..... *mellipes* (Norton).
 Four anterior femora blackish..... *gillettei* (MacGillivray).
 2. Posterior tibiæ black and white..... *cinctus nigriritibialis* Rohwer.
 Posterior tibiæ red and white..... 3
 3. Sheath sharply truncate; furrows bounding the postocellar area, joining the postocellar furrow in middle of the lateral ocelli..... *cinctus cinctus* (Linnæus).
 Sheath rounded below; furrows bounding the postocellar area joining the postocellar furrow well outside the lateral ocelli..... *cinctus cinctipes* (Norton).

A. mellipes (Norton) seems to be close to *A. cingillum* (Klug.).

ALLANTUS CINCTUS NIGRITIBIALIS, new subspecies.

Female.—Length 7.5 mm. Closest to *cinctus cinctipes* (Norton), but may be separated by the above table.

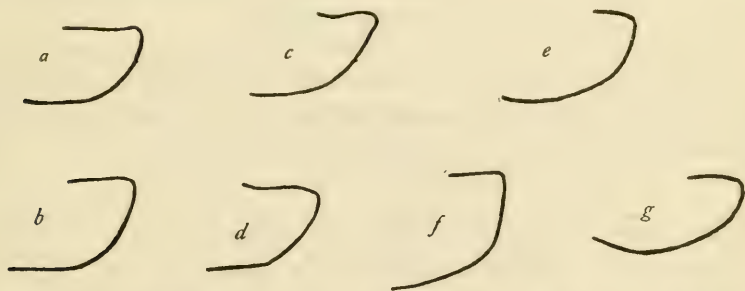


FIG. 14.—FIGURES OF THE APICES OF THE SHEATHS OF SPECIES OF ALLANTUS. *a, b*, OF *A. CINCTUS CINCTIPES* (NORTON); *c, d*, OF *A. CINCTUS NIGRITIBIALIS* ROHWER; *c* IS FROM THE SPECIMEN FROM JAPAN; *d*, OF THE SPECIMEN FROM CHINA; *e*, OF *A. GILLETTEI* (MAC GILLIVRAY); *f*, OF *A. CINCTUS CINCTUS* (LINNÆUS); *g*, OF *A. MELLIPES* (NORTON).

One female “crawling on Hemlocks, from Japan” collected by J. B. Smith at Rutherford, New Jersey, April 15, 1911. One female from Hong Kong, China, collected by A. Koebele.

Type.—Cat. No. 13980, U.S.N.M.

¹ Fauna Insect German, vol. 11, p. 32, pl. 12.

² Ent. News, vol. 22, 1911, p. 218; Bull. Tech. Ser. No. 20, pt. 2, Bureau of Entomology, 1911; Proc. U. S. Nat. Mus., vol. 39, No. 1777, 1911, p. 117.

Genus APHILODYCTIUM Ashmead.

APHILODYCTIUM MACULATUM, new species.

Female.—Length 8 mm. Close to *multicolor* (Norton), but may be separated as follows: Middle fovea sharply defined beneath and laterally; spot on the mesoepisternum small; posterior femora brownish.

Nevada, one female.

Type.—Cat. No. 12813, U.S.N.M.

APHILODYCTIUM MULTICOLOR ERYTHROGASTRUM, new subspecies.

Female.—Length 6.5 mm. Differs from *multicolor multicolor* in the orbits being entirely yellow, and the abdomen beyond the basal plates rufous.

Male.—Length 6 mm. Differs from the typical form as the female.

Westville, New Jersey, June 6, 1897; Long Island, New York; Great Falls, Virginia, June 12 (N. Banks); Falls Church, Virginia, June 4 (N. Banks); Maryland; North fork of Swannanoa River, Black Mountains, North Carolina; many males and females taken by N. Banks flying around *Betula*.

Type.—Cat. No. 12814, U.S.N.M.

Some of the males from North Carolina have the middle of the tergum with a black line.

APHILODYCTIUM RUBRIPES NIGRITARSIS, new variety.

Differs from the typical form by the entirely black four posterior tarsi. It is also somewhat more slender. There is a superficial resemblance to *Ametastegia glabrata* (Fallén).

Steamboat Springs, Colorado. One female and five males collected May 27, 1910, by T. D. A. Cockerell. Also one female and three males from Colorado, with no definite locality. It may be that this variety will be found only in western Colorado.

Type.—Cat. No. 13982, U.S.N.M.

Genus PERINEURA Hartig.

PERINEURA TURBATA, new species.

Antennæ with an annulus; abdomen and legs rufous; head and most of the thorax black.

Female.—Length 8 mm. Labrum acutely rounded; clypeus deeply, narrowly arcuately emarginate; surface granular; head rather coarsely granulato-reticulate; posterior orbits and occiput carinated; frons indicated below as in *rubi* (Panzer); pentagonal area only indicated; postocellar area poorly defined anteriorly, at least twice as wide as the cephal-caudad length; postocellar line shorter than the ocellocipital line; pedicellum angular, the length and width subequal;

antennæ somewhat flattened, about two-thirds as long as the insect, the third joint longer than the fourth; mesoscutum shining, finely punctured; scutellum opaque, finely granular; stigma broadest at base, tapering to the apex; the third cubital cell about twice as broad at the apex as at the base, receiving the transverse radius near the apex; sheath straight above, subtruncate, rounded below. Black; labrum, seventh to the ninth antennal joints, tegulæ, apex of the coxæ and trochanters, and the posterior tarsi white; mandibles, clypeus, supraclypeal area, two basal joints of the antennæ, pre-scutum, scutellum, angles of the pronotum, the legs below the trochanters, and the abdomen beyond the basal plates rufo-ferruginous or ferruginous. Wings hyaline, iridescent; venation dark brown, stigma at the base white.

Male.—Very like the female. The antennæ are entirely ferruginous. The hypopygidium is broadly rounded apically. The clypeus is in some specimens nearly white.

Two paratopotypes show that the species may vary thus: The base of the third antennal joint may be pale, the white of the antennæ may not be sharply defined but shaded into brown at either end, and the mesoepisternum may have a rufous spot.

North Fork of Swannanoa River, Black Mountains, North Carolina. Three females collected in late May, 1910, by F. Sherman. Five females and seven males collected in late May by N. Banks.

Type.—Cat. No. 14013, U.S.N.M.

Paratypes in the collection of the North Carolina Department of Agriculture and in the collection of N. Banks.

Genus TENTHREDINA Rohwer.

TENTHREDINA CYLINDRICA, new species.

Related to *Tenthredo fortunii* Kirby and *Tenthredo smithii* Kirby, which from the figures seem to belong to *Tenthredina*, but does not agree in all points with the description of these species.

Female.—Length 15 mm. Labrum longer than broad, obtusely pointed, margined; clypeus arcuately emarginate, lobes obtusely rounded, head shining; postocellar area much broader than the cephal-caudad length, well defined, not as wide as the postocellar line is long; ocelli in a low triangle, the area in front of the ocelli rather swollen; middle fovea with rounded walls, open above and joining with a depression from the anterior ocellus; antennæ wanting beyond the second joints in the type; mesonotum, mesopleuræ and scutellum shining, with separate distinct punctures; scutellum strongly elevated; third cubital cell subequal in length with the first and second; sheath rather narrow, parallel-sided, the apex obliquely truncate. Rufo-ferruginous, varied with black and yellow; clypeus, labrum, mandibles (apices piceous), most of face, lower part of poste-

rior orbits, margin of collar, posterior part of sutures of anterior lobe, scutellum, scutellar lobe, metanotum, broad band on pleuræ, metaepisternum, first and third segments of the abdomen *yellow*. Most of the lobes of the mesonotum, pectus, and base of some of the abdominal segments black. Legs yellowish, line on the four posterior femora above, black; posterior tibiæ and tarsi ferruginous. Wings yellowish hyaline, vitreous, cubital and radial cells dusky; venation dark brown, stigma and costa yellowish.

Southern China. One female.

Type.—Cat. No. 14014, U.S.N.M.

Genus MACROPHYA Dahlbom.

MACROPHYA TROSULA (Norton).

Allantus trosulus NORTON, Boston, Journ. Nat. Hist., vol. 7, pt. 2, p. 244; and other references.

Macrophya albifacies KIRBY, List of the Hymenoptera of the British Mus., vol. 1, 1882, p. 271, pl. 10, fig. 18.

Macrophya trossula DALLA TORRE, Cat. Hym., vol. 1, 1894, pl. 62. Emendation.

An examination of the type of *Macrophya albifacies* Kirby revealed no differences from *trosula* (Norton), Kirby's name is therefore considered a synonym.

MACROPHYA DYARI, new species.

Related to *Macrophya trosula* (Norton), but may be separated from that species by the following characters: Middle fovea entirely wanting; vertex without large shining areas; pleuræ and the bases of the posterior coxæ black; abdomen rufous beyond the basal plates; tarsi not black at the apices.

Female.—Length, 7 mm.

Van Cortlandt Park, New York. One female collected May 20, 1896. Named for Dr. H. G. Dyar, who collected the type. Also a female from Michigan, and one without locality label, which has the marking white.

Type.—Cat. No. 14015, U.S.N.M.

MACROPHYA NAPENSIS, new species.

Female.—Length, 6.5 mm. Differs from *pluricintella* Rohwer in the angulate emargination of the clypeus, elongate middle fovea, subfiliform antennæ, and banded venter.

Napa County, California. One female.

Type.—Cat. No. 14016, U.S.N.M.

MACROPHYA FUSCOTERMINATA, new species.

Allied to *fuliginea* Norton, but the tergum has distinct punctures and the posterior coxæ has a pale spot.

Female.—Length, 9.5 mm. Labrum truncate; clypeus broadly, deeply, arcuately emarginate; the lobes narrow and obtusely pointed;

middle and frontal foveæ well defined; antennal furrows poorly defined but present; postocellar area well defined, somewhat wider than the cephal-caudad length; head closely punctured except the area between the eyes and the ocelli, which is shining and polished; thorax with close and distinct punctures; stigma rounded below; the second and third cubital cells equal on the radius; the post-basitarsis equal in length with the following joints; sheath broadly rounded apically, concave above, convex below. Black; spot on the mandibles, the edge of the labrum, two spots on the posterior margin of the postocellar area, spot on the anterior femora and tibiæ beneath, and a spot on the posterior coxæ *white*. Wings hyaline, beyond the stigma fuscous, venation very dark brown.

Canton, North Carolina. One female collected in June, 1910, by F. Sherman.

Type.—Cat. No. 14017, U.S.N.M.

MACROPHYA ERRANS, new species.

Very close to *M. fuliginea* Norton and *fuscoterminata* Rohwer, but the clypeus is broadly arcuately emarginate, with the angles triangular and sharp; the antennal furrows are nearly complete; and from *fuliginea* it differs in having a pale spot on the posterior coxæ.

Female.—Length 9 mm.

One female from Pennsylvania, from the C. F. Baker collection.

Type.—Cat. No. 14018, U.S.N.M.

Genus TENTHREDO LINNÆUS.

TENTHREDO ELEGANTULA (Cresson).

Allantus elegantulus CRESSON, Trans. Amer. Ent. Soc., vol. 8, 1889, p. 17, male and female.

Labidia opimus var. *bigeminus* DYAR, Can. Ent., vol. 25, 1893, p. 195, female.

The type of *bigeminus* Dyar does not differ in any way from the description of *elegantulus* (Cresson).

TENTHREDO ELEGANTULA OREGANA, new subspecies.

Female.—Length 10.5 mm. Differs from *elegantula elegantula* in the black mesopectus and black prescutum.

Cowallis, Oregon. One female from the Ashmead collection.

Type.—Cat. No. 14019, U.S.N.M.

CRYSTALLIZED VARISCITE FROM UTAH.

By WALDEMAR T. SCHALLER

Of the United States Geological Survey.

INTRODUCTION.

The material on which the following descriptions are based was collected near Lucin, Utah, by Mr. Douglas B. Sterrett, of the United States Geological Survey. A part of the material consists of well crystallized variscite, a condition so unusual for this mineral that it was at first thought to be a new species. The detailed study has shown, however, that the mineral is identical with variscite, and the quantity of material was sufficient to determine all the chief properties of the mineral. Mr. Sterrett brought out a striking property of this mineral by heating a fragment of it before the blowpipe. At a low temperature the vivid green color was readily changed to a deep lavender. The chemical study of the mineral was extended in order to find out if possible the cause of this change, and the various properties of the lavender-colored variscite were studied, as well as those of the green mineral in order, if possible, to correlate the two. The author wishes to express his thanks to Mr. Sterrett for permission to describe this very interesting mineral and for his generosity in furnishing the material needed. The specimens described in this paper are the property of the United States National Museum. (Cat. No. S6993.)

OCCURRENCE AND GEM QUALITY.

The following notes on the occurrence of the variscite near Lucin, Utah, and of the kind and quality of the gem stones have been taken from the manuscript report on the "Production of precious stones in the United States for 1910," by Douglas B. Sterrett.

The variscite deposits, about 5 miles northwest of Lucin, Utah, are in the northern part of an irregular-shaped hill, called Utahlite Hill. Utahlite Hill is about a mile long in a northwest-southeast direction and about one-half mile wide. It has an elevation of about 5,000 feet above sea level, and rises over 300 feet above the mesas

and gentle slopes at its base and about 500 feet above the railroad at Lucin. Four claims have been located, and these are, in order from northwest to southeast, Utah Gem, Greenback Lode, Utahlite, and Protection Lode. The variscite deposits are in and around small rocky summits standing above the rest of the hill. These summits have cavities and small caverns in them, resembling those made by wave action. They were probably formed on one of the shore lines of the former Lake Bonneville. The work done at the time of examination consisted of an open cut 50 feet long and 2 to 5 feet deep, with several prospect pits.

The rock in which the variscite occurs and which forms the crest of the hill is cherty or chalcedonic quartz which contains inclusions of nodules and streaks of limestone. The limestone inclusions range up to a foot thick and in places are several feet long. The character of most of the rock is that of a hard breccia cemented together by silica. This breccia forms rough rocky ledges and knobs rising from a few feet to 25 feet above the hill slopes. Three of these knobs contain large quantities of variscite.

The variscite occurs in balls, nodules, and irregular masses in the chert. Veins of variscite are not common, but some with a northeast strike and northwest dip were seen on the Utah Gem claim. The nodules and balls of variscite range in size from a fraction of an inch to several inches across, and some of the segregations of variscite inclosing matrix are a foot across. The variscite fills fractured and brecciated zones in the rock, some of which it replaces and some of which it incloses. The replacements are generally rounded concretionary masses, often with a banded concentric structure. The fragments of some of the brecciated rock, especially white quartz, that have been inclosed by and cemented with variscite have remained angular and sharp. Some of the concretionary forms appear to grade from green variscite cores into the inclosing yellow, brown, gray, and white phosphatic and cherty minerals. There is considerable chalky mineral filling cavities in the variscite-bearing rock and coating the nodules and masses of variscite. A quantity of variscite pebbles and cobbles have been found in the open cut in the loose detritus below the main outcrop on the Utahlite claim. These pebbles probably owe their rounded form largely to the nodular shape of the variscite in the original rock, but also probably to some extent to water action on a former lake shore. The pebbles are coated with a white chalky substance, and have to be broken into before the presence or quality of the variscite can be determined.

Both the variscite and the matrix minerals possess various shades of color, several of which are sometimes present in a single specimen. The different colors combined with the various markings and patterns due to the structure of the mineral and brecciation of the matrix

furnish a large range in the types of stones that can be cut from the variscite. The variscite ranges in color from a very pale green through different shades to a bright grass green. The matrix is either white, gray, yellow, brown, or nearly black.

The gems that can be cut from the variscite from the Edison and Bird mine range from large pure stones with light to dark green color through those with small quantities of matrix, to those in which the matrix predominates. The dark and bright green variscite is obtained in pieces that will cut into pure stones measuring more than an inch across, and paler-colored mineral will yield even larger pure stones. Some of the bright-green variscite is partly translucent and thin pieces and small pebbles display their color well in the partially transmitted light. This is especially true of the coarser-grained, finely crystalline variscite. Specimens of matrix are obtained that will yield slabs 6 inches across, some of which show quite remarkable patterns and colors. One block of matrix found at this mine measures 4 to 6 inches in diameter and weighs several pounds. The whole mass is composed of variscite mottled with brown and white matrix. The pattern is the typical turtleback and the markings are coarser in some parts of the specimen than in others. The markings are due to rounded patches or nodules of pale to bright green variscite, some of which are surrounded by rims of white or gray, and all filled with purplish-brown matrix. The brown matrix occurs only as an inter-nodular filling and the seams are rarely over a millimeter thick. Occasional larger patches of matrix occur where several seams meet around the variscite nodules. The rounded masses of variscite vary from a fraction of a millimeter to a centimeter in diameter. Other smaller pieces of mottled variscite have been found along with specimens of brown, gray, and white matrix, with practically the same texture. Some pieces of mottled matrix contain little if any variscite, but would itself cut into stones with the turtleback markings.

Among other types of variscite matrix is that with bright grass-green variscite mottled with patches and cloudlike masses of lighter green material, or vice versa. Such matrix may contain seams and spots of white, gray, or yellowish mineral through it. A white quartz breccia, cemented and filled in with bright green variscite, is also a pleasing stone when cut, but is more difficult to polish because of the difference in hardness of the two minerals. The quartz occurs in sharp, angular fragments, which are in excess of the variscite in some specimens, but generally less prominent.

The variscite and variscite-matrix from this locality would yield very beautiful gems for the so-called barbaric jewelry. It is susceptible to nearly every form of cutting used with opaque gems, but on account of its comparative softness is not adapted to rough wear. For pendants, brooches, pins, belt stones, etc., it is well suited.

The especially bright colors of some of the variscite from this locality are rarely found in that from other places and the variety of markings shown by the matrix is probably equal to any other material found.

GENERAL DESCRIPTION.

The material available for study consists of nodular aggregates of variscite, irregular in shape and of various dimensions. The deep green aggregates of crystallized mineral consist of tabular crystals, a few of which reach a millimeter in length. Their breadth is about half their length, and their thickness varies from about one-fourth of a millimeter to very thin plates. The coarser aggregates of variscite consist of well-developed crystals (shown in pl. 33, upper figure), which are often nearly complete. The finer-grained material does not show such distinct crystals, while the very fine-grained compact mineral has more the appearance of a crypto-crystalline mass. Several small cavities in the coarse material were lined with projecting crystals, which furnished good material for crystallographical study. A view of such a cavity, enlarged six times, is shown in plate 33, lower figure. The crystals are transparent and pale green when viewed under the microscope.

OPTICAL PROPERTIES.

ORIENTATION AND PLEOCHROISM.

The crystallographical orientation of the variscite crystals was so chosen that the large flat face became the brachypinacoid b (010), and the striations on this face were placed vertically. Variscite being orthorhombic, these facts are sufficient to definitely orient the crystals, so that the optical relations can be readily comprehended. The basal pinacoid, c (001), was not observed on these crystals, and the macropinacoid, a (100), is a rare form, seldom larger than a narrow face between the unit prisms m and m''' .

The optical relations were ascertained by studying the flat crystals, and also by means of two thin sections of the granular aggregate, which were carefully prepared without being subjected to any heat. If a section of the granular variscite be made in the ordinary manner, it will be found that the heat employed in the operation is sufficient to cause the green color of the mineral to change to the deep lavender, with consequent changes in the various physical properties of the mineral.

The extinction is parallel in all sections, and the mineral behaves optically in strict concordance with the orthorhombic symmetry of the crystals.

The axial plane is parallel to the flat face b (010), the acute bisectrix is normal to the base c (001), the obtuse bisectrix then being normal to a (100). The mineral is positive, so that the acute bisec-

trix, identical in direction with the crystallographical axis c , is the axis of minimum velocity of light. The optical relationship can, therefore, be expressed in the conventional form as follows:

$$a = X = \alpha$$

$$b = Y = \beta$$

$$c = Z = \gamma$$

The optical angle is large; $2E$ was measured as about 113° . Dispersion was not marked and its kind could not be determined.

Viewed in transmitted light under the microscope the crystals are colorless if very thin, or pale green if somewhat thicker. The coloring pigment is not uniformly distributed, but is generally arranged in irregular cloudlike areas. In a few cases the coloring seemed to bear in its distribution some relation to the shape of the crystal, and in these cases the color was most intense near the edges of the crystals.

The pleochroism is distinct but slight, and its relation to the crystal directions is shown in the following scheme:

$$a (X) = \text{colorless.}$$

$$b (Y) = \text{pale green.}$$

$$c (Z) = \text{pale green.}$$

The weakness of the pleochroism is in striking contrast to that of the heated lavender-colored material in which, as described further on, the pleochroism is strong.

REFRACTIVE INDICES.

The indices of refraction were measured by the method of oil immersion for γ and α . The values found are $\gamma = 1.577$ and $\alpha = 1.547$. Therefore $\gamma - \alpha = 0.030$, which is very close to the average value (0.032) found by actual determination of the birefringence. This birefringence was measured accurately on the flat brachypinacoid, and the average value obtained is 0.032. The value was measured on 11 crystals with the following results:

Birefringence ($\gamma - \alpha$) measured on b (010).

Crystal No.	Thickness in milli- meters.	Birefrin- gence.
1.....	0.055	0.034
2.....	.041	.029
3.....	.042	.035
4.....	.070	.027
5.....	.051	.031
6.....	.051	.037
7.....	.066	.029
8.....	.055	.034
9.....	.042	.030
10.....	.053	.030
11.....	.047	.034
Average.....	.....	.032

As the value 0.032 is more accurate than the value 0.030, obtained by measuring the indices directly, the values of γ and α are each changed one unit so as to bring their difference in accord with the more accurately determined value of the birefringence. The values of γ and α are therefore taken as 1.578 and 1.546, respectively.

The value for β was found by measuring the difference of refraction ($\beta - \alpha$) in basal sections of the mineral. A thin section of the crystalline aggregate furnished basal and brachypinacoid sections of the same thickness, so that the value ($\beta - \alpha$) could be determined by noting the interference colors (blue first order) on the basal sections and comparing them with the colors on sections showing the maximum birefringence. The value ($\beta - \alpha$) was thus found to be 0.010. Therefore $\beta = 1.556$.

A section of a crystal that seemed to be nearly parallel to a (100), showed a very large axial angle and a difference of refraction of about 0.020, which, for a section parallel to a (100), should be 0.022.

Summarizing the optical properties as determined, we have:

Axial plane $\parallel b$ (010). $Bx_a \perp c$ (001). Positive.

$\alpha = 1.546$, $\beta = 1.556$, $\gamma = 1.578$

$(\gamma - \alpha) = 0.032$, $(\gamma - \beta) = 0.022$, $(\beta - \alpha) = 0.010$.

$$n = \frac{\alpha + \beta + \gamma}{3} = 1.560.$$

STRUCTURE OF CRYSTALS.

An additional feature of considerable interest is the structure of these crystals. Although the material is well crystallized and the individual crystals sharply bounded by plane and brilliant surfaces, the interior of the crystals is in most cases crowded with a mass of small particles of the same material irregularly bounded and not in parallel position with the crystal itself.

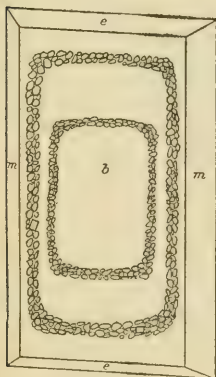


FIG. 1.—VARISCITE CRYSTAL, SHOWING REGULAR GROUPING OF SMALL PARTICLES— b {010}, m {110}, e {012}. THE BRACHYPINACOID b {010} IS DRAWN IN FRONT.

In some crystals these particles are entirely absent; in others they are sparsely scattered through the crystal. Still others contain a vast number of these particles, generally aggregated close together. These aggregates are either irregular in shape and occupy the center of the crystal or else they are arranged in a regular fashion patterned after the shape of the crystal itself. Such a regular grouping of these particles is shown in figure 1, which illustrates also the tabular habit of the variscite crystals.

In figure 1 the brachypinacoid b (010) is drawn in front, in order to better show the mode of distribution of the particles. These particles are generally irregular in their shape,

though occasionally a rectangular one can be noted among the mass. The particles still manifest themselves in the dehydrated lavender crystals and show no difference, except in their orientation and shape, from the rest of the crystal.

PROPERTIES OF DEHYDRATED LAVENDER VARISCITE.

The very remarkable color change undergone by the mineral on dehydration at a relatively low temperature (below 160°) also markedly affects the optical properties. The most striking change is in the pleochroism. The green crystals of variscite are only faintly pleochroic (colorless to pale green), whereas the lavender ones are strongly pleochroic with intense shades.

The optical orientation of these lavender colored crystals could not be determined, though numerous attempts were made, both on loose crystals and on thin sections of the granular aggregate. The birefringence of the mineral has become so low that no definite effects could be obtained when tests for axial angles were made. Both basal and brachypinacoidal sections seemed to show the emergence of a bisectrix with a very large axial angle, though, as stated, the results were inconclusive. It could, however, be easily seen that the optical orientation was changed. In the green crystals, viewed on the flat face, b (010), the vertical axis is a direction of minimum velocity, but on the lavender crystals this same direction is one of maximum velocity. Similarly on basal sections, the b axis is a direction of minimum velocity for the green crystals, whereas on the lavender ones the b axis is a direction of maximum velocity.

The pleochroism of the lavender crystals is strong and very striking. All the colors are combinations of red and blue, and therefore rather hard to describe accurately. On crystals that are not too thin the colors are very intense and beautiful. The brachypinacoidal sections are strongly pleochroic, whereas basal sections hardly show any difference in shade in different directions. The colors may be described as follows:

a axis = lavender.

b axis = pinkish lavender.

c axis = violet.

The color effects given above are such as were noted on crystals that had been gradually heated up to 160° C. If the green crystals be suddenly heated to a high temperature, as, for instance, by putting them on a piece of platinum foil and suddenly heating them in the hot flame of a Bunsen burner, the results are different. The crystals are then considerably cracked and on brachypinacoidal sections the optical orientation is like that of the green crystals, namely, the c axis

of the crystal corresponds to a direction of minimum velocity. Moreover, the pleochroism is interchanged, so that now:

a axis = violet.

c axis = lavender.

The changes in the indices of refraction and the birefringence undergone by the green variscite crystals on changing to the lavender phase are also very marked. The mean refractive index has dropped from 1.560 to about 1.448 and the birefringence from 0.032 to 0.003 or possibly even less. The birefringence does not exceed 0.003 in any section and is much less in most cases. The approximate values of the indices, determined by oil immersion, are as follows:

$$\alpha = 1.447, \beta = 1.448, \gamma = 1.450$$
$$\gamma - \alpha = 0.003.$$

This decrease in the values of the refractive indices and the birefringence is accompanied by the loss of water of the mineral, and it is a fact worth emphasizing that the loss of water, without destroying the optical possibilities of the mineral, decreases both these values.

When the lavender crystals are heated with water on the steam bath (not over 100° C.) for several days, they gradually lose their lavender color and become a dirty grayish white and are then non-pleochroic. A sample, treated in this way for about a week, was then air dried for several days and the loss on ignition (= water absorbed) determined. This amount was found to be 2.05 per cent. The ignited crystals had again become deep lavender in color. It therefore seemed possible by appropriate treatment to change the dehydrated lavender crystals back to their original vivid green color. With this view in mind, some of the lavender crystals were treated with hot water for several days until they became grayish white in color and then sealed in a glass bomb with a little water and heated for several hours at a higher temperature. The glass bomb was first heated for four hours at 170° C., the next day for the same time at 190° C., and the third day for a similar length of time at 225° C. Unfortunately it was not possible to heat the tube at these temperatures continuously, as should probably have been done. After three days' heating, as just described, the grayish white crystals had become very pale greenish yellow, but when the crystals were removed from the tube and the loss on ignition determined after they had been air dried for several days the result was disappointing. A loss of only 1.12 per cent was found, so that the crystals had absorbed less water in the glass bomb treatment than by simply treating with hot water.

The crystals from the glass bomb were very light brown or nearly colorless when viewed under the microscope. Pleochroism was distinct, though very slight. Parallel to the *c* axis, a direction of maxi-

imum velocity (unlike the green crystals), light brown; parallel to the a axis, a light brown with a decided greenish-yellow tint. The birefringence is about 0.006, the interference colors on the thicker crystals reaching into first-order yellow. The areas of "irregular aggregates" (shown in fig. 1) are stronger colored and indefinite in character. They somewhat resemble the kaolinization effects seen in rock slides.

RELATION TO ANALOGOUS MINERALS.

A brief comparison of the optical properties of variscite, as given, with those of the analogous minerals scorodite, strengite, and phosphosiderite, shows some close relationships as well as some marked differences.

The optical properties of variscite given by Lacroix¹ are not entirely in accord with those given in this paper, but this is due to the fact that Lacroix's material was fibrous and not in distinct crystals. He gives the axial plane as parallel to b (010), with negative acute bisectrix normal to a (100), whereas the positive acute bisectrix is normal to c (001). The value of $2E$ is given as about 96° and the mean index as 1.579, which is a little higher than the value 1.560 found on the Utah crystals, but is almost identical with the maximum index found thereon, namely (γ) 1.578. The birefringence is stated to be a little higher than that of quartz, but the birefringence observed by Lacroix was probably not the maximum, which reached a value of 0.032 in the crystals from Utah. It is not known to what extent, if any, the chromium and vanadium present in the green crystals from Utah influence the optical values.

The comparison of the chief optical properties of the different analogous minerals can be most conveniently shown in tabular form. The orientation of the variscite is so chosen that the axial plane is b (010), but it is possible, as shown beyond, to so orient the crystals that the axial plane is a (100), analogous to that of scorodite and strengite.

Comparison of optical relations.

Mineral.	Axial plane.	Opt. sign.	Bx_a	$2E$.	Mean index.	Birefringence.
Variscite.....	b (010)	+	\perp (001)	113°	1.560	0.03
Scorodite.....	a (100)	+	\perp (001)	130°	-----	.03
Strengite.....	a (100)	+	\perp (001)	60°	1.825	.03
Phosphosiderite..	b (010)	+	\perp (001)	126°	1.73	-----

In adopting the orientation for variscite as given in this paper, namely, with the optic axial plane parallel to b (010), an interesting condition obtains for the isomorphous mixtures of variscite ($AlPO_4 \cdot 2H_2O$) and strengite ($FePO_4 \cdot 2H_2O$), for in the latter mineral the optic axial plane is parallel to a (100). Such an isomorphous

¹ Lacroix, A. Mineralogie de France, vol. 4, 1910, p. 479.

mixture is represented by the mineral barrandite, of which two analyses are on record and in both of which the iron phosphate predominates, so that barrandite, instead of being a distinct mineral species is, in reality, only an aluminous strengite.¹ Now, in strengite the axial plane is a (100) and $2E$ equals 60° , whereas in variscite the axial plane is b (010) and $2E$ is nearly twice as large. The isomorphous admixture of a small amount of variscite in strengite would therefore tend to decrease the axial angle of strengite, and for a certain amount of variscite the axial angle becomes zero. A still greater amount of variscite in the mixture will give an increasing axial angle, but with the axial plane now parallel to b (010) as in pure variscite. Since the axial angle of strengite is much smaller than that of variscite, an isomorphous mixture with an axial angle of nearly 0° should contain more strengite than variscite.² Both the analyses of barrandite show an excess of the strengite molecule, in one in the ratio 4 : 3 and in the second 5 : 2. In that of the last ratio, it therefore becomes highly significant to note that Lacroix in describing³ barrandite says that the optic axes are very close together, so that the value of $2E$ is very small. In the analysis of barrandite given by Lacroix the ratio of Fe_2O_3 to Al_2O_3 is about as $2\frac{1}{2} : 1$. An approximate calculation of the value of the axial angle of such an isomorphous mixture shows that it should be very small and approximately 10° .

On the other hand, it must be stated that the density and mean refractive index of barrandite, as given by Lacroix, are not consistent with the values calculated from those of variscite and strengite, as is shown by the following table:

Comparison of values for barrandite.

Mineral.	Density.	Mean refractive index.
Variscite.....	2.54	1.560
Strengite.....	2.87	1.825
Barrandite* found.....	2.59	1.575
Barrandite* calculated.....	2.78	1.749

* Barrandite consists of 5 parts strengite and 2 parts variscite.

The wide discrepancies in the found and calculated values of the density and refractive index, respectively, are not in accord with the idea of the isomorphous character of barrandite as developed for the optical orientation.

¹ Compare the "Conclusions" of the paper "A study of the rutile group," in Bulletin 509, U. S. Geological Survey, entitled, "Mineralogical Notes, Series 2."

² It is interesting to note that should an isomorphous mixture of variscite and strengite be found (without definite crystals) in such proportions that the axial angle is 0° , the discoverer would be very likely to consider the find as a distinct new species, as it would be strictly uniaxial, while both variscite and strengite are biaxial.

³ Lacroix, A. *Mineralogie de la France*, vol. 4, 1910, p. 486.

CRYSTALLOGRAPHY.

INTRODUCTION.

The flat crystals are orthorhombic in their symmetry and simple in their combination. The large tabular face is taken as the brachypinacoid and the chief forms noted, as shown in figure 2, are: b (010), m (110), and e (012). In addition to these forms the macropinacoid a (100) is sometimes present as a narrow face. Occasionally the crystals are much longer and the prism faces more developed in comparison with the macropinacoid. The common habit of the crystals is as shown in figure 2. A better idea of the shape of the crystals can be had from figure 1, on page 418, which shows a variscite crystal so drawn as to bring the brachypinacoid b (010) in front. The rectangular, tabular shape of the crystals, due to the large development of the brachypinacoid, is there well shown.

Several other forms are present on these crystals, but they could not be determined. On crushing some of the coarsely crystallized aggregate and examining it under the microscope one occasionally sees an acutely terminated crystal which has the corners replaced by small faces, probably those of the unit pyramid.

In orienting the crystals of variscite three positions are available, depending on which pinacoid the broad face is referred to. This broad face is generally slightly striated vertically. In conformity with the analogous mineral scorodite, the striations are taken as parallel to the c axis. Striated crystals of scorodite have been described by several authors. Thus, Kokscharow¹ states that the form (010) is strongly striated vertically. Zimányi² describes scorodite crystals on which the prism d (120) is vertically striated, and Lacroix³ mentions vertical striations on (120) and the two pinacoids (100) and (010). He also describes scorodite crystals slightly flattened parallel to either a (100) or b (010) and states further that a rare phase of strengite is formed by plates flattened parallel to a (100).

The possibilities of the three available orientations will be discussed after the measurements of the variscite crystals are given.

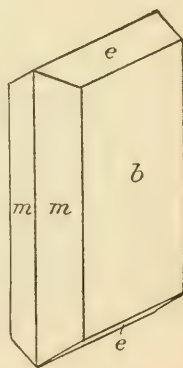
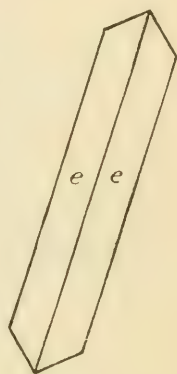


FIG. 2.—VARISCITE CRYSTAL b {010}, m {110}, e {012}.

¹ Kokscharow, N. Mineralogie Russlands, vol. 6, 1870, p. 309.

² Zimányi, K. Beiträge zur Mineralogie der Komitate Gömör und Aban]-Torna. Föld. Közl., vol. 35, 1905, p. 545.

³ Lacroix, A. Mineralogie de la France, vol. 4, 1910, p. 472.

CALCULATION OF ELEMENTS.

Variscite being orthorhombic, only two angular values are necessary for a determination of the crystallographical elements.

The fundamental values of variscite are:

$$b \wedge m = (010):(110) = 48^\circ 10'$$

$$b \wedge e = (010):(012) = 61^\circ 17'$$

From these values the axial ratio is calculated and found to be:

$$a:b:c = 0.8952 : 1 : 1.0957$$

The measurements from which the fundamental values for variscite were obtained are as follows: In the measurements of the angle (010):(110) it is possible to obtain eight values on each crystal, namely, (010 : 110), (010 : $\bar{1}10$), ($0\bar{1}0$: 110), ($0\bar{1}0$: $\bar{1}10$), $\frac{1}{2}(110 : \bar{1}10)$, $\frac{1}{2}(\bar{1}10 : 110)$, $90^\circ - \frac{1}{2}(110 : 110)$, $90^\circ - \frac{1}{2}(\bar{1}10 : \bar{1}10)$. In the following table only such ones of these possible eight values are given where the reflections from the faces were fairly good and distinct:

Measurements of angle $b \wedge m = (010) : (110)$.

Crystal No.....	1	2	4	5	6	7
	° /	° /	° /	° /	° /	° /
	48 28	48 26	48 19	48 02	48 07	46 59
	47 34	48 11	48 44	48 13	48 12	49 07
	48 42	48 33	47 56	.....	48 14	48 04
	47 21	47 51	48 22	.....	48 19	.....
	47 55	48 18	48 10	.....	.....	.....
	48 08	48 14	.....	.....	.....	.....
Average.....	48 01	48 14	48 18	48 08	48 13	48 03
Average of 26 measurements = 48° 10'.						

For the faces of e (012) the number of possible measurements was not so large as the crystals measured were broken off at the lower end.

Measurements of angle $b \wedge e = (010) : (012)$.

	° /		° /
Crystal No. 2.....	{61 21	Crystal No. 6.....	{61 31
	{61 15		{61 10
Crystal No. 3.....	{61 22	Crystal No. 7.....	{61 26
	{61 08		{61 10
Crystal No. 4.....	{61 28	Crystal No. 8.....	{61 14
Crystal No. 5.....	{61 19		{61 01
Average of 12 measurements = 61° 17'.			

The only crystallographical study hitherto made of variscite is the work of Chester¹ on the Arkansas mineral. He found some

¹ Chester, Albert H. Note on the crystallization of variscite. Amer. Journ. Sci., 3 ser., vol. 15, 1878, p. 207.

minute crystals with the forms b (010), a (100), m (110), and c (001). Of these, b , m , and c were well developed. The angle $m \wedge m''$ (110:110) is given as $65^\circ 54'$, but it has not been possible to correlate this angle with any simple form for the variscite-scorodite group.

The following table gives the coordinate angles for the forms of variscite. The table is adapted for measuring the crystals by the two-circle method, but, of course, it also gives the necessary interfacial angles.

Variscite.

a=0.8952, c=1.0957, p ₀ =1.2240, q ₀ =1.0957					
No.	Letter.	Symbol.		φ	ρ
		Gdt.	Miller.		
1	b	0 ∞	010	0 00	90 00
2	a	∞ 0	100	90 00	90 00
3	m	∞ 10	110	48 10	90 00
4	e	0½	012	0 00	28 43

The three possible orientations for the variscite crystals will now be given and their relation to the orientation of the analogous minerals scorodite, strengite, and phosphosiderite studied.

FIRST ORIENTATION.

The first orientation is the one chosen for the mineral, as it best shows the relation of variscite to the other minerals and at the same time yields the simplest indices for the crystal forms of variscite. In the comparisons, two orientations are given for phosphosiderite, both of which are different from the accepted position of that mineral. The first, phosphosiderite (1), is the one suggested by Brulms and Busz¹ and the second, phosphosiderite (2), is obtained by interchanging the a and c axes in the generally adopted position and then doubling the new a axis.

The close relation between the angles of variscite and the other minerals of analogous composition can be seen in the table below:

Comparison of angles (first orientation).

Angle.	Variscite.	Scorodite.	Strengite.	Phosphosiderite.	
				(1)	(2)
$b \wedge m = (010) : (110)$	48 10	49 07	49 08	50 33	48 45
$b \wedge e = (010) : (012)$	61 17	64 30	63 50	64 52	61 57

A comparison of the axial ratio also shows clearly the similarity in values and at the same time shows the very close agreement of

¹ Zeit. Kryst. Min., vol. 17, 1890, p. 555. Also given in Dana's System of Mineralogy, 6th ed., 1892, p. 823.

variscite with phosphosiderite (2) and their greater difference from the values of the other minerals.

Comparison of axial ratios (first orientation).

Mineral.	a axis.	c axis.
Scorodite.....	0.8658	0.9541
Strengite.....	.8652	.9827
Variscite.....	.8952	1.0957
Phosphosiderite (1).....	.8229	.9381
Phosphosiderite (2).....	.8772	1.0660

It is to be particularly noted that the agreement of values is much closer for variscite and phosphosiderite (second position) than for variscite and scorodite or strengite. This fact led to the suggestion that perhaps the mineral here described was not variscite but a new mineral bearing the same relation to true variscite that phosphosiderite is supposed to bear to strengite. The analysis, however, shows that the crystallized variscite from Utah agrees well with the formula $Al_2O_3.P_2O_5.4H_2O$. A careful study of the relations of phosphosiderite to strengite, considered with the close crystallographic values of phosphosiderite and variscite, lead to the conclusion that phosphosiderite and strengite are identical notwithstanding the apparent differences in the optical properties.

SECOND ORIENTATION.

In the second possible orientation the large face is made the macro-pinacoid a (100). As the optical axial plane of variscite is parallel to this large face, such an orientation would bring variscite into optical conformity with scorodite and strengite. It then becomes necessary, however, in order to retain the crystallographical analogy, to give to the prism m the symbol (340). The dome e then becomes (102) and the close angular agreement of the minerals in this position can be seen by the following table:

Comparison of angles (second orientation).

Angle.	Variscite.	Scorodite.	Strengite.	Phosphosiderite.	
				(1)	(2)
$b \wedge m = (100):(340)$	48 10	49 11	49 05	47 39	49 28
$b \wedge e = (100):(102)$	61 17	61 02	60 24	60 19	58 43

On the basis of the above angular values the following comparison of the axial ratios is made:

Comparison of axial ratios (second orientation).

Mineral.	a axis.	c axis.
Variscite.....	0.8379	0.9181
Scorodite.....	.8658	.9541
Strengite.....	.8652	.9827
Phosphosiderite (1).....	.8229	.9381
Phosphosiderite (2).....	.8772	1.0660

The agreement in values is much closer than for the first orientation, but the prism form loses its simple indices. It must be said, however, that this orientation has much to commend it and may perhaps be chosen in the future as the best one for the mineral, especially when the properties of strengite and barrandite are better defined than they are at present.

THIRD ORIENTATION.

A third orientation is still possible, namely, by considering the large face as the basal pinacoid. Though the angular values derived from this orientation show a close agreement, such a habit is entirely at variance with that of all the other minerals of this group, and the choice of orientation must be left to the first or second one.

By making the large face the basal pinacoid and taking *m* as (101) and *c* as (021), the following comparison is obtained:

Comparison of angles (third orientation).

Angle.	Variscite.	Scorodite.	Strengite.	Phosphosiderite.	
				(1)	(2)
$b \wedge m = (001):(101)$	48 10	47 47	48 38	48 45	50 33
$b \wedge c = (001):(021)$	61 17	62 20	63 02	61 57	64 52

From these values the following axial ratios are obtained:

Comparison of axial ratios (third orientation).

Mineral.	a axis.	c axis.
Variscite.....	0.8170	0.9126
Scorodite.....	.8658	.9541
Strengite.....	.8652	.9827
Phosphosiderite (1).....	.8229	.9381
Phosphosiderite (2).....	.8772	1.0660

TWIN CRYSTAL.

A twin crystal was observed under the microscope among the crushed aggregate. The twinning plane is (102) (first orientation) as the inclination of the twinned part of the complex to the untwinned part was measured as 31° and the angle (001):(102) is calculated as $31^\circ 28'$. Similar twins were noted on phosphosiderite, again showing the striking crystallographical closeness of variscite with phosphosiderite, and emphasizing the probable identity of phosphosiderite with strengite.

RELATION TO ANALOGOUS MINERALS.

It may be stated that the angular values for the minerals of this group are so close in three different directions that one must be very careful that the correct position has been chosen. This should always be verified optically if at all possible, as on poor crystals it would be difficult to distinguish with certainty some of the angles. This similarity in angular values can be well shown by the following table:

Comparison of angles showing similarity.

Angle.	Variscite.	Scorodite.	Strengite.	Phosphosiderite.	
				(1)	(2)
	° /	° /	° /	° /	° /
(100):(340)	50 03	49 11	49 05	47 39	49 28
(010):(110)	48 10	49 07	49 08	50 33	48 45
(001):(101)	50 45	47 47	48 38	48 45	50 33
(010):(012)	61 17	64 30	63 50	64 52	61 57
(001):(021)	65 28	62 20	63 02	61 57	64 52
(100):(102)	58 32	61 02	60 24	60 19	58 43

It is possible that the mineral vilateite,¹ the violet crystals of Des Cloizeaux's hureaulite, belong to this group. The crystals are described as monoclinic, but the angular differences from orthorhombic symmetry are slight, and Lacroix states that optically the mineral behaves somewhat like an orthorhombic substance. The similarity in axial ratios to scorodite, etc., can be seen in the following table. For vilateite, half the a axis, as given by Lacroix, has been taken.

Comparison of axial ratios.

Mineral.	a axis.	c axis.	β .
Vilateite.....	0.8479	0.8886	89 27
Variscite ².....	.8379	.9181	90 00
Scorodite.....	.8678	.9583	90 00
Strengite.....	.8652	.9827	90 00
Phosphosiderite (1).....	.8229	.9381	90 00

¹ Lacroix, A. *Mineralogie de la France*, vol. 4, 1910, p. 477.

² Second orientation.

CHEMICAL COMPOSITION.

GENERAL PROPERTIES.

The mineral is infusible before the blowpipe, but readily changes its color in a striking way. The deep emerald green changes to a deep lavender and the crystals take on a much more brilliant luster. As quantitative analyses showed, all the water of the mineral is given off during the change of color and the lavender variscite is anhydrous. Chester¹ mentions a similar change in color for the variscite from Arkansas, but his results seem to have been generally overlooked. In describing the properties of the crystallized variscite Chester says:

The colors observed are deep emerald green. * * * Before the blowpipe it becomes opaque, friable, and of a deep purple when hot, lighter purple when cold. In the glass tube yields much water and changes in color as above.

The density of the green mineral was found to be 2.54.

The powdered mineral is insoluble in boiling hydrochloric acid, but after dehydration and change in color it readily dissolves in acids. The striking color changes observed in the mineral suggested testing especially for such rarer elements as had a strong chromatic effect. It was found that chromium and vanadium were present in small amounts, and a trace of iron was also determined.

CHEMICAL ANALYSIS.

The results of the quantitative analysis and the ratios deduced therefrom are here given.

Analysis and ratios of crystallized variscite from Lucin, Utah.

Analysis.		Ratios.	
H ₂ O	22.68	1.260	4.00
P ₂ O ₅	44.73	.315	1.00
V ₂ O ₅ .....	.32	.002	} 1.02
Cr ₂ O ₃ .....	.18	.001	
Fe ₂ O ₃ .....	.06	.....
Al ₂ O ₃	32.40	.318	
Ni, Co, Cu, }	None.		
Mn, As, }			
Ca, Mg, }			
	100.37		

The ratios agree very well with the formula Al₂O₃.P₂O₅.4H₂O, thus comparing with strengite (Fe₂O₃.P₂O₅.4H₂O) and not with phosphsiderite (Fe₂O₃.P₂O₅.3½H₂O) even though the crystals of variscite are much closer in angular values to those of phosphsiderite than to those of strengite.

¹ Chester, Albert H. On the identity of the so-called peganite of Arkansas with the variscite of Breithaupt and Callainite of Damour. Amer. Journ. Sci., 3 ser., vol. 13, 1877, p. 295.

The results obtained as to loss of water at different temperatures are as follows:

Loss of water on heating.

Temperature °C.	Color of powdered sample.	Total percentage of loss due to water.
110° (first day).....	Pale green.....	
115° (second day).....	Pale green.....	5.09
110° (third day).....	Light gray*.....	9.67
140°.....	Pale lavender.....	12.48
160°.....	Lavender.....	19.81
	Deep lavender.....	22.50

*The color called light gray is very difficult to define. The mineral powder had lost its original green color but did not show any decided lavender shade. Perhaps the combination of some lavender and some green gave the resultant effect here called gray.

The vanadium and chromium were determined on a 4-gram portion of the mineral, the method used being that described by Hillebrand.¹ After the chromium had been determined colorimetrically, the correction necessary to apply to the vanadium determination was found by titrating a hot sulphuric acid solution of sodium chromate containing the same amount of chromium oxide (Cr_2O_3), as was present in the sample of variscite analyzed. Qualitative tests with ferricyanide showed that there was no ferrous iron in the solution of the mineral which had been heated to 160° C. Therefore, it was possible to determine the state of oxidation of the vanadium. For this purpose a gram of the mineral was heated to 160° C, which completely dehydrated it and changed its green color to the intense lavender. The powdered mineral was then dissolved in sulphuric acid and titrated with permanganate. The amount consumed was equivalent to 0.45 per cent vanadium oxide (V_2O_5) and, corrected for the chromium present, gave a value of 0.41 per cent vanadium oxide (V_2O_5). This is higher than the value obtained on the 4-gram sample (0.32 per cent) but the lower result is taken as being the most accurate. It may be here stated that a cold solution of bichromate in sulphuric acid will consume a small but appreciable amount of permanganate which has to be determined and allowed for in such instances as the present one. The ferric iron was determined colorimetrically using potassium sulphocyanide.

An adequate explanation of the remarkable color change and accompanying changes in physical and optical properties has not been found.

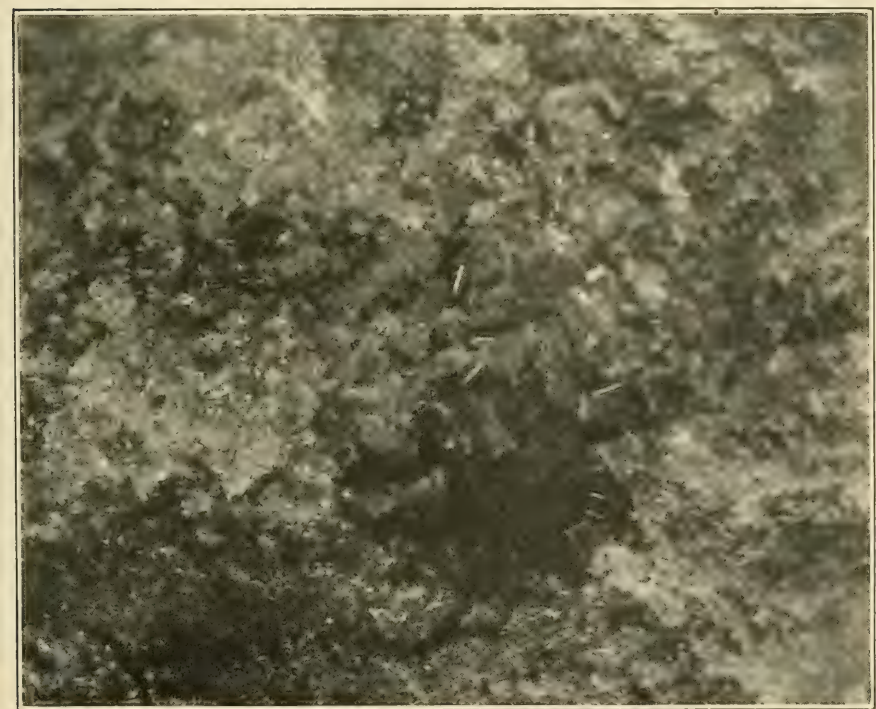
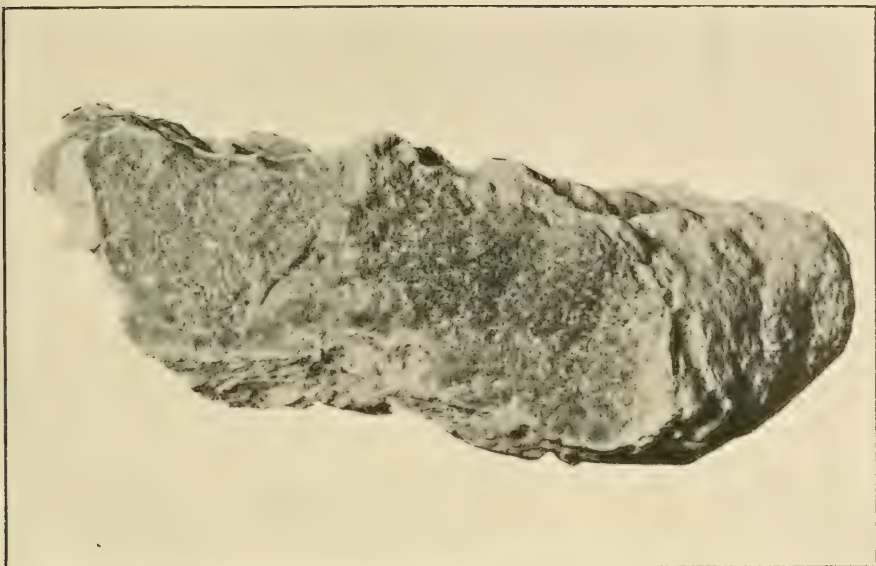
EXPLANATION OF PLATE 33.

Upper figure.—Nodule of variscite from Lucin, Utah. Shows the usual compact phase on the left and the crystalline aggregate on the right. Natural size.

Lower figure.—Crystallized variscite from Lucin, Utah. Shows a cavity in the crystalline aggregate with the tabular crystals. Enlarged 6 diameters.

Described on page 416.

¹ Hillebrand, W. F. The analysis of silicate and carbonate rocks. Bull. 422, U. S. Geol. Survey, 1910.



CRYSTALLIZED VARISCITE FROM UTAH.

FOR EXPLANATION OF PLATE SEE PAGE 430.

DESCRIPTIONS OF FIFTEEN NEW FISHES OF THE FAMILY
CHEILODIPTERIDÆ, FROM THE PHILIPPINE ISLANDS
AND CONTIGUOUS WATERS.

By LEWIS RADCLIFFE,¹

Scientific Assistant, United States Bureau of Fisheries.

The new species of Cheilodipteridæ herein described² were collected on the Philippine expedition of the United States Bureau of Fisheries steamer *Albatross*. It is noteworthy that three of them were secured at a single haul of the beam trawl at station 5442, on the west coast of Luzon. One species, *Amia hyalina*, was taken at Talisse Island, north of Celebes, outside the Philippine Archipelago.

Genus AMIA Gronow.

A new subgenus, *Amioides*, is herein described. Because of the unnatural groupings resulting from subdivisions of the genus based on single characters, such as presence or absence of serrations on the preopercle, character of teeth, character of lateral line, etc., it has seemed preferable to await a more thorough study of the whole group before deciding whether *Amioides* is entitled to generic rank.

AMIA DIENCÆA Smith and Radcliffe, new species.

Plate 34, fig. 1.

Dorsal VI-1,9; anal II,8; scales 4+8-24.

General form elliptical-ovate; head 2.46, pointed; dorsal contour from tip of snout to insertion of spinous dorsal straight, steep; body

¹ In the study of this collection the writer has been associated with Dr. Hugh M. Smith, who becomes joint author of the new genera and species herein described.

² The measurements herein used represent the ratio between length of part described and the standard length from tip of snout to end of last caudal vertebra, with the exception of eye, snout, maxillary, interorbital, fins, and least depth of caudal peduncle, which are expressed in ratio to head measured from tip of snout to posterior edge of opercle (not including opercular flap). The length of caudal peduncle is measured between the verticals drawn at base of last anal ray and at end of last vertebra. Even when the last dorsal and anal rays are cleft to base they are still counted as single rays. The scale formula indicates the number of scales in a transverse row from insertion of dorsal downward and backward to and including lateral line and the number of transverse rows above the lateral line, between upper angle of opercle and end of last caudal vertebra.

deep, strongly arched dorsally, ventral outline comparatively straight, depth 2.62; caudal peduncle slender, compressed, of nearly uniform depth, depth 2.50, length 1.70; eye 2.76, prominent; snout 4.50, short; nostrils well separated, anterior circular, near edge of snout, posterior elliptical, close to eye; maxillary 1.80, reaching vertical from posterior margin of eye; interorbital 4.06; vertical margin of preopercle with a few weak denticulations, angle, horizontal margin, and crest smooth; bands of villiform teeth, broadest in front, on jaws; vomerine and palatine teeth villiform, slightly larger than the others, in a single row along the ridge of the bone; scales small, regular, ctenoid; lateral line arched.

First dorsal spine small, second 2.13, longest and strongest; the second dorsal rounded, longest ray 1.86; caudal forked; anal 2, similar to second dorsal; ventrals 1.97; pectorals 1.60.

Color in alcohol: Ground color cream-buff; a stripe obscure anteriorly (probably brilliantly colored in life), dusky black posteriorly, about three-fourths width of eye, extends from scapula with a downward sweep, becoming horizontal on caudal peduncle, to tips of median caudal rays; lines of lighter color, most distinct anteriorly, margin this stripe; a walnut-brown bar as wide as pupil from eye to base of pectoral; fins hyalin.

Type.—Cat. No. 70243, U.S.N.M., a specimen 4.1 cm. in length, from Sulade Island, Jolo.

AMIA PARVULA Smith and Radcliffe, new species.

Plate 34, fig. 2.

Dorsal VI-I,9; anal II,8; scales 3 + 6-24.

General shape fusiform, compressed; head 2.60, large; body slender, arch of back greater than ventral surface, depth 3; caudal peduncle tapering, slender, compressed, depth 2.75, length 1.42; eye 3, prominent; snout 4; mouth nearly horizontal, tip of lower jaw projecting; maxillary 2.25, barely reaching vertical from middle of eye; interorbital 3.97, narrow, flat; preopercular margin finely serrate, crest smooth; teeth on upper jaw small, unequal, cardiform, mainly in one row, a wide toothless space at symphysis; a group of six or seven large, unequal teeth on each side of symphysis of lower jaw, narrowing to a single row of smaller teeth on sides, no teeth on vomer and palatines (a few scattered papillary structures along the ridge of the palatines); peritoneum silvery; scales regular, ctenoid; lateral line incomplete, six well-developed pores present anteriorly.

First dorsal spine 3.20, second longest 2.40, spines weak, membranes not deeply incised; anterior rays of second dorsal longest, 1.59, distal margin slightly concave; caudal long, deeply forked, lobes rounded; anal 1.85, similar to second dorsal; ventrals 1.90; pectorals 1.40, long.

Color in alcohol: Ground color cream-buff, scales edged with brown, darkest on dorsal surface; a median line on back from occiput to caudal, blackish under dorsals, elsewhere brownish; a narrow brownish stripe from snout, over eye, along lateral line, fading out posteriorly; a brown stripe nearly as wide as pupil from tip of snout through middle of eye to tip of opercle, continued on body as a narrow black line to caudal peduncle, ending in a large yellowish white area before base of caudal; a silvery stripe underneath this for its entire length; a black line along base of anal to base of caudal; a brown stripe from middle of maxillary, under eye, across opercles, to base of pectorals; snout dusky; a large black area on tip and under side of chin; anterior margin of spinous dorsal dusky black; a dusky brownish band above base of second dorsal to tip of posterior rays; a similar band on anal; all the fins slightly dusky.

Color in life: Body translucent, dorsal surface dusky with a narrow median black line; a black line from eye ending in a brilliant scarlet blotch larger than pupil, at base of caudal, margined below by a purplish stripe on head, changing to opalescent green on body; a black stripe below this on head; chin and nose black; top of head dusky with short silvery olive stripes; lower head and breast white; fins dusky; first dorsal spine blackish; a red-brown bar slightly nearer base than tip of rays across second dorsal; anal similar to second dorsal, the brown bar slightly nearer base and a black line along base continued on lower edge of caudal peduncle; iris dark.

Type.—Cat. No. 70244, U.S.N.M., a specimen 3.9 cm. in length, from Tataan Pass, Tawi Tawi group.

The collection contains many specimens, of which the type is the largest. Faded alcoholic examples closely resemble the young of *A. margaritophora*, but the black area on chin is larger, the stripes are darker, the pearly spots characteristic of *A. margaritophora* are lacking, and the lateral line is incomplete.

Among the 35 examples from Saboon Island, Ragay Bay, Luzon, of which the largest is 3 cm. in length, are several females with eggs in an advanced stage of development. One example 2.7 cm. in length is gravid, and the eggs are unusually large for so small a fish.

AMIA HYALINA Smith and Radcliffe, new species.

Plate 36, fig. 3.

Dorsal VII-1,9; anal II,8; scales 3 + 6-21.

General form ovate, compressed; head 2.60, very pointed, dorsal profile concave, ventral slightly convex; body short and deep, back arched, depth 2.27; caudal peduncle short compressed, depth 2.25, length 1.65; eye 3.50, small; snout 3.60, depressed, nearly as long as eye; nostrils widely separated, anterior tubular, near tip of snout;

posterior large, slitlike, close to eye; mouth nearly horizontal, upper jaw slightly longer, more or less overlapping the lower; maxillary 1.70, reaching vertical from posterior margin of eye; interorbital 4, rugose, flattened; margin and crest of preopercle smooth; broad bands of small, villiform teeth on jaws, vomer and palatines; scales ctenoid; lateral line arched, incomplete, 7 well-developed pores anteriorly, indistinct traces of pores posteriorly.

Fins rounded; first dorsal spine small, second half as long as the third, the latter is longest and strongest, 2; second dorsal 1.75, median rays longest; anal 1.77; ventrals 1.75; pectorals 1.48.

Color in alcohol: Ground color buff; a dusky brown stripe from snout to eye, another from eye to throat, a third from upper third of eye across opercles to lateral line, a fourth across nape; traces of three stripes on sides, first from in front of dorsal downward toward angle of preopercle, second from under origin of dorsal to behind pectoral base, the third under middle of spinous dorsal; slight traces of mottlings on first dorsal; ventrals mottled with grayish white; other fins hyalin.

Type.—Cat. No. 70245, U.S.N.M., a female 4.7 cm. in length, with nearly ripe eggs, from Talisse Island, north of Celebes. Ten cotypes 3.5 to 4.3 cm. in length.

Color in life of a cotype 4 cm. long: Ground color hyalin pearl; a brownish-red stripe from snout to eye, another from eye to throat, another across nape and three downward from base of spinous dorsal, these latter more or less olivaceous; spinous dorsal mottled finely with brownish; ventrals similarly mottled but darker; other fins immaculate; abdominal regions and lower side of head with more or less silver; iris very pale pink.

AMIA DIVERSA Smith and Radcliffe, new species.

Plate 37, fig. 1.

Dorsal VII-1,9; anal II,8; scales 3 + 6-25.

General shape fusiform in outline, strongly compressed; head 2.83, pyramidal, the dorsal outline slightly concave at occiput; body deep, dorsal and ventral outline strongly arched, greatest depth 2.60; caudal peduncle long, tapering to base of caudal, slender, depth 2.23, length 1.50; eye 2.62, large; snout 4.30, short, depressed; mouth oblique, lower jaw projecting; maxillary 1.92, reaching slightly beyond vertical from middle of eye; interorbital 3.66, flat; preopercular margin finely serrate, crest and orbital bones smooth; bands of villiform teeth on jaws, those at symphysis and along outer edge of lower jaw anteriorly, unequal; a row of small teeth on ridge of vomer and palatines; peritoneum silvery white; scales regular.

Fins low; first dorsal rounded, spines weak, third and fourth longest, subequal, 2.25; anterior rays of second dorsal longest, 1.46,

margin sinuous; caudal emarginate; anal similar to second dorsal, 1.60; ventrals 1.77; pectorals 1.40.

Color in alcohol: Ground color pinkish-buff dotted with brownish, darkest in front of and at base of anal; silvery reflections on scales on sides; some of scales on back with pearl-gray edgings; a seal-brown band across tip of snout and clin through eye, continued very faintly across opercles, margined below by a silvery line, a silvery line above it on eye; a blackish bar on upper part of eye; tip of opercle brown; a small round black spot on caudal peduncle at base of caudal; fins hyalin; upper membranes of anterior dorsal spines dusky; a narrow black line along base of second dorsal to tip of posterior rays.

Type.—Cat. No. 70246, U.S.N.M., a female 7.8 cm. in length, with immature eggs, from a small stream in Canmahala Bay, Ragay Gulf, Luzon.

This trim little fish appears to be quite distinct from related forms, distinguishable by its coloration and deep, compressed body. The eye is larger than in *A. jenkinsi*, the lower jaw not so prominent, caudal peduncle slenderer, nuchal spots and stripes on top of head lacking; caudal spot small; brown shade on tip of opercle.

AMIA NIGROCINCTA Smith and Radcliffe, new species.

Plate 37, fig. 2.

Dorsal VII-I,9; anal II,8; scales 3 + 6-25.

General shape fusiform, compressed; head 2.70, large, pyramidal; body deep, contour lines symmetrical, depth 2.65; caudal peduncle slender, compressed, depth 2.40, length 1.50; eye 2.95; snout 3.88, short, pointed; nostrils close together, anterior circular, posterior slitlike; mouth oblique, tip of lower jaw rounded, projecting beyond upper; maxillary 1.87, reaching vertical from posterior border of pupil; interorbital 3.70, broad, nearly flat; margin of preopercle and crest finely serrate; orbital rim with a few weak serrations on its lower, outer margin; teeth in upper jaw, slightly unequal, villiform, in a broad band which is narrow posteriorly; small caninelike teeth at symphysis of lower jaw, followed by a narrow band of cardiform teeth; a single row of small, stocky teeth along ridge of vomer, a similar row of somewhat slenderer teeth on palatines; peritoneum silvery white with dusky punctulations; scales regular, ctenoid.

Fins low; first dorsal rounded, spines short and slender, first small, fourth longest 2.26; margin of second dorsal sinuous, anterior rays longest 1.65; caudal emarginate, lobes rounded; anal 1.85, similar to second dorsal; ventrals 1.92, rounded; pectorals 1.40.

Color in alcohol: Pinkish-buff, darkest on back, becoming silvery white on belly, everywhere punctulate with minute brownish dots; scales with silvery reflections; a brown band from tip of snout and

chin to eye; traces of a continuation of this band across opercles, most distinct at preopercle, traces of a silvery marginal line above and below; a narrow black girdle encircles caudal peduncle at base of caudal, darkest at point where it crosses lateral line; a broad, dusky, black band across anterior dorsal spines; a subbasal black band on second dorsal and anal, the black is confined to the membranes; rest of fins hyalin.

Type.—Cat. No. 70247, U.S.N.M., 9.1 cm. in length, taken with a beam trawl February 15, 1908, at station 5143 (lat. $6^{\circ} 05' 50''$ N.; long. $121^{\circ} 02' 15''$ E.), in vicinity of Jolo, at a depth of 19 fathoms, on a bottom of coral sand.

This species resembles *A. jenkinsi* Evermann and Seale from the Philippines. The lower jaw is not so pointed and projects less; nuchal spots and traces of stripes on head are lacking; the large caudal spot is replaced by a narrow black girdle, and the bands on dorsal and anal are more distinct and at a distance from base of rays. *A. spilura* (Regan) is also similar, but it has no black stripe on second dorsal nor girdle on caudal peduncle; and it has a blackish stripe at base of anal, a slightly larger eye, and ventral surface less strongly decurved.

Among the specimens from the type locality are several gravid females and a male with eggs in mouth.

AMIA UNINOTATA Smith and Radcliffe, new species.

Plate 34, fig. 3.

Dorsal VII-I,9; anal II,8; scales 3+6-24.

General form elliptical ovate; head 2.40, conic; body robust, dorsal outline strongly arched, depth 2.45; caudal peduncle slender, compressed, depth 2.37, length 1.70; eye 3.10; snout 3.70, rounded; nostrils close together, near tip of snout, the anterior tubular, the tube about three-fifths diameter of pupil in length; posterior nostril slitlike, just above and behind base of anterior; mouth nearly horizontal, lower jaw slightly projecting; maxillary 1.85, barely reaching vertical from posterior margin of pupil; interorbital 4.40, flattened, rugose; margin of preopercle and crest smooth; teeth on jaws villiform, in bands; those on vomer and palatines in a single row, along the ridge; scales regular, ctenoid; lateral line strongly arched, complete, 24 pores.

Fins rounded; first dorsal spine very small; second slender, less than half as long as the third, the latter is longest and strongest, 2.18; second dorsal 1.95; anal 2.18; ventrals 1.85, barely reaching base of anal; pectorals 1.60, tips reaching vertical to first anal spine.

Color in alcohol: Ground color sepia, margins of scales darker; a blackish slate spot about three-fourths as large as eye on side above middle of pectoral; a light-colored oblique line halves the black blotch; a slaty line from eye downward toward angle of preopercle, traces of

another behind eye on opercle; vertical fins and ventrals very dark olive brown, almost black; pectorals body color.

Type.—Cat. No. 70248, U.S.N.M., 5.5 cm. in length, from Bisucay Island, Cuyos Islands.

Color in life of a specimen 5.5 cm. in length from Tara Island, Mindoro Strait: Dusky, with reddish brown shades a round blackish blotch larger than pupil midway between pectoral and lateral line.

Color in alcohol of a specimen 3.9 cm. in length from dredging station 5179: Drab gray, black blotch on side very distinct.

AMIA STRIATA Smith and Radcliffe, new species.

Plate 35, fig. 1.

Dorsal VII-1,9; anal II,8; scales 3+6-24.

General form elliptical, compressed; head 2.60, pyramidal, upper profile straight; body oblong, dorsal surface arched more than ventral surface, depth 2.71; caudal peduncle deep, compressed, depth 2.16, length 1.64; eye 3.38; snout 4.91, short; mouth very oblique, lower jaw projecting slightly; maxillary 1.75, longer than snout plus eye, reaching vertical from posterior border of eye; nostrils large, aperture of posterior larger than anterior; interorbital 4.50, narrow, rugose; upper margin of preopercle smooth, angle with strong serrations, crest smooth; outer orbital rim crenulate; a band of unequal cardiform teeth, largest at symphysis and along inner edge of mandible; a broad toothless space in front of upper jaw, a narrow band of unequal cardiform teeth, widening posteriorly, the teeth becoming smaller, villiform; a single row of rather stout teeth along ridge of vomer and palatines; peritoneum silvery white with dusky spots; scales ctenoid.

Fins rounded, dorsal spines relatively weak, fourth longest, 2.50; soft dorsal 1.69; anal 1.93; ventrals 1.75; pectorals 1.53.

Color in alcohol: Ground color sepia-brown with iridescent silvery reflections, crossed by 10 bistre crossbands of about same width as interspaces, this color is underneath scales; spinous dorsal blackish, base of spines light; soft dorsal dusky, a darker band near base, base light; caudal bistre; anal very light; ventrals light, dusky at base; pectorals light with some dusky points; sides of head iridescent silvery, punctulate with bistre, an indistinct bar from eye downward to edge of preopercular crest.

Type.—Cat. No. 68403, U.S.N.M., 8.9 cm. in length taken with a beam trawl at station 5442 (lat. $16^{\circ} 30' 36''$ N.; long. $120^{\circ} 11' 06''$ E.), west coast of Luzon, at a depth of 45 fathoms, on a bottom of coral sand.

This species is closely related to *Amia lineata* from Japan, but the interorbital is much narrower and not so flattened, the eye is larger, the snout shorter, the maxillary longer, the cross bands darker and

of about same width as interspaces, and the fins darker. This species is found in company with *A. ellioti*.

In some of the smaller examples in the collection the fins are much darker, almost black, and distal portions of anal and ventrals blackish.

AMIA ALBOMARGINATA Smith and Radcliffe, new species.

Plate 35, fig. 2.

Dorsal VII-I,9; anal II,8; scales 3 + 6-24.

General form elliptical ovate, compressed; head 2.57, stout, upper profile slightly concave, lower convex; body deep, back arched, depth 2.57; caudal peduncle deep, compressed, depth 2.13, length 1.50; eye 3.94, small; snout 3.94, as long as eye, blunt; mouth oblique, lower jaw projecting; maxillary 1.92, short, equal to snout plus eye, not reaching vertical from posterior border of orbit; anterior nostril small, posterior large, circular; interorbital 4.85, narrow, with a low median ridge; margin of preopercle nearly smooth, a few weak denticulations present; intramarginal crest and outer orbital rim weakly crenulate; teeth in jaws small, villiformlike, rather stocky at base, in bands; a single row of teeth along ridge of vomer and palatine bones; scales regular, ctenoid.

Fins rounded; spinous dorsal lower than soft dorsal, spines relatively weak, fourth longest, 2.52; soft dorsal 1.75; anal 1.94; ventrals 1.75; pectoral 1.53.

Color in alcohol: Ground color light yellowish brown, darkest on back, with silvery reflections especially on ventral surface; spinous dorsal blackish distally; soft dorsal dusky, tips of rays blackish, a dusky band near base; caudal dusky, lower margin white; anal yellowish, first ray and tips of others white; ventral similar to anal; pectoral without white edgings; opercle margined with blackish posteriorly; sides of head silvery.

Type.—Cat. No. 68402, U.S.N.M., a specimen 10.2 cm. in length, from the fish market at Cavite, Luzon.

This species is distinguished by the plain coloration, white fin-margins, smooth preopercle, and short maxillary, which is as long as snout plus eye. In the related species, *A. glaga*, *carinata*, *striata*, etc., the maxillary is longer than snout plus eye.

Some ichthyologists have placed in the genus *Mionorus* those species in which the preopercle is smooth. A comparison of this species with *A. glaga* and *carinata* (margin of preopercle crenate, without serrations) and *A. lineata*, *elliotti*, and *striata* (margin of preopercle serrate) leads us to the conclusion that a separation of these species based on the character of the armature of the preopercle can hardly be called a natural classification.

AMIA ATROGASTER Smith and Radcliffe, new species.

Plate 35, fig. 3.

Dorsal VII-I,9; anal II,8; scales about 3+6-24.

General form elliptical, elongate, more robust anteriorly; head 2.57, large, pointed; body slender, compressed, tapering, depth 3.27; caudal peduncle long, slender, compressed, depth 3.03, length 1.37; eye 3.37; snout 3.63; mouth oblique, tip of lower jaw projecting beyond upper; maxillary 2.31, short, reaching vertical from middle of eye; interorbital 4.11, flat, smooth; margin of preopercle strongly serrate, crest smooth, angle somewhat produced; mandible with a narrow band, of unequal cardiform teeth largest at symphysis; a similar band on upper jaw, the band on sides is somewhat wider and the teeth relatively smaller; a row of six or seven long slender teeth on each side of vomer; a similar row of smaller teeth along the ridge of the palatine bones; gill-rakers 5+15, long, slender; scales very deciduous.

Dorsal rounded, third spine longest, 2.64; anterior rays of second dorsal longest, 2.05, distal margin obliquely truncate; caudal forked; anterior anal rays longest, 2.17, margin sinuous; ventrals 2.26; pectorals 1.76.

Color in alcohol: Ground color cream-buff; traces of a slightly decurved, silvery-white band from scapula to base of caudal; tip of chin and snout to middle of eye dusky black; dusky points on head; iris silvery; tip of spinous dorsal blackish; caudal dusky distally; other fins hyalin; peritoneum silvery white; stomach jet black.

Type.—Cat. No. 70249, U.S.N.M., 5.9 cm. in length, taken with a beam trawl at station 5442 (lat. 16° 30' 36'' N.; long. 120° 11' 06'' E.), west coast of Luzon, at a depth of 45 fathoms, on a bottom of coral sand.

Of 7 cotypes 4.6 to 5.9 cm. in length, three are females with eggs in an advanced stage of development; one, evidently a male, has the mouth so filled with eggs that it is distorted and apparently incapable of being closed. The black stomachs of nearly all are well filled with food; one which was examined contained small crustaceans.

AMIODES Smith and Radcliffe, new subgenus.

Two long slender incurved canines at symphysis of each jaw; a narrow band of cardiform teeth merging posteriorly into a row of slender canines on lower jaw; a narrow band of cardiform teeth on front of upper jaw, widening posteriorly, and an outer row of slightly larger teeth; a single row of teeth on vomer and palatines; dorsal VII-I,10; anal II,8; scales large, ctenoid; gill-rakers long, about 3+8.

The teeth are much stronger than in any other species of *Amia*, their arrangement being very similar to that found in *Synagrops* and unlike that found in *Cheilodipterus*. *Siphamia* Weber has enlarged curved teeth, which are differently arranged, however, and in the type species (*tubifer*) there is more than one row on vomer and palatines.

AMIA (AMIOIDES) GROSSIDENS Smith and Radcliffe, new species.

Plate 36, fig. 1.

Dorsal VII-I, 10; anal II, 8; scales about 3 + 6-24.

General shape oblong, compressed; head 2.63, conic, compressed; contour lines of body unsymmetrical, depth 3.10; caudal peduncle short, strongly compressed, depth 2.50, length 1.80; eye 3.43, small; snout 3.60, pointed, tip of snout to origin of dorsal nearly straight; mouth oblique, lower jaw projecting slightly; maxillary 1.90, short, reaching slightly beyond vertical from middle of eye; interorbital 4.17, broad, flat, smooth; preopercle armed with strong serrations; subopercle well developed, projecting beyond tip of opercle; a strong, two-pronged scapular spine present; a pair of long slender, recurved canines at symphysis of lower jaw (one of these much smaller in this specimen), closing between two longer canines on upper jaw into pits at symphysis; a narrow band of unequal cardiform teeth anteriorly, merging into a row of long, slender, recurved or incurved canines; teeth in upper jaw in a cardiform band widening posteriorly and becoming smaller, more uniform, an outer row of small caninelike teeth, strongest anteriorly; a row of small caninelike teeth along ridge of vomer and a similar row of smaller teeth on palatine bones; peritoneum silvery white, scales etenoid, very deciduous.

Dorsal spines strong, the first short, the third longest, 2.05; spine of second dorsal 2.60, margin of fin nearly straight, anterior rays longest, 1.87; caudal forked; anal similar to second dorsal, second spine 2.72, longest ray 1.88; ventrals 1.93, not reaching vent; pectorals 1.58.

Color in alcohol: Ground color buff, dusky on back, silvery white reflections on sides and ventral surface; an indistinct blackish band encircling base of caudal; dorsals and caudal dusky, other fins hyalin.

Type.—Cat. No. 70250, U.S.N.M., 10.1 cm. in length, taken with a beam trawl at station 5442 (lat. 16° 30' 36'' N.; long. 120° 11' 06'' E.), west coast of Luzon, at a depth of 45 fathoms on a bottom of coral sand.

In *Siphamia tubifer* Weber the teeth are not so strong and differently arranged, and the gill-rakers are fewer and shorter. Apparently the group to which it belongs is quite closely related to this one. In our species the form and arrangement of the teeth are quite similar to that found in some species of *Synagrops*.

NEAMIA Smith and Radcliffe, new genus.

Dorsal fins united, VIII,I,9; anal II,8; scales large, about 23, ctenoid, lateral line complete; bands of small, villiform teeth on jaws; a few scattered teeth on vomer, none on the palatines; margin of preopercle entire; fins rounded.

This genus differs from *Fowleria* in having the dorsals united, the first of 8 spines, and the lateral line complete, with none of the pores rudimentary.

Genotype.—*Neamia octospina*.

NEAMIA OCTOSPINA Smith and Radcliffe, new species.

Plate 36, fig. 2.

Dorsal VIII,I,9; anal II,8; scales 3 + 6–22.

General form elliptical ovate, compressed; head 2.50, compressed, dorsal outline comparatively straight, ventral somewhat convex; body deep anteriorly, depth 2.50; caudal peduncle short, compressed, depth 2.15, length 1.87; eye 3.80, small; snout 4, rather blunt; nostrils close to eye, not widely separated; mouth large, nearly horizontal; jaws subequal; maxillary 1.75, reaching beyond vertical from posterior margin of eye; interorbital 5.60, narrow; margin of preopercle smooth; bands of villiform teeth on jaws; a few scattered villiform teeth on vomer, none on palatines; scales large, ctenoid, deciduous, lateral line following curvature of back, continuous, pores well developed.

Fins rounded; third dorsal spine longest and strongest, 2.24; the eighth short, at a slightly greater distance from spine of second dorsal than from the one before it, connected with spine of second dorsal by a low membrane; second dorsal high, median rays longest 1.72; median caudal rays longest; anal similar to second dorsal 2.03; ventrals 1.87, tips reaching nearly to origin of anal; pectorals 1.40.

Color in alcohol cream-buff; fins hyalin; traces of a dusky bar from eye upward toward scapula, a second from eye to angle of preopercle.

Type.—Cat. No. 70251, U.S.N.M., 3.7 cm. in length, from Rasa Island, Mantaguin Bay, Palawan.

Genus CHEILODIPTERUS Lacépède.

In the species *C. lineatus*, *quinquelineatus*, and *singaporensis* the vent is more than a half-diameter of eye in advance of the anal. In the two species herein described it is even more anterior, being nearer base of ventrals than origin of anal and almost as far forward as in *Acropoma*.

CHEILODIPTERUS NIGROTÆNIATUS Smith and Radcliffe, new species.

Plate 37, fig. 3.

Dorsal VI-1,9; anal II,8; scales 3 + 5-25.

General form elliptical; head 2.60, long, depressed; body slender, cylindrical, not strongly compressed, depth 4; caudal peduncle compressed, depth 2.90, length 1.66; eye 3.57; snout 3.67, nearly as long as eye; mouth nearly horizontal; maxillary 1.89, long, reaching vertical from posterior margin of eye; interorbital 5.10, narrow, flat, smooth; margin of preopercle smooth; mandible with a row of slender unequal canines; upper jaw with a row of unequal canines anteriorly, widening out into a band of cardiform teeth, these becoming smaller villiformlike; a single row of rather stout teeth on the vomer; a similar row of smaller teeth on palatine bones; peritoneum silvery white; position of vent cephalad, much nearer base of ventrals than origin of anal, its distance from anal 1.65 in distance from anal to base of ventrals; scales large, regular, ctenoid.

Dorsal spines feeble, first long, nearly as long as second, second and third subequal, 2.36; anterior second dorsal rays longest, 2.10, margin nearly truncate; caudal short, broad, forked; anal similar to second dorsal, 2.30; ventrals 2.27; pectorals 2.17.

Color in alcohol: Ground color silvery white tinged with yellow and dusky points; four dark longitudinal stripes, the first sepia, from interorbital along median line of back to base of caudal; the second Vandyke brown, from above eyes to upper caudal lobe; the third clove brown, encircling tip of snout, backward through middle of eye to end of lateral line; fourth almost black, from chin under eye, through base of pectoral to inferior caudal base; stripes broken up on base of caudal into irregular spots; interspaces wider than stripes, mesially washed with silver white; margins and articulations of caudal rays outlined with brown; other fins dusky.

Color in life: Stripes black, interspaces and lower surface dusky white; on head interspaces are bright yellow, area behind eye to second dorsal also yellow; first dorsal hyalin; second slightly dusky in front; caudal dusky, stripes on sides being broken into dots at base; other fins dusky or hyalin.

Type.—Cat. No. 70252, U.S.N.M., a specimen 8 cm. in length, from coral reefs on the northeast shore of Sacol Island, east of Zamboanga.

In this species and the one which follows the vent is nearly as far forward as in *Acropoma*. It agrees, however, in all essential characters with *Cheilodipterus*.

There are four examples in the collection, 7.5 to 8 cm. long, two from Sacol Island, one from Tutu Bay, Jolo, and one from Gomomo Island.

CHEILODIPTERUS ZONATUS Smith and Radcliffe, new species.

Plate 38, fig. 1.

Dorsal VI-1,9; anal II,8; scales 3+5-25.

General form elliptical; head 2.61, long, depressed, pyramidal; body slender, depth 4.02; caudal peduncle compressed, depth 3, length 1.47; eye 3.34, large, its upper margin encroaching on flattened interorbital; snout 3.80, bluntly rounded; mouth large, nearly horizontal; maxillary 1.91, scarcely reaching vertical from posterior margin of orbit; interorbital 5.04, narrow, flat, smooth; preopercular margin smooth, rounded; a row of slender canines on mandible; a row of slender, unequal canines on upper jaw becoming smaller posteriorly with smaller teeth inside the main row; a few small canineline teeth in a single row on vomer; a similar row of smaller teeth along ridge of palatine bones; peritoneum silvery white; vent anterior, nearer base of ventrals than anal, its distance from anal 1.76 in distance insertion anal to base of ventrals; scales ctenoid, regular.

Dorsal spines feeble, second longest, 2.40; anterior second dorsal rays longest, 2.03, margin nearly truncate; caudal forked; anal similar to second dorsal, 2.14; ventrals and pectorals of equal length, 2.14.

Color in alcohol: Ground color wood brown with silvery reflections; a narrow, dark chestnut brown to black stripe around snout through eye to below end of lateral line; a less distinct burnt umber stripe from above eye to upper caudal base; trace of a median stripe in front of dorsal; margins and articulations of caudal rays penciled with brown; an indistinct brown spot at base of caudal above and below end of lateral stripe; other fins pale dusky.

Color in life: Stripes black, the lower margined below with metallic green; ground color above dusky with an olive tinge shading into lavender on head; region below metallic green stripe dusky yellow; first dorsal with a slight tinge of yellow, other fins dusky hyalin.

Type.—Cat. No. 70253, U.S.N.M., 6.6 cm. in length, taken with dynamite at the southern end of Rita Island, Ulugan Bay, Palawan.

Color in life of the only other specimen in the collection, 6 cm. long, from Endeavor Strait, northwest coast of Palawan: Traces of a blackish stripe from nape to second dorsal; a narrow indistinct stripe from snout over eye to base of tail; a distinct black band from snout through eye to below end of lateral line, margined below by a light metallic green band of about one-half its width, body and chin below this dusky yellow, becoming bright yellow on opercle and lower part of iris; ground color between lateral stripes metallic green, becoming violet on upper part of opercle; interspaces on nape metallic green shading into lavender; converging bands on snout lavender, rest of snout dusky, washed with yellow; first dorsal and ventrals with yellow wash, other fins dusky hyalin.

This species closely resembles *C. nigrotæniatus*, but the caudal peduncle is longer, the snout shorter, and the coloration distinctive.

Genus SYNAGROPS Günther.

Four species have previously been described, *S. japonicus* from Japan, *S. philippinensis* from the Philippines, *S. argyrea* from the Hawaiian Islands, and *S. splendens* from the Gulf of Oman.

SYNAGROPS SERRATOSPINOSA Smith and Radcliffe, new species.

Plate 38, fig. 2.

Dorsal IX-1,9; anal II,7; scales about 3+7-28.

General form cylindrical ovate, compressed; head 3, short, depth nearly equaling length, dorsal and ventral contour lines nearly symmetrical, convex; body short, deep, depth 3; caudal peduncle compressed, depth 2.75, length 1.46; eye 2.65, large; snout 3.93, short, rounded; mouth small, oblique; maxillary 1.93, reaching vertical from middle of eye; interorbital 3.15, broad, convex, rugose; angle and horizontal margin of preopercle strongly serrate, angle of crest with four or five strong serrations; opercle ending in two feeble spines; subopercle produced beyond opercle; posterior angle of interopercle serrate; a pair of elongate, recurved canines at symphysis of lower jaw, in front of these a broad band of unequal cardiform teeth, narrowing posteriorly to a single row of long, slender canines with a very narrow outer band of small teeth, which entirely replaces the canines posteriorly; a pair of long canines on upper jaw, wider apart and allowing pair on lower jaw to close between them; a band of villiform, almost cardiform, teeth widening out on sides of lower jaw and again narrowing posteriorly; a semilunar patch of small paved teeth on vomer and a narrow band of cardiform teeth on palatines; throat blackish, peritoneum brownish black; pyloric cæca six; scales cycloid, very deciduous.

Origin of dorsal from tip of snout 2.50 in length; dorsal spines well developed, third longest, 1.63, first with a single spinule, second with strong regular close-set serrations, projecting tip of third with a single spinule; spine of second dorsal serrate, longest ray about 2.20; caudal forked; anal similar to second dorsal, about 2.20, second spine strong, serrate, 2.32; ventrals 1.46, spine serrate; pectorals 1.30.

Color in alcohol: Ground color cream-buff, dorsal surface dusky, ventral silvery; fins dusky.

Type.—Cat. No. 70254, U.S.N.M., 8.1 cm. in length, taken with a beam trawl at station 5365 (lat. 13° 44' 24'' N.; long. 120° 45' 30'' E.), Batangas Bay, Luzon, at a depth of 214 fathoms.

This species is frequently taken with *S. philippinensis*. It is smaller, with a deeper body, shorter, more robust head, larger eye,

broader interorbital, shorter snout, weaker canines, and more spines bearing serrations on anterior margin.

There is a large series of specimens in the collection from the Philippines from depths of 96 to 279 fathoms. The type is a female with eggs in an advanced stage of development.

Genus HYNNODUS Gilbert.

This genus differs from *Epigonus* in having teeth on the palatines and a more elongate body.

HYNNODUS MEGALOPS Smith and Radcliffe, new species.

Plate 38, fig. 3.

Dorsal VII-I, 10; anal II, 9; scales 4 + 7-50.

General form cylindrical ovate, elongate, depressed anteriorly, compressed posteriorly; head 2.90, pyramidal, depressed, breadth at occiput greater than its depth, 1.75 in its length; body cylindrical, tapering posteriorly, slender, its breadth at base of pectorals equal to its depth, 5.30; caudal peduncle slender, elongate, compressed, depth 3.70, length 1.37; eye 2.15, very large, horizontal diameter greater than vertical diameter; snout 4.07, short, pointed; mouth small, oblique, lower jaw included; premaxillaries, maxillaries, and mandibular bones slender, weak; maxillary 2.67, short, narrow, partly covered by overhanging preorbital, reaching vertical from front of pupil; anterior nostril circular with a raised border, posterior slit-like; interorbital 4.90, concave, orbital rims noticeably raised; preopercle with a thin lamina projecting backward at angle to posterior margin of opercle, no serrations; the thin laminae of interopercles overlapping on ventral surface; opercle with a strong spine near upper angle; teeth in jaws small, incurved, not crowded together; a single row of similar teeth on vomer; palatine teeth small, very slender and quite widely separated; peritoneum silvery, washed with brown; scales small, ctenoid, deciduous, lateral line very distinct, tubes large, about one-third breadth of scale, 54 pores; head with scales.

Origin of dorsal from tip of snout 1.70 in length; dorsal spines feeble, first short, third longest, about 2.20; spine of second dorsal distinct, slender, longest ray about 2.10; anal spines slender, longest ray about 2.30; ventrals 2.44, reaching halfway to origin of anal; pectorals 2.30, rounded.

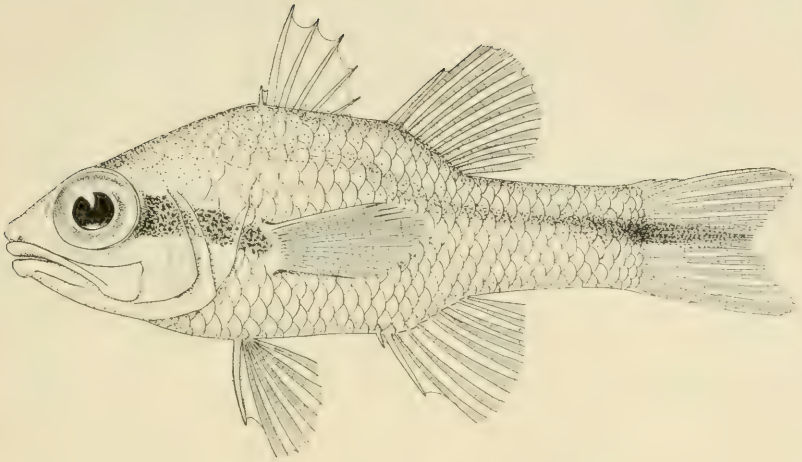
Color in alcohol: Ground color buff; scales margined with sepia, many of them entirely sepia colored, especially below the lateral line and near head; fins dusky; head dusky; opercle metallic blue shading into black posteriorly; throat blackish.

Type.—Cat. No. 70255, U.S.N.M., 15.6 cm. in length, taken with a beam trawl at station 5388 (lat. 12° 51' 30'' N.; long. 123° 26' 15''

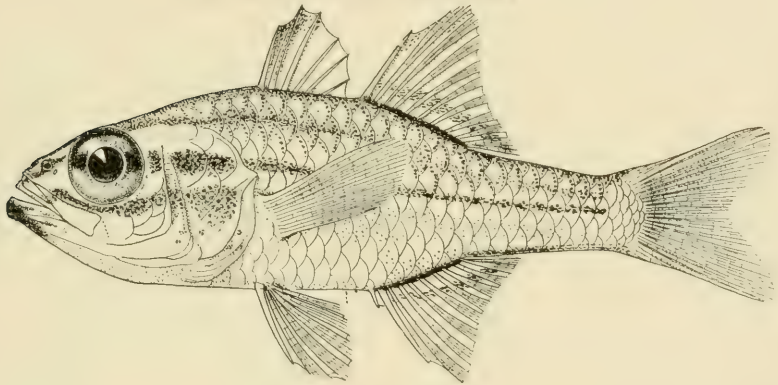
E.), between Burias and Luzon, at a depth of 226 fathoms, on a bottom of soft green mud.

This species resembles *H. atherinoides* Gilbert from the Hawaiian Islands. The latter is slenderer, has a shorter head, snout, and maxillary and a slenderer caudal peduncle.

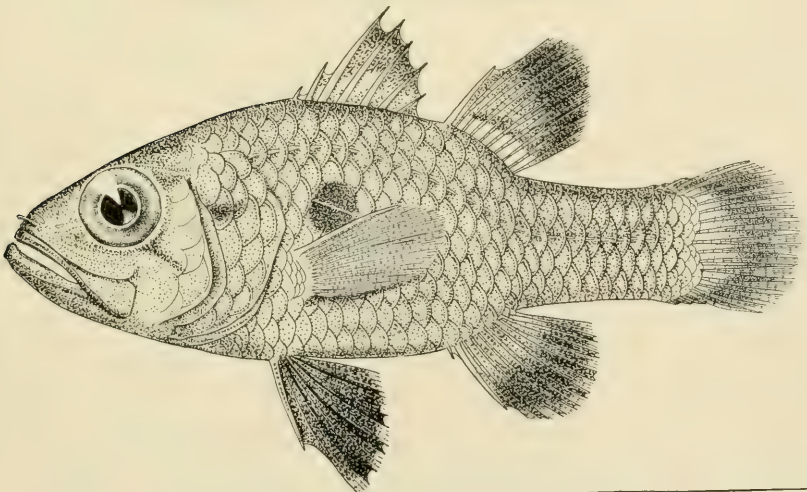
The collection contains three examples from station 5388 and one individual from station 5508, off northern Mindanao, in 270 fathoms.



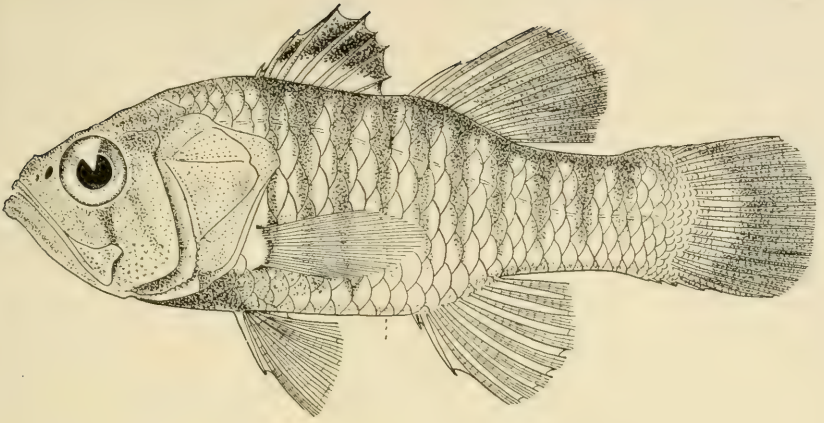
1. *AMIA DIENCÆA*. (PAGE 431.) FROM THE TYPE.



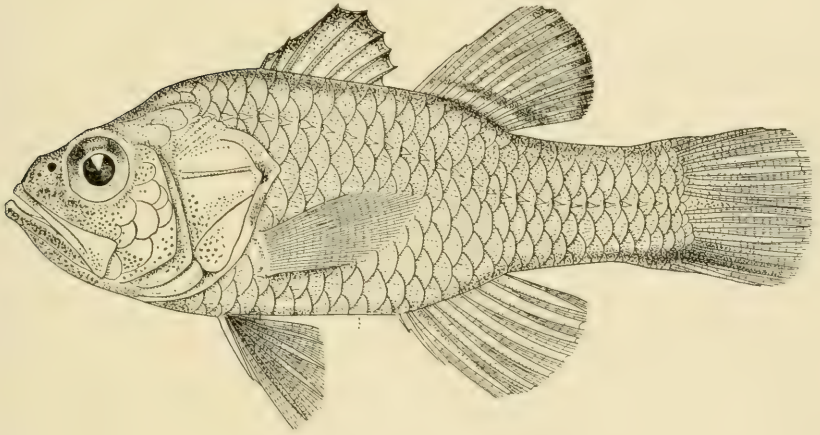
2. *AMIA PARVULA*. (PAGE 432.) FROM THE TYPE.



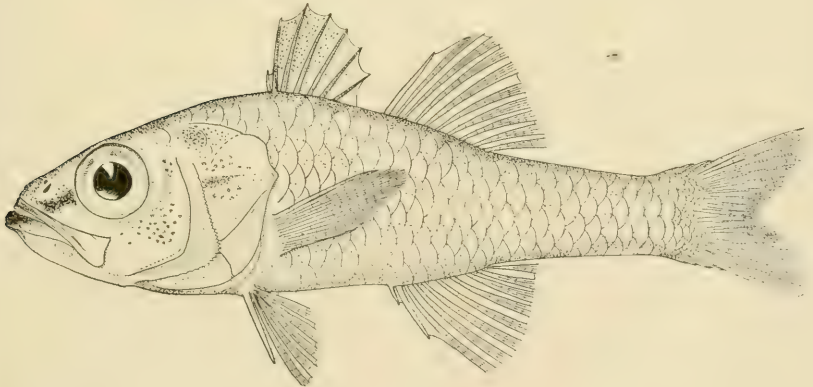
3. *AMIA UNINOTATA*. (PAGE 436.) FROM THE TYPE.



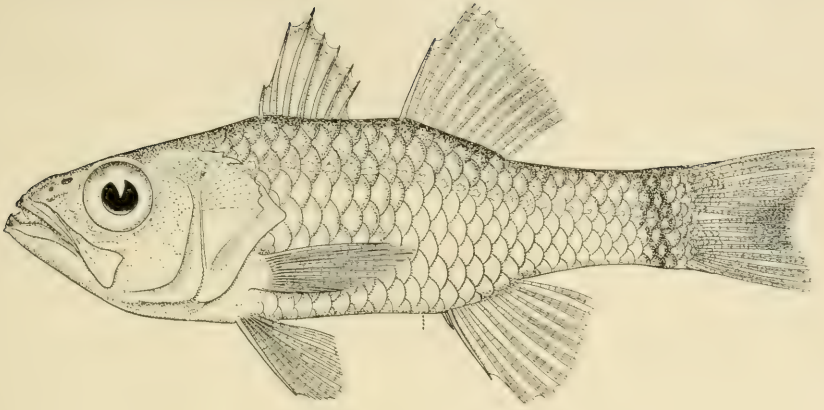
1. *AMIA STRIATA*. (PAGE 437.) FROM THE TYPE.



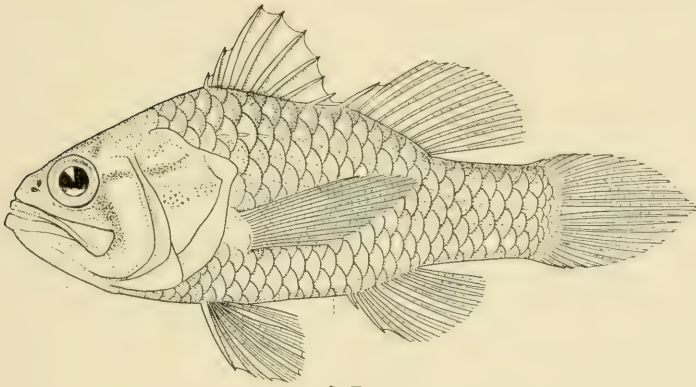
2. *AMIA ALBOMARGINATA*. (PAGE 438.) FROM THE TYPE.



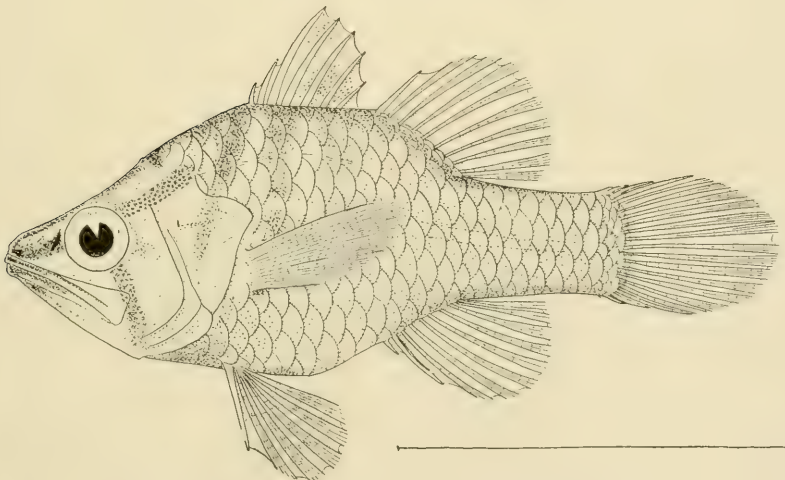
3. *AMIA ATROGASTER*. (PAGE 439.) FROM THE TYPE.



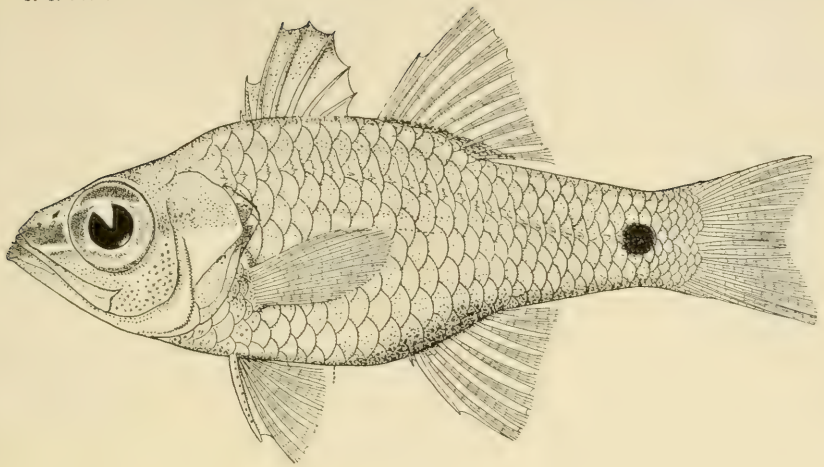
1. *AMIA (AMIODES) GROSSIDENS*. (PAGE 440.) FROM THE TYPE.



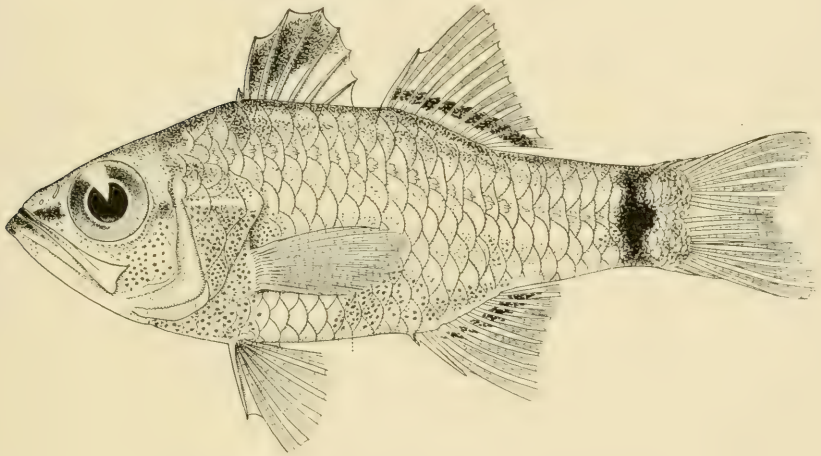
2. *NEAMIA OCTOSPINA*. (PAGE 441.) FROM THE TYPE.



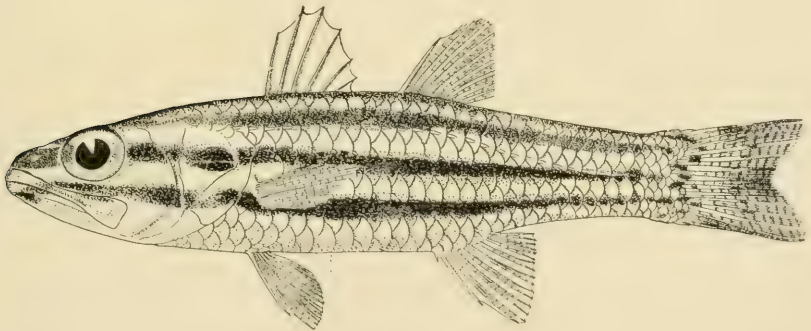
3. *AMIA HYALINA*. (PAGE 433.) FROM THE TYPE.



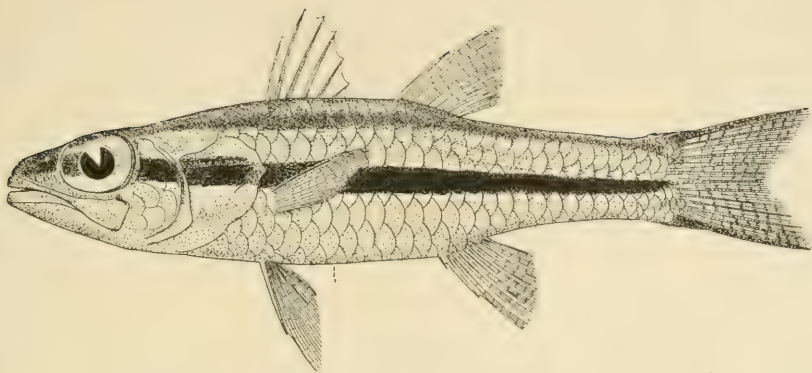
1. *AMIA DIVERSA*. (PAGE 434.) FROM THE TYPE.



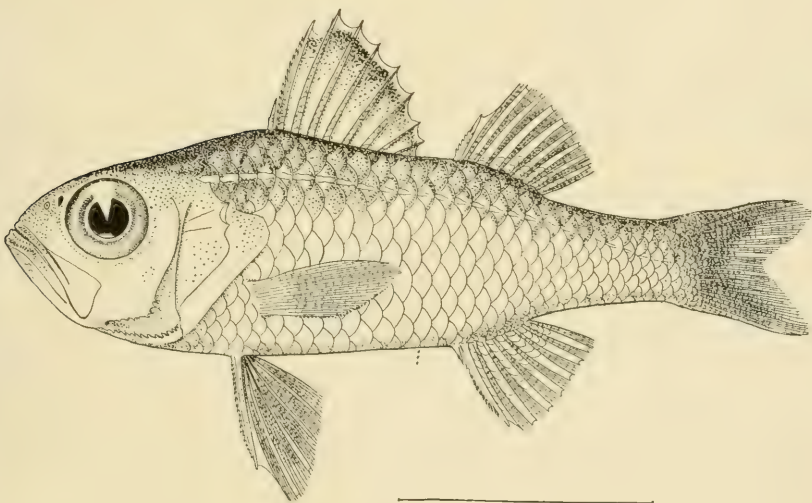
2. *AMIA NIGROCINCTA*. (PAGE 435.) FROM THE TYPE.



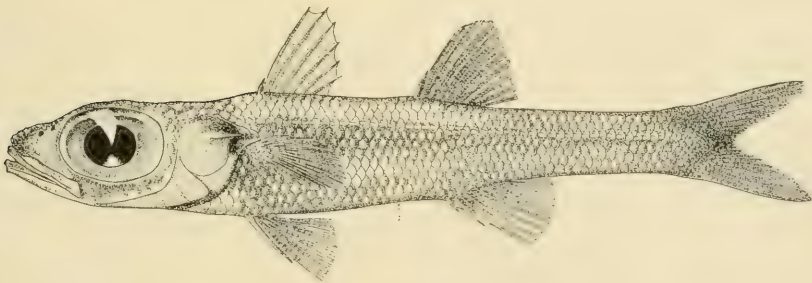
3. *CHEILODIPTERUS NIGROTÆNIATUS*. (PAGE 442.) FROM THE TYPE.



1. CHEILODIPTERUS ZONATUS. (PAGE 443.) FROM THE TYPE.



2. SYNAGROPS SERRATOSPINOZA. (PAGE 444.) FROM THE TYPE.



3. HYNNODUS MEGALOPS. (PAGE 445.) FROM THE TYPE.

DESCRIPTIONS OF NEW SPECIES OF WASPS IN THE COLLECTIONS OF THE UNITED STATES NATIONAL MUSEUM.

By S. A. ROHWER,

Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

Many of the following new species were received by the Bureau of Entomology, for determination, from Dr. W. E. Britton, of New Haven, Connecticut, and from Prof. Guillermo Gandara, of Mexico. The last lot contained a specimen of each species, with a number attached.

Some of the descriptions of the Mutillidæ may be considered too short, but as the genera are well defined and the species always placed in the species-group to which they belong, it is believed that they are of sufficient length to enable any one who is familiar with the group in question to satisfactorily determine the insect.

Superfamily VESPOIDEA.

Family BETHYLIDÆ.

Genus PARASIEROLA Cameron.

PARASIEROLA CELLULARIS (Say).

In view of the fact that Ashmead was the first reviser of this species his determination should stand as the type. The following notes taken from specimens reared from wheat stubble in Oxford, Indiana, and now in the National Museum, may be useful:

Female.—Length 3.75 mm. Mandibles tridentate; median carina smaller above the antennal hump and only about three-fourths as long as below the hump; antennal joints cylindrical, scape about one-third longer than the third joint, much shorter than the third and fourth, the third joint a trifle longer than the fourth; head granular, with distinct punctures sparsely interspread; pronotum widening posteriorly, the cephal-caudal length subequal with the posterior width; length of the meso- and metanotum subequal; propodeum shorter than the pronotum, dorsal aspect convex basally; dorsal and posterior aspects separated by a fine carina; thorax

granular, with a few large punctures interspread; abdomen polished, impunctate.

Specimens from the same rearing vary from black to piceous. The wings vary from clear hyaline to somewhat fuscous in the stigmal area.

PARASIEROLA DISTINGUENDA Kieffer.

This is at once distinguished from *cellularis* by the quadridentate mandibles and different antennæ. (Kieffer¹ describes the antennæ of *distinguenda* thus: "Schaft etwas länger als das 2. und 3. Fühlerglied, diese nur wenig länger als dick, die folgenden wenigstens so lang als dick.") Specimens which have been determined as this species have the pronotum anteriorly wider than the length. These specimens come from Texas and have been bred from *Bruchus prosopidis* (Hunter number 1410 of Bureau of Entomology) and an unknown *Bruchus* (number 1700).

Kieffer's variety *gracilicornis* has been taken at Los Angeles, California, by Mr. D. W. Coquillett; Mesilla Park, New Mexico, and "Ckll., 2704 on *Sisymbrium*," by Prof. T. D. A. Cockerell. The character of the antennæ is perhaps great enough to consider this a species.

Family EUMENIDÆ.

Genus ODYNERUS Latrielle.

ODYNERUS (STENODYNERUS) CANAMEXICUS, new species.

Belongs to *Stenodynerus* of Saussure's "Synopsis of American Wasps" and runs in his table to the species of this group to *huastecus* Saussure, but differs from the description of that species in a number of points; superficially separated by the red legs.

Vertex bituberculate; second ventral segment sharply perpendicular anteriorly, the dorsal and ventral apical margins reflexed.

Male.—Length, to apex of second segment, 10 mm. Clypeus much broader than long, apex broadly rounded, middle arcuately emarginate, the emargination bounded by a small tubercle laterally surface with separate, distinct punctures; front with close, distinct punctures; vertex and posterior orbits with separated punctures of the same size; ocellocipital line subequal with the first two flagellar joints; first joint of flagellum distinctly longer than the second, but not as long as the second and third; flagellar joints irregular; anterior angles of the pronotum subdentate; thorax with distinct, rather close punctures; metanotum perpendicular posteriorly, but not sharply so, slightly impressed medially; propodeum laterally and dorsally punctured like the rest of the thorax, posteriorly separated into two large, oval, shining areas by carinæ; legs normal; first segment but little

¹Berliner Ent. Zeit., vol. 50, 1905, p. 254.

smaller than the second; suture between the first and second ventral segments not foveolate; first two dorsal segments punctured like the mesoscutum, the apex of the second densely so and reflexed; second ventral segment rather more sparsely so except at the apex, where it is closely punctured. Black; clypeus pale yellow; scape, pedicellum, nasal orbits to and filling emargination, oblique line from superior orbits nearly meeting in middle, spot on posterior orbits, pronotum, except a triangular lateral spot, spot below tegulae, tegulae, two small spots on scutellum, line on metanotum, legs below trochanters, two nearly confluent spots on first and second dorsal segments and lateral spots on second ventral (these spots are confluent with the apical band) *rufous*; apex of all the segments narrowly yellow; clypeus, thorax and basal abdominal segments with appressed white pubescence, that of the clypeus somewhat silvery; head (dense on face) and thorax with erect black hairs; wings strongly dusky, apically with a violaceous tinge, basally with a yellowish tinge; venation dark brown.

Federal District of Mexico. One male from Prof. Guillermo Gandara.

Type.—Cat. No. 14176, U.S.N.M.

Genus ANCISTROCERUS Wesmeal.

ANCISTROCERUS (STENANCISTROCERUS) CEANOETHI, new species.

Superficially very like *sæcularis* Saussure, but has the tubercles between the lateral ocelli well developed. Very close to *fulvipes* Saussure, but differs from that species thus:

<i>A. fulvipes</i> Saussure.	<i>A. ceanoethi</i> , new species.
FEMALE.	FEMALE.
1. Anterior lateral angles of the pronotum dentate.	1. Anterior lateral angles of the pronotum not dentate.
2. Clypeus truncate.	2. Clypeus emarginate, bidentate.
3. Femora mostly rufo-ferruginous.	3. Femora mostly black.
4. Second dorsal segment without a free pale spot.	4. Second dorsal segment with a free pale spot.
MALE.	MALE.
5. Clypeus distinctly longer than wide, the emargination shallower and broader.	5. Clypeus but little longer than wide, the emargination narrow and deep, the teeth sharp.
6. Color characters of female.	6. Color characters of female.

Glencarlyn, Virginia. Female and two males collected June 8 on flowers of *Ceanothus*. Also a female collected June 14 on flowers of *Ceanothus* at Falls Church, Virginia. All collected by Mr. N. Banks.

Type.—Cat. No. 14183, U.S.N.M.

If Robertson's interpretation¹ of *sæcularis* Saussure is incorrect, this may prove to be Saussure's species, as it agrees well with his description.

¹ Trans. Amer. Ent. Soc., vol. 27, April, 1901, p. 196.

Family MASARIDÆ.

Genus PSEUDOMASARIS Ashmead.

PSEUDOMASARIS PHACELLÆ, new species.

Belongs in with *texanus* (Cresson), but is separated at once by the eyes being separated at the vertex by a distance slightly greater than the postocellar line (in *texanus* they are separated by much less than the length of postocellar line).

Male.—Length about 13 mm. Labrum obtusely pointed; clypeus strongly uniformly convex, arcuately emarginate in apical middle, finely punctured; front with rather large, separate punctures; scape not one and a half times as long as broad, third joint distinctly shorter than fourth; anterior ocellus large, subreniform; pronotum polished, with well-separated small punctures; mesonotum with distinct, well-separated punctures, which are somewhat closer in the depressed area; mesopleuræ and scutellum similarly punctured; propodeum normal; abdomen polished, with widely separated punctures which become smaller posteriorly; seen from above the first dorsal is arcuately emarginate anteriorly; second, third, and fourth dorsal segment depressed basally by about one-third the length of the entire segment; processes of the third ventral and apical segments essentially as in *texanus*; second cubital on the radius slightly longer than the distance between the recurrent veins. Black except where mentioned; apical half of scape, flagellum (except apical spots on fourth and fifth joints and greater part of club), face above level of antennæ (the lower margin has three indentations of black), most of clypeus, pronotum, large circular spot below tegulæ, tegulæ, spot above, two fan-shaped spots on anterior part of mesoscutum and a small spot in front depression, spot on scutellum and angles of propodeum yellow; abdomen with broad dorsal and ventral bands on apex of all segments reddish yellow (due in part to potassium cyanide?); legs reddish-yellow, knees yellowish; wings vitreous, hyaline, slightly yellowish in stigmal region; venation pale brown.

Female.—Length about 12 mm. Labrum broadly rounded apically; clypeus slightly convex, broadly arcuately emarginate teeth bounding emargination large, very finely granular, with large punctures intermingled; front with large, distinct punctures, which are more widely separated on the eye margins and vertex; postocellar line subequal with the ocellocular line; scape short, third joint of antennæ as long as the three following; pronotum with well-separated large punctures; mesoscutum with punctures the size of those of pronotum, but they are much closer and especially so in the depressed area; mesopleuræ more closely punctured than the mesoscutum; scutellum punctured like mesopleuræ, with an indistinct

carina medially; angles of propodeum nearly cylindrical, long; abdomen with well separated, distinct punctures, which become smaller posteriorly; first dorsal segment slightly emarginate anteriorly when seen from above; second and third dorsal segments depressed basally for about one-third; apical ventral segment with the large punctures well separated; second cubital cell on the radius as long as two-thirds of the distance between the recurrent veins. Black except where mentioned; antennæ rufo-piceous; posterior orbits dorsally, narrow line on inner orbits up to and filling the eye emargination, large spot on clypeus, spot above, posterior margin of pronotum narrowly, and an elongate lateral spot, large spot below tegulæ, tegulæ, spot above, large spot in front of depression on mesoscutum, most of scutellum, angles of propodeum, dorsal and ventral (except first) abdominal segments apically yellow; pronotum (except where mentioned), band on scutellum, elongate spots on second, third, and fourth segments rufous; legs rufous; wings dusky, especially near the veins; stigma and costa reddish-brown, veins dark brown.

The second female has more red on the three abdominal segments.

The female will fall next to *texanus*, from which it will easily be separated by the depression of the second and third dorsal segments.

If the sexes prove to be wrongly associated, the species should stand with the male as type.

New Mexico, Albuquerque. One male on flowers of *Phacelia neomexicana* May 13, 1910, collected by Mr. J. R. Watson. Mesilla, one female collected May 29 at flowers of *Phacelia* by Prof. T. D. A. Cockerell (Cockerell No. 5368). Filmore Canyon, one female collected August 28 by Prof. T. D. A. Cockerell.

Type.—Cat. No. 14143 U.S.N.M.

PSEUDOMASARIS ALBIFRONS, new species.

Male.—Length about 12 mm. Very like *texanus* (Cresson), from which it may be separated by the following characters: Very few large punctures on the front and these not sharply defined; posterior part of mesoscutum uniformly punctured (in *texanus* the depressed area is more closely punctured); punctuation of abdomen finer; second dorsal segment depressed by fully half its entire length (in *texanus* it is hardly depressed); third segment hardly depressed (in *texanus* it is depressed by fully one-third); punctures of the apical dorsal segment more widely separated; second cubital cell on the radius longer, being in the type greater than the distance between the recurrent veins (in *texanus* it is much less); markings whitish; clypeus except apical part pale; wings slightly yellowish in stigmal area, otherwise hyaline.

New Mexico. One male from Las Cruces, collected "on plum," March 25, 1896, by Prof. T. D. A. Cockerell. A male from Utah,

collected by Palm, from C. F. Baker collection, differs slightly in the venation and in having the third dorsal segment more depressed basally.

Type.—Cat. No. 14144 U.S.N.M.

PSEUDOMASARIS ZONALIS NEOMEXICANUS, new subspecies.

Female.—Length 10 mm. Separated from the typical form by the large, separate punctures of the head, thorax and abdomen; legs below the coxæ red; large spot on clypeus; only a narrow line on superior posterior orbits, and the emargination; spot on side of pronotum not connected with the posterior pale margin; small pale spot above tegulæ; flagellum black.

Aztec, New Mexico. One female collected May 4, 1899, at flowers of *Astragalus*. From C. F. Baker collection.

Type.—Cat. No. 14145 U.S.N.M.

PSEUDOMASARIS ZONALIS BASIRUFUS, new subspecies.

Female.—Length 9 mm. Differs from the typical form in the larger and separate punctures of the pronotum; a distinct depression in front of the anterior ocellus; legs below coxæ mostly red; wings nearly hyaline; three basal dorsal segments mostly red; orbits with a small spot in the emargination and a line on superior posterior margin; and lateral spot of pronotum not connected with the dorsal posterior margin.

From the subspecies *neomexicanus* it may be separated by the depression in front of anterior ocellus, closely punctured abdomen and red on the basal segments.

Death Valley, California. One female collected April, 1891, by Mr. A. Koebele.

Type.—Cat. No. 14146, U.S.N.M.

Family TIPHIIDÆ.

Genus TIPHIA Fabricius.

The following three species of *Tiphia* do not agree with the descriptions of any of the described species. The species of this genus, although as a rule possessing good characters, have in America not been described with sufficient accuracy to make their determination certain.

TIPHIA CANAMEXICA, new species.

Female.—Length 10.5 mm. Clypeus rounded anteriorly, not dentate; nasal margin of the eyes diverging to the clypeus; head with large, distinct, rather close punctures which are closer on the front; a glabrous streak from anterior ocellus; postocellar line distinctly shorter than the ocellocular line; ocelloccipital line and ocellocular line of approximately the same length; third antennal joint slightly shorter than the fourth, apical joint slightly tapering much longer

than the preceding joint; posterior margin of pronotum biarcuately emarginate; pronotum with close, small punctures; meso-scutum with large, rather close punctures; scutellum shining, very sparsely punctured; side of pronotum finely striate, the striæ stronger below; mesoepisternum with small well-scattered punctures; mesoepimeron and metapleuræ shining, practically impunctate; mesosternum punctured like the mesoepisternum, except the lateral posterior lobes which are practically impunctate; sternellum about one-fourth longer than greatest width, uniformly punctured, and with a complete longitudinal furrow; dorsal aspect of propodeum dull, irregularly, finely punctured, enclosure as in figure 1; not foveolate in front of the posterior carina; posterior face sharply defined; laterally obliquely striate; legs normal; abdomen shining with a few weak, scattered punctures; first dorsal without a transverse suture or carina; basal, transverse suture of second dorsal finely foveolate; pygidium coarsely punctured basally, apically finely granular, apex obtusely triangular; last ventral segment rounded to the truncate apex. Black; pubescence long, white; wings slightly dusky, vitreous; venation pale brown, stigma black.



FIG. 1.—PROPODEAL ENCLOSURE OF *TIPHIA CANAMEXICA* ROHWER.

Federal District of Mexico. One female received from Prof. G. Gandara.

Type.—Cat.—No. 14181, U.S.N.M.

***TIPHIA MEXIANA*, new species.**

Female.—Length 6 mm. Clypeus rounded apically, slightly broadly produced in the middle, not dentate; nasal margin of eyes distinctly diverging to the clypeus; head with median-sized well-separated punctures, somewhat closer on vertex and posterior orbits; postocellar line a little more than half as long as the ocellocular line; ocellocular line longer than ocelloccipital line; basal joints of flagellum carinate beneath, the first joint subequal with the second, apical joint distinctly longer than the preceding; posterior margin of pronotum biarcuately emarginate, surface punctured somewhat closer than the head; mesoscutum with rather larger, separated punctures; scutellum impunctate medially; side of pronotum very finely striate, striæ stronger below; mesoepisternum and sternum (except the impunctate posterior lobes) with well-separated, distinct punctures; mesoepimeron and metapleuræ very finely granular; sternellum one-fourth longer than apical width uniformly sculptured, with a deep longitudinal furrow; dorsal aspect of propodeum dull, inclosure as in



FIG. 2.—PROPODEAL ENCLOSURE OF *TIPHIA MEXIANA* ROHWER.

figure 2; anterior to the posterior carina very sparsely foveolate; posterior face sharply defined; sides finely striate; abdomen as in *canamexica* but more sparsely punctured; pygidium punctured basally, longitudinally striate in middle, shining apically, broadly rounded apically; last ventral plate rounded apically, very slightly emarginate medially. Black; pubescence white; wings clear hyaline, vitreous; venation dark brown, stigma black.

Federal District of Mexico. One female received from Prof. G. Gandara.

Type.—Cat. No. 14182, U.S.N.M.

TIPHIA FULVITARSIS, new species.

Male.—Length 5 mm. Clypeus somewhat depressed laterally, medially with a short, produced truncate process, surface with irregular, sometimes confluent, punctures; head transverse, with scattered distinct punctures; ocelli in a low triangle; postocellar line subequal with ocellocular line; scape rather short, much broader apically; pedicellum but little longer than broad, third joint subequal in length with the fourth, antennæ beyond the sixth joint wanting; pronotum carinate anteriorly notched in the middle, posterior margin produced in the middle, biarcuately emarginate, anterior part with large, separate punctures, posteriorly practically impunctate; nautali wanting; mesoscutum depressed medially where the punctures are closer, with large, separate punctures; scutellum punctured like the sides of mesoscutum; metanotum with close, small punctures; dorsal aspect of propodeum finely, subgranular, inclosure sharply defined, trapezoidal in outline, broader basally, with an indistinct median carina; sides of propodeum with strong longitudinal carinæ dorsally, ventrally finely striatopunctate; propodeal spiracle oval in outline, slightly basad of middle; sternellum acutely triangular, without a median sulcus; first dorsal without a medial transverse carina, very sparsely punctured, posterior margin with a punctate furrow; second dorsal polished, very sparsely punctured; apical part of third and the following dorsal segments with close, distinct punctures; posterior trochanter subangulate posteriorly; posterior calcaria slender, but little shorter than the basitarsis; stigma broadly rounded apically, broader apically; radial cell distinctly shorter than the first cubital, angulate at the first transverse cubitus; transverse median slightly basad of basal. Black; anterior tibiæ rufo-piceous; tarsi ferruginous; hairs white; wings hyaline, beyond stigma dusky.

Puira, Peru. One male collected November 1, 1910, by Mr. C. H. T. Townsend.

Type.—Cat. No. 14142, U.S.N.M.

Family MUTILLIDÆ.

Genus PYCNOMUTILLA Ashmead.

This includes Fox's groups *waco* and *asopus*. It is closest to *Dasymutilla* Ashmead, being separated by the tridentate mandibles and normally different conformation of the pygidium. The male have the tarsi with fewer spines.

PYCNOMUTILLA HARMONIA (Fox).

A pair, supposed to be taken in copula, brings to the light the male of this species known, heretofore, only from the female. The specimens were taken by Mr. A. H. Manee, Southern Pines, South Carolina, September 1, 1907.

The male belongs to group *asopus* of Fox, and in his table runs to *beaxar* (Blake), but may at once be distinguished from that species by the absence of a carina on the second ventral segment, and the larger and (seen from side) more strongly nodose petiole. The carina of the first ventral segment is nearly straight, being only slightly arcuate.

Superficially the male is like *Dasymutilla castor* (Blake), but as Mr. Fox places this in the group of bidentate mandibles it can not be that.

The female, which is rather rubbed, differs from the typical form in the markings of the second dorsal segment being wanting and the absence of black hair on same segment.

PYCNOMUTILLA HARMONIFORMIS, new species.

Male.—Length 12 mm. Differs from *harmonia* (Fox) in the carina of the first ventral segment being produced into a sharp tooth beneath; and the first segment (seen from the side) not nodose. The first segment is rufo-ferruginous.

Lyme, Connecticut. One male collected July 31, 1910, by Mr. A. B. Champlain.

Type.—Cat. No. 14123, U.S.N.M.

PYCNOMUTILLA BOULDERENSIS (Rohwer).

Ephuta boulderensis ROHWER, Tran. Amer. Ent. Soc., vol. 35, 1909, p. 133.

Type.—Cat. No. 14120, U.S.N.M.

PYCNOMUTILLA SPARSIFORMIS (Cockerell and Rohwer).

Ephuta sparsiformis COCKERELL and ROHWER, Psyche, 1908, p. 4.

Genus DASYMUTILLA Ashmead.

This is Fox's¹ group *occidentalis*.

¹ Trans. Amer. Ent. Soc., vol. 25, 1899, p. 230-249.

Group FERRUGATARUM.

[=Fox categories 22 to 27, pp. 232 and 233.]

Unless otherwise stated the pygidium is strongly longitudinally striated, and well defined laterally.

DASYMUTILLA FERRUGATA, var. BALABETEI, new variety.

Female.—Length 11.5 mm. Differs from the typical form in having red legs.

Crescent City, Florida. One female collected by Mr. Hubbard.

Type.—Cat. No. 14124, U.S.N.M.

DASYMUTILLA GEORGIANA, new species.

Separated from *ferrugata* by the very prominent eyes.

Female.—Length 8 mm. Head seen from in front with the outer margins of cheeks subparallel, cheeks not expanding beyond the inner margin of the eyes; length of the second and third joints of antennæ beneath subequal with the length of fourth and fifth; dorsulum more coarsely punctured than the head or sides; metapleuræ and sides of propodeum with large, separate punctures; carina of first ventral as in *ferrugata*; legs rather feebly spinose; second dorsal with nearly uniform, small, separate, irregular punctures. Antennæ and legs piceous; apex of second dorsal with a small, medial patch of white pubescence; otherwise colored as *ferrugata*, except appressed pubescence is not as dense.

Georgia.

Type.—Cat. No. 14125, U.S.N.M.

DASYMUTILLA PLESIA, new species.

Mutilla ferrugata CRESSON, Trans. Amer. Ent. Soc., vol. 4, 1872, p. 193 (part).

Separated from *ferrugata* by the second and third joints of antennæ being distinctly shorter than the fourth and fifth.

Female.—Length 10 mm. Eyes prominent, but not as distinctly so as in *georgiana*; cheeks and vertex sparsely punctured, front closely so; dorsulum more coarsely sculptured than the sides or head; metapleuræ and sides of propodeum with large separate punctures; legs strongly spined for group, apical spines of penultimate joint of posterior tarsi subequal with the length of ultimate joint; ventral carina of first segment as *ferrugata*; first dorsal sparsely punctured medially; second dorsal with lateral basal area and sides sparsely punctured, the rest with uniform small punctures. Rufo-ferruginous; antennæ piceous; legs, apex of second and all the following segments black or very dark piceous; head, thorax and most second dorsal with appressed golden pubescence; head most of thorax and the greater part of second dorsal with sparse erect golden hair; posterior face of propodeum and first dorsal with scattered, erect, black hairs;

apex of first dorsal with black hair; quadrate spot of black hair at basal middle of second dorsal; apex of second dorsal, except at extreme sides with black hair; apex of third and following and lateral apical margin of second with white hair; apical ventral margin of second and following segments with white hair.

Ocean Beach (opposite Miami), Florida. Eight females collected November 8 by Mr. C. H. T. Townsend. One female from Texas (Belfrage) and two females from Washington, District of Columbia.

Type.—Cat. No. 14126, U.S.N.M.

The largest specimen is 14 mm., the smallest one 8 mm.

DASYMUTILLA ERRANS, new species.

Mutilla ferrugata CRESSON, Trans. Amer. Ent. Soc., vol. 4, 1872, p. 198 (part).

Female.—Length 11 mm. Differs from *plesia* as follows: Metapleuræ without large punctures; apex of first dorsal segment with white hair; apex of second dorsal with band of white hair narrowly interrupted in middle; appressed black pubescence at base of second dorsal poorly defined or wanting; posterior tarsi feebly spined.

Texas (Belfrage); Brownsville, Texas, August 30, 1896, collected by Mr. C. H. T. Townsend.

Type.—Cat. No. 14127, U.S.N.M.

DASYMUTILLA BOSQUENSIS, new species.

Superficially like *errans*, but differs widely in structure as will be seen by the following description.

Female.—Length 10.5 mm. Fourth antennal joint distinctly narrowed below, the third joint subequal in length with the fourth and fifth ventrally; head with distinct separate punctures, but little closer on the front; metapleuræ without large punctures; sides of propodeum with large separate punctures; carina of first ventral broadly arcuate, anterior tooth larger; second dorsal coarsely punctures, punctures sometimes confluent; legs not strongly spinose. Colored like *errans* except the black spot in basal middle of second dorsal is better defined.

Waco, Bosque County, Texas. One female from the Belfrage collection.

Type.—Cat. No. 14128, U.S.N.M.

DASYMUTILLA BLAWA, new species.

Female.—Length 9 mm. Fourth antennal joint distinctly narrowed below, the third subequal in length with the fourth and fifth ventrally; cheeks sparsely punctured, vertex and front more closely so; punctures of the dorsulum not very compact, and of the same size as those of the pleuræ; metapleuræ without large punctures; carina of first ventral segment strongly bidentate, the anterior tooth

not as robust as the posterior one; first dorsal with large punctures in middle, second dorsal with uniform, rather close, and large punctures; tarsi not very strongly spined. Rufo-ferruginous; antennæ, legs, apex of the second and the following segments black or piceous; appressed, short, reddish-golden pubescence on head, thorax and most of second dorsal segment; insect generally with sparse, erect black hair; legs, apex of second and following segments, broadly interrupted laterally on the second and third with silvery pubescence; apex of second and a more or less defined basal middle of second dorsal segment with black hair.

Ames, Iowa, one female (type); Riley County, Kansas, July and September, two females, collected by Mr. C. L. Marlatt; and one female from Colorado, C. F. Baker collection.

Type.—Cat. No. 14129, U.S.N.M.

The specimen from Colorado has the basal spot on the second dorsal more sharply defined and the anterior tooth of the carina of the first ventral segment is larger than the posterior.

Except for some minor points this agrees well with the description of *sparsa* (Fox). It may eventually prove to be a variety of Fox's species.

DASYMUTILLA FERRUGATELLA, new species.

Superficially like *ferrugata*, but the carina of the first ventral segment and the relation of antennal joints are different.

Female.—Length 7 mm. Fourth joint of antennæ not or scarcely narrowed below, third joint much shorter than the fourth and fifth; cheeks more sparsely punctured than the front; dorsulum more coarsely punctured than the front; metapleuræ without large punctures; sides of propodeum with large, scattered punctures; first dorsal with a few large punctures in middle; second dorsal uniformly, sparsely punctured; carina of first ventral bidentate, teeth of equal size. Colored like *ferrugata*.

Pennsylvania (type) one female, C. F. Baker collection; Louisiana, one female, C. F. Baker collection.

Type.—Cat. No. 14130, U.S.N.M.

DASYMUTILLA COLORADELLA, new species.

Female.—Length 10 mm. Fourth antennal joint not, or scarcely, narrowed beneath, the third joint distinctly shorter than four plus five; cheeks more sparsely punctured than the front; dorsulum with large, close punctures; sides of propodeum more sparsely punctured; metapleuræ with appressed, whitish pubescence, with a few large punctures; carina of the first ventral segment bidentate, the anterior tooth robust, and rounded, the posterior one slender, acute, triangular; first dorsal with large punctures; second dorsal with sparse, elongate punctures (basally the punctures are circular); legs rather

feebly spined. Colored like *ferrugata* except the erect hairs of head and thorax are black.

Boulder, Colorado (type), one female collected May 3, 1909, by S. A. Rohwer; Florissant, Colorado, one female collected July 4, 1907, by S. A. Rohwer; three females from Colorado (C. F. Baker collection).

Type.—Cat. No. 14131, U.S.N.M.

Legs black or piceous.

DASYMUTILLA COLORADELLA VIRGINICA, new subspecies.

Female.—Length 11 mm. Differs from the typical form in having the erect hairs of the head and thorax sparse and reddish-golden. The propodeal spiracle is more elongate and it may prove to be a distinct species.

Woodstock, Virginia. One female collected June 9, 1898, by Mr. F. C. Pratt.

Type.—Cat. No. 14132, U.S.N.M.

DASYMUTILLA COLORADELLA KAMLOOPSENSIS, new subspecies.

Female.—Length 9 mm. Differs from the typical form in having the posterior tooth of the carina of the first ventral segment hooked posteriorly. (In the typical form this is straight.)

Kamloops, British Columbia. One female collected by Professor Wickham.

Type.—Cat. No. 14133, U.S.N.M.

DASYMUTILLA SEGREGATA, new species.

Female.—Length 10.5 mm. Fourth antennal joint not narrowed below, the third joint subequal with four plus five ventrally, joints four and five carinate beneath; cheeks punctured much like the front; dorsulum with rather small, sometimes confluent punctures; sides of propodeum with well separated punctures; metapleuræ with small, well-defined punctures; carina of first ventral segment bidentate, teeth rounded, the anterior one slightly larger; first dorsal without large punctures medially; second dorsal with close, rather small punctures, the lateral basal area impunctate, shining; legs rather strongly spined. Colored like *ferrugata*; metapleuræ without appressed pubescence.

Pennsylvania. One female from C. F. Baker collection.

Type.—Cat. No. 14134, U.S.N.M.

DASYMUTILLA SEGREGATA FINNI, new subspecies.

Female.—Length 9 mm. Differs from the typical form in the absence of a spot of black pubescence at base of second dorsal segment; red antennæ and legs; and larger anterior tooth carina of first ventral segment.

Egypt, Georgia. One female from Mr. W. H. Finn, for whom the form is named.

Type.—Cat. No. 14135, U.S.N.M.

The specimen is somewhat rubbed and in fresh specimens there may be a pale spot of pubescence in apical middle of the second dorsal segment.

DASYMUTILLA BRUNERI, new species.

Female.—Length 9 mm. Fourth antennal joint not or scarcely narrowed below, third joint distinctly shorter than the fourth and fifth; cheeks more sparsely punctured than the front; dorsulum with separate, well-defined punctures; sides of propodeum more sparsely punctured; metapleuræ shining, with very fine, separate punctures and a few larger ones interspread; middle of first dorsal with large punctures; second dorsal rather small, irregular, punctures uniformly distributed; carina of first ventral segment bidentate, the anterior tooth smaller and sharper; tarsi feebly spined. Ferruginous; antennæ, legs, margin of second and the entire following segments rufo-piceous; head, thorax and second dorsal with subappressed golden pubescence; erect hairs sparse, yellowish; legs with whitish hairs; apex of the second (dorsally interrupted to form three spots) and the following segments with yellowish hairs; metapleuræ without appressed pubescence.

Bismarck, North Dakota. One female collected August 9, 1895, by Prof. L. Bruner, for whom the species is named.

Type.—Cat. No. 14136, U.S.N.M.

DASYMUTILLA TEXENSIS, new species.

Female.—Length 8 mm. Fourth antennal joint not narrowed below, third joint distinctly shorter than the fourth and fifth; head with rather large distinct punctures, those of the front close, those of the cheeks separate; dorsulum with larger punctures than the front, sides of the propodeum with separate punctures; metapleuræ with appressed white pubescence, without large punctures; first dorsal with large punctures in the middle; second dorsal with nearly uniform, elongate, somewhat separate punctures; carina of the first ventral segment nearly straight, with a triangular-shaped median tooth; tarsi rather feebly spined. Ferruginous; antennæ and legs rufo-piceous; apex of second and the entire following segments blackish; head, thorax and second dorsal with appressed yellowish pubescence; erect hairs of head and thorax white; legs with white hairs; apex of the first and following segments with white hair, that of the second slightly interrupted medially.

Texas. One female.

Type.—Cat. No. 14137, U.S.N.M.

DASYMUTILLA MESILLÆ, new species.

Closest to *texensis* Rohwer, but distinct as the following description will show.

Female.—Length 8 mm. Fourth joint of antennæ scarcely narrowed below, third joint distinctly shorter than the two following; cheeks punctured almost as coarsely as front; dorsulum closely punctured, punctures small and sometimes confluent; sides of propodeum reticulate; metapleuræ with appressed white pubescence, without large punctures; first dorsal segment with large medial punctures; second dorsal with elongate close punctures, somewhat separated laterally; carina of first ventral segment with a small tooth posteriorly; legs feebly spined. Color differs from *texensis* as follows: Flagellum black; legs color of body; erect hair of head and thorax black; apex of first dorsal except laterally, large spot on base of second and wide apical middle of second dorsal with black pubescence.

Mesilla, New Mexico. One female collected June 17 by Prof. T. D. A. Cockerell.

Type.—Cat. No. 14138, U.S.N.M.

The first segment is short.

DASYMUTILLA BLAWANA, new species.

Very like *Dasymutilla blawa* Rohwer, but may be separated from that species by the following characters: Erect hairs of head and thorax white; carina of first ventral segment tridentate; teeth low, rounded apically, the distance between the middle and posterior one greater than the distance between the middle and anterior one; second dorsal more sparsely punctured laterally; pygidium granular.

Female.—Length 9 mm. —

Texas, two females from Befrage collection; and one female from C. H. T. Townsend, collected September 4, 1896.

Type.—Cat. No. 14139, U.S.N.M.

Superficially like *Pycnomutilla harmonia* (Fox).

DASYMUTILLA CHAMPLAINI, new species.

Female.—Length 9 mm. Fourth antennal joint not, or scarcely, narrowed below; third joint subequal in length with the fourth and fifth; front with confluent punctures, cheeks with separate punctures; dorsulum punctured similar to the front; sides of propodeum with somewhat finer, separated punctures; metapleuræ without appressed pubescence or large punctures; first dorsal with the middle area without appressed pubescence, dull; second dorsal with uniform (except an impunctate basal area) somewhat separate punctures which are basally circular, apically elongate; carina of first ventral segment tridentate, the middle tooth largest; tarsi rather strongly spined. Rufo-

ferruginous; antennæ, legs, apex of second and the entire following segments black; head, thorax, and second dorsal with appressed ferruginous pubescence with some erect black hairs intermingled; legs with shining white hairs; apex of first dorsal, second dorsal apically (except lateral spots) and a spot in basal middle clothed with black hair; second ventral (and dorsal laterally) and the following dorsal and ventral segments with slightly yellowish hair.

Paratopotypes indicate that the species may vary as follows: Smallest 7 mm. sides of second dorsal with separate punctures; ventral carina with the posterior tooth nearly as large as the middle, which makes the carina appear bidentate, but in reality the anterior tooth is present, although small; and first dorsal may be shining medially.

Lyme, Connecticut. Six females collected May 20, 1910, by Mr. A. B. Champlain and five females collected September 26 and 30, 1909, by Mr. A. B. Champlain from P. R. Myers' collection.

Type.—Cat. No. 14140, U.S.N.M.

Named for Mr. A. B. Champlain.

DASYMUTILLA CAROLINA, new species.

Female.—Length 11 mm. Differs from *coloradella virginica* Rohwer in having a broad, poorly defined laterally, pygidium, which has fine irregular, longitudinal striæ.

Columbia, South Carolina. One female received from Mr. G. F. Atkins.

Type.—Cat. No. 14141, U.S.N.M.

Group CYPRIDES.

DASYMUTILLA MUTATA MIAMENSIS, new subspecies.

Female.—Length 8 mm. Differs from *mutata mutata* as follows: Rufopiceous; second dorsal segment sparsely punctured laterally and without pale spots; calcaria black; legs black.

Miami, Florida. One female collected by Mr. H. C. Herricksen.

Type.—Cat. No. 14119, U.S.N.M.

DASYMUTILLA SCROBINATA, new species.

Runs in Fox's table¹ to *cypris*, but may be separated from the species of this group (*cyprides*) by having the scrobes defined by a carina above.

Female.—Length, 9 mm. Antennæ tapering, third joint distinctly longer than the fourth, but shorter than the fourth and fifth; scrobes punctate above, bounded by a carina dorsally; tubercle of the posterior lateral margin of the head subcircular in outline; posterior and dorsal aspect of propodeum more coarsely punctato-reticulate than the rest of the thorax; sides of the propodeum shining, with a

¹Trans. Amer. Ent. Soc., vol. 25, 1899, p. 232.

few scattered punctures; calcaria long, slender, pallid; carina of the first ventral segment not toothed, slightly higher at the rounded anterior end; punctures of the second dorsal segment close and sometimes confluent; apical part of pygidium granular, basal part longitudinally striate. Rufo-ferruginous; apex of mandibles, antennæ, legs, apical margin of the second and the entire following segments black; second dorsal segment with *two* large ferruginous spots; fourth and fifth dorsal and ventral segments beyond the second with rather dense, slightly yellowish pubescence; base and apex of second (connected by a narrow longitudinal medial line), and the third dorsal segments with black pubescence; part of first and second dorsal segments, head, and thorax with short appressed golden pubescence and with sparse black hairs; legs with white hairs.

Lyme, Connecticut. One female collected July 31, 1910, by Mr. A. B. Champlain.

Type.—Cat. No. 14117, U.S.N.M.

A metatype from Lake Forest, Illinois, July 24, 1899, differs only in having the posterior femora rufous beneath.

DASYMUTILLA ALLARDI, new species.

Belongs to group *cyprides*, but may be separated from the other species of the group by the bidentate carina of the first ventral segment.

Female.—Length, 10 mm. Differs from the above description of *scrobinata* in the following points: Scrobes not defined above; tubercles of the head elongate; sides of propodeum more closely punctured; calcaria shorter, more robust and brownish; carina of first ventral segment bidentate; pygidium nearly completely longitudinal striate; second dorsal segment with but little black, basal pubescence and with four pale spots; long hairs of head and thorax sparser and yellowish.

Thompsons Mills, Georgia. One female collected October, 1909, by Mr. H. A. Allard, for whom the species is named.

Type.—Cat. No. 14118, U.S.N.M.

DASYMUTILLA FORMICALIA, new species.

Belongs near *californica* (Radoszkowski), but may readily be distinguished by the spot of black pubescence at the base and apex of the second dorsal segments.

Female.—Length, 11 mm. Head distinctly narrower than the thorax anteriorly; clypeus truncate, rounded laterally; scrobes not defined above; head coarsely irregularly, sometimes confluent punctured; malar space greater than the diameter of the eye; scape punctured; third antennal joint slightly concave beneath, not as long as the two following joints; thorax hexagonal, but little longer than

the greatest width, sharply truncate posteriorly, punctured similar to the head; first segment much narrower than the second; second segment large, much higher than the first, subtruncate anteriorly, punctures large, not confluent; carina of the first ventral large, triangular, apex rounded; second ventral with large, distinct punctures; pygidium not strongly defined laterally, truncate apically surface coriaceous. Black; head, thorax and abdomen (except where mentioned) with long matted scarlet pubescence; cheeks, clypeus, scape, sides and venter of thorax, venter of abdomen and legs with white pubescence; first dorsal, a triangular spot at basal and apical middle of second dorsal segment with black pubescence.

Federal District of Mexico. One female from Prof. Guillermo Gandara.

Type.—Cat. No. 14175, U.S.N.M.

Superfamily SPHECOIDEA.

Family AMPULICIDÆ.

Genus RHINOPSIS Westwood.

RHINOPSIS CANICULATUS (Say).

Ampulex caniculata SAY, West. Quart. Rep. Cincinnati, vol. 2, 1823, p. 76.

Rhinopsis abbottii WESTWOOD, Arcan. Ent., vol. 2, 1844, p. 68.

Ampulex pennsylvanicus HALDEMAN, Proc. Acad. Nat. Sci. Phila., vol. 4, 1849, p. 203.

A proxytype (Rohwer) in the Museum collection, and figured on plate 6, figure 2, Howard's Insect Book, 1904, agrees with the original description accompanying the above three names. The synonymy established by Cresson is again confirmed.

Male.—Length, 6 mm. Not as strongly sculptured as the female and the basal part of the wings without a fuscous area. Clypeus with a single apical tooth.

RHINOPSIS MELANOGNATHUS, new species.

Separated from *caniculatus* by the following:

Clypeus not carinate apically, apical middle margin quinquedentate, the sides of the production sinuate; mandibles rufo-ferruginous; head uniformly sculptured; pronotum finely transversely striato-granular posteriorly; mesoscutum without large lateral punctures; notauli not foveolate; mesoepisternum granular with a few large punctures dorsally.....*caniculatus* (Say).

Clypeus with a carina in apical middle with one apical tooth, sides of production not sinuate; mandibles, except the piceous apices, black; front striato-punctate, rest of the head finely granular, with large scattered punctures; pronotum coarsely, transversely striato-reticulate; notauli foveolate; sides of mesoscutum with large punctures; mesoscuto-scutellar suture strongly foveolate; mesoepisternum with large, dorsally confluent, punctures; entirely black, wings marked as in *caniculatus*. Female. Length 10 mm.....*melanognathus* Rohwer

Manchester, Connecticut. One female collected September 13, 1910, by Mr. A. B. Champlain.

Type.—Cat. No. 14075, U.S.N.M.

Family SPECIDÆ.

Genus PODIUM Fabricius.

PODIUM (PARAPODIUM) CAROLINA (Rohwer).

Podium carolina ROHWER, Proc. U. S. Nat. Mus., vol. 40, No. 1837, 1911, p. 556.

This may be only a subspecies of *Podium (Parapodium) biguttatum* Taschenberg. It differs from the original description in the following points: Scape black; all the tibiæ and tarsi rufous; tegulæ in part black. From Kohl's description of this species it also differs in some minor points. Compared with his figure¹ of the wing the following differences are to be noted: The second cubital smaller, its first abscissa on the cubitus not strongly bent; third cubital not so distinctly narrowed above, the third transverse radius not bent; stigma truncate apically; radial cell with a narrow, truncate apical portion. The petiole is twice as long as the posterior coxæ and trochanter united; apical joint of antennæ slightly shorter than the preceding.

SPHEX (SPHEX) NIGROPILOSUS, new species.

Of the Central American species this seems to be nearest to *Sphex* (described as *Ammophila*) *zanthoptera* (Cameron), but differs from the description of that species in a number of characters, being readily separated from it by the wings beyond the stigma being strongly dusky, no bluish reflection to body, and the black pubescence.

The figures cited in the following description are those of Kohl's "Monographie der Gattung *Ammophile* W. Kirby."²

Female.—Length 22 mm. Habitus much as *zanthoptera* as figured by Cameron. Clypeus hardly produced, broadly truncate, lateral angles sharp, subdentate; inner eye margins subparallel, slightly closer together at the clypeus, similar to figure 117; ocelli in a low triangle, the lateral ones on the supraorbital line, see figure 113; occiput, seen from above concave; impressed frontal line strong; head, except lower posterior orbits shagreened; clypeus polished, with well separated punctures; flagellum filiform, the first joint subequal to the two following, apical joint truncate; pronotum short, rounded anteriorly, separated from the mesoscutum by a deep furrow; thorax except where mentioned, finely granular; scutellum rather deeply impressed, posteriorly finely longitudinally striate; suture of

¹ Abhand. k. k. zool. bot. Ges. Wien, vol. 1, fig. 4, p. 45.

² Ann. k. k. naturhist. Hofmus. Wien, vol. 21, 1906, p. 228, etc.

mesoepisternum distinct, not foveolate, gently curved; propodeum subequal in length with the mesonotum and metanotum combined, spiracle place at the approximate middle, posterior face oblique, sides as rest of thorax, dorsal aspect finely transversely striate; fore tarsi differing *scabrosa* (see fig. 133) in that the apex of the basal joint is strongly produced within and armed with a short spine, apex of second joint somewhat produced; claws with two small inner teeth, see figure 45; abdomen finely aciculate; shape of cubital cells nearer figure 108 but the second recurrent is received near the apex and the first well in the second cubital; first and second abscissæ of second cubital cell on cubitus subequal; radial cell similar to figure 102. Black; second, third and base of fourth segments red; very little appressed pubescence this as well as the erect hairs black; tibiæ with silvery pile; wings basad of base of stigma yellow, apical part and wing dusky; venation color of wings.

In Kohl's table to the Palæartic species this runs out at category 26, but is near those species running to 29, and if sought for in this group would run to *lateritia*.

Federal District of Mexico. One female received from Prof. Guillermo Gandara.

Type.—Cat. No. 14174, U.S.N.M.

Family BEMBICIDÆ.

Genus BEMBYX Fabricius.

Type.—*Apis rostrata* Linnæus [designated Latrielle 1810].

Fabricius originally spelled his genus *Bembyx*, not *Bembex*, and as far as known never changed this spelling. *Bembex* Oliver et auctorum will have to fall as a synonym of *Bembyx* Fabricius.

BEMBYX PRIMAÆSTATE Johnson and Rohwer.

Male.—Sufficiently like the female to be easily associated with it. The nearest ally of this species is *spinolæ* Lepeletier, but the male may be distinguished by the different outline of the genitalia stipes, pale markings of the pleuræ, and from Handlirsch's figure of the antenna in having the seventh joint with a sharp spine in the middle. The markings are more yellow than is usually the case in *spinolæ*. The intermediate femora are dentate.



FIG. 3.—APEX OF GENITALIA STIPES OF BEMBYX PRIMAÆSTATE JOHNSON AND ROHWER.

There is some variation in the extent of the pale markings to the pleuræ, and the apical dorsal segment may be black or pale. The accompanying figure is made from the darker of the specimens.

Two males from Springfield, Idaho, collected July 30, 1906, by Mr. A. J. Snyder.

BEMBYX CAMERONI, new species.

Related to *spinolæ* Lepeletier. Differs from the original description of this species in some minor points of coloration, viz, anus with a pale spot. From Handlirsch's interpretation of *spinolæ* the shape of the genitalia stipes and dentation of the antennæ will separate it.

Male.—Length 17 mm. Labrum not depressed; vertex, seen from in front, biemarginate; head with very sparse, irregular punctures; apex of flagellum dentate beneath, as in figure 4; the first joint slightly longer than the two following; thorax finely granular; legs practically as in *spinolæ*, except that the anterior femora are more robust and slightly flattened beneath; second and seventh ventral segments with large, simple processes; eighth dorsal segment sharply angled laterally, slightly, broadly produced in the middle; eighth ventral segment with the spine long, slender, acute; stipes

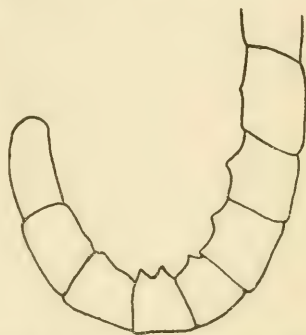


FIG. 4.—APICAL JOINTS OF THE FLAGELLUM OF *BEMBYX CAMERONI* ROHWER.



FIG. 5.—APEX OF GENITALIA STIPES OF *BEMBYX CAMERONI* ROHWER.

as in figure 5. Black; clypeus labrum, mandibles (except piceous apices), inner orbits broadly to near vertex, supraclypeal area, scape in front, tubercles, tegulæ, legs below bases of femora, large spots on first dorsal, sinuate bands on the second, third, fourth, and fifth dorsal segments, continuous band on sixth and a spot on seventh dorsal, small lateral spot on second and following ventrals, *yellow*; wings clear hyaline, vitreous; venation rather dark brown; head, thorax, and first abdominal segment with white pubescence.

Federal District of Mexico. One male from Prof. Guillermo Gandara.

Type.—Cat. No. 14177, U.S.N.M.

Named for Mr. P. Cameron, the writer on this group of insects in "Biologia Centrali-Americana."

BEMBYX OBSOLETA Howard.

Bembex obsoleta HOWARD, Insect Book, 1904, pl. 4, fig. 36.

This species has never been described, but the figure is enough to hold it, and the type must be the actual specimen figured, which is in the U. S. National Museum definitely labeled as such.

Type.—Cat. No. 14178, U.S.N.M.

Runs in Fox's table to North American *Bembex*¹ to *pruniosa* Fox,

¹ Proc. Acad. Nat. Sci. Phila., 1895, p. 354, etc.

but that species is marked much more strongly with greenish markings (in *obsoleta* the markings are yellow), the stipes are much different, the second and sixth ventral segments are simple (the same segments of *obsoleta* have ventral processes). Disregarding the character of the seventh ventral plate *obsoleta* runs to *amæna* Handlirsh which is very different.

Male.—Length 19 mm. Labrum not depressed; vertex seen from in front slightly biemarginate, the middle portion below the top of eyes; flagellum carinate beneath, the joints subdentate apically, first joint slightly longer than the two following; thorax finely granular; legs normal, intermediate femora simple; sev-

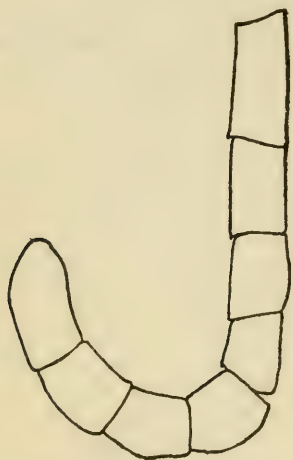


FIG. 6.—APICAL JOINTS OF THE FLAGELLUM OF *BEMBYX OBSOLETA* HOWARD.

enth dorsal segment rather narrowly truncate apically; second ventral segment with a low, median process which is truncate apically; sixth ventral segment with the process bidentate apically; seventh ventral segment with a long, median spine, the apex of which is bidentate; genitalia stipes as in figure 8. Black;

clypeus, labrum, mandibles (except piceous apices), inner orbits almost to vertex, small spot on supraclypeal area, scape in front, legs from below near middle of femora (except tibiæ above), lateral spots on first to fifth dorsal and second to fifth ventral segments inclusive bright yellow. Wings clear hyaline, vitreous; venation pale brown; head, thorax, and base of first segment with white pubescence.



FIG. 8.—APEX OF GENITALIA STIPES OF *BEMBYX OBSOLETA* HOWARD.

Los Angeles County, California. Five males collected by Mr. D. W. Coquillett.

Family GORYTIDÆ.

Genus GORYTES Latrielle.

GORYTES NIGRIFRONS Smith.

Gorytes nigrifrons SMITH, Cat. Hym. Brit. Mus., vol. 4, 1856, p. 368.

Gorytes (Gorytes) neglectus ROHWER, Proc. U. S. Nat. Mus., vol. 40, 1911, p. 567.

In this connection it will be well to call attention to some errors of numbering in Fox's table¹ of American *Gorytes*.

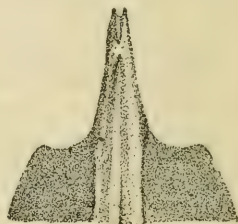


FIG. 7.—APICAL VENTRAL PLATE OF *BEMBYX OBSOLETA* HOWARD.

Page 518 under category 8 change 12 to 11 and under category 9 change 11 to 10.

PARAMELLINUS, new genus.

Euspongus ASHMEAD, Can. Ent., vol. 31, 1899, p. 200.

Genotype.—*Gorytes bipunctatus* Say.

Closest to *Hapalomellinus* Ashmead from which it may be separated by the inner orbits diverging below antennæ; pronotum very short, perpendicular anteriorly; transverse median of hind wings at right angles with the median and much before the cubitus; and other points. *Ammatomus* A. Costa is also related but has different venation, abdomen and head.

Sternauli wanting; first abdominal segment coarctate, subpetiolate; eyes strongly converging to level of antennæ, where they diverge; space between bases of antennæ greater than the space between one of them and the orbits; lateral ocelli on the supraorbital line; pronotum transverse, perpendicular anteriorly, but little lower than the mesoscutum; legs robust; stigma large, radius arising from near middle; first recurrent in first cubital cell or interstitial with first transverse cubitus; second recurrent near apex of second cubital cell; transverse median nearly interstitial with the basal.

ARIGORYTES, new genus.

Genotype.—*Gorytes coquillettei* Fox.

Sternauli present; first abdominal segment sessile with the second; eyes strongly converging to the clypeus; antennæ closer together at bases than the distance from their bases to eye margin; lateral ocelli on the supraorbital line; pronotum short, transverse and sharply perpendicular anteriorly; propodeal inclosure strongly striate; transverse median of fore wings much beyond basal; transverse median of hind wings and cubitus interstitial or nearly; abdomen without dense pile; mesoepisternum with a cephal-caudad dorsal suture; female with a tarsal comb; stigma small, the radius leaving at the apex.

TRICHOGORYTES, new genus.

Genotype.—*Trichogorytes argenteopilosus* Rohwer.

Similar to *Arigorytes* Rohwer, from which it may be known by the following characters. Nasal margin of eyes subparallel; lateral ocelli below the supraorbital line; pronotum long (for group), rounded anteriorly; propodeal inclosure smooth; cubitus of hind wings originating much beyond the transverse median; abdomen with dense pile; sternauli wanting; and in having the prepectus like *Mellinus*.

TRICHOGORYTES ARGENTEOPILOSUS, new species.

In Fox's table to North American *Gorytes* this species would run to *pictifrons* Fox, but is not closely allied to that species.

Female.—Length 7 mm. Slender; anterior margin of clypeus slightly emarginate anteriorly; head with rather large, distinct, separate punctures; antennæ slender, nearly filiform, third joint distinctly longer than fourth, apical joint acuminate; thorax finely sculptured; mesoscuto-scutello scuture foveolate; abdomen very finely granular; pygidium but little longer than the basal width, rounded apically, with a raised glabrous, medial line; radial cell obtusely rounded apically; legs feebly spined, tibiæ with only three or four spines. Black: antennæ beneath (apical joints almost entirely), tegulæ and anterior knees yellow; abdomen dull red; legs below coxæ fulvo-ferruginous, four anterior femora black; entire insect (including legs) except bases of second and following abdominal segments densely clothed with appressed, silvery pubescence; wings clear hyaline, iridescent; venation yellowish brown, costa black.

Hot Springs, Arkansas. One female collected June 26 by Schwarz and Barber.

Type.—Cat. No. 14169, U.S.N.M.

Family PHILANTHIDÆ.

Genus CERCERIS Latrielle

CERCERIS GANDARAI, new species.

Related to *Cerceris occipitamaculata* Packard, but may be distinguished from that species by the different sculpture of the propodeal inclosure, the lower part of mesoepimeron shining and practically impunctate, black first dorsal segment, etc.

Propodeal inclosure well defined, slightly foveolate laterally, with small, separate, uniform punctures.

Male.—Length 8 mm. Clypeus subconvex medially, apex truncate, lateral angles subdentate; head and thorax with separate, distinct, median-sized punctures; postocellar line distinctly shorter than the ocellocular line, subequal with the ocelloccipital line; antennal joints

short, the third distinctly longer than fourth, apical joint not hooked, obliquely truncate apically; lower half of mesoepisternum smooth, shining, practically impunctate; metapleuræ finely granular; legs normal; abdomen dorsally more sparsely punctured than the thorax, ventrally practically impunctate; pygidium punctured like abdomen dorsally, sharply defined, truncate apically; apical ventral plate emarginate as in figure 9. Black; face to a little above the antennæ, mandibles (except piceous apices), four anterior legs below apices of femora, posterior trochanters, femora except apex, base of tibiæ and



FIG. 9.—EMARGINATION OF THE APICAL VENTRAL PLATE OF CERCERIS GANDARAI ROHWER.

basitarsis, bands on second to sixth dorsal segments inclusive (narrowed medially and nearly of uniform size), lateral spots on second and third ventral segments, bright *yellow*; pubescence long and gray; wings subhyaline viterous; costa and stigma yellowish, rest of venation brown.

Federal District of Mexico. One male from Prof. G. Gandara, for whom the species is named.

Type.—Cat. No. 14180, U.S.N.M.

CERCERIS FLAVOTROCHANTERICA, new species.

Judging from the description this species is related to *mexicana* Saussure, but the propodeal inclosure and markings are different. There is some affinity with *sexta* Say, but the different colored legs readily separate it from that species.

Propodeal inclosure obliquely striate laterally, shining, with a medial, longitudinal furrow.

Male.—Length, 12 mm. Clypeus convex medially, tridentate apically, the middle tooth the largest and truncate apically; head with large, rather close, distinct punctures, those of the clypeus more separated; postocellar line distinctly shorter than the ocellocular line; nasal margin of eyes slightly converging to clypeus; third antennal joint distinctly longer than the fourth, apical joint not hooked, obliquely truncate apically; pronotum rounded anteriorly; mesosternum subangulate in front of intermediate coxæ; thorax more sparsely punctured than the head; legs normal; abdomen dorsally punctured like the thorax, ventrally finely granular; pygidium sharply defined, truncate apically, slightly narrowed basally, with large separate punctures; emargination of apical ventral plate as in figure 10. Black; face to just above level of antennæ (excluding the usual black, narrow apex of clypeus and supraclypeal foveæ), mandibles (except piceous apices), two spots on pronotum and scutellum, bands on second to sixth inclusive dorsal segments, narrowed medially and of uniform width, and lateral spots on second and third ventral segments, bright *yellow*; legs black; four anterior tibiæ and tarsi, posterior trochanters, posterior tibiæ (except a spot exteriorly) and two basal tarsal joints *yellow*; pubescence slightly yellowish; wings subhyaline darker in radial area, viterous; venation dark brown, stigma and costa yellowish brown.

Federal District of Mexico. One male received from Prof. G. Gandara.

Type.—Cat. No. 14179, U.S.N.M.



FIG. 10.—EMARGINATION OF THE APICAL VENTRAL PLATE OF *CERCERIS FLAVOTROCHANTERICA* ROHWER.

Family CRABRONIDÆ.

Genus STENOCRABRO Ashmead.

STENOCRABRO PLESIUS, new species.

Readily separated from the other males placed in *Stenocrabro* by the cylindrical anterior tarsi. In Fox's table to North American Crabroninae it runs to *ater*, to which it has no close relationship. If the apical segment is more distinctly punctured than the preceding it goes to *minimus*, but is larger and has different colored legs than that species. May easily be recognized by the entirely black four posterior legs and long white hair on the anterior femora beneath and mesosternum.

Male.—Length, 6 mm. Clypeus with a strong median carina, the apical middle tridentate, the middle tooth broad and rounded; impressed line from the anterior ocellus only indicated; postocellar line slightly longer than the ocellocular; a shallow, shining depressed area outside of each lateral ocellus; head with distinct, separate, fine punctures; third antennal joint distinctly longer than fourth, the following joints somewhat rounded beneath; pronotum neither carinated nor dentate, sharply defined, elevated; mesonotum punctured like the head; mesoscuto-scutellar suture foveolate; mesoepisternum punctured like the notum, the suture strongly foveolate; propodeum with the convexities finely striate, dull; posterior and lateral faces finely striate; the median furrow and basal area foveolate; anterior femora very stout basally; apical segment somewhat more coarsely punctured than the preceding one. Black; mandibles piceous; spot on mandibles, palpi, calcaria and anterior femora and tibiæ beneath yellowish-white; wings hyaline, iridescent, venation black; abdomen with white pile.

New Haven, Connecticut. One male collected April 17, 1910, by Mr. A. B. Champlain.

Type.—Cat. No. 14074, U.S.N.M.

Family TRYPOXYLONIDÆ.

Genus TRYPOXYLON Latrielle.

Group POLITUM.

Group characteristics.—Large (17 to 25 mm.); black except for the white, at least in the greater part, hind tarsi; wings very dark, with a purplish or bronzy reflection; eyes but little if any narrower at the clypeus; third antennal joint much longer than fourth, the male has the apical joint subequal in length with the four preceding, and the flagellum thickened apically (see fig. 11); ocelli in an equilateral triangle; clypeus much produced in the female, produced and variously

dentate in the male; thorax polished, finely sparsely punctured or impunctate; dorsal aspect of propodeum without sulci, smooth; posterior face of propodeum with a deep median channel; posterior femora somewhat flattened in female, more strongly so in male and beneath apically with a broad, flattened projection, more evident in some species; posterior tibiae strongly thickened apically, the longer calcarium strongly curved; posterior trochanter of male not dentate; first ventral segment (second of some authors) in the male with a large hook; pygidium fringed with long, fine hairs.

This group has long gone under the name *albitarse* Fabricius, but inasmuch as the type of Fabricius's species may still be in existence and his brief description would apply equally well with all the species discussed below, it has been deemed advisable to treat *albitarse* as an undetermined species. Fabricius says the posterior tarsi are white. In all Neotropical species discussed here the apical joint of the posterior tarsi is blackish.



FIG. 11.—ANTENNAE OF TRYPOXYLON POLITIFORME ROHWER. MALE.

TRYPOXYLON ALBITARSE Fabricius.

Trypoxylon albitarse FABRICIUS, Syst. Piez., 1804, p. 180, No. 1.

“T. atrum tarsis posticis, niveis.

“Habitat in America meridionali Dom. Smidt. Mus. Dom. Lund.

“Reliquis majus. Caput, thorax, abdomen, alæ atra, nitida, immaculata.

“Pedes nigri tarsis posticis niveis.” (Original description.)

What *albitarse* Saussure, Taschenberg, Cameron, is no one can say; but the name *mexicanum* (Saussure) described as a variety of *albitarse* is used for one of the species here treated.

Trypoxylon palliditarse Saussure (described from Argentina and Brazil) is another species which can not be determined with certainty. It undoubtedly belongs to this group and may be one of the species here treated.

Trypoxylon fuseipenne Fabricius is another species which can not be satisfactorily determined. It was also described from Brazil.

TRYPOXYLON POLITUM Say.

Trypoxylon politus SAY, Bost. Journ. Nat. Hist., vol. 1, pt. 4, 1837, p. 373, No. 1.—LECONTE, Writ. Th. Say Entom., vol. 2, 1859, p. 756, No. 1.—PACKARD, Proc. Ent. Soc. Phila., vol. 6, 1867, p. 413.

Trypoxylon albitarse WALSH and RILEY, Amer. Ent., vol. 1, 1869, p. 133, fig. 107.—Fox, Trans. Amer. Ent. Soc., vol. 28, 1891, pp. 136 and 138, No. 1.—Fox,

Proc. Acad. Nat. Sci. Phila., 1893, p. 472.—HOWARD, Insect Book, 1904, pl. 6, fig. 6.

Trypoxylon neglectum KOHL, Verh. zool. bot. Ges. Wien., vol. 33, 1883, p. 340, No. 1, pl. 18, fig. 3.—FOX, Trans. Amer. Ent. Soc., vol. 28, 1891, pp. 137 and 138, No. 2, pl. 3, figs. 1 and 12.

Fifteen specimens (4 females, 11 males) were bred in June (emerging from 15 to 18), 1894, by the Bureau of Entomology from material



FIG. 12.—LATERAL VIEW OF THE LOWER PART OF THE HEAD OF *TRYPXYLON POLITUM* SAY. MALE.

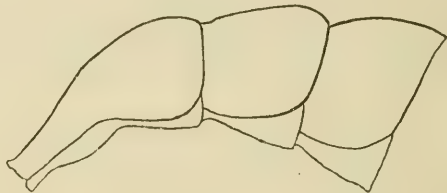


FIG. 13.—LATERAL VIEW OF THE BASAL ABDOMINAL SEGMENTS OF *TRYPXYLON POLITUM* SAY. FEMALE.

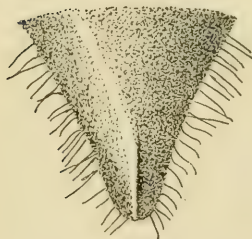


FIG. 14.—PYGIDIUM OF FEMALE OF *TRYPXYLON POLITUM* SAY.



FIG. 15.—LATERAL VIEW OF THE BASAL ABDOMINAL SEGMENTS OF *TRYPXYLON POLITUM* SAY. MALE.

received from Haverhill, Massachusetts. Pupation began May 31, 1894, the material having been received in March of the same year.

Say's type is no longer in existence, but a proxytype of this species is in the Museum collection. There can be but little doubt that this is the species Say had, as it is apparently the only one which occurs in northern United States. That Kohl's species is a synonym of this species (through the proxytype) there can be but little doubt, as the male agrees exactly with the figure and description given by Kohl.

TRYPOXYLON BASILE, new species.

Tryporylon politum HOWARD, Insect Book, 1904, pl. 6, fig. 9, male.

Male.—Length 21 mm. Clypeus differs from *politum*¹ as follows: Broader, the lateral tooth falling well inside of a line drawn tangent to the inner orbit, middle tooth much broader and rounded; vertex flat, not depressed behind lateral ocelli; front with rather close distinct punctures; pronotum strongly transversely sulcate; scutellum medially and basal middle of dorsal aspect of propodeum slightly impressed; posterior face of propodeum striato-punctate, where striate the striæ are dorsad-ventrad; first four abdominal segments as figure 16; the broad depression at base of third and the transverse suture near base of fourth dorsal segments make this species easily recognized. Color as usual, face with silvery pubescence, the rest of the pubescence black.

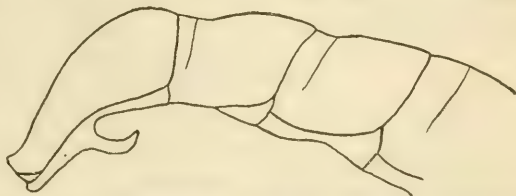


FIG. 16.—LATERAL VIEW OF THE BASAL ABDOMINAL SEGMENTS OF TRYPOXYLON BASALE ROHWER. MALE.

Female.—Length 25 mm. Produced portion of clypeus truncate, lateral angles sharp; third antennal joint nearly as long as the fourth and fifth, apical joint strongly tapering, distinctly longer than the preceding; vertex slightly depressed behind lateral ocelli; thorax as in male; abdomen long; first segment of the elongate type, second and third dorsal segments depressed basally; pygidium narrow, similar to figure 19. Colored as male.

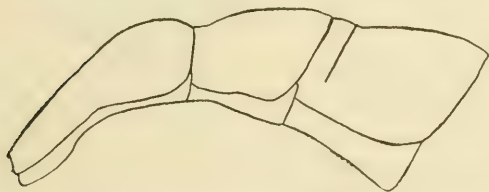


FIG. 17.—LATERAL VIEW OF THE BASAL ABDOMINAL SEGMENTS OF TRYPOXYLON BASALE ROHWER. FEMALE.

Utica, Mississippi, one male collected in August. Florida, one female without definite data.

Type.—Cat. No. 14170, U.S.N.M.

¹ For those who do not have *politum* see Kohl's figure of *neglectum* in Verh. zool. bot. Ges. Wien, vol. 33, 1883, pl. 18, fig. 3.

TRYPOXYLON POLITIFORME, new species.

Male.—Length 21 mm. Agrees well with *basale* from which it may be separated by the abdomen, which is very like *politum*. The abdomen differs from *politum* in the segments not being depressed basally; the first and second dorsal segments are narrowly depressed apically. Wings with a bronzy-purple reflection. Except where mentioned the description of *basale* will apply well here.



FIG. 18.—APICAL MARGIN OF THE PRODUCED PORTION OF THE CLYPEUS OF TRYPOXYLON POLITIFORME ROHWER. FEMALE SEEN FROM ABOVE OBLIQUELY.

Female.—Length 23 mm. The description of *basale* would do well

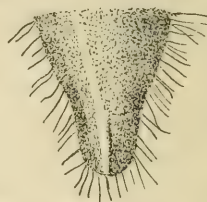


FIG. 19.—PYGIDIUM OF THE FEMALE OF TRYPOXYLON POLITIFORME ROHWER.

for this species except the abdomen which is like *politum* (excepting the first segment is more elongate and not unguulate ventrally). The pygidium is like *basale*, see figure 19.

Berwick, Louisiana. Many males and females collected May 3 and 8 by Mr. E. G. Titus. Florida, one male; Georgia, one male.

Type.—Cat. No. 14171, U.S.N.M.

TRYPOXYLON MEXICANUM (Saussure).

Trypoxylon albitarse, var. *mexicana* SAUSSURE, Reise d. Novara, Zool., vol. 2, 1867, p. 77 not *Trypoxylon mexicanum* SAUSSURE, same reference, p. 78, No. 4, pl. 4, fig. 45.

Specimens which agree well with Saussure's description of *albitarse* and have rufous mandibles, characteristic of his variety *mexicanum*, have been determined as that species. They are from the following localities: Mexico (C. F. Baker collection); Cordova, Mexico (collected by Dr. L. O. Howard, May 10); Guanajuato, Mexico (collected by A. Duges); San Antonio, Nicaragua, collected May, 1899.



FIG. 20.—APICAL MARGIN OF THE PRODUCED PORTION OF THE CLYPEUS OF TRYPOXYLON MEXICANUM (SAUSSURE). FEMALE SEEN FROM ABOVE OBLIQUELY.

This species is easily separated by the following table. In the specimens mentioned above there is very little variation. The apical joint of posterior tarsi is black.



FIG. 21.—LATERAL VIEW OF THE BASAL SEGMENT OF TRYPOXYLON MEXICANUM (SAUSSURE). MALE.

TRYPOXYLON GANDARAI, new species.

Male.—Length 22 mm. Median produced portion of clypeus broadly rounded apically, lateral teeth small and obtusely rounded apically; head and thorax very like *basale*; tooth of the first ventral segment near basal third, not as strongly hooked as *mexicanum*, but otherwise similar; first and second dorsal segments narrowly depressed apically, but not at all basally; second dorsal subequal in length with

the third; wings with a strong purplish reflection; apical joint of the posterior tarsi black; head and thorax (except that of the face which is silvery) with black pubescence; mandibles black.

Federal District of Mexico. One male received from Prof. Guillermo Gandara, for whom the species is named.

Type.—Cat. No. 14172, U.S.N.M.

TRYPOXYLON LEUCOTRICHUM, new species.

Male.—Length 18 mm. Clypeus like *gandarai*; front near the orbits with large separate, distinct punctures, in the middle and at the vertex with closer and smaller punctures; lateral ocelli slightly larger than the anterior one; mesoscutum with fine, separate, distinct punctures, anteriorly with two impressed, longitudinal lines; scutellum not impressed; posterior aspect of propodeum punctured laterally, the furrow deep; process of the first ventral segment near base,

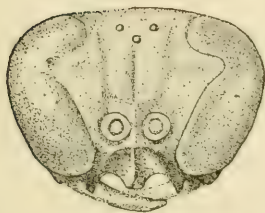


FIG. 22.—HEAD OF TRYPOXYLON LEUCOTRICHUM ROHWER. MALE.

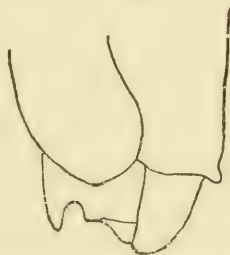


FIG. 23.—LATERAL VIEW OF THE LOWER PART OF THE HEAD OF TRYPOXYLON LEUCOTRICHUM ROHWER. MALE.

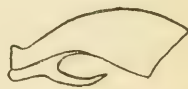


FIG. 24.—LATERAL VIEW OF THE BASAL SEGMENT OF TRYPOXYLON LEUCOTRICHUM ROHWER. MALE.

and not strongly curved; first and second dorsal segments not depressed apically. Mandibles rufous; wings with purple reflections; apical joint of the posterior tarsi black; head and thorax with white pubescence; abdomen with white pile.

Female.—Length 22 mm. Produced portion of clypeus subtruncate apically, the lateral angles rounded; third antennal joint subequal with the fourth and fifth, apical joint tapering and subequal with the preceding; mesoscutum without impressed lines anteriorly, and not as closely punctured as the male; dorsal aspect of propodeum polished; third dorsal segment narrowly depressed basally; pygidium of the narrow type, see figure 19.

Colored like the male with which it in general agrees.

Chanhamayo, Peru. Fifteen specimens (five females and 10 males) from Mr. N. F. H. Rosenberg. Also one female from Ancon, Canal Zone, Panama, collected by Mr. A. H. Jennings.

Type.—Cat. No. 14173, U.S.N.M.

Synopsis of foregoing species of Trypoxylon.

Males.....	1.
Females.....	6.
1. Clypeus with a narrow produced medial portion, which, when seen from the side, is at an acute angle with the face, see figure 23; Neotropical species.....	2.
Clypeus without a narrow produced medial portion, see figure 12; Nearctic species.....	4.
2. Process of the first ventral segment very near base and not strongly hooked, see figure 24; hair of head above emargination of eyes and the thorax white.....	<i>leucotrichium</i> Rohwer.
Process of first ventral segment not as near base and strongly hooked, see figure 21; pubescence of head and thorax black.....	3.
3. Apex of medial process of clypeus broadly rounded, process not carinate to the apex; mandibles black.....	<i>gandarai</i> Rohwer.
Apex of medial process of clypeus sharply angulate laterally and carinate nearly to the apex; mandibles rufous.....	<i>mexicanum</i> (Saussure).
4. Second and third dorsal segments broadly depressed basally, the fourth dorsal with a transverse suture at basal fourth; process of the first ventral segment robust and at the middle of segment.....	<i>basale</i> Rohwer.
Second and third dorsal segments not broadly depressed basally, the fourth dorsal without a transverse suture; process of the first ventral segment distinctly basal of middle and more slender.....	5.
5. Produced part of the clypeus very broad, so the lateral tooth falls well outside of a line drawn tangent to the inner orbits; the lateral tooth of clypeus not as large or as sharp; wings with a strong purplish reflection.....	<i>politiforme</i> Rohwer.
Produced part of clypeus not as broad, the lateral tooth falling well inside of a line drawn tangent to the eyes; the lateral tooth large and sharp; wings with a bronzy-purplish tinge.....	<i>politum</i> Say.
6. Pygidium broader, see figure 14; first segment rather shorter and ventrally slightly produced basally so to be undulating.....	<i>politum</i> Say.
Pygidium narrower, see figure 19; first segment longer and only uni-emarginate ventrally near the base.....	7.
7. Third dorsal abdominal segment broadly depressed basally.....	<i>basale</i> Rohwer.
Third dorsal abdominal segment not depressed basally, although somewhat constricted in some cases.....	8.
8. Anterior lateral margin of clypeus so sharply angled at the side as to appear dentate, see figure 18; mandibles black; posterior tarsi with the apical joint white.....	<i>politiforme</i> Rohwer.
Anterior lateral margin of clypeus not sharply angled, rounded, see figure 20; mandibles rufous; posterior tarsi with the apical joint black; Neotropical species.....	9.
9. Head above the emargination of the eyes and the thorax with black or blackish pubescence.....	<i>mexicanum</i> (Saussure).
Head above the emargination of the eyes and the thorax with white pubescence.....	<i>leucotrichum</i> Rohwer.

TRYPOXYLON SAUSSUREI, new name.

Trypoxylon mexicanum SAUSSURE, Reise d. Novara, Zool., vol. 2, 1867, Hym., p. 78, No. 4, pl. 4, fig. 45, not *Trypoxylon albitarse* var. *mexicana* SAUSSURE, same reference, p. 77.

A NEW MOSASAUROID REPTILE FROM THE CRETACEOUS OF ALABAMA.

By CHARLES W. GILMORE,

Assistant Curator of Fossil Reptiles, United States National Museum.

INTRODUCTION.

The specimen to be described was found in the L. C. Johnson collection belonging to the United States National Museum.

While the few fragmentary portions preserved indicate the mosasauroid affinities of the specimen, the unusual character of the teeth which differ so much from the dentition of the more typical mosasaurs that it becomes necessary to establish a new genus and species for its reception.

GLOBIDENS, new genus.

The characters of this genus are included in the description that follows of *Globidens alabamaensis*, the type-species.

GLOBIDENS ALABAMAENSIS, new species.

Type.—Cat. No. 6527, U.S.N.M. This specimen consists of the left maxilla, almost entire, containing mature and germ teeth, the frontal, posterior part of right presplenial, one posterior cervical vertebra, and numerous fragments.

Type-locality.—With the specimen was a label on which was the following data:—"Cretaceous, In Bogue Chitto Prairies west of Hamburg continuation of same. Perry and Dallas Co., Ala. Collected by L. C. Johnson." Unfortunately, the exact locality where this specimen was found can not now be learned.

Horizon.—The specimen was inclosed in a light-colored, chalky matrix, and Dr. L. W. Stevenson, of the United States Geological Survey, who is familiar with the rocks of this region, informs me that the specimen in all probability comes from the Selma chalk of the upper Cretaceous.

DETAILED DESCRIPTION.

Maxilla.—The left maxilla, lacking some of the posterior end, is present (see pls. 39 and 40), and shows this bone to be massive and stout as in *Brachysaurus overtonii*. There is evidence of at least ten teeth, and probably there were one or two more in the end, which is missing. The border meeting the premaxilla is very short, extend-

ing back only to the third tooth. The vertical part of this border is but a little shorter than the oblique portion. Back of this border, above the fifth tooth, is a rounded, free, emarginate edge marking the outer boundary of the narial opening. On the outer surface are two parallel rows of foramina, those of the lower row leading into the bases of the teeth. The border meeting the prefrontal is missing.

Measurements of maxilla.

	<i>mm.</i>
Greatest length as preserved	248
Greatest width over ninth tooth	55
Greatest width over second tooth	34
Width from alveolar border to narial border	51

Dentition.—In the maxillary there is evidence showing the presence of at least ten teeth, and the posterior end of this bone, which is missing, may have contained one or two more. (See pl. 40.)

Counting from the front, the first, second, fourth, and tenth teeth were lost in life, only the empty cavities remaining; the third, fifth, and eighth are represented by the broken bases of the crowns; the seventh and ninth, both mature teeth, are present and in a good state of preservation, as are the second, fourth, fifth, and sixth germ teeth. The dental series is well shown in plate 40.

The ninth maxillary tooth has a bulbous crown with a finely wrinkled enamel surface. This wrinkling of the enamel is coarsest at the apex and descending becomes gradually finer, ending in a nearly smooth surface on the lower constricted part of the tooth. As in all mosasauroid reptiles the tooth is attached to a spheroidal mass of ostein. On the posterior side of the ninth tooth there is a very faint carina which fades out before reaching the apex. The apex is worn.

The seventh tooth is slightly smaller in transverse diameter, with a more pronounced posterior carina. The shape of this tooth also differs from the ninth by a shallow depression encircling the base of the crown just above the more constricted neck, which meets the ostein base.

As shown by the broken crown, the fifth tooth has a similar encircling depression of the crown. The base of the eighth indicates that that tooth resembles the ninth more closely than it does those preceding it.

On the inner side of the dental border of the maxillary there are the usual pits or excavations, several of which contain young teeth in various stages of development.

The young tooth showing in the sixth socket appears to be more elongate vertically, with anterior and posterior carinæ which terminate in a slightly raised point on the apex of the tooth. The position of the carinæ on the inner and outer sides of the tooth, which is just emerging above the parapet of the jaw, appears to indicate a revolving movement of the tooth as it rises into place.

The other germ teeth, as well as the comparative size of the cavities, show that the teeth increase in size from front to back, the more anterior being somewhat elongated with subacute apices. The second germ tooth is elliptical in cross section.

The mature teeth contain in the interior a large conical pulp cavity, as shown by the broken base of the eighth tooth (see pl. 40).

Leidy,¹ in describing some isolated mosasaurian teeth, says: "They are generally divided in front and behind by an acute ridge into an inner and outer surface. In some teeth, apparently belonging to the most posterior dental series of the jaws, and to those of the pterygoid bones, there is only one ridge, which is situated along the back or concave border of the crowns." It is of interest to note a similar condition of the carinæ in the teeth described here.

It is in the peculiar type of dentition that this animal may be best distinguished from the other mosasauroians, and that these teeth indicate a food habit different from that usually attributed to members of this group is very evident.

Regarding the character of the food upon which the mosasauroians subsisted, Dr. S. W. Williston expresses the opinion that it "consisted almost exclusively of fishes, living or dead, and such small animals as drifted upon the water."² These observations are based upon those animals having the sharp, recurved teeth of the usual mosasaurian type. The teeth of *Globidens*, however, indicate different food habits.

The posterior teeth of this form were undoubtedly used only as crushing instruments, and being marine animals it is quite reasonable to suppose their food consisted of shell fish, crustaceans, etc., the harder portions of which were crushed between the bulbous teeth before being swallowed. The two functional teeth remaining intact show wear only on the very top.

Measurements.

mm.

The sockets for 9 teeth occupy a distance on the maxilla of..... 210

	Teeth.		
	Ninth.	Seventh.	Sixth.
	mm.	mm.	mm.
Greatest antero-posterior diameter.....	253	225	185
Greatest transverse diameter.....	250	220	.....
Greatest height above ostein base.....	220	235	.....

Frontal.—The frontal bone is broad and heavy with the usual triangular shape. In its massiveness it resembles those of *Platycarpus* and *Brachysaurus*, more particularly the latter.

¹ Smiths. Contr. Knowl., vol. 14, 1865, p. 49.

² Univ. Geol. Surv. Kansas, vol. 4, 1898, p. 214.

Viewed from above the posterior surface of the frontal is flattened with the median part slightly concave transversely. Forward of this area the bone is convex in cross section, with a median ridge which extends forward to the broken end of the bone (see fig. 1). The posterior part of this edge is obtuse, but more anteriorly it has a sharp edge. In front of the center, on either side of the ridge, the bone is shallowly concave. The carinate condition of the frontal is also found in *Platyacarpus* and, to a less degree, in some of the other genera. It is not present in *Tylosaurus*. The posterior border is nearly

straight, with a slight median emargination where it meets the parietal. On either side of the middle the borders are broken so that the exact outline of this edge can not be determined, although it approaches the frontal of *Brachysaurus* more nearly than that of any of the other genera.

The lateral margins are slightly undulatory and toward the front are convergent. The posterior angle, where this

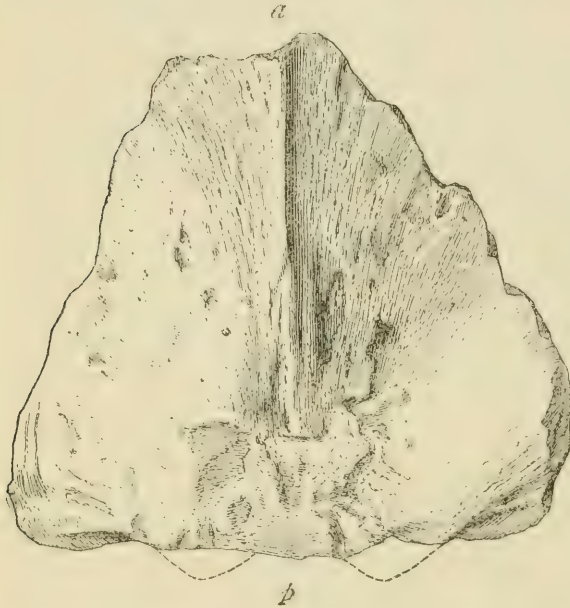


FIG. 1.—TOP VIEW OF FRONTAL OF *GLOBIDENS ALABAMAENSIS*. TYPE-SPECIMEN, $\frac{1}{2}$ NATURAL SIZE. *a*, ANTERIOR END; *p*, POSTERIOR END.

bone meets the post-frontal, is thickened. The median lateral margin forming the upper border of the orbit is slightly emarginate and obtusely rounded.

Immediately in front of the free orbital margin begins the line of union with the prefrontal. The entire pointed anterior part of this bone is missing, as shown in figure 1.

On the under side are two wide, massive parallel ridges which bound the cavity for the olfactory lobes. At the outer sides of these ridges the bone is deeply excavated for sutural union with the prefrontals.

Measurements of frontal.

	<i>mm.</i>
Greatest width of frontal.....	160
Greatest length of frontal.....	147
Greatest width between orbital margins.....	112
Greatest width olfactory cavity.....	24

The greatest width of the frontal of *Brachysaurus* is also 160 mm.

Presplénial.¹—A portion of the posterior part of the right presplénial shows that *Globidens* has the joint in the lower jaw as in the other genera of this group.² The portion preserved is massive, with the usual cupped articular end. The outer surface is rounded toward the lower margin, and the articular surface for union with the dentary approaches close to the posterior end as in *Mosasaurus*.

The upper side of this end is U-shaped in section, with each side extending upward as a thin margin, the inner portion being higher and heavier than the outer. Thirty millimeters from the posterior end on the inner side is a large foramen (see fig. 2), extending forward into the groove for Mechel's cartilage. The anterior part of this bone is missing. The articular end has a transverse width of 27 mm.

Vertebra.—There is only one vertebra preserved with this specimen and though undistorted by pressure the processes of this bone

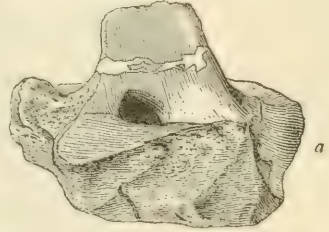


FIG. 2. INNER VIEW OF POSTERIOR PART OF RIGHT PRESPLÉNIAL *GLOBIDENS ALABAMAENSIS*. TYPE-SPECIMEN, $\frac{1}{2}$ NATURAL SIZE. a, POSTERIOR OR ARTICULAR END.

have been much damaged. Its chief characteristics are well shown in figure 3.

The presence of heavy transverse processes and a rudimentary hypapophysis indicates this vertebra to be one of the posterior cervicals, probably the sixth.

In the general proportions of the centrum it resembles the vertebræ of *Platyacarpus* more

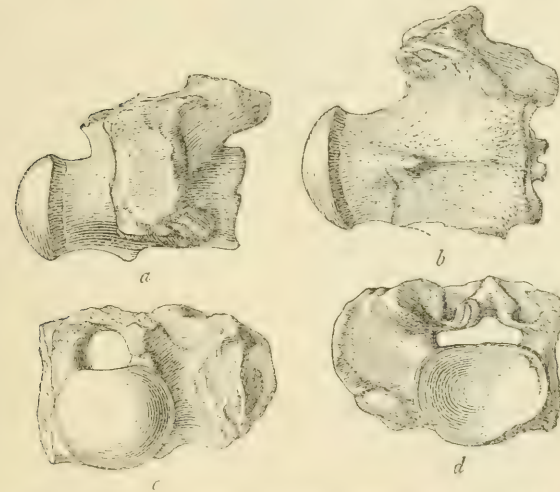


FIG. 3.—POSTERIOR CERVICAL VERTEBRA OF *GLOBIDENS ALABAMAENSIS*, (a) LATERAL VIEW; (b) VENTRAL VIEW; (c) POSTERIOR VIEW; (d) ANTERIOR VIEW. TYPE-SPECIMEN, $\frac{1}{2}$ NATURAL SIZE.

nearly than any of the other genera with which it was compared.

¹ Presplénial of Williston; splénial or opercular of other authors.

² Williston (Univ. Geol. Surv. Kansas, vol. 4, 1898, pp. 212-213) has discussed at some length the use of the peculiar ball and socket articulation at the middle of the lower jaw, and concludes that, in the true mosasaurians, it is to allow the lateral expansion of the jaws when swallowing large objects. It is of interest to note in this specimen a similar articulation, although, as indicated by the dentition, the food must have been of quite a different nature, and the use of such a joint is not easily accounted for.

On the anterior end is evidence of a zygosphene articulation, and although somewhat rudimentary, it appears to have been functional. In the weakness of this articulation this vertebra approaches those of *Platycaurus* and *Plioplatycaurus*.

The general character and proportions of this vertebra are well shown in the figures, and it appears unnecessary to further describe them.

Measurements of vertebra.

	mm.
Greatest length of centrum.....	61
Greatest width anterior end.....	36
Greatest width posterior end.....	33
Greatest depth posterior end.....	27
Greatest depth anterior end.....	29
Greatest width transverse process.....	87

Relationships.—The fragmentary nature of the type-specimen makes it impossible to say much of the relationships of this form, although the manner of tooth replacement and other characters of the maxilla, frontal, presplenial, and vertebra indicate *Globidens* to be a true member of the Pythonomorpha.

The short, massive maxilla and broad, heavy frontal give evidence of this animal having a short, broad, heavy skull of the *Platycaurus* or *Brachysaurus* type. The presence on the one vertebra found of a small but probably functional zygosphene articulation would further indicate its affinity with *Platycaurus*, and on account of the characters enumerated above, *Globidens* is referred for the present to the family *Platycaurinae*.

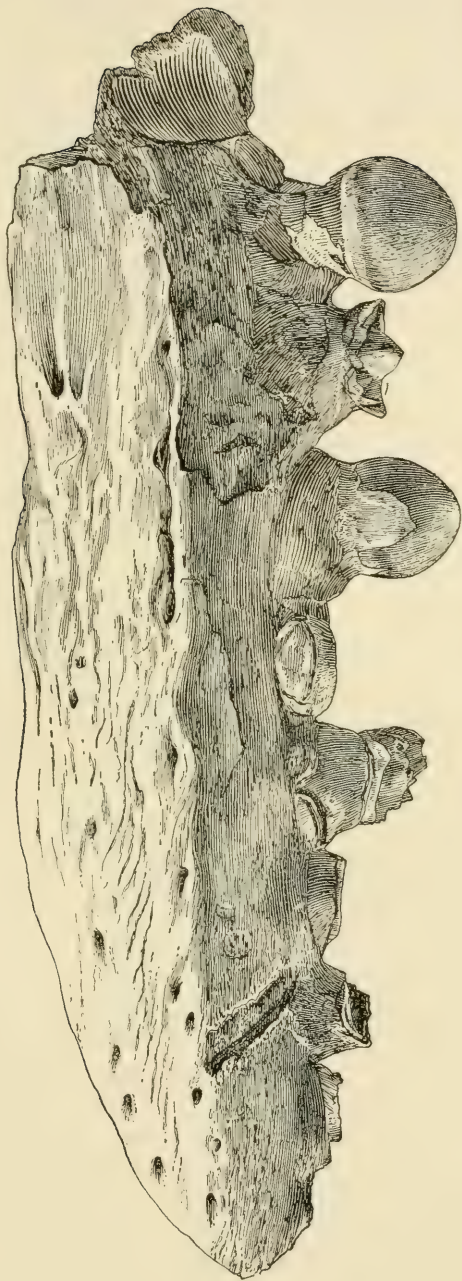
EXPLANATION OF PLATES.

PLATE 39.

Side view of left maxilla of *Globidens alabamaensis*, $\frac{3}{4}$ natural size. Type-specimen, Cat. No. 6527, U.S.N.M.

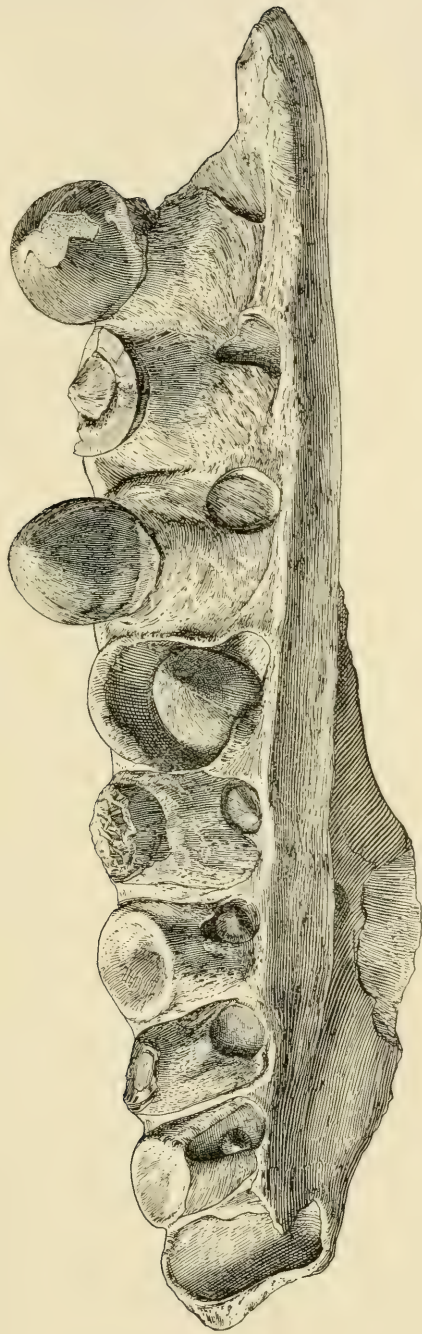
PLATE 40.

Oblique view of dental border of left maxilla of *Globidens alabamaensis*, $\frac{3}{4}$ natural size. Type-specimen, Cat. No. 6527, U.S.N.M.



MAXILLA OF *GLOBIDENS ALABAMAENSIS*.

FOR EXPLANATION OF PLATE SEE PAGE 484.



MAXILLA OF *GLOBIDENS ALABAMAENSIS*.

FOR EXPLANATION OF PLATE SEE PAGE 484.

THE WEST AMERICAN MOLLUSKS OF THE GENUS CINGULA.

By PAUL BARTSCH,

Assistant Curator, Division of Mollusks, United States National Museum.

Of the genus *Cingula* we now know six species on the West Coast of America, three of which are new. The first record was made by Doctor Krause in a paper on the Molluska of Bering Sea,¹ when he described *Cingula robusta* (Dall MS.) Krause. The following year Doctor Dall redescribed *Cingula robusta* and named the two extremes of this form *C. r. martyni* and *C. r. scipio*, suggesting *martyni* for the specific name, if the information he had received that *robusta* was preoccupied should prove true.² In the same paper, page 307, he described *Onoba aleutica* Dall, which I now refer to the present genus.

Of the three species now added, two—*C. alaskana* and *C. katherinæ*—come from Alaska, while the third—*C. montereyensis*—the southernmost member of the genus, comes from Monterey, California.

The four species described by Prof. C. B. Adams³ as *Cingula paupercula*, *Cingula* (?) *inconspicua*, *Cingula* (?) *terebellum*, and *Cingula* (?) *turrita*, are all Pyramidellidae and were referred to their proper places by Doctor Dall and the writer in Bulletin 68, United States National Museum.

CINGULA MARTYNI Dall.

Plate 41, figure 5.

Cingula robusta martyni DALL, Proc. U. S. Nat. Mus., vol. 9, 1886, p. 306, pl. 3, fig. 9.—*Cingula robusta* (Dall MS.) KRAUSE, Arch. f. Naturg., 1885, p. 270, pl. 17, fig. 1, a-b, not *Cingula robusta* H. C. LEA, Proc. Bost. Soc. Nat. Hist., 1844, p. 204.

Shell elongate-ovate, light chestnut brown. Nuclear whorls scarcely differentiated from the succeeding turns, smooth. Post-nuclear whorls well rounded, smooth excepting fine, incremental lines. Suture well constricted. Periphery and base of the last whorl

¹ Arch. f. Naturg., vol. 51, 1885, p. 270, pl. 17, fig. 1.

² See synonymy of *Cingula martyni*.

³ Ann. Lyc. Nat. Hist. N. Y., 1852, pp. 405-6.

inflated, well rounded, the latter narrowly umbilicated, smooth excepting fine, incremental lines. Aperture very large, broadly oval, almost circular; outer lip decidedly expanded, thin; columella strongly curved and very slightly reflected; parietal wall covered with a thick callus which renders the peritreme complete.

The type (Cat. No. 213527, U.S.N.M.) has a little more than five whorls and measures: length 5 mm., diameter 3.2 mm. In some specimens of this species faint, spiral lines are apparent.

Specimens examined.

Catalogue No.	Locality.	Number of specimens.
61337	Plover Bay, East Siberia.....	12
213535	do.....	2
213533	North end Nunivak Island, Alaska.....	48
160977	St. Paul, Pribilof Islands, Alaska.....	1
213534	Bering Island, Alaska (6 to 10 fathoms).....	151
161047	Kyska Harbor, Aleutians, Alaska.....	15
161070	do.....	1
161075	do.....	1
161099	do.....	8
161104	Kyska Harbor, Aleutians, Alaska (beach, low water).....	40
¹ 206036	Kyska Harbor, Aleutians, Alaska.....	18
210466	do.....	15
213527	do.....	1,332
213529	Kyska Harbor, Aleutians, Alaska (10 fathoms, sandy mud).....	26
213530	Kyska Harbor, Aleutians, Alaska (6 to 8 fathoms, sand).....	2
213532	Constantine Harbor, Amchitka Island, Aleutians, Alaska.....	40
213528	Korovin Bay, Atka Island, Alaska.....	2,662
213531	Nazan Bay, Atka Island, Alaska.....	19

¹ 1=type.

CINGULA MARTYNI SCIPPIO Dall.

Plate 41, figure 6.

Cingula robusta scipio DALL, Proc. U. S. Nat. Mus., vol. 9, 1886, p. 306, pl. 4, fig. 10.

Shell similar to *martyni* but more slender, with the spiral sculpture usually more pronounced.

The type (Cat. No. 213536, U.S.N.M.) has a little more than five post-nuclear whorls and measures: Length, 4 mm.; diameter, 2.2 mm.

Specimens examined.

Catalogue No.	Locality.	Number of specimens.
56400	St. Georges Island, Alaska.....	1
¹ 213536	Kyska Harbor, Aleutians, Alaska.....	5
213537	Chika Islands, Akutan Pass, Alaska (low water).....	14
213538	Unalaska, Alaska.....	4
213539	East side Simeonoff Island, Shumagins, Alaska.....	93
83230	West side Middleton Island, Alaska (10 to 12 fathoms, gravel) ..	1

¹ 1=type.

CINGULA ALASKANA, new species.

Plate 41, figure 4.

Shell subglobose, light brown. Nuclear turns one and one-quarter, well rounded, smooth excepting fine, incremental lines. Post-nuclear

whorls inflated, well rounded, marked by strong, incised, equal, and equally spaced, spiral grooves, which are about two-thirds as wide as the spaces that separate them; about 10 of these grooves occur between the sutures on the second, and 13 on the penultimate whorl. Suture well impressed. Periphery of the last whorl strongly inflated. Base rather short, inflated, well rounded, very narrowly umbilicated, marked like the spire with spiral grooves. In addition to the spiral sculpture the post-nuclear whorls are marked by rather strong, incremental lines, which extend over the entire surface of the post-nuclear spire. Aperture large, oval, slightly angulated at the posterior angle; outer lip thin, showing the external markings within; columella curved, slightly reflected; parietal wall glazed with a thick callus, which completes the peritreme; operculum horny, pauci-spiral.

The type (Cat. No. 160995, U.S.N.M.) has two and one-half post-nuclear whorls and measures: Length 2.6 mm. diameter 2 mm. It was collected by Doctor Dall at Amchitka Island, Alaska.

CINGULA ALEUTICA Dall.

Plate 41, figure 2.

Onoba aleutica DALL, Proc. U. S. Nat. Mus., vol. 9, 1886, p. 307, pl. 3, fig. 11.

Shell elongate-ovate, light yellow. Nuclear whorls scarcely differentiated from the succeeding turns. Post-nuclear whorls strongly rounded, appressed at the summit, marked by very fine, incremental lines only. Suture strongly constricted. Periphery of the last whorl and the moderately long base well rounded, the latter narrowly umbilicated, marked like the spire. Aperture large, oval, slightly expanded at the edge; posterior angle decidedly obtuse; peritreme complete, dark brown at the edge; outer lip thin; columella oblique, strongly curved; parietal wall covered with a thick callus, which is appressed to the succeeding whorl, completing the peritreme.

The type (Cat. No. 213525, U.S.N.M.) has five and one-half post-nuclear whorls and measures: Length 3.2 mm., diameter 1.7 mm.

Specimens examined.

Catalogue No.	Locality.	Number of specimens.
¹ 213525	Unalaska, Alaska.....	2
151618	St. Pauls Island, Alaska.....	1
160981	St. Paul, Pribiloff Islands, Alaska (6 to 9 fathoms).....	1
161089	Constantine Harbor, Amchitka Island, Aleutians, Alaska.....	1
160871	Popoff Strait, Shumagins, Alaska (6 fathoms).....	5
180354	Cooks Inlet, near Soldovia, Alaska.....	1
204022	Windfall Harbor, Admiralty Island, Alaska.....	1
203702	do.....	1
213526	Kyska Harbor, Aleutians, Alaska (beach, low water).....	126

¹ Figured type.

CINGULA KATHERINÆ, new species.

Plate 41, figure 3.

Shell subglobose, dark brown. Nuclear whorls about one and one-quarter, well rounded, smooth. Post-nuclear whorls strongly, roundedly shouldered at the summit, well rounded on the sides, marked by fine, incremental lines only. Suture strongly constricted. Periphery of the last whorl inflated. Base moderately long, well rounded, narrowly umbilicated, smooth excepting incremental lines. Aperture large, oblique, broadly oval; outer lip thin; columella curved and slightly reflected; parietal wall covered with a thick callus which renders the peritreme complete.

The type (Cat. No. 206103, U.S.N.M.) was collected by Mrs. Kate Stephens, for whom it is named, at Windfall Harbor, Admiralty Islands, Alaska. It has three post-nuclear whorls, and measures: Length 2.7 mm., diameter 2 mm.

CINGULA MONTEREYENSIS, new species.

Plate 41, figure 1.

Shell elongate-conic, light brown. Nuclear whorls one and one-half, well rounded, smooth. Post-nuclear whorls appressed at the summit, moderately rounded, marked by fine, incremental lines only. Suture only slightly constricted. Periphery of the last whorl somewhat inflated, well rounded, with a very narrow umbilical chink, smooth excepting fine, incremental lines. Aperture broadly oval, somewhat effuse anteriorly; posterior angle obtuse; outer lip thin; columella curved; parietal wall glazed with a moderately strong callus, which joins the posterior angle of the aperture with the insertion of the columella.

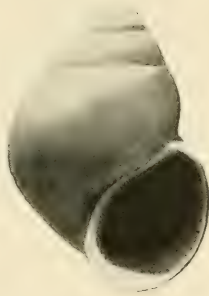
The type (Cat. No. 127547, U.S.N.M.) and four specimens come from Monterey, California. The type has five and a half post-nuclear whorls, and measures: Length 4 mm., diameter 2.1 mm.

EXPLANATION OF PLATE 41.

- Fig. 1.—*Cingula montereyensis* Bartsch. Type. Long. 4 mm.; p. 488.
 2.—*Cingula aleutica* Dall. Type. Long. 3.2 mm.; p. 487.
 3.—*Cingula katherinæ* Bartsch. Type. Long. 2.7 mm.; p. 488.
 4.—*Cingula alaskana* Bartsch. Type. Long. 2.6 mm.; p. 486.
 5.—*Cingula martyni* Dall. Type. Long. 5 mm.; p. 485.
 6.—*Cingula martyni scipio* Dall. Type. Long. 4 mm.; p. 486.



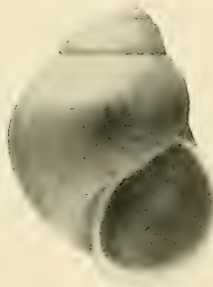
1



3



2



4



5



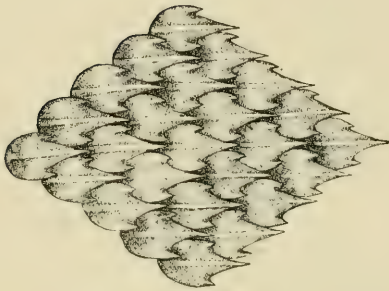
6

WEST AMERICAN MOLLUSKS OF THE GENUS CINGULA

FOR EXPLANATION OF PLATE SEE PAGE 488



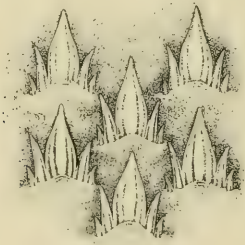
From the type. One-fourth natural size.



Dermal denticles of flank, enlarged.



Upper jaw.



Lower jaw.

Teeth in typical sections of jaws, enlarged.

PENTANCHUS PROFUNDICOLUS.

DESCRIPTION OF A NEW NOTIDANOID SHARK FROM
THE PHILIPPINE ISLANDS REPRESENTING A NEW
FAMILY.

By HUGH M. SMITH,¹

*United States Deputy Commissioner of Fisheries
and Director of the Albatross Philippine Expedition.*

Among the sharks collected in the Philippine Archipelago by the *Albatross* expedition is a remarkable deep-water form from the Mindanao Sea which has not hitherto been met with and becomes the type of a new family of Notidani or Diplospondyli.

PENTANCHIDÆ, new family (Notidani).

Notidanoid sharks characterized by five branchial apertures, the last three of which are above the base of the pectoral fin; elongate body, nearly straight tail; long, flat snout; inferior mouth; pluriserial, pluricuspid, erect teeth, similar in both jaws; minute spiracles; imbricate denticles; a single small dorsal fin without spine; long caudal fin, with large lower lobe; long anal fin; ventral fins inserted in advance of the center of the body; and large, broad, pectoral fins.

This family is intermediate between the other two known families composing the Notidani—the Hexanchidæ, with moderately elongate body, upbent tail, short dorsal and anal fins, inferior mouth, dissimilar teeth in the two jaws, and gill openings of normal shape; and the Chlamydoselachidæ, with greatly elongate body, straight tail, long dorsal and anal fins, terminal mouth, similar teeth in the two jaws, and frilled gill openings.

The presence of only five branchial openings, while not surprising in such an archaic type of shark as the one under consideration, is nevertheless not found in any other known shark referable to this order.

¹ In the study of this shark the writer has been associated with Mr. Lewis Radcliffe, who assumes joint authority for the new genus and species described.

PENTANCHUS Smith and Radcliffe, new genus.

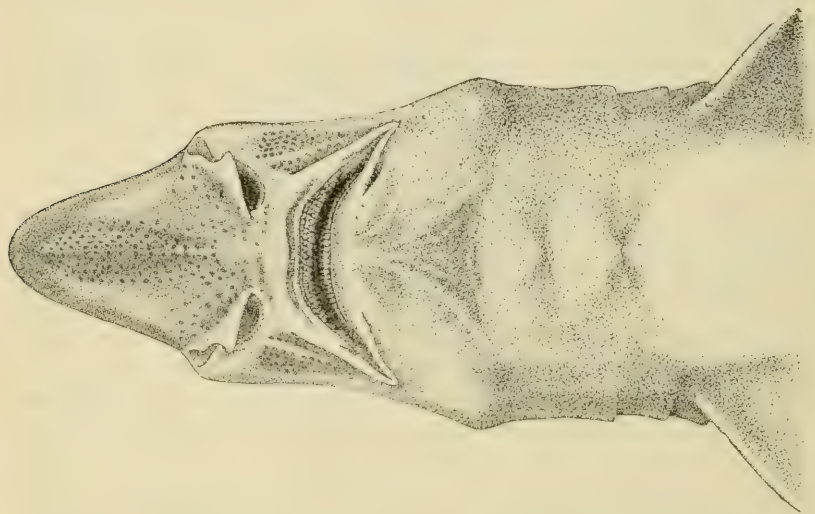
The characters of the genus are sufficiently indicated in the family description.

Genotype.—*Pentanchus profundicolus*.

PENTANCHUS PROFUNDICOLUS Smith and Radcliffe, new species.

Plate 42.

Form very elongate and slender, back not elevated, body tapering gradually into the long, slightly decurved tail; body and caudal peduncle much compressed; head long, broad, moderately depressed, length of head (to posterior gill-opening) .25 total length, width of head at angle of jaws equal to snout, depth .3 length; depth of caudal peduncle three times its thickness and .6 length of base of dorsal fin; eye superior, rather small, the length of orbital opening equal to dis-



PENTANCHUS PROFUNDICOLUS. UNDER SIDE OF HEAD. NATURAL SIZE.

tance between inner angles of nostrils, vertical diameter of eye less than width of cheek; snout very long, broad, and flat, slightly dilated at nostrils and tapering acutely from nostrils to the rounded tip, length of snout equal to distance from anterior margin of eye to second gill-opening, its width at nostrils .75 length, length of tapering side equal to distance to posterior corner of eye, under surface of snout flat, the upper and lower sides of snout forming a sharp edge, the preoral space more than .8 length of snout; mouth wide, crescentic, the jaws somewhat protruding, anterior margin of mouth entirely anterior to eye, the angle of mouth under pupil, a well-marked groove at angle extending more than .7 distance to nostril

and continued on lower jaw for about .5 distance to symphysis; nostrils very large, oblique, inferior, each .5 width of snout at their anterior margin; interorbital space flattish, twice diameter of eye; teeth in both jaws similar, erect, grooved, with a median lanceolate cusp and two smaller cusps on each side; body and fins completely covered with minute, closely imbricated, leaf-shaped denticles, with a strong median keel and one lateral keel on each side, the scales on the upper edge of peduncle enlarged; numerous pores on head, including a sharply defined elongate oval patch of large pores on upper and lower surfaces of snout, the pores arranged in regular lines, a patch of similar pores on cheek immediately in front of eye and another on corresponding portion of underside of snout posterior to nostril; branchial apertures small, the length of the series .33 anterior margin of pectoral; spiracle round, minute, close to posterior angle of orbital opening.

Dorsal fin over posterior end of anal, its origin midway between first gill-opening and end of tail, height of fin equal to snout, length of base .66 height; caudal fin very long, the upper lobe narrow and extending toward the dorsal as a low ridge, the lower lobe long, notched posteriorly, deep anteriorly, and contiguous with anal; origin of anal nearly midway from end of snout to tip of tail, its base as long as head (to first gill-opening), its greatest length about equal to that of lower caudal lobe; ventral fins small, their origin midway from eye to dorsal fin, the modified rays (claspers) round, thick, expanded at end, and reaching to anal; pectorals large, broad, with rounded corners and straight posterior margin, extending to ventrals when closely applied to body.

Color: Uniform dark brown.

Type.—Cat. No. 70260, U.S.N.M., a male specimen 50.8 cm. long, taken with a beam trawl on July 31, 1909, at station 5486 (lat. $10^{\circ} 02' N.$; long. $125^{\circ} 19' 20'' E.$), in the Sea of Mindanao, between the islands of Mindanao and Leyte, at a depth of 585 fathoms.

THE CHARACTERS OF THE FOSSIL PLANT GIGANTOPTERIS SCHENK AND ITS OCCURRENCE IN NORTH AMERICA.

By DAVID WHITE,

Associate Curator, Division of Paleobotany, U. S. National Museum.

INTRODUCTION.

The name *Gigantopteris* has been applied to a remarkable fernlike plant from the "Lui-ho" coal field in the province of Hu-Nan, in south-central China. The specimens on which the genus was founded were discovered in 1870 at the anthracite coal mines at Lui-Pa-Kou by Baron F. von Riehthofen, who, on account of the crushing throng of natives actuated by mingled curiosity and hostility, was able to gather but a small number of fossils of any kind. The striking novelty of the plant in question was at once recognized when, later, the collection was submitted to August Schenk, in Leipzig, who in 1883 described¹ the fragmentary material. The name *Megalopteris nictianæfolia* was given to the fossil on account of the evidently great size of the leaf and the resemblance of the fragments to the leaves of the cultivated tobacco plant.

No other specimens of the kind were found in any other region or collection until 1903, when a French engineer explorer, M. Counillon, obtained a small lot of plant fragments from a coal field in the southern part of the province of Yun-Nan, which lies in southwestern China, sloping from the Himalaya Mountains and forming the northeast border of Upper Burma. These fragments were described in 1907 by Prof. R. Zeiller,² who regarded the flora as probably basal Triassic or possibly uppermost Permian. Schenk, who, though a high authority on Mesozoic plants, was hardly familiar with the Paleozoic floras, had as the result, perhaps, of wrong identification of some of the associated plants assigned the above-mentioned von Riehthofen collection to the "coal measures." Although the fragments placed in Zeiller's hands were too small to throw much light on the nature or characters of Schenk's plant, with which the Yun-Nan material was specifically identified, they served to correct the nervation

¹ Von Riehthofen, *China*, vol. 4, Berlin, 1883, pp. 211-269, pls. 30-54.

² *Annales des Mines*, ser. 10, vol. 11, 1907, pp. 5-27, pl. 14.

delineated in a very misleading fashion by Schenk, thus giving a truer glimpse of the unique vein system and showing more clearly the filicoid aspect of the type, the fronds of which were regarded by the distinguished French paleobotanist as probably pedalate, like those of *Clathropteris*.

The specimens described by Schenk and Zeiller are all that have been known of *Gigantopteris* until the discovery of numerous fragments at a number of localities in the "red beds" Permian of the Western Interior basin, i. e., in the Enid formation of Oklahoma¹ and the Wichita formation of Texas.

In its nomenclatural history, as well as in other respects, the genus under consideration is singular. Schenk, on learning, soon after the publication of his memoir, that the generic name *Megalopteris* had been preoccupied by Dawson² autographically substituted in pencil the name *Idiophyllum*, given by Lesquereux to a specimen from the coal measures (Allegheny age) at Mazon Creek, in Illinois. This name was inscribed by him in the text of the copy presented by him to Zeiller and in the copy now in the library of the United States Geological Survey. However, the original specimen described by Lesquereux as *Idiophyllum* is included in the collection presented by Mr. R. D. Lacoë, of Pittston, Pennsylvania, to the United States National Museum.³ On reviewing the material in the Lacoë collection on the occasion of its transfer to the museum in 1893, the writer recognized in this type-specimen, which constitutes one-half of a nodule, a somewhat macerated pinna of *Neuropteris*. Several years later the other half of the nodule, the counterpart of the type-specimen, was found in the Geological Museum of Yale University by Dr. E. H. Sellards, who identified it as *Neuropteris rarinervis*,⁴ thus disqualifying the name *Idiophyllum* from further use in paleobotanical literature. *Gigantopteris* was a new name penciled by Schenk, in substitution for *Megalopteris*, in the copy of his paper now in the library of Dr. H. Potonié, in Berlin, as noted by the latter in Engler and Prantl's *Pflanzenfamilien*,⁵ where Schenk's manuscript name is for the first time put into print. Potonié places the genus among the ferns without reference to any particular group.

The American material embraces certain seeds and polleniferous (sporiferous?) scales so intimately associated with *Gigantopteris* and partaking of so many of its characters as to seem to justify placing the genus provisionally among the Cycadofilices, or Pteridosperms, rather than among the ferns.

¹ The plant-bearing horizons of the Enid formation (U. S. Geol. Surv., W. S. Paper 154, 1906) probably fall within the Chase stage of Kansas.

² Geol. Surv. Canada, Foss. Plant Dev. and Upper Sil. Form., Canada, 1871, p. 50.

³ No. 10258 of the fossil-plant collection of the U. S. National Museum.

⁴ Amer. Jour. Sci., ser. 4, vol. 14, 1902, p. 203.

⁵ Engler and Prantl, *Natürl. Pflanzenfam.*, Leipzig, Teil I, Abth. 4, 1900, p. 513.

DESCRIPTION OF THE FOSSILS.

Localities.—The American specimens which will be described in this paper come from the Wichita formation of Texas, the exact locality being the bank of the stream at the crossing of the old road, one-fourth mile south of the ford of Little Wichita River, 4 miles southeast of Fulda, a station in Baylor County. Here the fronds of *Gigantopteris* lie mingled with other plants in great profusion in a rather thin layer of bluish-gray friable clay shale about 3 feet above the "fish bed." The latter is a very thin, dark-colored, gnarly, bituminous limestone filled with the bones, spines, dermal plates, etc., of various fish and reptiles. It paves the road-crossing. The plant bed was first discovered by Prof. E. C. Case, of the University of Michigan, who, while collecting the vertebrate fossils¹ gathered also a few plant fragments which were kindly communicated by him to me for examination. A small collection from this most interesting locality was obtained in 1908 by Prof. C. H. Gordon and myself; and in 1909 I secured from the same locality much good plant material which, however, was largely ruined subsequently by becoming accidentally dampened.² On this account this collection was duplicated in 1910. The associated species will be noted, in connection with the discussion of the age of the beds, on a later page. It will suffice at this point to say that *Gigantopteris* is there mingled in a filicoid flora, with *Pecopteris*, *Tæniopteris*, *Odontopteris*, *Walchia*, *Gomphostrobus*, insect wings, *Estheria*, and fish scales. So numerous are the plant fragments and so friable and jointed are the clays that it is well nigh impossible to secure large or perfect specimens of the larger plant parts.

Besides the locality just described the genus has also been found in "Castle Hollow" $2\frac{1}{2}$ miles south of Fulda; in the red sandstones three-fourths mile east of Electra, Texas, the latter locality having been discovered by Prof. Charles N. Gould, to whom geologists are indebted for the greater part of our knowledge of the "Red Beds" of Oklahoma; in the red and green shales above the thin limestone horizon about 4 miles southeast of Electra; near Perry, Oklahoma; in the vertebrate-bearing beds near Eddy, Oklahoma; and near San Angelo, in Tom Green County, Texas. In fact this curious plant is present at nearly every point where vegetable remains have been found in the Wichita formation or its equivalents in Texas and Oklahoma. Everywhere it is associated with *Tæniopteris*. On account of the very singular aspect and nervation of the leaves small pieces of *Gigantopteris* have in several instances been temporarily mistaken for fragments of some fish or reptile.

¹ Bull. Amer. Mus. Nat. Hist., vol. 23, 1907, pp. 659, 665.

² The clays shrink and crack badly when dry, and melt to a paste when wet.

The sterile fronds.—The leaves of *Gigantopteris*, as commonly gathered, in apical or interdichotomal fragments, resemble nothing so much as portions of the broad lanceolate or linear-lanceolate leaves of some dicotyledonous genus with rather close, open, and well-defined secondary nerves. Only when the nervation is examined more closely or the dichotomy of the leaf is noted is the real nature of the plant suspected. The specific name, *nicotianæfolia*, given by Schenk to the Chinese form is therefore descriptively appropriate. When larger pieces are discovered or put together the fronds of the Texas plant are found to be broadly ribbonlike, sympodially (?) forking (pls. 43, 44, and 45) rather distantly, and slightly narrowed at the points of bifurcation, as shown in plate 43, so that the segments have a linear-lanceolate to lanceolate form. The angle of dichotomy is rather wide, generally about 60°. The lamina, which is not very thick, is generally strongly convex on the ventral surface between the secondary nerves; it is united for its whole width above each dichotomy, and is either abruptly terminated below, or gradually narrowed, while becoming lobately-incised or modified, at the base of the frond, as indicated in plate 46, figure 3, and plate 48, figure 5.

The border of the leaf is sinuate. As seen in fossils like that shown on the right in plate 45, it may be round-convex about the end of each secondary nerve; in other examples it is concave opposite the ends of the same nerves, as shown in plate 44 and plate 47, figure 1, while in still others, including the very young example, plate 46, figure 3, both phases are found. It is notable, however, that in the basal portions of the frond, in which lobation may be found, the margins are naturally convex opposite each secondary nerve, whose region of distribution corresponds to a lobe, and is in some specimens a well-defined lobe. The varying sinuosity of the margin is probably due to partial maceration and shrinkage in the lamina; convexity of outline opposite the secondary nerves is presumably the normal condition. The nervation appears to have offered greater rigidity and support for the lamina opposite the sutural nerves in the large leaves than appears to have been afforded at the ends of the secondary nerves themselves.

The nervation of *Gigantopteris* is an anomalous as well as very striking characteristic of the plant. As may be noted in the fragments shown in plates 43, 44, 45, and 47, figure 1, or even in the very young frond seen in plate 46, figure 3, the secondary nerves emerge, equidistant and parallel, at a conspicuously wide angle from the very broad, deeply depressed and irregularly lineate median nerve of the segment, and pass, ventrally depressed, nearly straight or with a slight outward turn toward the margin. They are a little decurrent at the base, and taper slightly upward to near the border where they become rapidly effaced like those of *Alethopteris*, as

shown in plate 45 and plate 48, figure 1. When the lamina is slightly shrunken they appear to pass, moderately strong, to the border. The tertiary nerves originate somewhat regularly, at a wide angle, from the secondary nerves and also from the midribs in Alethopteroid fashion. They rapidly diffuse in a somewhat fasciculate system by dichotomy into slightly divergent or nearly erect, straight nervilles, some of which may fork again, as shown in plate 46, figure 2. Similar nervilles spring directly from the secondary nerves and midribs. In the older or basal portions of the large frond, like that seen in plate 46, figure 2, the tertiary nerves are more distinctly fasciculate; but in the higher areas, such as that seen in the nature print, figure 2, they are less divided, while near the apex, plate 49, figure 4, many of the nerves are simple.

As seen in all the figures, particularly plate 46, figure 2, plate 47, figure 1, plate 48, figure 2, the nerves in each fascicle tend to coalesce very obliquely with those from the next fascicle on the same side, so as to form interfascicular nerves, while all the nervilles of all the fascicles on one side of a secondary nerve, unless they have already joined the interfascicular nerves, meet with those from the near side of the next secondary nerve, and the interfascicular nerves, to form a thin sutural nerve (see nature-print, pl. 48, fig. 2) which, intermediate to the secondary nerves, and thin, passes, parallel to the latter, completely to the margin of the leaf. The lateral union of the outside nerves of the fascicule and the junction of the consequent interfascicular nerve or of the remaining nervilles with the sutural nerve effects a remarkable type of very elongated, variable, and angular areolation, as is imperfectly shown in plate 45, plate 47, figure 1, plate 46, figure 2, and plate 47, figure 2. The position and aspect of the sutural nerve reminds one of the slightly decurrent sinus between two contiguous pinnules of *Alethopteris serbii* or of *A. grandini*. So distinct is it in some fragments (pl. 48, fig. 2) and so similar the union of interfascicular nerves and nervilles to the fascicles that in small fragments it is sometimes necessary to look closely in order to ascertain which is the medial side of the lamina, and which the secondary nerve. On account of the partial maceration of the lamina in the specimens the details of the nervation are not well shown. It is, however, sufficiently indicated in plate 47, figure 2, and the nature print, plate 48, figure 2, the latter figure in natural size. The sutural nerve in these specimens appears to take the place of the parting between the pinnules of *Callipteris*. In fact the leaf is not greatly unlike a *Callipteris* in which the pinnules are completely united and the nerves confluent, in *Goniopteris* nervation, along the suture except that the veins of each fascicle tend to join the successive nerves of the next fascicle in forming interfascicular nerves which are tributary to the sutural nerves.

The semifasciculate character of the nervilles and the unique areolation in our type of *Gigantopteris* is indicated very rudely in one ¹ of Schenk's figures, and it was the latter illustration which convinced me that the Chinese material is congeneric with the American, though the areolation shown in Schenk's other figures is quite incompatible therewith and probably wrong.² The generic agreement between the American and the Chinese plants is, however, confirmed by the nervation photographically illustrated by Zeiller from the fragments collected by the French expedition in Yun-Nan in western China, and referred by the distinguished French paleobotanist to the same species. The dichotomous mode of division of the leaf or frond is indicated by the lack of symmetry in the large fragments illustrated by Schenk.

So close is the relationship between the Chinese plant and that from Texas that I was at first disposed, on seeing Zeiller's figures, to refer it to the same species, *Gigantopteris nicotianafolia*; but on further examination it became evident that the specimens from Fulda, described above, represent a distinct species which I therefore designate *Gigantopteris americana*. The latter is distinguished from the Von Richthofen plant by its smaller and relatively narrower and more elongated segments, which are comparatively broader at the bifurcations; by the less dentate margins; and by the generally more open and less robust secondary nerves, which usually are nearly straight or slightly down-turned, instead of distinctly turning upward as in the Hu-Nan leaf. The ultimate nervation of the American plant is possibly indistinguishable from that seen in the small fragments from western China, referred by Zeiller to Schenk's species. The Hu-Nan plant is evidently much more robust than the other, though one or two fragments nearly as broad as Schenk's broadest figure were noted in the field. In this connection mention may be made of the presence, among the fossils from Oklahoma, of a form probably specifically different from that described above.

One of the most interesting specimens in the collection is that bearing the small and probably very young leaves shown in plate 46, figure 3. In this example two small leaves appear to have originated at the base of the petiole of a larger leaf, on the left. The two little leaves come together and their midribs seem to start from a common point, but it is not certain that they coalesce. It is important to note that while the larger of the two has a short naked petiole, the smaller leaf, which is bifurcate, like the large leaves, seems to be provided with a lamina to the base. The short tooth-lobe seen on the left at the base of the blade in the larger leaf has its representation

¹ Von Richthofen, China, vol. 4, pl. 35, fig. 6.

² In view of the validity of the generic distinction of the types I had in manuscript already given it a name not preoccupied, when from consultation of Zeiller's paper I learned of the name penciled by Schenk in the copy used by Potonié, as already mentioned.

in many large leaves in which the tooth is prolonged into an elongated lobe. The thick basal portion of the secondary nerve of such an enlarged lobe, broken away in exposing the young leaves, is seen on the lower left of the leaf fragment shown on the right in the figure. The downward continuation of the lamina, as shown in the smallest leaf, and its lobation may have to do, I believe, with the fructification of the plant, as will presently be explained

None of the specimens yet gathered present conclusive evidence as to whether the fronds of *Gigantopteris*, seen essentially in miniature in plate 46, figure 3, were borne on an aerial axis or stem, an elongating rhizome, or in tufts. The general form of the frond and the arrangement of the leaves in the specimen suggest, however, that they may have been developed along a prostrate stem or rhizome.

Seeds.—At every locality where *Gigantopteris* has been found in America there are associated with it numerous flat cordiform, alate seeds at first glance suggesting *Cardiocarpon*. On closer examination the seed, which is small and obovate, is found to lie in the slightly concave face of a very broadly round-obovate, slightly cuneate and asymmetrical bract, as shown in plate 49, figure 6. The latter has in every case a narrow keel, or rib, along one of its borders, which runs down to its point of attachment, as illustrated by plate 49, figure 4. From the convex side the seed appears somewhat thickly covered by the wing or bract substance so that it is somewhat dimly outlined (plate 49, figures 3, 4, and 6); but on the concave surface it is fairly clearly defined, apparently lying beneath a thin envelope, which, in a few cases, as in the specimen shown in figure 1, is sealed off, revealing the seed itself, which appears to have a thin, hard test like that of *Cardiocarpon*. At the broader end of the seed, which is slightly apiculate, a depression or small zonulate configuration, usually accompanied by a slight gathering or puckering of the "wing," may often be noted. This, which might casually be mistaken for a chalaza, appears to lack the hardness, fiber, and all other evidence of attachment to an axis. It has the appearance of a collapsed pollen chamber, the puckered wing being susceptible of interpretation as a micropylar environment. Further, it is to be noted that a forking vascular system radiates from the base toward the broad upper end of the wing where the nerves terminate at the margin. The origin of this vascular system is clearly seen in the specimen shown in figure 2, which is still attached to its axis. In this example the strands emerging from the stem or pedicel curve into the base of the wing, or bract, some of the forking bundles being clearly seen to traverse the wing. The seed seems originally to have been placed in a somewhat twisted position on the axis, the marginal rib being on the lower (proximal) side.

The nervation of the bract-wing of the seed is not clear throughout; but in most of the specimens, among the hundreds found in the collec-

tions, it may be more or less indistinctly seen branching radiately in passing to the distal margin, while in a few of the clearer examples it seems to anastomose near the distal border so as to form a mesh like the areolation of the *Gigantopteris* frond. While this areolation seems to exist, its occurrence is not, however, unquestionable. The small roundish body showing through the envelope in the upper part of the seed may be interpreted as the impression of the megaspore.

The seeds described above are provisionally referred to *Gigantopteris americana* on account of their generally abundant and most intimate association with the leaves of that plant wherever it has been found; on account of their asymmetry and solitary lateral attachment, as though on the ventral faces of lateral lobes or modified pinnules, along a longitudinal axis; and on account of the similarity of texture and the apparent though not indubitable similarity in the nervation of the bract-wing to the lamina and nervation of *Gigantopteris*. The characters of the asymmetrical and unilaterally ribbed lamina or wing-bract, as described above, strongly suggest a modified and reduced pinnule or secondary pinna of a fern-like frond. Such, according to my interpretation, it probably is. Mention has already been made of the deeper dissection of the shortening lobes at the base of some of the large fronds as well as in the young one shown in plate 46, figure 3. As to whether, supposing the seeds to belong to *Gigantopteris*, they were borne on reduced lobes at the bases of the fronds or on special seed-bearing pinnae cannot at present be ascertained, though it is perhaps more likely that they were distichously and obliquely placed on a short, special rachis, possibly situated in the axil of one of the fronds.

Anticipating that all doubt as to the connection between seed and leaf will later be fully removed, I do not give any other name to this new generic type of seed.

Supposed polleniferous scales.—In addition to the seeds which accompany the remains of *Gigantopteris* in the plant beds near Fulda, there are found several examples of a peculiar strobilus. This consists, as shown in figure 4, plate 48, of a rather thick, short axis bearing oppositely two distichous rows of closely placed broadly reniform or broadly ovate-reniform bracts, each about 1 centimeter in length. The bracts, which stand nearly at a right angle to the plane of the axis, partially clasp the latter in an oblique direction and are concavo-convex, the hollow side being downward, as shown in the figures (3 and 4, pl. 48). A border zone of the bracts, many of which are found detached, as shown in plate 49, figure 7, is smooth and bent slightly downward to form a curtain. The inner portion of the bract is thickened, more fibrous, and provided on the lower side with great numbers of small oval pendant sacs, probably for containing pollen, though they possibly are sporangia. The examples seen in plate 49,

figure 7, show the convex surface of the bracts with impressions of the sacs. The latter are shown in profile in figure 4, plate 48. The detailed structure of the sac is not clear, but each seems to be somewhat obliquely and separately seated, the vent being an apical or slightly obliquely placed pore.

In many of the detached bracts a radiate nervation is indistinctly shown; but in the bract shown in natural size in plate 48, figure 5, nerves radiate fasciculately from the asymmetrically placed central strand. In another very small and immature specimen, shown in plate 47, figure 3, and enlarged in figure 4, the nervilles appear to anastomose in a greatly elongated mesh comparable to that observed in the fronds already described. The bilateral arrangement of the bracts and their distinctly fern-like nervation leave little doubt as to their filicate or cycadofilic nature. The relation of the strobiles to *Gigantopteris* is made still more probable by the agreement in the peculiar texture and aspect of the residue. I therefore have little hesitation in referring these interesting strobili to the genus *Gigantopteris*. Whether the sacs, whose position and environment are so much like the pollen sacs of *Noeggerathia*, are really pollen sacs, remains in some doubt; but if the associated seeds, described above, also belong to this type, as I believe them to, the bracts bear the pollen sacs (anthers) of the plant, which must be placed with the cycadofilices (pteridosperms). In the latter case the strobiles compose bilateral spikes of the male flowers of *Gigantopteris*.

Mention has already been made of the lobation of the narrowing lamina in some of the leaf fragments collected. Several of the latter have lobes that seem to approach the specimen shown in figure 5, plate 48, in characters; but while they are interesting as illustrating reduction of the lamina in the broad portions of some of the fronds, they do not appear to justify the conclusion that the polleniferous (sporiferous?) bracts of the plant were thus produced, though such was perhaps the case. The aspect of the strobili and the characters of the relatively slender rachis suggest a position, possibly axillary, on the stem of the plant.

ASSOCIATED SPECIES AND AGE OF THE GIGANTOPTERIS-BEARING BEDS.

Asiatic distribution.—The fossils collected from the anthracite mine at Lui-pa-Koú, the type locality of *Gigantopteris*, in the Province of Hu-nan, as described by Schenk¹ are:

- | | |
|--|---|
| 1. <i>Annularia maxima</i> Schenk. | 6. <i>Cyatheites miltoni</i> Goeppert. |
| 2. <i>Calamites</i> , sp. | 7. <i>Megalopteris nicotianæfolia</i> Schenk. |
| 3. <i>Neuropteris flexuosa</i> Sternberg. | 8. <i>Lepidophyllum</i> , sp. |
| 4. <i>Neuropteris angustifolia</i> Brongniart. | 9. <i>Cordaites principalis</i> Geinitz. |
| 5. <i>Cyatheites unitus</i> Brongniart. | |

¹ China, vol. 4, 1883, pp. 230-239.

Several of the above-named plants were obviously wrongly identified by Schenk, whose paleobotanical experience had been limited almost entirely to the floras of the Mesozoic. According to his determinations of the fossils the flora should have been referred to the Allegheny or uppermost Pottsville. These species will be further considered together with the plants from Yun-Nan.

The small collections made by the French expedition in southern Yun-Nan, and described in 1907 by Zeiller,¹ are from three localities, (1) Tou-Tza, (2) Sini-Si-Keou, and (3) I-Ioui-Chao. The species, with their occurrence indicated by the above ordinal numbers, together with references to Zeiller's figures, are as follows:

<i>Pecopteris</i> (<i>Cladophlebis</i> ?), sp., 1 (fig. 6).	<i>Taniopteris</i> , sp., 3 (figs. 12, 13).
<i>Pecopteris</i> , sp., 3 (fig. 8).	<i>Taniopteris</i> ?, sp., 3.
<i>Pecopteris</i> (<i>Callipteridium</i> ?), sp., 3 (fig. 7, 7a).	<i>Gigantopteris nicotianæfolia</i> , 1, 2, 3 (figs. 14, 15, 15 ^a , 16).
<i>Neuropteridium</i> , cf. <i>bergense</i> , 1, 3 (fig. 10).	Cf. <i>Annularia maxima</i> , 1 (fig. 17).
<i>Neuropteridium</i> , sp., 2 (fig. 9).	<i>Stigmaria</i> , sp., 3 (fig. 18).
<i>Taniopteris</i> , sp., 2.	

In connection with his identification of the Yun-Nan fragment with Schenk's *Annularia maxima*, Zeiller points out that it belongs to a different and probably new genus. However that may be, it is interesting to note that the peculiar type figured by Zeiller seems to be exactly represented by several fragments in the Texas collections. Schenk's *Calamites* suggests the forms with very wide ribs figured by Kutorga and Eichwald from the Russian Permian. His *Neuropteris flexuosa* belongs apparently to the *N. planchardi* group, and is compared by Zeiller with *N. natheroni*. It is somewhat suggestive also of the leaflets figured by Zeiller as *Neuropteridium*. The pinnules wrongly placed by Schenk under *Neuropteris angustifolia* appear to represent an undescribed species from beds a little below the Wreford limestone in southern Kansas. Also the fragment of distinctly Mesozoic aspect figured by Zeiller as *Pecopteris*, sp., appears indistinguishable from like fragments found near the horizon of the Winfield formation in Kansas, as well as with *Gigantopteris* near Fulda, Texas. Schenk's pinnæ erroneously placed in *Cyatheites miltoni* and *C. unitus* also have their counterparts in the Western States, though they probably are not confined to the Permian of that region. His *Lepidophyllum* is generically unrecognizable, but his *Cordaites principalis* probably agrees with the specimens referred to that species in both Europe and America. It is somewhat characteristic of the Permian.

A *Cladophlebis*-like *Pecopteris*, possibly identical with that shown by Zeiller, is present in the Texas Permian, where also is to be found

¹ Résultats de la Mission géologique et minière du Yunnan méridional (Septembre 1903-Janvier 1904); Note sur quelques empreintes végétales des gites de charbon du Yunnan méridional, par R. Zeiller, Ann. d. Mines, Paris, ser. 10, vol. 11, 1907, p. 447 et seq., pl. 14.

a form of *Tæniopteris* apparently indistinguishable from that seen in Zeiller's figure 12. A type of *Stigmaria* with very small areoles very similar to that illustrated from western China is present in the Kansas Permian, and has also been found by Zeiller¹ in the collections from Shansi, and by Zalesky² in the material from Jantai, near Mukden in Manchuria.

From the foregoing it will be seen that five, and possibly eight, of the species found associated with *Gigantopteris* in the small collections from Hunan and Yun-Nan are present in the Permian of Kansas, Oklahoma, and Texas. It is particularly interesting to note the presence of the singular types illustrated as *Pecopteris*, sp., *Annularia maxima*, and *Tæniopteris*, sp., in association with *Gigantopteris* in Texas. The latter seems to be relatively abundant wherever it is present. On account of the distinctly Mesozoic aspect of *Gigantopteris* and several of the other associated plants the flora from both Yun-Nan and Hunan was regarded by Zeiller as probably middle or lower Triassic, a correlation supported by the presence of an upper Triassic fauna in the superior limestones, and of lower Permian invertebrates in the limestones below the red sandstones that underlie the plant-bearing horizon at one of the Yun-Nan localities. The comparison of the Chinese floras with the material now in hand from the Permian of the Texas-Kansas region shows that the Chinese horizons are in the lower Permian.

As representing other horizons which are probably not far, at most, below the Permian mention may here be made of the collections described by Schenk³ in the provinces of Sheng-King and Shansi; by Abbado⁴ and Zeiller from Shansi; and by Zalesky⁵ from the Jantai mines in Manchuria. None of these collections is large, yet they have sufficient in common to show that they do not differ widely in age.

Among the more interesting species collected by Von Riehthofen at "Pönn-hsi-hu in Liau-tung" (Liao-tung) in Sheng-King are a *Neuropteris*, possibly identical with *N. matheroni*, *Tæniopteris multinervis*, a Pterophyllum-like fragment, and the *Samaropsis affinis*, which probably belongs to the type of gymnospermous seed known as *Araucarites*. Several of the associated filicoid types, of cosmopolitan aspect, from "Pönn-hsi-hu" occur in the meager collection in Schenk's hands from the anthracite field of "Tsing-Pu-Shan," in southeastern Shansi. The *Tæniopteris multinervis*, which in Europe is unknown below the Permian, was figured by Abbado from "To-Jouan-fu," where it is associated with *Lepidodendron oculis-felis*, a

¹ Ann. d. Mines, Paris, ser. 9, vol. 29, 1901, pl. 7, fig. 83.

² Verhandl. kais. russisch. mineral. Gesell., ser. 2, vol. 42, 1905, p. 399.

³ China, vol. 4, 1883, p. 211.

⁴ Palæontographica Italica, vol. 5, 1899, p. 125.

⁵ Verhandl. kais. russisch. mineral. Gesell., ser. 2, vol. 42, 1905, p. 385.

type peculiar to this series in China, and several other insufficiently illustrated plants, including Sphenopterids, suggestive of the delicate forms in the Dunkard group in America.

The fragmentary flora from Jantai comprises forms referred by Zalessky to *Odontopteris reichiana*, *Callipteridium gigas*, *Pecopteris cyathea*, *Cordaites principalis*, and *Plagiozamites planchardi*, all characteristic of the lower Permian or highest coal measures of Europe, in company with *Lepidodendron oculis-felis*, and the small form of *Stigmaria* already mentioned. The flora of this, the nearest of the Asiatic localities to the American Continent, is clearly near the Permian-Pennsylvanian border line as pointed out by Zalessky, while, as already remarked, the floras from Shansi and Sheng-King, which are regarded by paleobotanists as approximately contemporaneous, can not be much older; they are certainly uppermost Stephanian, if not actually basal Permian. Those paleontologists and geologists who regard the upper part of the Commeny series in France as Permian can have no doubt as to the reference of all these plant beds to the latter epoch.

From the foregoing it seems probable that the most important coal-producing series in the Paleozoic of China and Manchuria are referable to the lower Permian and perhaps the uppermost Stephanian, there being, as in the western interior and the Appalachian basin of North America, no distinct discordance between the beds of the two epochs.

According to my interpretation the genus *Gigantopteris* is not closely related to any known Paleozoic type. Its nearest, though perhaps very distant, relatives are, I believe, to be found in the fossils described by Morris as *Pecopteris goepperti*, really a *Callipteris*, from the Permian sandstones near Bielebei in the Urals. In fact some of the Russian fossil fragments, such as those shown in figures 2^b and 2^c, on plate A, of the *Géologie de la Russie*,¹ or the illustrations comprising figures 1^b, 1^c and 1^e on plate F of the same great work, have so much in common with our genus, not only as to form but also as to the aspect of the nervation, that, had not Brongniart described the nerves as nonanastomosed, a reexamination of the type material would be suggested in order to ascertain whether, notwithstanding the apparent unity of the succession to the *Callipteris* type of pinna shown in the other illustrations, some of the specimens submitted to Morris and Ad. Brongniart may not really belong to the *Gigantopteris* type. Before passing it may be remarked that the western American collections seem to contain two or three Uralian Permian forms not yet known in western Europe or eastern North America.

¹ Murchison, Verneuil, and Keyserling, *Géologie de la Russie et des Montagnes de l'Oural*, vol. 2, pt. 3, 1845, pp. 1 and 5.

The Texas flora.—In Texas the major part of the Carboniferous system, as divided by the State geological survey, consists, in ascending order, of Millsap, containing Mississippian invertebrates; Strawn, which includes conglomerates and coals of upper Pottsville (lower Pennsylvanian) age; Canyon, mainly marine calcareous beds; Cisco, a coal-bearing formation from which a very few plants, probably of Monongahela age, have been obtained; Albany, Wichita, Clear Fork, and Double Mountain. The latter is unconformably overlain by the Triassic Doekum formation.¹ The Wichita formation has been stratigraphically proven by Adams, Cummins, and Gordon to grade horizontally into the "Albany," of which it represents at least the upper and greater part, the red and variegated sandstones and shales of the former being gradually replaced to the southward by the limestones of the latter. The general geology of the Wichita formation has been recently summarized by Gordon,² and the history of paleontological discovery and of opinions, which until very recently have been somewhat conflicting, as to the age of the beds, have been well reviewed by Beede.³ The Wichita formation is now regarded by all paleontologists as lower Permian, at least in the broad sense (including Artinsk) in which that term is generally employed in western Europe and America.

The "breaks" south of Little Wichita River, $4\frac{1}{2}$ miles southeast of Fulda, i. e., the locality from which the *Gigantopteris* specimens here described were obtained, is some distance above the base of the Wichita, though the interval has not been determined. A stratum in the Missouri, Kansas & Texas Railway cut 1 mile west of Henrietta, supposed to be much lower than the Fulda plant bed, yielded a small flora containing *Walchia* and *Taxiopteris*.

Another locality, "Castle Hollow," $2\frac{1}{2}$ miles south of Fulda, is stratigraphically so near the level of the main Fulda plant bed that its species will be associated with the others in the following provisional list of the fossils. It must, however, be distinctly borne in mind that the identifications in this list are based on a preliminary examination only and that, though of value and interest as closely indicating the character of the flora, they are not in all cases final.

Preliminary List of the Fossils from the Main Plant Bed (M), and "Castle Hollow" (H), near Fulda, Texas.

<i>Diplomema</i> , sp.?, M.	<i>Pecopteris</i> , sp., M.
<i>Pecopteris arborescens</i> , H.	<i>Aphlebia</i> , sp., H.
<i>Pecopteris hemitelioides</i> , H, M.	<i>Odontopteris neuropteroides</i> , M.
<i>Pecopteris densifolia</i> ?, H.	<i>Odontopteris fischeri</i> ? M.
<i>Pecopteris tenuinervis</i> , M.	<i>Gigantopteris americana</i> , M, H.
<i>Pecopteris grandifolia</i> , M, H?	<i>Neuropteris</i> cf. <i>lindahli</i> , H.

¹ See Cummins, Tex. Acad. Sci., 1897, pp. 93-98.

² Journ. Geol., vol. 19, 1911, p. 110.

³ Kans. Univ. Sci. Bull., vol. 4, No. 3, 1907.

Neuropteris cordata?, M.
Teniopteris multinervis, H, M.
Teniopteris abnormis, M.
Teniopteris coriacea?, M.
Teniopteris, new species, M.
Annularia spicata, H.
Annularia? maxima, M.
Sphenophyllum obovatum, M.
Sphenophyllum?, sp., H.
Sigillaria, sp., M.
Sigillariostrobus hastatus, H.
Cordaites cf. principalis, M.
Poacordaites cf. tenuifolius, M.

Walchia piniformis, M.
Walchia schneideri?, H.
Gomphostrobus bifidus, H.
Gomphostrobus? sp., M.
Aspidiopsis, sp., M.
Araucarites, new species, M, H.
Carpolithes, sp., H.
 Insect wings, M.
Anthracosia, M.
Estheria, M, H.
 Ostracods, M, H.
 Fish scales, M, H.

As will be noted on examining the above list, nearly all the species are found in the Permian of Europe or America. The species printed in boldfaced type are characteristic of the Permian. The beds are clearly of lower Permian age.

The red and green sandstones three-fourths mile east, and the beds of similar character about 4 miles southeast of Electra, Texas, contain great numbers of *Gigantopteris* mingled with *Teniopteris*. In this part, regarded by Gordon¹ as near the top of the Wichita formation, surviving "Coal Measures" ferns have not yet been found.

Several small fragments of *Gigantopteris* which were many years ago transmitted to the United States National Museum² from Fort Concho, near San Angelo, Tom Green County, Texas, were examined by Leo Lesquereux, who wrote on the label "Peculiar fern quite unknown to me." The fragments probably represent a new species of the genus.

The Oklahoma flora.—The Wreford limestone, which by the Kansas University Geological Survey is made the base of the Permian,³ is said to be replaced to the southward by arenaceous beds to which the name Payne has been applied by Kirk.⁴ Above this sandstone the Permian of Oklahoma is largely composed of red sandstones and shales. Fossil plants were collected from this series at two localities in the State: 1. About 2 miles north of Perry, in chocolate-red and greenish grits regarded by Gould as probably near the horizon of the Winfield formation of Kansas; 2. The McCann quarries in the red sandstone about 2 miles east of Eddy, in Kay County. The latter point, which is well up in the Enid formation,⁵ is also known as the source of some of the fossil vertebrates described by Prof. S. W. Williston.

¹ Journ. Geol., vol. 19, 1911, p. 114.

² U. S. Nat. Mus., Acc. 7255.

³ Rept., vol. 9, 1908, p. 77.

⁴ Oklahoma Dept. Geol. and Nat. Hist., 3d Bien. Rept., 1904, p. 9.

⁵ U. S. Geol. Surv., W. S. Paper 154, 1906.

Provisional List of the Fossil Plants from Perry (P) and Eddy (E), Oklahoma.

<i>Diplomema pachyderma</i> , E.	<i>Equisetites</i> , sp., E.
<i>Pecopteris cyathea</i> , P.	<i>Annularia stellata</i> , P.
<i>Pecopteris geinitzi</i> , P.	<i>Sphenophyllum obovatum</i> , E.
<i>Callipteris</i> , sp., E.	<i>Sphenophyllum</i> cf. <i>latifolium</i> , P.
<i>Gigantopteris americana</i> , E. P.	<i>Sphenophyllum stoukenbergi</i>? P.
<i>Odontopteris</i> cf. <i>permiensis</i> , E.	<i>Sigillaria</i> , sp.?, P, E.
<i>Neuropteris</i> , sp., E.	<i>Walchia imbricata</i>? P.
<i>Teniopteris multinervis</i> , P. E.	<i>Walchia</i> cf. <i>gracilis</i> , E.
<i>Teniopteris abnormis</i> , P.	<i>Araucarites</i> , sp., P, E.
<i>Teniopteris</i> , sp., E.	<i>Carpolithes</i> , E.
<i>Dolerophyllum?</i> , sp., E.	

All the species quoted above occur in beds regarded as Permian in the Old World, except two, one of which, *Sphenophyllum obovatum*, is present in the Permian of Kansas (Wellington formation), while the *Diplomema* is found in the Dunkard of West Virginia. Several of the Perry species that are known also to occur in the Pennsylvanian have not been found in the higher horizon, at Eddy. The smaller number of filicoid survivors in this flora as compared with the Fulda, Texas, flora is perhaps due to the less distinctly marsh habitat in which they grew and were buried. The *Araucarites* scale-fruit is identical in both regions. As in the preceding list the types distinctly characteristic of the Permian are printed boldface.

It is interesting to note the probable presence in the Oklahoma *Gigantopteris*¹ association of a *Sphenophyllum* and an *Odontopteris* hitherto unknown except in the Uralian region. The fragments of *Teniopteris* and *Gigantopteris* are very abundant in some of the sandstones at both localities. The evidence for the lower Permian age of these two Oklahoma plant beds needs no further discussion in this place.

The Kansas Permian plants.—The fossil plant materials here reported for the first time, in a preliminary way and with provisional determinations of the species, were mostly collected in the course of two short paleobotanical reconnoissance excursions for the purpose (1) of securing fossil plant evidence of a decisive nature relating to the mooted question of the age of the Chase group and Sumner group in Kansas, and of the Wichita formation in Texas: and (2) to procure, if possible, fossil plants in the Rocky Mountain region from the great "red beds" series, over 6,000 feet in thickness, the age of the greater part of which has, on account of failure to yield fossils, been largely the subject of mere supposition. On account of the interesting light some of the forms collected throw on the distribution of a number of plants characteristic of the Uralian region or of western Europe I

¹ The discovery of *Gigantopteris* in Oklahoma, at Perry, is due to the geological interest of Mr. L. L. Hutchison, of that place.

venture here to include several lists of the provisional identifications made in the course of a brief preliminary examination of the material. Full elaboration of the fossil specimens is postponed until additional collections may be made covering a wider stratigraphic as well as geographic range.

The "Big Blue series" in which Prosser¹ classed the Permian of Kansas consists of (1) the Chase group, beginning with the Wreford limestone and ending with the Winfield formation, and (2) the overlying Sumner group, markedly gypsiferous, and composed of the Marion and Wellington formations.

For accounts of the numerous pre-Permian formations and the description of the seven formations of the Chase group as well as of the two in the Sumner the reader is referred to the ninth volume of the Reports of the Kansas University Geological Survey, published in 1909.

Fossil plants were collected by me from the Wreford limestone west of Reece (R); from shales near the Winfield formation northeast of Washington (W); and from the Wellington formation south of Banner (B), and Carlton (C), and east of Salina (S). For the sake of brevity the names are combined in one list in which, by referring to the letters, the floras of the several localities² and formations may be integrated.

List of Species Provisionally Identified from the Permian of Kansas.

<i>Schizopteris</i> cf. <i>trichomanoides</i> , W.	<i>Neuropteris odontopteroides</i> , W.
<i>Pecopteris unita</i> , W.	<i>Neuropteris scheuchzeri</i> , var., W.
<i>Pecopteris pinnatifida</i> , W.	<i>Neuropteris permiana</i> , W.
<i>Pecopteris</i> cf. <i>geinitzii</i> , W.	<i>Taeniopteris multinervis</i> , W.
<i>Pecopteris hemitelioides</i> , W.	<i>Taeniopteris coriacea</i> , B, C.
<i>Pecopteris bucklandi</i> ? W.	<i>Taeniopteris coriacea</i> , var. <i>linearis</i> , B, C.
<i>Pecopteris polymorpha</i> , W.	<i>Sphenophyllum obovatum</i> , C, B.
<i>Scotecoelopteris clegans</i> , C.	<i>Sphenophyllum</i> cf. <i>stoukenbergi</i> , W.
<i>Cladophlebis</i> cf. <i>tenuis</i> , C.	<i>Sphenophyllum</i> cf. <i>thonii</i> , W.
<i>Callipteris conferta</i> , W, C.	<i>Sigillariostrobus hastatus</i> , R.
<i>Callipteris subauriculata</i> , S, C, B.	<i>Noeggerathia</i> ? new species, B.
<i>Callipteris</i> cf. <i>curretiensis</i> , C.	<i>Cycadospadix</i> ? sp., C.
<i>Callipteris</i> cf. <i>jutieri</i> , R.	<i>Cordaites principalis</i> , R.
<i>Callipteris</i> cf. <i>goepperti</i> , R.	<i>Poacordaites linearis</i> ? C.
<i>Callipteris oxydata</i> , S.	<i>Walchia piniformis</i> , R.
<i>Callipteris whitei</i> , B.	<i>Walchia</i> cf. <i>fliciformis</i> , R.
<i>Callipteris lyratifolia</i> ? S.	<i>Walchia</i> , sp., C.
<i>Callipteris</i> cf. <i>scheibei</i> , B.	<i>Voltzia</i> , sp. C.
<i>Odontopteris brardii</i> , W.	<i>Ulmannia</i> ? sp., C.
<i>Odontopteris minor</i> , W.	<i>Schützia</i> ? cf. <i>anomala</i> , R.
<i>Glenopteris splendens</i> , B, C.	<i>Araucarites</i> ? sp., C.
<i>Glenopteris lineata</i> , B.	<i>Rhabdocarpos</i> , new species, R.
<i>Glenopteris sterlingi</i> , B, C.	<i>Carpolithes</i> , sp., S. B.
<i>Glenopteris lobata</i> , C.	
<i>Neuropteris auriculata</i> ? W.	

¹ Journ. Geol., vol. 10, pp. 703-737.

² For exact descriptions of the localities and for excellent descriptions of many of the species, see the paper by E. H. Sellards in the State Survey volume cited.

All the specifically identified plants in the above list are found in beds referred to the Permian in their respective provinces, most of them being European. The species and types in bold face are diagnostic of the Permian.

An inspection of the rather short list from the Wrexford limestone reveals a flora, most of whose species are characteristic of the Permian, a small percentage only being common to the "Coal Measures." It is in fact somewhat surprising to note so few pre-Permian forms in this flora. On the other hand, at the Washington locality, the horizon of which is near the Winfield formation, a considerable number of Pennsylvanian survivors are present in the Carbonaceous muds, evidently the remains of an old swamp where they seem to have found refuge, perhaps making their last stand. But even these, nearly every one of which survived in the Permian of the Old World, are accompanied by a sufficient number of characteristic European Permian types clearly to show the Rothliegende age of the beds. The more ample material therefore confirms the conclusions reached by Sellards,¹ and substantiates the early opinions expressed by the present writer.²

The Wellington flora is characterized by an abundance of *Calopteris* forms and by great numbers of *Taxiopteris* and *Glenopteris*, to which are added types probably referable to *Ullmannia*, *Voltzia*, and *Araucarites*. The singular fronds of *Glenopteris*, doubtless a Cycadofilic, have many points of similarity to the Mesozoic *Cycadopteris* and *Lomatopteris*, as has been pointed out by Sellards. The relatively simple form of the leaves and the thick leathery texture are xerophytic characters strongly suggestive either of long dry seasons or a climate more arid in general than that of the earlier series.

The Colorado flora.—In Colorado the search for plants in the "Red Beds" was confined to two points: Fairplay and the Canyon of the Arkansas River below Salida. At the former locality an unsuccessful effort was made to rediscover the point at which Prof. Arthur Lakes in 1883 collected plants and insects.

Plants were located by myself in buff and dark Carbonaceous shales nearly 4 miles southwest of Fairplay, the locality and horizon being not far, as subsequently ascertained, from the plant bed discovered by Professor Lakes.

It will be remembered that the early collection was placed in the hands of Lesquereux, and the insects were submitted to Scudder. The former³ pronounced the beds Permian, while the latter⁴ adjudged them to be Triassic, and so confidently and emphatically reiterated

¹ Kans. Univ. Quart., vol. 9, 1900, p. 179. Report Kans. Univ. Geol. Surv., vol. 9, 1909, p. 462.

² Bull. 211, U. S. Geol. Surv., 1903, p. 117.

³ Bull. Mus. Comp. Zool. Harvard Univ., vol. 7, 1883, p. 244.

⁴ Mem. Boston Soc. Nat. Hist., vol. 4, No. 12, 1890, p. 457.

the Triassic correlation that the bed has become known as an important source of Triassic insects in America. A portion at least of the material examined by Lesquereux now rests in the Lacoë collection in the United States National Museum. Probably it belongs to a horizon somewhat higher than the fossils collected by myself. I therefore designate the Lesquereux species A, those collected by myself being marked B in the following list:

Provisional List of Plants from Fairplay, Colorado.

- | | |
|--|---|
| <i>Sphenopteris schimperiana?</i> B. | <i>Neuropteris auriculata</i> Germar, B. |
| <i>Sphenopteris lebachensis</i> Weiss, A. | <i>Calamites kutorgae?</i> B. |
| <i>Sphenopteris dentata</i> F. and I. C. W., A. | <i>Sphenophyllum obovatum</i> Sellards, |
| <i>Sphenopteris gutzholdi</i> Gutbier, A. | B. |
| <i>Pecopteris pinnatifida</i> Gutbier, B. | <i>Sigillaria?</i> sp., B. |
| <i>Pecopteris foeminaeformis</i> (Schlotheim) | <i>Sigillariostrobus hastatus</i> , A, B. |
| Zeiller., A. | <i>Poacordaites</i> , sp., A. |
| <i>Pecopteris arborescens</i> (Schlotheim) Bron- | <i>Walchia piniformis</i> (Schlotheim), |
| gniart, B. | A, B. |
| <i>Pecopteris</i> (Danaeites Göppert), sp., B. | <i>Walchia hypnoides</i> , A, B. |
| <i>Scoleopteris elegans</i> Gutbier, B. | <i>Walchia gracilis?</i> A. |
| <i>Callipteris</i> cf. <i>hymenophylloides</i> | <i>Ullmannia</i> , sp., A, B. |
| Weiss, A. | <i>Voltzia</i> , sp., A. |
| <i>Callipteris</i> cf. <i>lyratifolia</i> (Göppert), | <i>Araucarites</i> , sp., A, B. |
| B. | <i>Gomphostrobus bifidus</i> , B. |
| <i>Odontopteris subcrenulata</i> Rost, B. | |

As in previous lists, the types distinctly indicative of Permian age are in boldface type. All of the forms that occur in rocks of Pennsylvanian age have also been found in formations regarded by all as Permian. The evidence of the *Sphenopteris*, the *Callipteris*, and of the gymnosperms leaves little room for doubt that this flora is of Permian age, probably Rothliegende.

In the Canyon of the Arkansas near Wellsville Station a lower group of sandstones, limestones, and thin coals contains fossil plants of Pottsville age. This belt of basal Pennsylvanian rocks in similar composition, with coals and similar plants, appears to extend from the region of Pecos City, New Mexico, northward to the vicinity of Manitou, Colorado, and probably farther. It is unconformable, at least locally, on older formations. A thin series, largely limestone, which follows next at Wellsville, verges rapidly into the "Red Beds" series. The latter carries lower "Coal Measures" plants about 900 feet above its base; and near a thin coal, about 1,100 feet higher, a few fragments were found which seem to indicate a very high place in the Pennsylvanian.

Near the south portal of the railway tunnel, probably 800 feet above the horizon last mentioned, or about 2,800 feet above the base of the "Red Beds" series, a small but interesting flora was obtained, which leaves little doubt as to the Permian age of its horizon.

List of Plants from the Denver and Rio Grande Tunnel Below Swissvale, Colorado.

<i>Callipteris</i> , sp.	| <i>Sigillariostrobus hastatus</i> .
<i>Psymmophyllum</i> cf. <i>cuneifolium</i>.	| <i>Walchia</i> cf. <i>piniiformis</i> .
<i>Odontopteris subcrenulata</i> Rost?	| <i>Walchia</i> cf. <i>imbricata</i> .
<i>Macrostachya</i> ? sp.	| <i>Rhabdocarpos dyadicus</i> Geinitz?

From beds apparently about 1,550 feet higher between Badger Creek and the Wellsville "One mile" signal beds were located containing *Schizopteris*, *Callipteris*, *Odontopteris*, *Walchia*, and *Rhabdocarpos*. It is therefore probable that 2,000 feet, at least, of this section of the "red beds" is Permian.

Fragmentary and incompletely representative of the several floras as the lists may be, they yet show some interesting aspects of the distribution of the Permian species. Thus, the genus *Walchia*, unknown in the Permian of the Appalachian trough, is present at most of the localities, while *Callipteris*, which is very meagerly represented in eastern North America, is common and highly differentiated in Kansas and Colorado. *Gomphostrobus*, another type characteristic of the Permian of western Europe and hitherto unknown in North America, is present in Kansas, Colorado, Oklahoma, and Texas. The common type of simple leafed *Tæniopteris*, diagnostic of the western European lower Permian, is nearly everywhere present, sometimes accompanied by other forms, one of which, with distant, simple nerves, is of distinctly Mesozoic aspect.

In addition to the many *Callipteris* and *Walchia* species just mentioned, the provisional lists from the western Permian include a number of other forms near to, if not identical with, diagnostic Old World Permian types hitherto unknown in this continent. Among these are *Schizopteris* cf. *trichomanoides*, *Sphenopteris lbachensis*, *Pecopteris geinitzi*, *Pecopteris pinnatifida*, *Cladophlebis?* cf. *tenuis*, *Scolecopteris elegans*, *Odontopteris subcrenulata*, *Tæniopteris abnormis*, *Annularia spicata*, *Rhabdocarpos* cf. *dyadicus*.

It is probable that several cosmopolitan species of *Pecopteris* and *Sphenopteris* will be found to have accompanied *Tæniopteris multinervis* from western Europe to eastern China.

The examination of the materials from the Western Interior and Rocky Mountain basins shows that while the flora is composed mainly of types common to western Europe which have undoubtedly been distributed along essentially the same northeastern Arctic-American route by which the Pennsylvanian floras migrated, it contains also a somewhat unique element unmistakably derived from eastern Asia. The latter includes the *Gigantopteris*, the peculiar *Annularia*, and a *Tæniopteris* form, to which should possibly be added the representatives of *Araucarites* and *Neuropteridium*. The

migration of this land plant element was very probably by the north Pacific.

The most important deduction to be drawn from the occurrence of *Gigantopteris* and its particular associates in North America is the essential continuity of environmental conditions indicated thereby. The vital conditions under which the types lived in Oklahoma and Texas can not have been very far different in their essential respects from those prevailing in the Chinese habitats of the types. Environmental conditions sufficiently uniform to enable these plants to thrive must have attended the route of their land migration. We may therefore conclude that a climatic environment essentially similar extended from China to western North America; that is, that during *Gigantopteris* time western North America and portions of eastern Asia were probably included in the same climatic province. The mingling of the western European flora with the Chinese elements in Oklahoma and Texas suggests that the latter region may have been on the eastern border of the province.

Another interesting feature of the western Permian is the presence of fronds possibly identical with *Psygmoephyllum cuneifolium*, *Odonopteris permianensis*, *Odonopteris fischeri*, and *Sphenophyllum stoukenbergi*, species that seem not to have been known outside of the Uralian region, from which they were described. Possibly the remarkable Kansas type described by Sellards¹ as *Glenopteris*, which is unlike any European type of its period, and which may be nearest related to the *Neuropteris salicifolia* of Morris, also is of Uralian or Asiatic descent. The types of Uralian origin also may have reached western North America by the north Pacific route.

According to their composition and relations the floras of the younger Carboniferous in Shansi and Sheng-King, or Manchuria, which are either at the latest Pennsylvanian stage or in the early Permian, may with probable safety be assumed to have antedated the early Gondwana glaciation and the existence of the *Gangamopteris* flora in southern Asia. The question arises, then, whether the floral peculiarities of the *Gigantopteris* province are due in part to climatic changes leading to refrigeration in India, and whether later the climate of the *Gangamopteris* province extended over a portion at least of the *Gigantopteris* province, and if so, whether it did not cover a part of western North America.

CONCLUSIONS.

The genus *Gigantopteris* Schenck, common in the Permian "Red Beds" of Texas and Oklahoma, is a plant with large sympodially(?) dichotomous pinnæ, and confluent (and thus elongately meshed) Goniopteroid nervation. It is in many respects strongly suggestive

¹ Kans. Univ. Quar., vol. 9, 1900, p. 179.

of *Callipteris goepperti* Morris, which may be its nearest known relative.

On the evidence of association, bract texture, and nervation, certain obovate seeds borne in the ventral faces of rather large, cuneate-obovate, distantly distichous bracts, and representing a new generic type of fructification, are regarded as the probable fruits of *Gigantopteris*. Likewise, certain strobili, composed of two opposite rows of distally concavo-convex reniform disks, bearing on their under surfaces numerous pendant oblong sacs are on account of the agreement in the texture and filicoid nervation of the disks with the lamina and nervation of *Gigantopteris*, provisionally referred, with a high degree of probability, as the polleniferous strobili of that genus.

The genus *Gigantopteris* is therefore regarded as a cycadofilic (Pteridospermic) type.

In China (provinces of Hun-Nan and Yun-Nan) *Gigantopteris* is associated with certain European Permian forms and a number of American types, all showing the Permian age of the *Gigantopteris* bearing beds.

The very incomplete collections of fossil plants from the Wichita formation in Texas, from its supposedly approximate equivalents in Oklahoma, from the Chase and Sumner groups in Kansas, and from the great series of undifferentiated "Red Beds" in the Rocky Mountain region of southern Colorado, show a mixed flora embracing (1) mainly representatives of the Permian flora of western Europe, and including many types not previously known in North America; (2) a smaller portion peculiar to the *Gigantopteris* association in south central, and southwestern China; and (3) several types apparently identical with or very close to forms hitherto known only in the Permian of the Uralian region.

The distribution of the floral elements indicates that the western European or cosmopolitan elements of the flora migrated between North America and Europe, presumably by the same general north-eastern route as that followed by their Pennsylvanian predecessors, while the distinctly Chinese types must have come to Texas and Oklahoma by the north Pacific (Alaskan) route, by which the related Uralian forms may also have migrated. Since the land migration of the Chinese types could hardly have been accomplished without the aid of essential continuity of environmental conditions, and since it is probable that the *Gigantopteris* elements lived under climatic conditions mainly similar in both Texas and China, the conclusion appears justified that the climatic province under which they thrived in Asia extended to western North America and that it included the region of north Pacific migration. The mingling of western European species with *Gigantopteris* in the southwestern "Red Beds" is con-

strued to indicate that this region was probably on the eastern border of the *Gigantopteris* province.

The *Gigantopteris* flora (early Permian) very probably preceded the development of the *Gangamopteris* flora in southern Asia. Did the *Gangamopteris* (Permian) flora, which came by an Antarctic route to southern South America, ever follow the *Gigantopteris* flora by the northern route into western North America? The extension of the eastern Asiatic province to the western border of this continent in *Gigantopteris* time, and the reported presence of *Glossopteris*, a survivor of the *Gangamopteris* flora in the Mesozoic of western Mexico, makes it seem not impossible that the *Gangamopteris* flora also may have reached North America. In view of the almost total lack of paleobotanical knowledge concerning the Pennsylvanian and Permian rocks of all North America west of the Rocky Mountains, it will readily be recognized that the *Gangamopteris* flora may be present, though it may be a long time before paleontological exploration will have been carried so far as to unearth its remains.

EXPLANATION OF PLATES.

PLATE 43.

Gigantopteris americana.

Young frond showing nearly equal division and slight constriction at the point of dichotomy. The border of the lamina in this specimen is seen to be sometimes concave, sometimes convex, opposite ends of the secondary nerves.

(Cat. No. 34070, U.S.N.M. Photographed in natural size.)

PLATE 44.

Gigantopteris americana.

Fragment of leaf in which the incomplete lamina appears to be gradually narrowed downward, becoming slightly lobate at the same time. The basal portion of the lamina, which is slightly macerated, has been destroyed.

(Cat. No. 34069, U.S.N.M. Photographed in natural size.)

PLATE 45.

Gigantopteris americana.

Portion of large leaf showing the union of two lobes far above the point of dichotomy, with very little constriction at the sinus. The border is seen to be convex opposite the secondary nerves in the upper part of the division on the right. The secondary nerves are opposite to alternate.

(Cat. No. 34071, U.S.N.M. Figure reduced to $\frac{5}{8}$ natural size.)

PLATE 46.

Gigantopteris americana.

Fig. 1.—Fragment of a relatively slender lobe showing the Goniopteroid aspect of the margin and nervation. The sutural nerves are evident in this young pinna, and the border is concave opposite the ends of the secondary nerves, probably as the result of slight shrinkage.

(Cat. No. 34062, U.S.N.M. Photographed in natural size.)

Fig. 2.—Fragment from the lower part of a leaf showing the nervation which is more characteristically represented in the middle of the enlarged illustration.

(Cat. No. 34074, U.S.N.M. Figure twice natural size.)

Fig. 3.—Two young leaves, one bifurcated and gradually narrowed downward, the other abruptly constricted at the base of the lamina and petiolate. On the left is seen the base of a partly grown leaf, while on the right is shown a fragment of a leaf, perhaps fully grown.

(Cat. No. 34073, U.S.N.M. Photographed in natural size.)

PLATE 47.

Gigantopteris americana.

Fig. 1.—Fragment of a leaf of average size illustrating the dicotyledonous aspect of many of the examples. In portions of the specimen the conditions of maceration have brought the nervation into high relief, as photographically represented. The base of the fragment is probably near the point of bifurcation.

(Cat. No. 34072, U.S.N.M. Figure in natural size.)

Fig. 2.—Photographic enlargement, showing the nervation of a leaf slightly larger than that seen in figure 1. On the left is seen the secondary nerve, on the right the sutural nerve. A part of the same specimen is shown in natural size in the nature print in plate 48, figure 2.

(Cat. No. 34061, U.S.N.M. Photograph, twice the natural size.)

Fig. 3.—Immature scale detached from a strobilus of the type shown in plate 48, figures 3 and 4. It is probably the polleniferous scale of *Gigantopteris americana*.

(Cat. No. 34066, U.S.N.M. Illustrated in natural size.)

Fig. 4.—The same specimen photographed twice the natural size to show the *Gigantopteris* nervation of the immature scale. The inner convex portion corresponds to the polleniferous (?) area of the scales seen in plates 48 and 49.

PLATE 48.

Gigantopteris americana.

Fig. 1.—Apex of leaf illustrating the dicotyledonous aspect of the fragments.

(Cat. No. 34063, U.S.N.M. Figure in natural size.)

Fig. 2.—Photographic print made from a carbon-paper impression of the surface of a leaf fragment to show the nervation. The nature print serves excellently to illustrate the aspect of the nervilles and the thin sutural nerves.

(Cat. No. 34061, U.S.N.M. Figure in natural size.)

Fig. 3.—Strobilus supposed to comprise the polleniferous disks of the same plant. The specimen is broken slightly obliquely to the axis so that the upper convex surfaces of the distichous scales or bracts are seen in the upper part of the figure, while the under concave surfaces are shown in the fragments lying beyond the plane of the axis in the lower part of the photograph. The polleniferous (?) sacs are imperfectly seen at a few points on the underside of the bracts.

(Cat. No. 34077, U.S.N.M. Figure, natural size.)

Fig. 4.—Similar strobilus, broken longitudinally along the axis. Numerous polleniferous (sporiferous?) sacs are shown on the underside of the bracts, the borders of which are bent downward.

(Cat. No. 34078, U.S.N.M. Figure in natural size.)

Fig. 5.—Lobe bract, similar to the fertile bracts of the strobilus, showing *Gigantopteris* nervation. This specimen is comparable to that seen in figure 3 on plate 47.

(Cat. No. 34075, U.S.N.M. Photograph, natural size.)

Fig. 6.—Similar bract strongly concavo-convex, partially clasping the axis, and showing a nervation apparently in agreement with that of the *Gigantopteris* sterile frond.

(Cat. No. 34067, U.S.N.M. Figure, natural size.)

PLATE 49.

Gigantopteris americana.

Fig. 1.—Fruit from which the thin outer envelope (wing, or lamina) has been partially broken away, exposing the flattened nutlet, which has a thin sclerotic test.

(Cat. No. 34081, U.S.N.M. Photographed in natural size.)

Fig. 2.—Seed attached to axis. The photograph shows the asymmetrical form of the fruit, the narrow keeled rib at the lower border, and the nervation radiating from the point of attachment. The small roundish body in the upper part of the nucellus may be interpreted as a megaspore. The lamina wing is puckered about the micropylar region.

(Cat. No. 34082, U.S.N.M. Figure, natural size.)

Fig. 3.—Seed covered by the wing lamina in which the nervation, apparently in accord with that of *Gigantopteris*, is indistinctly seen. The nutlet is slightly apiculate.

(Cat. No. 34083, U.S.N.M. Photograph, natural size.)

Fig. 4.—Seed in which the outline of the nutlet is indistinctly seen beneath the wing lamina, which, as in the other specimens, is narrowly ribbed on one side (left), radiately nerved, and puckered about the micropylar region.

(Cat. No. 34064, U.S.N.M. Figure, natural size.)

Fig. 5.—Seed in which the nervation of the wing lamina, radiating from the point of attachment, and the lateral rib are more distinctly shown.

(Cat. No. 34079, U.S.N.M. Illustrated, natural size.)

Fig. 6.—Seed dimly outlined beneath the wing lamina. The broken lateral rib is shown on the right, and the nervation is indistinctly seen along the upper border of the wing.

(Cat. No. 34068, U.S.N.M. Figure, natural size.)

Fig. 7.—Detached fertile scales of the type shown in figures 3 and 4 on plate 49. The photograph shows the upper or convex surface through which the impressions of the supposed pollen sacs lying underneath the scales are brought into relief. The border zone of these specimens is the same as that shown in figure 5, plate 48, and figures 3 and 4 on plate 47.

(Cat. No. 34076, U.S.N.M. Illustrated, natural size.)



GIGANTOPTERIS AMERICANA, WICHITA FORMATION, TEXAS.

FOR EXPLANATION OF PLATE SEE PAGE 514.



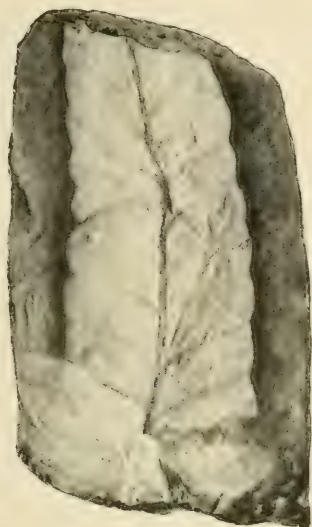
GIGANTOPTERIS AMERICANA, WICHITA FORMATION, TEXAS.

FOR EXPLANATION OF PLATE SEE PAGE 514.



GIGANTOPTERIS AMERICANA, WICHITA FORMATION, TEXAS.

FOR EXPLANATION OF PLATE SEE PAGE 514.



1



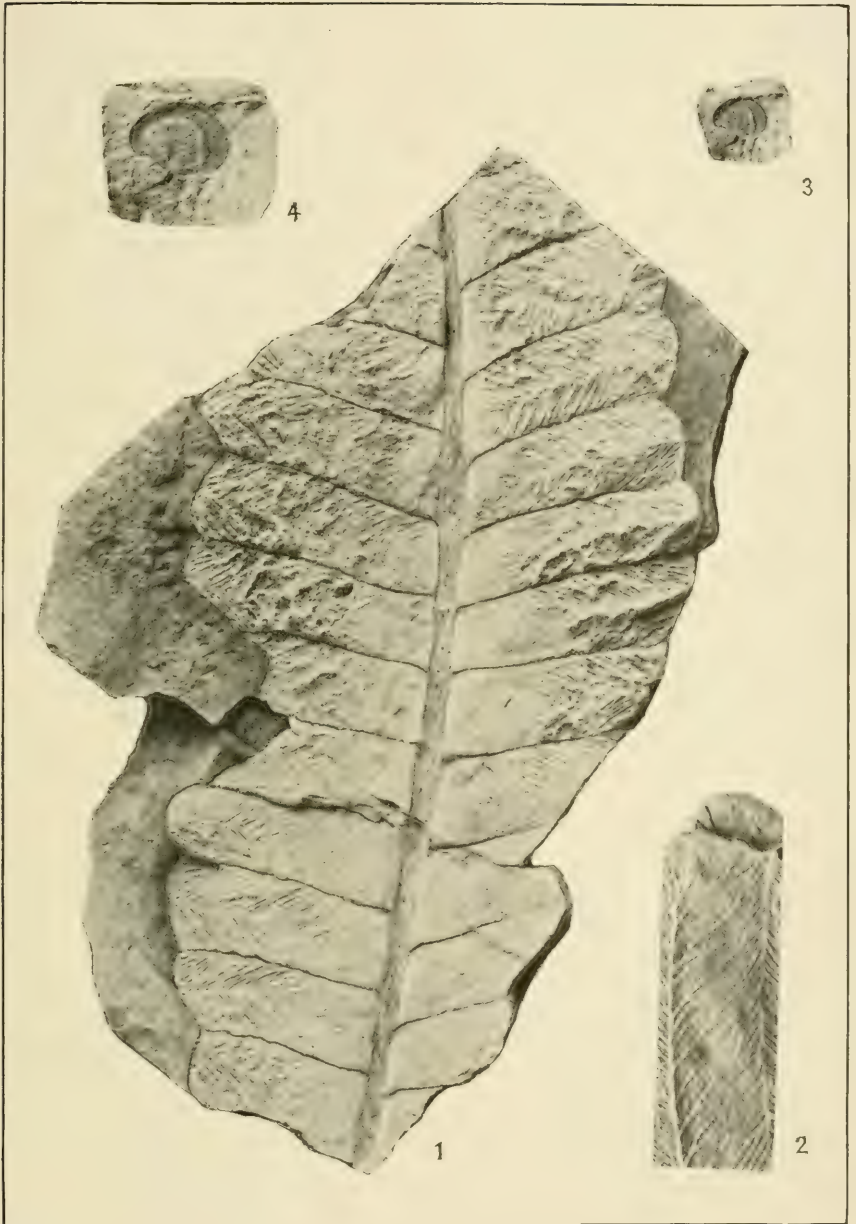
2



3

GIGANTOPTERIS AMERICANA, WICHITA FORMATION, TEXAS

FOR EXPLANATION OF PLATE SEE PAGES 514-515.



GIGANTOPTERIS AMERICANA, WICHITA FORMATION, TEXAS.

FOR EXPLANATION OF PLATE SEE PAGE 516.



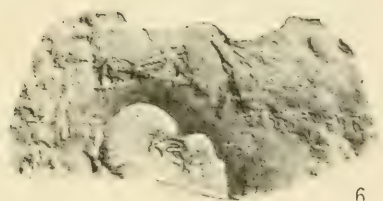
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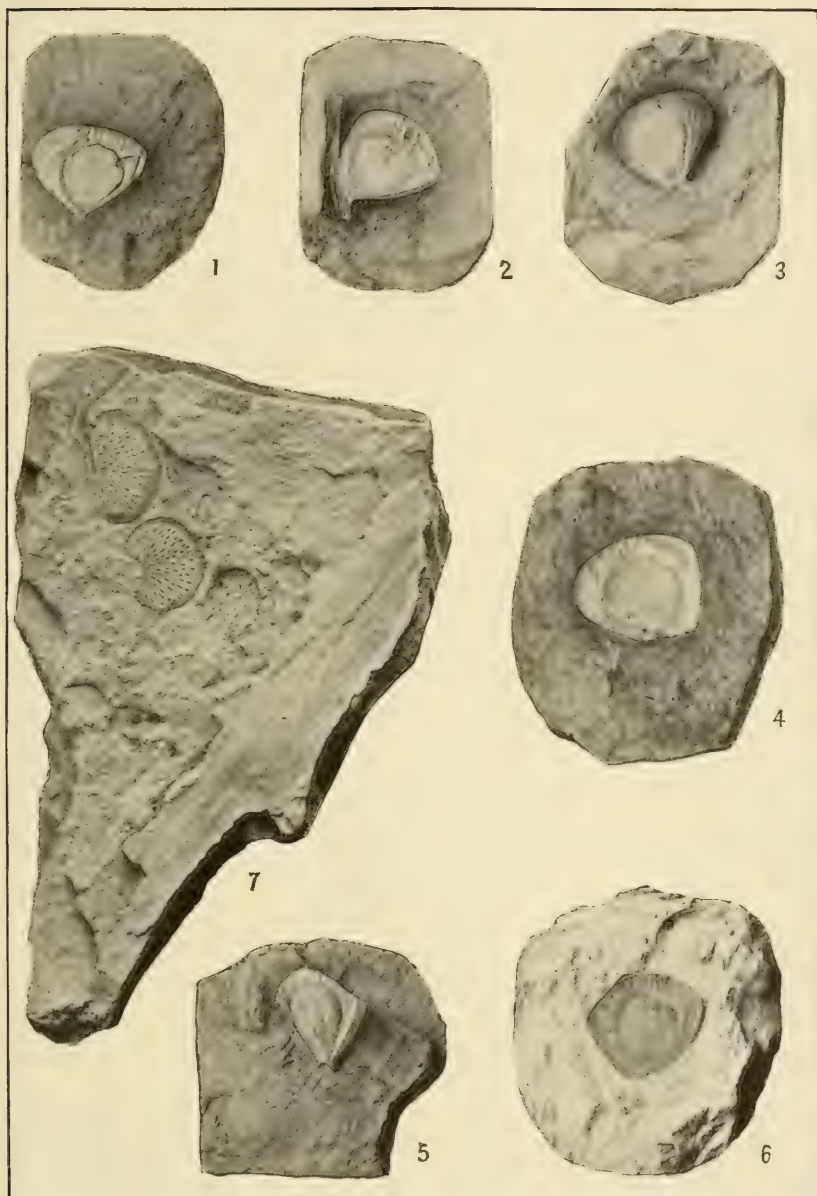
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4

GIGANTOPTERIS AMERICANA WITH SUPPOSED POLLENIFEROUS STROBILI.

FOR EXPLANATION OF PLATE SEE PAGES 515-516.



GIGANTOPTERIS AMERICANA ? SUPPOSED FRUCTIFICATIONS.

FOR EXPLANATION OF PLATE SEE PAGE 516.

DESCRIPTION OF A NEW SALAMANDER FROM IOWA.

By ALEXANDER G. RUTHVEN,

Head Curator, University of Michigan Museum, Ann Arbor.

In May, 1911, the writer received from Prof. W. H. Norris, of Grinnell College, a specimen of *Ambystoma* that could not be referred to any of the described species. This salamander was labeled "Bloomfield, Iowa," and had been sent to Professor Norris by Mr. George H. Berry, Cedar Rapids, Iowa. To verify the locality record the writer wrote to Mr. Berry, who very kindly forwarded three more of the six specimens obtained and the habitat data included in this paper. A study of this material demonstrates that it represents an undescribed species, and the writer takes great pleasure in dedicating it to the eminent herpetologist, Leonhard Stejneger.

AMBYSTOMA STEJNEGERI, new species.

Diagnosis.—Body slender; costal furrows 12; palatine teeth in four patches; tail very long, .94 to 1.05 of length of body (from snout to behind anus), strongly compressed throughout, becoming very thin at the distal end; digits long, distance from wrist to tip of longest finger in length of head and body 9.27–10.6, distance from ankle to tip of longest toe in length of body 6.8–7.57.

Habitat.—Southeastern Iowa.

Type-specimen.—Cat. No. 48598, U.S.N.M.; Bloomfield, Davis County, Iowa, July 27, 1906; Mr. George H. Berry, collector. Paratypes No. 48599, U.S.N.M., and Nos. 41971–41972, University of Michigan Museum.

Description of type-specimen.—Costal grooves 12. Tongue longitudinally oval. Palatine teeth in four patches, the central two the largest, the four groups forming an angle with the point about opposite the middle of the internal nares and the sides extending below and slightly beyond the outer margin of the choanæ.

Form slender as in *A. macrodactylum*. Head broad and depressed; greatest width about two-thirds of the distance from snout to gular fold; width between anterior end of orbits about three-fourths of greatest width; distance between eye and end of snout about one-

half of greatest width and about one-third of the distance between end of snout and gular fold. Body depressed, distance from axil to groin 2.1 in total length (exclusive of tail). Tail very long, 1.03 times length of head and body (to behind anus), very strongly compressed throughout, but more so distally, becoming very thin at the end. Digits relatively long; distance from wrist to tip of longest finger contained in length of head and body 10 times; distance from ankle to tip of longest toe in length of head and body 7 times.

The ground color is brown, shading from dark brown along the dorsal stripe to plumbeous on the flanks. There is a well-defined dorsal stripe extending from the end of the snout along the vertebral region to the distal fourth of the tail. This stripe is narrow on the snout, expands into a large triangular spot behind the eyes, contracts again to form a medium wide stripe on the body, and is narrowly restricted to the dorsal margin of the tail, becoming obscure on the distal fourth. There are faint evidences of pale blotches on the limbs (see notes on paratypes).

Additional notes on paratypes.—The other specimens agree closely in proportions (see measurements) and color with the type. They differ in that the pale spots on the limbs are more distinct; there is a small round pale spot above each eye, and the occipital expansion of the dorsal stripe incloses more or less completely a dark brown spot.

Measurements.

	U. M. M. 41971.	U. S. N. M. 48598.	U. M. M. 41972.	U. S. N. M. 48599.
	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>	<i>mm.</i>
Snout to anus.....	51	52.5	53	48.5
Tail.....	Broken.	54	50	51
Snout to eye.....	4	4	4	4
Snout to gular fold.....	12	11.75	12.5	11.5
Snout to axil.....	18	17.5	16.5	17
Axil to groin.....	21	24.5	27.5	21
Width of head.....	8	7.5	8	7.5
Between anterior end of orbits.....	5.5	5.5	5.5	5
Nostrils.....	3.5	3.5	3.5	3.5
Humerus.....	5.5	6	5.75	5.5
Elbow to tip of longest finger.....	11	11.5	10	10.5
Wrist to tip of longest finger.....	5.5	5.25	5	5
Free part of longest finger.....	3.5	3	3	3
Thigh.....	5.5	5	5.25	5.5
Knee to tip of longest toe.....	13	13.5	13	12.25
Ankle to tip of longest toe.....	7.5	7.5	7	6.75
Free part of longest toe.....	4.75	5	4.5	4.5

Remarks.—*A. stejneri* is, with little doubt, most nearly related to *A. macrodactylum*. It may easily be told from the latter by the longer and more compressed tail. The anterior digits also appear to be longer than in *macrodactylum*. In the specimens of the latter examined the distance from the wrist to the tip of the longest finger is contained in the length of the head and body 12.6 and 12.7 times as compared with 9.27, 9.7, 10, and 10.6 times in *A. stejneri*.

Habits.—Mr. Berry has kindly sent me the following account of the habits of the specimens obtained: “The locality in which they occurred was a basin in a tract of timber, which I should judge would contain quite an amount of water in the spring months, but which at the time was nearly dry, although still damp. In this situation we obtained them [six specimens] under decaying red cedar logs. They were scarce, the six specimens representing a whole day’s search. They are very active.”

A REVIEW OF THE SPARIDÆ AND RELATED FAMILIES
OF PERCH-LIKE FISHES FOUND IN THE WATERS OF
JAPAN.

By DAVID STARR JORDAN and WILLIAM FRANCIS THOMPSON,
Of Stanford University, California.

In the present paper is given a review of the species of fishes belonging to those percomorphous families allied to the Sparoid fishes, or fishes related to the tai or porgy of the waters of Japan, which have not been hitherto discussed in these pages by the senior author and his associates. The families of Kuhliidæ, Priacanthidæ, Theraponidæ, Banjosidæ, Hæmulidæ, Sparidæ, Kyphosidæ, and Erythrichthyidæ are thus included.

The paper is based on material collected in Japan in 1900 by Professors Jordan and Snyder and now divided between the United States National Museum and the museum of Stanford University. Most of the cuts are from drawings by Mr. Sekko Shimada.

The families here named are adopted provisionally only. The distinctions between Sparidæ, Hæmulidæ, Lutianidæ, and their relatives are of doubtful value, while at present no definite boundaries can be assigned to the Serranidæ.

1. Family KUHLIIDÆ.

Body oblong, strongly compressed; scales large, ciliated. Lateral line complete, the tubes straight and occupying the half or more of the exposed surface of the scale. Mouth rather large, protractile; maxillary exposed, without supplemental bone; teeth in jaws in villiform bands; teeth on vomer, palatines, entopterygoids, and ectopterygoids; tongue smooth; head partly naked; preorbital and preopercle denticulate; opercle with 2 spines. Gill membranes separate; 6 branchiostegals; pseudobranchiæ large; gill-rakers long and slender. Dorsal fins connected at the base, with X, 9 to 13 rays, the spinous portion longer than the soft. Anal as much developed as the soft dorsal, with III, 10 to 12 rays. Dorsal and anal fins fitting in a well-developed sheath. Caudal emarginate. Pectorals obtusely pointed, with 14 or 15 rays, upper the longest. Ventrals behind base of pec-

torals, close together, with a strong spine. Posterior processes of the premaxillaries not extending to the frontals; supraoccipital bone extending forward to between the post-frontal processes, its crest not extending on the upper surface of the cranium; parietals short, without crest. Precaudal vertebræ with transverse processes behind the fourth; ribs, all but the last 2 to 4, sessile, inserted on the centrum behind the transverse processes. Vertebræ 25 (10 or 11 + 14 or 15). Two genera with 7 or 8 species inhabiting the Pacific Ocean, especially fresh and brackish waters of East Africa, and the islands of the Indian and Pacific Oceans and north Australia, some species strictly marine. Doctor Boulenger has shown in *Kuhlia* the presence of skeletal characters of the American family of sun fishes, Centrarchidæ. In his Catalogue, *Kuhlia* is placed in the latter family, but there are important differences and the natural character of the group Centrarchidæ disappears if these fishes are introduced. We therefore continue to recognize the family of Kuhlidiæ as distinct. In appearance, as in habit, the species of *Kuhlia* resemble the black bass.

Key to genera.

- a*¹. Maxillary short, $2\frac{2}{3}$ in head; soft dorsal and anal long and low; gill-rakers 10+25; peritoneum black. Marine species *Boulengerina*, 1.
*a*². Maxillary long, 2 to $2\frac{1}{3}$ in head; soft dorsal and anal shorter and higher; gill-rakers about 9+18; peritoneum silvery, dotted. Species inhabiting rivers. . . *Kuhlia*, 2.

1. Genus BOULENGERINA Fowler.

Boulengerina FOWLER, Journ. Acad. Nat. Sci. Phila., 1906, p. 512.

Type.—*Dules mato* Lesson = (*Dules malo* Cuvier and Valenciennes).

This genus includes the marine species of Kuhlidiæ, with the mouth relatively small, the maxillary $2\frac{1}{3}$ in length of head, the caudal deeply forked, the soft dorsal and anal fins long and low, the scales relatively small, and the body silvery in color, gill-rakers about 10 + 25. Tropical Pacific, especially about coral reefs.

(Named for George Albert Boulenger of the British Museum.)

1. BOULENGERINA TÆNIURA (Cuvier and Valenciennes).

GINDOKUGYO (poison silver perch).

Dules tæniurus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1829, p. 114 (Java).—BLEEKER, Verh. Bat. Gen. Kunst. Wet., vol. 22, Pisc., 1849, p. 49 (Pagotang, Java).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 267 (Chinese Seas).—KNER, Reise *Novara*, Fische, 1860, p. 47 (Tahiti).

Paradules tæniurus BLEEKER, China, Ned. Tijd. Dierk., vol. 4, 1873, p. 139.

Moronopsis tæniurus KLUNZINGER, Fische Roth. Meer., 1884, p. 25.

Kuhlia tæniura JORDAN and BOLLMAN, Proc. U. S. Nat. Mus., vol. 12, 1889, p. 159, name only).—BOULENGER, Cat. Fish. Brit. Mus., 2d ed., 1895, p. 39 (Socotra, Zanzibar, Seychelles, Port Natal, South Africa, Mauritius, Laccadives, China, Tahiti).—JORDAN and SEALE, Fishes Samoa, Bull. U. S. Bur. Fish., vol. 25 (1905), 1906, p. 255 (Tutuila, Samoa, Johnston Island, Marcus

Island, Tubuai, Paumotu Island, Tahiti).—JORDAN and STARKS, Fishes Tanega and Yaku, Proc. U. S. Nat. Mus., vol. 30, 1906, p. 698 (Tanegashima).—SEALE, Fishes South Pacific, Bishop Mus., vol. 4, No. 1, 1906, p. 34 (Fate, New Hebrides).

Percu argentea BENNETT, Fish. Ceylon, 1830, pl. 22, (Ceylon).

Dules argenteus KLUNZINGER, Syn. Fische Roth. Meer., Verh. z. b. Ges. Wien., vol. 20, 1870, p. 730 ("Zweibrüderinseln, Koseir").—GÜNTHER, Fische Südsee, 1873, p. 25, pl. 19, fig. C (Tahiti, Kingsmill Islands).—DAY, Fishes India, 1875, p. 67, pl. 18, fig. 2 (India); Fauna India, vol. 1, 1889, p. 504.

Dules bennetti PETERS, Monatsber. kön. Akad. Wiss. Berlin, 1855, p. 432 (Mozambique, fresh water).—GÜNTHER, Cat. Fish. Brit. Mus., 1859, vol. 1, p. 270 (no locality).

Kuhlia arge JORDAN and BOLLMANN. Proc. U. S. Nat. Mus., vol. 12, 1889, p. 159 (Chatham Island, Galapagos Archipelago).—JORDAN and EIGENMANN, Bull. U. S. Fish. Comm., vol. 8, 1890, p. 419.—JORDAN and EVERMANN, Fishes N. and M. Amer., vol. 1, 1898, p. 1014 (Clarion Island, Chatham Island), (American specimens, the eye described as a little smaller, but in fact agreeing entirely with Samoan examples).

Habitat.—Coral reefs of the tropical Pacific from the offshore islands of Mexico to Japan and East Indies.

Description of numerous small specimens, the longest 65 mm. in length, from Tanegashima, Japan, collected by Anderson and Anderson, and of two adults, 210 and 225 mm. in total length, from Okinawa, one adult from Misaki, besides four from Samoa, and one from Lord Howe Island in Australia, agreeing with the Japanese specimens in all regards. Specimens typical of *Kuhlia arge* from offshore islands of Mexico are also included.

Head $3\frac{3}{8}$ in body length; depth $2\frac{3}{8}$; eye 3 in head; snout 4; maxillary, $2\frac{3}{8}$; interorbital space 3; D. IX-I, 10; A. III, 11; scales in lateral line 53, in transverse series $6\frac{1}{2}$ -11 or 12 from insertion of dorsal to anal; gill-rakers 10+25.

Body profile not symmetrical, highest part of line of back much behind lowest part of belly line; that of head straight dorsally; the width of body lessening quickly from above lateral line to the narrow ventral edge; caudal peduncle long, from last anal rays to last vertebra contained $1\frac{1}{8}$ in head, and as long as anal base. Tip of snout at or above middle point of eyes. Maxillary short, not extending beyond anterior third of eyes; mandible articulated under anterior half of eye, its length $2\frac{1}{8}$ in head. Preorbital and preopercle serrated very plainly, the latter's angle somewhat produced and emarginate on the vertical border. Lower opercular spine not extending behind upper pectoral base. Teeth on vomer and palatines rather feeble in adults, those on jaws in one row laterally in mandible, in upper jaw in a moderately broad band.

Dorsal spines stiff, fourth highest, contained $1\frac{1}{2}$ in head, penultimate two-thirds length of last, which is 3 in head. First ray $2\frac{1}{2}$ in head, twice length of last; fin base contained $1\frac{3}{8}$ in head. Second anal spine nearly as long as third, which is one-third of head length.

First ray, $2\frac{1}{2}$ in head, twice length of last, fin outline slightly concave, its base, including spines $1\frac{1}{6}$ in head. Pectoral somewhat sharp, its length $1\frac{2}{3}$ in head. Ventrals short, 2 in head, extending slightly over halfway to anal insertion. Anus halfway between anal spines and tip of ventral. Caudal deeply forked, lobes acute.

Color in alcohol uniform, silvery on sides and below, somewhat darker above. Dorsals margined with black, caudal tipped on both lobes, with oblique stripes from base of outer rays to tips of inner, and a median one along whole length of central two rays. Peritoneum dense black.

The young of this species was seen by Doctor Jordan in a tide pool at Misaki, besides the specimens above mentioned from Tanegashima, an offshore island of southern Japan. We have compared the types of *Kuhlia arge* with this species, and we are sure that no difference exists.

This species, unlike most others of the family, is strictly marine, living outside the coral reefs, the young entering tide pools among the rocks.

Kuhlia xenura Jordan and Gilbert, described from specimens alleged to come from Salvador, seems to be the same as *Boulengerina sandvicensis* (Steindachner) (*Kuhlia malo*, var. *sandvicensis*) from Hawaii.

(*ταβία*, ribbon; *ὄσπα*, tail.)

2. Genus KUHLIA Gill.

Kuhlia GILL, Proc. Acad. Nat. Sci. Phila., vol. 13, 1861, p. 48 (*ciliatus*).

Moronopsis GILL, Proc. Acad. Nat. Sci. Phila., vol. 15, 1863, p. 82 (*marginatus*).

Paradules BLEEKER, Ned. Tijd. Dierk., vol. 1, 1863, p. 257 (*marginatus*).

Type.—*Perca ciliata* Kuhl and Van Hasselt.

Body oblong, much compressed; head compressed; mouth short, oblique; maxillary without supplemental bone, relatively long, 2 to $2\frac{1}{2}$ in head; lower jaw projecting; no canines; the teeth subequal; pre-orbital sharply serrate; angle of preopercle without strong spine. Gill-rakers slender, about 9+18 in number, smaller and fewer than in *Boulengerina*. Pseudobranchiæ large. Scales moderate, not very rough; lateral line distinctly arched in front; top of head naked. Dorsal fin deeply notched, but not divided to base, with 10 slender spines; caudal lunate; anal spines graduated, the fin relatively short and high. Coloration bright silvery, mottled with dark olive, the peritoneum silvery, or spotted with brown. Tropical Pacific, the species inhabiting clear streams and pools at the foot of waterfalls, with the habit of the American black bass.

(Named for Kuhl, a naturalist, associate of Van Hasselt, and the discoverer of the typical species in the streams of Java.)

2. *KUHLIA MARGINATA* (Cuvier and Valenciennes).

DOKUGYO (poison perch).

Dules marginata CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1829, p. 116, pl. 3 (Java).—BLEEKER, Sumatra, Nat. Tidj. Ned. Ind., vol. 3, 1852, p. 573, (Padang).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 268, (Java, Amboyna; Fiji); Fische Südsee, 1873, p. 24 (Sumatra, Java, Amboyna).—DAY, Fishes India, 1875, p. 67, pl. 18, fig. 1 (seas of India).

Paradules marginatus BLEEKER, Ned. Tidj. Dierk., vol. 1, 1863, p. 257.

Kuhlia marginata BOULENGER, Cat. Fish. Brit. Mus., 2d ed., vol. 1, 1895, p. 33 (New Guinea, etc.).—PERUGIA, Ann. Mus. Civ. St. Nat. Genova, ser. 2, vol. 16, 1896, p. 48.—JORDAN and EVERMANN, Fishes Formosa, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 340 (Kotosho).—ISHIKAWA, New and Little Known Fish., Proc. Dep. Nat. Hist. Tokyo Imp. Univ., vol. 1, 1904, p. 9, pl. 3, fig. 1 (Wadamura and Tojingawa, Idzu, Japan).—JORDAN and RICHARDSON, Bull. U. S. Bur. Fish., vol. 27, 1908, p. 233 (Aparri, Mindoro, P. I.); Fish. Formosa, Mem. Carnegie Mus., vol. 4, 1909, No. 4, p. 183; Check List P. I. Bur. Sci. Publ., No. 1, Manila, 1910, p. 25.

Dules maculatus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 7, 1831, p. 475 (Celebes).—?BLEEKER, Nat. Tijds. Ned. Ind., vol. 5, 1853, p. 33 (Amboyna), (said to be different from *Dules marginata* Cuvier and Valenciennes).

Dules malo HOMBRON and JACQUIMOT, Voy. Pôle Süd. Dumont d'Urville, Poiss., 1846, pl. 3, fig. 4 (not of Cuvier and Valenciennes).

Moronopsis ciliatus BLEEKER, Arch. Neerl. Soc. Holl. Sciences, Harlem, vol. 7, 1872, p. 376 (Java, Bali, Sumatra, Nias, Celebes, Batjan, Buro, Amboyna, Ceram), (composite species?).—BLEEKER, Atlas Ichth., vol. 7, p. 120, pl. 316, fig. 1; pl. 324, fig. 2 (localities as above), (not of Kuhl and Van Hasselt).

?*Dules ciliatus* MACLEAY, Proc. Linn. Soc. N. S. Wales, vol. 7, 1882, p. 237 (New Guinea), (= "*marginatus*, *maculatus*, *malo*.").

Dules papuensis MACLEAY, Proc. Linn. Soc. N. S. Wales, vol. 8, 1883, p. 257 (New Guinea, Goldie River).

Dules species? ISHIKAWA, Prel. Cat. Tokyo Imp. Mus., vol. 1, 1897, p. 55 (Wadamura, Izu, Japan).

Habitat.—East Indian, Chinese, and Japanese Seas.

Description of a specimen from Kotosho, Formosa, 138 mm. in total length; 7 from Apia, Samoa, the longest 145 mm.; 2 from Mindoro, Philippine Islands, 210 and 140 mm. in length; that from Formosa described in particular. Measurements include lower jaw.

Head $3\frac{1}{2}$ in body length; depth $2\frac{5}{8}$; eye $3\frac{1}{2}$ in head; maxillary $2\frac{1}{2}$; snout $3\frac{3}{4}$; interorbital space $3\frac{1}{3}$; D. X, 11; A. III, 11; scales in lateral line 42, in transverse series $5\frac{1}{2}$ –8 between insertions of dorsal and anal; gill-rakers on lower limb of first arch 16; branchiostegals 6.

Body symmetrical on upper and lower outlines, evenly arched; body not much thinner ventrally; depth of caudal peduncle $2\frac{2}{3}$ in head, its length $1\frac{2}{3}$ in head. Tip of snout at level of center of eyes; nostrils nearer tip of snout than center of eye; maxillary ending under anterior half of pupil; length of mandible half that of head, ending below center of eye. Preorbital coarsely serrate, its teeth directed more backwards than in *K. rupestris*. Preopercular margin more finely serrate, vertical edge slightly emarginate, horizontal one

straight, the angle slightly produced. Opercle with two stout spines. Teeth bristle like, on vomer, in \wedge -shaped band, on jaws and palatines in narrow bands, that on upper jaw several times as broad as that of lower jaw, which is in two or three series.

Dorsal spines stiff, fifth contained $1\frac{4}{5}$ in head; the penultimate 3 in head, last 2; longest dorsal ray 2 in head, first not extending beyond base of last when supine; fin outline truncate, base of soft dorsal $1\frac{2}{3}$ in head. Soft anal base slightly longer than that of soft dorsal; third anal spine $2\frac{2}{3}$ in head; first soft ray extending to base of seventh. Pectoral $1\frac{1}{2}$ in head. Ventrals extending to anus, $1\frac{1}{2}$ in head. Caudal forked, rather deeply, inner rays slightly more than half length of outer, measuring from last scales, but two-thirds from last vertebra.

Color in alcohol somewhat silvery below lateral line, much darker above, frequently in irregular spots. Soft dorsal and anal narrowly edged with white, black submarginally; spinous dorsal edged with black; caudal dark, edged with darker. Peritoneum silvery, spotted with brown.

This species is nearest allied to *Kuhlia rupestris*, another river species from the same regions. It varies principally in a shorter maxillary, shorter head, mandible, number of transverse series of scales below the lateral line, form of soft dorsal, anal, of caudal, and in more spotted peritoneum. In all these characters and in physiognomy it approaches slightly to *Boulengerina*.

Our Formosan specimen and the two from Mindoro, Philippine Islands, correspond very closely, save for a somewhat shorter first anal spine, longer soft dorsal base, and wider spread opercular spines in the former. Since the number of specimens we have is so small, it is very likely that these are individual variations. The Formosan specimen has the first anal spine 0.055 of body length to last vertebra; soft dorsal base 0.2; and spread of opercular spines 0.05. The Samoan specimens have one more scale above and one more below in transverse series, and gill-rakers 8 to 10 + 22 to 24 (instead of 8 + 15 to 17).

The synonymy of this species, now current and given in part above, is nearly worthless because of the great probability of variation in these fresh-water fishes from island to island. There are at least two species included in Boulenger's *Kuhlia marginata*, and it is very probable that there are more. The Samoan specimens, at least, are not identical with those here described. We have no Japanese specimens of this fish. A memorandum of Doctor Jordan refers to a specimen from Izu, in the Imperial Museum in Tokyo. This is mentioned by Ishikawa as "*Dules* sp."

(*marginatus*, edged.)

2. Family PRIACANTHIDÆ.

The CATALUFAS.

Body oblong or ovate, compressed, covered with small, firm, rough scales; all parts of the body and head, even the snout and maxillaries, being densely scaly, each scale with a more or less developed plate on its posterior border, most developed in the young. Head deep. Mouth large, very oblique, the lower jaw prominent. Villiform teeth on jaws, vomer, and palatines, none on the tongue. Premaxillaries protractile. Maxillary broad, without supplemental bone, not slipping under the very narrow preorbital, which is usually serrate; no suborbital stay. Eye very large, forming about one-half the length of the side of the head. Posterior nostril long, slit-like, close to the eye. Preopercle more or less serrated, one or more strong spines at its angle; operculum very short, ending in two or three points behind; no barbels. Gill membranes separate, free from the isthmus. Pseudobranchiæ very large, extending along whole length of opercle. Postorbital part of head very short, the opercle small. Gills 4, a slit behind the fourth. Gill-rakers long. Branchiostegals 6. Lateral line continuous, not extending on the caudal. Dorsal fin continuous, its rays X, 9 to 15, the spines depressible in a groove; anal rays III, 9 to 15, the soft part long, similar to the soft dorsal, the spines strong; ventrals very large, thoracic, I, 5, close together, in advance of base of pectoral, joined to belly by a membrane which incloses a groove; no axillary process; spine strong; pectorals small, pointed, not symmetrical, of 19 or 20 rays, the upper longest; caudal fin truncate or lunate. Spines of fins generally rough with small serræ. Air bladder large. Pyloric cœca few. Vertebræ in reduced number, 9 or 10 + 13 = 22 or 23, the first vertebra being very small or absent; transverse processes beginning on the seventh (sixth) vertebra, the last 2 precaudals bridged across; ribs attached to the transverse processes; epipleurals absent on the last three precaudal vertebræ. Supraoccipital crest very low, continued forward to over front of orbit, where it is joined by the parietal crests; processes of premaxillaries moderate. Carnivorous fishes of the tropical seas, chiefly in deep waters; mostly rose-colored in life. The family is a sharply defined group, not close to any other, but the affinities on the whole seem to be nearest to the Serranidæ and their tropical allies. Genera 2, species about 10.

Key to genera.

- a¹. Scales very small, 80 to 100 in lateral line; body oblong, its depth not half its length; preopercle with a flat spine; dorsal and anal each with 12 to 15 soft rays *Priacanthus*, 3.
a². Scales large and very rough, 35 to 50 in lateral line; body ovate, its depth more than half its length; preopercle without spines; dorsal and anal each with 9 to 11 soft rays *Pseudopriacanthus*, 4.

3. Genus **PRIACANTHUS** (Cuvier) Oken.

Les Priacanthus CUVIER, Règne Animal, 1817, p. 281 (*macrophthalmus*).

Priacanthus OKEN, Isis, 1817, p. 1783 (same type).

Type.—*Anthias macrophthalmus* Bloch (= *Sciæna hamrur* Forskål).

Scales very small, 80 to 100 in the lateral line; body oblong, more than twice as long as deep; preopercle with a spine at angle; interorbital area externally transversely convex, the cranium itself transversely concave, the elevation being formed of flesh; a conspicuous foramen in the interorbital area; lateral line extending upward and backward from upper angle of gill opening toward second dorsal spine, below which it changes its course, following outline of back to end of dorsal fin, thence direct to middle of caudal; anal fin rather long, its rays about III, 14; dorsal rays about X, 14. Species rather numerous in the tropical seas.

(*πρίων*, saw; *ἄκανθα*, spine; some of the fin spines being serrated.)

Key to genera.

- a*¹. Scales in transverse series above lateral line 9 to 11; posterior nostrils not widely open; tenth dorsal spine not more than twice length of second, not three-fifths of head; scales 97–100; anterior margin of preopercle covered with scales.
1. Dorsal rays X, 14 or 15; anal rays III, 14 or 15; depth of body about equal to head; preopercular spine weak and lobes of caudal slightly produced in adult. *hamrur*, 3.
- b*². Dorsal rays X, 12 or 13; anal rays III, 12 to 14; depth greater than head; preopercular spine strong; lobes of caudal not produced in adult . . . *macracanthus*, 4.
- a*². Scales in transverse series above lateral line 20 to 22; posterior nostrils widely open; tenth dorsal spine more than twice length of second, at least three-fifths of head; dorsal rays X, 12; anal rays III, 12; scales 87 to 93; anterior margin of preopercle not covered, serrated *japonicus*, 5.

PRIACANTHUS HAMRUR (Forskål).**BAKAKINME** (fool gold eye).

Sciæna hamrur FORSKÅL, Descr. Anim., 1775, p. 45 (Djidda, Red Sea).

Anthias hamrur BLOCH and SCHNEIDER, Syst. Ichth., 1801, p. 307 (after Forskål).

Lutjanus hamrur LACÉPÈDE, Hist. Nat. Poiss., vol. 4, 1802, pp. 178 and 209.

Priacanthus hamrur CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1829, p. 104 (Lohaia).—RÜPPELL, N. W. Fische, 1835, p. 95 (Red Sea).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 219 (Red Sea).—KLUNZINGER, Syn. Fische Roth. Meer., Verh. z. b. Ges. Wien, vol. 20, 1870, p. 708 (part).—BLEEKER, Ned. Tijd. Dierk., vol. 4, 1873, p. 176 (Java, Sumatra, Batu. Celebes, Sangi, Ternate, Batjan, Buro, Amboyna) (part); Atlas Ichth., vol. 7, 1876, p. 13, pl. 353, fig. 3 (after Ned. Tijd. Dierk., vol. 4).—STEINDACHNER and DÖDERLEIN Beitr. Fische Japan's I, Denkschr. Akad. Wiss. Wien, vol. 47, 1883, p. 239 (Tokyo).—KLUNZINGER, Fische Roth. Meer., 1884, p. 17.—DAY, Fauna India, Fish. vol. 1, 1889, p. 482.—SAUVAGE, Poiss. Madag., 1891, p. 125 (Amboyna).—MACLEAY, Proc. Linn. Soc. N. S. Wales, vol. 7, 1883, p. 235 (New Guinea).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 83.—SEALE, Fishes South Pacific, Bishop Mus., vol. 4, No. 1, 1906, p. 38, fig. 12 (Shortland Island, Solomons).—JORDAN and SEALE, Fishes Samoa, Bull. U. S. Bur. Fish., vol. 25 (1905),

1906, p. 261.—EVERMANN and SEALE, Bull. U. S. Bur. Fish., vol. 26 (1906), p. 78, 1907 (Bulan P. I.).—JORDAN and RICHARDSON, Bull. U. S. Bur. Fish., vol. 27, 1908, p. 257 (Calayan); Check List, P. I. Bur. Sci. Publ., No. 1, Manila, 1910, p. 27.

Anthus macropthalmus BLOCH, Ichthyologia, 1792, pl. 319 ("Japan").

?*Priacanthus speculum* CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 7, p. 471, 1831 (Mahe).—VALENCIENNES, in Cuvier, Règne An. Illust. Poiss., 1836, pl. 11, fig. 1.—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 221 (after Cuvier and Valenciennes).—PLAYFAIR, Proc. Zool. Soc., 1867, p. 850.—SAUVAGE, Poiss. Madag., 1891, p. 117, pl. 14, fig. 2 (Bourbon Island, Seychelles).

Priacanthus dubius TEMMINCK and SCHLEGEL, Fauna Japonica, 1842, p. 19 (Nagasaki).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 221 (after Temminck and Schlegel).

Priacanthus japonicus BLEEKER, Nat. Tijd. Ned. Ind., vol 2, 1851, p. 171 (Siboga, East Sumatra), (not of Cuvier and Valenciennes).

Priacanthus blochii BLEEKER, Batavia, Nat. Tijd. Ned. Ind., vol. 4, 1853, p. 456 (Batavia, Siboga) (part).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 218 (Moluccas, Amboyna).—DAY, Fishes India, 1875, p. 48.

?*Priacanthus schlegeli* HILGENDORF, Sitzungb. Ges. Nat. Freunde, 1879, p. 79, Tokyo.

Habitat.—Coasts of Asia, occasionally northward to Japan.

Description after Boulenger, as we have no Japanese specimens.

Head $3\frac{1}{4}$ to $3\frac{1}{2}$ in total length; depth 3 to $3\frac{1}{2}$; eye $2\frac{1}{3}$ to $2\frac{1}{2}$ in head without mandible; snout one-half to two-thirds diameter of eye; interorbital space $3\frac{1}{2}$ to 4 in head; D. X, 14–15, A. III, 14–15; scales above lateral line 100–120; in lateral line 75–80; in transverse series 9–11–38–46; gill-rakers 18 to 23 on lower limb of first arch.

Spine at angle of preopercle short, indistinct in old specimens. Dorsal spines gradually increasing in length to the last, which is $1\frac{1}{2}$ to $1\frac{3}{4}$ as long as second and one-half to three-fifths length of head; longest soft rays not much longer than longest spine; spines feebly spinulose in the young, merely striated in the adult; soft rays feebly spinulose. Pectoral one-half to three-fifths length of head. Ventral nearly as long as head, the spine three-fifths to two-thirds its length. Third anal spine as long as sixth or seventh (of the) dorsal; the spinules on the spines disappearing in the adult. Caudal crescentic in the adult; the lobes more or less produced. Scales spinulose. Red above, silvery beneath, the fins usually blackish toward the edge.

Total length, 360 mm.

Boulenger records specimens from Red Sea, Zanzibar, Seychelles, Ceylon, Madras, Amboyna, and Japan.

Our specimen from Calayan, Philippine Islands, shows these measurements: Head (including lower jaw) $3\frac{1}{4}$ in body length; depth $2\frac{1}{2}$ in body; maxillary 2 in head; snout 3 in head without mandible, or seven-eighths diameter of eye; scales in lateral line 72, in series above 97, in transverse between insertions of dorsal and anal 11–41. The difference in scales and in other regards may indicate a different species than that of Boulenger. His measurements and counts have a wide variation and it is quite possible that he includes more than

one species under the name of *Priacanthus hamrur*. It may be that the Japanese form should stand as *Priacanthus dubius* Temminck and Schlegel, or, better, as *Priacanthus macropthalmus* (Bloch), as Bloch's specimens were reported to come from Japan.

The black ventral spot supposedly characteristic of *Priacanthus dubius* is also found in the East Indian fish, and there are no direct measurements available by which we can judge of its depth, which is said to be greater. It may be that more than the single species is found in both Japanese and East Indian Seas, but we have no facts which will justify a separation or division of the current synonymy.

The changes which this fish undergoes with age seem to be rather marked, if they are not attributable to a confusion of two species. The caudal is first truncate, then becomes very crescentic, the lobes much produced, and the spine on the preopercle much shorter in the adult. The body loses its transverse bands of color, if it ever possessed them. Sauvage describes a specimen 8 inches long with truncate caudal and long spine, and other authors figure specimens with caudal emarginate. *Priacanthus schlegeli* of Hilgendorf has a truncate caudal, long spine, and transverse bands, leading one to believe it a young specimen of *P. hamrur*. However, he gives the head as much shorter, and the depth greater. His description is translated as follows:

Br. 6, D. 10/14, A. 3/15, L. 1. ca. 85, L. tr. /44. Depth $2\frac{1}{2}$ times in length (with caudal). Head $3\frac{2}{3}$ in body length; diameter of eye $2\frac{1}{2}$ in head; length of snout over one-half eye diameter; interorbital breadth two-thirds eye diameter. Preopercle with a long flat spine, extending over the subopercle; posterior and lower borders forming a large blunt angle, both thickly and finely toothed, the vertical intramarginal border entirely buried by scales. Opercle with two weak spines. Fourth dorsal spine longest. Caudal truncate. Scales ctenoid. Red with five dark crossbands. Ventrals black. (Museum of Berlin, No. 10599.)

This species is referred by Doctor Boulenger to the synonymy of the American species, *Priacanthus cruentatus*. This is doubtless incorrect, as the ventrals in the latter are not black, and the scale count does not correspond, although this, as well as the fin-ray count, may be due to different methods of enumeration.

It has not been recorded by any later authors.

4. PRIACANTHUS MACRACANTHUS Cuvier and Valenciennes.

BENIMEBARU (red pop-eye); KINME (gold eye).

Priacanthus macracanthus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1829, p. 108 (Amboyna).—BLEEKER, Verh. Bat. Gen. Kunst. Wet., vol. 22, 1849, p. 48 (Batavia).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 220 (Japan).—CASTELNAU, Proc. Linn. Soc. N. S. Wales, vol. 3, 1878, p. 369 (Port Jackson).—SAUVAGE, Poiss. Madag., 1891, p. 125 (part).—ISHIKAWA, Prel. Cat. Tokyo Imp. Mus., vol. 1, 1897, p. 55.—BOULENGER, Cat. Fish. Brit. Mus., 2d ed., 1895, p. 354 (Japan, Formosa, off Banda, Arafura Sea, Port Jackson).—JORDAN and SNYDER, Proc. U. S. Nat. Mus., vol. 23, p. 358, 1901 (Toyko); Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 83 (Yokohama).

Priacanthus benmebari TEMMINCK and SCHLEGEL, Fauna Japonica, 1844, p. 19, pl. 7, fig. 1 (Japan).—RICHARDSON, Ichth., China and Japan, 1846, p. 237.—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 218 (Japan); Ann. and Mag. Nat. Hist. (3), vol. 20, 1867, p. 57 (Sydney).—NYSTRÖM, Jap. Fisksaml., K. Svenska Vet. Akad., vol. 13, 1887, Afd. 4, No. 4 (Nagasaki).—GÜNTHER, Challenger Rep., Zool., vol. 1, pt. 6, 1880, p. 39 (Arafura Sea).

Priacanthus bleekeri, CASTELNAU, Proc. Zool. Soc. Victoria, vol. 2, 1873, p. 100 (according to Boulenger).

Priacanthus hamrur BLEEKER, Atlas Ichth., vol. 7, 1876, p. 13 (part).—SAUVAGE, Poiss. Madag., 1891, p. 125 (part).

Habitat.—Australian, East Indian, and Japanese Seas.

Description of two specimens from Tokyo and Nagasaki, respectively 163 and 305 mm. in total length. Head measurements include lower jaw.

Head $3\frac{1}{4}$ in body length; depth of body $2\frac{3}{4}$; eyes $2\frac{3}{4}$ in head; maxillary $2\frac{1}{5}$; snout $3\frac{1}{3}$; interorbital space 4; D. X, 13; A. III, 14; scales in lateral line 75–78, above 97–103, below 76–80, in transverse series between insertions of dorsal and anal 10 or 11/36; gill-rakers 3 or 4 + 21.

Breadth of body two in its depth, depth of caudal peduncle two-thirds of eye diameter. Interorbital space but very slightly arched, bone width one-half eye diameter. Gular space much swollen, produced as rounded ridge below borders of dentaries. Nostrils not open widely, but valved. Preopercle with strong flat spine at angle, its tip reaching junction of sub- and interopercles, and usually single; its base usually two-fifths to one-half of its length, which is 4 in eye. Posterior margin of preopercle serrate throughout, and on lower side of spine, but not on upper. Subopercle and interopercle entire, as well as anterior edge of preopercle. Opercle with one short blunt spine and an upper point. Teeth minute in \wedge shaped band on vomer, in narrow bands on palatines, a single row on jaws.

Dorsal spines long, flexible, spinulose on alternate sides, fitting into groove when supine; second two-thirds of length of last, which is 2 in head. Dorsal rays soft, spinulose on both sides; first eight or nine of equal length, $1\frac{7}{8}$ in head, last reaching but halfway to end of caudal peduncle. First anal spine two-thirds of length of third, which is contained $2\frac{1}{3}$ in head; anal rays $1\frac{7}{8}$ in head. Pectoral $1\frac{3}{8}$ in head. Ventrals equal to head; their spines $1\frac{1}{2}$ in head; tip of rays reaching second anal spine, spinulose on lower side, the innermost attached to body by membrane. Base of spinous dorsal contained $2\frac{7}{8}$ in body length; of soft dorsal $4\frac{1}{8}$; of anal $2\frac{7}{8}$. Caudal nearly truncate.

Scales roughly ctenoid, hard to the touch, broad, bases three pronged, present over whole of head save lips, absent on all fins.

Color of alcoholic specimens uniform yellowish silvery, apparently red in life. Membranes of ventrals with a few much faded spots. The vertical fins are said to be spotted in life with olive brown.

This species is not very common in southern Japan. Our specimens are from Tokyo and Nagasaki. It is close to *Priacanthus cruentatus* of the West Indies, but the latter species has rougher spines. The types of *Priacanthus macracanthus* came from Amboyna, and it may possibly be that the Japanese species, *Priacanthus benmebari* Temminck and Schlegel, is really different.

(μακρός, long; ἄκανθα spine.)

5. PRIACANTHUS JAPONICUS Cuvier and Valenciennes.

CHIKAMEKINME (near-sighted gold eye).

Priacanthus japonicus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1829, p. 106, pl. 50 (Japan).—TEMMINCK and SCHLEGEL, Fauna Japonica, 1844, p. 20 (Nagasaki).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 217 (Japan).—STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's, I, Denkschr. kais. Akad. Wiss. Wien., vol. 47, 1882, p. 239, and Beitr. II, vol. 48, 1883, pl. 1, fig. 1 (Japan).—ISHIKAWA, Prel. Cat. Tokyo Imp. Mus., vol. 1, 1897, p. 55 (Tokyo Market).

Priacanthus supraarmatus HILGENDORF, Sitzungb. Ges. Nat. Freunde, 1879, p. 79 (Japan).

Priacanthus boops STEINDACHNER and DÖDERLEIN, Reise Aurora, Ann. Nat. Hofmus. Wien., vol. 11, 1896, p. 198 (Inland Sea of Japan).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 83 (Yokohama).—BOULENGER Cat. Fish. Brit. Mus., 2d ed., vol. 1, 1895, p. 357 (part from Japanese and Chinese Seas, not synonymy), (not *Anthias boops* Forster).

Habitat.—Coasts of southern Japan.

Described from two specimens 235 and 290 mm. in total length from Bingo in Kiusiu, one 210 mm. from Misaki, and one 280 mm. from Tokyo. All head measurements including lower jaw.

Head $2\frac{2}{3}$ in body length; depth 2 or $2\frac{1}{4}$; eye $2\frac{1}{2}$; maxillary $2\frac{1}{2}$ or 2; snout $3\frac{1}{2}$; interorbital space two-thirds eye diameter; D. X, 12; A. III, 12; scales in lateral line 56, above 87-93, below 75, in obliquely transverse series between insertions of dorsal and anal 20 to 22/45; gill-rakers 6+18; branchiostegals 7.

Body deep, width $2\frac{2}{3}$ in depth; profile straight from tip of lower jaw to insertion of dorsal, arched most strongly along bases of soft dorsal and anal. Depth of caudal peduncle two-thirds of eye diameter. Tip of lower jaw produced in a prominent knob. Interorbital space but slightly arched. Posterior nostril widely open, its width one-third of its length; anterior nostril small, posterior edge flapped. Suborbital bones coarsely serrated on both edges; preopercle serrated somewhat less coarsely on both margins, its anterior marginal ridge serrated, not covered by scales, spine not extending as far back as does interopercle; opercle not serrated, its spine not pointed but serrated at tip; sub- and interopercle finely toothed, as is whole exposed margin of shoulder girdle. Teeth small, pointed, in two rows in both jaws, lacking at premaxillary symphyses, and in three or four rows at the mandibular; in vomer in a \wedge shaped band; on palatines in narrow bands.

Dorsal spines strong, not flexible, spinulose on alternate sides but only at base; length gradually increasing to last, which is twice the second and contained $1\frac{2}{3}$ in head. First dorsal ray $1\frac{1}{2}$ times as long as tenth spine and equal to head; other rays abruptly shortening from third, leaving fin acutely angular, its point reaching to base of caudal in well-developed specimens, but always to last scales in adults. Anal spines similar to dorsal, third twice the first, and half length of head. Soft anal similar to soft dorsal but not as long, its first rays $1\frac{1}{3}$ in head. Both dorsal and anal rays spinulose on both sides. Pectorals $1\frac{7}{8}$ in head, spinulose on outer base. Ventrals reaching to first or second ray of anal, length equal to head plus one-third eye, their spines $1\frac{1}{2}$ in head; spines and rays spinulose below. Caudal truncate.

Scales hard, finely toothed, present everywhere save on fins and lips. A row of modified scales present on upper edge of premaxillary and on anterior bordering membrane of eye. Scales of snout and lower jaw much modified, thick, rough, and hard. Bases of scales truncate.

Color in alcohol uniform; evidently red above and silvery below. Membranes of dorsal and ventral fins black, others colorless. Peritoneum silvery.

This species is moderately common on the coasts of southern Japan. We have it from Bingo, Misaki, and Tokyo.

Priacanthus supraarmatus of Hilgendorf is said to have "D. A. und V. schwarz," but differs in no other regard.

From Günther's *Priacanthus boops* (= *P. macropus* Quoy and Gaimard), *P. japonicus* differs in a larger eye and greater depth, judging by the description; and according to Sauvage, also in the form of the scale, which is truncate across the basal end in *P. japonicus*, while it is three-pointed in *P. boops*. From *P. alticlarens*, our fish differs in the much less prominent opercular spine, greater depth and larger eye, judging from the figure by Sauvage of that species.¹ It seems entirely probable that *P. japonicus* has not yet been observed south of the Chinese Seas, nor in the Atlantic Ocean, although Boulenger has identified it with *Priacanthus boops* (Forster) of the South Atlantic, and *P. alticlarens* (Valenciennes) from Bourbon, near Madagascar. We have no material for comparison.

4. Genus PSEUDOPRIACANTHUS Bleeker.

Pseudopriacanthus BLEEKER, Versl. kon. Akad. Wet. Amst., (2), vol. 3, 1869, p. 241 (*niphonius*).

Type.—*Priacanthus niphonius* Cuvier and Valenciennes.

Scales large, very rough, 35 to 50 in the lateral line; body broad, ovate, not twice as long as deep; preopercle with 2 small spines at

¹ Poiss. Madag., p. 127, pl. 16, fig. 3.

angle; interorbital space broad and flat, there being little flesh between skin and skull; posterior free edge of cheek above edge of preorbital serrated; post-temporal and scapular bones strongly serrate; eye very large; preopercular spine obsolete; no foramen in interorbital area; lateral line changing its course below the fourth dorsal spine; middle dorsal spines longest; anal short, its rays III, 9 to 11; dorsal X, 11. Otherwise essentially as in *Priacanthus*, the species living in deeper water.

(φευδής, false; *Priacanthus*.)

6. PSEUDOPRIACANTHUS NIPHONIUS (Cuvier and Valenciennes).

KURUMADAI (wheel porgy); **KINKODAI** (little gold porgy).

Priacanthus niphonius CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1829, p. 107 (Japan).—TEMMINCK and SCHLEGEL, Fauna Japonica, 1844, p. 21, pl. 7A (Nagasaki).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 217 (Japan).—BLEEKER, Verh. kon. Nat. Ver. Neder., Ind., vol. 8, 1860, p. 73 (Japan).—STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's, I, Denkschr. kais. Akad. Wiss. Wien, vol. 47, 1883, p. 239 (Tokyo, Oshima).

Pseudopriacanthus niphonius BLEEKER, Versl. kon. Akad. Wet. Amst., (2), vol. 3, 1869, p. 241 (Japan); Atlas Ichth., vol. 7, 1876, p. 14, pl. 350, fig. 5, and 354, fig. 3 (Japan).—BOULENGER, Cat. Fish. Brit. Mus., 2d ed., 1895, p. 358 (Japan; Manado, Celebes).—JORDAN and SNYDER, Check List, Ann. Zool. Japan, vol. 3, pts. 2 and 3, 1901, p. 83 (Yokohama).

Priacanthus meyeri GÜNTHER, Proc. Zool. Soc., 1871, p. 656, pl. 67 (Manado, Celebes).—SAUVAGE, Bull. Soc. Philom., (7), vol. 6, 1882, p. 168; Poiss. Madag., 1891, p. 131.

Habitat.—Japanese Seas, recorded once from Celebes, in East Indian Seas.

Description after Boulenger, of a specimen 275 mm. long.

Head $2\frac{1}{2}$ to 3 in total length; depth 2 to $2\frac{1}{4}$; snout one-third to one-half diameter of eye; eye $1\frac{1}{8}$ to 2 in head without mandible; interorbital width 3 to $4\frac{1}{2}$ in head; D. X, 11 or 12; A. III, 10 or 11; scales in lateral line 34–40, in series above 55–59, in transverse series 5 or 6/30 to 34; gill-rakers on lower part of first arch 17.

Dorsal originating above base of pectoral; spines strongly striated, middle longest two-thirds to three-fourths length of head and as long or longer than longest soft rays. Pectoral three-fifths to two-thirds length of head. Ventral about three-fourths length of head; second and third anal spines nearly equal, as long as tenth dorsal; caudal rounded. Color red above, silvery beneath; the soft fins edged with blackish; young with dark crossbands.

Steindachner and Döderlein say that their specimens had 48 to 52 scales above the lateral line, and that the ventrals reached usually to the anal insertion. According to the plate given by Temminck and Schlegel, the young have black dorsals and anals.

This rare species of the deeper waters of Japan was not seen by us.

Boulenger identifies *Priacanthus refulgens* of Sauvage with this species, but a transverse scale count of 8/24 is given, the eye is as

long as the snout, and the figure¹ shows an entirely different fish, as can easily be seen by a comparison with Günther's figure of the type of *Pseudopriacanthus meyeri* (Celebes) and the excellent figures of Temminck and Schlegel. It is worthy of note that the present species has been found but once beyond the waters of Japan, namely, in Celebes. Günther's figure of this specimen corresponds exactly with those of Temminck and Schlegel.

(*Nippon* or *Nippon*, the native name of Japan, which word is a corruption of *Nippon*.)

3. Family THERAPONIDÆ.

Body oblong, covered with moderate or small scales. Mouth moderate, with villiform teeth, the outer sometimes enlarged; those on the vomer and palatines deciduous or wanting. Maxillary slipping beneath the preorbital. Branchiostegals 6. Preopercle serrated; opercle with one or two strong spines; preorbital entire or serrate. Dorsal fin notched, with 12 or 13 stout spines. Anal spines 3, strong. Air bladder divided into two parts by a constriction. Pyloric cæca in moderate number. Carnivorous fishes of the tropical seas, referable to two genera. The family, here provisionally adopted, differs from *Hæmulidæ* in having the aid bladder constricted, and externally in having deciduous teeth on the vomer, and in having the opercle, as in the *Serranidæ*, armed with spines.

5. Genus THERAPON Cuvier.

Terapon CUVIER, Règne Animal, vol. 1, ed. 1, 1817, p. 295 (*servus*), (error of transcription for *Therapon*).

Pelates CUVIER, Règne Animal, vol. 1, ed. 2, 1829 (*quinquelineatus*).

Therapon CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1829, p. 125 (*servus*).

Datnia CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1829, p. 138 (*datnia*).

Pterapon GRAY, Indian Zoology, about 1835 (emendation for *Terapon*).

Mesopristes BLEEKER, Atlas Ichth., no description.

Eutherapon FOWLER, Journ. Acad. Nat. Sci. Phila., 1904, p. 527 (*theraps*; scales 55.)

Type.—*Holocentrus servus* Bloch.

This genus includes those *Theraponidæ* in which the teeth in the jaws are simple, villiform, or conic. In some species (*Eutherapon*) the scales are rather large. In some (*Pelates*, *Datnia*), the snout is more or less prolonged and the dorsal undivided.

(*θεράπων*, a slave; suggested by the name *servus*.)

Key to species.

a¹. *Therapon*. Dorsal deeply divided; the last spine much longer than the penultimate; teeth in outer row enlarged, wide set; opercle with a strong spine.

¹ Poiss. Madag., pl. 5, fig. 5.

- b*¹. Snout short; gill-rakers 8+13; scales about 18-95-33; maxillary ending under pupil; bands on body 3 in number, curved, the convexity downward; spinous dorsal with a large black spot *servus*, 7.
- a*². *Pelates*. Dorsal fin not deeply divided, the last two spines subequal; teeth all villiform, the outer scarcely enlarged; opercular spines weak.
- b*². Snout produced; gill-rakers 8+13; peritoneum pale; scales 15-72-22; maxillary ending under nostrils; body bands straight, 4 strong and 4 alternating weaker ones; spinous dorsal broadly margined with black, no large spot present. *oxyrhynchus*, 8.

7. THERAPON SERVUS (Bloch).

YAGATAISAGI (arrow bass).

Holocentrus servus BLOCH, Ichthyologia, pl. 238, 1797, fig. 1 (Japan).

Grammistes servus BLOCH and SCHNEIDER, Syst. Ichth., 1801, p. 185 (Japan), (after Bloch).

Therapon servus ISHIKAWA, Prel. Cat., 1897, p. 55 (Wadamura, in Izu, Miyakojima.)

Therapon jarbua SMITH and POPE, Proc. U. S. Nat. Mus., vol. 31, 1907, p. 476 (Kochi).—JORDAN and STARKS, Proc. U. S. Nat. Mus., vol. 32, 1907, p. 495 (Okinawa).—JORDAN and RICHARDSON, Fishes of Formosa, Mem. Carnegie Mus., vol. 14, 1909, No. 4, p. 187 (Takao), (not *Sciæna jarbua* Forskål).

Habitat.—Coasts of Asia, north to Japan.

Description of 7 specimens from Kagoshima, Japan, ranging from 69 to 157 mm. in body length, the largest taken as typical.

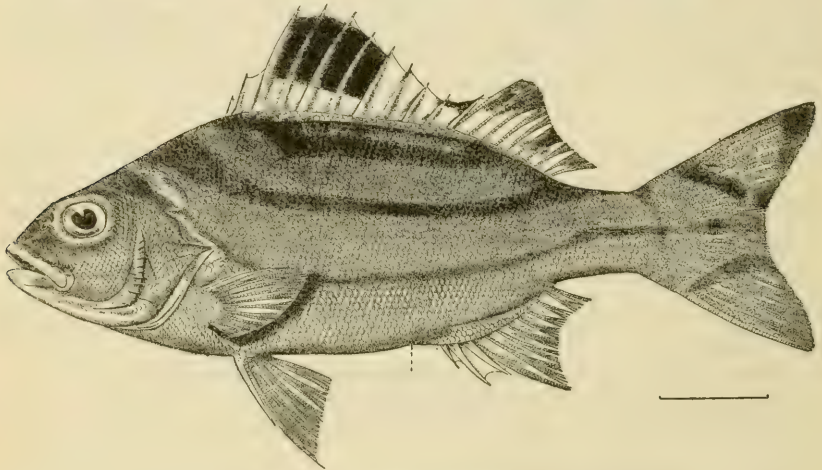


FIG. 1.—THERAPON SERVUS.

Head with spine 3 in length to last vertebra; depth $2\frac{2}{3}$; eye 5 in head with spine; snout $3\frac{1}{2}$; maxillary $2\frac{2}{3}$; least width of preorbital $8\frac{1}{2}$; D. X or XI, I, 10; A. III, 8 or 9; scales in longitudinal series¹ above lateral line 86 to 107 (usually 90 to 105); in longitudinal series below 83 to 93; in transverse to origins of dorsal and anal 17 to 20+30 to 34; gill-rakers 8+13; branchiostegals 6.

Snout somewhat arched in profile; interorbital space flat, narrowing quickly before eyes, ridged above temporal region; jaws equal,

¹ Those that run upward and backward.

maxillary ending under pupil. Preorbitals coarsely serrate on lower margin, their greatest width 7 in head. Preopercle toothed strongly at angle, less strongly above, three larger teeth at angle very acute in adults, longest less than half diameter of pupil. Serrations on lower limb abruptly smaller. Two opercular spines, the upper nearly obsolete, lower very strong, extending the distance of length of maxillary from hinder margin of preopercle. Clavicle with five coarse teeth, pointing back and upwards, of nearly same size as those of preopercle. Post-temporal serrated similarly to preorbital. Teeth in outer row conical, somewhat canine-like, not closely set, larger near middle of jaw; inner bands villiform, and smaller in size. Teeth on vomer and palatines present in young, but deciduous or few in number in adults.

Dorsals deeply divided; first spine very small, usually lacking in adults and much longer in the very young. Fourth and fifth spines longest, slightly less than two in head; penultimate three-fourths of eye diameter; last $4\frac{1}{2}$ in head, adnate to first ray, which is $2\frac{1}{2}$ in head. Second anal spine $3\frac{2}{3}$, third 4 in head, or equal to the second. First anal rays nearly twice length of third spine. Soft dorsal, anal, and caudal margins deeply concave. Pectorals short, 2 in head. Ventrals $1\frac{1}{2}$ in head, not reaching anus.

Scales small, roughly ctenoid, absent on inter- and preopercle, suborbital regions, snout and jaws. A temporal band of four or five series of scales present; a low sheath present along bases of dorsal and anal.

Body with three concentric black bands, first along bases of dorsals from first spines to first rays, leaving a clear space above in which lies a black streak from sixth to tenth dorsal spines; second from nuchal region to last dorsal rays, its upper edge passing through lateral line, but not below; third narrower, from occiput to middle caudal rays, fourteen scale rows below lateral band at its middle. A black blotch on spinous dorsal from fourth to seventh spines, another from ninth to eleventh or twelfth. First four soft rays tipped with black on distal halves, as are sixth and seventh, frequently a black spot present on last two rays. Caudal with central longitudinal stripe, an oblique band above and below, and upper lobe tipped with black. Other fins colorless. Peritoneum clear.

We have specimens of what is generally termed the same species from Formosa (2); Swatow, China (4); Samoa (2); Australia (2); Arabia (1); Manila, Cavite, and San Fabian, Philippine Islands (5); and Sumatra (1). Of these the Arabian specimen seems to be distinct in several respects. Its body bands are more convex, the upper nearly touching the lateral line, the second dropping four or five scales below the lateral line instead of as above. The maxillary ends under the anterior margin of the eye instead of the pupil; the body

depth is less for its size; the third anal spine is shorter, as is the anal base, the ventrals and ventral spine. Of the others, the Sumatran and Philippine specimens show only 80 to 83 scales in longitudinal series above the lateral line (90 to 105 in Japanese) and the size of the eye is greater than that of the Japanese, usually less than $4\frac{2}{3}$ in head. The Australian specimens correspond closely to the Japanese. The Samoan examples have slightly larger eyes and have the same scale counts as those of the East Indies. The Chinese and Formosan specimens correspond to the Japanese in scale counts, but have larger eyes, probably due in part to the smaller size of the specimens. The preopercular serrations of the East Indian fish are seemingly blunter than those of the Japanese. Outside of these characters no differences have been discovered in color or measurements. Since the scale counts differ so greatly, the Japanese species is probably not the same as that of the East Indies, Philippines, and Samoa, and is the same as the Formosan and Chinese form. The Arabian specimen must be taken as typical of *Sciæna jarbua* Forskål.¹ It should stand as *Therapon jarbua*, while the Japanese species is *Therapon servus*. We have specimens of this species from Kagoshima. Others from Izu and Miyakojima are in the Imperial Museum.

(*servus*, slave.)

Scale counts in longitudinal series above lateral line in *Therapon servus* and *Therapon jarbua*.

Number of scales.....	75.	80.	83.	86.	90.	95.	100.	105.
Japan (<i>servus</i>).....				1	1	1	2	2
China and Formosa (<i>servus</i>).....					1	3	2	
Australia (<i>servus</i>).....					1	1		
Samoa (<i>jarbua</i>).....	1	1						
East Indies (<i>jarbua</i>).....		2	4					

8. THERAPON OXYRHYNCHUS Temminck and Schlegel.

Therapon oxyrhynchus TEMMINCK and SCHLEGEL, Fauna Japonica, 1842, p. 16, pl. 6, fig. 3 (Nagasaki).—BLEEKER, Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, p. 64 (Japan).—RICHARDSON, Ichth. China and Japan, 1846, p. 239.—GÜNTHER Cat. Fish. Brit. Mus., vol. 1, 1859, p. 281 (Japan, China, India).—BLEEKER, Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 7 (Nagasaki, Shimoda).—STEINDACHNER and DÖDERLEIN, Beitr. II, Denkschr. kais. Akad. Wiss. Wien, 1883, p. 10 (Tokyo).—NYSTRÖM, Jap. Fisksaml., K. Svenska Vet. Akad., vol. 13, 1887, Afd. 4, No 4, p. 9 (Nagasaki).—JORDAN and SNYDER, Proc. U. S. Nat. Mus., vol. 23, 1900, p. 355 (Tokyo).—SMITH and POPE, Proc. U. S. Nat. Mus., vol. 31, 1907, p. 475 (Kochi, Matsushima Bay).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 78.

Habitat.—Seas of Japan, China, and India.

Description of numerous specimens from Shimiju, Suruga, Wakanaoura, Kagoshima, Nagasaki, Akune, Nagaoka, and Tokyo, Japan; and Swatow, China. Length from 60 to 195 mm.

¹ Descr. Animal, 1775, p. 50.

Head 3 to $3\frac{1}{2}$ in body; depth 3 to $3\frac{1}{2}$; maxillary 3 in head; longitudinal diameter of eye 5; snout $2\frac{1}{2}$; interorbital space $3\frac{2}{3}$ to $4\frac{1}{3}$; D. XII, 10; A. III 8. Scales above lateral line to base of caudal 72, below 60 to 70, with 51 pores, in transverse series between insertions of dorsal and anal $15/22$ to 25; gill-rakers 8+15.

Dorsal and ventral contours of body similarly arched, the dorsal profile of head straight; snout conical, long, somewhat pointed; mouth small, maxillary ending before eye, under nostrils; lower jaw included; eye small, set rather low, leaving interorbital space convex from side to side; preorbital border serrated, that of preopercle at angle with strong teeth about one-fourth of eye diameter in length, diminishing in size above, with rather fine serræ on lower limb; opercle with two spines, the upper smaller than those on preopercle, the lower over half diameter of eye in length, flat and strong; clavicle set with teeth about half as long and strong as those on preopercle; post-temporal with much smaller teeth. Teeth in jaws small, conical, set in many rows anteriorly in both jaws and posteriorly in upper, but in two rows posteriorly in lower; outer rows only slightly larger, not closely set as in *Therapon quadrilineatus*; none on vomer, palatines or tongue. Gill-rakers short, stout, one-third of eye diameter in length.

Dorsals not deeply divided; spines strong; fourth, fifth, and sixth longest, $2\frac{1}{2}$ in head, last $3\frac{1}{2}$ in head, equal to the preceding spine; dorsal rays $2\frac{2}{3}$ in head, fin outline convex. Anal spines stout, second longest, $2\frac{2}{3}$ in head; first anal ray one-third longer, fin border straight. Pectoral small, $1\frac{3}{4}$ in head, slightly shorter than ventrals. Caudal short, 2 in head, concave.

Scales present everywhere on body save preorbital, dorsal surface of head, lips, and mandible. Dorsals and anal naked, save for a moderate sheath of scales; caudal scaled on basal half.

Colors somewhat variable in intensity, a specimen from Wakanoura almost black above and very dark below, others grayish silvery. Pattern constant, of four strong, longitudinal brown stripes, as broad as pupil, the third from snout, through eye to caudal, and of four fainter stripes alternating with these; all running down on snout, save that on middle of back and the lowermost; spinous dorsal with basal and distal bands, latter broader, former continued on soft dorsal; body bands not continued on caudal, which is irregularly mottled; other fins colorless. Peritoneum and gill cavities clear.

This species is very different from *Therapon servus*, and it should perhaps be placed in a different genus. It is, however, not closely related to the type of *Pelates*. This species is not rare on the coasts of southern Japan, as far north as Matsushima Bay.

A third species, *Therapon quadrilineatus* (Bloch), allied to *T. oxyrhynchus* and common in the East Indies, is mentioned by Bleeker as from "Japan." The record is probably from the Riu Kiu Islands.

The species has the gill-rakers 16 + 21, the scales 14–83–18, the bands on the body 4 in number and straight, the spinous dorsal with a large spot.

(ὀξύς, sharp; ῥογχός, snout.)

4. Family BANJOSIDÆ.

A small group of percoid fishes, allied to the Hæmulidæ, to the Serranidæ, and to the Histiopteridæ.

Body rather robust, covered with small firm scales. Mouth moderate, the maxillary mostly sheathed; outer teeth of jaws short and thick, the inner villiform; vomer with villiform teeth; no teeth on the palatines. Gill structures as in the Hæmulidæ. Dorsal fin deeply notched, the rays X, 12, the spines all very long, strong, and flattened; anal short, with three strong spines. Caudal slightly notched. Preopercle finely serrate; opercle and suborbital bones entire.

A single species of the seas of southeastern Asia.

6. Genus BANJOS Bleeker.

Anoplus TEMMINCK and SCHLEGEL, Fauna Japonica, 1842, p. 17 (no specific name; name preoccupied by *Anoplus* Schönherr, 1826, a genus of beetles).

Banjos BLEEKER, Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 7. (*typus*).

The characters of this genus are included above.

Type.—*Banjos typus* Bleeker = (*Anoplus banjos* Richardson).

(From the Japanese *Banzai*, signifying long life.)

9. BANJOS BANJOS (Richardson).

BANZAIDAI: CHOSENBAKAMA (Korean garment; a fish dressed in a Korean bakama or cloak).

Banjos Voy. de Krusenstern, pl. 54, fig. 1a.

Anoplus TEMMINCK and SCHLEGEL, Fauna Japonica, 1842, p. 17, pl. 8 (Nagasaki).

Anoplus banjos RICHARDSON, Ichth. China and Japan, 1846, p. 236 (after Temminck and Schlegel).

Banjos typus BLEEKER, Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 7, No. 112.

Anoplus banjos STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's, II, Denkschr. kais. Akad. Wiss. Wien, 1883, p. 7 (Tokyo).—JORDAN and RICHARDSON, Fishes Formosa, Mem. Carnegie Mus., vol. 4, No. 4, 1909, p. 188 (Formosa).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901 p. 82 (Yokohama).—JORDAN and SNYDER, Proc. U. S. Nat. Mus., vol. 23, 1900, p. 357 (Tokyo).

Habitat.—Coasts of southern Japan and of China.

Described from a single specimen 225 mm. in length, collected at Tokyo by the U. S. Bureau of Fisheries steamer *Albatross*, recorded by Jordan and Snyder (1900).

Head 3 in body length, depth 2; eye $3\frac{1}{2}$ in head; snout $2\frac{1}{3}$; inter-orbital space (bone) $4\frac{2}{3}$; preorbital $3\frac{2}{3}$; D. X., 12; A. III, 7; scales

above lateral line 71, with pores 50; in transverse series between insertions of dorsal and anal, 13/32; branchiostegals 7; gill-rakers 5+14.

Body very deep, dorsal profile high, straight from snout to occiput, slightly arched to insertion of dorsal; base of spinous dorsal nearly straight, that of soft dorsal descending quickly to caudal peduncle, which tapers quickly in depth from the last dorsal ray. Ventral profile but slightly arched to anal base, which rises quickly to caudal peduncle. Mouth low; snout narrow, a trifle pointed; eyes large; interorbital space flat, with two low central ridges; nostrils small, close together, not far removed from eye; preorbital two-thirds as

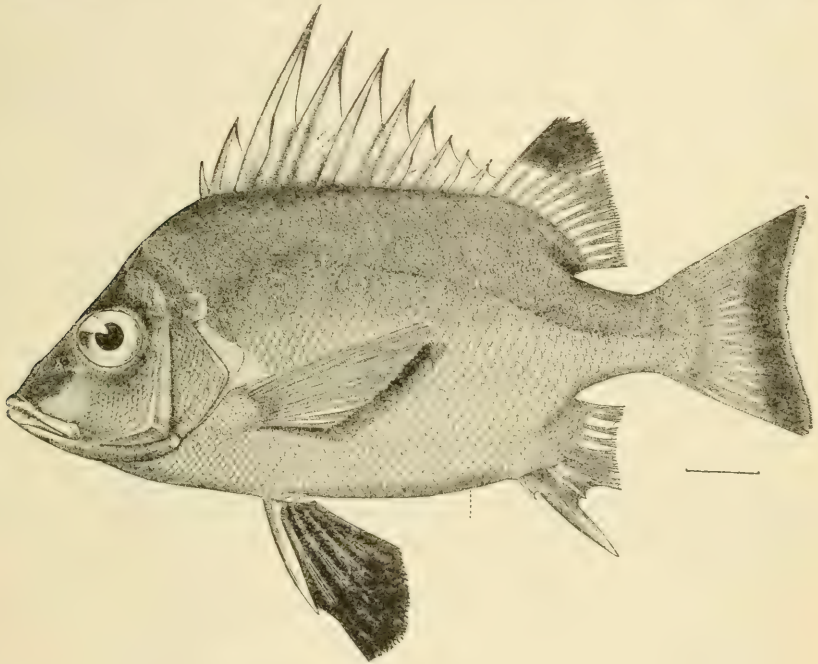


FIG. 2.—BANJOS BANJOS.

long as deep; maxillary ending under anterior border of eye, almost completely sheathed by preorbital. Preopercular margin forming a right angle, slightly concave on vertical margin near angle, very finely serrated on both. Opercle without spines, but one soft point present. Teeth in outer series of both jaws bluntly conical, of moderate size, and closely set, inner band three rows wide, of smaller but similar teeth. Vomerine teeth present, very short, thick and conical, almost molar. Gill-rakers short, thick, those on lower limb of first arch 8 in eye, those on upper only stubs.

Dorsals deeply divided; dorsal spines very large and strong, third longest, $1\frac{1}{2}$ in head, last short, $4\frac{1}{2}$ in head. Outline of spinous dorsal from third to last spine nearly straight. Longest dorsal ray $1\frac{1}{8}$ in

head. Anal spines very strong, second $1\frac{5}{8}$ in head, third weaker and shorter, $3\frac{1}{2}$ in head. Anal rays shorter than second spine, fin outline concave. Pectorals falcate, equal to length of head. Ventrals as long as head less one-half eye diameter, their spines two-third of their length, very strong. Caudal emarginate.

Scales not strongly ctenoid, present on bases of soft dorsal and anal, and in a sheath at base of spinous dorsal; absent on dorsal surface of head, preorbitals, and along margins of preopercle.

Color in alcohol uniform, olivaceous, darker above on body and head, the latter much more so. Spinous dorsal margined slightly with black; soft dorsal, anal, and caudal narrowly with white. First five rays of soft dorsal tipped with a black spot below white margin. Caudal submargined with black. Peritoneum and gill cavities clear.

Steindachner describes the color of the young as follows: Color whitish, with 7 or 8 broad dark longitudinal bands on the body, parallel to each other, and set with darker spots. On the caudal are three crossrows of spots, of which the middle row is smaller than the others and indistinct. The spots on the posterior row lie very close to the caudal margin, one very large, and deep blackish brown. A larger black spot is present between the three last dorsal spines and another white-margined one on the upper part of the first dorsal rays. The anal has one not very sharply margined between the second spine and third ray. Tips of the upper and lower rays of the caudal white. Ventrals deep black, pectoral yellow, with a dark spot at its base.

This species is rare in Japan and apparently not common anywhere. The specimen described was taken in the Tokyo market. We have later found it in abundance in the market of Osaka, and at Fusan, in Korea. It is known as Banzaidai.

5. Family HÆMULIDÆ.

The GRUNTS.

Body oblong, or more or less elevated, covered with moderate-sized, adherent scales, which are more or less strongly ctenoid or almost cycloid; lateral line well developed, concurrent with the back, usually not extending on the caudal fin; head large, the crests on the skull usually largely developed; no suborbital stay; mouth large or small, usually terminal, low and horizontal; premaxillaries protractile, their spines not greatly produced backward; maxillary without supplemental bone, for most of its length slipping under the edge of the preorbital, which forms a more or less distinct sheath; preorbital usually broad; teeth all pointed, none of them forming marked canines; no teeth on the vomer, palatines, or tongue; lower pharyngeals separate, with pointed teeth; gills 4, a large slit behind the fourth; pseudobranchiæ large; gill-rakers moderate;

gill membranes separate, free from the isthmus; preopercle serrate; opercle without spines; sides of head usually scaly; dorsal fin single, continuous or deeply notched, sometimes divided into two fins, the spines usually strong, depressible in a groove; the spines heteracanthous, that is, alternating, the one stronger on the right side, the other on the left, the spines 9 to 14 in number; anal fin similar to the soft dorsal, with 3 spines; ventral fins thoracic, I. 5, with a more or less distinct scalelike appendage at base; caudal fin usually more or less concave behind; air bladder present, simple; stomach cæcal; pyloric cæca few; vertebræ usually 10+14=24. Branchiostegals usually 6 or 7. Cranium with its muciferous system moderately developed or rudimentary. Intestinal canal short. Carnivorous fishes of the warm seas, most of them valued as food. Genera about 12; species nearly 130. The group is very close to the Lutianidæ on the one hand and to the Sparidæ on the other, while some of its members show affinities with certain Scienidæ and Serranidæ.

Key to genera.

a¹. Chin without central groove.

b¹. PLECTORHYNCHINÆ. Preorbital scaly, its margin unarmed; soft parts of vertical fins scaly at base.

c¹. Dorsal without antrorse spine; chin without barbels; caudal emarginate or forked; scales small, over 100.

d¹. Gill-rakers rather long and slender, 7+11; dorsal spines 14; preorbital narrow; body rather elongate; anal rays III, 8, the fin with a scaly sheath.

Parapristipoma, 7.

d². Gill-rakers short and thick, about 16+24; preorbital broad; dorsal spines 9 to 12; body rather deep.....*Plectorhynchus*, 8.

c². Dorsal preceded by an antrorse spine; lower jaw with a tuft of small barbels or papillæ, the tip of snout papillate; caudal rounded; scales about 66; dorsal spines 11.....*Hapalogenys*, 9.

b². SCOLOPSINÆ. Preorbital scaled; soft part of vertical fins naked; dorsal spines 10; scales large, about 38; gill-rakers very short and blunt, 6+5.

e¹. Preorbital with a free posterior margin; a spine or other serrations on suborbital.....*Scolopsis*, 10.

7. Genus PARAPRISTIPOMA Bleeker.

Parapristipoma BLEEKER, Archiv. Neerl. Soc. Sci. Harlem, vol. 8, 1872, p. 4.

Type.—*Perca trilineata* Thunberg.

This genus is allied to *Plectorhynchus*, with which it agrees in lacking the central groove at the chin, characteristic of *Hæmulon*, *Pomadasis*, and their relatives. The body is relatively slender, covered with small scales. Dorsal fin continuous, with 13 or 14 rather slender spines. Anal III, 8. Preorbital unarmed; preopercle with fine serræ. Snout and jaws scaly; soft parts of vertical fins scaly at base, the anal with a scaly sheath.

One species of the Japanese seas.

The South American genus *Isacia* Jordan and Fesler (*Isacia conceptionis*) is closely related, differing mainly in the long anal (III, 13), which has a slight scaly sheath.

(*παρά* near; *Pristipoma*, an allied genus properly called *Pomadasis*.)

10. PARAPRISTIPOMA TRILINEATUM (Thunberg).

ISAKI, ISSAKI, ISAGI.

Perca trilineata THUNBERG, Beskr. 2 nya Fiske, Kongl. Vet. Acad. nya Handl., vol. 14, 1793, p. 55, pl. 1, fig. 2 (Nagasaki, Japan).

Parapristipoma trilineatum BLEEKER, Arch. Neerl. Soc. Holl. Sci. Harlem, vol. 8, 1872, p. 4 (Kiusiu and China).

Pristipoma japonicum CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 288 (Japan).—TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 60, pl. 26, fig. 2 (southwest coast of Japan).—RICHARDSON, Ichth. China and Japan, 1846, p. 228 (China).—BLEEKER, Vierde Beitr. Verh. Kon. Nat. Ver. Neder. Ind. (Act. Soc. Reg. Scient. Ind. Neerl.), vol. 3, 1857, p. 14 (Nagasaki).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 303 (Chinese seas).—NYSTRÖM, Jap. Fisksaml., K. Svenska Vet. Akad., vol. 13, Afd. 4, 1887, No. 9, p. 9 (Nagasaki).—STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's II, Denkschr. kais. Akad. Wiss. Wien, vol. 48, Abth. 1, 1883 (Tokyo).

Diagramma japonicum BLEEKER, Nalez. Ichth. Japan, Verh. Bat. Gen., vol. 25, 1852, p. 31, pl. 17, fig. 1 (Japan).

Diagramma aporognathus REGAN, Ann. and Mag. Nat. Hist., ser. 7, vol. 16, 1905, p. 18 (Inland Sea of Japan).

Habitat.—Coasts of Japan and China.

Described from 35 specimens from Tokyo, Misaki, Enoshima, Wakanoura, and Nagasaki, from 30 to 295 mm. in length.

Head $3\frac{1}{2}$ in body; depth 3 to $3\frac{1}{3}$; eye 4 in head; maxillary 3; pre-orbital width $2\frac{3}{4}$ in eye; interorbital, 3 in head; snout equal to interorbital width; dorsal rays XIV, 17; A. III, 8. Scales above lateral line 106 to 115, below 85, between lateral line and spinous dorsal 12, between lateral line and anal 17; between insertions of dorsal and anal $\frac{1}{2}\frac{8}{4}$. Gill-rakers 16 + 24.

Dorsal profile more highly arched than ventral, that of head nearly straight; caudal peduncle $2\frac{1}{2}$ times as long as deep. Snout rounded, rather short; mouth strongly oblique, lower jaw slightly projecting; maxillary ending under anterior border of eye, not all sheathed by preorbital; eyes set low, leaving interorbital area high and arched. Teeth feeble, minute, present on jaws only, in a narrow band anteriorly, a single row posteriorly. Preopercle with fine serræ nearly same in strength as teeth. Opercle with spines almost lacking. Gill-rakers slender, their length half diameter of eye.

Dorsal spines flexible, low, first inserted over point of opercle; fourth, fifth, and sixth longest, $2\frac{1}{2}$ in head, last equal to eye. Dorsals not divided, rays not appreciably higher than last spine. Anal spines stout, long, third $2\frac{1}{3}$ in head, slightly shorter and weaker than the second, first very short, $2\frac{1}{2}$ in eye; first anal rays one-fifth longer than third spine, last one-half first; margin of fin straight. Pectoral

somewhat falcate, long, nearly equal to head, ventrals $1\frac{1}{2}$ in head. Caudal margin deeply concave, its angles sharp, its length slightly less than head.

Scales present everywhere, save on soft dorsal and anal, which are deeply sheathed, and on lips; a patch of scales on exposed portion of maxillary. Rows on body very oblique.

Color in spirits: adults nearly plain dark above, clearer below, with narrow stripes of darker following rows of scales, especially below lateral line. In young, three narrow clear lines as wide as pupil, cutting dark above axis of body; the second running from upper edge of eye along lateral line to upper part of caudal, the first running parallel, about midway to mid-dorsal line of body; the third from the point of opercle to middle of caudal sometimes merged into clear ventral color. These lines may persist in adults to some degree. Fins nearly as dark as body; dorsals edged with black. Peritoneum, gill, and mouth cavities clear. The body lines are variable according to preservation, and much less distinct with age. In life, dark gray, with dark streaks along the rows of scales; yellow shades on back, head, and the lower fins; dorsal spines yellow; caudal blackish. The yellow streaks distinct in the young, vanishing in the adult.

This species, known everywhere as "*Isaki*," is one of the common food fishes of Japan, taken daily at every port south of Tokyo. It was seen at Tokyo, Misaki, Enoshima, Wakanoura, and Nagasaki.

(*trilineatus*, marked with three lines.)

8. Genus PLECTORHYNCHUS Lacépède.

Plectorhynchus LACÉPÈDE, Hist. Nat. Poiss., vol. 3, 1801, p. 135 (*chætonoides*).

Les Diagrammes CUVIER, Règne Animal, vol. 1, 1817, p. 280 (*diagramma*).

Diagramma OKEN, Isis, 1817, p. 1783 (*diagramma*).

Spilotichthys FOWLER, Journ. Acad. Nat. Sci. Phila., 1904, p. 528 (*radjabon*).

Type.—*Plectorhynchus chætonoides* Lacépède.

Body oblong, compressed, the upper outline parabolic. Mouth small, horizontal, the jaws with villiform teeth. Preopercle serrate; suborbitals without spines or serræ; branchiostegals 6 or 7. Chin with pores, but with no central groove and with no barbels. One dorsal fin with 9 to 12 stout spines. Soft parts of vertical fins scaly at base. Anal spines 3. Caudal forked or emarginate. Snout and jaws not scaly. Scales small. Air bladder simple.

Species numerous, of the tropical Pacific. We here exclude the genus or subgenus *Euclatichthys* Fowler (*affinis*) with large scales and 14 dorsal spines.

(πλεκτός, joined together: ῥύγχος, snout.)

Key to species.

α¹. DIAGRAMMA. Dorsal rays about IX or X, 22; scales small, about 95 below lateral line; color dark, with white stripes, broken into spots and highly variegated in the young.....*pictus*, 11.

a². PLECTORHYNCHUS. Dorsal rays about XII, 16; scales moderate, about 65 below lateral line; color dark, with brown spots and streaks.....*cinctus*, 12.

11. PLECTORHYNCHUS PICTUS (Thunberg).

Perca picta THUNBERG, Kongl. Vet. Akad. Nya Handl., vol. 13, 1792, p. 141, pl. 5, fig. 1 (Nagasaki).

Grammistes pictus BLOCH and SCHNEIDER, Syst. Ichth., 1801, p. 190.

Lutjanus pictus LACÉPÈDE, Hist. Nat. Poiss., vol. 5, 1803, pp. 687, 688.

Diagramma pictum CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 315 (Java, Pondicherry).—TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 62 (Nagasaki).—RICHARDSON, Ichth. China and Japan, 1846, p. 227 (Hongkong).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 327.—DAY, Fishes India, 1875, p. 81, pl. 21, fig. 3.—SAUVAGE, Poiss. Madag., 1891, p. 513 (name only).

Plectorhynchus pictus BLEEKER, Ned. Tidj. Dierk., vol. 4, 1872, p. 298 (Sumatra, Nias, Pinang, Singapore, Bintang, Bangka, Java, Diuzend-insel, Bawean, Celebes, Batjan, Ternate, Ceram, Amboyna).—BLEEKER, Atlas Ichth., vol. 8, p. 24, pl. 329, fig. 4; pl. 333, fig. 2 (after above).—EVERMANN and SEALE, Bull. U. S. Bur. Fish., vol. 26 (1906), 1907, p. 84 (Bulan, Jolo).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 78.

Spilotichthys pictus JORDAN and SEALE, Bull. U. S. Bur. Fish., vol. 26 (1906), 1907, p. 22.

Perca pertusa THUNBERG, Kongl. Vet. Acad. nya Handl., vol. 14, 1793, p. 198, pl. 7, fig. 1 (Nagasaki).

Lutjanus pertusus BLOCH and SCHNEIDER, Syst. Ichth., 1801, p. 328 (after Thunberg).

Diagramma pertusum GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 321 (after Cuvier and Valenciennes).

Plectorhynchus pertusus JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 78 (after Thunberg).

Holocentrus radjabon LACÉPÈDE, Hist. Nat. Poiss., vol. 4, 1803, pp. 335, 374.—JORDAN and EVERMANN, Proc. U. S. Nat. Mus., 1903, vol. 25 (Formosa).

Anthias diagramma BLOCH, Ichthyologia, 1797, pl. 320 (East Indies).

Grammistes diagramma BLOCH and SCHNEIDER, Syst. Ichth., 1801, p. 184.

Sparus diagramma SHAW, Zool., vol. 4, 1803, p. 440, pl. 65.

Diagramma punctatum RÜPPELL, Atlas Reise nörd. Afrika, 1828, p. 126, pl. 32, fig. 2 (Northern Red Sea) (Ehrenberg).—CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 302 (Java and Batavia).—QUOY and GAIMARD, Voy. Astrol. Poiss., 1834, pl. 12, fig. 2, p. 699 (Vanikoro).—TEMMINCK and SCHLEGEL, Fauna Japonica, 1842 p. 60 (Nagasaki).—BLEEKER, Sciën. Verh. Bat. Gen., vol. 23, 1850, p. 25 (Batavia).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 323 (Red Sea, Ceylon, China).—KNER, Reise Novara Fisch., 1860, p. 54 (Java).—DAY, Fishes India, 1875, p. 83, pl. 21, fig. 4.—SAUVAGE, Poiss. Madag., 1891, p. 513 (name only).

Plectorhynchus punctatus BLEEKER, Atlas Ichth. Perc., 1875, pl. 22, fig. 1.—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 78.

Diagramma cinerascens RÜPPELL, Atlas Reise nörd. Afrika, 1828, p. 127 (Red Sea).—CUVIER and VALENCIENNES, Hist. Nat. Poiss., 1830, vol. 5, p. 307 (Trincomalee).

? *Diagramma lineatum* RÜPPELL, Atlas Reise nörd. Afrika, 1828, p. 125 (Massaua).

? *Diagramma blochii* CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 312 (Trincomalee).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 329 (after Cantor), (East Indies).

Plectorhynchus blochii CANTOR, Cat. Malay. Fish, 1850, p. 77 (Pinang).

Diagramma pœcilopterum CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 314, (Pondicherry).—TEMMINCK and SCHEGEL, Fauna Japonica, 1842, p. 62 (Nagasaki).—RICHARDSON, Ichth. China and Japan, 1846, p. 227 (Canton).—GÜNTHER, Cat. Fish. Brit. Mus., 1859, vol. 1, p. 329.

Plectorhynchus pœcilopterus JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 78.—JORDAN and EVERMANN, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 349 (Keerun and Giran, Formosa).

Diagramma ocellatum (Kuhl and Van Hasselt) CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 303 (Java).

Diagramma balteatum (Kuhl and Van Hasselt) CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 316 (Java).

Plectorhynchus balteatus CANTOR, Cat. Malay. Fish, 1850, p. 78 (Singapore).

Diagramma centurio CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 308 (Seychelles).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 322 (after Cuvier and Valenciennes).—PLAYFAIR, Fish. Zanzibar, p. 127 (according to Bleeker).

Diagramma thunbergii CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 308 (locality uncertain).—BLEEKER, Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, p. 18, No. 121 (after Cuvier and Valenciennes).

Habitat.—Indian Ocean, Red Sea, Chinese and Japanese Seas.

Described from a series, 21 in all, from Manila and Cavite, Philippine Islands, from Formosa, and from Onomichi and Nagasaki, Japan; ranging from 32 to 200 mm. in body length.

Head 3 to $3\frac{1}{2}$ in body; depth $2\frac{1}{2}$; eye 4 in head; maxillary 3; pre-orbital width 4 to $4\frac{1}{3}$; interorbital width 4; snout $2\frac{1}{2}$; D. IX or X, 21 to 23; A. III, 6 or 7; scales above lateral line 110 to 122, below 84 to 95, between insertions of dorsal and anal 16 or 17/21 to 24; gill-rakers 7 + 11 or 12.

Dorsal profile of body much more strongly arched than ventral; greatest depth of body above pectoral fin, leaving space from snout to first spine very convex with a longer slope to the caudal. Snout low, its apex half the diameter of eye below latter's lower edge; inter-orbital space convex from eye to eye; maxillary ending under anterior border of eye; lips somewhat fleshy. Teeth in jaws villiform. Pre-opercle finely serrate. Opercle with two points. Post-temporal very finely serrate. Gill-rakers short, rather stout.

Dorsal spines highest in second, which is 2 in head or $2\frac{2}{3}$ in body depth (in adult); last spine two-thirds of second, equal to first soft ray. Dorsals not divided. Last rays longest, $1\frac{2}{3}$ in head. Anal spines of same strength as dorsal, second and third subequal, $2\frac{2}{3}$ to $3\frac{1}{3}$ in head, first very short, 7 in second; anal rays $1\frac{1}{2}$ times length of spines. Caudal truncate or somewhat emarginate. Pectorals $1\frac{2}{3}$ in head, ventrals $1\frac{1}{2}$.

Scales small, ctenoid, present everywhere save tip of snout, lips, maxillary and lower jaw. Preorbital scaled. A sheath present along spinous dorsal; bases of soft dorsal, anal and caudal covered.

Color of adult in alcohol uniform on body, with indications only of rows of brown dots half as large as pupil on flanks and upper surface. Dorsal and caudal fins with similar spots, dorsals bordered with black, first part of soft dorsal broadly. Anal and ventrals tipped with black. Peritoneum, mouth and gill cavities clear.

The changes which this fish undergoes during its life, particularly in color, are apparently very marked, and have given rise to much confusion and synonymy. The depth of the body becomes greater with age, ranging from 35 to 40 hundredths of the body length; the eye varies as usual; the dorsal spines become markedly lower in proportion, being two-thirds to three-fourths of the the body depth in the young and two-fifths in adult, ranging from 15 to 25 hundredths of body length; the caudal is elongate, equal to head, and pointed, with the outer rays much shorter than the central, while in the adult the caudal becomes emarginate and but two-thirds of head length. The anal spines also shorten, as do the gill-rakers. In color the young, 32 mm. in length, described as *D. pictum* and *balteatum*, etc., shows two very broad black stripes, so broad as to become the ground color of the upper part of the body. The first runs from the snout along the bases of the dorsals to the last rays, leaving an interrupted narrow white line in the center of the head and occiput and a spot at the base of the first dorsal ray. The second stripe, its width one-third of the body depth, runs through the eye to the lower caudal rays, leaving a narrow white stripe from above the eye to the upper caudal rays. Below the second black stripe the body is clear, but sometimes showing another indistinct dark band. The dorsals are black save for the first spine, and the margin and last rays of the soft dorsal. In later life the clear spot below the first spines spreads, splitting the first black stripe into two, the dark bands narrow and traces of still narrower ones appear below the pectorals; the dorsals are margined with black, with the body bands continued on them. At this stage the fish is about 100 mm. long, and has been described as *Diagramma blochii*, etc. The upper black line left by the splitting of the broad upper one then breaks into round spots, a row of which appears in the white stripe above the eye, and the previously indistinct dark lines below the lowermost broad line also break up into spots, extending to the cheeks. The membrane between the first three dorsal spines clears. This stage, 120 mm. long, has also been described as a separate species. From this on the tendency is to break up the stripes into round spots, leaving the dorsal margined with black. With age the spots disappear from the body leaving it uniform,

and are present only on the fins. This adult has been known as *Diagramma punctatum*.

We see no characters which would indicate that *Plectorhynchus pertusus* of Thunberg is a different species. The subgenus *Spilotichthys* Fowler, represented by this species, differs from typical *Plectorhynchus* in the smaller scales and few dorsal spines. This species is common along the coast of southern Japan. It was taken by us at Onomichi and Nagasaki.

(*pictus*, painted.)

12. PLECTORHYNCHUS CINCTUS (Temminck and Schlegel).

KOSHODAI (noble porgy).

Diagramma cinctum TEMMINCK and SCHLEGEL, Fauna Japonica, 1842, p. 61, pl. 26, fig. 1 (Nagasaki).—RICHARDSON, Ichth. China and Japan, 1846, p. 226 (Canton).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 325 (China, Japan, Nepal).—BLEEKER, Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, p. 18, No. 117 (name only), (Japan, China).—NYSTRÖM, K. Svenska Vet. Akad., vol. 13 (Afd. 4), 1887, No. 4, p. 11 (Nagasaki).—STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's II, Denkschr. kais. Akad. Wiss. Wien., vol. 48, 1883, p. 11 (Tokyo).

Plectorhynchus cinctum BLEEKER, Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 7 (name only), (Kiusiu and Shikoku).

Plectorhynchus cinctus STEINDACHNER, Reise Aurora, Ann. Nat. Hofmus. Wien, vol. 11, 1896, Heft 2, p. 199 (Inland Sea of Japan).

Habitat.—Coasts of southern Japan and China.

Description of nine specimens, five half-grown from Yokohama, three adult from Wakanoura, and one from Misaki, ranging from 88 to 370 mm. in length.

Head 3 in body length; depth $2\frac{1}{4}$; eye 5 in head; maxillary 3; preorbital $4\frac{1}{2}$; interorbital $3\frac{1}{3}$; snout $2\frac{1}{2}$; D. XII, 15; A. III, 7. Scales above lateral line 94, below 65 to 70; in transverse series between insertions of dorsal and anal, $17/26$. Gill-rakers 8 + 15.

Body deep, nuchal region high, arched from snout to insertion of dorsal, and less so from insertion to base of caudal. Interorbital space arched from eye to eye. Mouth low, its tip below lower border of eye by half diameter of latter. Jaws equal; maxillaries ending below or slightly before anterior margin of eyes; lips fleshy, maxillary well sheathed by preorbitals. Nostrils large, slit-like. Preopercular margin finely serrated. Opercle without spines, but with two obscure points. Teeth in jaws minute, bluntly conical, in narrow bands above and below; absent on vomer and palatines. Gill-rakers slightly pointed, short, one-fourth of eye diameter in length.

Dorsals deeply divided. Fourth spine longest, $1\frac{2}{3}$ to $2\frac{1}{4}$ in head, last 3 to 4. Longest dorsal rays $2\frac{1}{4}$ in head. Second anal spine longest, of equal strength with third, former 2 to $2\frac{1}{2}$ in head, latter 3. Pectoral short, $1\frac{2}{3}$ in head, pointed. Ventrals longer, $1\frac{1}{2}$ in head. Caudal truncate in adult, somewhat rounded in young.

Scales everywhere ctenoid, present on all of head save preorbitals, snout, maxillaries, and lips, extending well down over interorbital space, over bases of soft vertical fins and present as a low sheath at base of spinous dorsal.

Color of alcoholic specimens: a curved dark band extending from the nuchal region, just behind the pectorals to the anal fin, becoming faint distally; from the third to seventh spines of the dorsal another band describes a parallel arc which ends at the upper part of the caudal root, becoming narrower distally; and along the base of the soft dorsal a third much fainter, short band. These bands at their inception are about as broad as a third of the head length. Much deeper in color than the bands and distributed only through the region between the line of the back and the lower edge of the second band, are numerous spots, diminishing in size and intensity of coloration with age, scarcely larger than a scale in adults but as large as pupil in young. The dorsal and caudal fins are colored as is the body, save that the spots on the spinous dorsal are fewer and somewhat larger. The ventrals are usually tipped with black, the pectorals are colorless. Peritoneum, gill cavity, and mouth lining colorless.

This species is not rare on the southern coasts of Japan. Our specimens are from Misaki, Yokohama, and Wakanoura.

(*cinctus*, banded.)

NOTE ON ANOMALODON BOWDITCH.

A genus of this family, *Anomalodon* Bowditch (Fishes of Madeira, 1825, p. 237), allied to *Plectorhynchus* and to *Pomadasis*, has been overlooked by recent writers. It has the dorsal notched, and its rays, D. XI, 15; A. III, 10. The species *Anomalodon incisus* Bowditch may be the same as *Pristipoma bennetti* Lowe (D. XII or XIII, 16; A. III, 11 or 12) or perhaps *Pristipoma rogeri* Cuvier and Valenciennes (D. XII, 15; A. III, 10) or *Pristipoma peroteti* Cuvier and Valenciennes (D. XI, 17; A. III, 10). The genus *Anomalodon*, if with a chin groove, should differ from *Orthopristis* by the notched dorsal. If without chin groove, *Anomalodon* should be compared with *Isacia* (*conceptionis*), and with *Parapristipoma*.

9. Genus HAPALOGENYS Richardson.

Hapalogenys RICHARDSON, Ann. Mag. Nat. Hist., vol. 13, 1844, p. 463 (*nitens*).

Type.—*Hapalogenys nitens* Richardson = (*Pogonias nigripinnis* Schlegel).

Body compressed, elevated, covered with moderate ctenoid scales. Mouth moderate, horizontal. Chin with several pores, hidden by a mass of short crowded barbels or papillæ, these little developed in the young; no central groove. Tip of snout naked, with small papillæ. Teeth small, uniform. Preopercle serrate. One dorsal, with eleven

Preopercular angle produced backward somewhat, its margins finely serrated. Opercle with two small inconspicuous flat spines. Teeth in jaws only, bluntly conical, minute, largest in external rows.

Dorsal deeply divided; last dorsal spine one-fifth of fourth, which is longest and 2 in head; spines strong, a stout procumbent one present anteriorly. Spinous dorsal outline rounded, not concave. Rays slightly longer anteriorly, $2\frac{1}{2}$ in head. Anal spines stout, second longest and strongest, 4 in head, third 6; third ray longest, $2\frac{1}{3}$ in head. Pectorals short, broad, their length contained $1\frac{5}{8}$ in head. Ventrals about equal to pectorals. Caudal $1\frac{2}{3}$ in head, its margin rounded.

Scales roughly ctenoid, lacking before nostrils on snout and jaws, replaced by papillate skin; present on exposed portion of maxillary, at bases of soft anal and caudal, and in low sheath at base of spinous dorsal, not extending on soft dorsal or anal, save as a minute row on each side of rays and of dorsal spines.

Color of alcoholic specimens nearly uniform, but showing traces of dark bands much as in *Plectorhynchus cinctus*, that is, a rather narrow one from the nuchal region, down through the area behind the pectoral and back in a long arch to the lower part of the caudal peduncle; another parallel to the first from the first dorsal spines to the upper part of the caudal peduncle; and a third below the soft dorsal. Fins all dark, without pattern. A young specimen shows a clear caudal; first dorsal margined with black, and second dorsal and anal with colorless edge. Peritoneum, gill and mouth cavities clear. The young specimens have a very much flatter interorbital, eye 4 in head.

Günther regards *Hapalogenys maculatus* as a doubtful synonym of *H. nigripinnis*,¹ and we see no reason to question this, especially as our alcoholic specimens have nearly lost the bands which Richardson regarded as characteristic of *H. maculatus*. Steindachner found no procumbent spine in his example, but in our largest specimen this was more deeply buried in the flesh than in the others, and his specimen was twice as large (41 cm.).

This species is rather common in southern Japan. We have examples from Wakanoura and Tsuruga.

(*niger*, black; *pinna*, fin.)

14. HAPALOGENYS MUCRONATUS (Eydoux and Souleyet).

HEGEDAI (bearded porgy).

Pristipoma mucronatum EYDOUX and SOULEYET, Voy. de la *Bonite*, 1841, p. 161, pl. 2, fig. 1.

Hapalogenys mucronatus GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 318 (China).—STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's, II, Denk-

¹ Cat. Fish. Brit. Mus., vol. 1, 1859, p. 317.

schr. kais. Akad. Wiss. Wien, vol. 48, 1883, p. 11 (Osaka).—NYSTRÖM, K. Svenska Vet. Akad., vol. 13, 1887, Afd. 4, No. 4, p. 9 (Nagasaki).

Hapalogenys analis RICHARDSON, Voyage *Sulphur*, 1846, p. 85, pl. 43, fig. 3; Ichth. China and Japan, 1846, p. 235 (Canton).

Habitat.—Coasts of southern Japan and China.

Description of numerous specimens from Kobe, Onomichi, and Hiroshima, ranging from 120 to 155 mm. in length.

Head $2\frac{3}{5}$, depth 2 in body length; eye $3\frac{1}{2}$, snout $2\frac{2}{3}$, preorbital $5\frac{1}{2}$, interorbital width, $3\frac{4}{5}$; maxillary $2\frac{1}{2}$ in head; D. XI, 15; A. III, 10. Scales above lateral line 67, below 59, with pores 47, in transverse series between insertions of dorsal and anal 10/26, in vertical transverse series 10/19. Gill-rakers 8+15.

Dorsal profile greatly arched, ventral very little; outline of head straight, or strongly concave just back of eyes, seemingly very variable in this regard; back strongly arched at insertion of dorsal, but slightly so until soft dorsal is reached, where it falls quickly to caudal peduncle. Interorbital region but slightly convex from eye to eye. Nostrils large, close to eye, anterior one much the largest, somewhat tubular, and with small flap posteriorly. Mouth large, maxillary ending under middle of eye, but little exposed, jaws equal. Preopercle serrate as in *H. nigripinnis*, post-temporal and clavicle serrated more finely.

Opercle with two obscure flat points of equal size. Teeth in jaws conical, pointed, regularly and closely arranged, of moderate strength, in four rows below and above, the inner three absent posteriorly.

Dorsals deeply divided, the last spine equal to diameter of pupil. Spines very strong, third longest, $1\frac{1}{4}$ in head in adult, outline of spinous dorsal slightly concave or straight, a procumbent spine present anteriorly. Longest dorsal ray $2\frac{1}{2}$ in head, outline of fin rounded. Anal spines strong, second much stronger and longer than third, their lengths being contained respectively $2\frac{1}{3}$ and 4 in head. Soft anal truncate or slightly rounded. Pectorals, ventrals, and caudals, $1\frac{2}{3}$ in head, nearly of equal length save for filaments on ventrals.

Scales roughly ctenoid, present on bases of vertical fins and a minute row extending along each side of both spines and rays half or two-thirds of the way to their tips. A sheath also present along base of spinous dorsal. Scales replaced on snout, lips, maxillary and lower jaws by papillæ, which are slightly longer on latter in adults.

Color on body in broad, transverse black bands, rather irregular, and variable. First band from first half of spinous dorsal and pectoral to ventrals as broad as length of head without snout; second band from soft dorsal narrowing ventrally; third band above anal. Vertical fins all margined narrowly with black; ventrals broadly so; pectoral clear. Peritoneum and gill cavity black, lining of mouth clear.

This species is fairly abundant in southern Japan. Our specimens are from Kobe, Onomichi, and Hiroshima.

(*mucronatus*, having a short, sharp point.)

15. *HAPALOGENYS KISHINOUEI* Smith and Pope.

Hapalogenys kishinouei SMITH and POPE, Proc. U. S. Nat. Mus., vol. 31, 1907, p. 476, fig. 6 (Urado). (*Type*, Cat. No. 55610, U.S.N.M.)

Habitat.—Coasts of southern Japan.

Having no specimens of this species, we reproduce the original description.

Head 2.6 in length; depth 2; eye 3 in head; snout 3.4; interorbital 4; dorsal XII, 14; anal III, 10; scales in lateral line 50; gill-rakers 11+5.

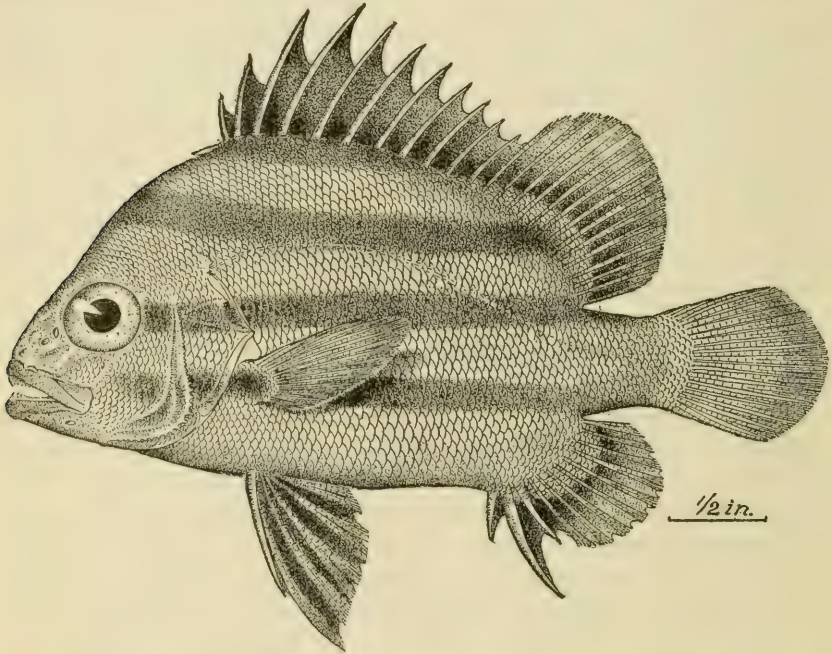


FIG. 3.—*HAPALOGENYS KISHINOUEI*.

Body short, high, much compressed; dorsal outline greatly arched, ventral outline nearly straight; caudal peduncle compressed, its least depth 3 in head; snout bluntly pointed; mouth moderate, horizontal, the jaws about equal; maxillary reaching to beyond anterior margin of pupil; jaws with villiform teeth, the anterior larger and sharply pointed; roof of mouth toothless, but lined with villiform membranes; symphyseal notch of upper jaw deep; 4 large pores on lower side of mandible; papillæ on mandible minute and close-set; gill-rakers short and thick; preopercle serrate, the denticulations much coarser at the rounded angle; opercle with 2 short spines, the lower the sharper; spinous dorsal preceded by a sharp procumbent spine a

little shorter than the first upright spine; all the spines strong, the fourth the longest and equal to distance from tip of snout to posterior rim of orbit, the remaining spines graduated; soft dorsal short and rounded, with finely scaled base; base of spinous dorsal about twice length of soft portion; anal short and rounded, similar to soft dorsal and preceded by 3 strong spines, of which the second, the longest, is 0.5 head; caudal rounded; ventrals with outer rays the longest; scales finely ctenoid; snout and chin naked; lateral line concurrent with dorsal profile. Color in alcohol silvery gray, with 4 reddish-brown horizontal bands, the first band running along the base of spinous dorsal, the second from midway between eye and origin of dorsal to middle of base of soft dorsal, the third from eye to end of soft dorsal at top of caudal peduncle, the fourth from cheek under eye to end of anal on caudal peduncle; dorsal, anal, and ventrals black; caudal and pectorals slightly dusky.

Described from a specimen 115 mm. long, collected by Dr. Hugh M. Smith, at Urado, May 10, 1903.

(Named for Kaminichi Kishinouye, Imperial Commissioner of Fisheries for Japan.)

10. Genus SCOLOPSIS Cuvier.

Scolopsis CUVIER, Règne Animal, ed. 1, 1817, p. 280 (le *Kurite* de Russell).

Scolopsides CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 327; same type.

Type.—*Scolopsides kurita* Cuvier and Valenciennes (= *Anthias japonicus* Bloch) a species not yet known from Japan.

Body oblong, symmetrical, covered with rather large ctenoid scales. Snout moderate, the mouth small, the jaws equal. Teeth small; chin without a central groove; no barbels. Preorbital naked, a more or less distinct spine hooked backward on the second suborbital; below this usually are one or more points. Preopercle sharply serrate. Branchiostegals 6, the last one very small. Dorsal rays X, 8. Anal rays III, 7. Vertical fins scaleless.

This genus is strongly distinguished from its relatives by the presence of a spine or hook on a suborbital bone, as also by the shorter and scaleless vertical fins. The species all belong to the East Indian region. From the related genus *Heterognathodon* it is distinguished by the suborbital spine, a character little developed in the Japanese species.

(σκόλοψ, a stake or sharp point for impaling.)

16. SCOLOPSIS INERMIS (Temminck and Schlegel).

TAMAGASHIRA (ball head).

Scolopsides inermis TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 63, pl. 28, fig. 1 (Nagasaki).—BLEEKER, Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, p. 83 (Nagasaki).—SMITH and POPE, Proc. U. S. Nat. Mus., vol. 31, 1907,

p. 477 (Kagoshima).—JORDAN and SNYDER, Proc. U. S. Nat. Mus., vol. 33, 1901, p. 751 (Yokohama); (not of Richardson).

Scolopsis inermis GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 357 (after Bleeker).—BLEEKER, Atlas Ichth., vol. 8, 1876, p. 4, pl. 341, fig. 5 (Sangir; Nagasaki); Ned. Tijd. Dierk., vol. 4, 1873, p. 352.—STEINDACHNER, Beitr. Fische Japan's II, Denkschr. kais. Akad. Wiss. Wien, 1883, p. 14 (Kagoshima).—NYSTRÖM, K. Svenska. Vet. Akad., vol. 13, Afd. 4, 1887, No. 4, p. 13 (Nagasaki).

Heterognathodon guliminda ISHIKAWA, Prel. Cat. Tokyo Imp. Mus., 1897, p. 54 (Kagoshima) (not of Cuvier and Valenciennes).

Heterognathodon döderleini ISHIKAWA, Prel. Cat. Tokyo Imp. Mus., vol. 1, 1897, p. 10, pl. 4 (Kagoshima, same specimen as above).

Habitat.—Coasts of southern Japan.

Description of a specimen 153 mm. in body length from Nagasaki.

Head 3 in body; depth $2\frac{3}{4}$; eye $3\frac{1}{2}$ in head; interorbital space 4; snout $3\frac{1}{2}$; maxillary $2\frac{3}{4}$; D. X, 9; A. III, 7; scales in lateral line 36; in transverse series between insertion of dorsal and insertion of anal $3\frac{1}{2}/10$; gill-rakers 6 + 5; branchiostegals 6.

Dorsal profile slightly more arched than ventral. Snout conical; interorbital space slightly rounded, without raised edge of skin over eyes, broadening forward from center of pupil; edge of orbit not prominent anteriorly; preorbitals flat; jaws equal, maxillary ending under anterior margin of eye. Margin of second suborbital bone with four or five serrations posteriorly, the upper largest, somewhat spine-like, contained four or five times in pupil. Posterior suborbitals finely serrated on lower edges, the retrorse spine present in other species rudimentary or almost lacking. Preopercle finely and closely serrate. Opercle with a small blunt spine. Teeth in jaws small, bristlelike, largest in outer row, with a band of smaller villiform teeth behind. Gill-rakers short, blunt, with an accessory one on the ceratohyal.

Fourth dorsal spine highest, $2\frac{1}{4}$ in head; last spine 3 in head, nearly equal to the following ray. Longest dorsal ray $2\frac{1}{2}$ in head. Second and third anal spines equal, $2\frac{3}{4}$ in head, anal rays slightly longer, of nearly same length throughout. Soft dorsal and anal outlines not pointed, but truncate or slightly rounded. Ventrals $1\frac{3}{4}$ in head, their spines three-fourths of the ray length. Caudal forked, $1\frac{5}{8}$ in head.

Scales slightly ctenoid, not present on interorbital region, snout, suborbitals, jaws, or lower limb of preopercular margin. Those on cheek in four rows, on opercle in six.

Color of entire fish bright light red in life, with broad crossbands of deeper red. Alcoholic specimens clear yellow, slightly tinged with bronze above. Fins all clear and colorless save for a hint of darker spots on membrane of spinous dorsal. Peritoneum and gill cavity lining silvery.

We can see no distinguishing marks in the specimen described by Doctor Ishikawa as *Heterognathodon döderleini*, and the plate given corresponds very closely to our specimen and to the published descriptions of *Scolopsis inermis*.

This handsome fish is generally common in southern Japan. We saw it at Nagasaki. Another species, *Scolopsis bilineata* (Bloch), finely marked with a pearl-white stripe, occurs in the Riu Kiu Islands and may reach Japan. *Scolopsis japonica* Bloch is not yet known from Japan.

(*inermis*, unarmed.)

6. Family SPARIDÆ.

The PORGIES or TAI.

Body oblong, or more or less elevated, covered with rather large, adherent scales, which are never truly ctenoid. Lateral line well developed, concurrent with the back, not extending on caudal fin. Head large, the crests on the skull usually largely developed. No suborbital stay. Mouth small, terminal, low, and horizontal. Pre-maxillaries little protractile; maxillary short, peculiar in form and in articulation, without supplemental bone, for most of its length slipping under the edge of the preorbital, which forms a more or less distinct sheath; preorbital usually broad, teeth strong, those in front of jaws conical, incisorlike or molar; lateral teeth of jaws conical and sharp or more or less blunt and molar; no teeth on vomer or palatines except in *Evyomis* and *Neolethrinus*, the former with a group on the vomer, the latter having the roof of the mouth with molar teeth; posterior nostril largest, usually more or less oblong or slitlike; lower pharyngeals separate; gills 4, a large slit behind the fourth; pseudo-branchiæ large; gill-rakers moderate; gill membranes separate, free from the isthmus; preopercle entire or serrulate; opercle without spines; sides of head usually scaly; dorsal fin single, continuous, or deeply notched, the spines usually strong, depressible in a groove; spines heteracanthous, that is, alternating, the one stronger on the right side, the other on the left; the spines 10 to 13 in number; anal fin rather short, similar to the soft dorsal, and with 3 spines; soft dorsal and anal fins naked; ventral fins thoracic, the rays I, 5, with a more or less distinct scalelike appendage at base; caudal fin usually more or less concave behind; air bladder present, usually simple; pyloric cæca few; vertebræ usually 10+14=24; intestinal canal short. Carnivorous shore fishes of the tropical seas, especially abundant in the Mediterranean, Red Sea, and West Indies. Genera about 18, species about 115, most of them much valued as food.

Key to genera.

- a¹. Front teeth of jaws conical, some of them canine, none of them incisorlike; second interhæmal bone normal, not pen-shaped.
- b¹. LETHRININÆ. Cheeks naked; top of head naked; upper teeth of jaws laterally in a single series, conical or molar. Dorsal spines 10, body compressed. *Lethrinus*, 11.
- b². SPARINÆ. Cheeks scaly.
- c¹. Lateral teeth of jaws conical; no molar teeth.
- d¹. Cheeks with three rows of large scales; body rather elongate; top of head scaly. Canines moderate, in upper jaw only; none of the dorsal spines filamentous; the spines not exerted beyond the membranes. . . . *Euthyopteroma*, 12.
- d². Cheeks with more than three rows of scales; body rather deeper.
- e¹. Top of head naked; canines moderate; in both jaws; dorsal spines low, 10 in number. . . . *Gymnocranius*, 13.
- e². Top of head scaly; limb of preopercle scaly; lateral teeth of jaws in one series, conical, not molar, and with a band of small granular teeth; canines strong in both jaws; dorsal spines low, 12 in number. *Taius*, 14.
- c². Lateral teeth in jaws molar; upper molars in two or more series; top of head scaly; scales on cheeks in several rows.
- f¹. Vomer with a few conical teeth in front; third and fourth dorsal spines elevated; molars in two series, preopercular limb naked; frontal bone spongy; supraoccipital crest extending well forward. . . . *Evynnis*, 15.
- f². Vomer toothless.
- g¹. Molars in two series; color crimson or yellowish; preopercular limb usually with some scales; parietal crests of cranium very low; supraoccipital crest not extending far forward; none of the dorsal spines elevated. . . . *Pagrosomus*, 16.
- g². Molars in three or more series; parietal crests of cranium moderate; color olive silvery, preopercular limb naked. . . *Sparus*, 17.

11. Genus LETHRINUS Cuvier.

Lethrinus CUVIER, Règne Animal, ed. 2, 1829.

Type.—*Sparus chærorhynchus* Bloch and Schneider.

Body oblong, compressed, covered with rather large scales. Snout moderate (much prolonged in the allied genus *Lethrinella*); jaws with canine teeth in front; a single series laterally of conical or molar teeth. No teeth on vomer. Cheeks naked, top of head naked; preopercle naked. D. X, 9; A. III, 8. Dorsal spines low, their membranes somewhat notched. Pyloric cæca two or three; air bladder notched posteriorly, with short lateral appendages. Angle of mouth red within, as in *Hæmulon*.

Species numerous, largely of the East Indian seas. Superficially they resemble the species of *Lutianus*.

We separate as a new subgenus *Lethrinichthys*, those species without molar teeth, the type being *Lethrinus nematacanthus*.

(*ληθρίνος*, a name unexplained.)

Key to Japanese species.

- a¹. *Lethrinichthys*. Lateral teeth of jaws conical, not molar.
 b¹. Second dorsal spine filamentous, $1\frac{1}{2}$ in head. Six rows of scales above lateral line. Depth 3 in length *nematacanthus*, 17.
 b². Second dorsal spine not elevated, longest dorsal spine $2\frac{2}{3}$ to 3 in head. Centers of the scales darker; vertical fins red in life. Five rows of scales above lateral line. Depth $2\frac{2}{3}$ in length..... *hæmatopterus*, 18.
 a². *Lethrinus*. Lateral teeth of jaws distinctly blunt and molar.
 c¹. Six rows of scales above lateral line. Depth $2\frac{1}{2}$ in length *chærorhynchus*, 19.

17. LETHRINUS NEMATACANTHUS Bleeker.

FUEFUKIDAI (flute-mouth porgy); **KUCHIBIDAI** (red-mouth porgy).

Lethrinus nematacanthus BLEEKER, Japan, Nat. Tijds. Ned. Ind., vol. 6, 1854, p. 403 (Nagasaki); Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, p. 90, pl. 6; Ned. Tijds. Dierk., vol. 4, 1873, p. 327.—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 456 (Louisade Archipelago).—BLEEKER, Atlas Ichth., vol. 8, 1877, p. 114, pl. 337, fig. 3 (Amboyna).—EVERMANN and SEALE, Bull. U. S. Bur. Fish., vol. 26, 1906, p. 86 (Bulan, Philippine Islands).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 80.

Habitat.—East Indies, north to southern Japan.

Description of five specimens from Wakanoura, two from Tokyo, the Imperial University, one from Bulan, Philippine Islands, and one from Moreton Bay, Australia. Body lengths varying from 110 to 163 mm.

Head $2\frac{2}{3}$ to 3 in body length; depth $2\frac{2}{3}$ to $3\frac{1}{2}$; eye $3\frac{1}{3}$ to $3\frac{1}{2}$ in head; snout $2\frac{1}{4}$ to $2\frac{1}{2}$; D. X, 9; A. III, 8; scales in lateral line 48, in transverse series to insertions of dorsal and anal fins 6/14; gill-rakers 4 to 6+6.

Dorsal and ventral profiles of body equally and evenly arched from snout to caudal. Upper profile of snout straight or slightly convex, never concave or with tip produced. Preorbital depth contained 3 to $3\frac{1}{2}$ in head; width of preopercle at angle about one-half eye diameter, its margin very flexible, the posterior one nearly vertical. Nostils closer together than the posterior one is to the eye. Prefrontals more prominent than usual, the interorbital space broadening anteriorly, at its narrowest point somewhat less in breadth than the eye. Maxillaries ending under anterior margin of eye, well hidden by prefrontals, which cover their posterior halves, as well as the angle of the mouth. Jaws with a single row of rather large conical teeth, becoming smaller and more acute anteriorly, where they form a band behind the canines. These teeth more obtuse posteriorly, only those of the upper jaw blunt enough to be called molar. Lower jaw anteriorly with two canines on each side, the outermost pointing slightly back and outward in tusklike fashion. Upper jaw with two on a side. Canines varying, worn blunt and short in some specimens.

Dorsal spines weak, flexible; second filamentous, $1\frac{1}{2}$ in head in best preserved specimen; third about 2 in head; last spine a trifle longer than penultimate, $3\frac{1}{4}$ in head. Succeeding dorsal rays somewhat longer than last spine. Second and third anal spines equal in strength, third a little longer, 3 in head. Anal rays subequal, $2\frac{2}{3}$ in head. Pectoral reaching anus, $1\frac{1}{2}$ in head. Ventrals reaching first anal spine, somewhat shorter than pectorals.

Scales strongly ctenoid. Temporal band in a double row. Lateral line little arched, without strong bend at root of caudal.

Body with small irregular blotches on sides, arranged in very indistinct transverse stripes; a spot two-thirds the size of the eye, below seventh scale of lateral line. Dorsum of head dark, with an indistinct band between the eyes. Cheeks with small sinuate streaks of dark. Premaxillaries tipped with dark. Dorsal fin with three

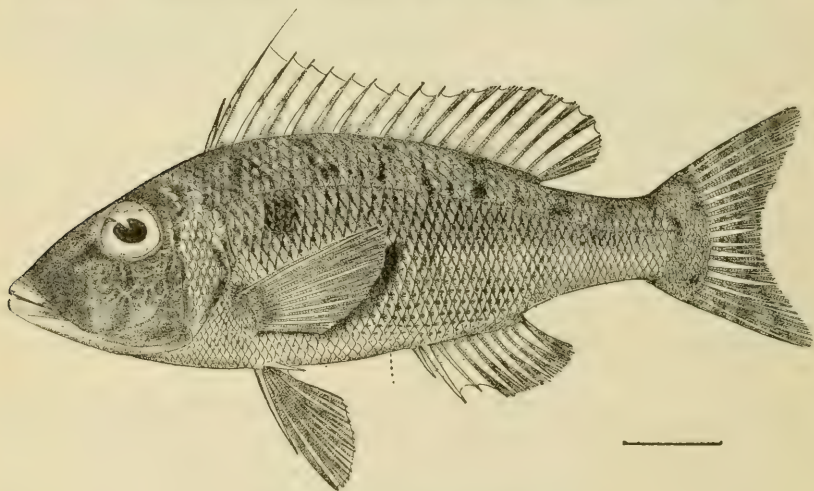


FIG. 4.—LETHRINUS NEMATACANTHUS.

rows of spots on spines, two on soft fins; caudal with five or six transverse bands of these spots, anal with one or two; ventrals with four or five; pectorals colorless. Color patterns badly preserved.

In life, olive green, with irregular dark bands and dull yellow spots. Cheeks vermiculate with pearly blue, a characteristic mark; angle of mouth red; fins barred with dull orange and yellowish.

This species is rather common in southern Japan. It was seen by us at Tokyo and at Wakanoura.

(οἰῆμα, thread; ἄκανθα, spine.)

18. *LETHRINUS HÆMATOPTERUS* Temminck and Schlegel.

ITOFUEFUKIDAI (thread flute-mouth porgy).

Lethrinus hæmatopterus TEMMINCK and SCHLEGEL, Fauna Japonica, 1844, p. 74, pl. 38 (southwest coast of Japan).—RICHARDSON, Voyage Sulphur, 1846, p. 144, pl. 64, figs. 1-3 (China).—BLEEKER, Nieuwe Nalez. Verh. Bat. Gen., vol. 26,

1857, p. 91 (Nagasaki).—KNER, *Reise Novara*, Fisch., 1860, p. 80 (Manila).—BLEEKER, *Revis. Lethrini*, Ned. Tij. Dierk., vol. 4, 1873, p. 323; *Atlas Ichth.*, vol. 8, 1877, p. 112, pl. 331, fig. 4 [Amboyna, Manila (Luzon)].—JORDAN and SNYDER, *Check List*, *Ann. Zool. Jap.*, vol. 3, pts. 2 and 3, 1901, p. 80 (Riu Kiu).—EVERMANN and SEALE, *Bull. U. S. Bur. Fish.*, vol. 26, 1907, p. 86 (Bacon, Philippine Islands).

Lethrinus richardsonii GÜNTHER, *Cat. Fish. Brit. Mus.*, vol. 1, 1859, p. 456 (China Sea).

Habitat.—East Indies, north to southern Japan and China.

Description of six specimens from Nagasaki, ranging from 112 to 195 mm. in body length.

Head $2\frac{2}{3}$ in body length, depth $2\frac{2}{5}$; eye $4\frac{1}{3}$ in head; snout 2; D. X, 9; A. III, 8; scales in lateral line 49; in transverse series between insertions of dorsal and anal $5\frac{1}{16}$; gill-rakers 5 + 5.

Dorsal profile of body more arched than ventral, that of head straight from snout to occiput. Depth of preorbital $2\frac{1}{2}$ in head; width of preopercle at angle $1\frac{1}{2}$ in eye, its margin flexible, its posterior limb extending somewhat forward from vertical. Nostrils farther apart than the distance between the eye and the posterior one. Prefrontals not very prominent; interorbital region broadening but little, about 4 in head. Maxillary not entirely sheathed by preorbital, ending under anterior nostril. Teeth in jaws conical, in a single row, becoming smaller anteriorly, where a patch of bristlelike teeth lie behind the canines; no true molar teeth. Two canines on either side in both jaws, the outermost largest below.

Dorsal spines rather stout, none filamentous, third and fourth longest, $2\frac{2}{3}$ in head; last two of equal length, $3\frac{1}{2}$ in head. Dorsal rays a third longer than spines. Anal spines similar to those of dorsal, second $3\frac{1}{2}$ in head, third $3\frac{1}{4}$. Anal rays one-fourth longer than third spine. Pectorals $1\frac{1}{2}$ in head, reaching first anal spine. Ventrals $1\frac{2}{3}$ in head.

Scales roughly ctenoid. Lateral line moderately arched. Temporal band of scales double.

Color in alcohol uniform, save for the darker center of scales above the lateral line, a darker area at the root of the caudal, and indications of rows of spots on soft dorsal, anal, and ventrals. A young specimen shows an almost entirely faded black spot between the pectoral and lateral line, and by looking closely indications of this can be seen in the larger specimens.

In life, with dull orange crossbands and pale blue spots which fade at death, a dusky shoulder blotch; fins dull orange; inside of mouth with orange.

In the adults the eye is not as broad as the interorbital space, is contained twice in the snout, and the dorsal spines are shorter than in this young specimen. In the latter the eye is broader than the interorbital space and contained $1\frac{2}{3}$ in the snout. These would

cover the differences between *L. richardsonii* Günther and *L. hæmatopterus* Bleeker. The sharpness of the lateral teeth, size of the eye, and height of the dorsal spines are all age marks. Kner¹ is probably right in calling these one species.

This fish is rather common in southern Japan. We saw it in Nagasaki.

(αἷμα, blood; πτερόν, fin.)

19. *LETHRINUS CHÆRORHYNCHUS* (Bloch and Schneider).

Sparus chærorhynchus BLOCH and SCHNEIDER, Syst. Ichth., 1801, p. 278 (Japan).

Lethrinus hæmatopterus GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 469 (Sea of Japan), (not of Temminck and Schlegel).

Lethrinus güntneri BLEEKER, Arch. Neerl. Soc. Holl. Science, Haarlem., vol. 8, 1872, pp. 153-154, fig. (Kiusiu, Nagasaki).

Lethrinus richardsonii JORDAN and EVERMANN, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 350 (Keerun, Formosa), (not of Günther).

Habitat.—Southern Japan and Formosa.

Description after Bleeker, in the absence of a well-preserved specimen.

Head 3 in body, 4 in total length; depth $2\frac{1}{4}$ in body, $3\frac{1}{2}$ in total length; eye 3 in head; interorbital space 4; D. X, 9 or 10; A. III, 8 or 9; scales in lateral line 48; in transverse series $6\frac{1}{16}$ or 17.

Breadth of body $2\frac{1}{3}$ in its depth; head somewhat acute, its height equal to its depth; upper profile of head somewhat convex before eyes, slightly concave on snout; nostrils distant, anterior tubular, valved; snout little longer than eye; suborbital breadth a little less than eye diameter; jaws equal, maxillary ending before the eye, 3 in head; lower jaw $2\frac{2}{5}$ to $2\frac{1}{2}$ in head. Teeth in jaws in many series in front, laterally and posteriorly in one row; two curved canines in front of both jaws, moderate in size in upper, small in lower jaw; lateral series of about 12 teeth, anteriorly conical, acute or obtuse, posteriorly rounded molars. Lips fleshy; opercular spine indistinct.

Dorsal spines moderately stiff, middle ones longest 3 in depth of body; dorsal rays a little higher; pectorals longer than ventrals, a little shorter than head; anal spines moderate, second and third subequal, shorter than first ray, soft fin a little longer than high, convex, angulated posteriorly. Caudal moderately emarginate, lobes acute, slightly shorter than head.

Color of body above olivaceous, below golden; iris yellow or reddish; fins reddish or yellow. Our young specimen shows a distinct blotch between the pectoral and lateral line.

Bleeker remarks that this is distinguished from the true *hæmatopterus* by one more row of scales above the lateral line and by the rounded molars of the jaws, which, he says, are different in fishes of

¹ *Novara* Reise, Fische, 1860.

the same ages. Günther's *L. hæmatopterus* was a much larger fish and had a smaller eye, which was contained twice and a third in the snout and was not equal to the interorbital space. Our small specimen, labeled *Lethrinus richardsoni*, from Formosa, fits Bleeker's description well save for a lesser depth and corroborates his differentiating marks, i. e., the molars and the six rows of scales above the lateral line. There appear to be only two specimens of this recorded besides ours and that of Bloch and Schneider.

There is not much doubt that this is the original *Sparus charorhynchus* of Bloch and Schneider, described from Japan. It is a species with broad body, clouded in color, with the anterior teeth conic, the posterior molar, the opercles scaly, the cheeks naked. D. X, 9; A. III, 11.

(χοῖρος, pig; ῥύγχος, snout.)

12. Genus EUTHYOPTEROMA Fowler.

Euthyopteroma FOWLER, Journ. Acad. Nat. Sci. Phila., 1904, p. 527 (*blochii*).

Type.—*Dentex blochii* Bleeker = *Sparus japonicus* Bloch.

Body rather elongate, covered with rather large ctenoid scales; about 50 in the lateral line; mouth rather small, the jaws equal; upper jaw with small canine teeth, none in the lower jaw; lateral teeth pointed, no molars; suborbitals unarmed; preopercle coarsely or finely serrulate; cheeks with three series of large scales; top of head scaly; preopercle naked, opercle without spine. Branchiostegals 6; air bladder notched. Dorsal rays X, 9; anal III, 7. Soft dorsal and anal scaleless, no sheath of scales at their base. Spines feeble, sometimes filamentous; caudal deeply forked, the upper lobe sometimes filamentous.

Species numerous in the East Indian region, mostly brightly colored, and showing analogies to *Aprion* and *Pristipomoides*. The genus is close to the European genus *Dentex*, differing in the more elongate body and the much larger scales on the cheek.

We here accept Fowler's division of the genus *Nemipterus* Swainson = *Dentex* Bleeker, not of Cuvier¹ = *Synagris* Günther.

In this group the following genera or subgenera may be recognized:

a¹. Lower jaw as well as upper with distinct canines; dorsal spines low, the membranes not notched, none of the spines or rays filamentous.

Synagris (= *Anemura*).

a². Lower jaw without distinct canines.

b¹. Dorsal spines all low, with the membranes not notched, the spines scarcely exerted.....*Euthyopteroma*.

b². Dorsal spines unequal, the first two (or one) produced in long filaments, the membranes of the others not notched, the other spines scarcely exerted.

Nemipterus.

b³. Dorsal spines unequal, the middle ones highest, their membranes deeply notched, so that the tips of the spines are largely free*Odontoglyphis*.

¹ The genus *Dentex* of Cuvier is based distinctly on *Sparus dentex* of Linnæus, a Mediterranean species.

The following is the synonymy of the sections or genera included under *Nemipterus* and *Synagris*.

Nemipterus SWAINSON, Nat. Hist. Class. Anim., vol. 2, 1839, pp. 172, 223 (*filamentosus*=*nematophorus*) (dorsal spines caudal and ventral filamentous).

Synagris GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 373 (*furcosus*, etc.).

Dentex BLEEKER, Atlas Ichth., vol. 8, p. 83 (*taniopterus*); not of Cuvier.

Anemura FOWLER, Journ. Acad. Nat. Sci. Phila., 1904, p. 527 (*notatus*).

Odontoglyphis FOWLER, Journ. Acad. Nat. Sci. Phila., 1904, p. 527 (*tolu*).

Euthyopteroma FOWLER, Journ. Acad. Nat. Sci. Phila., 1904, p. 527 (*blochii*).

(εὐθύς, straight; πτέρωμα, fin system.)

Key to species.

2¹. Upper lobe of caudal filamentous.

b¹. Preorbital width $4\frac{1}{2}$ in head, without distinct concavity near edge of maxillary. Side of body with a bright yellow streak which never fades in preservation, this obsolete in young; sides in life with other yellow stripes. *virgatum* 20.

b². Preorbital narrow, its width 7 in head, the suborbital region with a distinct concavity near edge of maxillary. Side of body without permanent yellow streak, but with stripes of brassy and golden in life. *bathybium*, 21.

20. EUTHYOPTEROMA VIRGATUM (Houttuyn).

ITOYORI (twisted thread, probably from the yellow stripe on side).

Sparus virgatus HOUTTUYN, Holl. Maat. Wet. Haarlem, vol. 20, Deel 2, 1782, p. 3 (Nagasaki).

Nemipterus virgatus JORDAN and EVERMANN, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 346 (Keerun, Formosa).—JORDAN and RICHARDSON Fishes Formosa, Mem. Carnegie Mus., vol. 4, No. 4, 1909, p. 186 (Keerun).

Sparus sinensis LACÉPÈDE, Hist. Nat. Poiss., vol. 4, 1803, p. 46 (China, Japan).

Synagris sinensis GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 379 (China); STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's, II, Denkschr. kais. Akad. Wiss. Wien, vol. 48, 1883, p. 16 (Tokyo, Tango, Kochi, Osima).—STEINDACHNER, Reise *Aurora*, Ann. Nat. Hofmus. Wien, vol. 11, Heft 2, 1896, p. 200 (Kobe or Nagasaki).

Nemipterus sinensis JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 77.

Dentex setigerus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 253 (Japan).—TEMMINCK and SCHLEGEL, Fauna Japonica, 1844, p. 73, pl. 37, fig. 1 (Nagasaki).

Habitat.—Coast of southern Japan and Formosa.

Description of four specimens from Tokyo and Nagasaki and one from Keerun, Formosa, the longest 330 mm. in total length without the caudal filament.

Head $3\frac{1}{2}$ in body, $4\frac{1}{2}$ in total length; depth $3\frac{1}{2}$ in body, $4\frac{1}{2}$ in total; eye 5 in head (in adult); snout $2\frac{2}{3}$ to $3\frac{1}{2}$; maxillary $2\frac{2}{3}$; D. X, 9; A. III, 8. Scales in lateral line 49, in transverse series from insertion of dorsal to insertion of anal $3\frac{1}{2}$ /10.

Body somewhat elongate, little compressed, its width one-half its depth; dorsal and ventral profiles similar. Head small, its dorsal outline somewhat arched, as it is in cross section. Eye small, $3\frac{1}{2}$ in head in a young specimen 170 mm. in total length, 5 in head in one

330 mm. in total length. Preorbital nearly quadrate, its posterior margin oblique. Maxillary largely sheathed, reaching barely to front of eye, mouth small. Preopercular margin slightly serrate, with a narrow dermal edge. Opercle with two flat points. Four or five small recurved canines in premaxillaries on either side of tip of upper jaw. Outer row on either side slightly enlarged, inner band narrow, villiform. In lower jaw an outer row anteriorly only. Inner row becomes single and enlarged somewhat laterally, although a villiform band anteriorly. Gill-rakers very short and stumplike, 6+8 in number.

Dorsal spines rather weak and flexible, of nearly equal length, $2\frac{3}{4}$ in head. Dorsal rays of equal length with spines, the last slightly longer. Anal spines also weak, third longest, 3 in head, first two-thirds length of third. Anal rays similar in length to those of dorsal.

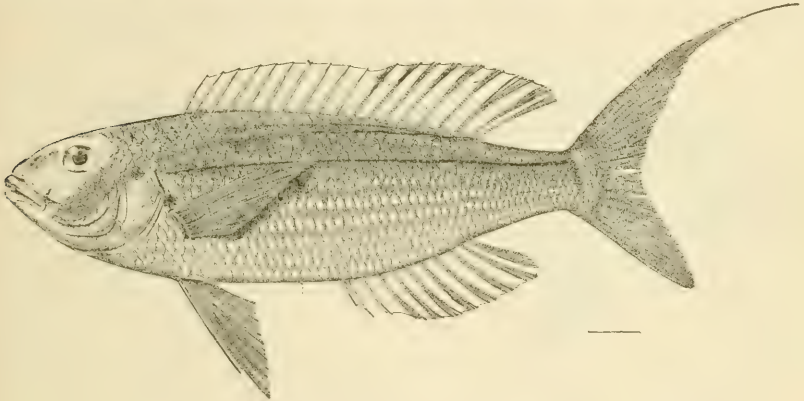


FIG. 5.—EUTHYOPTEROMA VIRGATUM.

Pectorals and ventrals subequal, nearly equal to length of head. Caudal deeply forked, the upper lobe prolonged into a filament nearly equal to length of head, and its length from base of caudal four times that of middle caudal rays.

Scales large, finely ctenoid; present across occiput, on cheeks, opercle, sub- and interopercle, not on limbs of preopercle or preorbitals. Scales on cheeks large, in three rows.

Color of alcoholic specimen silvery, darker above, more or less bright red in life. A narrow line of intense and permanent yellow extending from angle of opercle straight to upper rays of caudal, another parallel to it, one row of scales above lateral line, but broader and fainter anteriorly and ending at last rays of soft dorsal. Following rows of scales, or rather between them, below lateral line 6 or 7 silvery stripes as broad as pupil. In young fish the yellow lines have disappeared.

This beautiful fish is common in southern Japan. Our specimens are from Tokyo and Nagasaki.

(*virgatus*, streaked, from the yellow line.)

The following is the substance of Houttuyn's account of his *Sparus virgatus*:

The stripes of the scales plainer and much larger. In this respect, as also in shape, it is similar to the *Salpa* of authors, which has on its side eleven stripes of a golden hue. It is hence called in French "Virgabelle." The body is oval and flat, the head is blunt, the tail fork-shaped. In the dorsal I count 8 bony and 10 limber rays. P. 12; A. II, 8; V. 6; C. 22. My specimen is 5½ inches long.

21. *EUTHYOPTEROMA BATHYBIUM* (Snyder).

Nemipterus bathybius SNYDER, Proc. U. S. Nat. Mus., vol. 40, 1911, p. 532. (Kagoshima).

The following is Professor Snyder's description of this species. We present a figure of his type-specimen from Kagoshima.

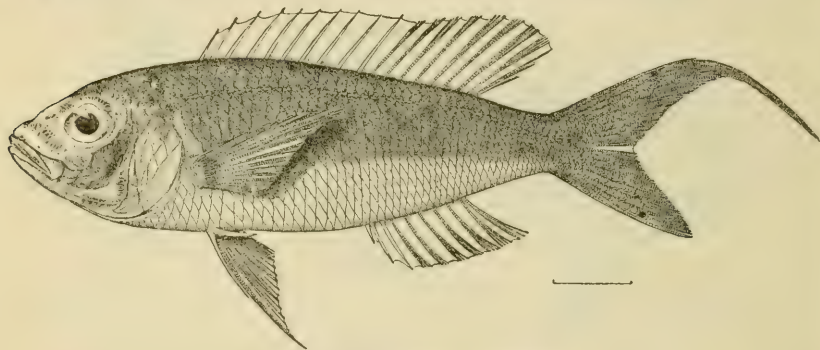


FIG. 6.—*EUTHYOPTEROMA BATHYBIUM*.

Three specimens of a *Euthyopteroma* which appears to be undescribed, were purchased in the Kagoshima market. The width of the suborbital at the narrowest point is not over half the diameter of eye, the maxillary extends to a point below anterior edge of pupil, there are 3 or 4 canines on either side of upper jaw, the dorsal fin is not filamentous, the last spine is highest, the upper lobe of the caudal is falcate, the ventrals extend to origin of anal, and there are 45 scales in the lateral line.

The species appears to be related to *Nemipterus japonicus* (Bloch), a species probably from Java, and not as yet known from Japan. When compared with specimens of the latter from Cavite, *E. bathybius* may be easily distinguished by the narrower preorbital which is deeply concave on its ventral edge.

Head 3.2 in length to base of caudal; depth 3.4; depth of caudal peduncle 3 in head; eye 3.6; snout 3.2; maxillary 2.6; width interorbital space 4; D. X, 9; A. III, 7; scales in lateral line 45; between lateral line and base of dorsal 3; between lateral line and origin of anal, obliquely downward and backward 9.

The interorbital space is convex; the snout rather pointed; suborbital area narrow, the width contained about 2.2 times in the longitudinal diameter of eye, the ventral edge with a deep and rather abrupt concavity near end of maxillary; the concavity together with the convex posterior edge giving the suborbital a distinctive form. Edge of preopercle smooth except for some very minute denticulations at its upper edge. Maxillary extending to anterior edge of pupil. Teeth of upper jaw villiform, an enlarged outer row with 3 or 4 canines on either side anteriorly; lower jaw with 2 rows of comparatively strong teeth anteriorly, a single row of enlarged teeth along the sides. Gill-rakers short and stubby, 4+9 on the first arch. Opercle with 3 rows of scales.

Dorsal spines high, rather slender and acute, the membrane not incised between their tips; last 3 spines longest, about 2.4 in head; anterior rays equal in height to the preceding spines, the posterior ones somewhat longer. Second anal spine intermediate in height between the first and third, 7.5 in head; last ray 2.3 in head. Lower lobe of caudal pointed, 1.3 in head; upper lobe falcate, a little over twice as long as the lower; edge of caudal deeply emarginate. Ventrals reaching origin of anal. Pectorals acutely pointed, equal in length to ventrals.

In life the body was bright silvery with a pinkish tinge and pearly reflections; a narrow lemon yellow stripe extends from upper edge of axil to middle of caudal peduncle, a faint brassy stripe along base of dorsal, a wide red stripe above lateral line, lateral line bordered by a light stripe with pearly reflections, below which is a brassy stripe narrowly bordered by dark pink; head pinkish, the snout purple; chin, breast, throat, belly, and lower surface of tail bright lemon yellow; dorsal translucent, the edge yellowish orange; vermiculations of lemon on membrane of fin; caudal bright pink, the filamentous rays yellow, becoming orange toward tip, upper edge of fin orange; anal and ventrals translucent; pectorals pink.

In spirits the body is rather reddish above, plain silvery below, all the bright tints having disappeared and no indication of the stripes remaining.

Type-specimen 280 mm. long including the caudal filament. Locality Kagoshima, Japan. Two smaller examples are like the type except that the ventrals are slightly shorter.

NOTE ON DENTEX THUNBERGI.

A species of Sparoid fish has been described from Japan under the name of *Labrus thunbergi*. The scanty description agrees in all respects with *Pristipomoides sparus*, on which species the description was probably based; but as no count of fin rays is given, the identification is perhaps too uncertain to justify the adoption of the name

Pristipomoides thunbergi in place of *P. sparus*. The following is the synonymy and the substance of the description:

- Labrus thunbergi* LACÉPÈDE, Hist. Nat. Poiss., vol. 4, 1803, p. 467 (Nagasaki).
Dentex thunbergii CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 237 (Japan).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 77 (after Cuvier and Valenciennes).
Synagris thunbergii BLEEKER, Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 7.

Body elongate, compressed, head equal to depth of body, which is contained nearly four times in the total length. The body is covered with finely ciliated scales. The teeth are very small, but there are four very large ones on each jaw, curved, well removed from one another, with smaller ones set in the intervals. Suborbital narrow and elongate. Caudal forked, pectoral short. Color brown, without spots. Edge of scales whitish.

13. Genus GYMNOCRANIUS Klunzinger.

- Gymnocranius* KLUNZINGER, Verh. z. b. Ges. Wien., vol. 20, 1870, p. 765 (*rivulatus*).
Paradentex BLEEKER, Atlas Ichth., vol. 8, 1876, p. 98 (on plate 30, fig. 3), (*microdon*).

Type.—*Gymnocranius rivulatus* Rüppell.

This genus is allied to *Dentex* and *Euthyopteroma*, differing in having the top of the head naked. Body deep, compressed. Mouth small; both jaws with small canines; more than three rows of scales on cheeks. Scales large, about 50; D. X, 10; A. III, 10. Species few, of the East Indian region.

(γυμνός, naked; κρανίον, skull.)

22. GYMNOCRANIUS GRISEUS (Temminck and Schlegel).

OMEDAI (big-eyed porgy).

- Dentex griseus* TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 72, pl. 36 (Nagasaki).—BLEEKER Nat. Tijds. Ned. Ind., vol. 7, 1854, p. 80 (Siboga), (in part); Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, p. 88 (in part), (Nagasaki).—STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's, II, Denkschr. Acad. Wiss. Wien, vol. 48, 1883, p. 16 (Tokyo).

- Gymnocranius griseus* BLEEKER, Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 7, No. 115 (Nagasaki); (not of Bleeker, Atlas Ichth., vol. 8, 1896, p. 96).

- Dentex xanthopterus* BLEEKER, Arch. Ned. Ind., vol. 2, 1845, p. 522 (name only).

- Dentex lethrinoïdes* BLEEKER, Verh. Bat. Gen. Kunst. Wct., vol. 23, 1849, p. 11; Nat. Tijds. Ned. Ind., vol. 1, 1850, p. 102 (Java).

- Gymnocranius lethrinoïdes* BLEEKER, Atlas Ichth., vol. 8, 1877, p. 96, pl. 334, fig. 3 (Java, Sumatra).

- ? *Lobotes microprion* BLEEKER, Nat. Tijds. Ned. Ind., vol. 2, 1851, p. 174 (Batavia) (young).

Habitat.—East Indies and southern Japan.

Description of five specimens 270 to 330 mm. in total length, from Wakanoura and Nagasaki, also some from Misaki, 130 to 170 mm. in length.

Head 3 in body length; depth, $2\frac{1}{5}$ to $2\frac{3}{5}$; eye, 3 to $3\frac{1}{3}$; snout, $2\frac{1}{3}$; maxillary, 3; suborbital width, $3\frac{1}{2}$; D. X., 10; A. III, 10; scales in longitudinal series 50 to 52, in transverse series from dorsal to anal insertion $5\frac{1}{2}/16$ or 17.

Body deep, compressed, its width about 3 in depth. Dorsal and ventral profiles similar, save for low position of tip of snout below axis of body. Head deeper than long, its dorsal outline arched and rising rapidly. Prefrontals prominent, interorbital space narrowest above pupils. Preorbitals deep as long, nearly quadrate, sheathing maxillary almost entirely. Jaws equal; mouth small; maxillary ending below anterior margin of eyes; lips papillate. Preopercular angle smooth, its posterior margin slightly oblique. Opercle short with two flat, obtuse points, the upper little prominent. In upper jaw several stout, curved and blunt canines of moderate size ante-

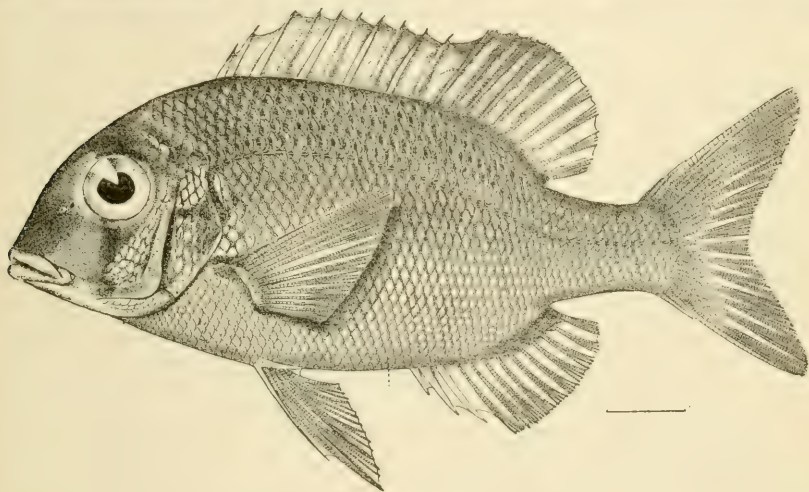


FIG. 7.—GYMNOCRANIUS GRISEUS.

riorly, in an outer row with a band of small, slender, sharp teeth behind them, latter merging into a single lateral row, posteriorly, of stout conical teeth, nearly molar in character and of slightly shorter length than canines. Lower jaw similarly toothed. Vomer, palatines and tongue edentulous.

Dorsal spines not flexible, fourth but very slightly longer than remainder, $2\frac{1}{2}$ to 3 in head. Dorsal rays higher, fifth and longest contained 2 in head. Anal spines strong, third longest, $2\frac{1}{2}$ to 3 in head; first two-fifths of length of third. First anal rays longest, slightly shorter than dorsal. Pectoral $1\frac{1}{5}$ in head, its first ray longest, its last two-fifths of its length. Ventrals extending to third anal spine, its first ray slightly filamentous, $1\frac{1}{8}$ in head. Caudal forked, its lobes (measuring from hypural plate) twice length of middle rays, which are $1\frac{1}{2}$ times longitudinal diameter of eye.

Scales absent on dorsal surface of head, preorbitals, lower jaw, maxillary, limbs of preopercle and anterior margin of opercle. A sheath of small scales present at bases of soft dorsal and anal. Membranes of caudal scaled at base and to tip of outer rays. Scales very finely ctenoid.

Young alcoholic specimens (up to 170 mm. in length) with about eight transverse bars of dark on body, first through angle of opercle and axil of pectoral; second from insertion of dorsal to lateral line, continued by a spot just behind ventrals; third from fifth and sixth dorsal spines across body; fourth similar, from last spines of dorsal to insertion of anal; fifth from second and third dorsal rays to first of anal; sixth from last of dorsal to axis of body, joining there with seventh from dorsal part of caudal peduncle, and ending at last anal rays; last indistinct across base of caudal. These bars more or less indistinct in different specimens. In our adults, of about 330 mm. length, they are barely to be seen and are much narrower, save for that through eye. Dorsal surface of head also dark; as is anterior half of spinous dorsal, anterior thirds of soft dorsal and anal, ventrals and caudal. A median lighter stripe sometimes present on caudal, parallel to fin margin. Pectorals clear, lining of mouth, of gill cavity, and peritoneum colorless.

This species is the *Gymnocranius lethrinoides* of Bleeker's Atlas¹ and not his *Gymnocranius griseus*. He had previously identified his Japanese specimens with *G. lethrinoides*, which view seems to be correct. Later he separated another species, which had been confused with *G. lethrinoides* and identified these as *G. griseus* Temminck and Schlegel. Unless both species are found in Japan, of which there is no record, his later decision seems erroneous. Our specimens correspond with the description given by him in "Nieuwe Nalezingen op de Ichthyologie van Japan" in its differences from *G. griseus* of the Atlas (namely, deeper preorbital, wider interorbital and smaller eye). We think therefore that his first identification should hold, and that *Gymnocranius lethrinoides* must be regarded as the same as the Japanese *G. griseus*.

This species is not rare in southern Japan. Our specimens are from Misaki, Wakanoura, and Nagasaki.

(*griseus*, gray.)

14. Genus TAIUS Jordan and Thompson.

Taius JORDAN and THOMPSON, new genus.

Type.—*Chrysophrys tumifrons* Temminck and Schlegel.

This genus contains, so far as known, a single species, with the skull structure, coloration and general aspect of *Pagrosomus*, but with a single row of conical teeth in the sides of the jaws besides a

¹ Vol. 8, 1877, p. 96.

band of granular teeth, and no true molar teeth at all. Mouth rather large. Both jaws with canines in front. Scales on cheeks in more than three rows; preopercle more or less scaly. Dorsal rays XII, 10, the spines low with exerted tips. Body compressed and elevated, with a deep preorbital. Parietal crests of cranium little developed. A single known species has the general aspect of *Pagrus* or rather of *Pagrosomus* with the dentition more like that of *Dentex*. The type of skull is precisely that of *Pagrosomus major*. In *Dentex dentex* of the Mediterranean the frontals are porous as in *Evygnis*. There is no hyperostosis of the supraoccipital. The parietal or epiotic crest is elevated as a thin edge, and it is placed farther from the supraoccipital than in *Pagrosomus* or *Taius*.

In spite of the absence of molars, *Taius* is much more nearly allied to *Pagrus* and *Pagrosomus* than to *Dentex*.

(*tai*, porgy, the common name of *Pagrosomus major* and of related species.)

23. TAIUS TUMIFRONS (Temminck and Schlegel).

KOTAI (baby porgy); **MAKODAI** (true baby porgy); **BENIKODAI** (red baby porgy); **KINKODAI** (red baby porgy); **KITAI** (yellow tai or porgy).

Chrysophrys tumifrons TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 70, pl. 34 (Nagasaki).

Pagrus tumifrons GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 470 (after Temminck and Schlegel).—NYSTRÖM, Jap. Fisksaml. K. Svenska Vet. Akad., vol. 13, Afd. 4, 1887, No. 4 (Nagasaki).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 79.—KISHINOUE, Journ. Fish. Bur. Tokyo, vol. 10, 1901, No. 3, p. 38, pls. 3; pl. 5, fig. 5-8; pl. 7, fig. 2 (Japan: Hondo, Shikoku, Kiushu, and Formosa).

Sparus tumifrons BLEEKER Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 7.

Dentex hypselosomus BLEEKER, Japan, Nat. Tijd. Ned. Ind., vol. 6, 1854, p. 402 (Nagasaki); Verh. Bat. Gen., vol. 26, 1857, pl. 4, fig. 2 (Japan) p. 89.—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 371 (after Bleeker).—STEINDACHNER, Reise Aurora, Ann. Nat. Hofmus. Wien., vol. 11, 1896, Heft 2, p. 199 (Japan).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 77.—JORDAN and EVERMANN, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 345, fig. 17 (Formosa).—JORDAN and RICHARDSON, Fishes Formosa, Mem. Carnegie Mus., vol. 4, 1909, No. 4, p. 185, fig. 15.

Synagris hypselosoma BLEEKER, Atlas Ichth., vol. 7, 1876, pl. 36, fig. 2; Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 7.

Habitat.—Southern Japan and China.

Description of three specimens from Takao, Formosa, 245 to 280 mm. in body length:

Head $2\frac{2}{3}$ in body length to last vertebra; depth 2; eye $3\frac{3}{8}$; interorbital breadth $3\frac{3}{8}$; preorbital depth $3\frac{3}{4}$; snout $2\frac{1}{4}$; D. XII, 10; A. III, 8; scales in lateral line 49; in transverse series from insertion of dorsal to that of anal 6/14 (6/12-17, Kishinouye); gill rakers 8+11; pyloric cæca 4.

Profile of head rising steeply, slightly concave before eyes, convex over them; rising in a steep, even curve to nape. Interorbital space arched rather strongly from eye to eye, more so in older specimens; preorbital depth equal to, or less than eye, contained $1\frac{2}{3}$ in its own length; maxillary $2\frac{2}{3}$ in head, ending under anterior border of eye. Breadth of preopercle at angle equal to that of cheek, its margin not very flexible. Posterior nostril as far from eye as from anterior nostril. Posterior margin of suborbitals, between smaller and larger, strongly notched in all our specimens (not in Kishinouye's figure). Vomer toothless. Jaws without distinct molars, a single row of stoutly conical, sharp teeth laterally in each jaw, with several inner rows of very small granular teeth. Four large, stout, somewhat

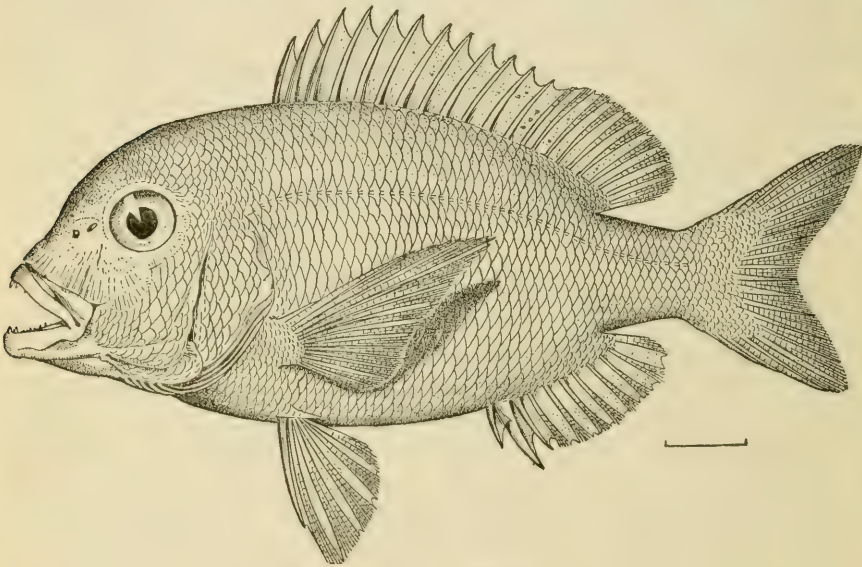


FIG. 8.—*TAIUS TUMIFRONS*.

recurved canines in front of each jaw. Gill rakers half length of gill filaments.

Dorsal spines stout, first $5\frac{1}{2}$ in head, or two-thirds of eye; second slightly longer than eye, 3 in head; third $2\frac{2}{3}$ in head. Dorsal rays equal to last spine, $3\frac{1}{2}$ in head. Anal spines stouter than dorsal spines, second somewhat longer than third, 3 in head; rays about same length. Pectorals 3 in body length, or $1\frac{1}{10}$ in head; lower rays slightly produced; ventrals reaching nearly to anus, $1\frac{1}{2}$ in head.

Scales present on preopercular limbs, in 3 or 4 rows, on cheek in 5 or 6, on interopercle in 3 rows; on bases of dorsal and anal fins as a low sheath. Scales finely ctenoid.

Color (Kishinouye) reddish with golden luster, two or three markings of yellowish found dorsally; lower portion of body silvery white; no blue spots present; membrane on posterior margin of opercle

pale blue. Iris reddish. In life the snout is golden yellow, and there is a diffuse yellow blotch under the dorsal.

Skeletal characters: Frontals heavy, thick, slightly porous, approaching those of *Pagrosomus major*. Supraoccipital crest inserted over middle of eyes, moderately high. Parietal crest typical of Asiatic allies of *Pagrus*, here called *Pagrosomus*, low, hardly produced as a thin layer of bone, as far from the supraoccipital as from the outer crest. Hyperostosis or thickening not evident, although the supraoccipital crest is slightly thickened above. First spurious interneural small, slender.

This species not very common in Japan. No specimens are in our collection except from Formosa. In spite of the absence of molars, this species is in essentials like the species of *Pagrosomus*. Since the above was written we have found this species in great abundance in the markets of Osaka, taken by the trawlers off Tsushima. It forms the principal part of the catch of these vessels between Nagasaki and Fusan.

(*tumifrons*, having the forehead swollen.)

13. Genus *EVYNNIS* Jordan and Thompson.

Evynnis JORDAN and THOMPSON, new genus.

Type.—*Sparus cardinalis* Lacépède.

This genus differs from *Pagrosomus* in the presence of a group of conical bluntish teeth on the head of the vomer, a character unique in this family. In one other genus, *Neolethrinus*, there are molar teeth on the vomer and elsewhere on the roof of the mouth. Supraoccipital crest in old specimens very high, advanced forward to near the front of the eye, largely covering the spongy frontal bones which are full of pores. No scales on preopercular limb. In the single known species the third and fourth dorsal spines are elevated, as in the species of *Argyrops* (*spinifer*, etc.), but to a less degree.

(*εῖ*, well; ὄνυξ; vomer.)

24. *EVYNNIS CARDINALIS* (Lacépède).

CHIDAI (blood red tai or porgy); **HIRKODAI** (small fin porgy); **HORENAGA** (long fin); **HANADAI** (flower porgy); **CHIKODAI** (child porgy); **KUNDAI**.

Sparus cardinalis LACÉPÈDE, Hist. Nat. Poiss., vol. 4, 1803, p. 141.—STEINDACHNER, Reise *Aurora*, Ann. Nat. Hofmus. Wien, vol. 11, Heft 2, 1896, p. 200 (Japan).

Chrysophrys cardinalis CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 130 (Japan).—TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 69, pl. 33 (Nagasaki).—RICHARDSON, Ichth. China and Japan, 1846 (Canton).—BLEEKER, Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879.

Pagrus cardinalis GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 470 (China).—STEINDACHNER and DÜDERLEIN, Beitr. Fische Japan's, II, Denkschr. kais. Akad. Wiss. Wien., 1883, p. 19 (Tokyo, Oshima, Nagasaki).—NYSTRÖM, K. Svenska. Vet. Akad., vol. 13, Afd. 4, 1887, No. 4, p. 14 (Nagasaki).—JORDAN

and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 79 (Yokohama).—KISHINOUE, Journ. Fish. Bur. Tokyo, vol. 10, No. 3, 1901, p. 36, pls. 2, 5, and 7, fig. 3 (Japan, Kiusiu, southern coast of Shikoku, northwestern and northeastern coasts of Hondo, China, Korea).

Habitat.—Coasts of Japan and China.

Description of five specimens from Tokyo and one from Matsushima, 160 to 247 mm. in length:

Head $3\frac{1}{6}$ in body length, depth $2\frac{1}{3}$; eye 4 in head; preorbital depth 4; interorbital width 3 to $3\frac{1}{3}$; maxillary $2\frac{1}{2}$; snout $2\frac{2}{7}$; D. XII, 10; A. III, 9; scales in longitudinal series 58 to 64; in transverse series between insertions of dorsal and anal $7/15$ or 16; gill-rakers 7 or 8 + 11 or 12.

Profile of head and occiput rising steeply in a strong curve; interorbital space much arched, more so than in *Pagrosomus major*; occiput usually prominent, depth of preorbital contained $1\frac{1}{2}$ in its length, its depth less than that of *P. major*; maxillary ending under anterior margin of eye. Width of preopercle greater than that of scaled portion of cheek, or at least equal. Posterior nostril oval, its distance from the eye contained 4 times in the latter's length. Vomer with several conical teeth. Teeth in upper jaw in two rows of molars posteriorly, the inner larger but replaced anteriorly by a band of granular teeth, outer teeth larger and more conical anteriorly; a set of two canines on a side in front. Teeth in lower jaw similar save that the inner row is larger posteriorly, and three canines are present on a side.

Dorsal spines flexible, the third and fourth somewhat filamentous. Second spine 5 in head, three-quarters of eye diameter in length; third spine over half length of head; fourth slightly less; fifth $2\frac{1}{6}$ to $2\frac{1}{2}$ in head. Anal spines equal, $3\frac{1}{6}$ in head. Pectoral longer than head by about half eye, the lowermost rays half as long, being slightly produced. Ventrals $1\frac{1}{2}$ in head. Caudal forked.

Scales as in *Pagrosomus major*, 7 rows on cheek, 4 rows on interopercle.

Color in life (after Kishinouye) in general resembling that of *Pagrosomus major*, but much brighter. Posterior margin of preoperculum dark red. Iris partly brown, partly silver white.

The males and females of this species, according to Kishinouye, differ in the profile of the head: "In the male the occipital crest is rectangular, so that the forehead is very prominent. In the female, on the other hand, the occipital crest is triangular and the forehead is beautifully arched." He writes that these fish grow to a length of half a meter.

From *Pagrosomus major* this species may be distinguished by the teeth on the vomer, the cavernous frontals, the anterior hyperostosis of the supraoccipital crest, the lack of the same in the first spurious interneural, and by the filamentous second and third dorsal spines.

Kishinouye records the collection by Mr. Nakamura of a skull lacking these vomerine teeth and supposes it a hybrid with *P. major*. Whether the difference in frontals is due to hyperosteal thickening is questionable.

This species is rather common in Japan, less abundant and smaller in size than the red Tai. We saw this species at Matsushima, Tokyo, Misaki, and probably in other places.

(*cardinalis*, cardinal red.)

16. Genus PAGROSOMUS GILL.

Pagrosomus GILL, Mem. Nat. Acad. Sci., vol. 6, 1893, p. 97 (*auratus*=*unicolor*).

*Sparosomus*¹ GILL, Mem. Nat. Acad. Sci., vol. 6, 1893, pp. 116, 123.

(*auratus*) (*lapsus* for *Pagrosomus*).

Type.—*Labrus auratus* Bloch and Schneider.

Body oblong, rather deep, compressed, covered with large scales. Head large; preopercle entire; opercle not armed. Mouth rather small, terminal, low, the anterior teeth in the jaws cardiform, the outer series of teeth generally enlarged, caninelike, not compressed, the teeth behind the canines slender and acute. Both jaws with 2 or 3 series of rounded molar teeth, which are sometimes irregularly mixed with slender teeth. No teeth on vomer or palatines. Posterior nostril oblong, not slitlike, much larger than anterior. Preopercle with a few scales or none. Dorsal spines about 12 in number, depressible in a groove; anal spines moderate, the second not greatly developed; second interhæmal spine not pen shaped; no antrorse dorsal spine; supraoccipital crest high, the inner lateral or parietal crests low, little developed. Caudal fin forked; air bladder simple; gill-rakers short; branchiostegals 6; intestinal canal short; pyloric cæca few. Carnivorous fishes, mostly of the coasts of Asia and Australia, closely related to the Atlantic genus *Pagrus*,² but differing, as understood by us, in the deep body, the depth about two-fifths of the length, and in the little development of the inner lateral crest of the cranium. This is obsolescent in *Pagrosomus auratus* and *Pagrosomus major*. In the related genus, *Argyrops*³ (*spinifera*) the body is still deeper and the back more elevated; the parietal crests are rather higher and further removed anteriorly from the supraoccipital crest, although rather lower than in the genera *Pagrus* and *Dentex*. In *Argyrops*, the dorsal spines are much elevated, and filamentous, even more so than in *Evynnis cardinalis*. On the whole, *Argyrops spinifera* seems to be generically

¹ Not *Sparisoma* Swainson, Class. Anim., vol. 2, 1839, p. 227, a genus of Scaroid fishes; not *Sparisoma* Sauvage, Bull. Soc. Geol. (3), vol. 11, 1883, p. 487, a genus of fossil fishes.

² Cuvier, Règne Animal, ed. 1, 1817, p. 272, *Type*, *Sparus pagrus* Linnæus.

³ *Argyrops* Swainson, Nat. Hist. Class. Fishes., vol. 11, 1839, p. 221 (*spinifer*). *Argyrops spinifera* (Forskål) occurs in Formosa, but is not known from Japan.

distinct from *Pagrosomus*, and we adopt the latter name for the Japanese species.

(πάργος: porgy; σώμα: body.)

Key to species.

*a*¹. Dorsal rays XII, 10; scales 53.

*b*¹. Width of preorbital $4\frac{3}{4}$ in head; 8 rows of scales above the lateral line; hyperostosis, or thickening, of supraoccipital crest at its base *major*, 25.

*b*². Width of preorbital $3\frac{1}{2}$ in head; 9 or 10 rows of scales above lateral line; hyperostosis on upper edge of supraoccipital crest *auratus*, 26.

25. PAGROSOMUS MAJOR (Temminck and Schlegel).

TAI, AKADAI (red porgy); ODAI (big porgy); MATADAI (fork porgy).

Chrysophrys major TEMMINCK and SCHLEGEL, Fauna Japonica, 1842, p. 71, pl. 35 (Nagasaki).

Pagrus major GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 470 (China and Japan).—STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's, II, Denkschr. kais. Akad. Wiss. Wien, 1883, p. 19 (Tokyo).—NYSTRÖM, Jap. Fisksaml. K. Svenska. Vet. Akad., vol. 13, Afd. 4, 1887, No. 4 (Nagasaki).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901.—KISHINOUE, Fish. Bur. Tokyo, vol. 10, No. 3, 1901, p. 32, pls. 4, 6, 7, fig. 1 (Japan, from southern part of Hokkaido to Formosa, Korea, China). (Cranium, interneurals, and jaws figured, with an excellent colored plate.)

Sparus major BLEEKER, Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879.

Pagrus unicolor RICHARDSON, Ichth. China and Japan, 1846, p. 242 (Canton).—KNER, Reise Novara Fische, 1860, p. 85 (Hongkong and Auckland).—REGAN, Ann. and Mag. Nat. Hist., ser. 7, vol. 15, 1905, p. 20 (Inland Sea of Japan).—STEINDACHNER, Sitzungber. Akad. Wiss. Wien, vol. 61, 1870, p. 625 (China).

Description of numerous specimens up to 300 mm. in length from Wakanoura, Aomori, Tokyo, and Nagasaki, one from Tokyo, 163 mm. in body length, taken as typical:

Head $3\frac{1}{8}$ in body length; depth $2\frac{1}{2}$; eye 4 in head, preorbital width $4\frac{3}{4}$; interorbital space 3 to $3\frac{1}{3}$; maxillary $2\frac{1}{2}$; snout $2\frac{1}{4}$ to $2\frac{1}{2}$; D. XII, 10; A. III, 8; scales in longitudinal series 56 to 63; in transverse series between insertions of dorsal and anal 8/16 to 18; gillrakers 7 to 9+10.

Profile of head and occiput rising less steeply than in *Evyinnis cardinalis*, interorbital space not as highly arched, occiput not usually as gibbous; depth of preorbital contained $1\frac{3}{4}$ in its length; maxillary ending under anterior margin of pupil. Width of preopercle considerably less than width of scaled cheek. Posterior nostril slit like, nearer eye and slightly longer than in *Evyinnis cardinalis* or *Taius tumifrons*, its distance from the eye about 6 in orbital length. Vomer toothless. Teeth in upper jaw in two rows posteriorly, the inner molar, the outer less so, the latter becoming more conical anteriorly, the former being replaced by a band of minute granular teeth in three series. Two stout canines present on either side anteriorly. In lower jaw dentition similar, but with three anterior canines on a

side. Supraoccipital crest high, not extending forward before eye; frontal bone solid with few pores, epiotic or parietal crests little developed. Dorsal spines not filamentous; second equal, or slightly less than length of eyes, about $3\frac{5}{8}$ in head, longer than in *Evyinnis cardinalis*; third and fourth about 2 in head; fifth $2\frac{1}{4}$. Second and third anal spines usually equal, second sometimes stronger, 3 to $3\frac{1}{2}$ in head. Pectoral extending slightly beyond anal insertion, longer than head by half length of eye, its lowest rays slightly elongate; ventral $1\frac{1}{2}$ in head. Caudal deeply forked.

Scales not present on bases of soft dorsal and anal. Head scaled to above eyes. Preopercular limbs with an occasional scale; cheeks with 7 rows.

Color (Kishinouye): Back reddish, generally with greenish luster and many blue spots; belly silvery. Iris of eyes brownish with golden luster, upper portion of orbit blue. Upper posterior margin of operculum and base of pectoral fin dark brown; lower part of caudal fin whitish, tinged with blue, while the posterior margin of the fin is generally fringed with black. In old specimens the coloration is dusky, and blue spots are not generally found. Our alcoholic specimens are nearly uniform in color, with a few traces of blue spots. Peritoneum and gill cavities silvery.

This species has frontals which differ markedly from those of *Evyinnis cardinalis*, being heavy, thick, and little cavernous. The supraoccipital crest is thickened greatly in its posterior, lower part, and the first spinous interneural is enlarged and thick in its upper portion. The thickening of the supraoccipital and the interneural is evidently due to hyperostosis (with age), but this is not so evident in the case of the frontals, as a young specimen 10 cm. in length had frontals as little porous as the adult, although not nearly as heavy. The whole cranium is longer for its depth than that of *Evyinnis cardinalis*.¹ The observations recorded above as to the relative widths of the scaled portion of the cheek and of the preopercle do not seem to apply to Kishinouye's figure, although it was true of all our specimens.

We can find no distinguishing characteristics in *Pagrus arthurius* Jordan and Starks from Port Arthur on a careful comparison of the type with specimens of *Pagrosomus major* from Japan. The depth of the preorbital stated to distinguish it is exactly the same, as is the size of the eye, measuring in hundredths of body length. The shortness of the third spine of the dorsal is due to injury. *Pagrus arthurius* is therefore a synonym of *Pagrosomus major*, as is also *Pagrus ruber* Döderlein. This nominal species is thus described.

Head 3 or less in body; depth $2\frac{2}{8}$; eye $2\frac{2}{8}$ in head; interorbital space 4; snout 3; preorbital height $1\frac{2}{8}$ to $1\frac{1}{8}$ in eye; D. XII, 10;

¹ See Kishinouye, Journ. Fish. Bur. Tokyo, vol. 10, No. 3, 1901, for figures of skull, etc.

A. III, 8; scales in lateral line 53-54; in transverse series 8/1/13 (or 14?).

Interorbital space flat from side to side, posterior to it a prominent ridge rises along the midline of the occiput to the insertion of the dorsal, formed on the head by the supraoccipital crest. Profile of the head ascending less rapidly than in *Pagrosomus major* and *Evyinnis cardinalis*. Maxillary ending before the middle of the eye. Molar teeth small, in two rows in both jaws, canines in the premaxillaries as in *Pagrosomus major* and *Evyinnis cardinalis*.

Third, or third and fourth, dorsal spines slightly exceed half the head length, in one case contained $1\frac{4}{5}$, in another $1\frac{9}{10}$ in the head. Second dorsal spine equals or is somewhat less in length than the eyes, and is contained $1\frac{3}{5}$ to $1\frac{1}{2}$ times in the height of the third spine. Second anal spine is somewhat longer than the third.

Color of ventrals gray in distal half; dorsal with gray-brown spots here and there, especially on the soft portion.

According to Döderlein this species differs from *Pagrosomus major* in the more elongated body, the larger eyes, and the lesser number of scales along the lateral line. Kishinouye notes that he considers the presence of this species in Japanese waters "ambiguous," as he is unable to find any specimens to correspond to this description. Döderlein had two specimens to which he applied this name, the one described being 133 mm. long. The differences given do not warrant a division. One of our specimens of *Pagrosomus major* has 55 scales in the lateral line, yet differs in no other way from the typical specimens.

Pagrosomus major is the common red "Tai" or "Akadai" of the markets of Japan. It is everywhere very abundant to the southward of Tokyo. Its flesh is excellent, firm, and white. It is in a way the national emblem of Japan. It is the fish borne in all pictures of the fishery god *Ebisu*, and luck comes to the fisherman with the red Tai or porgy.

We saw this species at Aomori, Misaki, Tokyo, Wakanoura, and Nagasaki.

(*major*, larger.)

26. PAGROSOMUS AURATUS (Forster).

The Snapper of the Australian Seas.

Labrus auratus (*Sciæna aurata* Forster) BLOCH and SCHNEIDER, Syst. Ichth., 1801, p. 266 (Queen Charlottes Sound).

Sciæna aurata FORSTER, Descr. Anim., Ed. Lichtenstein, 1844, p. 307, same specimen.

Pagrosomus auratus GILL, Mem. Nat. Acad. Sci., vol. 6, 1893, p. 97, and of Stead and other Australian ichthyologists.

Sparosomus auratus GILL, Mem. Nat. Acad. Sci., vol. 6, 1893, pp. 116, 123.

Chrysophrys unicolor QUOY and GAIMARD, Voy. *l'Uranie*, 1824, p. 229 ("Baie des Chiens Marins," Dick Hartog Island, Australia).

Pagrus unicolor CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 162, same specimens.—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 468 (New Zealand, Australia; Chinese Seas?).

Sparosomus unicolor and *Pagrosomus auratus* of many AUTHORS.

Pagrus guttulatus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1830, p. 160 (King Georges Sound).—LESSON, Voy. *Coquille*, Zool., vol. 2, 1830, p. 188 (New Zealand).

Pagrus micropterus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1830, p. 163 (New Zealand).

Pagrus latus RICHARDSON, Rep. Brit. Ass. Adv. Sci., 1842, p. 209.

Described from two specimens, 220 and 460 mm. long, from Caloundra Banks, Australia, and from Wanganui, New Zealand, respectively.

Head 3 in body length; depth $2\frac{1}{4}$; eye $3\frac{3}{8}$ ($5\frac{1}{3}$ in large specimen) in head; depth of preorbital $3\frac{5}{8}$; snout $2\frac{1}{8}$; maxillary $2\frac{1}{3}$; D. XII, 10; A. III, 8; scales in lateral line 57, in transverse series between insertions of dorsal and anal 9 or 10/17; gill-rakers 8 + 11.

Body deepest before insertion of dorsal, tapering posteriorly, head profile very steep, and but slightly arched, save at occiput. Length of maxillary equal to that of preorbital, which is $1\frac{1}{2}$ times its depth. Distance between nostrils equal to length of posterior one. Width of preopercle less than that of scaled cheek, its margin ribbed, but not serrate. Teeth as in *Pagrosomus major*, in two series in both jaws, the inner molar like, the outer more conical, inner row becoming replaced by minute granular teeth, outer becoming more conical anteriorly. Two pairs of canines above and three below in front. Gill-rakers short and stout.

Fourth dorsal spine highest, $2\frac{1}{3}$ in head, not produced; second and third anal spines subequal, $3\frac{1}{2}$ in head; pectoral equal to head plus half eye, its lower rays somewhat produced; ventrals $1\frac{3}{8}$ in head, reaching anus; caudal deeply forked, its lobes equal to head.

Scales not present on vertical fins save as low sheath, nor on preorbitals, snout before eyes, lips, or jaws. An occasional scale on the preopercle. Cheeks with 7 or 8 rows.

Color silvery, darker above, fins uniform.

Cranial crests as in *Pagrosomus major*, the inner or parietal little developed; supraoccipital crest inserted above anterior margin of eye, its upper edge thickened by hyperostosis as in *Evygnnis cardinalis*. First spurious interneural also thickened.

Pagrosomus auratus, the most abundant and valuable of Australian food fishes, has been recorded several times from Chinese Seas and by Regan from the Inland Sea of Japan, under the name of *Pagrus unicolor*. None of the authors give any details regarding their specimens, however, and it is not impossible that all of them are really *Pagrosomus major*, to which *P. auratus* is closely related. The latter differs mainly in these regards: A larger eye in specimens of

similar size, a deeper preorbital, longer snout (?), and in the supra-occipital crest, which is thickened by hyperostosis in the same region as in *Evynnus cardinalis*. The following table gives a comparison of *Pagrosomus major*, *P. auratus*, and the type of *Pagrus arthurius*:

	"Pagrosomus major," Tokyo.	"Pagrus arthurius," Port Arthur.	"Pagrosomus auratus," Australia.	"Pagrosomus auratus," New Zealand.
Body length.....mm.	195	252	220	460
Head ¹	31.5	32.0	34.0	35.0
Depth.....	42.5	44.0	44.0	43.0
Eye.....	8.5	8.5	9.5	6.5
Preorbital depth.....	7.5	7.5	9.0	9.0
Snout.....	14.5	14.5	16.0	17.0
Maxillary.....	12.0	13.0	13.0	15.0
Height of fourth dorsal spine.....	14.5	14.0	15.0	14.0
Height of second anal spine.....	10.0	10.5	11.0	10.0
Dorsal rays.....	XII, 10	XII, 10	XII, 10	XII, 10
Anal rays.....	III, 8	III, 8	III, 8	III, 8
Scales in lateral line.....	57	55	57	56
Scales in transverse series.....	8/17	8/17	9/17	10/17
Gill-rakers.....	7+9	8+9	8+10	8+11

¹ Measurements given in hundredths of body length.

(*auratus*, gilded.)

Since this paper was completed Mr. Regan has written to me concerning the Japanese specimen recorded by him as *Pagrus unicolor*:

I have compared my Japanese *unicolor* with Australian specimens, and with Japanese *major*. I should say they are the same species as the latter, but I should certainly not like to say that they are specifically different from the Australian specimens. I shall be interested to see what you consider the distinctive characters of the two forms.

The species *Pagrosomus auratus* should therefore be omitted from the list of Japanese fishes. At the same time it must be confessed that *Pagrosomus major* is very close to it and that it may ultimately prove indistinguishable. The only differences we detect are those slight ones indicated in the above description.

17. Genus SPARUS Linnæus.

Sparus ARTEDI, Genera Piscium, 1738, p. 35.

Sparus LINNÆUS, Syst. Nat., ed. 10, 1758, p. 277 (*aurata*, *pagrus*, etc.).

Chrysophrys CUVIER, Règne Anim., ed. 1, 1817, p. 272 (*aurata*).

Aurata RISSO, Europe Méridionale, 1826, p. 356 (*semilunata*=*aurata*).

Sparus FLEMING, British Animals, 1828, p. 211 (restricted to the gilthead, *Sparus aurata*).

?*Chrysoblephus* SWAINSON, Nat. Hist. Class. Anim., vol. 2, 1839, p. 221 (*gibbiceps*); (median molars very large; preopercular limb scaly).

Pagrichthys BLEEKER, 1860 (dried specimen, with one anal spine removed).

Type.—*Sparus aurata* Linnæus.

This genus agrees in general with *Pagrus*, but the species are olive and silvery in color, never red, and the teeth are in broader bands, the upper molars in three or more series. The scales are smaller than in *Pagrus*, *Pagrosomus*, and *Argyrops* and the body is still deeper.

The parietal (epiotic) crests of the cranium are well developed, much as in *Pagrus pagrus*. Species rather numerous on the coasts of the Old World from England to Japan. The group called *Chrysoblephus*, from South Africa, with the median molars enlarged, is probably generically distinct. The genus *Calamus*, from tropical America, resembles *Sparus* externally, but differs remarkably in the enlarged and hollow interhæmal spine.

(*sparus*, σπάρδος, the ancient name, from σπαίρω, to gasp.)

Key to species.

- a*¹. Snout very blunt, the profile approaching the vertical; anal rays III, 11; dorsal rays XI or XIII, 13; scales about 60; rows of olivaceous stripes along the series of scales *aries*, 27.
- a*². Snout more or less acute, the profile oblique; anal rays III, 8; scales 45 to 54.
- b*¹. Body rather deep, the depth $2\frac{1}{2}$ in body length; dorsal rays XI, 12; scales 45; second anal spine $1\frac{1}{2}$ in head; olivaceous spots along the series of scales; a dark spot at origin of lateral line; lower fins yellow. *latus*, 28.
- b*². Body moderately elongate, the depth $2\frac{3}{4}$ in length; dorsal rays XI, 12; scales 54; second anal spine $2\frac{1}{4}$ in head; no distinct streaks of spots along rows of scales; color dark; anal fin partly black. *swinhonis*, 29.

27. SPARUS ARIES (Temminck and Schlegel).

HYODAI (front porgy); HEDAI (grunt porgy).

?*Sparus sarba* FORSKÅL, Descr. Anim., 1775, p. 31 (Red Sea).

?*Chrysophrys sarba* CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 102 (Isle de France).—RÜPPELL, N. W. Fische, 1835, p. 110, pl. 28, fig. 1 (Red Sea).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 488 (Red Sea).—KNER, Reise Novara, Fisch., 1860, p. 88.—KLUNZINGER, Syn. Fische Roth. Meer., Verh. z. b. Ges. Wien, vol. 20, 1870, p. 759 (Red Sea).—DAY, Fishes India, 1875, p. 142, pl. 34, fig. 6 (Madras).—SAUVAGE, Poiss. Madag., 1891, p. 195, pl. 25a, fig. 3 (Lagunes of eastern coast of Madagascar).

Sparus sarba JORDAN and SEALE, Fishes Hongkong, Proc. Davenport Acad. Sci., vol. 10, 1905, p. 10 (not synonymy).

?*Sparus bufonites* LACÉPÈDE, Hist. Nat. Poiss., 1803, pp. 141, 143, pl. 26, fig. 3.

?*Sparus psittacus* LACÉPÈDE, Hist. Nat. Poiss., 1803, pp. 141, 143.

?*Chrysophrys chrysargyra* CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 107 (Vizagapatam).

Chrysophrys aries TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 67, pl. 31 (Nagasaki).—BLEEKER, Verh. Bat. Gen., vol. 26, 1857, p. 87 (Nagasaki).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 489 (China).—STEINDACHNER and DÖDERLEIN, Beitr. Fische Japan's, II, Denkschr. kais. Akad. Wiss. Wien, vol. 48, 1883, p. 18 (Tokyo, Tango).

Sparus aries JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 79 (Yokohama).

Sparus latus JORDAN and EVERMANN, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 350 (Giran, Formosa).—JORDAN and RICHARDSON, Fishes Formosa, Mem. Carnegie Mus., vol. 4, No. 4, 1909. (Not of Houttuyn, not *Pagrus latus* Richardson.)

Habitat.—Coasts of southern Japan and China. Possibly identical with *Sparus sarba* Forskål of the Red Sea and East Indian region.

Description of nine specimens from Wakanoura, one from Nagasaki, three from Tokyo, two from Hongkong, and one from Moreton Bay, Queensland, Australia. Body lengths ranging up to 250 mm.

Head $3\frac{1}{2}$ in body length; depth $2\frac{1}{6}$; eye $4-4\frac{1}{2}$ in head; depth of preorbital $3\frac{1}{2}$ to $4\frac{1}{2}$; D. XI or XII, 13; A. III, 11; scales in longitudinal series 56 to 64, in transverse between insertions of dorsal and anal 7 or 8/13 or 14; gill-rakers 6+8.

Dorsal profile arched more strongly from snout to dorsal than posteriorly; mouth low, close to straight ventral profile; lower jaw included; snout short, rounded, slightly overhanging premaxillaries, its profile approaching the vertical at tip. Eyes well below upper surface of head, interorbital region arched strongly from side to side, 3 in head; frontals prominent. Snout $2\frac{1}{4}$ in head, maxillary $2\frac{1}{2}$, ending under anterior half of pupil. Preorbitals broader than eye in adults. Preopercular margin entire, flexible. Jaws powerful, heavy. Teeth in upper jaw in four rows of molars, outer rounded,

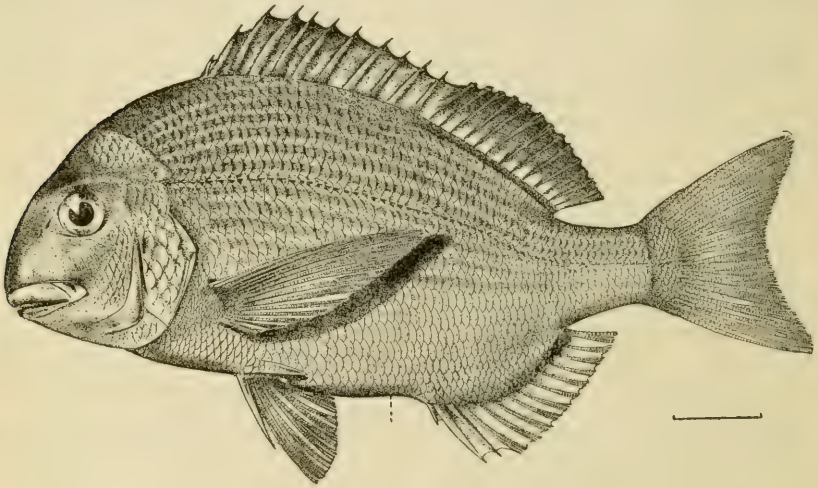


FIG. 9.—SPARUS ARIES.

small; inner largest; third consisting posteriorly of two very large molars; fourth and innermost ending at middle of jaw. Three rows of molars in lower jaw, outermost smallest, rounded, second enlarging posteriorly, to form three very large molars, the last largest; third row ending before middle of jaw. Three incisor teeth on either side of both jaws in front, set somewhat rodent-like.

Third and fourth dorsal spines longest, $2\frac{1}{3}$ to $2\frac{1}{2}$ in head; last $2\frac{2}{3}$ in head, slightly longer than succeeding ray, which is longer than the last rays. Anal spines similar to dorsal spines, the second and third equal and of same length as the latter. Anal rays rapidly decreasing in length to last, which is half that of first. Fin outline straight. Pectoral long, reaching anal, equal to head plus two-thirds of eye diameter. Ventrals $1\frac{1}{2}$ to $1\frac{1}{3}$ in head. Caudal nearly as long as head.

Scales smooth to touch, cycloid, present as a sheath at bases of dorsal and anal, present on cheeks in five or six rows. Lateral line but little arched.

Color of alcoholic specimens uniformly silvery, unsealed portions of head dusky, the iris yellow. Peritoneum black, gill cavity lining clear. A small black spot at beginning of lateral line, in some specimens obsolete; anal fin more or less dusky.

This species is generally common in southern Japan, and may be known at once by its deep body, blunt snout, and long anal fin.

The eye in *Sparus sarba* is described and figured as much larger than in *Sparus aries* (3 to $3\frac{1}{4}$ in head in *S. sarba*, and 4 to $4\frac{1}{2}$ in *S. aries*). The anterior profile is much steeper and more convex in the latter, apparently, than is shown in the plates of *Sparus sarba*. The specimens from Hongkong recorded as *Sparus sarba* by Jordan and Seale are quite identical with the Japanese specimens. The dentition is the same, and not as described. If the Japanese form should prove inseparable from that of the East Indies, it would stand as *Sparus sarba*.

(*aries*, ram.)

28. SPARUS LATUS¹ Houttuyn.

KAIDSU.

Sparus latus HOUTTUYN, Holl. Maat. Wet. Haarlem, XX, Deel. 2, 1782, (Nagasaki).

?*Sparus hasta* BLOCH and SCHNEIDER, Syst. Ichth., 1801, p. 275 (Coromandel Coast and India).

Chrysophrys hasta GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 490 (Japan) (part).—STEINDACHNER and DÜDERLEIN, Beitr. Fische Japan's, II, Denkschr. kais. Acad. Wiss. Wien, 1883, p. 17 (Tokyo).

?*Coius datnia* HAMILTON BUCHANAN, Fish. Ganges, 1822, p. 88, pl. 9, fig. 29 (Ganges).

Sparus datnia BLEEKER, Versl. kon. Acad. Wet., 2 Rks., vol. 11, 1876, p. 5, pl. 2 (Nagasaki, not Calcutta).—BLEEKER, Atlas Ichth., vol. 8, p. 109 (Nagasaki).

?*Sparus berda* CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 113 (Pondicherry).—JORDAN and RICHARDSON, Check List Philippine Island Bur. of Sci., 1, Manila, 1910, p. 31.

Sparus berda RICHARDSON, Ichth. China and Japan, 1846, p. 240 (Canton).—JORDAN and EVERMANN, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 350 (Formosa).—JORDAN and RICHARDSON, Fishes Formosa, Mem. Carnegie Mus., vol. 4, No. 4, 1909, p. 189 (Formosa), (not *Sparus berda* Forskål, 1775).

Chrysophrys longispinis CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 116 (Japan), (not type, from Calcutta).

?*Calamara* RUSSELL, Fishes of Vizagapatam, vol. 1, 1803, p. 63, pl. 92 (Coromandel).

?*Chrysophrys calamara* CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 117 (Java, Malabar).—CANTOR, Cat. Malay. Fish, 1850, p. 48 (Sea of Pinang).

Chrysophrys auripes RICHARDSON, Ichth. China and Japan, 1846, p. 241 (Canton).

Chrysophrys xanthopoda RICHARDSON, Ichth. China and Japan, 1846, p. 241 (Canton).

¹ The following is the substance of Houttuyn's account of *Sparus latus*: "I have called this species in which the scales are placed in stripes lengthwise 'wide sea-brassen' because it is one of the widest of the family, the specimen 3 inches long, an inch and a half wide. Color yellowish, silvery under the scales. D. XII, 9; A. III, 8."

Chrysophrys schlegeli BLEEKER, Nat. Tijd. Ned. Ind., vol. 6, 1854, p. 400 (part, specimen with 45 scales), (Nagasaki); Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, pp. 20 and 86 (Nagasaki).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 80 (part).

Sparus chrysopterus KISHINOUE, Zool. Mag. Tokyo, vol. 19, 1907, p. 327 (Kiusiu, Shikoku, Inland Sea and Pacific coast of Central Hondo).

Habitat.—Southern Japan and China.

Described from a specimen 155 mm. long from Kobe and one 190 mm. long from Wakanoura, besides four specimens 100 to 108 mm. in body length from the latter place.

Head $3\frac{1}{4}$ in body length; depth of body $2\frac{1}{3}$; eye $4\frac{1}{3}$ in head; depth of preorbital 6; second anal spine $1\frac{1}{2}$ in head; D. XI, 11 or 12; A. III, 8; scales in lateral line 45, in transverse series 5 or 6/12; gill rakers 6 + 9 or 10.

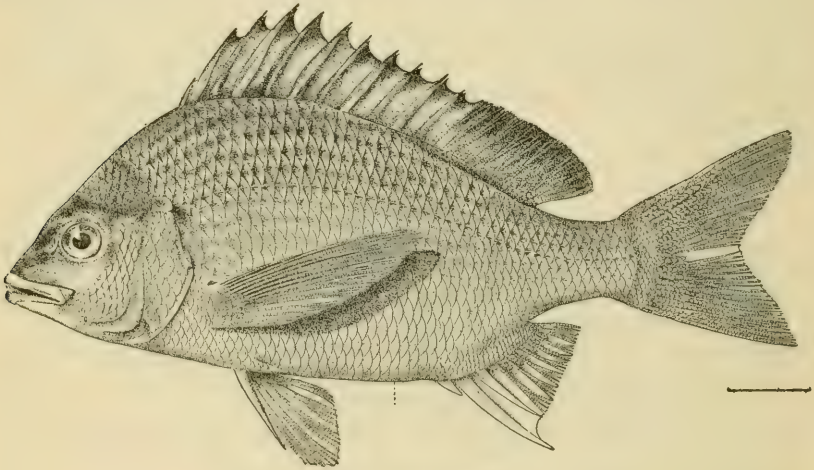


FIG. 10.—SPARUS LATUS.

Dorsal profile of head nearly straight to occiput, body profile most strongly arched anteriorly, sometimes slightly concave behind eyes. Snout more pointed than in *S. aries*, the upper profile not approaching the vertical; lower jaw not included, upper jaw not overhung by tip of snout; preorbital narrow, not as broad as eye is long. Interorbital space arched moderately. Maxillary ending under center of pupil, $2\frac{1}{2}$ in head; preopercle very minutely serrated, not flexible. Teeth in jaws only; lower jaw with two rows posteriorly, both of rounded molars; inner row broadest save posteriorly, where it is replaced by much smaller ones; both becoming granular anteriorly. A third inner row of small rounded molars present along anterior halves of each mandible. Upper jaw with three rows of rounded molars in front, the outer conical anteriorly, the middle row extending only half way to snout, where it is replaced by another row inside of the third, all becoming granular anteriorly. Six conical canines present in front in each jaw.

Third and fourth dorsal spines longest, $1\frac{3}{4}$ to 2 in head, last spine $2\frac{1}{2}$ in head. Dorsal rays but little longer than the latter. Anal spines very strong, heavy, the second strongest, $1\frac{1}{2}$ to $1\frac{1}{2}$ in head, third $2\frac{1}{3}$ to $2\frac{1}{4}$ (in adults). First ray much shorter than second spine but equal to third, tip of second spine nearly coinciding with that of last ray when supine, or extending beyond its middle. Pectorals long, falcate, reaching third anal spine, equal to head plus eye diameter. Ventrals $1\frac{1}{3}$ in head. Caudal forked, nearly as long as head.

Scales very slightly ctenoid below lateral line, present as low sheath at bases of vertical fins; rows on cheek 6 or 7. Lateral line more strongly arched anteriorly than in *S. aries*.

Color of alcoholic specimens uniform, save for indistinct small blotch at upper angle of gill opening. Dorsal margined strongly and somewhat shaded below with black. Anal lightly stippled with black; a faint dusky shade at base. Caudal margined with black. Scale rows indicated by longitudinal stripes, but not as prominently as in *Sparus aries*. A dark spot at origin of lateral line. Peritoneum silvery. Gill cavity lining colorless. In life silvery with dark brown streaks; fins and lower lobe of caudal bright golden.

It is very questionable whether this fish extends into the Indian Seas, or beyond Formosa. Bleeker considered it identical with specimens from Calcutta, but says that there is a difference in the number of dorsal spines, 12 in the Indian, 11 in Japanese. His first description of *S. schlegeli* from Japan was composite, according to his later paper.¹ The characters were certainly taken from the species here called *S. swinhonis*, and not from the present species. However, he applied the name *S. schlegeli* to the latter, and identified it with Indian specimens. He decided that *S. hasta* was distinct from either, as it probably is. On this basis his Indian synonymy has been worked out. *Sparus berda* of Forskål, from the Red Sea, is not the same as our fish, if we may judge by Rüppell's figure, and all published descriptions from that locality. Steindachner and Döderlein say² that *Chrysophrys cuvieri*, *schlegeli*, *datnia*, and *hasta* of Bleeker are the same species in all probability, but the evidence available is all against this view. A careful comparison of actual specimens from all localities will be necessary to decide the number of species present.

We adopt for the Japanese fish the name *Sparus latus*. Houttuyn's careless description has three distinct characters of the species, the deep body, the rows of olive spots on the rows of scales, and the presence of rays III, 8 in the anal. *Sparus aries* has the anal III, 11. *Sparus swinhonis* has no distinct rows of spots. The name *Sparus berda*, from the Red Sea, is older than Houttuyn's name, and it may prove, after all, that the two species are identical, although the present evidence points to the contrary. If the pre-

¹ Versl. kon. Acad. Wet., vol. 11, 1876, p. 5.

² Beitr., vol. 2, 1883.

ceding species is called *Sparus sarba*, this one may well be *Sparus berda*. But our material is inadequate to settle either question.

We consider *Sparus chrysopterus* Kishinouye identical with the present species as there is no character given by which it may be distinguished. The black spot "in the anal fin near its base" is represented in our specimens by a slight dusky shade. Mr. Kishinouye gives the following translation of the original description:

D. XI, II; A. III, 8. Scales 4 or 5-42-11. Pyloric cœca 4. Vertebrae 24. Height of the body $2\frac{3}{4}$ in the total length with caudal, and the length of head $4\frac{3}{8}$ in the same. Snout obtuse and the supraoccipital region is a little elevated. Incisors 4-6 in each jaw, and molars are weakly developed and sparsely distributed in 3 irregular rows. The second spine of the anal very long, longer than the length of the insertion of the same fin. Grayish or greenish gray at the back and silvery white at the abdomen. A black spot respectively near the origin of the lateal line and in the anal fin near its base. Ventrals, anal, and the lower lobe of the caudal yellow.

It is told that this species grows to the length of about 36 cm. This species seems to spawn in the autumn. Known from warmer parts of our country—Kiushiu, Shikoku, Inland Sea, and at the Pacific coast of the central part of Hondo.

This species is generally common in southern Japan. Our specimens are from Wakanoura and Kobe.

(*latus*, broad.)

29. SPARUS SWINHONIS Günther.

KURODAI (black porgy).

Chrysophrys longispinis TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 68, pl. 32 (Nagasaki).—RICHARDSON, Ichth. China and Japan, 1846, p. 240 (on specimen of Temminck and Schlegel), (not of Cuvier and Valenciennes).

Chrysophrys schlegeli BLEEKER, Japan, Nat. Tijd. Ned. Ind., vol. 6, 1854, p. 400 (Nagasaki) (part, not of described specimen); Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, p. 86 (after above). (See Versl. kon. Acad. Wet., 2 Rks., vol. 11, 1876, p. 7.)

Sparus swinhonis GÜNTHER, Ann. and Mag. Nat. Hist., 1874, p. 155 (Chifu in China).

Sparus schlegeli BLEEKER, Versl. kon. Acad. Wet., 2 Rks., vol. 11, 1876, p. 2 (Nagasaki), (not of Nieuwe Nalez., p. 86).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 80 (Japan), (in part).

Sparus longispinis JORDAN and RICHARDSON, Fishes Formosa, Mem. Carnegie Mus., vol. 4. No. 4, 1909 (Takao).

Habitat.—Coasts of southern Japan and China.

Description of a specimen from Kobe, one from Wakanoura, and 12 from Tokyo. Body lengths from 60 to 225 mm.

Head $3\frac{1}{2}$ in length of body, depth $2\frac{3}{8}$; eye $4\frac{3}{8}$ to 5 in head; depth of preorbital 6; D. XI, 12; anal III, 8; scales in longitudinal series 53 to 56 to last vertebra; in transverse series between insertions of dorsal and of anal $7/15$; gill-rakers 6+8.

Dorsal profile similar to that of *Sparus latus*; straight from snout to occiput; most strongly arched anteriorly; sometimes slightly concave behind eyes. Snout somewhat pointed, upper profile not overhanging premaxillaries. Lower jaw not included, equal to upper.

Preorbitals not as broad as eyes. Interorbital space occasionally slightly gibbous. Maxillary $2\frac{1}{2}$ in head, ending under anterior half of eye. Preopercle very minutely serrated. Teeth in jaws much as in *S. latus*, in three rows above, in two below, all rounded molars save outer row above, which is somewhat incisorlike anteriorly, and all becoming granular in front. Six moderate canines present in front on each jaw.

Dorsal spines longest in third and fourth, $2-2\frac{1}{2}$ in head, last $2\frac{1}{5}$ to $3\frac{1}{4}$; dorsal rays of nearly equal length, about $2\frac{1}{5}$ in head. Anal spines of moderate strength, between those of *S. aries* and *S. latus*; second contained 2 to $2\frac{1}{2}$ in head, third $2\frac{2}{3}$ to $2\frac{3}{4}$. First anal ray nearly equal to length of second spine, and longer than third. Fin outline straight or but slightly concave, tip of second spine not extending beyond middle of last ray, when supine. Pectoral long, falcate, reaching to second anal spine. Ventrals $1\frac{1}{3}$ in head. Caudal nearly equal to head.

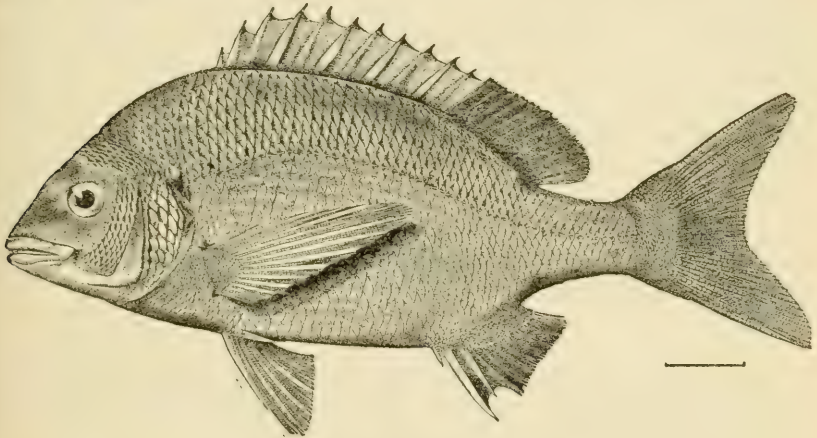


FIG. 11.—SPARUS SWINHONIS.

Scales slightly ctenoid below lateral line; not present on snout, preorbitals, jaws, interorbital space, or preopercular margin; present as a low sheath along bases of vertical fins, on cheek in 7 or 8 rows.

Color of alcoholic specimens uniform, those from Tokyo with darker color, probably because of preservation. Rows of scales indicated by prominent stripes on cheeks as well as on body. Vertical fins all dusky, dorsal margined with denser black, pectorals and ventrals somewhat clearer; anal largely black. Peritoneum silvery, gill cavity clear.

This species differs from *Sparus latus* in a greater number of scales, lower dorsal and anal spines, the latter not reaching beyond half the length of the last ray, beside several smaller points of difference.

This well-marked species is very common in southern Japan and China. Our specimens are from Tokyo, Wakanoura, and Kobe. It

has been confused with *Sparus latus* under the name of *schlegeli* and with *Sparus longispinis* from India, but it is distinct from both, and it is not yet recorded from the East Indies.

(Named for Mr. R. Swinhoe, consul at Chifu.)

7. Family KYPHOSIDÆ.

The RUDDER FISHES.

Herbivorous fishes, with incisor teeth only in the front of the jaws. Body oblong or elevated, with moderate or small scales, ctenoid or smooth. Mouth moderate, with incisor-like teeth in the front of each jaw; no molars; teeth on vomer and palatines present or absent; premaxillaries moderately protractile; preorbital rather narrow, sheathing the maxillary. Gill rakers moderate; pseudobranchiæ well developed; opercles entire. Gills 4, a slit behind the fourth; gill membranes separate, free from the isthmus; dorsal fin continuous or divided, with 10 to 15 rather strong spines, the soft dorsal naked or scaly; anal with 3 spines; ventrals thoracic, the rays I, 5, an accessory scale at base; caudal lunate or forked; pectoral fin with all its rays branched. Intestinal canal elongate, with few or many pyloric cæca. Air bladder usually with 2 posterior horns. Vertebrae in ordinary or slightly increased number, 24 to 28. Post-temporal of normal percoid form, the stout forks not adnate to the cranium. Herbivorous shore fishes, feeding largely on green or olive algæ; chiefly of the Mediterranean Sea and the Pacific Ocean; most of them valued as food.

Key to genera.

- a*¹. GIRELLINÆ. Soft part of dorsal and anal fins naked or partly scaled; head more or less naked; teeth in broad bands, all freely movable, none on vomer; pyloric cæca very numerous; vertebrae in somewhat increased number. Pacific Ocean.
- b*¹. Incisors all tricuspid.
- c*¹. Dorsal spines 14 or 15; each jaw with a series of flat, movable, tricuspid incisors, behind which is a broad band of similar smaller ones; dorsal continuous, its spines low.....*Girella*, 18.
- a*². KYPHOSINÆ. Soft parts of vertical fins closely scaled; teeth more or less fixed, usually present on vomer; pyloric cæca numerous.
- d*¹. Top of head as well as sides and jaws closely scaled; broad bands of teeth behind the incisors; villiform teeth on vomer, palatines and tongue; dorsal spines low; incisor teeth lanceolate.
- e*¹. Incisor teeth strong, with horizontal, backward projecting roots; soft dorsal and anal not much elevated.
- f*¹. Incisor teeth well developed, each with a conspicuous horizontal process or root; caudal fin moderate, about as long as the head, the outer rays not 3 times as long as middle rays; junction of gill membranes forming an angle.....*Kyphosus*, 19.

18. Genus GIRELLA Gray.

Girella GRAY, Ill. Ind. Zool., about 1835 (*punctata*).

Melanichthys TEMMINCK and SCHLEGEL, Fauna Japonica, 1844, p. 75 (*melanichthys*).

Camarina AYRES, Proc. Cal. Acad. Sci., 1860, p. 81 (*nigricans*).

Type.—*Girella punctata* Gray.

Body oblong-ovate, compressed, covered with rather large scales. Mouth small, with a series of tricuspid, movable incisors, behind which is a broad band of similar smaller ones; no molar teeth; no teeth on vomer or tongue; lower pharyngeal teeth slender. Cheeks with very small scales; opercles and top of head chiefly naked. Gill rakers slender. Dorsal fin rather low, with about 14 spines, on the bases of which the scales extend, forming an imperfect sheath; no groove at base of dorsal; no procumbent dorsal spine; anal spines small, graduated; caudal lunate. Air bladder divided into 2 posterior horns. Pyloric cæca numerous; intestinal canal elongate; peritoneum black. Vertebræ 11+16 or 17=27 or 28. Herbivorous. Pacific Ocean. This genus contains several species found on the east coast of Asia and one characteristic of the rocky shores of California. They are herbivorous fishes, feeding on seaweeds.

(From the French "Girelle," which is a derivative of Julis, and is applied to smaller Labroids.)

Key to species.

*a*¹. Dorsal rays XV, 13; anal rays III, 12; scales about 53; a dark spot on each scale on sides, these forming lengthwise stripes; no dark opercular flap; no pale vertical band *punctata*, 30.

*a*². Dorsal rays XIV, 14.

*b*¹. Scales about 50; scales with dark edges; opercular flap pale; young with a whitish vertical bar at the shoulder; anal rays III, 11; lower half of opercle scaled *mezina*, 31.

*b*². Scales about 62; scales all dark; sides without longitudinal streaks of spots; no pale bar at shoulder; anal rays III, 13; lower half of opercle scaleless.

melanichthys, 32.

30. GIRELLA PUNCTATA Gray.

MEJINA.

Girella punctata GRAY, Ill. Ind. Zool., 1830-1835, pl. 98, fig. 34 (Canton).

Crenidens punctatus RICHARDSON, Ichth. China and Japan, 1842, p. 242 (Canton), (dorsal rays XV, 14).

Girella punctata GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 427 (Canton and Japanese Seas), (not synonymy).—STEINDACHNER and DÖDERLEIN, Beitr. Fische Japans, II, Denkschr. kais. Akad. Wiss. Wien., 1883, p. 21 (Tokyo).—NYSTRÖM, K. Svenska. Vet. Akad., vol. 13, Afd. 4, No. 4, 1887, p. 15 (Nagasaki).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 80 (Yokohama).—ISHIKAWA, Prel. Cat. Tokyo Imp. Mus., vol. 1, 1897, p. 53.—JORDAN and STARKS, U. S. Nat. Mus., vol. 32, 1907, p. 497, fig. 5 (Wakanoura, Tokyo, Yokohama, Nagasaki, Misaki, and Tsuruga).

Habitat.—Coasts of southern Japan and China.

Description of specimens from Tsuruga, Akune in Satsuma, Nagasaki, and Tokyo; ranging from very young to 30 cm. in body length, a specimen 15.5 cm. long from Tokyo, taken as typical.

Head $3\frac{3}{8}$ in length to last vertebra; depth $2\frac{2}{5}$; eye 4 ($3\frac{1}{2}$ –5) in head; snout 3; maxillary $3\frac{1}{3}$; interorbital space $2\frac{1}{2}$ to $2\frac{3}{4}$; D. XV, 13; A. III, 12; scales in lateral line 50 to 56; in transverse series between insertion of dorsal and anal $9/18$.

Snout not greatly rounded; premaxillaries at tip not vertical but protruding, their upper edge nearly on level of nostrils. Jaws equal, maxillary ending below posterior nostril or before eyes, mouth strongly oblique. Prefrontals somewhat prominent. Distance of preopercular margin from posterior border of eye contained $1\frac{1}{2}$ in eye. Preopercle finely serrated on upright limb, only partially on horizontal. Cheek

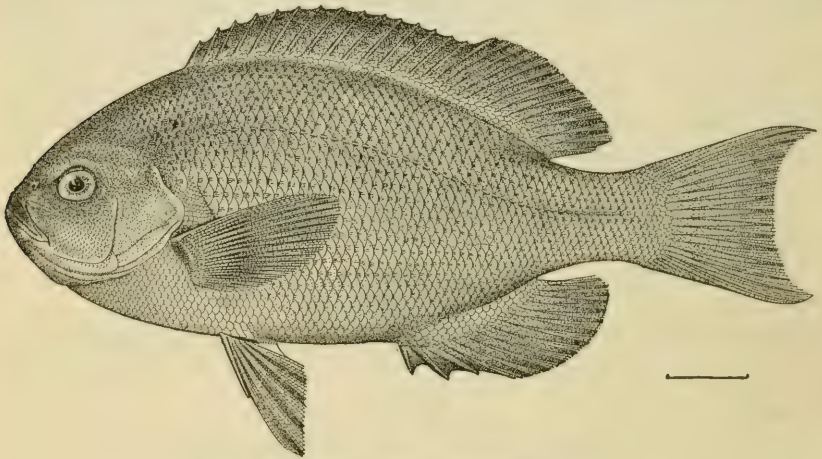


FIG. 12.—GIRELLA PUNCTATA.

longer than deep, measured from eye to lower margin of preopercle and from end of maxillary to vertical margin of preopercle. Gill-rakers 26 to 30 on lower limb of first arch. A single series of tricuspid teeth in both jaws backed by a band of much smaller ones.

Dorsal spines increasing in length to last, which is 2 in head. Dorsal rays slightly longer. Third anal spine longer than second, and contained thrice in head. Soft dorsal and anal fin straight, posterior angles rather pointed. Caudal emarginate in adults, truncate in young, lobes not rounded. Pectorals slightly shorter than head, tips rounded. Ventrals reaching anus, $1\frac{1}{2}$ in head.

Scales roughly ctenoid, smooth to touch on head. Present on proximal half of pectoral, two-thirds of dorsal and anal, and in two or three small rows along bases of dorsal and anal fins. Head scaled to between eyes, on cheeks and suborbitals, minutely on upper limb of preopercle, not on lower, and on upper half of opercle. No scales on subopercle or lower half of opercle, and only occasional scales on interopercle. Snout and jaws naked.

Color in alcohol uniform brown, dark greenish in life, lighter along ventral edge of body and head. Dorsal fin as dark as body; caudal more lightly colored; ventrals light, or white, on lower side save at dark tips, and darker above; pectorals similar, a narrow dark bar across their bases. Scale rows marked by a dark spot at base of each scale. Preopercular flap colored like the body.

This species is generally common on the shores of southern Japan. We have seen specimens of various sizes from Tsuruga, Akune, Wakanoura, Tokyo, Yokohama, Misaki, and Nagasaki. It is valued as a food fish.

It is easily known by the number of 15 dorsal spines, and by the presence on the sides of stripes along the rows of scales.

(*punctatus*, spotted.)

31. GIRELLA MEZINA Jordan and Starks.

Girella mezinga JORDAN and STARKS, Proc. U. S. Nat. Mus., vol. 32, 1907, p. 496, fig. 3 (Naha, in Riu Kiu Islands).—JORDAN and RICHARDSON, Mem. Carnegie Mus., vol. 4, No. 4, 1909, p. 190 (Takao in Formosa).

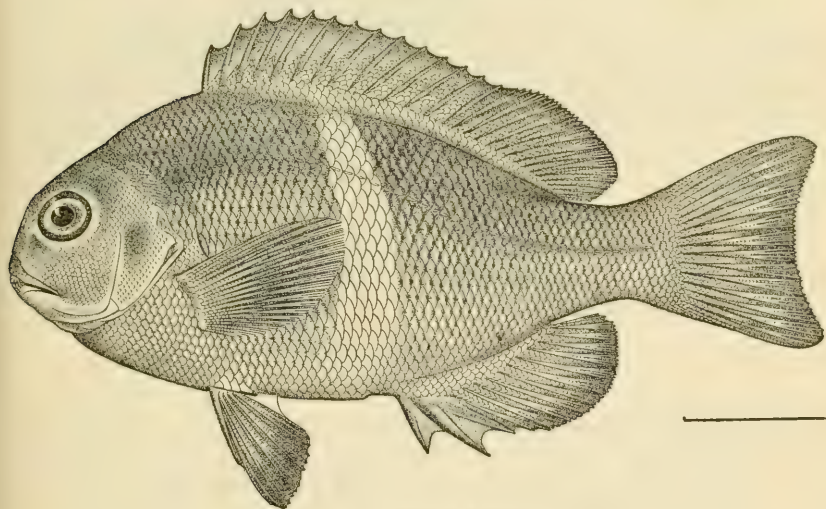


FIG. 13.—GIRELLA MEZINA.

Habitat.—Southern Japan to Formosa.

Description of a specimen 73 mm. in total length from Misaki, Japan, collected by Professor Snyder,¹ and of the type and two cotypes of the species from Naha, Okinawa, Riu Kiu Islands.

Head $3\frac{2}{3}$ in length to base of caudal; depth $2\frac{1}{4}$; eye $3\frac{1}{2}$ in head; maxillary 3; interorbital space $3\frac{2}{3}$; D. XIV, 14; A. III, 11; scales in lateral line 50, in transverse series between insertions of dorsal and anal 8/17.

¹ Record by permission taken from Snyder's manuscript notes.

Snout much rounded in profile; premaxillaries vertical or slightly receding, their upper margin at or below level of lower border of eye, in very young the premaxillaries protrude as in the other species. Maxillary ending under or slightly behind anterior border of eye. Depth of cheek from eye to horizontal border of preopercle greater than its length from end of maxillaries to vertical margin. Vertical margin of preopercle finely serrated, lower but partially. Teeth three pointed. Gill-rakers 22 on lower limb of first arch.

Dorsal spines increasing to last, which is 2 in head. Dorsal rays $1\frac{1}{2}$. Second anal spine equal to third, $2\frac{1}{3}$ in head. Pectoral $1\frac{1}{2}$ in head, ventrals $1\frac{1}{8}$, the latter's spines $2\frac{1}{3}$. Posterior angle of dorsal not pointed. Anal margin rounded, as is pectoral tip. Caudal emarginate or lunate, less nearly truncate in young, angles not very sharp.

Scales roughly ctenoid. Head scaled to above anterior margin of eyes, and on all opercles but the interopercle, including the lower half of the opercle. Rows extending up both anal and dorsal spines, and over basal half of soft fins.

Color in alcohol comparatively light, darker above. A conspicuous white band usually present across body from eighth or ninth dorsal spines toward anus, never reaching it, and vanishing sometimes before lateral line, this band more indistinct with age, or even becoming obsolete. Dorsal, anal, and caudal dark, apparently somewhat mottled. Pectorals and ventrals lighter, former with an indistinct bar across its base, latter darker above. Scale rows marked by darker margin of scales. Opercular flap pale.

Of this species we have seen the original type, from the Riu Kiu Islands, and one example taken by Professor Snyder at Misaki.

(*Mejina*, the local name.)

32. GIRELLA MELANICHTHYS (Richardson).

KUROMEJINA (black mejina).

Melanichthys TEMMINCK and SCHLEGEL, Fauna Japonica, 1844, p. 75, pl. 39, (Nagasaki).

? *Crenidens leonina* RICHARDSON, Ichth. China and Japan, 1846, p. 242, (Canton); (may be *Girella mezina*).

Girella leonina JORDAN and STARKS, Proc. U. S. Nat. Mus., vol. 32, 1907, p. 496, fig. 4 (Wakanoura).

Crenidens melanichthys RICHARDSON, Ichth. China and Japan, 1846, p. 243 (after Temminck and Schlegel).

Girella melanichthys BLEEKER, Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 8 (= *Melanichthys* Schlegel = *Melanichthys crenidens* Bleeker), [Kiusiu, Nagasaki].

Melanichthys crenidens BLEEKER, Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, p. 20 (= *Crenidens melanichthys* Richardson) (Japan, China).

Habitat.—Southern Japan and China.

Description of a specimen 145 mm. in body length from Wakanoura, Japan.

Head $3\frac{1}{2}$ in length to last vertebra; depth $2\frac{1}{2}$; eye $4\frac{1}{2}$ in head; snout 3; maxillary $3\frac{1}{2}$; interorbital space 3; depth of preorbital 5; D. XIV, 14; A. III, 13; scales in lateral line 62, in transverse series 13 + 22 (including 3 smaller rows above and 2 below at insertions of dorsal and anal).

Snout rounded but moderately; premaxillaries protruding, upper edges on level with nostrils; cleft of mouth strongly oblique; distance from end of maxillaries to vertical margin of preopercle greater than distance from eye to horizontal margin. Flaps of nostrils large, tufted. Profile of snout slightly concave, prefrontals prominent. Teeth in jaws in outer two rows tricuspid, outer largest, an inner broad band of much smaller teeth present. Teeth tipped with a transparent brown. Gill-rakers 20 on lower limb of first arch.

Dorsal spines short, last longest, $2\frac{1}{2}$ in head; dorsal rays $2\frac{1}{8}$ in head, margin of fin not rounded posteriorly. Third anal spine longest 3

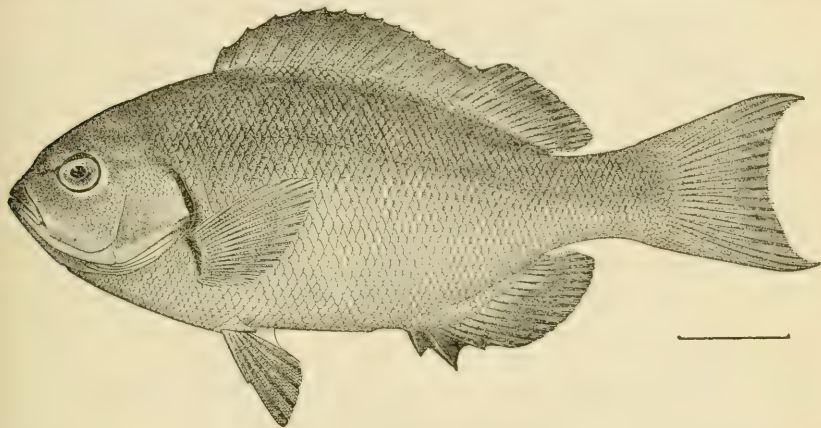


FIG. 14.—GIRELLA MELANICHTHYS.

in head; soft anal margin similar to soft dorsal. Caudal deeply emarginate, lobes acute. Ventrals $1\frac{1}{2}$ in head, their spines $2\frac{3}{4}$. Pectorals $1\frac{1}{4}$ in head.

Scales ctenoid wherever present. Soft dorsal and anal scaled on basal halves, and rows extending out along dorsal spines but apparently not on anal spines. Scales on head extending to between nostrils, buried in skin on upper surface. Lower half of opercle, sub- and interopercle, and lower limb of preopercle naked. Scales on preorbital deeply buried anteriorly. Snout and lower jaw naked.

Color dark greenish in alcohol, much more so above. Opercular flap deep brown or black, as is a bar across base of pectorals. Fins corresponding in color to their respective parts of body. Peritoneum black. Scale rows unmarked by color pattern.

This species is not rare in southern Japan. Our specimens are from Wakanoura. It is readily known by the presence of 14 dorsal spines

and by the plain black color. The opercular flap is black. This may be the *Crenidens leoninus* described by Richardson from Canton as having 14 dorsal spines, but his scant account applies equally well to *Girella mezina*. We have therefore adopted the name which is not open to question.

(μελάς, black; ἰχθύς, fish.)

19. Genus KYPHOSUS Lacépède.

- Kyphosus* LACÉPÈDE, Hist. Nat. Poiss., vol. 3, 1802, p. 114 (*bigibbus*=*fuscus*).
Pimelepterus LACÉPÈDE, Hist. Nat. Poiss., vol. 4, 1803, p. 429 (*bosqui*=*sectatrix*).
Dorsuarius LACÉPÈDE, Hist. Nat. Poiss., vol. 5, 1803, p. 482 (*nigrascens*=*fuscus*).
Xyster LACÉPÈDE, Hist. Nat. Poiss., vol. 5, 1803, p. 484 (*fuscus*).
Saleima BOWDICH, Excursion Madeira, 1825, p. 238, (*aurata*).
Opisthistius GILL, Proc. Acad. Nat. Sci. Phila., vol. 14, 1862, p. 245 (*tohmel*).

Body elongate-ovate, regularly elliptical, moderately compressed, head short, with blunt snout; eye large; mouth small, horizontal; maxillary barely reaching front of eye; each jaw with a single series of rather narrow obtusely lanceolate incisors, implanted with compressed conspicuous roots posteriorly; behind these a narrow band of villiform teeth; fine teeth on vomer, palatines, and tongue. Branchiostegals 7; gill-rakers long. Preopercle obsoletely serrate; preorbital narrow, covering but little of the maxillary. Squamation very complete, the space between and about the eyes being the only naked part; scales smallish, thick, ctenoid, 50 to 70 in the lateral line, which is continuous; similar scales entirely covering the soft parts of the vertical fins, and extending up on the paired fins. Dorsal fin low, with about 11 spines, which are depressible in a groove of scales, the fin continuous, but the last spines low, so that a depression occurs between the two parts of the fin, the bases of the spinous and soft parts about equal; soft dorsal rather low or elevated in front, not falcate, pointed behind; anal similar to soft dorsal, with three spines; caudal fin moderately forked; pectoral fins small, ventrals well behind them. Intestinal canal long. Pyloric cæca very numerous. Vertebrae 9 or 10+15 or 16=25. This genus contains some 10 species, chiefly confined to the Pacific Ocean, and most of them found in the East Indies.

(κῦφος, a hump, referring to a deformed specimen with a hump back.)

Key to species.

- a¹. KYPHOSUS; soft dorsal not elevated in front, its longest rays not longer than longest dorsal spine; dorsal rays X, 14; anal rays III, 13. Scales in lateral line 53.....*lembus*, 33.
a². OPISTHISTIUS; soft dorsal elevated in front, its longest rays longer than longest dorsal spine; dorsal rays XI, 12, anal rays III, 11. Scales in lateral line about 56.....*cinerascens*, 34.

33. KYPHOSUS LEMBUS (Cuvier and Valenciennes).

Pimblepterus lembus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 7, 1831, p. 269 (Vanicolo).—BLEEKER, Nat. Tijd. Ned. Ind., vol. 4, 1853, p. 469 (Batavia).—BLEEKER, Verh. kon. Akad. Wet., vol. 17, 1877, p. 14.—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 498 (Moluccas).—BLEEKER, Atlas Ichth., vol. 9, 1877, p. 15, pl. 364 (Batu, Pinang, Singapore, Java, Celebes, Ternate, Batjan, Amboyna).

Pimblepterus ternatensis BLEEKER, Nat. Tijd. Ned. Ind., vol. 4, 1853, p. 605 (Ternate).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 499.

Habitat.—Coasts of southern Japan and East Indian Seas.

Description of one specimen 360 mm. in total length, from Wakanoura.

Head $3\frac{2}{3}$ in body length; depth $2\frac{1}{4}$; eye $4\frac{1}{2}$ in head; interorbital space $2\frac{1}{2}$; snout 3; maxillary 3; scales in lateral line 53, above 69, below 61; in transverse series to insertions of dorsal and anal 11/19; D. X, 14; A. III, 13; gill-rakers 24 on lower limb of first arch.

Body arched evenly above and below, greatest depth at center of body which is $2\frac{2}{3}$ in total length to tip of middle caudal rays. Head conical, somewhat convex in profile. Prefrontals prominent, interorbital space strongly arched. Nostrils overhung by prefrontals, posterior opening nearly horizontal. Preorbital edge entire; opercle with one obscure point; preopercle with minute serrations (nearly lost with age). Teeth in a single prominent row, 13 or 14 on each side in both jaws, besides supplementary teeth under loose lips; horizontal parts of teeth somewhat longer than vertical, measuring on inner angles. A narrow band of villiform teeth behind these in both jaws; broad patches on vomer, and tongue; narrow bands on palatines.

Dorsal fins slightly notched, longest spines the fourth and fifth, which are contained $2\frac{2}{3}$ in head; dorsal rays not longer than spines, of nearly even length throughout; base of soft dorsal slightly longer than head, and longer than base of spinous dorsal. Anal spines weak, third longest, slightly shorter than eye diameter; first rays $1\frac{1}{2}$ to $1\frac{2}{3}$ times length of last, but with straight fin margin; anal base equal to length of head. Pectorals and ventrals short (tips worn off). Caudal forked, lobes acute.

Scales ctenoid, thickly covering vertical fins, outer side of pectoral and along ventral rays. Snout and jaws naked; maxillary scaled; preorbitals naked, save for occasional buried scale. Rows between center of dorsal fin and ventrals 11/18.

Color in alcohol uniform, darker above, fins similar in color. Margins of scales dark, forming indefinite lines between rows by superposition. Peritoneum black.

This species must be rare in Japan. We obtained one specimen from Wakanoura, the only record from this region.

(λέμβος, a long swift boat.)

34. *KYPHOSUS CINERASCENS* (Forskål).

Sciæna cinerascens (tahmel) FORSKÅL, *Descrip. Anim.*, 1775, p. 53, No. 66, (Red Sea.)

Pimblepterus cinerascens DAY, *Fishes India*, 1875, p. 143, pl. 35, fig. 3 (Seas of India).—BLEEKER, *Atlas Ichth.*, vol. 8, 1875, p. 15, pl. 364 (Sumatra, Bangka, Cocos, Java, Bali, Solor, Flores, Celebes, Timos, Obi-major, Amboyna, Saparua, Philippines, New Guinea); *Enum. Poiss. Verh. kon. Akad. Amst.*, vol. 18, 1879, p. 8 (Japan).

Kyphosus cinerascens JORDAN and RICHARDSON, *Bull. U. S. Bur. Fish.*, vol. 27, 1908, p. 260 (Calayan).—JORDAN and RICHARDSON, *Philippine Islands, Bur. of Sci. Publ. No. 1*, Manila, 1910, p. 31.

Pimblepterus tahmel RÜPPELL, *N. W. Fische*, 1829, p. 35, pl. 10, fig. 4 (Djidda, Red Sea).—GÜNTHER, *Cat. Fish. Brit. Mus.*, vol. 1, 1859, p. 499.—KLUNZINGER, *Syn. Fische Roth. Meer., Verh. z. b. Ges. Wien*, vol. 20, 1870, p. 795 (part), (Red Sea).

Opisthistiis tahmel GILL, *Proc. Acad. Nat. Sci., Phila.*, vol. 14, 1862, p. 242.

Pimblepterus indicus (Kuhl and Van Hasselt) CUVIER and VALENCIENNES, *Hist. Nat. Poss.*, vol. 7, 1831, p. 270 (Java).—TEMMINCK and SCHLEGEL, *Fauna Japonica*, 1844, p. 86 (Nagasaki).—STEINDACHNER and DÖDERLEIN, *Beitr. Fische Japan's, II, Denkschr. kais. Akad. Wiss. Wien*, 1883, p. 21 (Tokyo).

Kyphosus indicus JORDAN and SNYDER, *Check List, Ann. Zool. Jap.*, vol. 3, pts. 2 and 3, 1901, p. 80 (Yokohama).

Habitat.—East Indies, north to Japan.

This species was not seen by us. The following account is translated from that given by Steindachner of a specimen from Tokyo, 57 centimeters in length, in the Vienna Museum:

The greatest body depth is between $2\frac{1}{2}$ and $2\frac{3}{4}$, the head length somewhat less than 4 times in the body length. The broad interorbital space is transversely strongly arched. The angle of the mouth lies vertically under the anterior edge of the eye. The scaleless low snout ascends much more sharply than the upper part of the dorsal profile of the head rises to the occiput. Both margins of the preopercle are toothed (serrated).

The sixth to eighth dorsal spines are equal in height and are the highest of the fin; each is at least half the head length, while the greatest height of the soft dorsal is equal to only two-thirds of the head length. The lateral line irregularly skips several scales and has 55-56 scales from the shoulder to the beginning of the caudal, while there are 70 to 73 scales between the head and caudal.

D. XI, 12. A. III, 11. L. tr. 12/1/22.

Stomach moderately large, intestine much convoluted, both filled with fragments of algae. Air bladder large, pancreas rather small.

Iron gray, darker above, passing into white below. Ventrals blackish. On the lower end of the pectoral base a brownish black spot. Scaleless preorbital is shiny silvery-gray.

A specimen of this genus, with deep body, probably belonging to this species, was seen alive by us in the aquarium at Asakusa Park, near Tokyo.

The above synonymy, after Bleeker, is more or less open to question. This fish is, however, probably the original *cinerascens* of Forskål, which has the dorsal XI, 12 and the soft dorsal elevated. The latter character probably varies with age. Day's figure represents it but very slightly higher than the spines. Steindachner's

specimen, as stated above, possessed higher spines by a half than is given by any descriptions and figures or is shown by our small specimen from Calayan (3 in head). The same is true of the soft dorsal.

(*cinerascens*, becoming ashen.)

8. Family ERYTHRICHTHYIDÆ.

Sparoid fishes with the body spindle-shaped and the mouth toothless or with small deciduous teeth. Body elongate, not much compressed, covered with moderate, ciliated scales; head scaly, except the tip of snout; premaxillaries excessively protractile, the spines extending to the occiput; maxillary rather broad, slipping under the preorbital; lower jaw projecting; no teeth on palate; lower pharyngeals with cardiform teeth; preopercle entire or with flat thin serrae; opercle ending in a flat point. Dorsal fins separate with free spines between, the first with slender spines, the number about 15; soft dorsal moderate, low, naked, with a sheath of scales at base, both dorsal and anal with the last ray produced; anal with three small spines and about nine rays. Caudal widely forked. Pylorus cæca few. This family, provisionally adopted, contains but few species, all of them fishes of rather deep water, of bright colors and active movements, their relationships uncertain. They have much in common with *Aphareus* among the Lutianidæ. They have also qualities in common with the Gerridæ. Jordan and Evermann associated them with the European genera *Merolepis* Rafinesque (= *Mæna* Cuvier), and *Spicara*, to form a family Mænidæ. This name Mænidæ is not eligible, and *Erythrichthys* has little in common with *Merolepis* save the protractile mouth. Besides *Erythrichthys*, the genera *Dipterygonotus* and *Inermia* in this family are probably valid.

20. Genus ERYTHRICHTHYS Temminck and Schlegel.

Erythrichthys TEMMINCK and SCHLEGEL, Fauna Japonica, p. 117, 1845 (*schlegeli*).

?*Enmelichthys* RICHARDSON, Voyage *Erebus* and *Terror*, 1846, p. 47 (*nitidus*).

?*Boxaodon* GUICHENOT in Gay, Histoire de Chile, vol. 2, 1847, p. 208 (*cyanescens*).

Type.—*Erythrichthys schlegeli* (Bleeker).

This genus has the maxillary very broad and scaly, and the preopercular angle nearly a right angle. Whether the same is true of the other (nominal) genera of this group we do not know. The allied genus *Dipterygonotus* Bleeker is said to have the maxillary naked.

In *Inermia* the maxillary is narrow.

(ἔρυθρός, red; ἰχθύς, fish.)

35. *ERYTHRICHTHYS SCHLEGELI* (Bleeker).

Erythrichthys TEMMINCK and SCHLEGEL, Fauna Japonica, 1845, p. 117, pl. 63, fig. 1 (Nagasaki).

Emmelichthys schlegeli BLEEKER, Nieuwe Nalez. Verh. Bat. Gen., vol. 26, 1857, p. 20 (after Temminck and Schlegel); Enum. Poiss., Verh. kon. Akad. Amst., vol. 18, 1879, p. 8.—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, p. 82, 1901 (Yokohama).

Erythrichthys schlegeli GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 395 (after Temminck and Schlegel).

Habitat.—Coasts of southern Japan.

Description of two specimens, 410 and 400 mm. in total length, from Tokyo and one from Misaki, 155 mm. Measurements of head, including lower jaw.

Head $3\frac{1}{2}$ to $3\frac{1}{2}$ in body length; depth 4; eye $3\frac{3}{4}$ in head; maxillary $2\frac{1}{2}$; snout $3\frac{3}{4}$; interorbital space $3\frac{3}{4}$; D. XI, 11; A. III, 10; scales

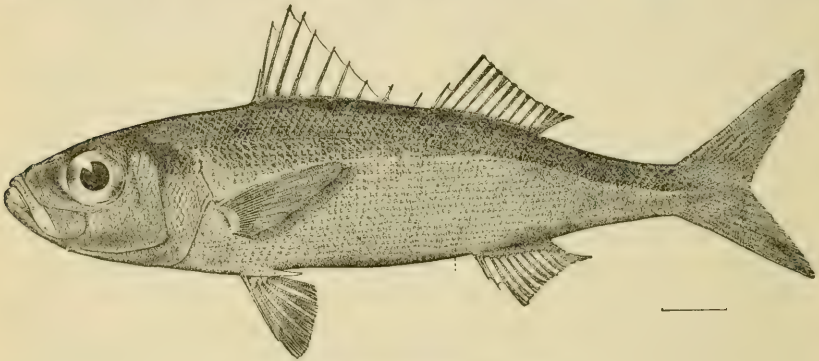


FIG. 15.—*ERYTHRICHTHYS SCHLEGELI*.

in lateral line 65 to 72; in transverse series between dorsal and anal insertions 10/17; gill-rakers 25 on lower limb of first arch; branchiostegals 7.

Body outlines evenly symmetrical; caudal peduncle slender, its depth $4\frac{3}{4}$ in head (to tip of lower jaw), and with a distinct ridge on each side along lateral line; breadth of body contained about twice in its depth. Axis of head coinciding with that of body; lower jaw projecting, its tip conical, produced; maxillary breadth two-thirds of that of eye, ending under anterior margin of pupil; upper lip broad, its breadth $4\frac{1}{2}$ in eye. Nostrils situated nearer center of eye than tip of snout; close together, separated by less than breadth of anterior one. Eye without prominent adipose lids. Preopercular margin flexible, slightly crenate, vertical limb not deeply concave, but straight, its angle less than 45° . Opercular points two, separated by half diameter of eye; above upper a smaller more obscure one. Teeth in jaws minute, present anteriorly only, all pointing backward. Palatines with a small band or patch.

Dorsals not separated (appearing thus only when interradi-
al membrane is broken). Dorsal spines slender, flexible, third longest
 $1\frac{7}{8}$ in head, penultimate shorter than last. Longest ray is first, $2\frac{3}{4}$
in head. Soft dorsal base $7\frac{1}{3}$ in body length. Second anal spine
slightly more than half length of third, which is $4\frac{2}{3}$ in head. Soft
anal similar to soft dorsal; its longest ray 3 in head; its base $7\frac{2}{3}$ in
body length. Pectorals contained $1\frac{1}{2}$ in head; ventrals 2, latter
reaching less than half way to anal insertion. Caudal deeply forked.

Scales roughly ctenoid, present on whole of head (including
preopercle) save lips, and on bases of soft dorsal and anal as a heavy
sheath.

Colors uniformly light brown in alcohol, more silvery and lighter
below. Fins uniform. Peritoneum silvery.

Of this species we have seen the three specimens mentioned above.
It is certainly rare in Japan.

(Named from Prof. H. Schlegel, of Leyden.)

NOTE ON ERYTHRICHTHYS SCINTILLANS JORDAN AND THOMPSON, A
NEW SPECIES FROM HAWAII.

The Hawaiian species described and figured by Jordan and Ever-
mann as *Erythrichthys schlegeli*¹ seems to be a distinct species for
which we suggest the name of *Erythrichthys scintillans*.

The most striking difference is the longer anal base in *E. scintillans*
which is contained $6\frac{1}{3}$ in the body length, and is to that of our Jap-
anese specimens of *E. schlegeli* as 0.16 is to $0.12\frac{1}{2}$, using measure-
ments in hundredths of body length. Other differences are, a
longer soft dorsal base, $5\frac{2}{3}$ in body length; larger eye, $3\frac{1}{4}$ in head;
greater body depth, $3\frac{1}{2}$ in length; greater depth of caudal peduncle,
which in Japanese specimens is only two-thirds of that in *E. scin-
tillans*; longer second anal spine, five-sixths of length of third;
ventrals extending over half way to anal insertion; the small upper
point on the opercle is lacking; the opercular points are nearer
together, the distance between them only one-quarter of the eye
diameter; the vertical preopercular margin is deeply emarginate,
and the nostrils are midway between the center of the eye and the
tip of the premaxillaries, hence farther before the eye than in those
from Japan despite its own larger eye.

We may adopt as our type of *E. scintillans* the specimen described
and figured by Jordan and Evermann. The characters noted are all
verified on the example before us, collected by Doctor Jordan at
Hilo, Hawaii.

¹ Bull. U. S. Fish Comm., vol. 23, pt. 1, 1903, p. 245, pl. 19.

SUMMARY (WITH LOCALITIES FROM WHICH JAPANESE SPECIMENS WERE TAKEN).

1. Family KUHLIDÆ.

1. *Boulengerina* Fowler, 1906.1. *taniura* (Cuvier and Valenciennes), 1829; Tanegashima, Misaki.2. *Kuhlia* Gill, 1861.2. *marginata* (Cuvier and Valenciennes), 1829; Izu.

2. Family PRIACANTHIDÆ.

3. *Priacanthus* (Cuvier), 1817.3. *hamrur* (Forskål), 1775.4. *macracanthus* Cuvier and Valenciennes, 1829; Tokyo, Nagasaki.5. *japonicus* Cuvier and Valenciennes, 1829; Tokyo, Misaki, Bingo.4. *Pseudopriacanthus* Bleeker, 1869.6. *niphonius* (Cuvier and Valenciennes), 1829.

3. Family THERAPONIDÆ.

5. *Therapon* Cuvier, 1817.§ *Therapon*.7. *servus* (Bloch), 1797; Kagoshima.§ *Pelates* Cuvier, 1829.8. *oxyrhynchus* Temminck and Schlegel, 1842; Nagasaki, Tokyo, Kochi, Shimiju, Suruga, Wakanoura, Kagoshima, Akune, Nagaoka.

4. Family BANJOSIDÆ.

6. *Banjos* Bleeker, 1879.9. *banjos* (Richardson), 1846; Tokyo, Osaka, Fusan.

5. Family HÆMULIDÆ.

7. *Parapristipoma* Bleeker, 1872.10. *trilineatum* (Thunberg), 1793; Tokyo, Misaki, Enoshima, Wakanoura, Nagasaki.8. *Plectorhynchus* Lacépède, 1801.§ *Diagramma* Cuvier, 1817.11. *pictus* (Thunberg), 1792; Onomichi, Nagasaki.§ *Plectorhynchus*.12. *cinctus* (Temminck and Schlegel), 1842; Yokohama, Misaki, Wakanoura.9. *Hapalogenys* Richardson, 1844.13. *nigripinnis* (Temminck and Schlegel), 1843; Wakanoura, Tsuruga.14. *mucronatus* (Eyedoux and Souleyet), 1841; Kobe, Onomichi, Hiroshima.15. *kishinouyei* Smith and Pope, 1907; Urado.10. *Scolopsis* Cuvier, 1817.16. *inermis* (Temminck and Schlegel), 1843; Nagasaki.

6. Family SPARIDÆ.

11. *Lethrinus* Cuvier, 1829.§ *Lethrinichthys* Jordan and Thompson, 1911.17. *nematacanthus* Bleeker, 1854; Tokyo, Wakanoura.18. *hæmatopterus* Temminck and Schlegel, 1844; Nagasaki.§ *Lethrinus*.19. *chærorhynchus* (Bloch and Schneider), 1801; Urado.12. *Euthyopteroma* Fowler, 1904.20. *virgatum* (Houttuyn), 1782; Tokyo, Nagasaki.21. *bathybium* (Snyder), 1911; Kagoshima.13. *Gymnocranius* Klunzinger, 1870.22. *griseus* (Temminck and Schlegel), 1843; Misaki, Wakanoura, Nagasaki.14. *Taius* Jordan and Thompson, 1911.23. *tumifrons* (Temminck and Schlegel), 1843; Tsushima.15. *Evynnis* Jordan and Thompson, 1911.24. *cardinalis* (Lacépède), 1803; Matsushima, Tokyo, Misaki.16. *Pagrosomus* Gill, 1893.25. *major* (Temminck and Schlegel), 1842; Misaki, Tokyo, Wakanoura, Aomori, Nagasaki; Port Arthur..26. *auratus* (Forster) Bloch and Schneider, 1801 (probably not Japanese).17. *Sparus* Linnæus, 1758.27. *arics* (Temminck and Schlegel), 1843; Tokyo, Wakanoura, Nagasaki.28. *latus* Houttuyn, 1782; Kobe, Wakanoura.29. *swinhonis* Günther, 1874; Tokyo, Wakanoura, Kobe.

7. Family KYPHOSIDÆ.

18. *Girella* Gray, 1835.30. *punctata* Gray, 1835; Misaki, Wakanoura, Tokyo, Yokohama, Tsuruga, Akune, Satsuma, Nagasaki.31. *mezina* Jordan and Starks, 1907; Misaki.32. *melanichthys* (Richardson), 1846; Wakanoura.19. *Kyphosus* Lacépède, 1802.§ *Kyphosus*.33. *lembus* (Cuvier and Valenciennes), 1831; Wakanoura.§ *Opisthistius* Gill, 1862.34. *cinerascens* (Forskål), 1775; Tokyo.

8. Family ERYTHRICHTHYIDÆ.

20. *Erythrichthys* Temminck and Schlegel, 1845.35. *schlegeli* (Bleeker), 1857; Tokyo, Misaki.

THE CRUSTACEA OF THE ORDER CUMACEA IN THE COLLECTION OF THE UNITED STATES NATIONAL MUSEUM.

By WILLIAM T. CALMAN,

Of the British Museum (Natural History), London, England.

INTRODUCTION.

Some seven years ago Dr. Richard Rathbun was good enough to entrust to me for examination the entire collection of unidentified Cumacea belonging to the United States National Museum. The working out of the collection was unavoidably delayed, and meanwhile additional consignments were sent to me as they were received at the National Museum, until a total of 292 bottles and tubes was reached—one of the largest collections of Cumacea, if not the very largest, that has ever been in the hands of a single investigator. Even now the interest of the material is far from being exhausted, for, to my regret, lack of time has prevented me from utilizing fully the opportunities it offers for studying the variations of several of the commoner species.

The examination of this collection has been carried out in the zoological department of the British Museum, and the results are published here by permission of the trustees of that institution. The authorities of the United States National Museum have courteously allowed a selection of duplicate specimens, including paratypes of many of the new species, to be retained for the British Museum.

The bulk of the material consists of specimens dredged by the *Albatross* and other vessels of the United States Bureau of Fisheries off the New England coast and in Alaskan waters, together with the rich Alaskan collections of Dr. W. H. Dall. The remainder includes specimens from other localities on the coasts of North and South America and a few from Greenland and Japan.

In all, 49 species have been recognized, including 17 that appear to be new to science, and one new genus has been established. A small number of specimens have been set aside which may possibly represent new species but do not afford adequate material for proper description.

The figures accompanying this paper have been drawn by Miss Gertrude M. Woodward.

LIST OF SPECIES IN THE UNITED STATES NATIONAL MUSEUM.

Miss M. J. Rathbun has kindly prepared for me a list of the named Cumacea in the Museum collection. Most of these I have not seen, but I have no reason to doubt the correctness of the identifications, and I have therefore included them (with some minor changes in nomenclature) in the following list, distinguishing them by enclosing the names of the species or localities within square brackets.

The regions from which the specimens in the collection have been obtained are indicated by the letters standing after the name. More precise details regarding the distribution of the species examined by me will be found in a later part of this paper.

- A. Coasts of northern Europe.
- B. West Greenland and Labrador.
- C. Atlantic coast of North America south of Labrador.
- D. Gulf of Mexico.
- E. Atlantic coast of South America.
- F. Pacific coast of South America.
- G. Pacific coast of North America south of Puget Sound.
- H. Alaskan area, including Aleutian Islands, and the Pacific coast of North America north of Puget Sound.
- I. Sea of Okhotsk.
- J. Japan.

BODOTRIIDÆ.

- [*Bodotria scorpioides* (Montagu). A.]
- Bodotria* sp. J.
- Cyclaspis longicaudata* G. O. Sars. C.
- Cyclaspis varians*, new species. C.
- [*Iphinoë trispinosa* (Goodsir). A.]
- [*Vauntomponia cristata* Sp. Bate. A.]
- Heterocuma sarsi* var. *granulata* Miers. J.
- Heterocuma diomedex*, new species. J.
- Bathycuma* (?) *longicaudata*, new species. G.
- Leptocuma kinbergii* G. O. Sars. E.
- Leptocuma minor*, new species. C.

LEUCONIDÆ.

- Leucon nasica* (Krøyer). [A], C.
- Leucon nasicoides* Lilljeborg. C.
- Leucon longirostris* G. O. Sars. C.
- Eudorella emarginata* (Krøyer). [A], B, C.
- Eudorella truncatula* (Sp. Bate). C.
- Eudorella hispida* G. O. Sars. C.
- Eudorella monodon*, new species. D.
- Eudorellopsis deformis* (Krøyer). C.
- Eudorellopsis integra* (S. I. Smith). B, C, H.
- Eudorellopsis biplicata*, new species. C.

NANNASTACIDÆ.

- [*Cumella pygmaea* G. O. Sars. A.]
- Cumella carinata* (Hansen). C.

NANNASTACIDÆ—Continued.

Cumella sp. H.

[*Nannastacus unguiculatus* Sp. Bate. A.]

[*Procampylaspis armata* Bonnier. A.]

Campylaspis rubicunda (Lilljeborg). C.

[*Campylaspis verrucosa* G. O. Sars. A.]

Campylaspis horrida G. O. Sars. C, J. (?)

Campylaspis affinis G. O. Sars (?). C.

[*Campylaspis sulcata* G. O. Sars. A.]

Campylaspis vitrea Calman (?). C.

LAMPROPIDÆ.

Lamprops fuscata G. O. Sars. H.

Lamprops quadriplicata S. I. Smith. C.

Lamprops (?) *beringi*, new species. H.

[*Hemilamprops cristata* (G. O. Sars). A.]

[*Hemilamprops uniplicata* (G. O. Sars). A.]

Paralamprops orbicularis (Calman). C.

DIASTYLIDÆ.

Diastylis scorpioides (Lepechin). B, C.

Diastylis dalli, new species. H, I.

Diastylis bidentata, new species. H.

Diastylis alaskensis, new species. H.

Diastylis planifrons, new species. E.

Diastylis nucella, new species. H.

Diastylis aspera, new species. H, I.

Diastylis argentata, new species. F.

Diastylis rathkii (Krøyer). [A], B, C, H.

Diastylis sulcata, new species. H.

Diastylis polita S. I. Smith. C.

Diastylis sculpta G. O. Sars. C.

[*Diastylis rugosa* G. O. Sars. A.]

Diastylis quadrispinosa G. O. Sars. C.

[*Diastylis cornuta* (Boeck). A.]

[*Diastylis abbreviata* G. O. Sars. C.]

Diastylis stygia G. O. Sars. C.

Diastylis lucifera (Krøyer). [A], C.

Diastylis goodsiri (Bell). [A], C.

[*Diastylis spinulosa* Heller. A.]

[*Diastylis josephinæ* G. O. Sars. A.]

[*Diastylis rostrata* (Goodsir). A.]

[*Diastylis tumida* (Lilljeborg). A.]

[*Diastylodes biplicata* (G. O. Sars). A.]

[*Diastylodes serrata* (G. O. Sars). A.]

Diastylopsis dawsoni S. I. Smith. G, H.

Diastylopsis resima (Krøyer). C.

[*Leptostylis longimana* (G. O. Sars). -C.]

[*Leptostylis ampullacea* (Lilljeborg). C.]

[*Leptostylis macrura* G. O. Sars. A.]

Oxyrostylis smithi, new genus and species. C, D.

Colurostylis (?) *occidentalis*, new species. G.

PSEUDOCUMIDÆ.

[*Pseudocuma longicornis* (Sp. Bate). A.]

Petalosarsia declivis (G. O. Sars). C.

REMARKS ON GEOGRAPHICAL DISTRIBUTION.

It is necessary once more to insist on the fact that our knowledge of the Cumacea, except in one or two narrow areas, is far too fragmentary to admit of any profitable discussion of the subject of geographical distribution. Even the rich collections from the New England and Alaskan coasts now examined present, in all probability, only an incomplete and one-sided picture of the Cumacean fauna of these regions. The employment of other methods of collecting, specially adapted for obtaining the more minute organisms of the sea bottom, would no doubt add very largely to the lists of species and materially alter the aspect of the fauna as compared with that of better known regions. Nevertheless, while no importance can be attached to the negative features of the lists here given, there are one or two positive features which seem to be of sufficient interest and importance to merit further consideration. These are concerned with the relations between (1) the North Pacific fauna and those of the Arctic and Atlantic Oceans, and (2) the relations between the faunas of the eastern and western coasts of the Atlantic.

As regards the first point, the following species¹ are recorded below from both the Pacific and Atlantic coasts:

Leucon nasica.

Eudorellopsis integra.

Diastylis rathkii.

Of these, *D. rathkii* is known to have practically a circumpolar range in Arctic seas, the only considerable gap being in the unexplored waters of the Arctic-American archipelago, between Wellington Channel and Point Franklin, Alaska. *Leucon nasica* may also be found to have a circumpolar distribution, since it is already known from west Greenland eastward to the mouth of the Yenisei. The remaining species, *Eudorellopsis integra*, is especially interesting since it is known only from Bering Sea, west Greenland, and the northern part of the Atlantic coast of America. It is very undesirable to press too far the evidence from a single case of this kind, more especially when it concerns a minute bottom-living species, whose apparent absence in many localities may be due to imperfect collecting, but it is at all events suggestive that a similarly limited range is recorded for several species of decapod crustacea. The crab *Chionacetes opilio* and the shrimps *Nectocranion lar* and *Spirontocaris grænlandica* may be mentioned as examples.² These and other similar instances seem

¹ Excluding, for the present, *Campylaspis horrida* and *Lamprops fuscata*, the identification of which in the Pacific is doubtful.

² Ortmann, Bronn's Thierreich, Crustacea, Abth. 2, 1900, p. 1265. See also Rathbun, Harriman Alaska Exped., vol. 10, 1901, pp. 61, 137, and 174; and Hansen, Danish Ingolf-Exped., vol. 3, Crust. Malacostraca, I, 1908, pp. 12, 59, and 64.

to point to the existence of an Arctic-American (but *not* circumpolar) fauna, extending into the boreal regions on both sides of the American continent. I learn from Dr. W. H. Dall that there is some evidence pointing in the same direction to be obtained from the Mollusca, among which, however, there are some species common to the east and west boreal regions that are not known from the Arctic seas.

As regards the relation between the faunas of the American and European coasts of the Atlantic, the list given above includes a considerable number of species that are common to both. The great majority of these are species that range into the Arctic region and have a continuous distribution in the colder waters of the north. A few, like *Cyclaspis longicaudata* and *Paralamprops orbicularis*, are deep-water species, for which we may suppose a similar continuity in the deeper levels. There remain a small number of forms, of which *Eudorella truncatula* is an example, which are neither truly Arctic nor deep-water species. These appear to exist in separate colonies on the two sides of the Atlantic, and, as in the similar case of the European and American lobsters (*Homarus gammarus* and *H. americanus*), we should expect to find at least the beginnings of specific differentiation between the forms inhabiting the two areas. In the case of *E. truncatula* I have discussed the relation of the American form described by Sars as *E. pusilla* to the European species, and, failing to find any trustworthy characters on which to separate them, I have united them under one specific name. It is by no means unlikely, however, that some future student may be more successful in distinguishing the two forms, which will then appear as representative species on the two sides of the Atlantic, bearing to each other the same relation that *Lamprops quadruplicata* bears to *L. fasciata*, or *Diastylis quadrispinosa* to *D. cornuta*.

In all these cases, however, we need more evidence as to the range of variation within the species, and there is abundant work still to be done in comparing minutely and carefully the specimens from various localities.

Another element in the Cumacean fauna of the Atlantic coast of North America is represented by *Leptocuma minor* and *Oxyurostylis smithi*. These appear to be southern types which reach their northern limit on the New England coast. *O. smithi* is recorded also from the Gulf of Mexico, while the only other species of the genus *Leptocuma* occurs on the east coast of South America.

Finally, there are a few species peculiar, so far as is yet known, to the New England coast and adjacent waters and not obviously related to species occurring elsewhere. To this group belong *Diastylis sculpta* and *D. polita*.

CLASSIFICATION.

None of the new species contained in this collection can be said to throw much new light on the problems of Cumacean classification. In *Oxyrostylis smithi* the simply pointed apex of the telson, without apical spines, calls attention once more to the impossibility of basing the distinction between the families Diastylidæ and Lampropidæ on the presence in the former of a pair, and in the latter of three or more, apical spines. The species described as *Colurostylis* (?) *occidentalis* presents several remarkable characters, and, whether it is rightly assigned to the genus *Colurostylis* or not, it joins with the type of that genus in breaking down the barrier between the Diastylidæ and Pseudocumidæ. The discovery that the male of *Leptocuma* has only three pairs of pleopods perhaps points the way toward a union of the Bodotriidæ (including Vauntomponiidæ) and the Leuconidæ. It is of course possible, as I have elsewhere pointed out,¹ to base on facts such as these an argument for the opposite course of action, and, instead of reducing the number of families, to increase it very greatly. A step in this direction has recently been taken by Mr. Stebbing² in establishing a new family Dicidæ. In the paper quoted above, which had passed out of my hands before I saw that of Mr. Stebbing, although it was not actually published until later, I have described species that divide among them some of the chief characters used to define the genus *Dic* and the family Dicidæ. Thus *Diastylis fistularis* has a similar form of telson, and the species of *Gynodiastylis* have no pleopods in the male sex; while Doctor Zimmer had previously figured, in *Leptostylis thileniusi*,³ a form of third maxilliped which, in the great expansion of the ischial, or third, segment, resembles that of *Dic* more than that of any other Cumacean. Whether or not the family Dicidæ may afterwards find a place in the classification, its acceptance at present would require to be balanced by the creation of a considerable number of additional families for genera now included in the Diastylidæ, and for this, it seems to me, the time is not yet ripe. Every extensive collection of Cumacea recently examined from tropical and southern seas has yielded species presenting novel and unexpected combinations of characters, and there is no reason to believe that the supply is approaching exhaustion. For the present, therefore, it seems advisable to avoid, as far as possible, establishing new systematic divisions.

SYSTEMATIC NOTES AND DESCRIPTIONS OF NEW SPECIES.

In the following descriptions "total length" is to be understood as including the telson (when distinct), but not the uropods. The "post-anal" region of the telson is measured from the upper posterior mar-

¹ Trans. Zool. Soc., vol. 18, 1911, p. 343.

² Ann. South African Mus., vol. 6, 1910, p. 415.

³ Zool. Jahrb., Abth. Syst., vol. 17, 1902, p. 462, fig. Q.

gin of the anal valves to the apex of the telson. The distance from the same point to the base of the telson may be conveniently, if not quite accurately, called "pre-anal."

The bibliographical data under each species include, as a rule, references to (1) the first description of the species, (2) the fullest description hitherto published, and (3) the chief records of its occurrence in American waters. No attempt is made to give the full synonymy for each species.

Following the practice of the United States National Museum, a single individual has been selected and labeled as the "holotype" of each of the new species here described. It will be readily understood, however, that this specimen is not in all cases that from which the drawings have been prepared or that to which the dimensions recorded in the description apply. The drawings often combine features taken from several more or less imperfect specimens, while the descriptions are based chiefly on specimens selected for dissection and partly or completely destroyed in the process.

BODOTRIA, ? species.

A single female specimen of an undescribed species of this genus is in the collection from Japan, but, as it lacks the uropods and is otherwise imperfect, it can not be fully described. It has a strongly marked lateral ridge on the carapace as well as on the thoracic somites, differing in this from *B. pulcx* Zimmer, the only species hitherto recorded from Japan. It is also distinguished from all the known species of the genus by having the carpus of the first legs expanded and about one and one-half times as broad as the merus.

Locality.—*Albatross* station 3730, off Omai Zaki Light, Honshu Island, Japan; surface tow-net, surface temperature, 64° F.; U.S.N.M. 43096; 1 female.

CYCLASPIS LONGICAUDATA G. O. Sars.

Cyclaspis longicaudata G. O. Sars, Forh. Vidensk. Selsk. Christiania, 1864 (1865), p. 207; Crust. Norway, vol. 3, 1899, p. 16, pls. 7 and 8.

This species has not hitherto been recorded from the western side of the North Atlantic, although, as an inhabitant of the deeper waters, its occurrence there is not surprising. It may not be without significance that at all the stations off the American coast the depth exceeds the maximum (1,450 fathoms) hitherto recorded for the species off the European coasts.

Localities.—*Albatross* station 2570; lat. 39° 54' 00'' N.; long. 67° 05' 30'' W.; 1,813 fathoms; bottom temperature, 36.8° F.; U.S.N.M. 44013; 1 female.

Albatross station 2221; lat. 39° 05' 30'' N.; long. 70° 44' 30'' W.; 1,525 fathoms; bottom temperature, 36.9° F.; U.S.N.M. 8505; 13, male and female.

Albatross station 2711; lat. $38^{\circ} 59' 00''$ N.; long. $70^{\circ} 07' 00''$ W.; 1,544 fathoms; U.S.N.M. 44014; 2 females.

Albatross station 2714; lat. $38^{\circ} 22' 00''$ N.; long. $70^{\circ} 17' 30''$ W.; 1,825 fathoms; U.S.N.M. 11998, 44011, and 44012; 5, male and female.

CYCLASPIS VARIANS, new species.

Ovigerous female.—Total length, 3.4 mm.

Carapace slightly more than two-sevenths of total length, compressed, its vertical height a little more than half its length. The dorsal edge is distinctly keeled and the anterior part just behind the ocular lobe is, in many specimens, cut into a number of fine

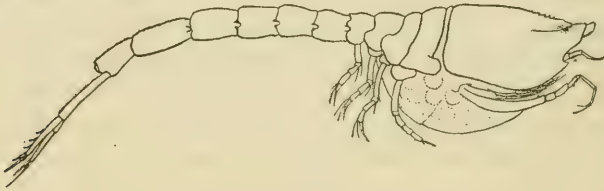


FIG. 1.—CYCLASPIS VARIANS, FEMALE, FROM THE SIDE.

teeth; in some specimens, however, the dorsal edge is quite smooth. The pseudorostrum is of moderate length, acute, the lateral plates meeting in front of the ocular lobe for a distance equal to half the length of the lobe. The antennal notch is rather widely open and the

antennal tooth acute. The ocular lobe is slightly prominent on the dorsal surface and the eye is pigmented. The surface of the carapace is quite smooth.

The first leg-bearing somite is exposed both dorsally and at the sides. The dorsal keel is not very marked on any of the thoracic somites. The abdomen is about equal in length to the cephalothoracic region. The first five somites have lateral articular processes.

Antennules of moderate length, the last segment of the peduncle longer than the preceding. First legs short,

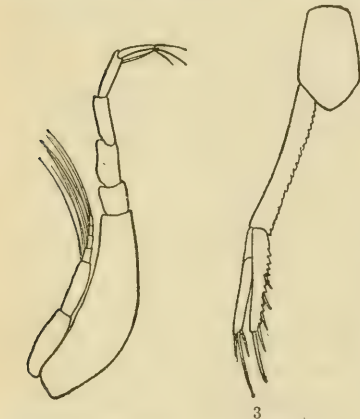


FIG. 2-3.—CYCLASPIS VARIANS, FEMALE. 2, FIRST LEG; 3, LAST SOMITE AND UROPOD.

extending beyond the tip of the pseudorostrum by about one-fourth of the length of the carapace. The basis is not shorter than the distal segments together, without a tooth or plumose setae at the distal end. The dactylus is a little shorter than either the propodus or the carpus.

The peduncle of the uropods is longer by one-half than the last somite and its inner edge is serrated. The rami are subequal and more than two-thirds as long as the peduncle. The endopod has

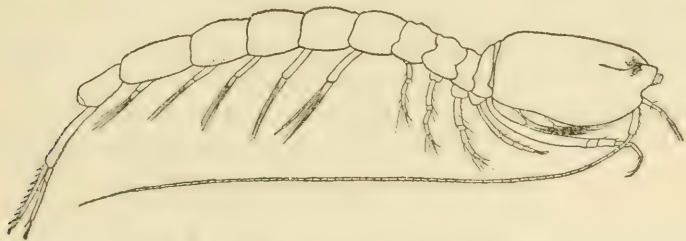


FIG. 4.—CYCLASPIS VARIANS, MALE, FROM THE SIDE.

the inner edge serrated, with four spines, and has a rather slender apical spine; the exopod has three unequal apical spines.

Adult male.—Total length, 4.3 mm.

Differing from the female in the usual characters. The dorsal edge of the carapace is quite smooth. The pseudorostrum is more truncated than in the female and the antennal angle is rounded.

The peduncle of the uropods is nearly twice as long as the last somite and its inner edge is clothed with plumose hairs. The endopod is less than two-thirds as long as the peduncle and a little shorter than the exopod; it has about ten spines on its inner edge. The exopod has plumose setæ on its inner edge.

The integument in both sexes is rather thin and slightly calcified, and there is a good deal of irregularly distributed pigment, especially in the female.

Remarks.—The occasional presence of serrations on the dorsal crest gives this species something of the aspect of an *Iphinoë*, from which genus, however, it is at once distinguished by the unsegmented endopod of the uropods, the lateral articular processes of the abdominal somites, and other characters. On the other hand it is closely related to some of the members of the genus *Cyclopsis*. In the key which I have given to the species of that genus¹ it would find its place next to *C. levis* Thomson. From that species it is distinguished by its much smaller size, by the fact that the ocular lobe does not reach to the tip of the pseudorostrum, by the presence of an apical spine on the endopod of the uropods, and by a number of other small characters mentioned in the description.



FIG. 5.—CYCLASPIS VARIANS, MALE, LAST SOMITE AND UROPOD.

¹ Trans. Zool. Soc., vol. 18, pt. 1, 1907, p. 6.

All the specimens are labeled as having been taken at the surface, and in some of the tubes they are accompanied by copepods, zoeæ, and other plankton organisms.

Localities.—Vineyard Sound, surface; U. S. F. C., 1875; U.S.N.M. 34890–34894; 20, male and female.

Vineyard Sound, surface; U. S. F. C., 1881; U.S.N.M. 34301, 34309, 34315, 34316, 44015; many, male and female.

Woods Hole, surface; U. S. F. C., 1882 and 1885; U.S.N.M. 35249, 44016, 44017; 14, male and female, including holotype (44016).

HETEROCUMA SARSI, var. GRANULATA Miers.

Heterocuma sarsi, var. *granulata* MIERS, Proc. Zool. Soc., 1879, p. 58.—CALMAN, Ann. Mag. Nat. Hist., ser. 8, vol. 6, 1910, p. 614.

The 15 immature specimens of both sexes show the well-marked ridges of the abdomen characteristic of the variety *granulata*, but there is considerable variation among them in the degree of granulation of the carapace. I can find no evidence, however, on which to separate the variety as a distinct species.

Locality.—Albatross stations 4894 and 4895; off Goto Island, Korea Strait; 95 fathoms; U.S.N.M. 44127, 44128; 15, male and female.

HETEROCUMA DIOMEDEÆ, new species.

Immature female.—Total length, 14.3 mm.

Carapace a little more than one-fifth of total length, its vertical height a little more than, and its transverse width about equal to,



FIG. 6.—HETEROCUMA DIOMEDEÆ, IMMATURE FEMALE, FROM THE SIDE.

one-half of its length. On the anterior half of the dorsal surface (on the frontal lobe) is a sharp crest cut into three large teeth; on the posterior half is a pair of tuberculated ridges set close together. The long and narrow ocular lobe reaches quite to the extremity of the pseudorostrum and bears a pigmented eye. The antennal notch is deep and angular. The antero-lateral angle is bluntly pointed and does not extend as far forward as the tip of the pseudorostrum. The lower edge is serrated anteriorly. The sides of the carapace are dotted with rather widely spaced rounded tubercles.

The first free thoracic somite is overlapped at the sides by the second. A pair of dorsal ridges closely approximated on the second somite diverge somewhat on the succeeding somites, and a pair of

dorso-lateral ridges first become apparent on the third somite. These two pairs of ridges are continued on the abdominal somites, becoming less distinct toward the last somite; a more obscure lateral ridge is visible on the penultimate somite. The penultimate thoracic somite has a procurved median ventral tooth.

Basis of third maxillipeds produced distally into an acute lobe; merus only slightly produced externally; carpus not expanded.

The first legs have the propodus not twice as long as the carpus and nearly one-third longer than the dactylus.

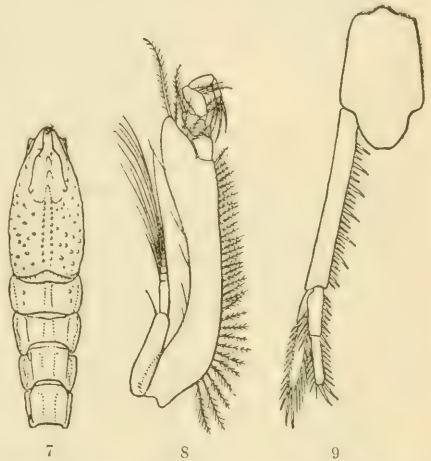
The second and third legs carry well-developed exopods, divided into basal portion and flagellum, that of the third a little smaller than that of the second.

The peduncle of the uropods is longer, by about one-third, than the last somite, and bears on its inner edge about seven strong spines with smaller spines between. The exopod is a little more than half as long as the peduncle, its proximal segment half as long (on the outer edge) as the distal; the endopod is a little shorter than the exopod, its two segments about equal in length. The inner edge of the endopod carries spines and its outer edge setæ; both edges of the exopod are setose distally.

Immature male.—(Incomplete.) Resembling the female, but with the abdomen stouter and its crests more distinct. Five pairs of pleopods are present. The third and fourth thoracic somites have each a ventral spine, and the pleural plates of the fourth are produced forward in a narrow lobe.

Remarks.—In having the exopods of the second and third legs well developed and consisting of an expanded peduncle and a segmented flagellum, this species agrees with the male which I described under the name of *H. weberi*.¹ From *H. weberi* the new species is distinguished by the tuberculation and by the serrated dorsal crest of the carapace.

Locality.—Albatross station 3708; off Ose Zaki, Honshu Island, Japan; 60–70 fathoms; 1 male (U.S.N.M. 44125), 1 female (holotype, U.S.N.M. 44126).



FIGS. 7-9.—*HETEROCUMA DIOMEDEE*, IMMATURE FEMALE. 7, ANTERIOR PART OF BODY FROM ABOVE; 8, THIRD MAXILLIPED; 9, LAST SOMITE AND UROPOD.

¹ *Cumacea of Siboga Exped.*, 1905, p. 6, pl. 1, figs. 7-12.

BATHYCUMA (?) LONGICAUDATA, new species.

Immature female.—Total length, 18.5 mm.

Carapace a little more than one-fourth of total length, its height a little greater than its transverse width and about three-fifths of its length; its dorsal edge arched and keeled, at least in its anterior half, where it bears a double series of fine serrations, for the most part

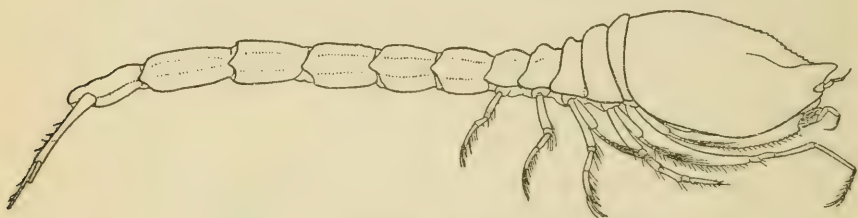


FIG. 10.—BATHYCUMA (?) LONGICAUDATA, IMMATURE FEMALE, FROM THE SIDE.

alternating. The pseudorostrum is short, pointed, and slightly upturned. There is a well-marked, angular, antennal notch defined below by a bluntly pointed antennal tooth, the lower margin of which is obscurely serrated. There is no distinct eye, and the ocular lobe is reduced to a narrow process carrying the serrated dorsal crest for a little way between the plates of the pseudorostrum. The free thoracic somites diminish rapidly in height; the dorsal surface in the third and fourth is raised in a transverse ridge. The abdomen exceeds, by more than one-fourth, the length of the cephalothoracic region, and is very slender, the vertical height of the anterior somites being little more than a third of that of the carapace. All the somites except the last have a pair of dorsal and a pair of dorso-lateral ridges, while a pair of less sharply marked ventro-lateral ridges on the anterior somites become more pronounced and lateral in position on the last two somites. The last somite is produced, as a prominent rounded lobe, between the bases of the uropods.



FIGS. 11-12.—BATHYCUMA (?) LONGICAUDATA, IMMATURE FEMALE. 11, THIRD MAXILLIPED; 12, FIRST LEG.

The second and third segments of the antennule are subequal and much more slender than the first. The third maxillipeds have the

The second and third segments of the antennule are subequal and much more slender than the first. The third maxillipeds have the

basis not increasing in width distally, produced into a lobe which nearly reaches the end of the merus. The lower surface of the basis carries a row of teeth toward the distal end.

The first legs are longer by one-half than the carapace; the basis is armed with spines on its lower surface and is about equal in length to the distal segments together. The dactylus is about equal to the carpus and two-thirds as long as the propodus. The second legs have the ischium distinct; the dactylus is longer than the two preceding segments together. The last pair of legs is distinctly shorter than the preceding and has the carpus about equal in length to the basis.

The peduncle of the uropods is about equal in length to the last somite and bears a series of spines of varying length on its inner edge. The tip of the endopod is broken in the type-specimen, but probably it did not greatly exceed four-fifths of the length of the peduncle. The proximal segment is longer by one-half than what remains of the distal. The exopod is broken.

Remarks.—Zimmer has lately cast doubt on the distinctness of the genus *Bathycuma*, pointing out that the three species referred to it have no common character which they do not share with some species of *Vauntomponia* except the lack of the eye. While there is much to commend this view, I retain the name provisionally in the present case to indicate that the immediate affinities of the new species seem to be with the three species hitherto referred to *Bathycuma*. From these species¹ it is distinguished by the ridges of the abdominal somites as well as by its much greater size and by various differences of proportion noted in the description given above.

Locality.—Albatross station 4382; off San Diego, California; 642–666 fathoms; U.S.N.M. 43095; 1 female (holotype).

Genus LEPTOCUMA G. O. Sars.

The characters of this genus have hitherto been very incompletely known, and the occurrence of a new species represented by numerous individuals of both sexes throws some welcome light on its affinities. Most of the new characters described below, the form of the mandibles and maxillulæ for example, are quite in accordance with Sars' suggestion² that *Leptocuma* should be referred to the family Vauntomponiidae. I have recently³ supported Hansen's suggestion that this



FIG. 13.—BATHYCUMA (?) LONGICAUDATA, IMMATURE FEMALE, SECOND LEG.

¹ See Calman, Fisheries, Ireland, Sci. Invest., 1904, No. 1 (1905), p. 18, and Cumacea of Siboga Exp. (1905), p. 10.

² Arch. Math. Naturvid., vol. 4, 1879, p. 12.

³ Ann. Mag. Nat. Hist., ser. 8, vol. 6, 1910, p. 615.

family ought to be united with the Bodotriidæ, and the new species now described brings a little additional evidence for this by having male pleopods that, in the form of the endopod, resemble those of *Cumopsis* more than those of *Vauntompsonia* and by the number and form of its branchial lobules. The most surprising feature of the new species, however, is the fact that only three pairs of pleopods are present in the male instead of the five pairs that are universal throughout the extended family Bodotriidæ. This character helps to diminish the distance separating this family from the Leuconidæ, in which only two pairs of male pleopods are present. Possibly the three-segmented antenna of the female may point in the same direction, for this character is found in some species, at least, of the genus *Leucon*.¹

LEPTOCUMA KINBERGII G. O. Sars.

Leptocuma kinbergii G. O. Sars, Kgl. Svenska Vet. Akad. Handl., vol. 11, No. 5, 1873, p. 24, pl. 6.—CALMAN, Trans. Zool. Soc., vol. 18, 1907, p. 30.

The specimen is a female with embryos in the marsupium. It measures 17 mm. in length of body and is thus intermediate in size between the two previously recorded. In most points it agrees with the large specimen which I have described from the Copenhagen Museum rather than with that of Sars. The second legs, however, fall considerably short of the anterior margin of the carapace. The peduncle of the uropods is slightly shorter than the last somite; the exopod is equal to, and the endopod a little longer than, the peduncle. Of the two segments of the endopodite the second is about two-thirds the length of the first, as in Sars' figure. The basis of the third maxilliped is not produced distally and the distal segments are not expanded.

The *Albatross* specimen was taken in the type-locality of the species, off the mouth of the Rio de la Plata. I have already recorded the occurrence of the species in the Straits of Magellan.

Locality.—*Albatross* station 2765; lat. 36° 43' 00'' S.; long. 56° 23' 00'' W.; 10½ fathoms; U.S.N.M. 44134; 1 female.

LEPTOCUMA MINOR, new species.

Ovigerous female.—Total length, 7.5 mm.

Carapace slightly more than one-fifth of total length, its vertical height less than three-fourths of its length, moderately compressed. The pseudorostrum is short and truncated, but the lateral plates meet in front of the ocular lobe for a distance about equal to one-half the length of the lobe. The eye is pigmented. The antennal notch is more open than in *L. kinbergii*. The first leg-bearing somite is only exposed on the dorsal surface; the second and third have the

¹ Sars, Arch. Math. Naturvid., vol. 4, pp. 24, 27, pl. 28, fig. 3.

pleural plates greatly expanded. The abdomen is stout and longer by about one-fifth than the cephalothoracic region.

The antennules rather short and stout, the first segment of the peduncle longer than the second or third, which are subequal; the outer flagellum has two segments and is hardly longer than the last segment of the peduncle; the inner flagellum is unsegmented and

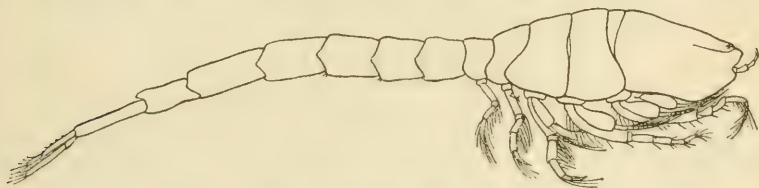


FIG. 14.—LEPTOCUMA MINOR, FEMALE, FROM THE SIDE.

half as long as the first segment of the outer. The antennæ consist of three segments, the terminal one bluntly conical and twice as long as it is wide at the base. The mandibles are of normal form, the portion proximal to the molar process being nearly twice as long as that distal to it; there are only about six spines, and there is a *lacinia mobilis* on the left mandible. The palp of the maxillula has two setæ. The branchial apparatus has about seven broad, flattened, marginal lobules arranged in a straight row, and a very large reflexed lobule. The third maxilliped has the basis slightly produced at its outer distal corner.

The first legs are short; the basis is a little longer than the distal segments together; the propodus is equal to the carpus and longer than the dactylus; there is a group of long setæ at the distal end of the inner edge of the propodus. The second legs have the basis a little shorter than the distal segments together; the carpus is a very little longer than the merus; the propodus is a little longer than the dactylus and together with it a little longer than the carpus. The third legs have a well-developed exopod. The fourth legs have a vestigial exopod of two segments, the distal one very minute.

The peduncle of the uropods is nearly $1\frac{1}{2}$ times as long as the last somite and bears a series of unequal spinules on the inner edge. The endopod is about four-fifths as long as the peduncle, its proximal seg-



FIG. 15-16.—LEPTOCUMA MINOR, FEMALE. 15, THIRD MAXILLIPED; 16, FIRST LEG.

ment more than twice as long as the distal, with the inner margin spined; the distal segment is four times as long as wide. The exopod is a little longer than the endopod and has slender spines or setae on the inner edge and terminally but not on the outer edge.

Adult male.—Total length, 6.4 mm.

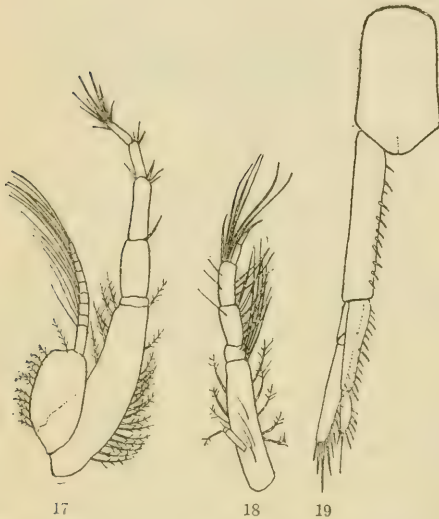
Carapace more than one-fifth of total length, the pseudorostrum still shorter than in the female, the antennal notch shallower, and the antero-lateral angle more broadly rounded. The thoracic somites present no conspicuous differences from those of the female and the abdominal somites are only a little stouter. The antennular peduncle is not dilated and has no conspicuous distal brush of hairs. The thoracic limbs present no marked differences from those of the female except that large exopods are present on the first four pairs of legs.

There are only three pairs of pleopods; the endopod of each has a narrow process on its outer margin.

The uropods are similar to those of the female, but the

spines on the inner edge of the peduncle and endopod are more numerous.

Remarks.—This species resembles very closely the type of the genus, but all the specimens examined differ from it in the following characters—the size of adult female specimens is less than



FIGS. 17-19.—LEPTOCUMA MINOR, FEMALE. 17, SECOND LEG; 18, FOURTH LEG; 19, LAST SOMITE AND UROPOD.

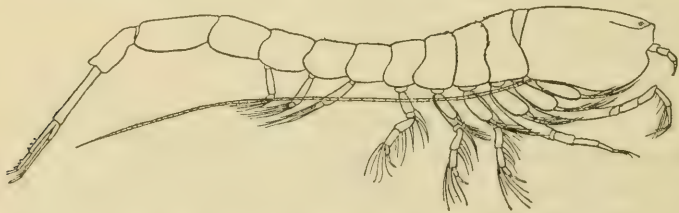


FIG. 20.—LEPTOCUMA MINOR, MALE, FROM THE SIDE.

half that of adult females of *L. kinbergii*; the lateral plates of the pseudorostrum meet in front of the ocular lobe; the basis of the third maxillipeds is distinctly produced at the distal outer corner; the propodus of the first legs is not longer than the carpus; the peduncle of the uropods is distinctly longer than either the last

somite or the rami; the rami are much more slender and the outer edge of the exopod is without setæ.

Localities.—U. S. F. C. station 141 (1878); Gloucester Harbor; 8½ fathoms; U.S.N.M. 34857, 44135; 3 males.

U. S. F. C. station 145 (1878); Gloucester Harbor; 8 fathoms; U.S.N.M. 34858, 34859, 36646, 44136, 44138; many, male and female (including holotype, 34858).

Vicinity of Woods Hole; U. S. F. C.; U.S.N.M. Acc. 11306; 1 female.

LEUCON NASICA (Krøyer).

Cuma nasica KRØYER, Naturh. Tidsskr., vol. 3, 1841, p. 524, pl. 6, figs. 31–33.

Leucon nasica KRØYER, Naturh. Tidsskr., ser. 2, vol. 2, 1846, p. 189, pl. 2, figs. 5a–b.

Leucon nasicus WHITEAVES, Amer. Journ. Sci., vol. 7, 1874, p. 214; Rep. dredging operations in Gulf of St. Lawrence, 1874, p. 16.—S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 114.—G. O. SARS, Crust. Norway, vol. 3, 1900, p. 30, pls. 21, 22.

So far as I know, this species has not hitherto been recorded from the Pacific side of America. The specimens from the south coast of Alaska seem to agree exactly with those from Labrador and with Sars' figures. The species has been recorded from the Gulf of St. Lawrence by Whiteaves and by Smith.

Localities.—Off Beachy Island, between Flint Island and Cape Mugford, Labrador; 80 fathoms; Owen Bryant, August 22, 1908; U.S.N.M. 44143; 1 female.

Albatross station 4272; Afognak Bay, Afognak Island, Alaska; 12–17 fathoms; U.S.N.M. 44141; 1 female.

Off Round Island, Coal Harbor, Unga, 6–8 fathoms; W. G. Hall; Dall collection; U.S.N.M. 44142; 1 female.

LEUCON NASICOIDES Lilljeborg.

Leucon nasicoides LILLJEBORG, Oefvers. Kgl. Vet. Akad. Förh., vol. 12, 1855, p. 122.—S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 115.—G. O. SARS, Crust. Norway, vol. 3, 1900, p. 31, pl. 23.

This species has been recorded from Eastport, Maine, and from the Gulf of St. Lawrence, by S. I. Smith.

Locality.—Albatross station 2466; lat. 45° 29' 00" N.; long. 55° 24' 00" W.; 67 fathoms; bottom temperature 30° F.; U.S.N.M. 44144; 18, male and female.

LEUCON LONGIROSTRIS G. O. Sars.

Leucon longirostris G. O. SARS, Kgl. Svenska Vet. Akad. Handl., vol. 9, No. 13, 1871, p. 42, fig. 75.—CALMAN, Mitth. Zool. Stat. Neapel, vol. 17, 1906, p. 414, pl. 27, figs. 1–8.

This species, to which a very young specimen in the collection appears to belong, has been recorded from Davis Straits (1,750 fathoms) by Norman.

Locality.—Albatross station 2084; lat. 40° 16' 50" N.; long. 67° 05' 15" W.; 1,290 fathoms; bottom temperature 40° F.; U.S.N.M. 44140; 1 young.

EUDORELLA EMARGINATA (Krøyer).

Leucon emarginatus KRØYER, Naturh Tidsskr., ser. 2, vol. 2, 1846, p. 181, pl. 1, fig. 7, pl. 2, figs. 3a-h.

Eudorella emarginata S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 115.—G. O. SARS, Crust. Norway, vol. 3, 1900, p. 36, pls. 27, 28.

This well-marked species does not seem to have been recorded hitherto south of Halifax on the American coast.

Localities.—Egg Harbor, Labrador; 7 fathoms; Owen Bryant, August 10, 1908; U.S.N.M. 44106; 1 female.

Twenty miles ESE. of Cape Sable, N. S.; 70 fathoms; Owen Bryant, October 7, 1908; U.S.N.M. 44105; 1 female.

Albatross station 2497; lat. 45° 04' 00" N.; long. 59° 36' 45" W.; 57 fathoms; bottom temperature 33° F.; U.S.N.M. 38207; 12, female and young.

U. S. F. C. station 311; off Cape Cod; 16 fathoms; bottom temperature 49° F.; U.S.N.M. 34873; 1 male.

U. S. F. C. station 992; off Marthas Vineyard; 36 fathoms; bottom temperature 48° F.; U.S.N.M. 44104; 1 male.

EUDORELLA TRUNCATULA (Spence Bate).

Eudora truncatula SP. BATE, Ann. Mag. Nat. Hist., ser. 2, vol. 17, 1856, p. 457, pl. 14, fig. 3.

Eudorella truncatula G. O. SARS, Arch. Math. Naturvid., vol. 4, 1879, p. 34, pls. 30-32; Crust. Norway, vol. 3, 1900, p. 37, pl. 29.

Eudorella pusilla G. O. SARS, Oefvers. Kgl. Vet. Akad. Förh., 1871, p. 79; Kgl. Svenska Vet. Akad. Handl., vol. 9, No. 13, 1871, p. 46, pls. 16, 17.—S. I. SMITH, Rep. U. S. Comm. Fisheries, pt. 1, 1874, p. 554; Trans. Conn. Acad., vol. 5, 1879, p. 116.

The American form which has been distinguished by G. O. Sars and S. I. Smith, under the name of *E. pusilla*, from the European *E. truncatula*, does not seem to me to deserve specific rank. At all events, a somewhat close examination of the series from American localities in the present collection has only revealed one trifling character which might possibly prove to be distinctive, namely, the shortness of the exopod of the uropods. In the American specimens (females) this seems to be always a little shorter than the first segment of the endopod, while in the few European specimens at hand for comparison, as in Sars' figures of *E. truncatula*, it is a little longer than that segment. Further research is required to ascertain whether this difference is constant and whether it is accompanied by any others, but for the present it does not seem adequate for the separation of the species. Another character presented by some of the specimens in this collection is the possession of a small anteriorly curved tooth on the dorsal surface of the carapace close to the hinder margin of the respiratory opening. This tooth is easily overlooked, and it is possible that it may be found in some European specimens. In any case, it can not be regarded as a specific character, since, in a

number of adult females from one gathering, absolutely indistinguishable by any other character, it was present in some and absent in others. A similar tooth in a slightly different position is found in the specimens of *E. monodon* described below.

Localities.—U. S. F. C. stations 133–134 (1878); Massachusetts Bay; 26–33 fathoms; U.S.N.M. 44113; 1 female.

U. S. F. C. station 154 (1878); Massachusetts Bay; 38 fathoms; bottom temperature, 41° F.; U.S.N.M. 34852; 1 female.

U. S. F. C. station 160 (1878); Massachusetts Bay; 54 fathoms; bottom temperature, 39° F.; U.S.N.M. 44114; 1 female.

U. S. F. C. station 337; off Plymouth; 16 fathoms; bottom temperature, 47° F.; U.S.N.M. 34875; 1 female.

U. S. F. C. station 992; off Marthas Vineyard; 36 fathoms; bottom temperature, 48° F.; U.S.N.M. 34300; 2 females.

U. S. F. C. station 1231; Vineyard Sound; 16 fathoms; bottom temperature, 62° F.; U.S.N.M. 12697, 12698; many, female and young.

U. S. F. C. station 811; off Block Island; 19½ fathoms; bottom temperature, 60° F.; U.S.N.M. 44112; 1 female.

U. S. F. C. station 1240; Block Island Sound; 18½ fathoms; U.S.N.M. 12699, 12700; many females.

EUDORELLA HISPIDA G. O. Sars.

Eudorella hispida G. O. Sars, Oefvers. Kgl. Vet. Akad. Förh., 1871, p. 80; Kgl. Svenska Vet. Akad. Handl., vol. 9, No. 13, 1871, p. 49, pl. 18, figs. 95–97.—S. I. SMITH, Rep. U. S. Comm. Fisheries, pt. 1, 1874, p. 555; Trans. Conn. Acad., vol. 5, 1879, p. 115.

This species is by no means always so easily distinguished from the preceding as might be gathered from Sars' description and figures, and I have had a good deal of hesitation in deciding as to the position of individual specimens. All those determined as *E. hispida* possess the following characters: (1) The antero-lateral tooth of the carapace is strong and more or less horizontal; (2) the carpus of the second leg is a good deal longer (at least 1½) than the merus; (3) the exopod of the uropods reaches at least to the middle of the second segment of the endopod. In each of these characters, however, there is some variation, while among the specimens referred to *E. truncatula* (1) the antero-lateral tooth may be much stronger than in any of Sars' figures; (2) the carpus of the second leg may be a little longer than the merus, and (3) the exopod of the uropods, in European specimens at least, may be longer than the first segment of the endopod. At all events there can be no question that the outline of the anterior margin of the carapace does not possess the constancy attributed to it by Sars.

None of the specimens referred to *E. hispida* possess a dorsal tooth on the carapace.

Localities.—Twenty miles ESE. of Cape Sable, Nova Scotia; 70 fathoms; Owen Bryant, Oct. 7, 1908; U.S.N.M. 44109; 1 female.

U. S. F. C. station 18 (1877); Massachusetts Bay; 45 fathoms; U.S.N.M. 37836; 2 females.

Casco Bay; U. S. F. C., 1873; U.S.N.M. 34308, 34965, 44107; many males and females.

U. S. F. C. station 296; off Cape Cod; 26 fathoms; bottom temperature, 39° F.; U.S.N.M. 34864; 1 female.

U. S. F. C. station 301; off Cape Cod; 27 fathoms; bottom temperature, 42° F.; U.S.N.M. 34871; 1 female.

U. S. F. C. station 310; off Cape Cod; 21 fathoms; bottom temperature, 47° F.; U.S.N.M. 44108; 2 females.

U. S. F. C. station 311; off Cape Cod; 16 fathoms; bottom temperature, 49° F.; U.S.N.M. 34869; 1 female.

U. S. F. C. station 350; off Cape Cod; 31 fathoms; bottom temperature, 43° F.; U.S.N.M. 34872; 1 female.

U. S. F. C. station 993; off Marthas Vineyard; 39 fathoms; bottom temperature, 46° F.; U.S.N.M. 44110; 1 male.

EUDORELLA MONODON, new species.

Ovigerous female.—Total length, 4.7 mm.

Body slender, its surface sparsely beset with inconspicuous setæ. Carapace about one-fifth of total length, its depth nearly four-fifths

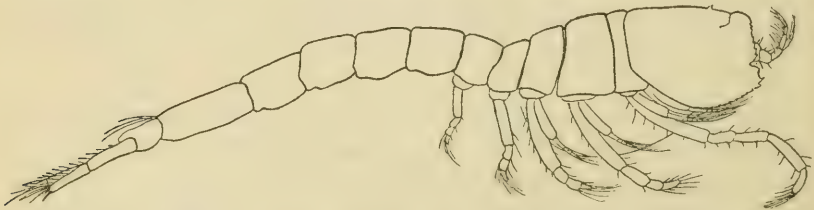


FIG. 21.—EUDORELLA MONODON, FEMALE, FROM THE SIDE.

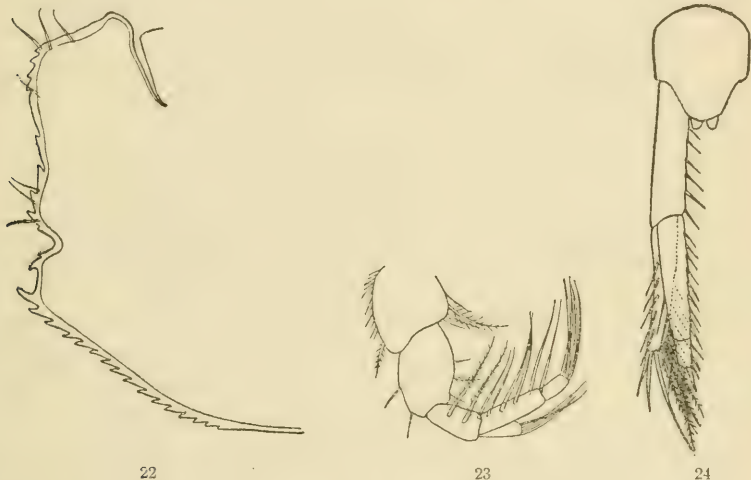
of its length. Anterior margin most nearly resembling that of *E. hirsuta* Sars, but the antero-lateral tooth is more prominent and the serrations on the upper part of the margin (anterior margin of the pseudorostral plate) point downward. On the upper surface of the carapace about one-third of its length from the front margin is a small, anteriorly curved tooth.

The antennules have the second segment of the peduncle dilated, its width about two-thirds of its length. The inner flagellum does not nearly reach to the end of the first segment of the outer.

The first legs have the propodus distinctly longer than the carpus and more than twice as long as the dactylus. The second legs have the carpus about equal to the merus and hardly longer than the propodus and dactylus together.

The peduncle of the uropods is longer by about one-fifth than the last somite and has six long spines on its inner edge. The endopod is equal to the peduncle, its proximal segment four times as long as the distal, with about 15 spines on its inner edge, a well-defined apical spine, and setæ on the outer edge. The exopod is shorter than the endopod, with long setæ on the outer and inner margins.

Remarks.—The variability of the dorsal spine of the carapace in *E. truncatula*, as described above, throws doubt upon its value as a specific character in this case. Apart from this, however, the specimens differ from Sars' figures of *E. hirsuta* in so many other characters, the dilated second segment and short inner flagellum of the antennule



FIGS. 22-24.—EUDORELLA MONODON, FEMALE. 22, ANTERIOR EDGE OF CARAPACE FROM THE SIDE; 23, ANTENNULE; 24, LAST SOMITE AND UROPOD.

being perhaps the most conspicuous, that I hesitate to identify them with that species, which is only known from the Norwegian coast.

Locality.—Beach near Calcasieu Pass, Louisiana; M. H. Spaulding, collector; U.S.N.M. 44111; 2 females.

EUDORELLOPSIS DEFORMIS (Krøyer).

Leucon deformis KRØYER, Naturh. Tidsskr., ser. 2, vol. 2, 1846, p. 194, pl. 2, fig. 4.

Eudorella deformis G. O. SARS, Kgl. Svenska Vet. Akad. Handl., vol. 9, No. 13, 1871, p. 50, figs. 101-118.—S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 116.

Eudorellopsis deformis G. O. SARS, Crust. Norway, vol. 3, 1900, p. 40, pls. 31-32.

Recorded from off Long Island and from Gloucester, Mass., by Sars and by Smith.

Localities.—Albatross station 2497; off Nova Scotia; lat. 45° 04' 00" N.; long. 59° 36' 45" W.; 57 fathoms; bottom temperature, 33° F., U.S.N.M. 44119; 1 female.

U. S. F. C. station 145 (1878); Gloucester Harbor; 8 fathoms; bottom temperature, 51° F.; U.S.N.M. 44118; 1 male.

U. S. F. C. station 1231; off Vineyard Sound Lightship; 16 fathoms; bottom temperature, 62° F.; U.S.N.M. 44120; 1 female.

EUDORELLOPSIS INTEGRATA (S. I. Smith).

Eudorella integra S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 116.

Eudorellopsis integra H. J. HANSEN, Vidensk. Medd. Kjøbenhavn, 1887 (1888), p. 201, pl. 7, figs. 3-3d.

Four specimens from Bering Sea are in the collection and appear to agree perfectly with specimens from the Atlantic coast. Many of the latter have, on the dorsal surface of the carapace, a minute denticle placed at about one-third of the distance from the pseudorostrum to the posterior margin of the carapace.

The species has been recorded from West Greenland (up to lat. 69° 58' N.) (Hansen), Gulf of St. Lawrence, and Halifax (S. I. Smith), at depths of from 15-280 fathoms.

Localities.—1 mile north of Battle Harbor, Labrador; 50 fathoms; Owen Bryant, September 14, 1908; U.S.N.M. 44122; 1 female.

Albatross station 2458; lat. 46° 48' 30'' N.; long. 52° 34' 00'' W.; 89 fathoms; bottom temperature, 29.5° F.; U.S.N.M. 35247; many, male and female.

Albatross station 2497; lat. 45° 04' 00'' N.; long. 59° 36' 45'' W.; 57 fathoms; bottom temperature, 33° F.; U.S.N.M. 10909; many, male and female.

U. S. F. C. station 100 (1877); off Halifax, Nova Scotia; 42 fathoms; bottom temperature, 34° F.; U.S.N.M. 34297, 34878; 3 females.

U. S. F. C. station 101 (1877); off Halifax, Nova Scotia; 42 fathoms; U.S.N.M. 34318, 34854, 44153, 44156; 13, male and female.

U. S. F. C. stations 106-108 (1877); off Halifax, Nova Scotia; 110 fathoms; bottom temperature, 36° F.; U.S.N.M. 34328; 1 female.

U. S. F. C. station 112 (1877); off Halifax, Nova Scotia; 52 fathoms; bottom temperature, 35° F.; U.S.N.M. 34880; 2 females.

U. S. F. C. stations 112-118 (1877); off Halifax, Nova Scotia; 52 fathoms; bottom temperature, 35° F.; U.S.N.M. 34879, 34900; 20, male and female.

U. S. F. C. station 39 (1877); Gulf of Maine; lat. 42° 44' 00'' N.; long. 66° 27' 00'' W.; 75 fathoms; bottom temperature, 39° F.; U.S.N.M. 44121; 1 female.

Albatross station 3252; Bering Sea; lat. 57° 22' 20'' N.; long. 164° 24' 40'' W.; 29 fathoms; bottom temperature, 44° F.; U.S.N.M. 44123; 4, male and female.

Albatross station 3253; Bering Sea; lat. 57° 05' 50'' N.; long. 164° 27' 15'' W.; 36 fathoms; bottom temperature, 35° F.; U.S.N.M. 44124; 1 female.

EUDORELLOPSIS BIPPLICATA, new species.

Ovigerous female.—Total length, 5.5 mm.

Carapace more than one-fourth of total length, only a little longer than deep. Anterior margin shaped as in *E. integra*, but more sinuous, with a strong convexity at the base of the pseudorostrum; with a few inconspicuous serrations in its upper part, interspersed with longish setæ. Pseudorostrum nearly vertical, acute, anterior margin concave. On the side of the carapace are two oblique curved ridges.



FIG. 25.—EUDORELLOPSIS BIPPLICATA, FEMALE, FROM THE SIDE.

The first leg-bearing somite is firmly united to the posterior edge of the carapace. The abdomen is about four-fifths as long as the cephalothoracic region. The last somite is crossed by a very distinct transverse groove and its posterior edge is broadly rounded, as seen from above.

The antennules resemble those of *E. integra*, and the spines which they carry are comparatively few and inconspicuous. The mouth parts do not differ greatly from those of *E. deformis*, but the basis of the third maxillipeds, measured along its inner edge, is nearly twice as long as the distal segments together. The first legs are rather longer than in *E. deformis*, and the three distal segments diminish successively in length.

Peduncle of uropods about equal in length to the last somite; width, as seen from above, about half its length. Exopod more than one and one-half times as long as the peduncle, narrowed at the tip and curved outward, with rather long setæ on the inner edge and at the tip; outer edge serrated distally and with a group of setæ about the middle of its length. Endopod shorter than the exopod, its stout terminal spine reaching about to the apex of the latter, with about 13 spines on the inner and some small spines on the outer edge.



FIG. 26.—EUDORELLOPSIS BIPPLICATA, FEMALE, LAST SOMITE AND UROPOD.

Remarks.—From the three known species of the genus this new form is at once distinguished by the two oblique ridges on the side of the

carapace. In its other characters it approaches most closely to *E. integra* S. I. Smith, but it is distinguished by a difference in the outline of the anterior part of the carapace, by the marked transverse groove of the last somite (hardly indicated in *E. integra*), by the more nearly equal rami of the uropods, and by a number of other small characters.

Localities.—*Albatross* station 2466; lat. $45^{\circ} 29' 00''$ N.; long. $55^{\circ} 24' 00''$ W.; 67 fathoms; bottom temperature, 30° F.; U.S.N.M. 44116, 44117; 2 females (including holotype, 44117).

Albatross station 2497; lat. $45^{\circ} 04' 00''$ N.; long. $59^{\circ} 36' 45''$ W.; 57 fathoms; bottom temperature, 33° F.; U.S.N.M. 44115; 12, female and young.

CUMELLA (?) CARINATA (Hansen).

Campylaspis carinata HANSEN, Vidensk. Medd. Kjøbenhavn, 1887 (1888), p. 207, pl. 7, figs. 4, 4a. — CALMÁN, Fisheries, Ireland, Sci. Invest., 1904, No. 1 (1905), p. 28.

The specimens examined agree very well as regards external characters with Hansen's excellent figures.

I have previously discussed the systematic position of this peculiar species and have suggested that it might possibly belong to the genus *Cumellopsis*. A renewed examination of the mouth parts, however, leaves no doubt in my mind that the species is most nearly related to the genus *Cumella*. In the third maxillipeds the basis is slightly produced at its distal outer corner and the merus projects externally. The second maxilliped resembles very closely that of *Nannastacus unguiculatus* as figured by Sars, and is very different from that of *Cumellopsis*, the protuberance on the outer side of the merus being especially well-marked. The terminal segment of the first maxillipeds is distinctly broadened and sub-discoidal, much as in Sars' figure of *Cumella pygmaea*. An even more important indication of affinity is given by the branchial apparatus, on which I can discover no trace of lobules. The remaining mouth-parts differ only in trivial characters from those of *Cumella* and *Nannastacus*, the maxilla, which I was unable to examine previously, being of normal type, with two movable endites. The palp of the maxillula has two setae.

The only character which could at present be regarded as excluding the species from the genus *Cumella*, apart from the strongly calcified and brittle integument and the tuberculated carapace, is the presence of a distinct ischium in the second maxilliped. This, however, is a character somewhat difficult to observe, and it is by no means certain that it is absent in all the species referred to *Cumella*. In any case it would not, by itself, justify the establishment of a new genus.

Only two specimens of this species have hitherto been recorded. That described by Hansen was from Disco, Greenland, while that in the Museum of University College, Dundee, is from the coast of Labrador.

Localities.—*Albatross* station 2458; lat. $46^{\circ} 48' 30''$ N.; long. $52^{\circ} 34' 00''$ W.; 89 fathoms; bottom temperature, 29.5° F.; U.S.N.M. 44006; 1 female.

Albatross station 2466; lat. $45^{\circ} 29' 00''$ N.; long. $55^{\circ} 24' 00''$ W.; 67 fathoms; bottom temperature, 30° F.; U.S.N.M. 44007; 4 females.

CUMELLA, ? species.

The specimens, which are all males, belong to a species closely allied to *C. pygmaea* G. O. Sars, but apparently distinct from it. The most noticeable difference is that in these Alaskan specimens the last three thoracic and the first three abdominal somites are each elevated dorsally into a transverse ridge, appearing in side view as a prominent angular tooth. It is to be noted, however, that in male specimens of *C. pygmaea* from the west of Ireland the dorsal outline of these segments is more uneven than in Sars' figures. Further, in the Alaskan specimens the pseudorostrum is a little longer and the antero-lateral angle of the carapace slightly more produced than in *C. pygmaea*; the peduncle of the uropods is much stouter and shorter (only a little longer than the last somite, while in *C. pygmaea* it is twice as long), with strong serrations, but only two spines on its inner edge; the endopod is also stouter and has only four spines on the inner edge.

As this species comes so near to *C. pygmaea* it is desirable to await the discovery of the female before describing it under a new name.

Localities.—Old Harbor, Kodiak Island; *Albatross*, August, 1888; U.S.N.M. 44004; about 8 males.

Kodiak, Alaska, surface, electric light; *Albatross*, 1888; U.S.N.M. 44003; many males.

CAMPYLASPIS RUBICUNDA (Lilljeborg).

Cuma rubicunda LILLJEBORG, Oefvers. Kgl. Vet. Akad. Förh., vol. 12, 1855, p. 121.

Campylaspis rubicunda S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 120.—

G. O. SARS, Crust. Norway, vol. 3, 1900, p. 84, pls. 56, 57.

Localities.—U. S. F. C. station 165 (1878); Gulf of Maine; 35 fathoms; bottom temperature, 41.5° F.; U.S.N.M. 34886; 1 female.

U. S. F. C. station 992; off Marthas Vineyard; 36 fathoms; bottom temperature, 48° F.; U.S.N.M. 44002; 1 female.

CAMPYLASPIS HORRIDA G. O. Sars (?).

Campylaspis horrida G. O. SARS, Forh. Vidensk. Selsk. Christiania, 1869 (1870), p. 162.—Crust. Norway, vol. 3, 1900, p. 89, pl. 62.

Two specimens are referred to this species, with some doubt in both cases. One, a young female from the Atlantic, has been dried and is very much broken. From what remains, however, it would appear that the sculpturing of the carapace was in general agreement with the figures of Sars.

The Japanese specimen is an immature male (total length, 7.7 mm.), and it differs somewhat from Sars' figures of the adult female. The

tubercles on the carapace are slightly smaller and more acutely conical, and they show less tendency to run together into continuous ridges. The distal segments of the third maxillipeds and first and second legs are noticeably more slender than in Sars' figures.

It is possible that the examination of further material may show this Japanese form to be distinct from that found in the Atlantic.

Localities.—*Albatross* station 2212; lat. $39^{\circ} 59' 30''$ N.; long. $70^{\circ} 30' 45''$ W.; 428 fathoms; bottom temperature, 40° F.; U.S.N.M. 44000; 1 female.

Albatross station 5087; Sagami Bay; 614 fathoms; bottom temperature, 37.5° F.; U.S.N.M. 44001: 1 male.

CAMPYLASPIS AFFINIS G. O. Sars (?).

Campylaspis affinis G. O. Sars, Forh. Vidensk. Selsk. Christiania, 1869 (1870), p. 160.—Crust. Norway, vol. 3, 1900, p. 91, pl. 64.

Five specimens, including two subadult females, are referred with considerable doubt to this species. They differ from Sars' account of it chiefly in having on each side of the carapace a shallow oblique depression in the same position as that present in *C. sulcata* but much less extensive and less sharply defined. From the last-named species they are also distinguished by the much less strongly vaulted carapace and by other characters. As I have no typical specimens of *C. affinis* for comparison, I am uncertain what value to attach to these differences.

Locality.—U. S. F. C. stations 992 and 993; off Marthas Vineyard; 36–39 fathoms; bottom temperature, 46.5° – 48° F.; U.S.N.M. 43098, 43099; 5, male and female.

CAMPYLASPIS VITREA Calman (?).

Campylaspis vitrea CALMAN, Mitth. Zool. Stat. Neapel, vol. 17, 1906, p. 425, pl. 28, figs. 28–34.

An immature male specimen is referred with some doubt to this species, with which it agrees in general form. It differs, however, from the type-specimens in the following characters: (1) It is considerably larger (7.2 mm. as against 4.7 mm. for an immature female); (2) the integument is much less pellucid; (3) the ridges on the carapace are blunter and less elevated; (4) the two connecting ridges between the upper and lower oblique ridges are much less conspicuous; (5) there is a median posterior connecting ridge between the transverse ridges crossing the postero-dorsal part of the carapace (this median connecting ridge, however, is traceable in one of the types, although not indicated in the figure); (6) the crests on the abdominal somites are much less prominent, although arranged in the same way.

Locality.—*Albatross* station 2048; lat. $40^{\circ} 02' 00''$ N.; long. $68^{\circ} 50' 30''$ W.; 547 fathoms; bottom temperature, 29° F.; U.S.N.M. 12576; 1 male.

LAMPROPS FUSCATA G. O. Sars.

Lamprops fuscata G. O. Sars, Forh. Vidensk. Selsk. Christiania, 1864 (1865), p. 192.—Crust. Norway, vol. 3, 1900, p. 20, pl. 11.

A small and immature specimen is referred, without much doubt, to this species, which is known from Greenland, Franz-Joseph Land, Nova Zembla, and the north of Norway.

Locality.—Albatross station 2466; off Newfoundland; 67 fathoms; U.S.N.M. 44129.

With this species I also associate provisionally four ovigerous female specimens from Alaska. They differ from Sars' account of the species in the following characters: (1) The size is much greater—about 8.7 mm. total length; (2) the pseudorostrum is shorter, the lateral plates only meeting for a very short distance in front of the ocular lobe; (3) the dorsal crest on the anterior part of the carapace is very strongly marked; (4) the first legs are shorter, not extending beyond the pseudorostrum, but the relative lengths of the segments are much as in Sars' figures; (5) the last two segments of the second legs are shorter, together equaling the length of the carpus; (6) the peduncle of the uropods is a little longer than the telson. As I have not been able to compare the specimens with an adequate series of the Atlantic and Arctic form, it would be hazardous to regard these differences as specific.

Localities.—Shahafka Cove, Kodiak Island, Alaska; W. H. Dall, July 10, 1880; U.S.N.M. 44130.

Chiniak Bay, Kodiak, Alaska; W. H. Dall, July 12, 1880; U.S.N.M. 44131.

LAMPROPS QUADRIPLICATA S. I. Smith.

Lamprops quadriplicata S. I. Smith, Trans. Conn. Acad., vol. 5, 1879, p. 118.

It is doubtful whether this species is entitled to rank as distinct from the *L. fasciata* of European coasts. The first of the four oblique ridges on the carapace varies in distinctness and is by no means altogether absent in European specimens, in some of which it is nearly as well marked as in those from America. All the European specimens I have seen, however, agree with Sars' figures in having only one pair of lateral spines on the telson, while in American specimens, as in Smith's description, there are at least two pairs. There are also some small differences, which may be constant, in the spinulation and proportions of the uropods.

Localities.—Albatross station 2438; off Newfoundland; lat. 43° 36' 00'' N.; long. 50° 03' 30'' W.; 37 fathoms; bottom temperature 36.8° F.; U.S.N.M. 10499; 1 female.

Casco Bay; U. S. F. C., 1873; U.S.N.M. 34885; 1 female.

U. S. F. C. station 141 (1878); Gloucester Harbor; 8½ fathoms; bottom temperature 44.5° F.; U.S.N.M. 44132; 1 female.

U. S. F. C. station 311; Cape Cod Bay; 16 fathoms; bottom temperature 49° F.; U.S.N.M. 44133; 1 male.

U. S. F. C. station 352; Cape Cod Bay; 10½ fathoms; bottom temperature 62° F.; U.S.N.M. 34874; 1 male.

U. S. F. C., November 22, 1879; U.S.N.M. 36639; 1 male.

LAMPROPS (?) BERINGI, new species.

Ovigerous female.—Total length, 12.7 mm.

Carapace about one-fifth of total length, its dorsal surface keeled in front, flattened or faintly sulcate behind. A single oblique ridge

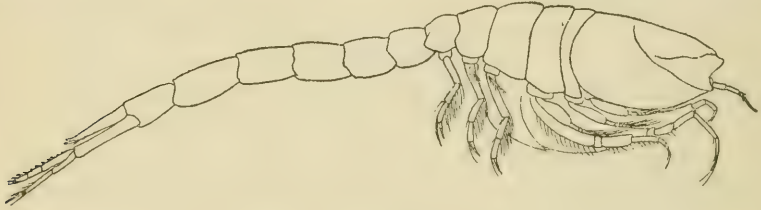


FIG. 27.—LAMPROPS (?) BERINGI, FEMALE, FROM THE SIDE.

on each side of the carapace ends below on the antero-lateral tooth and meets its fellow of the opposite side on the dorsal surface a little behind the middle of the carapace. The pseudorostrum is very short and blunt; the antennal notch is well-marked and rounded; the antero-lateral corner projects as far forward as the pseudorostrum and is sharply pointed.

In the first legs the three distal segments are subequal in length and the distal end of the carpus extends slightly beyond the pseudorostrum in the natural position. The second legs have the two distal segments subequal and together equal to the carpus.

The telson is nearly one and a half times as long as the last somite, with five or six lateral spines on each side (not symmetrically placed) and three apical spines of which the median is the longest.

Peduncle of uropods about equal in length to the telson, with rather slender spines on its inner edge. Endopod nearly as long as peduncle, exopod slightly shorter; second and third segments of endopod subequal and together about three-fifths of length of first segment.

Remarks.—In the absence of the male it can not be decided whether this species should be placed in *Lamprops* or in *Hemilamprops*, although the presence of a well-marked antennal notch in the front margin of the carapace suggests the former of these genera. In hav-



FIG. 28.—LAMPROPS (?) BERINGI, FEMALE, LAST SOMITE, TELSON, AND UROPOD.

ing a single lateral ridge on the carapace it resembles *H. uniplicata* G. O. Sars, but it is distinguished by the antennal notch, the much shorter first legs, and the different proportions of the uropods.

Locality.—Bering Island; N. Grebnitzky; U.S.N.M. 13678; 1 female.

PARALAMPROPS ORBICULARIS (Calman).

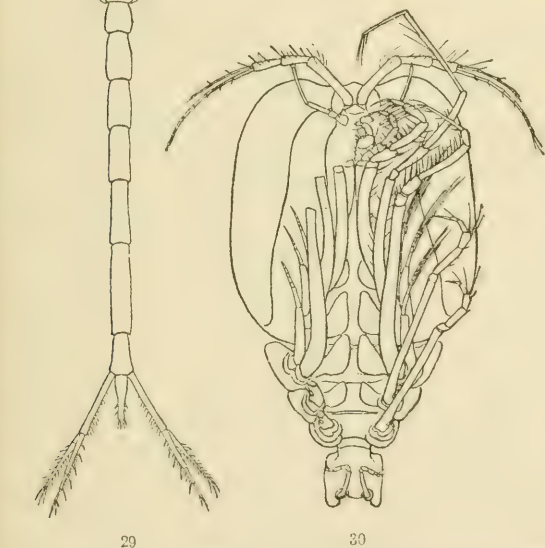
Platyaspis orbicularis CALMAN, Fisheries, Ireland, Sci. Invest., 1904, No. 1 (1905), p. 43, pl. 5, figs. 77-81.

Immature female (with developing oöstegites).—Total length, 16 mm. A less perfect ovigerous female is about the same size.

Carapace, viewed from above, roughly square in outline, with broadly rounded corners, the lateral margins very slightly convergent anteriorly; the anterior margin is concave, with a slight pseudorostral projection in the middle. The greatest transverse width is a little less than the length measured in the middle line. On the dorsal surface a median serrated ridge, or rather a row of minute teeth, runs backward from the small ocular lobe to a little past the middle

of the length of the carapace; there are no paired ridges on the posterior part of the dorsal surface. The under surface of each wing of the carapace is divided into two by a somewhat sinuous longitudinal ridge.

The first leg-bearing somite is larger than those that follow it, but its pleural plates are completely overlapped by those of the second somite. The last thoracic somite is similar to, but shorter than, the first abdominal somite.

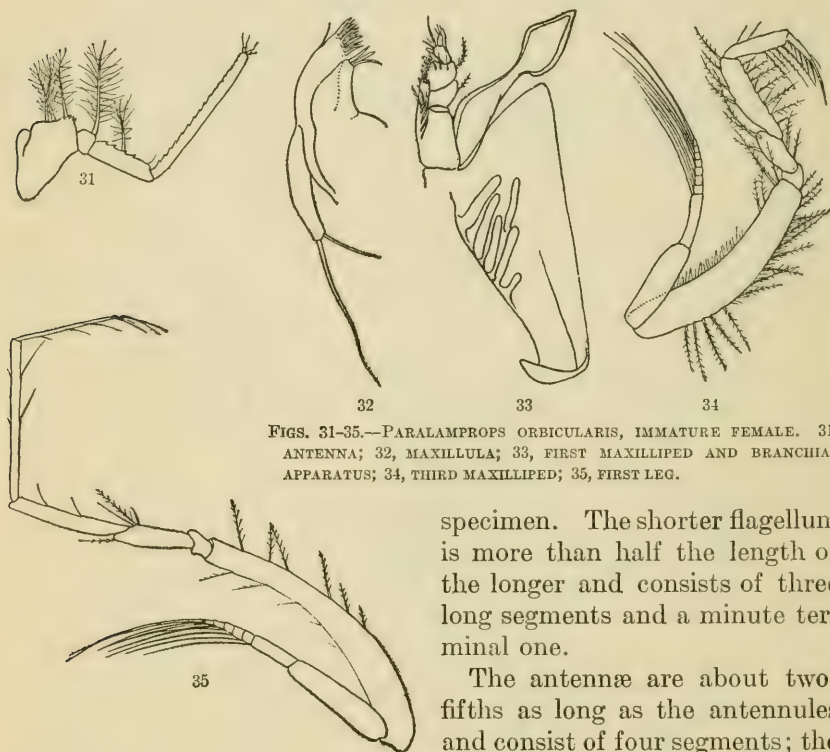


FIGS. 29-30.—PARALAMPROPS ORBICULARIS, IMMATURE FEMALE. 29, FROM ABOVE; 30, ANTERIOR PART OF BODY FROM BELOW.

The abdomen, including the telson, is about $1\frac{3}{4}$ times as long as the cephalothoracic region, and is very slender; the fifth somite is more than four times as long as wide and twice as long as the last somite. The telson is a little longer than the last somite; not much narrowed

at the tip, which is rounded and bears five spines; there are two pairs of lateral spines.

The antennules measured to the tip of the longer flagellum are only a little shorter than the carapace, the peduncle forming about half their length. The first segment of the peduncle is about equal to the other two together and the three are beset with rather numerous setæ, apparently of considerable length, although nearly all of them are broken off in the specimens examined. The longer flagellum has six long segments and a minute terminal one in two of the specimens, but only five segments and a terminal one in another



FIGS. 31-35.—*PARALAMPROPS ORBICULARIS*, IMMATURE FEMALE. 31, ANTENNA; 32, MAXILLULA; 33, FIRST MAXILLIPED AND BRANCHIAL APPARATUS; 34, THIRD MAXILLIPED; 35, FIRST LEG.

specimen. The shorter flagellum is more than half the length of the longer and consists of three long segments and a minute terminal one.

The antennæ are about two-fifths as long as the antennules and consist of four segments; the first segment is stout and carries three (perhaps four) plumose setæ; the other segments are slender, the second one-fourth as long as the third, which again is less than half as long as the fourth; the second and third have each a single seta, and the third an apical group of very minute setæ.

The mandibles and maxillæ are of normal type. The maxillulæ have a well-developed palp, carrying two setæ.

The first maxilliped and its branchial apparatus resemble closely those of *Paralamprops serratocostata* as figured by Sars.

The third maxillipeds have the basis slender and shorter than the distal segments together. The first legs are about equal in length to the whole cephalothoracic region; the basis is about three-fifths of the length of the distal segments together; the very slender dactylus is about equal to the carpus and two-thirds as long as the propodus.

The second legs are also long and slender, considerably longer than the carapace; the basis is about equal to the distal segments together; the carpus has a row of unequal spines along the inner edge and is about equal to the last two segments together; the slender dactylus is nearly four times as long as the propodus; there is a well-developed exopod.

The third and fourth pairs of legs are similar to one another, only a little shorter than the carapace, and each having a minute exopod of two segments; the basis is longer by one-half than the distal segments together.

The fifth legs are very small, less than one-fourth of the length of the preceding pair; the basis is shorter than the distal segments together.

The peduncle of the uropods is longer by about one-half than the last somite, and has a row of unequal spines on the inner edge. The endopod is about equal in length to the peduncle, of three segments, the first about three times as long as either the second or the third, spinose on the inner edge. The exopod is a little longer than the first two segments of the endopod and has setæ on both edges.

Remarks.—The specific identity of this form with that to which I gave the name *Platyaspis orbicularis* is not beyond doubt. The type specimen from the west of Ireland is, however, very incomplete, lacking the abdomen and most of the thoracic somites. Its carapace is only about half as long as that of the specimen described above and it shows no trace of oostegites. It is therefore quite probable that the differences in the outline of the carapace and the absence of the paired ridges on its dorsal surface in the larger specimens may be due to the difference in age.



FIG. 37.—PARALAMPROPS ORBICULARIS, IMMATURE FEMALE, THIRD LEG.



FIG. 36.—PARALAMPROPS ORBICULARIS, IMMATURE FEMALE, SECOND LEG.

The Irish specimen was referred to the genus *Platyaspis* chiefly on account of the general shape of the carapace. The more complete

specimens now described show, however, that the species can not belong to that genus, since it has well-developed exopods on the second pair of legs and vestigial exopods on the third and fourth pairs in the female sex. In these and in many other respects it agrees much more closely with the type of the genus *Paralamprops* (*P. serratocostata*) described by Sars from Kerguelen. I have, therefore, placed it for the present in that genus, although it differs in one character so important and unexpected that it might almost justify the creation of a new genus. This character



FIG. 38.—PARALAMPROPS ORBICULARIS, IMMATURE FEMALE, FIFTH LEG.

is the possession of a normal maxillular palp. The only Cumacea in which this palp is lacking are *Platyaspis typica* and *Paralamprops serratocostata*, and this common character has been used by Zimmer as an argument against the separation of the Platyaspidæ from the Lampropidæ. In other respects, however, the case against this separation is strengthened by the characters of the species described above, which unites the greatly expanded carapace of *Platyaspis* with the arrangement of exopods characteristic of *Paralamprops*.

Localities.—Albatross station 2547; lat. 39° 54' 30'' N.; long. 70° 20' 00'' W.; 390 fathoms; bottom temperature, 39.6° F.; U.S.N.M. 38210.

Albatross station 2680; lat. 39° 50' 00'' N.; long. 70° 26' 00'' W.; 555 fathoms; U.S.N.M. 44148.

U. S. F. C. station 891; lat. 39° 46' 00'' N.; long. 71° 10' 00'' W.; 480 (?) fathoms; U.S.N.M. 34306.

U. S. F. C. station 997; lat. 39° 42' 00'' N.; long. 71° 32' 00'' W.; 335 fathoms; bottom temperature, 40° F.; U.S.N.M. 34304.

DIASTYLIS SCORPIOIDES (Lepechin).

Oniscus scorpioides LEPECHIN, Acta Acad. Sci. Petropol., 1778, pt. 1 (1780), p. 248, pl. 8, fig. 2.

Diastylis scorpioides G. O. SARS, Crust. Norway, vol. 3, 1900, p. 58, pl. 44.

This species was found by Stuxberg on the voyage of the *Vega* as far east as the Liakhov Islands.¹

Localities.—Upernavik Harbor, Greenland; 13 fathoms; Ensign C. S. McClain, U. S. S. *Alert*, June 14, 1884; U.S.N.M. 13769; 1 female.

Greenland (?); Ensign C. S. McClain, U. S. S. *Alert*, 1884; U.S.N.M. 14766; 1 female.



FIG. 39.—PARALAMPROPS ORBICULARIS, IMMATURE FEMALE, LAST SOMITE, TELSON, AND UROPOD.

¹ Bihang Kgl. Svenska Vet. Akad. Handl., vol. 5, 1880, No. 22, p. 26, and *Vega* Exped. Vetensk. Iakttagelser, vol. 1, 1882, p. 710, as *D. edwardsi*.

Shoal Tickle, near Nain, Labrador; Owen Bryant, August 15, 1908; U.S.N.M. 44088; 1 female.

Albatross station 2697; off Newfoundland; lat. $47^{\circ} 40' 00''$ N.; long. $47^{\circ} 35' 30''$ W.; 206 fathoms; U.S.N.M. 44089; 2 females.

DIASTYLIS DALLI, new species.

Adult female (with empty brood-pouch).—Total length, 24 mm.

Resembling *D. scorpioides* (Lepechin) in general appearance; surface of carapace much smoother and the ridges not crenulated. There are only four oblique ridges on each side of the carapace; the first is rather obscure and runs forward on the side of the pseudorostrum; the others are very bold and prominent; the second and third run, without uniting, to the lower edge of the carapace, while the fourth approaches or actually joins the third near its lower end. The longitudinal ridges uniting the upper ends of the three posterior oblique ridges on the dorsal surface are very prominent and the area between them is grooved in the middle line. The pseudorostrum is very short,



FIG. 40.—DIASTYLIS DALLI, IMMATURE FEMALE, FROM THE SIDE.

its upper edge sloping slightly downward and the lateral plates meeting only for a distance not greater than the length of the ocular lobe. The ocular lobe is as long as broad.

The pleural plates of the second free thoracic somite are pointed in front. The abdomen (excluding the telson) is about as long as the cephalothoracic region.

The telson is longer by one-third than the last somite and nearly equal in length to the peduncle of the uropods; it tapers from the base and the post-anal portion is longer by one-half than the pre-anal. There are about 11 pairs of lateral spines which are considerably smaller than the apical pair.

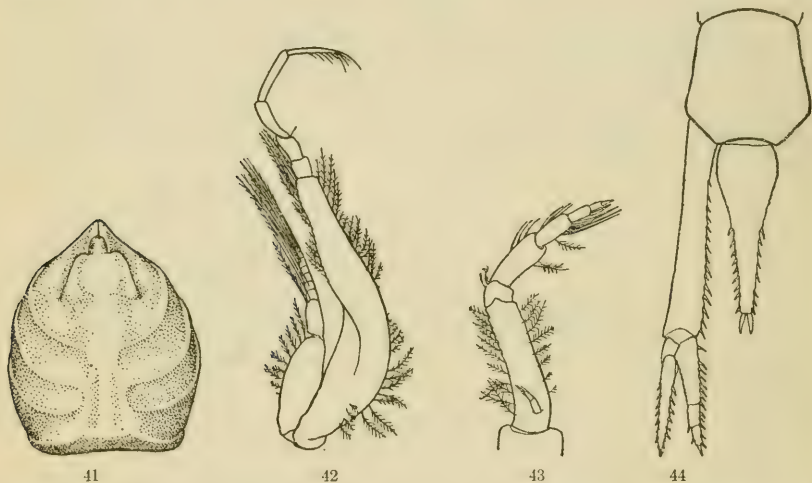
Peduncle of antennule with last segment longer and much more slender than the second, first longer than second and third together. Penultimate segment of antenna elongated.

Third maxilliped not expanded distally; its length along the inner edge more than eight times its width; ischium large, longer than merus as seen from below; merus expanded externally but not broader than ischium.

The first pair of legs have the basis about half as long again as the distal segments together, and not distinctly spinous; the propodus is a little longer than the carpus and about equal to the dactylus. In the legs of the second pair the carpus is only a little longer than the last two segments together.

The legs of the third and fourth pairs bear each a vestigial exopod of two segments.

The peduncle of the uropods has a row of small spines on the inner edge. The endopod is about half as long as the peduncle and slightly longer than the exopod; its three segments well defined, the first much longer than the other two together. The inner edges of both rami



FIGS. 41-44.—*DIASTYLIS DALLI*, IMMATURE FEMALE. 41, CARAPACE FROM ABOVE; 42, FIRST LEG; 43, THIRD LEG; 44, LAST SOMITE, TELSON, AND UROPOD.

bear series of short spines; the terminal spines are broken off in all the full-grown specimens examined, but in younger specimens they are quite short.

Remarks.—Although bearing a striking general resemblance to *D. scorpioides*, this species is at once distinguished from it by having only four in place of five oblique ridges on the carapace. The presence of vestigial exopods on the third and fourth legs, while they are absent in the closely allied *D. scorpioides*, shows that this character can no longer be regarded as of generic value.

It seems likely that this species or the next is that referred to by Stuxberg as “en vackert röd- och gulfärgad *Diastylis* (lik *Diast. scorpioides*),” taken by the *Vega* at East Cape.¹

¹ Bihang Kgl. Svenska Vet. Akad. Handl., vol. 5, 1880, No. 22, p. 29, and *Vega* Exped. Vetensk. Iakttagelser, vol. 1, 1882, p. 715.

This fine species, one of the largest of the Cumacea, may be appropriately associated with a name famous in the history of the scientific exploration of Alaska, that of Dr. W. H. Dall.

Localities.—Bering Strait; W. H. Dall, 1880; U.S.N.M. 13379; 1 female (holotype).

Off Cape Sabine; 13 fathoms; W. H. Dall; U.S.N.M. 44046; 5, female and young.

Off Cape Sabine; 13 fathoms; W. H. Dall, August 24, 1880; U.S.N.M. 44044; about 10, female and young.

Off Point Hope, Alaska; 25 fathoms; U. S. R. S. *Corwin*, Capt. M. A. Healy, 1884; U.S.N.M. 44049; about 20, female and young male.

Albatross station 2841; lat. $54^{\circ} 18' 00''$ N.; long. $165^{\circ} 55' 00''$ W.; 56 fathoms, U.S.N.M. 44045; 1 immature male.

Ridge, Captains Harbor, Alaska; 80 fathoms; W. H. Dall, 1874; U.S.N.M. 13364; 1 immature male.

Alaska; W. H. Dall; 1 immature female.

Albatross station 5023; off Cape Patience, Sakhalin Island; 75 fathoms; bottom temperature 30.9° F.; U.S.N.M. 44048.

DIASTYLIS BIDENTATA, new species.

Adult female (with empty brood-pouch).—Total length, 11.5 mm.

Resembling *D. scorpoides* (Lepechin) in general appearance; surface of carapace smoother, the ridges very finely crenulated. There



FIG. 45.—DIASTYLIS BIDENTATA, IMMATURE FEMALE, FROM THE SIDE.

are only four oblique ridges on each side of the carapace; the first is short and runs forward on the side of the pseudorostrum; the others are very strong and run from the dorsal surface to the lower margin parallel to each other; just at the lower margin the fourth ridge curves forward to meet the third. The second ridge is produced, a little way from its lower end, into a strong acute tooth directed outward and forward. The longitudinal ridges uniting the upper ends of the three posterior oblique ridges on the dorsal surface are distinct but not very prominent and approach each other anteriorly. The pseudorostrum is much as in *D. scorpoides*, the lateral plates meeting for

a distance much greater than the length of the ocular lobe. The ocular lobe is slightly broader than long and bears a few small denticles; just behind it, on the frontal lobe, are two short transverse denticulated ridges.

The pleural plates of the second free thoracic somite are pointed anteriorly and almost or entirely conceal those of the first somite.

The dorsal part of the fourth somite is strongly produced backwards in the middle line.

The telson is longer by about one-half than the last somite and longer than the peduncles of the uropods; it is slightly expanded at the base and then contracts rapidly to a narrow distal part; the post-anal division is $1\frac{1}{2}$ times as long as the pre-anal. There are about 10 pairs of lateral spines and a pair of somewhat larger apical spines.

Peduncle of antennule with last segment slender, nearly half as long again as the second, first shorter than second and third together. Penultimate segment of antenna elongated.

Third maxilliped not expanded distally; its length along the inner edge nearly eight times its greatest

width; merus expanded externally, broader than ischium.

The first pair of legs have the basis about one-third longer than the distal segments together, with some small teeth on the lower surface and inner edge; the last three segments are subequal. In the legs of the second pair the carpus is only a little longer than the last two segments together. The legs of the third and fourth pairs have each a minute exopod of two segments.

The peduncle of the uropods is spinous on the inner edge. The endopod is about three-fourths as long as the peduncle and very slightly longer than the exopod; its three segments are well defined, the first only a little less than twice as long as the other two together. The inner edges of both rami are spined. The terminal spine of the endopod is short, well defined at the base; the exopod has two apical spines, one of them long and slender.

Adult male.—Total length, 12mm.

Differing from the female in the usual characters, the body being more slender and the carapace less arched. The ridges of the carapace are strongly marked and arranged as in the female, but the tooth of the second ridge is represented only by a slight angulation of the ridge not projecting from the surface, and the transverse

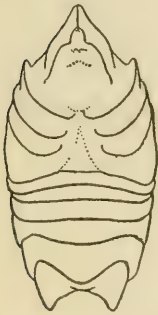


FIG. 46.—DIASTYLIS BIDENTATA, IMMATURE FEMALE, ANTERIOR PART OF BODY FROM ABOVE.

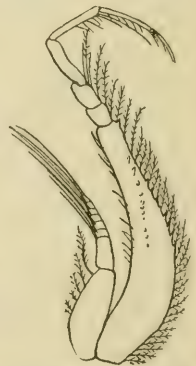


FIG. 47.—DIASTYLIS BIDENTATA, IMMATURE FEMALE, FIRST LEG.

ridges behind the ocular lobe are less pronounced. The pseudorostrum is longer and more acute than in the male of *D. scorpoides*. The penultimate thoracic somite is produced backward dorsally as in the female. The lateral processes of the last thoracic somite are more produced than in the female, though still blunt.

There is a stout median ventral spine, followed by a small tubercle, on the first abdominal somite, and two median tubercles on the second. The telson is about two and a half times as long as the last somite; the distance from its base to the dorsal protuberance is less than half that from the protuberance to the tip; the lateral spines are longer and more numerous than in the female.

The antennal flagellum is about as long as the body. The uropods, as usual, are much longer and more slender than in the female, though the peduncle is shorter than the telson, and have very numerous serrate spines on the inner edges of peduncle and endopod.

Young males, in which the pleopods are not furnished with natatory setæ, resemble the females in general form and have a large lateral spine on the carapace.

Remarks.—This species has a considerable resemblance to *D. dalli*, but it differs conspicuously in the large lateral teeth of the carapace.

There is a certain amount of variation in some characters. A number of specimens from Point Franklin (No. 7928, U.S.N.M.), the most northerly locality from which the species has been obtained, reach a much greater size than the holotype, an ovigerous female having the carapace 4.75 mm. in length, indicating a probable total body length of about 16.5 mm. when complete. The carapace is more inflated, the pseudorostrum more obtuse, the ridges on the carapace less prominent, and the tooth of the second ridge much more blunt than in the typical form. On the other hand, specimens from *Albatross* station 2841 (near Unalaska) of about the average size, with the ridges of the carapace relatively inconspicuous, have the tooth very large and more acute than in the specimen figured.

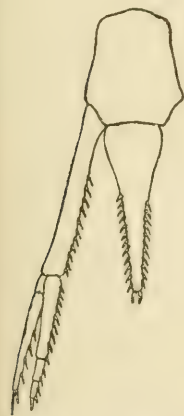


FIG. 49.—*DIASTYLIS BIDENTATA*, IMMATURE FEMALE, LAST SOMITE, TELSON, AND UROPOD.



FIG. 48.—*DIASTYLIS BIDENTATA*, IMMATURE FEMALE, THIRD LEG.

Localities.—Near Point Belcher, Arctic Ocean; 9 fathoms; sand; W. H. Dall; U.S.N.M. 13382.

Ten miles west of Point Franklin, Alaska; 13½ fathoms; sand; Point Barrow Expedition, August 31, 1883; U.S.N.M. 7928; 10 females (very large).

Off Cape Sabine; 13 fathoms; W. H. Dall, August, 1880; U.S.N.M. 44033; 1 female.

Albatross station 3637; lat. $57^{\circ} 06' 30''$ N.; long. $170^{\circ} 28' 00''$ W.; 32 fathoms; bottom temperature, 39° F.; U.S.N.M. 44041; 3 females.

Albatross station 3600; lat. $55^{\circ} 06' 00''$ N.; long. $163^{\circ} 28' 00''$ W.; 9 fathoms; bottom temperature, 40° F.; U.S.N.M. 44040; about 15, male and female.

Albatross station 3548; lat. $54^{\circ} 44' 00''$ N.; long. $165^{\circ} 42' 00''$ W.; 91 fathoms; bottom temperature, 39.5° F.; U.S.N.M. 44039; 1 female.

Albatross station 2841; lat. $54^{\circ} 18' 00''$ N.; long. $165^{\circ} 55' 00''$ W.; 56 fathoms; bottom temperature, 41° F.; U.S.N.M. 44036; 1 female.

Nazan Bay, Atka Island; W. H. Dall; U.S.N.M. 44043; 6 females.

Bay of Islands, Adak, Alaska; 9–16 fathoms; mud, sand; W. H. Dall, 1873; U.S.N.M. 13373; 1 male, 1 female.

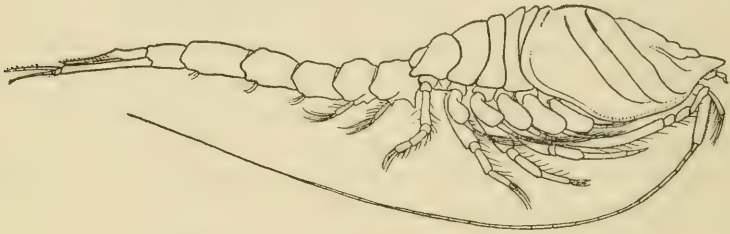


FIG. 50.—*DIASTYLIS BIDENTATA*, MALE, FROM THE SIDE.

Kiska Harbor, Aleutians; 10 fathoms; W. H. Dall; U.S.N.M. 44151; 1 male.

Kiska Harbor; 14–9 fathoms; sandy; W. H. Dall, July, 1873; U.S.N.M. 14276; 3 males.

Kiska Harbor; 9–12 fathoms; sand, mud; W. H. Dall, 1873; U.S.N.M. 13369; 3 males.

Kiska Harbor; 14–9 fathoms; sandy; W. H. Dall, July, 1873; U.S.N.M. 14272; 2 males, 5 females.

Kiska Harbor; 9–12 fathoms; sandy mud; W. H. Dall; U.S.N.M. 14266, 44034, 44035; many, male and female (including holotype, 14266).

Kiska Harbor; 9–12 fathoms; sandy mud; W. H. Dall; U.S.N.M. 44042; 2 females.

Kiska Harbor; 9–12 fathoms; sandy mud; W. H. Dall, 1873; U.S.N.M. 13368; 4, male and female.

Kiska Harbor; 6–8 fathoms; sand; W. H. Dall; U.S.N.M. 14263 about 10, male and female.

Albatross station 2872; lat. $48^{\circ} 17' 00''$ N.; long. $124^{\circ} 52' 00''$ W.; 38 fathoms; bottom temperature, 45.5° F.; U.S.N.M. 44038; 5 females, 1 adult male.

DIASTYLIS ALASKENSIS, new species.

Ovigerous female.—Total length, 13.5 mm.

Carapace less inflated than in *D. scorpioides*, its greatest height about half of its length, narrowing forwards from the hind margin as seen from above; with six transverse ridges more or less completely encircling it and with the hind margin strongly everted. Pseudo-



FIG. 51.—DIASTYLIS ALASKENSIS, FEMALE, FROM THE SIDE.

rostrum rather long and acute, the lateral plates meeting for a distance equal to twice the length of the ocular lobe. The ocular lobe is a little longer than broad and its anterior end forms the dorsal part of the first transverse ridge.

The pleural plates of the second free thoracic somite are rounded anteriorly and hardly overlap the somite in front. The dorsal part of the fourth somite is not conspicuously produced backwards. The abdomen (excluding the telson) is a little shorter than the cephalothoracic region.

The telson is very slightly longer than the last somite and reaches to about the distal third of the uropod peduncles. It narrows slightly from the base to a rather sudden constriction about the middle of its length; the post-anal division is about three-fourths as long as the pre-anal. There are about six pairs of lateral spines and a pair of somewhat larger apical spines closely approximated.

Peduncle of antennule with last segment slender, longer than second, first much shorter than the other two together. Penultimate segment of antenna elongated.

Third maxilliped with basis expanded distally; its length along the inner edge about four and one-half times its greatest width, merus not expanded externally, narrower than ischium.

First pair of legs with basis about as long as the distal segments together, without conspicuous teeth; propodus longer than either carpus or dactylus. In the second pair the carpus is longer by one-

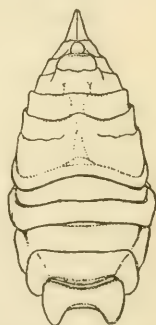


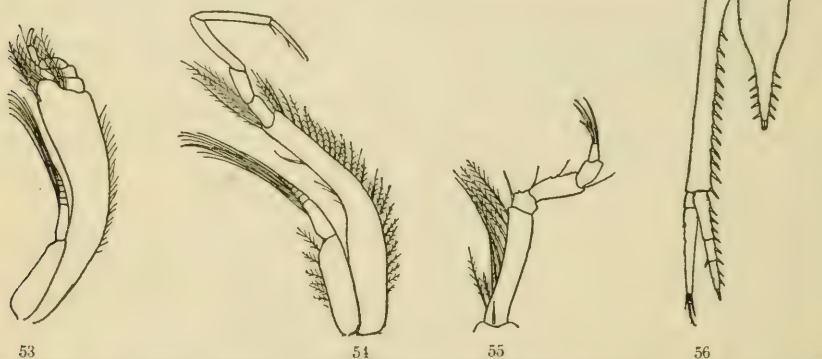
FIG. 52.—DIASTYLIS ALASKENSIS, FEMALE, ANTERIOR PART OF BODY FROM ABOVE.

half than the last two segments together. The legs of the third and fourth pairs have each a minute exopod of two segments.

The peduncle of the uropods is spinous on the inner edge. The exopod is a little less than half as long as the peduncle and very slightly longer than the endopod; the three segments of the latter are well defined, the first equal to or shorter than the other two together; the inner edge of the endopod is spined, and the short, stout apical spine is well defined at the base.

Adult male.—Total length, 10.6 mm.

Sculpture of carapace resembling that of female, but with only five conspicuous transverse ridges, that corresponding to the hindmost ridge of the female being barely traceable; in addition, a horizontal ridge on each side runs forward from the hind margin to the last transverse ridge a little way above the lower edge of the carapace. The pleural plates of the third free thoracic somite overlap those of the somite in front; the lateral processes of the last thoracic somite are short



FIGS. 53-56.—*DIASTYLIS ALASKENSIS*, FEMALE. 53, THIRD MAXILLIPED; 54, FIRST LEG; 55, THIRD LEG; 56, LAST SOMITE, TELSON, AND UROPOD.

and blunt. The first two abdominal somites have each a small median ventral spine. The telson is about one and a half times as long as the last somite; the dorsal protuberance is at about the middle of its length. The antennal flagellum is about as long as the body.

Remarks.—This species is evidently allied to the two preceding, but it differs from them in the greater number of ridges on the carapace, which give it an annulated appearance. With the possible exception of *D. bidentata* it would seem to be the most abundant Cumacean in Alaskan waters.

Localities.—Lat. $63^{\circ} 37' 00''$ N.; long. $165^{\circ} 19' 00''$ W.; 12 fathoms; G. M. Stoney, June, 1884; U.S.N.M. 44019; 1 male.

Albatross station 3600; Bering Sea; lat. $55^{\circ} 06' 00''$ N.; long. $163^{\circ} 28' 00''$ W.; 9 fathoms; bottom temperature, 40° F.; U.S.N.M. 44020, 44021; many, male and female (including holotype, 44020).

Port Levashef, Unalaska; 20–30 fathoms; W. H. Dall; U.S.N.M. 44026; 1 female.

Eider village anchorage, Captains Bay, Unalaska; W. H. Dall, 1873; U.S.N.M. 13372; 8, male and female.

Ridge, Port Levashef, Unalaska; W. H. Dall, 1880; U.S.N.M. 13365; about 12 females.

Off Round Island, Coal Harbor, Unga; 8–9 fathoms; sand, stones; W. G. Hall; Dall's collection; U.S.N.M. 44024; 1 female.

Coal Harbor, Unga Island, Alaska; 8–9 fathoms; sand, stones; W. G. Hall, 1872; Dall's collection; U.S.N.M. 13371; 2 females.

Popof Strait, Alaska, near reef; 5–7 fathoms; sand; W. H. Dall, 1872; U.S.N.M. 13370; 1 male, 2 females.

Chignik Bay; 7–18 fathoms; sand; W. H. Dall; U.S.N.M. 44027; 8 females.

Chiniak Bay, Kodiak, Alaska; W. H. Dall, July, 1880; U.S.N.M. 13378; 5, female and young male.

Shahafka Cove, Kodiak, Alaska; 12–14 fathoms; mud, sand; W. H. Dall; U.S.N.M. 14277; 1 female.



FIG. 57.—*DIASTYLIS ALASKENSIS*, MALE, FROM THE SIDE.

Shahafka Cove, Kodiak, Alaska; 12–14 fathoms; W. H. Dall, July, 1880; U.S.N.M. 13377; about 25, male and female.

Old Harbor, Kodiak; *Albatross*, August 11, 1888; U.S.N.M. 44023; 2 females.

Albatross station 4272; Afognak Island; 17–12 fathoms; bottom temperature, 54° F.; U.S.N.M. 44022; 3 females.

Chugachik Bay, Cooks Inlet, Alaska; 20–60 fathoms; sandy mud; W. H. Dall, June, 1880; U.S.N.M. 13376; 4 females.

Chiachi Islands, Alaska; 20 fathoms; mud; W. H. Dall, 1874; U.S.N.M. 13374; 1 female.

Chiachi Islands; 20 fathoms; mud; W. H. Dall; U.S.N.M. 44025; 1 female.

DIASTYLIS PLANIFRONS, new species.

Ovigerous female.—Total length, 14 mm.

Carapace inflated, its greatest height nearly two-thirds and its greatest width three-fourths of its length. A prominent, very oblique ridge on each side dies away on the side of the pseudorostrum; at about one-third of its length from the front it is joined by a curved

ridge running up from the lower edge of the carapace, and the point of junction forms a prominent blunt tooth. Posteriorly, at about one-third of the length of the carapace from its hind margin, the oblique ridges meet a pair of convergent longitudinal ridges separated by a depression of the dorsal surface. The dorsal area enclosed by the oblique ridges is flattened, with a blunt median ridge, interrupted by



FIG. 58.—*DIASTYLIS PLANIFRONS*, FEMALE, FROM THE SIDE.

two transverse grooves just behind the ocular lobe. The pseudo-rostrum is horizontal and pointed, the lateral plates meeting in front of the ocular lobe for more than twice the length of the latter. The antero-lateral angle is blunt. The ocular lobe is at least as broad as long and bears three well-marked corneal areas.

The pleural plates of the second free thoracic somite are rounded and rather small. The postero-lateral angles of the fifth somite are acute but very little produced. The abdomen (excluding the telson) is nearly equal in length to the cephalothoracic region. The telson is longer by about one-third than the last somite and about two-thirds as long as the peduncles of the uropods; it is subcylindrical for about a third of its length from the base and then narrows to the slender post-anal

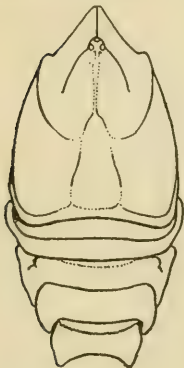


FIG. 59.—*DIASTYLIS PLANIFRONS*, FEMALE, ANTERIOR PART OF BODY FROM ABOVE.



FIG. 60.—*DIASTYLIS PLANIFRONS*, FEMALE, THIRD MAXILLIPED.

part, which, measured to the apex of the anal valves, occupies rather more than one-third of its length. There are 5 pairs of rather long lateral spines.

Third maxilliped with basis expanded distally, its length along the inner edge about four times its greatest width, its distal outer angle

produced as a narrow rounded lobe, ischium produced externally into a curved tooth, wider than merus.

The first legs are imperfect in both the specimens examined but the basis appears to have been distinctly longer than the distal segments together and the carpus is more than one-third longer than the propodus.

In the second pair of legs the carpus is nearly twice as long as the last two segments together.

In the third and fourth pairs a minute exopod of two segments is present.

The peduncle of the uropods has a row of rather slender spines on the inner edge; the exopod is half as long as the peduncle and the endopod a little shorter.

Remarks.—This species bears a somewhat vague resemblance in the sculpturing of the carapace to the form which Zimmer has figured under the name of *Leptostylis manca* G. O. Sars,¹ but it differs too widely in the shortness of the first legs and in many other characters to be identified with that species. The outline of the carapace as seen from above has a certain similarity to that of *D. bidentata*.

Localities.—Albatross station 2771; east coast of South America; lat. $51^{\circ} 34' 00''$ S.; long. $68^{\circ} 00' 00''$ W.; 50 fathoms; bottom temperature 49.4° F.; U.S.N.M. 44055; 1 female (holotype).

Albatross station 2778; Straits of Magellan; lat. $53^{\circ} 01' 00''$ S.; long. $70^{\circ} 42' 15''$ W.; 61 fathoms; bottom temperature 47.9° F.; U.S.N.M. 44054; 1 female.

DIASTYLIS NUCELLA, new species.

Ovigerous female.—Total length, 9.5 mm.

Cephalothoracic region much inflated, almost globose. Height and width of carapace subequal and about seven-eighths of its length.

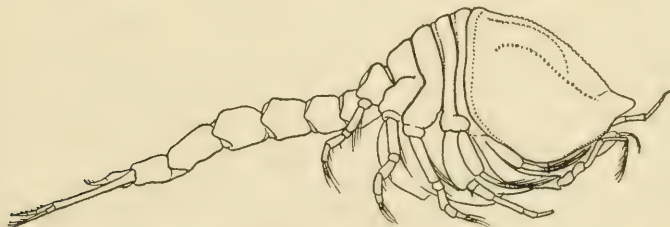


FIG. 62.—DIASTYLIS NUCELLA, FEMALE, FROM THE SIDE.

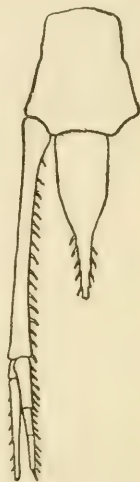


FIG. 61.—DIASTYLIS PLANIFRONS, FEMALE, LAST SOMITE, TELSON, AND UROPOD.

The surface is rough with minute granules and there are on the dorsal side three pairs of longitudinal, finely serrate ridges, or, rather, rows

¹ Hamb. Magalh. Sammelreise, Cumaceen, p. 8, figs. 11-14.

of minute square-cut teeth. The pseudorostrum is short, horizontal, and deeply grooved on the dorsal surface. There is no ocular lobe. The anterior part of the lower edge of the carapace is serrated, with square-cut teeth.

The surface of the free thoracic end of the abdominal somites is finely roughened. The pleural plates of the second free somite are rounded anteriorly and hardly overlap the somite in front.

The abdomen, excluding the telson, is about as long as the cephalothoracic region.

The telson is about as long as the last somite and reaches to about the middle of the uropod peduncles; the basal part is slightly expanded; the post-anal part is about equal in length to the pre-anal; there are generally two pairs of lateral spines (sometimes two spines on one side and one or three on the other) and a pair of larger apical spines.

The peduncle of the antennule has the last segment longer than either the first or second. Penultimate segment of antenna not elongated.

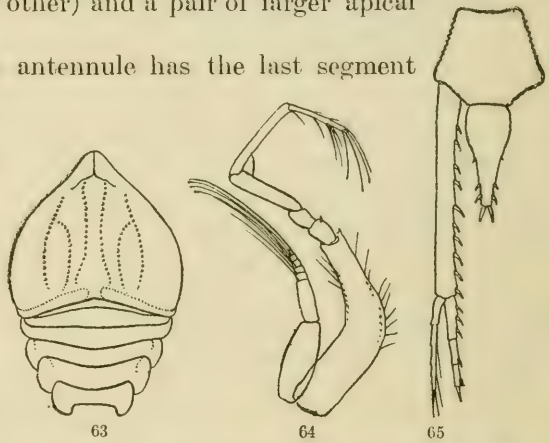
Third maxilliped with basis not expanded or produced distally. Ischium and merus of about equal width, the latter with (?) two teeth externally.

First legs with basis bent nearly to a right angle about the middle of its length; its length along the inner edge a little less than that of the distal segments together. Basis of second legs somewhat expanded internally, carpus about as long as the last two segments together. Posterior legs rather short and stout, third and fourth pairs without exopods.

The peduncle of the uropods has about ten spines on its inner edge. The exopod is less than half as long as the peduncle and longer than the endopod; the three segments of the latter are well defined, the proximal twice as long as either the second or third. Proximal segment of the exopod nearly one-half as long as the distal.

Remarks.—This pretty species is unlike any other known to me in the shape and ornamentation of its carapace, and it is not easy to suggest in what direction its immediate allies are to be sought.

Locality.—Cape Smyth, Alaska; $2\frac{1}{2}$ fathoms; Point Barrow Exped., August, 1883; U.S.N.M. 7937, 44053; 10 females, including holotype (7937).



FIGS. 63-65.—*DIASTYLIS NUCELLA*, FEMALE. 63, ANTERIOR PART OF BODY FROM ABOVE; 64, FIRST LEG; 65, LAST SOMITE, TELSON, AND UROPOD.

DIASTYLIS ASPERA, new species.

Ovigerous female.—Total length, 12.2 mm.

Carapace inflated, less than one-third of total length, its height a little more than two-thirds and its width five-sixths of its length. A very oblique (nearly horizontal) ridge on each side runs on to the side of the pseudorostrum; a little way behind the ocular lobe it is joined by a curved ridge running up from the lower edge of the carapace. The latter ridge also receives the lower end of an oblique ridge



FIG. 66.—DIASTYLIS ASPERA, FEMALE, FROM THE SIDE.

forming an angle with the first and, like a much fainter parallel ridge just behind it, passing at its upper end into a prominent dorsal longitudinal ridge, which, with its fellow, bounds the deeply hollowed cardiac region. There are several other minor ridges on the surface of the carapace, the most conspicuous being two transverse folds crossing the frontal lobe behind the slightly prominent ocular lobe. The whole surface is rough with small spiniform points becoming larger anteriorly and arranged in rows along the more prominent ridges. The pseudorostrum is of moderate length, horizontal, and acute. The antero-lateral angle is hardly indicated. The ocular lobe is broader than long and its corneal areas are obscure.

The pleural expansions of the second free thoracic somite are small and rounded anteriorly. The dorsal surface of all the somites is smooth, but the anterior margins of first, second, and fifth are finely serrate. The postero-lateral angles of the fifth somite are rounded.

The length of the abdomen, including the telson, is slightly greater than that of the cephalothoracic region. The first somite has a pair of small dorso-lateral teeth; the posterior somites have a group of granules and some shallow depressions on each side, and the penultimate has also a pair of small postero-lateral teeth.

The telson is about twice as long as the last somite, cylindrical at the base, with the narrow post-anal part occupying about half of its length. There appear to have been about nine pairs of lateral spinules.

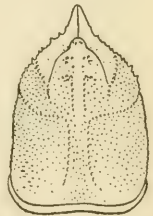


FIG. 67.—DIASTYLIS ASPERA, FEMALE, CARAPACE FROM ABOVE.

The antennules have the last segment of the peduncle more slender and a little longer than the preceding.

The third maxillipeds have the basis of nearly the same width throughout, about one-seventh of its length along the inner edge, its distal outer corner not produced; the merus is only a little narrower than the ischium and has a small tooth internally.

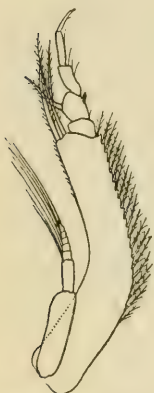


FIG. 68.—*DIASTYLIS ASPERA*, FEMALE, THIRD MAXILLIPED.

The first legs have the basal segment slightly shorter than the distal segments together and carrying a row of teeth on its lower (or outer) surface. The carpus is a little shorter than the propodus and longer than the dactylus.

In the second pair of legs the carpus is about as long as the last two segments together.

The third and fourth pairs of legs are without exopods.

The peduncle of the uropods is about as long as the telson and has a row of rather slender spines on its inner edge. The rami are wanting in the single specimen examined.

Male.—A young male specimen about 9 mm. in length differs from the female described above in having a longer pseudorostrum, the ridges on the side of the carapace much less distinct (those on the dorsal surface are well developed) and the peduncle of the uropods shorter than the telson.

Remarks.—From other species of *Diastylis* that have the surface of the carapace spinulose, this species appears to be distinguished by the arrangement of the ridges on the carapace and by the shortness of the abdomen.

Locality.—Shahafka Cove, Kodiak, Alaska; W. H. Dall, July, 1880; U.S.N.M. 44031, 44032; 1 male, 1 female, holotype (44032).

A female specimen, which, though considerably larger (15.6 mm. total length) than that described above, has only small rudiments of oöstegites visible, may provisionally be referred to the same species. It differs from the female specimen described above in the flatter dorsal surface of the anterior part of the carapace and in some details of the sculpturing; also in having the body beset with long feathered hairs, which, on the carapace, are arranged in rows along the more prominent ridges.

Locality.—Albatross station 5023; Okhotsk Sea, off eastern coast Sakhalin Island, vicinity of Cape Patience; 75 fathoms; bottom temperature, 30.9°; U.S.N.M. 44030; 1 female.



FIG. 69.—*DIASTYLIS ASPERA*, FEMALE, TELSON.

DIASTYLIS ARGENTATA, new species.

Ovigerous female.—Total length, 7.7 mm. (Females, apparently adult, varied from about 7.5 to about 9.5 mm. in length.)

Carapace less than one-third of total length, its height two-thirds and its breadth more than three-fourths of its length; seen from



FIG. 70.—DIASTYLIS ARGENTATA, FEMALE, FROM THE SIDE.

the side, its dorsal outline is moderately arched, with a distinct notch at the base of the pseudorostrum, which is horizontal and acute. The surface of the carapace is rather coarsely pitted; there are a few denticles on the dorsal side of the base of the pseudorostrum and a curved lateral line of denticles runs backwards for a little way on each side from the pseudorostrum. Just above the lower edge of the carapace at about one-third of its length from the front is a small procurved tooth. A rounded tubercle from which a slight ridge runs forward marks the posterior end of each branch of the frontal fissure, and just internal to it is a deep pit. The ocular lobe is small, without distinct ocular elements. There is no antennal notch and the anterior part of the lower margin of the carapace is rather coarsely serrated.

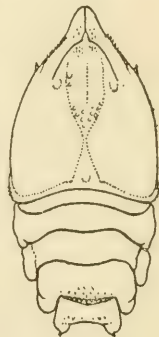


FIG. 71.—DIASTYLIS ARGENTATA, FEMALE, ANTERIOR PART OF BODY FROM ABOVE.



FIG. 72.—DIASTYLIS ARGENTATA, FEMALE, FIRST LEG.

The surface of the body, and especially of the carapace, has a silvery nacreous luster.

The pleural plates of the second and third free thoracic somites are rather coarsely serrate anteriorly. There are a few minute denticles on the dorsal surface of the last three thoracic somites, and the hinder edge of the fourth somite is crenated. The postero-lateral lobes

of the fifth somite are rounded, as seen from above, and each tipped with a small denticle.

The abdomen (excluding the telson) is a little shorter than the cephalothoracic region; the first somite has a pair of dorso-lateral

denticles on its posterior margin, and the fifth somite has also a few denticles posteriorly.

The telson is about twice as long as the last somite, its sides about parallel for half its length, then converging gradually. There are about six pairs of lateral spines, the distal ones at least as large as the terminal pair.



FIG. 73.—*DIASTYLIS ARGENTATA*, FEMALE, SECOND LEG.

In the peduncle of the antennules the second segment is not more than half the diameter of the first, and the third is still more slender; the third is shorter than the first and about half as long again as the second. None of the segments of the antennæ are elongated.

The basis of the third maxillipeds is not expanded or produced distally, and the ischium and merus are narrow.

The basis of the first legs is slender and has a row of strong curved teeth on the distal part of its outer edge; it is a little shorter than the distal segments together. The dactylus is about three-fourths as long as the propodus and a little shorter than the carpus.

In the second legs the basis has a row of strong spiniform teeth along its outer margin; the ischium has a curved spiniform tooth on its inner edge; the carpus is longer by one-fourth than the distal segments together.

The posterior pairs of legs have the basis serrated on the outer side. There are no exopods on the third and fourth pairs.

The peduncle of the uropods is not quite two and a half times as long as the last somite; the exopod is about two-thirds as long as the peduncle and extends beyond the terminal spine of the endopod; the endopod has only one articulation, about the middle of its length, the second and third segments being completely coalesced, and its short stout terminal spine is not defined at its base. The peduncle bears spines on the distal part of its inner edge, and the endopod has about seven spines internally.



FIG. 74.—*DIASTYLIS ARGENTATA*, FEMALE, LAST SOMITE, TELSON, AND UROPOD.

Adult male.—Total length, 9.2 mm.

Height of carapace less than half, its breadth about two-thirds, of its length; seen from the side its dorsal outline is slightly arched, with a distinct notch at the base of the pseudorostrum. There are a few denticles above on the pseudorostrum and frontal lobe and an oblique line running backwards on the side of the pseudorostrum. The

usual serrated lateral keel or line of denticles is present and ends anteriorly in a strong curved tooth close to the antero-lateral margin. A number of other minute denticles are scattered over the surface of the carapace, and some are more or less distinctly arranged in longitudinal rows. The pleural plates of the free thoracic somites are margined with denticles; the dorsal surface is flattened, and on the last three somites the dorso-lateral corner is occupied by a group of denticles, not in a single row. The postero-lateral angles of the last somite are bifid. The abdominal somites carry a few denticles, of which the most conspicuous in side view are a dorso-lateral pair on each of the first two somites and on the fifth somite; the ventro-lateral edges are serrated in the fourth somite. The telson is about twice as long as the last somite; it has about ten pairs of slender lateral spines and a stronger apical pair.

The antennular peduncle is dilated distally, with a terminal brush of setæ.

The exopod of the uropods is two-thirds as long as the peduncle; the proximal segment of the endopod is much longer than the

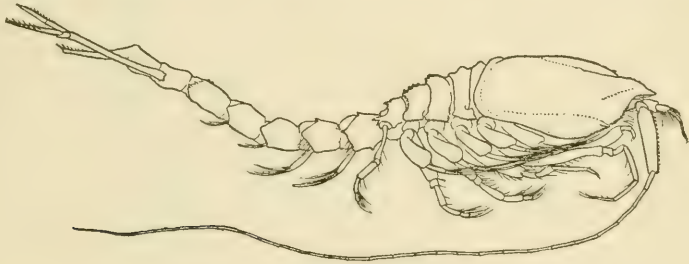


FIG. 75.—*DIASTYLIS ARGENTATA*, MALE, FROM THE SIDE.

distal; the spines on the inner edge of the endopod are long and feathered.

Remarks.—The male specimen described above resembles so closely *D. fimbriata* described by Sars from the South Atlantic (off Cape Frio) that I was at first disposed to identify it with that species. Since it differs, however, in possessing an antero-lateral tooth on the carapace and a row of spinules on the side of the pseudorostrum, as well as a bifid postero-lateral tooth on the last thoracic somite and a larger number of lateral spinules on the telson, it seems best, for the present, to record the Chilean examples under a new name.

Locality.—Albatross station 2787; off Chile; lat. $46^{\circ} 47' 30''$ S.; long. $75^{\circ} 15' 00''$ W.; 61 fathoms; bottom temperature, 53.9° F.; U.S.N.M. 44028, 44029; many, male and female (including holotype, 44029).

DIASTYLIS RATHKII (Krøyer).

- Cuma rathkii* KRØYER, Naturh. Tidsskr., vol. 3, 1841, p. 513, pls. 5, 6, figs. 17-30.
Diastylis rathkii S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 107 (with synonymy).—G. O. SARS, Crust. Norway, vol. 3, 1900, pp. 44 and 107, pls. 33, 34, 70-72.—ZIMMER, Die arktischen Cumaceen, in Römer u. Schaudinn, Fauna Arctica, vol. 1, Lief. 3, 1900, p. 423.
Diastylis rathkii, var. MURDOCH, Rep. Int. Polar Exp. Pt. Barrow, Alaska, 1885, p. 142.
Diastylis rathkii, var. *glabra* ZIMMER, Die arktischen Cumaceen, in Römer u. Schaudinn, Fauna Arctica, vol. 1, Lief. 3, 1900, p. 424.
Diastylis rathkii, var. *sarsi* NORMAN, Ann. Mag. Nat. Hist., ser. 7, vol. 10, 1902, p. 478.

A lengthy, though not exhaustive, list of references to literature is given by Zimmer.¹

The specimens which I refer to this species show a considerable range of variation, especially as regards the spinulation of the carapace, but there is no evident discontinuity to justify the separation of named varieties. It would be possible to select a series of specimens leading by small gradations from the perfectly smooth forms (var. *glabra* Zimmer) to some that are even more spinous than that figured by Sars² and named var. *sarsi* by Norman. Spiny and smooth individuals sometimes occur in the same gathering, and it is perhaps worthy of note that immature males generally, perhaps always, have the dorsal spinules conspicuously developed even when they accompany females of the smooth type. As only a very small number of adult males are in the collection I am not able to say whether noteworthy variations occur in this sex. The specimens examined do not differ perceptibly from that described by Sars and attributed to the var. *sarsi* of Norman.

This species has not hitherto been recorded from the North Pacific, although Stuxberg traced it along the northern coasts of Asia as far as the East Cape, and Murdoch has recorded specimens of the smooth type from Point Franklin on the east side of Bering Strait. The present collection contains specimens from various localities on the coast of Alaska and the Aleutian Islands and as far south as Sitka. On the Atlantic coast of North America the species does not appear to have been recorded south of Halifax, Nova Scotia. The list of localities given below carries it as far south as latitude 41° 11' N. at a depth of 499 fathoms. The species is known from a depth of 649 fathoms (Norwegian North Atlantic Expedition).

Localities.—Godhavn, Greenland; Ensign C. S. McClain, June, 1884; U.S.N.M. 13774; 1 female.

Off Battle Harbor, Labrador; 50 fathoms; Owen Bryant, September, 1908; U.S.N.M. 44086; 1 female.

¹ Fauna Arctica, vol. 1, p. 424.

² Crust. Norway, vol. 3, pls. 70-72.

- Nain, Labrador; 7 fathoms; Owen Bryant, August, 1908; U.S.N.M. 44084; 2 females.
- Port Manvers, Labrador; 30 fathoms; Owen Bryant, August, 1908; U.S.N.M. 44085; 1 male.
- Halfway from Cape Mugford to Hebron, Labrador; 60 fathoms; Owen Bryant, August, 1908; U.S.N.M. 44087; 1 female.
- Labrador; Owen Bryant, 1908; U.S.N.M. 44083; 1 female.
- U. S. F. C. station 101 (1877); off Halifax, Nova Scotia; 42 fathoms; U.S.N.M. 37834; 2 females.
- Albatross* station 2458; lat. $46^{\circ} 48' 30''$ N.; long. $52^{\circ} 34' 00''$ W.; 89 fathoms; bottom temperature, 29.5° F.; U.S.N.M. 38209; 1 female.
- Albatross* station 2466; lat. $45^{\circ} 29' 00''$ N.; long. $55^{\circ} 24' 00''$ W.; 67 fathoms; bottom temperature, 30° F.; U.S.N.M. 44074; 1 female.
- Albatross* station 2497; lat. $45^{\circ} 04' 00''$ N.; long. $59^{\circ} 36' 45''$ W.; 57 fathoms; bottom temperature 33° F.; U.S.N.M. 10504, 10910, 35053, 38261; many, male and female.
- Albatross* station 2078; lat. $41^{\circ} 11' 30''$ N.; long. $66^{\circ} 12' 20''$ W.; 499 fathoms; bottom temperature, 40° F.; U.S.N.M. 36918; 2 females.
- Near Point Belcher, Alaska; 9 fathoms; W. H. Dall; U.S.N.M. 44076; 1 male and 1 female.
- Cape Lisburne, Alaska, 5-7 fathoms; W. H. Dall, 1880; U.S.N.M. 13380; 2 males.
- Between Icy Cape and Cape Lisburne, Alaska; 15-20 fathoms; W. H. Dall; U.S.N.M. 14285; 6, male and female.
- Between Icy Cape and Cape Lisburne, Alaska; 10-15 fathoms; W. H. Dall; U.S.N.M. 14286; 8, male and female.
- Lat. $70^{\circ} 15' 10''$ N.; long. $162^{\circ} 55' 00''$ W.; 16 fathoms; U. S. R. S. *Corwin*, Capt. M. A. Healy, August, 1884; U.S.N.M. 14235; a large quantity, male and female (some adult males).
- Off Cape Sabine; 13 fathoms; W. H. Dall; U.S.N.M. 13381; 1 female.
- Lat. $63^{\circ} 37'$ N.; long. $165^{\circ} 19'$ W.; 12 fathoms; Lieut. G. M. Stoney, U. S. Navy, 1884; U.S.N.M. 13642; 11, male and female.
- Cape Etolin, Nunivak Island; W. H. Dall, 1874; U.S.N.M. 13375; 1 female.
- Nazan Bay, Atka Island; 10-16 fathoms; W. H. Dall, 1873; U.S.N.M. 13366, 13367; many, male and female (some adult males).
- Kiska Harbor, Aleutian Islands; 10 fathoms; W. H. Dall; U.S.N.M. 14273; 1 female.
- Chichagof Harbor, Attu Island; 5-7 fathoms; W. H. Dall; U.S.N.M. 44078; 17 females and 1 adult male.
- Sitka Harbor; 15 fathoms; W. H. Dall; U.S.N.M. 44081; 1 female.
- Alaska; W. H. Dall; U.S.N.M. 44082; 1 male.

DIASTYLIS SULCATA, new species.

Female (with developing oöstegites).—Total length, 13 mm.

Carapace elongated and slender, its height a little less, and its transverse width a little more, than one-half of its length. The dorsal edge, as seen from the side, is only very slightly arched. A transverse ridge crosses the dorsal surface just behind the ocular lobe, where it is very prominent and bears about six strong teeth; passing downward and slightly backward on each side, it is less strongly marked but becomes more prominent again as it curves sharply backward to run parallel to and a little distance above the lower edge of the carapace, from which it is separated by a deep groove; it dies out before reaching the hind margin of the carapace; along the lower part of its course it is obscurely dentated. The pseudorostrum is horizontal and acute; there is no distinct antennal notch, but the anterior part of the lower edge of the carapace is rather coarsely serrate. The ocular lobe is very small and there is no distinct eye.



FIG. 76.—DIASTYLIS SULCATA, IMMATURE FEMALE, FROM THE SIDE.

The free thoracic somites together are shorter than the carapace; the pleural plates of the second somite are narrowly rounded in front and overlap, but do not conceal those of the first; the lateral expansions of the third and fourth somites are more strongly produced backward than they are in *D. rathkii*, that of the third somite being about one-third as long as the carapace; the last thoracic somite is produced postero-laterally in a pair of stout spiniform teeth.

The abdomen, including the telson, is distinctly longer than the cephalothoracic region. The fifth somite is slightly longer than the sixth. The telson is longer by about one-third than the sixth somite, narrowing almost from the base, the post-anal portion twice as long as the pre-anal, with about nine pairs of short lateral spinules and a pair of short apical spinules.

The peduncle of the antennules has the first segment nearly three times as long as the second and twice as long as the third. The segments of the antenna are short.

The first legs have the basis nearly half as long again as the distal segments together; the last three segments are subequal. The sec-

ond legs have a conspicuous slender spine on the inner side of the ischium; the carpus is longer than the two distal segments together.

The posterior legs are very stout; the carpus of the third pair is as broad as the merus and only a little longer than broad; no exopods are present on the third and fourth pairs. The peduncle of the uropods, which does not quite reach the tip of the telson, has a row of small spines on its inner edge; the exopod is less than two-thirds, and the endopod about one-half, as long as the peduncle; of the three segments of the endopod the first is longer than the other two together; the spines on the inner edge are small.

The immature male resembles the female in general form.

Remarks.—This species is very closely allied to *D. rathkii*, but it appears to be sufficiently distinguished from that species by the more elongated form of the carapace and its less arched dorsal outline, and especially by the marked groove and ridge above the anterior part of its lower edge on each side.

The slender form of the cephalothorax and the backward projection of the third and fourth free thoracic somites, resulting in a gap being left between the second and third pairs of legs, give the species a certain resemblance in general form to *Diastylopsis dawsoni*. That this resemblance does not imply any close relationship between the two species, however, is shown by the absence in the present case of any antennal notch, by the large size of the last thoracic somite, the form of the antenna and third maxilliped, and by many other characters.

Locality.—Alaska, lat. 63° 37' N.; long. 165° 19' W.; 12 fathoms; G. M. Stoney, June, 1884; U.S.N.M. 44101–44103; 10, male and female (including holotype, 44103).

DIASTYLIS POLITA S. I. Smith.

Diastylis politus S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 108.

The specimens that I have examined agree in all essential details with Professor Smith's excellent and minute description. As no figures of the species have hitherto been published, I give outline figures of both sexes to illustrate the chief differences from *D. sculpta*. In the female these differences are as follows: The areas between the ridges on the carapace are much less deeply hollowed; there are only

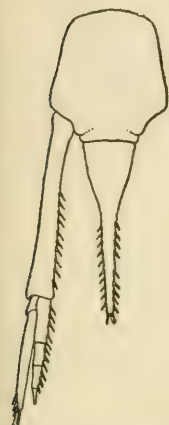


FIG. 78.—DIASTYLIS SULCATA, IMMATURE FEMALE, LAST SOMITE, TELSON, AND UROPOD.



FIG. 77.—DIASTYLIS SULCATA, IMMATURE FEMALE, ANTERIOR PART OF BODY FROM ABOVE.

three instead of four oblique lateral ridges, of which the third fails to unite below with the second, while the lateral ridge of the pseudo-rostrum does not extend back to the first; the first legs are distinctly shorter; the carpus of the second legs is more than twice as long as the merus; the postero-lateral angles of the last thoracic somite are strongly produced and spiniform. The male is distinguished from that of *D. sculpta* (as figured by Sars) by possessing a strong horizontal ridge on each side of the carapace, running forward from the



FIG. 79.—*DIASTYLIS POLITA*, FEMALE, FROM THE SIDE.

hind margin. Adult specimens of both sexes are considerably larger (male 14 mm., female 12 mm.) than those of *D. sculpta*.

The localities given for the species by Professor Smith extend from the Gulf of St. Lawrence to Vineyard Sound and from the surface to 190 fathoms.

Localities.—U. S. F. C. station 91 (1877); off Halifax, Nova Scotia; 6½ fathoms; bottom temperature, 49° F.; U.S.N.M. 38024; 1 female.

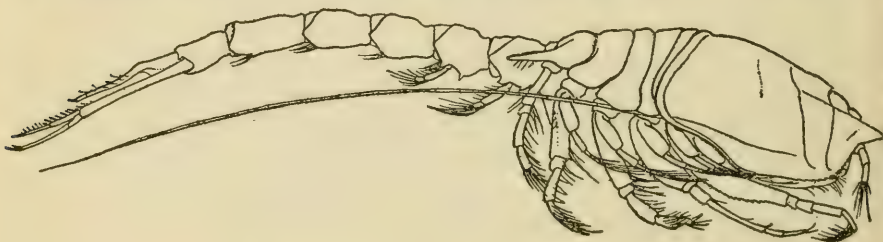


FIG. 80.—*DIASTYLIS POLITA*, MALE, FROM THE SIDE.

U. S. F. C. stations 72-73 (1877); Halifax Harbor, Nova Scotia; 18 fathoms; bottom temperature, 39.5°-41.5° F.; U.S.N.M. 44058; 1 female.

La Have Islands, Nova Scotia; 6 fathoms; in fine mud; Geol. Surv. of Canada, Aug. 7, 1910; U.S.N.M. 44062; 7 females.

U. S. F. C. station 141 (1878); Gloucester Harbor; 8½ fathoms; bottom temperature, 44.5° F.; U.S.N.M. 36647, 36648, 44061; many, male and female.

U. S. F. C. station 145 (1878); Gloucester Harbor; 8 fathoms; bottom temperature, 51° F.; U.S.N.M. 36640, 36643, 44155; many, male and female.

U. S. F. C. stations 141-146 (1878); Gloucester Harbor; 8-9 fathoms; bottom temperature, 44.5°-51° F.; U.S.N.M. 36362, 44059; many, male and female.

U. S. F. C. station 335; off Plymouth; 7 fathoms; bottom temperature, 55° F.; U.S.N.M. 34870; 4, male and female.

Woods Hole, Massachusetts; received April, 1877; U.S.N.M. 36644; 12 males.

Woods Hole; surface; February, 1888; U.S.N.M. 13100; 1 male.

Woods Hole; surface; V. N. Edwards, Bureau of Fisheries; U.S.N.M. Acc. No. 11929; 5, male and female.

U. S. F. C. stations 816-818; Narragansett Bay; 8½-10 fathoms; bottom temperature, 63°-66° F.; U.S.N.M. 44056, 44060; many, male and female.

U. S. F. C. station 1240; Block Island Sound; 18½ fathoms; bottom temperature, 60° F.; U.S.N.M. 12694; 4 males.

DIASTYLIS SCULPTA G. O. Sars.

Diastylis sculpta G. O. Sars, Oefvers. Kgl. Vet. Akad. Förh., vol. 28, 1871, p. 71; Kgl. Svenska Vet. Akad. Handl., vol. 9, No. 13, 1871, p. 24, pls. 1-9, figs. 1-49.—S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 111.

Although some specimens of this species have the areas between the ridges of the carapace less deeply hollowed than in the typical form as figured by Sars, there is no difficulty in distinguishing, almost at a glance, between this species and *D. polita*.

I have not identified any adult males among the material sent to me.

The known range of this species is from the Gulf of St. Lawrence to off Long Island and from the surface to 190 fathoms. The localities of the specimens that I have examined all fall within these limits.

Localities.—U. S. F. C. stations 72-73 (1877); off Halifax, Nova Scotia; 18 fathoms; bottom temperature, 39.5°-41.5° F.; U.S.N.M. 44157; 2 females.

U. S. F. C. station 87 (1877); off Halifax, Nova Scotia; 21 fathoms; bottom temperature, 48.3°-49° F.; U.S.N.M. 34877; 1 female.

Off Halifax, Nova Scotia; U. S. F. C.; U.S.N.M. 34322; 1 female.

U. S. F. C. station 70 (1877); about 120 miles south of Halifax, Nova Scotia; 190 fathoms; bottom temperature, 38.5°-39° F.; U.S.N.M. 37833; 1 female.

U. S. F. C. stations 133-134 (1878); Massachusetts Bay, 26-33 fathoms; U.S.N.M. 44090; 1 female.

Nahant, Massachusetts; S. D. Judd, 1893; U.S.N.M. 44094; 2 females.

U. S. F. C. station 292; mouth Cape Cod Bay; 29 fathoms; bottom temperature, 41° F.; U.S.N.M. 34863, 34865; 6 females.

U. S. F. C. station 247; off Cape Cod; 34 fathoms; U.S.N.M. 38022; 1 female.

U. S. F. C. stations 987-989; off Marthas Vineyard; 28-30 fathoms; bottom temperature, 49°-49.5° F.; U.S.N.M. 44092, 44093; 9 females.

U. S. F. C. station 1025; off Marthas Vineyard; 216 fathoms; bottom temperature, 45° F.; U.S.N.M. 34313; 1 female.

Woods Hole; surface; V. N. Edwards, Bureau of Fisheries; U.S.N.M. Acc. No. 11929; 1 female.

U. S. F. C. station 811; off Newport, R. I.; 19½ fathoms; bottom temperature, 53° F.; U.S.N.M. 44091; 3 females.

U. S. F. C. station 1240; Block Island Sound; 18½ fathoms; bottom temperature, 60° F.; U.S.N.M. 44137; many, female and young.

DIASTYLIS QUADRISPINOSA G. O. Sars.

? *Cuma bispinosa* STIMPSON, Mar. Invert. Grand Manan, Smiths. Contr., vol. 6, Art. 5, 1853, p. 39.

Diastylis quadrispinosa G. O. Sars, Oefvers. Kgl. Vet. Akad. Förh., vol. 28, 1871, p. 72; Kgl. Svenska Vet. Akad. Handl., vol. 9, 1871, No. 13, p. 28, pls. 10, 11, figs. 50-61.—S. I. SMITH, Rep. U. S. Comm. Fisheries, pt. 1, 1873, p. 554, pl. 3, fig. 13; Trans. Conn. Acad., vol. 5, 1879, p. 112.

Prof. S. I. Smith, while regarding this as the species indicated rather than described by Stimpson under the name *Cuma bispinosa*, preferred to retain the name given to it by G. O. Sars, and I can perceive no advantage to be gained by departing from this precedent.

A single adult male which I believe to belong to this species is in the collection from Massachusetts Bay. Unfortunately it is much damaged and I am unable therefore to give a satisfactory figure of the entire animal. It resembles in general form the male of *D. cornuta*¹ as figured by Sars, but the lateral longitudinal ridge of the carapace dies out anteriorly and there is no ridge joining it to the lower edge. On the dorsal surface are two pairs of low tubercles answering to the teeth of the female. The antero-lateral corners are less coarsely dentate than in *D. cornuta*. The postero-lateral angles of the last thoracic somite are more produced than in the female. The first abdominal somite has a pair of small dorso-lateral teeth (sometimes visible also in the female) on its very concave hinder border. The third, fourth, and fifth abdominal somites have a median dorsal ridge, obscurely serrated, the same somites have also a pair of dorso-lateral ridges which end behind in small spines, most conspicuous in the case of the fifth somite. The telson is of the usual form, a little longer than the uropod peduncles, and with at least twelve pairs of long slender spinules. The peduncle of the uropods has spinules only on the distal half of its inner edge.

¹ I take this opportunity of noting that the specimens which I recently referred to *D. capreensis* (Bull. Mus. Hist. Nat. Paris, 1910, p. 181) seem to be only a form of *D. cornuta* Böeck. I have now examined specimens which are intermediate in many points (e. g., in having the large antero-lateral spines bifurcate) between these and the typical *D. cornuta*. In all probability, the type-specimens of *D. capreensis* (Mith. Zool. Stat. Neapel, vol. 17, 1906, p. 429), should also be referred to *D. cornuta*.

The range of this species as hitherto known extended from the Gulf of St. Lawrence to New Jersey (lat. $39^{\circ} 54' 00''$ N.). The list of localities given below extends the southern limit to latitude $35^{\circ} 42' 00''$ N., near Cape Hatteras. The known range in depth is from 2 to 190 fathoms, but I learn that there are specimens in the United States National Museum from *Albatross* station 2484 at a depth of 204 fathoms.

Localities.—*Albatross* station 2497; off Nova Scotia, lat. $45^{\circ} 04' 00''$ N.; long. $59^{\circ} 36' 45''$ W.; 57 fathoms; bottom temperature, 33° F.; U.S.N.M. 44063; 1 female.

U. S. F. C. stations 72–73 (1877); Halifax Harbor, Nova Scotia; 18 fathoms; bottom temperature, 39.5° – 41.5° F.; U.S.N.M. 34881; 1 male.

U. S. F. C. station 87 (1877); Halifax Harbor, Nova Scotia; 21 fathoms; bottom temperature, 48.3° – 49° F.; U.S.N.M. 34321, 34882, 37832; 6, male and female.

U. S. F. C. station 101 (1877); off Halifax, Nova Scotia; 42 fathoms; U.S.N.M. 34883; 1 female.

Off Nova Scotia; U. S. F. C., 1877; U.S.N.M. 37837; 1 female.

Seal Cove, Grand Manan; 8–10 fathoms; U. S. F. C., 1872; U.S.N.M. 36637; many, male and female.

U. S. F. C. station 160 (1878); Gulf of Maine; 54 fathoms; bottom temperature, 39.5° F.; U.S.N.M. 44073; 1 female.

U. S. F. C. station 166 (1878); Gulf of Maine; 35 fathoms; bottom temperature, 41.5° F.; U.S.N.M. 36357, 36358; many, male and female.

U. S. F. C. station 134 (1878); Massachusetts Bay; 26 fathoms; U.S.N.M. 34939; 1 female.

U. S. F. C. stations 133–134 (1878); Massachusetts Bay; 26–33 fathoms; U.S.N.M. 36360; 7 females.

U. S. F. C. stations 135–136 (1878); Massachusetts Bay; 25–26 fathoms; bottom temperature, 40° – 40.5° F.; U.S.N.M. 36364; 5 females.

U. S. F. C. station 206; Massachusetts Bay; 42 fathoms; U.S.N.M. 38023; 4, male and female.

U. S. F. C. station 215; Massachusetts Bay; 35 fathoms; bottom temperature, 50.5° F.; U.S.N.M. 36361; 1 male (adult).

U. S. F. C. station 222; Massachusetts Bay; 40 fathoms; U.S.N.M. 36359; 1 female.

Nahant, Massachusetts; S. D. Judd, 1893; U.S.N.M. 44065; 6, male and female.

U. S. F. C. station 283; off Cape Cod (Massachusetts Bay); 31 fathoms; bottom temperature, 38.5° F.; U.S.N.M. 34866; 11 females.

U. S. F. C. station 322; off Cape Cod; 67 fathoms; bottom temperature, 40.5° F.; U.S.N.M. 34320, 34876; 2 females.

U. S. F. C. station 321; Cape Cod Bay; $29\frac{1}{2}$ fathoms; bottom temperature, 44.5° F.; U.S.N.M. 34868; 2 females.

U. S. F. C. station 337; Cape Cod Bay; 16 fathoms; bottom temperature, 47.2° F.; U.S.N.M. 34861; many females.

U. S. F. C. station 784; off Newport, Rhode Island; 20 fathoms; bottom temperature, 53.5° F.; U.S.N.M. 34323, 34326; 9 females.

U. S. F. C. station 786; off Newport, Rhode Island; 19 fathoms; bottom temperature, 53.5° F.; U.S.N.M. 44066; 1 female.

U. S. F. C. station 788; off Newport, Rhode Island; 18 fathoms; bottom temperature, 54° F.; U.S.N.M. 44067; 3, male and female.

U. S. F. C. station 793; off Newport, Rhode Island; 19 fathoms; U.S.N.M. 34329; 7, male and female.

U. S. F. C. station 795; off Newport, Rhode Island; 19 fathoms; bottom temperature, 63° F.; U.S.N.M. 34295, 34324; about 17, male and female.

U. S. F. C. station 811; off Newport, Rhode Island; $19\frac{1}{2}$ fathoms; bottom temperature, 53° F.; U.S.N.M. 36299, 36363; many, male and female.

U. S. F. C. station 812; off Block Island; $28\frac{1}{2}$ fathoms; bottom temperature, 46° F.; U.S.N.M. 44069; 1 female.

U. S. F. C. station 860; Vineyard Sound; $17\frac{1}{2}$ fathoms; bottom temperature, 64° F.; U.S.N.M. 34299; 1 male, 1 female.

U. S. F. C. station 863; Vineyard Sound; 18 fathoms; bottom temperature, 65° F.; U.S.N.M. 34327; 1 male, 1 female.

U. S. F. C. station 871; off Marthas Vineyard; 115 fathoms; bottom temperature, 49° F.; U.S.N.M. 34314; 1 female.

U. S. F. C. station 873; off Marthas Vineyard; 100 fathoms; bottom temperature, 51° F.; U.S.N.M. 34319; 1 male.

U. S. F. C. station 878; off Marthas Vineyard; $142\frac{1}{2}$ fathoms; bottom temperature, 52° F.; U.S.N.M. 34312; 1 male.

U. S. F. C. station 987; off Marthas Vineyard; 28 fathoms; bottom temperature, 49° F.; U.S.N.M. 44070; 6, male and female.

U. S. F. C. stations 987-989; off Marthas Vineyard; 28-30 fathoms; bottom temperatures 49° - 49.5° F.; U.S.N.M. 44071; 6 females.

U. S. F. C. station 992; off Marthas Vineyard; 36 fathoms; bottom temperature, 48° F.; U.S.N.M. 44064; 1 female.

U. S. F. C. station 993; off Marthas Vineyard; 39 fathoms; bottom temperature, 46.5° F.; U.S.N.M. 44072; 1 female.

U. S. F. C. station 2746; lat. $38^{\circ} 46' 00''$ N.; long. $73^{\circ} 5' 45''$ W.; 102 fathoms; bottom temperature, 51.2° F.; U.S.N.M. 33914; 1 male, 1 female.

Albatross station 2307; near Cape Hatteras, lat. $35^{\circ} 42' 00''$ N.; long. $74^{\circ} 54' 30''$ W.; 43 fathoms; bottom temperature, 57.3 F.; U.S.N.M. 34298; 6 females.

DIASTYLIS STYGIA G. O. Sars.

Diastylis stygia G. O. Sars, Oefvers. Kgl. Vet. Akad. Förh., vol. 28, 1871, p. 798; Kgl. Svenska Vet. Akad. Handl., vol. 11, 1873, No. 6., p. 6, pl. 2, figs. 4-7; Rep. Cumacea *Challenger*, 1886, p. 44, pls. 6-8.

This characteristically deep-water species has not hitherto been recorded from a less depth than 620 fathoms,¹ and I am inclined to suspect an error in the label which attributes one of the specimens in the present collection to U. S. F. C. station 1038, at which the depth was only 146 fathoms. The species is known to descend to 2,600 fathoms.

Localities.—*Albatross* station 2706; lat. 41° 28' 30'' N.; long. 65° 35' 30'' W.; 1,188 fathoms; U.S.N.M. 11900; 1 female.

Albatross station 2575; lat. 41° 07' 00'' N.; long. 65° 26' 30'' W.; 1,710 fathoms; bottom temperature, 37.1° F.; U.S.N.M. 11013; 8, male and female.

Albatross station 2573; lat. 40° 34' 18'' N.; long. 66° 09' 00'' W.; 1,742 fathoms; bottom temperature, 37.3° F.; U.S.N.M. 11006; many, male and female.

Albatross station 2572; lat. 40° 29' 00'' N.; long. 66° 04' 00'' W.; 1,769 fathoms; bottom temperature, 37.8° F.; U.S.N.M. 10998, 38206; many, male and female.

Albatross station 2535; lat. 40° 03' 30'' N.; long. 67° 27' 15'' W.; 1,149 fathoms; bottom temperature, 37.8° F.; U.S.N.M. 38208, 44096; 3 females.

Albatross station 2534; lat. 40° 01' 00'' N.; long. 67° 29' 15'' W.; 1,234 fathoms; bottom temperature, 37.8° F.; U.S.N.M. 10890; 3 females.

U. S. F. C. station 1038(?); lat. 39° 58' 00'' N.; long. 70° 06' 00'' W.; 146 fathoms; bottom temperature, 47° F.; U.S.N.M. 44095; 1 female.

Albatross station 2570; lat. 39° 54' 00'' N.; long. 67° 05' 30'' W.; 1,813 fathoms; bottom temperature, 36.8° F.; U.S.N.M. 10892, 11009; many, male and female.

Albatross station 2043; lat. 39° 49' 00'' N.; long. 68° 28' 30'' W.; 1,467 fathoms; bottom temperature, 38.5° F.; U.S.N.M. 44097; 1 female.

Albatross station 2221; lat. 39° 05' 30'' N.; long. 70° 44' 30'' W.; 1,525 fathoms; bottom temperature, 36.9° F.; U.S.N.M. 8506, 34302, 34303, 44098, 44099; many, male and female.

Albatross station 2711; lat. 38° 59' 00'' N.; long. 70° 07' 00'' W.; 1,544 fathoms; U.S.N.M. 11983; 4 females.

Albatross station 2228; lat. 37° 25' 00'' N.; long. 73° 06' 00'' W.; 1,582 fathoms; bottom temperature, 36.8° F.; U.S.N.M. 44100; 1 male, 1 female.

¹ Sars, Norweg. N. Atl. Exped. Crustacea, vol. 2, 1886, p. 22.

DIASTYLIS LUCIFERA (Krøyer).

Cuma lucifera KRØYER, Naturh. Tidsskr., vol. 3, 1841, p. 527, pl. 6, figs. 34-35.

Diastylis luciferus S. I. SMITH, Trans. Conn. Acad., vol. 5, 1879, p. 112.

Diastylis lucifera G. O. SARS, Crust. Norway, vol. 3, 1900, p. 48, pl. 37.

Localities.—*Albatross* station 2697; off Newfoundland; 206 fathoms; U.S.N.M. 44053; 3, male and female.

U. S. F. C. station 160 (1878); Gulf of Maine; 54 fathoms; bottom temperature, 39.5° F.; U.S.N.M. 34292; 2 females.

DIASTYLIS GOODSIRI (Bell).

Alauna goodsiri BELL, in Belcher, Last of the Arctic Voyages, vol. 2, 1855, p. 403, pl. 24, figs. 2-2n.

Diastylis goodsiri G. O. SARS, Crust. Norway, vol. 3, 1900, p. 54, pl. 41.

This fine species has been recorded from West Greenland (lat. 65° 35' N.) by Hansen. It had previously been recorded from the Labrador coast by Packard, but the specimens appear to have been wrongly identified.¹ The localities given below extend its range far to the southward.

Localities.—*Albatross* station 2697; lat. 47° 40' 00'' N.; long. 47° 35' 30'' W.; 206 fathoms; U.S.N.M. 11785, 44050; 7, male and female.

Albatross station 2488; lat. 44° 35' 00'' N.; long. 57° 13' 30'' W.; 150 fathoms; U.S.N.M. 10501; 1 male.

Albatross station 2471; lat. 44° 34' 00'' N.; long. 56° 41' 45'' W.; 218 fathoms; bottom temperature, 40.4° F.; U.S.N.M. 10500; 1 male.

Albatross station 2511; lat. 44° 05' 30'' N.; long. 63° 31' 30'' W.; 84 fathoms; bottom temperature, 41.6° F.; U.S.N.M. 10502; 2 females.

Twenty miles ESE. of Cape Sable, Nova Scotia; 70 fathoms; Owen Bryant; October, 1908; U.S.N.M. 44051; 2 females.

DIASTYLOPSIS DAWSONI S. I. SMITH.

Diastylopsis dawsoni S. I. SMITH, Geol. Survey Canada, Report 1878-79 (1880), p. 215B.

Female (with developing oöstegites).—Total length, 14.5 mm. (An ovigerous female measured only about 12.5 mm. in length.)

Carapace elongated and slender, its height a little less than, and its transverse width about equal to, one-half of its length. In its anterior part it is encircled by four very fine transverse lines which converge as they approach the lower margin. In the second and third of these lines the dorsal portion crossing the frontal lobe is separated from the lateral portion which ends in front of it on the frontal suture; it appears as though this dislocation were due to the forward growth of the lateral plates of the carapace, carrying with it the lateral portions of the lines. The pseudorostrum is horizontal and acute; there is a deep, rounded, antennal notch defined by a

¹ See Smith, Trans. Conn. Acad., vol. 5 p. 107.

prominent acute antero-lateral tooth, behind which the lower edge of the carapace is finely serrated. The ocular lobe is very small and there is no distinct eye.

The free thoracic somites together are about equal in length to the carapace. The pleural plates of the second somite are rounded in

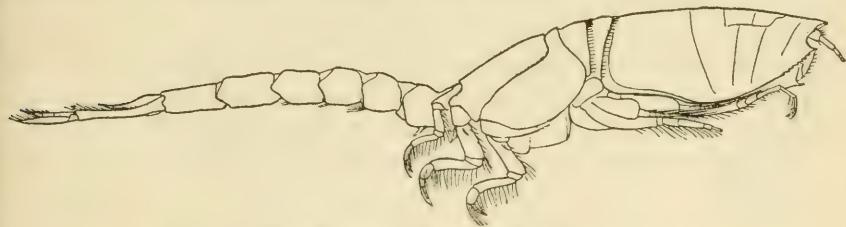
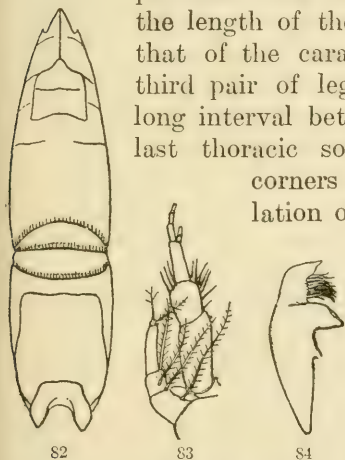


FIG. 81.—*DIASTYLOPSIS DAWSONI*, IMMATURE FEMALE, FROM THE SIDE.

front, defined above by a narrow notch, and completely conceal those of the first somite. The third and fourth somites are more firmly connected together than they are with the adjacent somites, but the line of junction is strongly marked. The third somite is very short in the middorsal line, but its pleural expansions are strongly produced backward to embrace the long fourth somite; the length of these lateral expansions is about one-half that of the carapace. The point of attachment of the third pair of legs is thus carried backward, leaving a long interval between them and the second pair. The last thoracic somite is small and its postero-lateral corners are not produced beyond the articulation of the fifth legs.



FIGS. 82-84.—*DIASTYLOPSIS DAWSONI*, IMMATURE FEMALE. 82, ANTERIOR PART OF BODY FROM ABOVE; 83, ANTENNULE AND ANTENNA; 84, MANDIBLE.

The last thoracic somite bears a pair of stout curved teeth on the sternal surface and the first abdominal a single tooth. The abdomen, including the telson, is shorter than the cephalothoracic region. The fifth somite is not longer than the sixth. The telson is about three-fourths as long as the sixth somite, swollen in its basal part. There are about four pairs of slender setiform lateral spines, and the terminal pair, though stouter, are still unusually

long and slender, being about one-third as long as the telson.

The first segment of the peduncle of the antennules is nearly as long as the second and third together; the third is about half the diameter of the second and longer than it. The shorter flagellum is about equal to the first segment of the longer and is apparently composed of only two segments. The antenna has four segments, the penultimate elongated (about four times as long as wide) and

the terminal one very minute. The mandible has both the molar and the incisor processes unusually short and stout. The maxillula and maxilla are of normal form; the palp of the former carries two setæ.

The third maxillipeds have the basis expanded distally, where its width is nearly one-fourth of its length along the inner edge; its inner distal angle is produced into a strong, acute tooth; the ischium is very wide and is produced externally into a stout tooth; the merus is not more than one-third of the width of the ischium; the terminal segments are very slender and in the specimens dissected they are doubled back behind (i. e., on the inner or upper surface of) the basis.

The first legs are unusually short, hardly extending beyond the antero-lateral angle of the carapace; the distal segments together



FIGS. 85-87.—*DIASTYLOPSIS DAWSONI*, IMMATURE FEMALE. 85, THIRD MAXILLIPED; 86, FIRST LEG; 87, SECOND LEG.

are about two-thirds as long as the basis; the last three segments successively diminish in length.

The second legs have the carpus nearly twice as long as the two distal segments together.

The third and fourth pairs of legs have each a very minute vestige of an exopod, apparently unsegmented.

The peduncle of the uropods extends for nearly half its length beyond the telson. It has a closely set series of slender spines along its inner edge; the exopod is more, and the endopod less, than half the length of the peduncle; of the three segments of the endopod the first occupies about half of its length and the third is much longer than the second; the marginal spines of both rami are slender.

Male.—Total length, about 9 mm.

In general form the carapace resembles that of the female and it is similarly marked with four transverse lines; there is, however, no antennal notch, the antero-lateral margin sloping backwards from the lower edge of the pseudorostrum with hardly an indication of

the antero-lateral tooth; the anterior part of the lower margin is finely serrated. The ocular lobe is slightly swollen, but there is no pigment and the visual elements are not distinctly visible.

The free thoracic somites together are about two-thirds as long as the carapace. The pleural plates of the second somite are concealed beneath those of the third. The pleural plates of the third and fourth somites are not so strongly produced backwards as in the female and the length of both together is just about one-half that of the carapace. There is no marked interval between the second and third pairs of legs.

The last thoracic somite probably bears a pair of short curved sternal teeth as in the female, but only one remains in the specimen examined. The first abdominal somite has a single large curved sternal tooth anteriorly and the first and second have each a lateral tooth external to the attachment of the pleopods. The telson is about as long as the last somite and dorsally humped. There are some nine pairs of setiform lateral spines.

The third segment of the peduncle of the antennule is nearly as stout as the preceding and bears a terminal brush of fine hairs. The flagella are much longer than in the female, the major flagellum having four or five segments.

The flagellum of the antenna extends to the tip of the uropods.

The legs appear not to differ greatly from those of the female except in the presence of exopods on all except the last pair. The ischium of the penultimate pair has a conspicuous tooth posteriorly.

The uropods resemble those of the female, but the spines on the inner edge of the endopod and peduncle are more numerous and pectinated.

Remarks.—Of this species, the genotype of the genus *Diastylopsis*, no figures have hitherto been published. The specimens examined agree so well with Smith's description, however, that there can be no doubt of their specific identity. Of the other species referred to the genus, *D. thileniusi* Zimmer¹ apparently comes nearest to the type, but is distinguished from it,

among many other characters, by the remarkable structure of the third maxillipeds, on which I have already commented.² A closely similar modification of the third maxillipeds is found in Mr. Stebbing's genus *Dic*.³

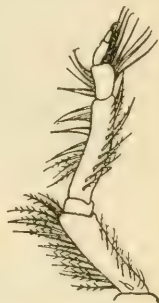


FIG. 88.—DIASTYLOPSIS DAWSONI, IMMATURE FEMALE, THIRD LEG.



FIG. 89.—DIASTYLOPSIS DAWSONI, IMMATURE FEMALE, LAST SOMITE, TELSON, AND UROPOD.

¹ Zool. Jahrb. Syst., vol. 17, 1902, p. 449, text figs.

² Ann. Mag. Nat. Hist., ser. 8, vol. 1, 1908, p. 239.

³ Ann. S. Afr. Mus., vol. 6, 1910, p. 415, pl. 47.

Localities.—Chignik Bay; 7–18 fathoms; sand; W. H. Dall; U.S.N.M. 43092; 10 females.

Albatross station 2884; off Oregon, lat. $45^{\circ} 55' N.$; long. $124^{\circ} 2' W.$; 29 fathoms; bottom temperature, $50.2^{\circ} F.$; U.S.N.M. 43091; 2 females.

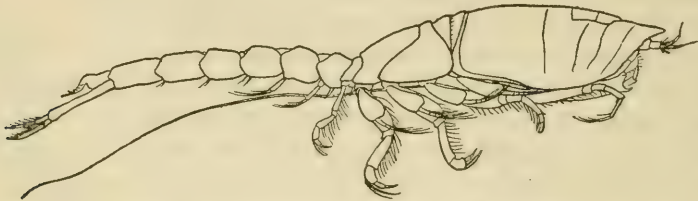


FIG. 90.—*DIASTYLOPSIS DAWSONI*, MALE, FROM THE SIDE.

Albatross station 4442; Monterey Bay, California; 26–31 fathoms; U.S.N.M. 43093; 4, male and female.

Albatross station 4564; Monterey Bay, California; 9–10 fathoms; U.S.N.M. 43094; 1 female.

DIASTYLOPSIS (?) RESIMA (Krøyer).

Cuma resima KRØYER, Naturh. Tidsskr., ser. 2, vol. 2, 1846, p. 165, pl. 2, figs. 2a–b.

Diastylopsis resima G. O. SARS, Crust. Norway, vol. 3, 1900, p. 65, pl. 47.

Sars quotes Verrill as authority for the occurrence of this species on the Atlantic coast of North America, but I have not been able to find the record to which he refers. The species occurs on the coast of South Greenland (Krøyer). As Zimmer points out,¹ the relationship of this species to *Diastylopsis dawsoni* is by no means close, and it is doubtful whether the definition of the genus can be stretched to include it along with some of the other species that have been regarded as congeneric.

Locality.—*Albatross station* 2497; off Nova Scotia, lat. $45^{\circ} 04' 00'' N.$; long. $59^{\circ} 36' 45'' W.$; 57 fathoms; bottom temperature, $33^{\circ} F.$; U.S.N.M. 44057; 6 females.

OXYUROSTYLIS, new genus.

Resembling *Diastylis* in general characters, but with the telson tapering to an acute point and without apical spines. The carapace is not elongated and has no antennal notch. The lateral portions of the third and fourth free thoracic somites are not greatly produced backwards and there is no interval between the second and third pairs of legs. The antennule has a brush of hairs in the male. The penultimate segment of the antenna is enlarged in the female. The third maxilliped has an exopod in both sexes. The third and fourth pairs of legs have exopods, vestigial in the female but well developed in the male. The male has two pairs of biramous pleopods.

¹ Cumaceen, Deutsch. Tiefsee Exped., 1908, p. 184.

Except for one character it would, I believe, be impossible to exclude the species described below from the genus *Diastylis*. That character, the structure of the apex of the telson, is, however, one that infringes the current definition of the family Diastylidæ, and on this account it seems advisable to distinguish the species by a generic name from the assemblage of unclassified Diastylidæ that form the genus *Diastylis*.

It is to be noted that the simply pointed apex of the telson shows no trace of the coalescence of a median apical spine like that of *Pseudodiastylis*. From that genus the present species differs widely in most of its characters.

Type-species.—*Oxyurostylis smithi*, new species.

OXYUROSTYLIS SMITHI, new species.

Immature female.—Total length, 6.6 mm.

Carapace rather less than one-third of total length, its depth less, and its width slightly more than two-thirds of its length. The dorsal edge, as seen from the side, is arched posteriorly, sloping in

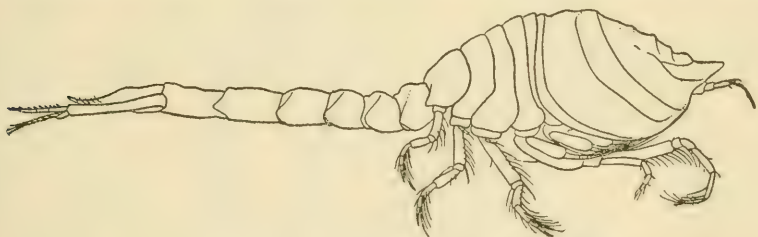


FIG. 91.—OXYUROSTYLIS SMITHI, IMMATURE FEMALE, FROM THE SIDE.

front to the short horizontal pseudorostrum. There is no antennal notch and the antero-lateral angle is hardly indicated. On each side of the carapace are two parallel oblique ridges uniting with each other on the lower edge while their upper ends are connected by a short longitudinal ridge forming one side of the depressed "cardiac" area; in front of these is a short sinuous ridge passing forward on to the side of the pseudorostrum; on the dorsal surface, the frontal lobe is crossed by two prominent transverse ridges and two others, much fainter, behind these. The ocular lobe is broader than long and about half as long as the line of junction of the lateral plates of the pseudorostrum; there is no ocular pigment and the visual elements are indistinct.

All the leg-bearing somites are distinct; the postero-lateral corners of the last thoracic somite are very slightly produced and bluntly pointed.

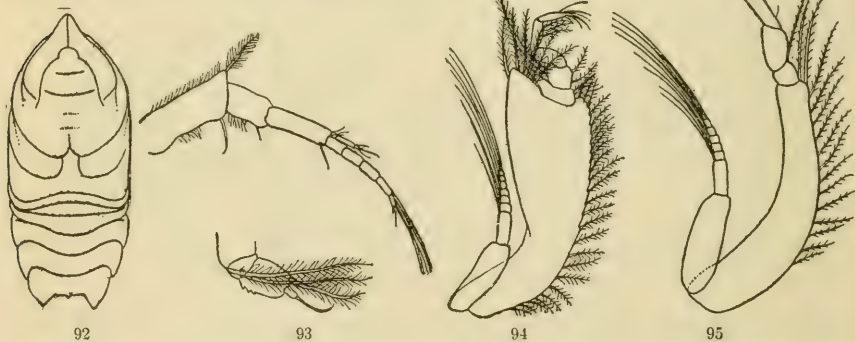
The abdomen, including the telson, is longer by about one-sixth than the cephalothoracic region and the last somite is a little shorter than the preceding. The telson is about one and one-half times

as long as the last somite, inflated at the base but very slender distally, the post-anal part about four-sevenths of its length. There are about six pairs of rather long and slender lateral spines and no apical spines at all; the telson tapers evenly from the post-anal constriction to an acute and upturned point which extends well beyond the last pair of lateral spines.

The antennules have the first segment of the peduncle nearly as long as the second and third together, the second about two-thirds as long as the third. The outer flagellum is composed of five segments and the inner of three; the latter extends beyond the middle of the second segment of the former.

The penultimate segment of the antenna is expanded and flattened, with one or two teeth on the margin; the terminal segment is of moderate size.

The mouth-parts from the mandibles to the second maxillipeds appear to present no conspicuous divergences from the normal type of the *Diastylidæ*. The third maxillipeds have



FIGS. 92-95.—*OXYUROSTYLIS SMITHI*, IMMATURE FEMALE. 92, ANTERIOR PART OF BODY FROM ABOVE; 93, ANTENNULE AND ANTENNA; 94, THIRD MAXILLIPED; 95, FIRST LEG.

the basis much expanded distally, its greatest width being nearly one-third of its length along the inner edge; it is produced at the distal outer corner into a bluntly pointed lobe. The ischium is produced externally into a long pointed process. The merus is narrow. There is a well developed exopod.

The basis of the first leg, measured along its inner edge, is about as long as the distal segments together. The carpus and propodus are subequal and longer than the dactylus. The basis of the second legs is about as long as the distal segments together; the carpus is a trifle longer than the propodus and dactylus together.

The posterior pairs of legs are stout. The third and fourth have each a minute exopod of two segments placed unusually near the proximal end of the basis and therefore very easily overlooked.

The peduncle of the uropods falls a little short of the tip of the telson and has about ten strong spines on its inner edge. The rami are subequal, and, excluding the terminal spines, about two-thirds as long as the peduncle. The endopod has three segments, of which the first is distinctly, and the third slightly, longer than the second; there are about eight spines on the inner edge and a stout terminal spine. The exopod has a few slender spines on its outer edge.

Male.—Total length, 7.3 mm.

Carapace less than one-third of total length, its depth distinctly less than two-thirds of its length,



FIG. 97.—*OXYUROSTYLIS SMITHI*, IMMATURE FEMALE; *a*, LAST SOMITE, TELSON, AND UROPOD FROM ABOVE; *b*, APEX OF TELSON FROM THE SIDE, FURTHER ENLARGED.

the dorsal outline less arched than in the female. The ridges of the carapace are arranged as in the female, but there are only two transverse ridges on the frontal lobe and there is a horizontal ridge a little above the lower margin between the hinder edge and the posterior oblique ridge.

The postero-lateral angles of the last thoracic somite are strongly produced and acute. The telson is twice as long as the last somite, with about seven pairs of lateral spines. It is dorsally "humped" in the usual way and the structure of the apex is as in the female.

The antennules have the third segment of the peduncle about as wide as

the first, with a terminal brush of fine setæ. The convex area bearing the setæ is, however, distinctly defined from the body of



FIG. 96.—*OXYUROSTYLIS SMITHI*, IMMATURE FEMALE, FOURTH LEG.

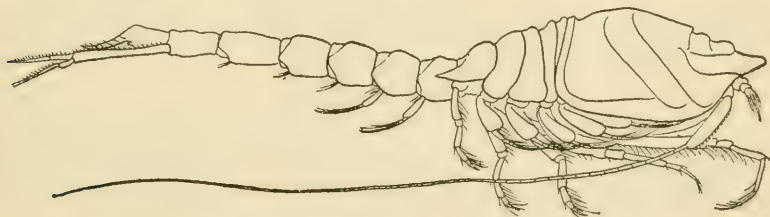


FIG. 98.—*OXYUROSTYLIS SMITHI*, MALE, FROM THE SIDE.

the segment by a line of apparent articulation, and it would seem to be in fact the enlarged proximal segment of the outer flagellum.¹

¹ I suspect that a similar arrangement will be found in all those Diastylidæ which have been described as carrying a brush of setæ on the male antennular peduncle. Compare also the structure of the male antennule in *Heterocuma weberi*. (Rep. Cumacea Siboga, p. 7, pl. 1, fig. 9.)

Beyond this setose basal segment the flagellum has five segments. The inner flagellum is composed of four segments. The setæ on the anterior face of the antennal peduncle are relatively short; the flagellum extends back to the tip of the uropod peduncles.

Strongly developed exopods are present on all the legs except the last pair.

The first and second pairs of pleopods are biramous with the exopod of two segments.

The peduncle of the uropods extends a little beyond the tip of the telson and has about 20 spines on its inner edge. The endopod is distinctly longer than the exopod, its second and third segments subequal, and shorter than the first; there are about 20 spines on the inner edge.

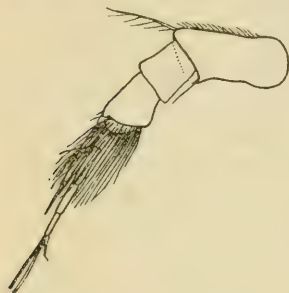


FIG. 99.—*OXYUROSTYLIS SMITHI*,
MALE, ANTENNULE.

Remarks.—Several lots of this species are labeled as having been taken at the surface. The thin and only lightly calcified integument suggests that the species is adapted for a partly pelagic life.

The specific name is chosen in recognition of my indebtedness to the writings of Prof. S. I. Smith.

Localities.—Casco Bay; U. S. F. C., 1873; U.S.N.M. 34899; 1 male. Vineyard Sound; surface; U. S. F. C., 1881; U.S.N.M. 44152, 44154; 8, male and female.

Vineyard Sound; U.S.N.M. 34897; 1 female.

Woods Hole; surface; U. S. F. C., 1882; U.S.N.M. 44145; 1 female, 2 males.

Woods Hole; surface; V. N. Edwards, Bureau of Fisheries; U.S.N.M. 44159–44165; many males and females (including holotype, 44162).

Punta Rassa, Florida; 1 fathom; H. Hemphill; U.S.N.M. 44147; 1 female.

Calcasieu Pass, Louisiana; tow, wharf; M. H. Spaulding, September, 1907; U.S.N.M. 44146; 1 male.

COLUROSTYLIS (?) OCCIDENTALIS, new species.

Ovigerous female.—Total length, 12 mm. (An imperfect specimen of an ovigerous female must have exceeded this length by about one-third when complete.)

The carapace is about two-sevenths of the total length, its vertical height about two-thirds of its length, and its width a little less; not inflated, with its dorsal edge as seen from the side slightly arched posteriorly then sloping downward to the short horizontal pseudo-rostrum. The antero-lateral margin below the pseudo-rostrum is

nearly straight and vertical and is defined below by a strong antero-lateral tooth. On each side of the carapace are four oblique ridges; the first ridge does not pass on to the dorsal surface above, and near its lower and anterior end it is bent upward at a right angle to pass on to the side of the pseudorostrum; the other three ridges are parallel to one another, the second ending below on the antero-lateral tooth

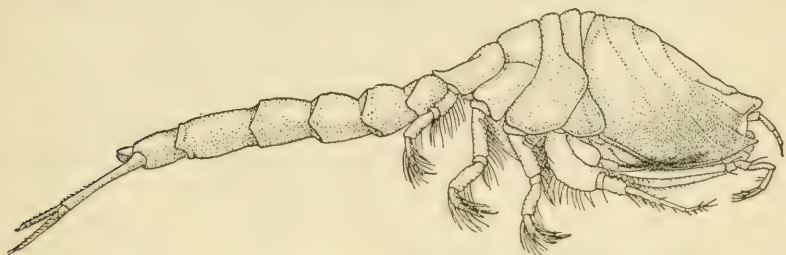
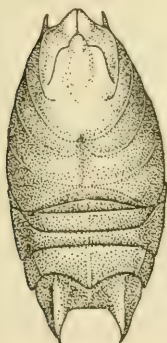
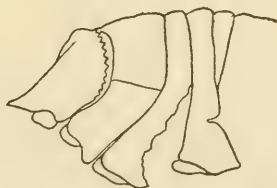


FIG. 100.—*COLUROSTYLIS* (?) *occidentalis*, FEMALE, FROM THE SIDE.

and the other two on the lower edge of the carapace; above, the second and the fourth pairs of ridges are continued across the dorsal surface, while the third pair bend forward to meet the second. The ocular lobe is small, broader than long, and shorter than the line of junction of the lateral plates of the pseudorostrum; there is no pigment, but three rather large lenticular elements can be seen.



101



102



103

FIGS. 101-103.—*COLUROSTYLIS* (?) *occidentalis*, FEMALE. 101, ANTERIOR PART OF BODY FROM ABOVE; 102, FREE THORACIC SOMITES FROM THE SIDE, PLEURAL PLATES OF THIRD SOMITE PARTLY CUT AWAY; 103, ANTENNULE.

The first free thoracic somite is only exposed on the dorsal side, its lateral portions being overlapped by the second somite. The lateral plates of the second somite are greatly expanded and are separated from the tergum by a deep narrow incision of the anterior margin. The pleural plates of the third somite are also greatly expanded, overlapping those of the second somite above and produced backward below. The third and fourth somites have a

median dorsal keel. The tergum of the fourth somite is produced backward in the middorsal line, where its length is equal to that of the three preceding somites together; its lateral plates are not expanded, but are slightly produced downward between the coxæ of the third and fourth pairs of legs; each lateral plate is defined by a suture line at about half the height of the somite. The fifth somite has its anterior margin coarsely serrate, with rather widely separated teeth; it has a pair of dorso-lateral keels which are continued into the strong, vertically compressed, slightly upturned, and acutely pointed postero-lateral teeth.

The abdomen is a little shorter than the cephalothoracic region; the last somite is about half as long as the preceding. The telson is half as long as the last somite, little longer than broad, rounded, and quite unarmed; the tip does not project beyond the anal valves.

The antennules have the second segment of the peduncle very stout, about half as long as either the first or the third; the inner flagellum has three segments and is about half as long as the first segment of the outer flagellum.

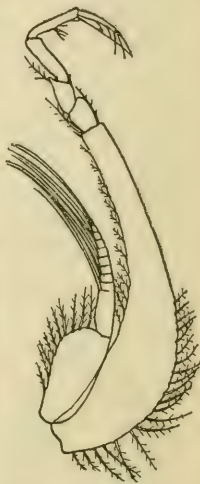
The antenna is composed of four distinct segments; the penultimate is expanded, ovate, serrated on both edges; the last segment is very minute and inserted within the margin of the preceding.



104



105



106

FIGS. 104-106.—*COLUROSTYLIS* (?) *occidentalis*, FEMALE. 104, ANTENNA; 105, THIRD MAXILLIPED; 106, FIRST LEG.

The mandible and other mouth parts are of normal form. The third maxillipeds have the basis only slightly expanded and not produced at its distal angle. The ischium bears a curious comblike row of short spines on its outer margin.

The first legs have the basis, measured along the inner edge, twice as long as the distal segments together; the carpus and propodus are subequal, the dactylus a little shorter. The second legs have the basis expanded, less than twice as long as broad, and about half as long as the distal segments together; the merus is a little more than half as long as the carpus, which is one and a half times as long as the propodus and more than twice as long as the dactylus.

The third and fourth pairs of legs each bear a conspicuous exopod of two segments.

The peduncle of the uropods is about two and a half times as long as the last somite, with a row of rather longish spines on its inner edge. The exopod is about half as long as the peduncle and the endopod about three-quarters as long as the exopod. The endopod is composed of three segments, of which the first is nearly four times as long as the other two together; the terminal segment is of very unusual form, having a strong compressed spine produced backward from its lower surface and projecting far beyond the bluntly rounded tip. Both exopod and endopod bear spines on their outer and inner edges.

Adult male.—Total length, 11.8 mm.

Resembling the female except that the general form is more slender, with the cephalothoracic region less inflated and the carapace slightly



FIGS. 107-109.—*Colurostylis* (?) *occidentalis*, FEMALE. 107, SECOND LEG; 108, THIRD LEG; 109, *a*, LAST SOMITE, TELSON, AND UROPOD FROM ABOVE; *b*, TIP OF ENDOPOD FROM THE SIDE, FURTHER ENLARGED.

depressed. The ridges of the carapace are less prominent and the eye much larger and more distinct, although without pigment. There is no dorsal keel on the third free thoracic somite, but the fourth somite is as in the female. The expanded pleural plates of the third somite are somewhat swollen and are separated from the dorsal part of the somite on each side by a shallow groove in line with the pleural suture of the fourth somite. Each of the first two abdominal somites has a strong, backwardly curved tooth in the midventral line in front of the attachment of the pleopods, and each of the three following somites has a pair of articulated spines on the ventral side behind the middle of its length. The telson is longer than in the female, with the dorsal surface hollowed; its rounded distal edge

projects beyond the anal valves and bears about four setæ directed downward.

The distal segment of the antennular peduncle is not enlarged; there is a rather scanty brush of hairs springing apparently from the enlarged first segment of the outer flagellum. The antennal flagellum is as long as the body. The first four pairs of legs carry well-developed

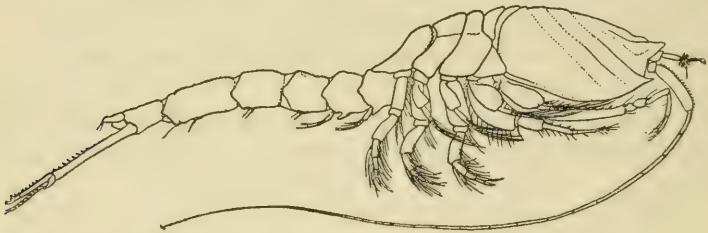
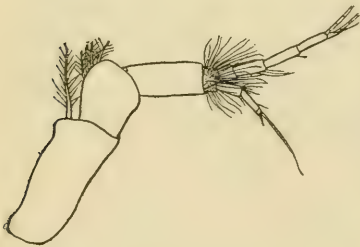


FIG. 110.—COLUROSTYLIS (?) OCCIDENTALIS, MALE, FROM THE SIDE.

exopods. Both pairs of pleopods are biramous, with the exopod in each case of two segments. The uropods resemble those of the female, but are provided with much more numerous spines.

Remarks.—This species resembles *Colurostylis pseudocuma*¹ in the small size of the telson and in the general characters of antennules, antennæ, and male pleopods. It differs, however, in many important characters, and it is possible that some of these, especially the peculiar form of the thoracic pleural plates, the expanded penultimate segment of the female antenna, and the remarkable structure of the endopod of the uropods deserve to be recognized by making it the type of a separate genus.



111



112

FIGS. 111-112.—COLUROSTYLIS (?) OCCIDENTALIS, MALE. 111, ANTENNULE; 112, LAST SOMITE AND TELSON.

In having the endopod of the uropods of three segments it is nearer the normal type of the Diastylidæ than *C. pseudocuma*. The narrow notch on the anterior margin of the second free somite recalls that of *Diastylopsis dawsoni*.

Localities.—Albatross station 3094; off Oregon, lat. 43° 01' 00'' N.; long. 124° 30' 30'' W.; 35 fathoms; bottom temperature, 46.7° F.; U.S.N.M. 44010; 1 female (holotype).

Pacific Grove, California; J. O. Snyder, July, 1895; U.S.N.M. 44009; 4, male and female.

Albatross station 4564; Monterey Bay, California; 9 fathoms; U.S.N.M. 44008; 1 female.

¹ Calman, Trans. Zool. Soc., vol. 18, 1911, p. 377, pl. 36, figs. 23-36.

PETALOSARSIA DECLIVIS (G. O. Sars).

Petalopus declivis G. O. Sars, Forh. Vidensk. Selsk. Christiania, 1864 (1865), p. 197.

Petalosarsia declivis G. O. Sars, Crust. Norway, vol. 3, 1900, p. 77, pl. 54.

On the coasts of Europe this species is known to range from Franz-Joseph Land to Heligoland and the Irish Sea. It has not hitherto been recorded from the American coasts.

Localities.—*Albatross* station 2458; off Newfoundland; 89 fathoms; bottom temperature 29.5° F.; U.S.N.M. 44149; 1 female.

U.S.F.C. station 993; off Marthas Vineyard; 39 fathoms; bottom temperature, 46.5° F.; U.S.N.M. 44150; 1 female.

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SAY, THOMAS.—An account of the Crustacea of the United States (continued).

Journ. Acad. Nat. Sci. Philadelphia, vol. 1, Nos. 11 and 12, 1818, pp. 313-319.

Diastylis arenarius described from a single male individual taken from sand in a shore-pool on the "Coast of Georgia and Florida." This species, the genotype of the extensive genus *Diastylis*, has not since been rediscovered.

NICOLET, H.—Crustaceos.

In Historia física y política de Chile, por Claudio Gay, Zoología, vol. 3. Paris, 1849. Atlas, 1854.

On p. 220 *Cuma gayi* is described, and it is figured on pl. 3 (Crustaceos), fig. 1-1b, in the Atlas. It appears to be a species of *Diastylis*, but has not since been recognised.

STIMPSON, W.—Synopsis of the marine invertebrata of Grand Manan.

Smiths. Contr., vol. 6, Art. 5, 1853, 68 pp., 3 pls.

Cuma bispinosa, new species, is described on p. 39. See remarks under *Diastylis quadrispinosa* above.

SARS, G. O.—Nya arter af Cumacea samlade under k. svenska korvetten *Josephines* Expedition i Atlantiska Oceanen år 1869 af F. A. Smitt och A. Ljungman.

Öfvers. Kgl. Vet. Akad. Förh., vol. 28, 1871, No. 1, pp. 71-81.

———.—Beskrivelse af de paa Fregatten *Josephines* Expedition fundne Cumaceer.

Kgl. Svenska Vet. Akad. Handl., vol. 9, No. 13, 1871, 57 pp., 20 pls.

In these two papers the following species are described from the Atlantic coast of North America: *Diastylis sculpta*, *D. quadrispinosa*, *D. abbreviata*, *Eudorella pusilla*, *E. hispida*, all new species, and *Eudorella* (now *Eudorellopsis*) *deformis* Krøyer.

———.—Beskrivelse af fire Vestindiske Cumaceer opdagede af Dr. A. Goës.

Öfvers. Kgl. Vet. Akad. Förh., vol. 28, 1871, No. 6, pp. 803-811.

———.—Beskrivelse af syv nye Cumaceer fra Vestindien og det Syd-Atlantiske Ocean.

Kgl. Svenska Vet. Akad. Handl., vol. 11, No. 5, 1873, 30 pp., 6 pls.

In these papers *Diastylis antillensis*, *Leucon anomalus*, *Campylaspis pulchella*, and *Stephanomma goëssii* are described from the West Indies, and *Diastylis fimbriata*, *Leptostylis manca*, and *Leptocuma kinbergii* from the Atlantic coast of South America. All are new species.

SMITH, S. I.—Crustacea, in Report upon the Invertebrate animals of Vineyard Sound and the Adjacent waters.

Rep. U. S. Comm. Fisheries, 1871-1872 (1873). Cumacea, pp. 554-555.

Diastylis quadrispinosa is figured (pl. 3, fig. 13).

WHITEAVES, J. F.—On recent deep-sea dredging operations in the Gulf of St Lawrence.

Amer. Jour. Sci., vol. 7, 1874, pp. 210-219.

———.—Report on Deep-sea dredging operations in the Gulf of St. Lawrence.

29 pp. Printed in Ottawa, 1874.

Seven species of Cumacea are recorded as identified by Prof. S. I. Smith.

SMITH, S. I.—Notes on Crustacea collected by Dr. G. M. Dawson at Vancouver and the Queen Charlotte Islands.

Geol. Survey Canada Rept. 1878-79 (1880), pp. 206B-218B.

Diastylopsis dawsoni, new genus and new species, is described from Queen Charlotte Islands. This species has been redescribed and figured above.

——.—The Stalk-eyed Crustaceans of the Atlantic Coast of North America north of Cape Cod.

Trans. Conn. Acad., vol. 5, 1879, pp. 28-138, pls. 8-12.

This is the most important paper on the Cumacea of the Atlantic coast. Seventeen species are recorded, of which three are new. With the exceptions of *Diastylis abbreviata* G. O. Sars, *Leptostylis longimana* (G. O. Sars), and *L. ampullacea* (Lilljeborg), all the species are represented in the collection now examined.

MURDOCH, JOHN.—Marine Invertebrates (exclusive of Mollusks).

Rep. International Polar Exp. Point Barrow, Alaska, 1885, pp. 136-176, 2 pls.

Diastylis rathkii var. is recorded from the north coast of Alaska.

SARS, G. O.—Report on the Cumacea.

Challenger Reports, 1886, 78 pp., 11 pls.

Eudorella abyssii, new species, and *Diastylis stygia* G. O. Sars are recorded from depths exceeding 1,000 fathoms off the Atlantic coast.

HANSEN, H. J.—Isopoden, Cumaceen u. Stomatopoden der Plankton-Expedition, 1895, 105 pp., 8 pls.

Pachystylis rotundata, new genus and new species from off the coast of Brazil, and *Nannastacus hirsutus*, new species from the Bermudas, are described in this memoir.

ZIMMER, CARL.—Cumaceen.

In Hamburger Magalhaensische Sammelreise, 1902, 18 pp., text figs.

Six new species are described from the coasts of Patagonia and the Magellan region.

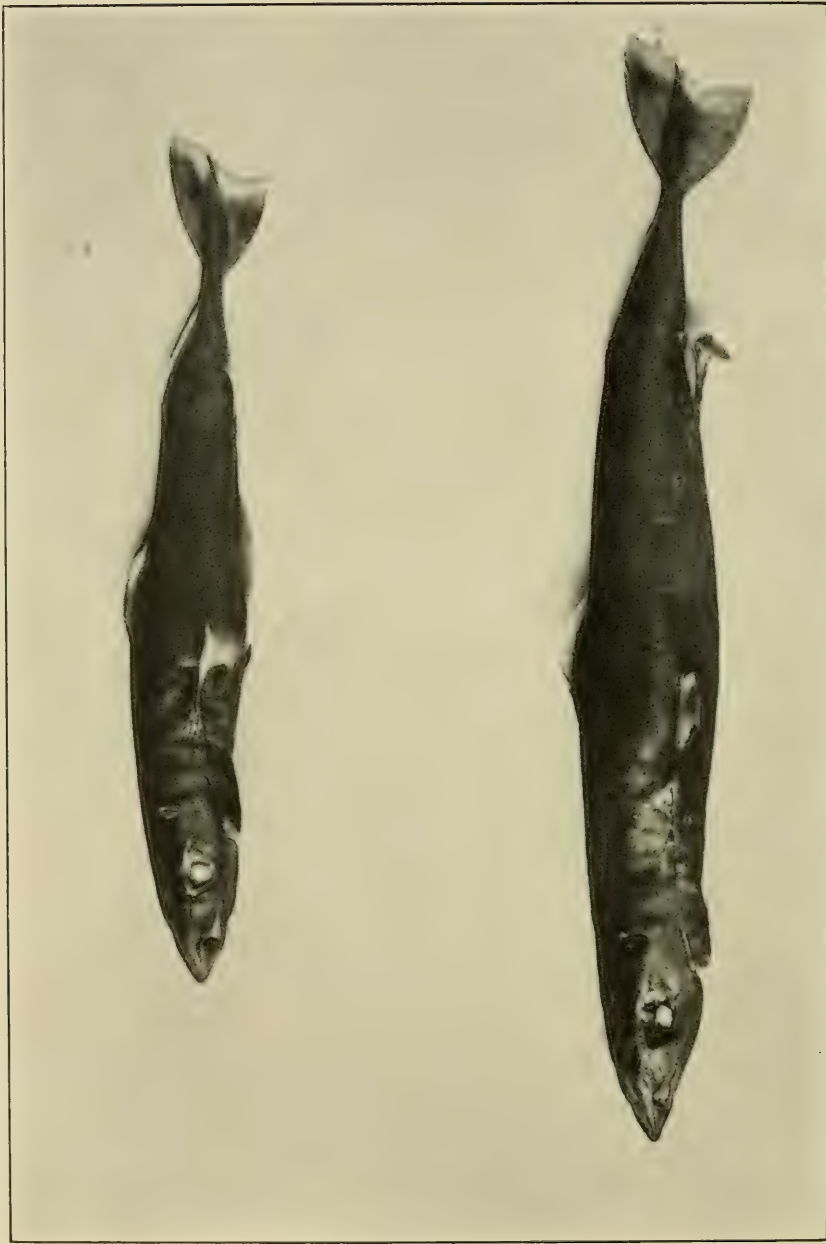
CALMAN, W. T.—On new or rare Crustacea of the Order Cumacea from the collection of the Copenhagen Museum.

Part 1, Trans. Zool. Soc., vol. 18, pp. 1-39, pls. 1-9, 1907; Part 2, pp. 341-385, pls. 31-37, 1911.

Six new species are described from the West Indies and one species is recorded from the Straits of Magellan.

ZIMMER, CARL.—Die Cumaceen der Schwedischen Südpolarexpedition, 31 pp., 8 pls., 1909.

Two species are recorded from the Falkland Islands.



SQUALIOLUS LATICAUDUS.

From photograph of alcoholic specimens, lower figure the type. Natural size

THE SQUALOID SHARKS OF THE PHILIPPINE ARCHI-
PELAGO, WITH DESCRIPTIONS OF NEW GENERA AND
SPECIES.

By HUGH M. SMITH,¹

*United States Deputy Commissioner of Fisheries
and Director of the Albatross Philippine Expedition.*

No sharks of the family of Squalidæ have up to this time been recorded from the Philippine Islands. The *Albatross* collection contains numerous specimens representing six species: two of them are Japanese and the remaining four are undescribed. Two of the latter belong in known genera, while each of the other two necessitates the erection of a new genus for its accommodation. All of the species herein noted inhabit rather deep water and are of small size.

The genera of squaloid sharks represented in the Philippine fauna may be diagnosed as follows:

Key to genera of Philippine squaloid sharks.

- a. Both dorsal fins well developed and elevated, and each with a conspicuous antecedent spine; caudal fin more or less elongate; snout not conical.
- b. Snout of moderate breadth and depressed but not flat.
- c. Teeth in upper jaw simple, without basal cusps.
- d. Teeth alike in both jaws, with laterally deflected point and horizontal or oblique cutting edge..... *Squalus*.
- d¹. Teeth unlike in both jaws, those in upper jaw erect or nearly so, those in lower jaw oblique, with laterally deflected point..... *Lepidorhinus*.
- c¹. Teeth in upper jaw with two or four basal cusps..... *Etmopterus*.
- b¹. Snout very broad and flat..... *Nasisqualus*.
- a¹. Both dorsal fins small; second dorsal very long and low, without vestige of spine; caudal fin comparatively short and broad; snout conical..... *Squaliolus*.

SQUALUS PHILIPPINUS Smith and Radcliffe, new species,

Plate 51.

Body rather slender, moderately compressed, back somewhat elevated; caudal peduncle long, depressed, .5 head, least depth .25 length, a depressed keel on either side; tail not bent upward head;

¹ In the study of this collection the writer has been assisted by Mr. Lewis Radcliffe, who becomes joint authority for the new genera and species described.

broad, 4.33 in total length, its width more than .5 its length; snout short, obtusely pointed, .33 head; eye large, lateral, rather shorter than snout and .66 interorbital space; mouth broad, very slightly curved, its width less than .33 length of head and its distance from end of snout equal to distance to first gill slit; nostrils small, midway from tip of snout to middle of pupil; spiracles small, immediately above posterior corner of eye and separated therefrom by a narrow fold of skin; skin soft to touch, the denticles small, dense, and consisting of a long, pointed spine and two smaller lateral spines on a flat base.

First dorsal fin placed well forward, its origin midway between tip of snout and second dorsal, the spine more than .5 height of fin;

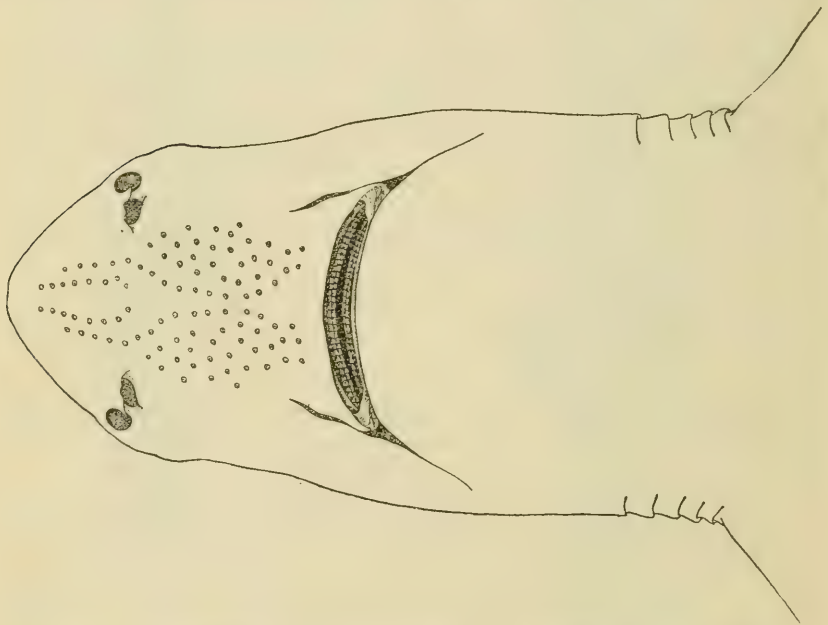


FIG. 1.—*SQUALUS PHILIPPINUS*. UNDER SIDE OF HEAD. ENLARGED ABOUT ONE-FOURTH.

second dorsal much smaller, its origin much nearer to origin of first dorsal than to tip of caudal, the spine more curved and rather stouter than the other and .75 height of fin; caudal fin rather large and spreading, longer than head, lower lobe broad, more than .5 total length of fin; ventrals small, their origin nearer to spine of first dorsal than to spine of second; pectorals broad, posterior margin slightly incised, tips extending to posterior end of dorsal base.

Color: Above dark gray, below light gray; outer part of dorsal fins black, base pale; middle of caudal black, the lobes light yellowish gray; a small light spot on base of pectoral immediately behind the last gill opening.

Type.—Cat. No. 70256, U.S.N.M., a young male specimen 32.5 cm. long, taken with a beam trawl January 16, 1908, at station 5111 (lat. $13^{\circ} 45' 15''$ N.; long. $120^{\circ} 46' 30''$ E.), off Sombrero Island, west coast of Luzon, at a depth of 236 fathoms.

This species appears to differ from *S. mitsukurii* from Japan in the much more anterior insertion of the ventral fins, longer caudal fin, larger lower caudal lobe, larger anterior dorsal fin, much larger pectorals, and greater arching of back. The drawing and the description¹ of that species do not harmonize; and not having access to the types we are unable to verify the differences between the two species. *S. megalops* from Australia may apparently be distinguished from this species by the more posterior insertion of ventrals and shorter pectorals, shorter snout, etc.

LEPIDORHINUS FOLIACEUS Günther.

A specimen 31 cm. long was taken with a beam trawl on August 3, 1909, between the islands of Leyte and Mindanao, at a depth of 960 fathoms. It is a male with very feeble development of claspers, and agrees closely with the description and figure of the type² from Japan, except that the second dorsal fin is lower and the pectorals are a little longer.

ETMOPTERUS LUCIFER Jordan and Snyder.

This species, described from Japan and heretofore known only from that locality, appears to be common in moderately deep water in various parts of the Philippines. The collection contains 21 specimens from 14 dredging stations in 9 localities, 10 of the specimens being from 5 stations in Mindanao Sea off the northern coast of Mindanao and 2 others from 2 stations between the islands of Negros and Siquijor. Other specimens are from Balayan Bay, Luzon; Verde Island Passage, between Luzon and Mindoro; off east coast of Mindoro; near Malavatuan Island, between Lubang and Luzon; off west coast of Jolo Island; and between Jolo and Tawi Tawi. The depth range of the specimens taken is 170 to 318 fathoms, and the size limits are 11 to 28 cm. Males with fully developed claspers are 22.5, 24, and 27 cm. long; young males, with evident but undeveloped claspers, are 11 cm. long. Another specimen, a fully developed male 29.5 cm. long, has become separated from its label, and no locality or other data can be given for it.

ETMOPTERUS BRACHYURUS Smith and Radcliffe, new species.

Plate 52.

Form slender; body compressed; head broad, moderately depressed, .25 total length, its width at spiracles about .5 its length, its depth at spiracles .33 its length; snout short, broad, slightly

¹ Proc. U. S. Nat. Mus., vol. 26, pp. 629-630, fig. 3.

² Challenger Deep-Sea Fishes, p. 5, pl. 2, fig. B.

decurved, obtuse, its sides forming an angle of about 45 degrees, its length 3.5 in head and 1.5 in distance from its tip to mouth, its breadth 2.5 in head and equal to distance from its tip to mouth; eye lateral, .25 head, .66 interorbital, equal to space between spiracles, the center of pupil midway between nostril and spiracle; nostrils large, separated by a space somewhat greater than their diameter; mouth slightly curved, very broad, .8 width of snout, .3 head, anterior margin slightly posterior to pupil; teeth in upper jaw small, pentacuspoid, the cusps lanceolate and evenly graduated; the unicuspid teeth in lower jaw larger, the point sharp and oblique; spiracles rather large, nearly midway from tip of snout to last gill open-

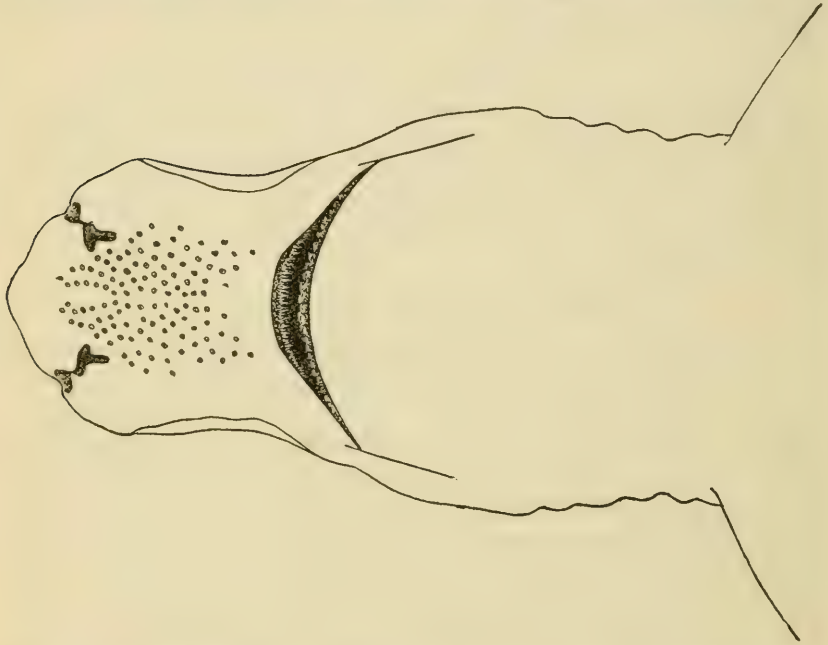


FIG. 2.—ETMOPTERUS BRACHYURUS. UNDER SIDE OF HEAD. ENLARGED ABOUT THREE-FOURTHS.

ing, space between spiracles equal to .5 distance from spiracles to tip of snout; gill openings very narrow; entire upper surface of body, top of head, caudal peduncle, and bases of fins covered with well-marked longitudinal lines of overlapping spiniferous denticles separated by relatively wide naked spaces, the spines longest and the rows most marked on the tail; abdomen, breast, and under side of snout densely covered with rough denticles without regular arrangement; under side of head for a considerable distance before and behind mouth naked, with numerous large pores.

Each dorsal fin with a spine that is naked nearly to its base; first dorsal very short, its origin nearer to posterior base of second dorsal than to tip of snout, the spine about .5 height of fin; second dorsal

entirely behind ventrals, rather high, the posterior rays much produced, the spine very strong and about height of fin; space between dorsal fins seven times length of base of first dorsal without spine; caudal fin short and broad, the lower lobe .6 total length; distance from base of second dorsal to upper caudal lobe .5 distance from first dorsal spine to posterior base of second dorsal and .66 length of peduncle; pectorals short, broad, their length less than .5 head and their tip barely reaching vertical from first dorsal spine; origin of ventrals about midway from first dorsal spine to middle of base of second dorsal.

Color: Above light brown, below darker; all fins pale yellowish brown.

Type.—Cat. No. 70257, U.S.N.M., a fully developed male specimen 22.7 cm. long, taken with a beam trawl on September 17, 1909, at station 5550 (lat. $6^{\circ} 02' 00''$ N.; long. $120^{\circ} 44' 40''$ E.), off Jolo Light, island of Jolo, at a depth of 263 fathoms, on a bottom of sand, globigerinæ, and foraminifera.

The claspers are short and provided with 4 long, sharp spines. In order to accommodate those organs, the fins cross one another at right angles.

This species is most closely related to *E. lucifer* Jordan and Snyder, differing therefrom in the broader head; shorter, more obtuse snout; wider mouth; and shorter, broader caudal fin.

NASISQUALUS Smith and Radcliffe, new genus.

Squaloid sharks having a strongly compressed body; broad, depressed head; a broad, flat, elongate snout, with a conspicuous lateral angle and rounded tip; a well-marked median cartilaginous keel on upper and lower surfaces of snout; a wide, slightly curved mouth, with a straight oblique fold at each angle; unicuspid teeth in both jaws, those in upper jaw triangular, those in lower jaw very strongly deflected laterally, the cutting edge nearly horizontal; large subequal dorsal fins with a conspicuous exposed spine; a postanal median keel; and dense squamation, each denticle consisting of three slender spines on a short base.

Genotype.—*Nasisqualus profundorum*.

NASISQUALUS PROFUNDORUM Smith and Radcliffe, new species.

Plate 53.

Form elongate, body and caudal peduncle greatly compressed, tail bent slightly upward; head long, broad, flat, its length (to posterior gill slit) contained 3.75 times in total length; greatest width (at spiracles) .5 length, depth .6 width; body rather deep, back elevated, depth under first dorsal spine contained seven times in total length, thickness of body less than diameter of eye; caudal peduncle

short, its depth .6 diameter of eye; snout very long, 2.8 in head, flat, foliaceous, pointed in profile, width in front of eyes nearly equal to length, the sides parallel, knife-like, the tip very thin, flat, and broadly rounded, a well-marked lateral angle occurring at the nostril, a distinct median cartilaginous keel on upper and lower surfaces; eye large, lateral, the length of orbital slit about equal to distance from eye to lateral angle of snout and 1.75 times in interorbital space, pupil about half way between last gill slit and end of snout; mouth broad, moderately curved, its width equal to distance from eye to first gill slit; a long, straight groove as long as eye at angle of mouth, the groove inclined obliquely forward and inward, and if produced meeting its fellow at a point opposite anterior third of eye; preoral space long, more than .5 head; nostrils large, inferior, oblique, extending to margin of snout at angle, width of each nostril

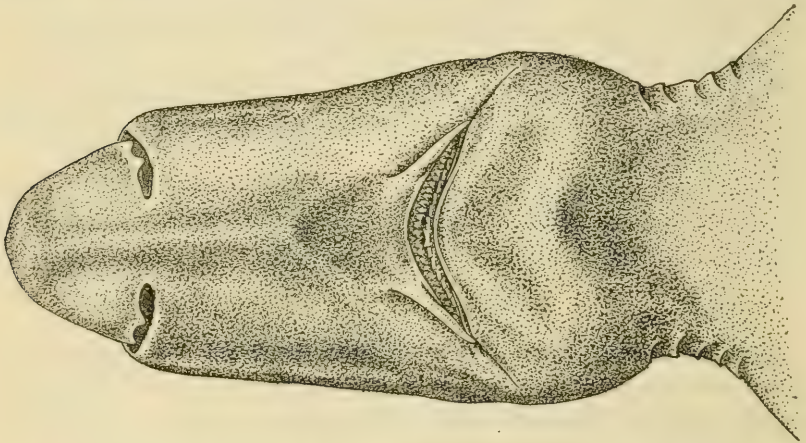


FIG. 3.—*NASISQUALUS PROFUNDORUM*. UNDER SIDE OF HEAD. SEVEN-EIGHTHS NATURAL SIZE.

nearly one-third width of snout; teeth as indicated in generic description; spiracles large, about diameter of pupil and separated from eye by a space greater than their diameter; skin velvety, densely scaled, each denticle consisting of three slender spines in the form of a trident, the denticles deficient on margin of fins.

Dorsal fins nearly equal in length; origin of first dorsal midway between second dorsal and anterior angle of orbit, length of base (exclusive of spine) equal to distance between center of spiracles, the spine one-third exposed and .6 height of fin; second dorsal fin higher than first, beginning behind base of ventrals, its base longer than that of first dorsal, its posterior rays slightly produced and nearly reaching caudal fin, the spine long, .5 expose, .75 height of fin; caudal fin, from anterior edge of lower lobe, equal to distance from snout to first gill slit, lower lobe .5 total length, its distance behind ventral base equal to .5 length of head; middle of ventral base midway from

tip of caudal to middle gill slit and well in advance of second dorsal spine, the modified rays (claspers) long, straight, and acutely pointed; pectorals large, broad, length from last gill slit .5 head, the posterior margin straight, the rays reaching vertical from base of dorsal spine.

Color: Uniform dark brown.

Type.—Cat. No. 70258, U.S.N.M., a male specimen 44 cm. long, taken with a beam trawl on August 1, 1909, at station 5491 (lat. $9^{\circ} 24'$ N.; long. $125^{\circ} 12'$ E.), between the islands of Leyte and Mindanao, at a depth of 736 fathoms, on a bottom of green mud and coral.

The collection contains six additional specimens, as follows, all taken with the beam trawl in water from 392 to 976 fathoms deep: Station 5219, between Marinduque and Luzon, April 23, 1908, 530 fathoms, one female specimen 44 cm. long; station 5491, between Leyte and Mindanao, August 1, 1909, 736 fathoms, one female specimen 50.5 cm. long; station 5495, between Leyte and Mindanao, August 1, 1909, 976 fathoms, one female specimen 59 cm. long; station 5511, off Camp Overton Light, northern Mindanao, August 7, 1909, 410 fathoms, two specimens 21 and 33.5 cm. long; station 5527, between Siquijor and Bohol Islands, August 11, 1909, 392 fathoms, one specimen 22.5 cm. long.

SQUALIOLUS Smith and Radcliffe, new genus.

Squaloid sharks with subcylindrical body, much contracted caudal peduncle; cylindrical head, conical snout; erect lanceolate, unicuspid teeth in upper jaw, oblique teeth with laterally deflected points in lower jaw; small first dorsal fin with naked spine; long, low second dorsal without vestige of spine; very short and broad caudal fin with straight tail; ventral fins far behind middle of body and under origin of second dorsal; entire body covered with flat, widely separated quadrate denticles.

The presence of a spine in the anterior dorsal fin and the entire absence of one in the posterior dorsal necessitate a modification in the current definition of the Squalidæ, and perhaps justify the institution of a new subfamily when taken in connection with other characteristic features of this genus—form of head, second dorsal and caudal—that are possessed by no other members of the family. The peculiar shape of the caudal is approached, but not attained, by *Lamna* and other large typical sharks.

Genotype.—*Squaliolus laticaudus*.

SQUALIOLUS LATICAUDUS Smith and Radcliffe, new species.

Plates 50 and 54.

Form very elongate, graceful, cigar-shaped, body moderately compressed, caudal peduncle much constricted and slightly depressed; head long, cylindrical, 3.2 in total length, its depth at spiracles equal to its breadth and 3.1 in its length; body deepest under first dorsal fin, the depth 2.7 in head and equal to distance from spiracle to fourth gill slit; eye large, lateral, the upper margin of orbital opening slightly arched, the lower margin nearly semicircular, the width but slightly greater than depth and contained 7 times in head, 2 times in interorbital space, and 2.25 times in snout; snout conical, 3 in head, acutely pointed, the breadth somewhat greater than depth; nostrils lateral, nearer to tip of snout than to anterior margin of eye; interorbital space very wide and convex; spiracles large, above level of upper margin of eye and separated from eye by a space nearly equal to diameter of eye; gill openings very narrow, occupying a

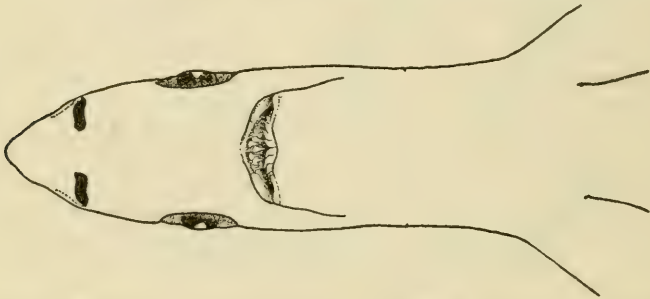


FIG. 4.—SQUALIOLUS LATICAUDUS. UNDER SIDE OF HEAD. ENLARGED ONE-HALF.

shallow groove that extends from pectoral through the entire series; mouth rather small, nearly horizontal, its width 1.5 times diameter of eye, distance of mouth from tip of snout less than .5 head, a deep groove as long as width of mouth extending backward from each angle; teeth in upper jaw unicuspid, erect, lanceolate, and curved backward; those in lower jaw larger, oblique, with sharp point and long, oblique, cutting edge, resting on a broad quadrangular base; entire body and head covered with flattish denticles consisting of a circular center resting on a square base, with a ridge extending from each corner of the square.

First dorsal low, with small but stout spine exposed for about half its length, the posterior rays somewhat produced, the dorsal origin midway between second dorsal and anterior margin of eye; second dorsal very long and low, without vestige of spine, the length of base more than .3 length of head, the posterior rays produced and reaching halfway from base of fin to base of caudal, original of fin over ventral

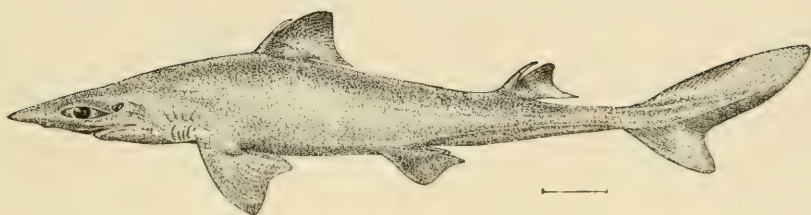
base; caudal fin short and broad, its length equal to distance from mouth to tip of snout, its breadth about .75 length; the tail not inclined upward, expanded posterior to the contracted peduncle, and terminating in a sharp point on the posterior margin of the fin; ventrals short, the base thickened, the ends expanded into broad plates, as large as eye, directed backward, while from the anterior and outer base of each plate there extends forward a long, slender spine bifid at its tip; pectorals short and broad, their base well in advance of dorsal origin and their tip reaching to a point under middle of dorsal base.

Color: Uniform jet black; first dorsal brownish at base, margin white; second dorsal white; caudal lobes brownish, posterior margin white; ventral rays and plate-like expansions white; pectorals white, with black area at upper extremity.

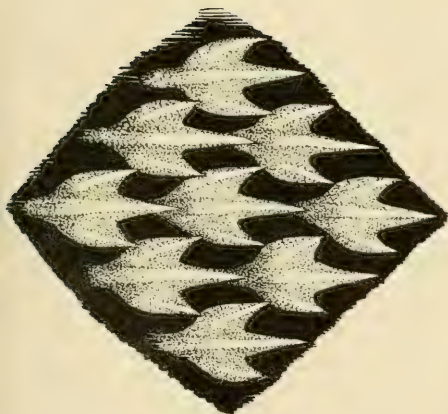
Type.—Cat. No. 70259, U.S.N.M., a male specimen 15 cm. long, taken with a beam trawl on June 8, 1908, at station 5268 (lat. $13^{\circ} 42'$ N.; long. $120^{\circ} 57' 15''$ E.), in Batangas Bay, Luzon, at a depth of 170 fathoms, on a bottom of sand, shells, and pebbles.

Another specimen, 11.5 cm. long, taken with a beam trawl on July 24, 1909, at station 5297, in the same locality, agrees with the type in all respects, except that it has no modification of the ventral fins and is apparently a female.

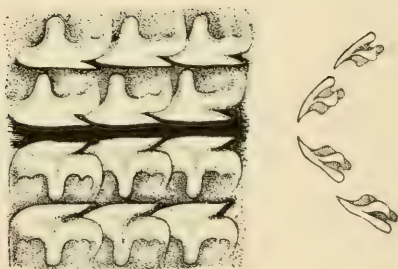
This is one of the smallest known sharks, the fully developed male specimen which is the type being only 6 inches in length.



From the type. One-third natural size.

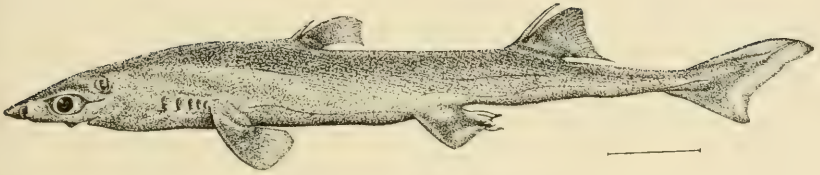


Dermal denticles from flank, enlarged.

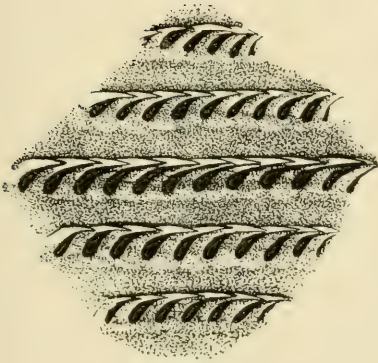


Front and side views of teeth of upper and lower jaws, enlarged.

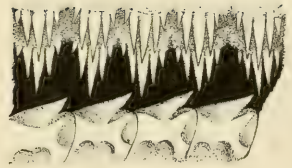
SQUALUS PHILIPPINUS.



From the type. One-half natural size.

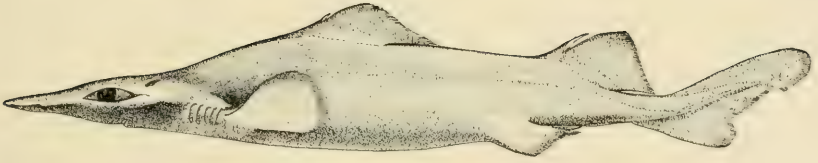


Side view of lines of dermal denticles, enlarged.



Teeth of upper and lower jaws, enlarged.

ETMOPTERUS BRACHYURUS.



From the type. One-fourth natural size.

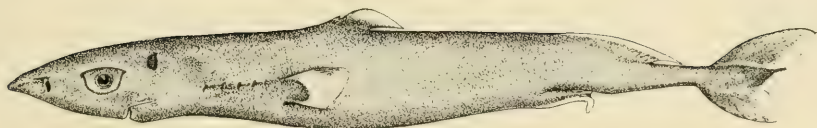


Dermal denticles from flank, enlarged.

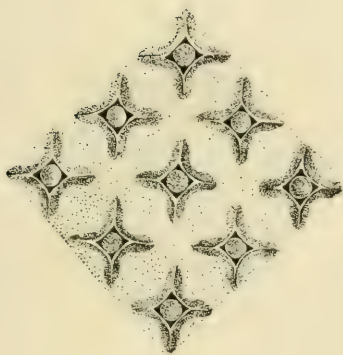


Teeth of upper and lower jaws, enlarged.

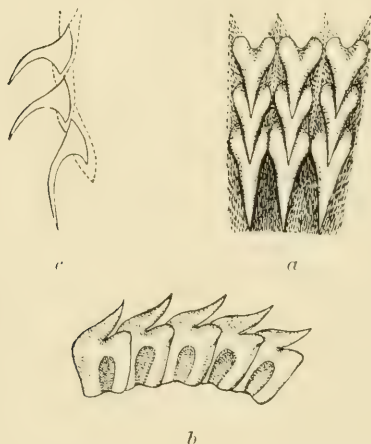
NASISQUALUS PROFUNDORUM.



From the type. Three-fourths natural size.



Section of skin from flank, showing dermal denticles, enlarged.



Teeth, enlarged. *a*, front view of teeth in upper jaw; *b*, same, lower jaw; *c*, side view of teeth in upper jaw.

SQUALIOLUS LATICAUDUS.

THE MOUNTED SKELETONS OF CAMPTOSAURUS IN THE UNITED STATES NATIONAL MUSEUM.

By CHARLES W. GILMORE.

Assistant Curator of Fossil Reptiles, United States National Museum.

INTRODUCTION.

Recently the exhibition collection of vertebrate paleontology in the United States National Museum has been enriched by the addition of two mounted dinosaur skeletons from the Morrison Beds of Wyoming. These specimens are unusually perfect as fossil skeletons, and are noteworthy as being the types of the two species *Camptosaurus nanus* Marsh (Cat. No. 2210, U.S.N.M.) and *Camptosaurus browni* Gilmore (Cat. No. 4282, U.S.N.M.). Since a detailed description of the osteological features of these specimens has been given in a previous article,¹ the present paper will briefly describe the mounted skeletons.

These specimens formed a part of the Marsh collection that was transferred to the Museum some years ago by the United States Geological Survey, and are from one of the celebrated fossil deposits of the Morrison beds, known to the collectors as "Quarry 13," located about 8 miles east of "Como Bluff," Albany County, Wyoming.

The skeletons are typical examples of the large and small species of the genus, and as they are mounted upon the same base, show well the great difference in size. (See pls. 56 and 57.) They are standing on a base of artificial matrix that represents the color and texture of the layer of sandstone in which the bones were found.

The larger skeleton (*C. browni*) is mounted in a quadrupedal posture, an attitude which it is believed was often assumed, and the smaller specimen (*C. nanus*) has been erected in the more familiar pose of walking on the hind limbs.

The skeleton of *Camptosaurus browni* was mounted by the writer, while the skeleton of *C. nanus* was erected by Mr. Norman Boss, preparator in the section of vertebrate paleontology, and to his skill is due the workmanlike manner of the finish and its life-like pose.

¹ C. W. Gilmore. Osteology of the Jurassic Reptile *Camptosaurus*, with a revision of the Species of the Genus, and Description of two new species. Proc. U. S. Nat. Mus., vol. 36, 1909, pp. 197-333, pls. 6-20.

SKELETON OF CAMPTOSAURUS BROWNI.

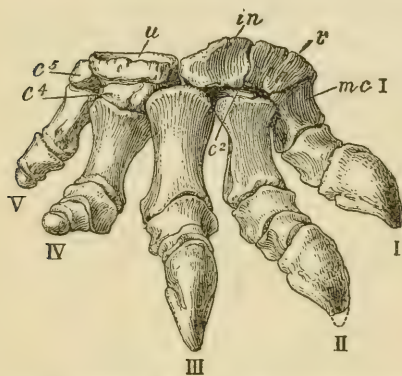
Although Prof. O. C. Marsh made the first pictorial¹ restoration of *Camptosaurus dispar* as early as 1894 the United States National Museum has the distinction of being the first to erect in a life-like posture the actual skeleton of one of the large species of *Camptosaurus*, and while Marsh's earlier restoration gave a good general idea of the appearance of the animal, it is now known, as has been pointed out previously, to have been in error in several particulars.

The most striking of the changes brought about by the study and reconstruction of these specimens is the shortening of the presacral region. In the first restoration (Marsh's) there are 30 presacral vertebræ, 9 of which belong to the cervical region, thus leaving 21 thoracic vertebræ. The two skeletons considered here agree in having 16 dorsals each, and accepting this as the correct number, the series has been shortened by 5 vertebræ, making the proportions quite different from the first conception. It lessens perceptibly the space between the fore and hind limbs, producing a more compact and better balanced animal.

It is also shown by these specimens that all of the vertebræ preceding the sacrum carried ribs, and therefore there are no true lumbar vertebræ.

Other features which can best be appreciated in the mounted

FIG. 1.—RIGHT FORE FOOT, CAMPTOSAURUS DISPAR MARSH, CAT. NO. 4277, U.S.N.M.; $\frac{1}{4}$ NAT. SIZE. SEEN FROM THE FRONT. c^2 , CARPAL TWO; c^4 , CARPAL 4; c^5 , CARPAL FIVE; in , INTERMEDIUM; $mc I$, METACARPAL I; r , RADIALE; u , ULNARE; I TO V, DIGITS ONE TO FIVE. UNGUAL OF FIRST DIGIT RESTORED.



skeleton are the small head, curved neck, short and widely expanded body cavity, long tail, and the great disparity in size between the fore and hind limbs.

The great strength of the hind legs is at once evident from the size of the femora, tibiæ, and feet. (See fig. 4.) The enormous development of the fourth trochanter on the femur indicates a powerful caudo-femoral muscle. That the animal usually walked with an upright, bipedal gait, as amplified by the small skeleton, seems apparent, although certain characters of the fore feet appear to indicate a considerable use in locomotion.

The compact ossified carpus, with smooth, well-defined, articulating surfaces, short and stout metacarpals, all are indicative of a foot

¹ Amer. Journ. Sci., vol. 47, Mar., 1894, pl. 6.

whose function was that of support rather than of a grasping or prehensile organ.

As stated previously, while the writer believes that the upright bipedal posture was frequently assumed, it does appear from the facts mentioned above that *Camptosaurus* used the quadrupedal mode of progression more frequently than any other known member of the Ornithopoda, and in this genus it may represent the beginning of the development of a fore foot where quadrupedalism was to become a fixed means of locomotion as it has in *Stegosaurus* and in the Ceratopsia.

The stiff divergent pollex, brought about by the ankylosis of the first metacarpal (which is much shortened) with the radiale, is an interesting feature of the fore foot. In this respect there seems to be a trend toward the development of a "spikelike" digit as found in the fore foot of the *Iguanodon* of Europe. (Compare figs. 1 and 2.) The skull has been modeled after a careful study of all known cranial material, and it is believed to be the most correct restoration yet produced, although future discoveries will probably show the present conception to be in error in some particulars.

In *Camptosaurus* the dentition is confined to the rear portions of the jaws, the anterior part of the mouth being toothless and probably sheathed in a horny beak which served for cropping off the bushes or herbage on which these animals fed. The teeth are of moderate size with sculptured margins (see fig. 3), implying a food of rather yielding character which did not require forcible mastication.

These skeletons represent the animals as touching nearly the whole length of the toes (excepting the first) to the ground. They were so mounted because of the fact that all the three-toed supposed dinosaurian footprints show the imprint of nearly the full length of the phalanges.

The pathological condition of the right ilium of *C. browni* is of interest in showing to what extent the shape of a bone may be modified by external injury (see pl. 58). On the posterior half, the comparatively thin, platelike part of the ilium is divided vertically, the two halves swelling out to form the walls of a cavity which extends downward, emerging on the ventral border. The cavity is longer than wide, measuring on the upper border of the opening 86 mm. in a longitudinal direction and 46 mm. in the transverse, the ventral exit being

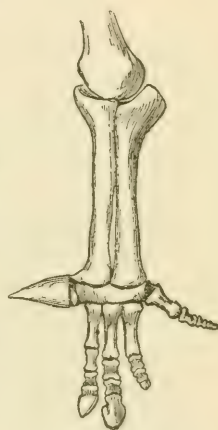


FIG. 2.—LEFT FORE FOOT OF IGUANODON. I, FIRST DIGIT OR POLLEX.

considerably smaller. As indicated by a deep depression on the dorsal border, the injury was probably received from above.

The exostosis of the bone was greatest on the front side of the cavity where it measures 72 mm. in width. The normal width of this part of the ilium, as shown by one on the opposite side, is only 21 mm. A second injury was found on one of the caudal vertebræ near the root of the tail, as indicated by the pathological condition of the spinous process, which is considerably enlarged and has near its base an elongated opening which perforates the bone. While the wound in the ilium must have been an exceedingly painful one at the time of infliction, it in no way utterly disabled the animal, at least to the extent of leading to its death, as all of the broken margins of the bone had healed. Although these injuries may have been inflicted by some of its large carnivorous contemporaries, the position

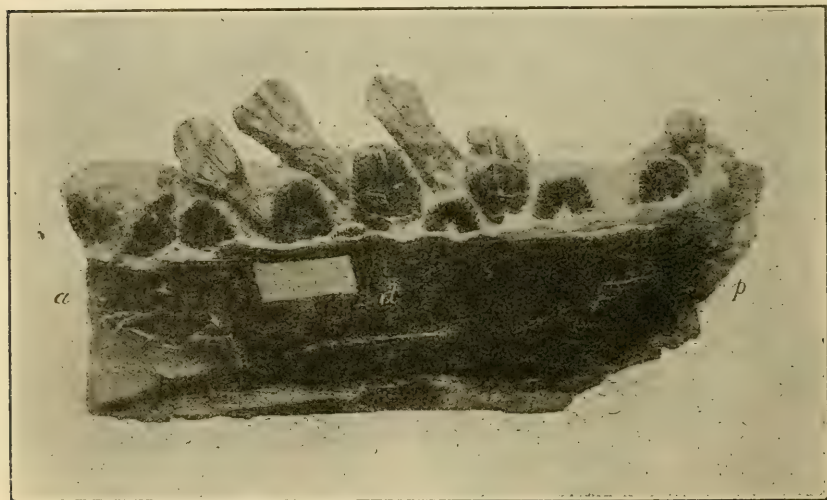


FIG. 3.—RIGHT DENTARY OF CAMPTOSAURUS. INTERNAL VIEW SHOWING DENTITION OF LOWER JAW. ABOUT $\frac{2}{3}$ NAT. SIZE. a, ANTERIOR END; d, DENTARY; p, POSTERIOR END.

of the wounds suggests the idea that this individual was a female who might have received the injuries during copulation.

The evolutionary history of *Camptosaurus* is largely unknown. The nearest allied form appears to be *Iguanodon*, found in Europe, and Prof. O. C. Marsh was among the first to recognize the many similarities in structure between *Camptosaurus* and *Iguanodon*. While the former is proportionally much lighter and more delicately constructed, the habits and mode of life of the two animals must have been very similar. In many particulars, however, *Camptosaurus* represents a more generalized type, as is shown by the somewhat simpler structure of the teeth, the less reduced pollex and hallux, the postpubis reaching to the end of the ischium, and the more proximal position of the fourth trochanter of the femur.

Amount of restoration.—The drawing, plate 58, shows plainly all of the restored parts. The bones supplied from other individuals are listed below.

No. 4277. Right hind foot, excepting unguual of digit IV.

No. 4697. Left hind foot.

No. 5959. Right femur, tibia, astragalus, and fibula.

No. 5961. Left fibula and calcaneum.

No. 6001. Fifth cervical vertebra.

No. 6016. Left femur.

No. 7076. Left tibia.

All of the bones introduced are from individuals found in the same quarry ("13") as the type-specimen. Those bearing the catalogue numbers 4277, 4697, and 5959 have been identified as belonging to the species *Camptosaurus dispar* Marsh. It was at first intended to replace these missing parts with restored bones, but since they must necessarily be copies of these bones, it was finally decided to use the originals even though they do pertain to another species. In this connection it is reasonable to suppose that when the hind limbs of *C. browni* are known, they will be found to differ but little from those bones introduced.

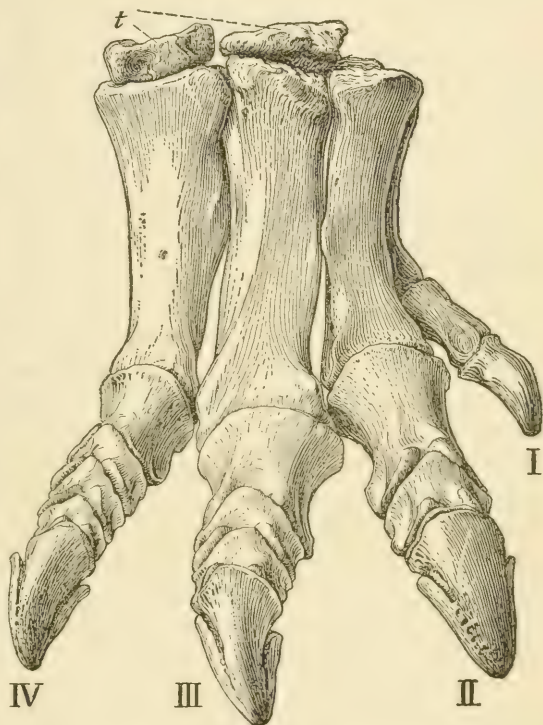


FIG. 4.—RIGHT HIND FOOT, CAMPTOSAURUS DISPAR MARSH. CAT. NO. 4277, U.S.N.M.; $\frac{1}{2}$ NAT. SIZE. SEEN FROM THE FRONT: *t*, TWO TARSAI BONES OF THE DISTAL ROW; I, II, III, IV, FIRST TO FOURTH DIGITS. UNGUALS OF DIGITS I, III, AND IV DRAWN FROM THE FEET OF OTHER INDIVIDUALS.

To make the record of this skeleton complete, diagrams 5 and 7 of quarry 13 and an account of the way in which the bones were found in the ground are here appended.

The accompanying map (see pl. 55) shows how the bones of *Camptosaurus browni* were found as they lay embedded in the ground. The map was drawn at the time of disinterment, and the painstaking care bestowed on it is worthy of the highest commendation. A quarter of a century has elapsed since this skeleton was collected.

During the interval the material from this area had become widely scattered, but by the aid of the map the specimens were not only assembled, but it was possible to again place all of the elements in their original relative positions.

Most of the skeleton lay in diagram 5, but a study of the contiguous area represented by diagram 7 showed other elements which could, beyond a reasonable doubt, be associated with the same individual, although collected a year later. The main axis of the skeleton lay in a northeast and southwest direction, and apparently not far removed from where the animal died.

As indicated by the original quarry numbers, the left fore limb and foot and anterior dorsal vertebræ were the first elements discovered. The limb and foot bones lay on the left side of the vertebral column in the positions indicated on the map (see Nos. 83, 84, and 85), the scapula and coracoid being removed some 5 feet to the left of the lower limb bones, but inasmuch as this is the only skeleton of *Camp-tosaurus* found in this part of the quarry, and as it pertains to the left side, there can be no doubt of their proper association. The vertebral column, which appears quite complete, was disarticulated at intervals. Beginning with the anterior portion of the backbone as preserved, cervicals 78, 77, and 76 were articulated by their zygapophyses and represent, respectively, the eighth and ninth cervicals and first dorsal. No. 83, although not interlocked with 78, was but little removed from it, and appears without question to represent the seventh cervical. Two other cervicals, No. 109 and another from which the original quarry number has been erased, are also provisionally associated with this skeleton, and represent the fourth and third cervicals, respectively. On account of the erasure of the quarry number the position of the third cervical could not be found on the map, although it was associated with the bones of this skeleton. The vertebræ of the next series, Nos. 101 to 106, while not interlocked by their zygapophyses, were so closely associated that there can be no question of their representing a series, and when articulated fit one another perfectly. The position of the capitular facets and shape of the spinous processes show them to pertain to the anterior dorsal region. An interval of a foot or more existed between No. 106 of this series and No. 76. In the next series, Nos. 120 to 136, the vertebræ were found occupying their relative positions and but little disturbed. From the adhering matrix the writer was able to connect up this series from the mid-dorsal through the sacrals to the fourth caudal, inclusive. Caudals Nos. 168 to 169 and Nos. 158 and 159 were removed somewhat laterally, but were intermediate in size and appear to fill the gap between 136 and 170. Nos. 170 to 174, with their chevrons, were found articulated. Another series of four vertebræ (block 208) was

shown in diagram 7, some 14 feet to the east of No. 174; but an anterior zygapophysis, retained in place by the matrix of the latter, was found to fit on the first vertebra of this series, and so fixed beyond doubt their proper position in the tail. Some 14 or 15 feet to the north and east another series of 18 distal caudals (Nos. 218 to 235) was found, most of them articulated or so closely associated that it appears none are missing in the series.

It is perhaps fortunate that while the other bones in this area represent the remains of several individuals, nearly all pertain to the genus *Stegosaurus*, from which the elements of *Camptosaurus* are readily distinguishable. This remark applies particularly to the rounded distal caudals of *Camptosaurus*, which may at once be distinguished from the short hexagonal caudal centra of *Stegosaurus*. That this distal series belongs to *C. browni* there can be but little question. The ilia, Nos. 140 and 167, lay on their respective sides of the sacrum and but little removed from it, with their anterior ends directed forward. The other pelvic bones were not indicated on the map, but from their quarry numbers it was determined they could not have been far removed. Nothing of the hind limbs was found. The right fore limb (and foot) Nos. 98, 101, 119, and 120, were found to the west and right of the anterior cervicals. From the fact that all of the elements pertain to a right limb and closely agree in size with the left, its assignment appears certain. Some scattered ribs and pieces found near the dorsals have been provisionally associated with them. All of the remaining material from diagrams 5 and 7 has been gone over carefully in the hope of finding some elements of the skull and other missing parts, but without reward. It appears remarkable that in a skeleton which shows so little displacement of the elements as this one that the heavy bones of the hind limbs should be missing. An unusual feature is the preservation of both fore limbs and feet. Experience of several seasons' field work has shown that while it is not unusual to find hind limbs fairly complete, the front legs, particularly of the Jurassic sauropods, are rare.

By reference to the quarry map (see pl. 55), all of the evidence as to the association of the parts may be plainly seen. The bones not numbered pertain to one or more genera different from *Camptosaurus*. The series to the east of the vertebral column represents a caudal series of *Stegosaurus*, and most of the other scattered elements have been recognized as belonging to that genus. With the exception of two caudal vertebræ, no duplicate bones of *Camptosaurus* have been found. There can be therefore little question but that all of the elements indicated as *Camptosaurus* belong to one individual.

The position of the bones of the skeleton, as found in the quarry, is shown in diagrams 5 and 7, plate 55. The position of the different parts is indicated by the original quarry numbers as follows:

IN DIAGRAM 5.

80. Chevron, 15th.	129 to 133. Sacral.
81. Dorsal rib.	134 to 136. Caudals (1, 2, and 3 of series).
83. Fifth dorsal rib of the-right side.	140. Left ilium.
84. Left humerus.	157. Portion of dorsal rib.
85. Left radius, ulna, and manus.	158. Caudal (6th of series).
98. Spinous process.	159. Caudal (5th of series).
101 to 106. Dorsals (2, 3, 4, 5, 6, and 7 of series).	167. Right ilium.
106. Eighth thoracic rib of the right side.	168. Caudal (3d of series).
107. Head of dorsal rib.	169. Caudal (4th of series).
109. Piece of dorsal rib.	170 to 174. Caudals (7, 8, 9, 10, 11, and 12 of series).
113. Portion of right ischium.	175, 176. Caudal vertebræ.
115. Left ischium.	178. Chevron.
116. Dorsal rib (portion of head).	— Portion of right pubis.
120 to 128. Dorsals (8th to 16th of series).	— Part of left pubis.

IN DIAGRAM 7.

45. Left scapula.	101. Right scapula.
46. Left coracoid.	109. Fourth cervical.
76. First dorsal.	119. Right radius and ulna.
77. Ninth cervical with one rib.	120. Right manus.
78. Eighth cervical with both ribs.	177. Ungual of Digit IV, right hind foot.
83. Seventh cervical.	208. Caudals (13, 14, 15, and 16 of series).
84. Right humerus.	218 to 235. Caudals (22d to 38th of series).
98. Right coracoid.	

Dimensions.—The entire length of the animal measured along the back bone is 17 feet; from the base to the top of the hip bones is 4 feet 6 inches in length. The tail measures 8 feet 6 inches in length.

SKELETON OF CAMPTOSAURUS NANUS.

The small skeleton shown in plates 59 and 60 was in 1894 briefly described¹ by Prof. O. C. Marsh as the type of a new species, and later a more detailed account² of this specimen was given by the writer.

The elements preserved are as follows:

Axis intercentrum, axis, 7 cervical, 16 dorsal, 4 sacral, and 34 caudal vertebræ, 1 cervical and numerous thoracic ribs, right forelimb (scapula, coracoid, humerus, radius, and ulna), 2 femora, 2 tibiæ, left fibula, 2 ilia, 2 ischia, portion of left pubis, 2 metacarpals, 1 carpal, and parts of ossified tendons.

The specimen was collected by Mr. W. H. Reed from "quarry 13" in 1882.

¹ O. C. Marsh. Amer. Journ. Sci., ser. 3, vol. 48, 1894, p. 85 pl. 5, fig. 3.

² C. W. Gilmore. Proc. U. S. Nat. Mus., vol. 36, 1909, pp. 280-285.

The skeleton as mounted is composed of the bones of one individual with the exception of the second and third metatarsals of the left hind foot which are from another individual (Cat. No. 5960) of the same proportions, and from the same quarry as the type. The other missing parts have been restored and painted a light color to make these distinct from the fossil portions.

As shown in plates 57 and 59 the specimen has been given the bipedal pose, with the intention of conveying to the observer the impression of a rapidly walking animal. The head is thrown forward, the arms balancing the sway of the shoulders. The right hind leg is at the end of the forward stride and bears the greater part of the weight of the animal. The left foot is just about to be lifted preparatory to the forward step, while the tail is doubly curved and lifted slightly from the ground to balance the weight of the forward part of the animal.

The head is comparatively small, and carried on a gracefully curved neck of moderate length. The thoracic region, which has 16 dorsal vertebræ, is of good proportions, and as the articulated ribs show in the posterior view (see pl. 60), the back was broad with a widely expanded body cavity. The animal was supported by stout clawed limbs of which the hinder are much longer and stouter than the fore. In life this animal was evidently strong and agile in movement, and the structure of the feet, as in *C. browni*, appear to indicate a strictly land-living form.

Unlike several of the other predentate dinosaurs, there have been no dermal ossifications found, so we have no knowledge as to the character of the external covering. The line drawing (see pl. 61) shows clearly the restored and original parts of the skeleton.

The caudal series consists of 42 vertebræ, of which 31 are considered as carrying chevrons.

The ischia, as articulated in these two skeletons, only meet at their distal extremities. The writer is, however, inclined to the opinion that in life the borders of the lower part of their shafts were in contact, somewhat after the manner of the ischia in *Trachodon* and *Ceratosauros*, but, probably owing to distortion, it was found impossible to so articulate them when mounting the specimens.

As with *Camptosaurus browni*, the skull, which is wholly restored, is modeled in the proper proportions after a study of all known cranial material, and undoubtedly gives an accurate idea of the cranium.

In order to place on record all of the evidence relating to the primary association of the backbone of this skeleton, a complete list of the articulated vertebræ as found is given below.

Axis free; 3d cervical to 2d dorsal articulated; 3d dorsal free; 4th to 8th dorsals articulated; 9th to 13th dorsals articulated; 14th dorsal

free; centrum of 15th dorsal detached, although the spinous process remained attached to the 16th; 16th dorsal and sacral vertebræ articulated; 1st caudal free; 2d to 21st caudals articulated; 22d to 25th caudals articulated; 26th caudal free; 27th to 29th caudals articulated; 30th and 31st caudals articulated; 35th caudal free.

Dimensions.—The entire length of the animal, measured along the backbone, is 9 feet 11 inches; from the base to the top of the hip bones, 1 foot 9 inches; from base to top of head, 2 feet 8½ inches; length of tail, 3 feet 6 inches.

EXPLANATION OF PLATES.

PLATE 55.

Diagrams 5, 7, and part of 4, of quarry 13, near Como, Albany County, Wyoming, worked by Mr. Fred Brown for Prof. O. C. Marsh, during the years 1884, 1885, and 1886. The numbered bones show the positions in which the various elements of the type of *Camptosaurus browni*, Cat. No. 4282, U.S.N.M., were found in the quarry. The unnumbered bones scattered about pertain chiefly to members of the Stegosauria.

A. Plesiotype of *Diracodon laticeps*, Cat. No. 4288, U.S.N.M.

B. Series of caudals and dermal plates of *Stegosaurus*, Cat. No. 4714, U.S.N.M.

The scale is about 4 feet to the inch.

PLATE 56.

Mounted skeletons of *Camptosaurus browni* Gilmore, Cat. No. 4282 U.S.N.M., and *C. nanus* Marsh, Cat. No. 2210, U.S.N.M.

Type-specimens. Oblique side view.

About one-twentieth natural size.

PLATE 57.

Mounted skeletons of *Camptosaurus browni* Gilmore and *C. nanus* Marsh. Type-specimens. Viewed from the left side.

About one-twentieth natural size.

PLATE 58.

Drawing of the skeleton of *Camptosaurus browni* showing the real and restored parts. Original bones are represented by line shading and parts restored are left in outline.

More than one-twentieth natural size.

PLATE 59.

Mounted skeleton of *Camptosaurus nanus* Marsh. Oblique view. Type-specimen. About one-eighth natural size.

PLATE 60.

Rear view of *Camptosaurus nanus* Marsh. Showing the pose of the tail and expanded body cavity. Type-specimen.

PLATE 61.

Drawing of the skeleton of *Camptosaurus nanus* Marsh. Showing the real and restored parts. Original bones are represented by line shading and parts restored are left in outline.

More than one-eighth natural size.



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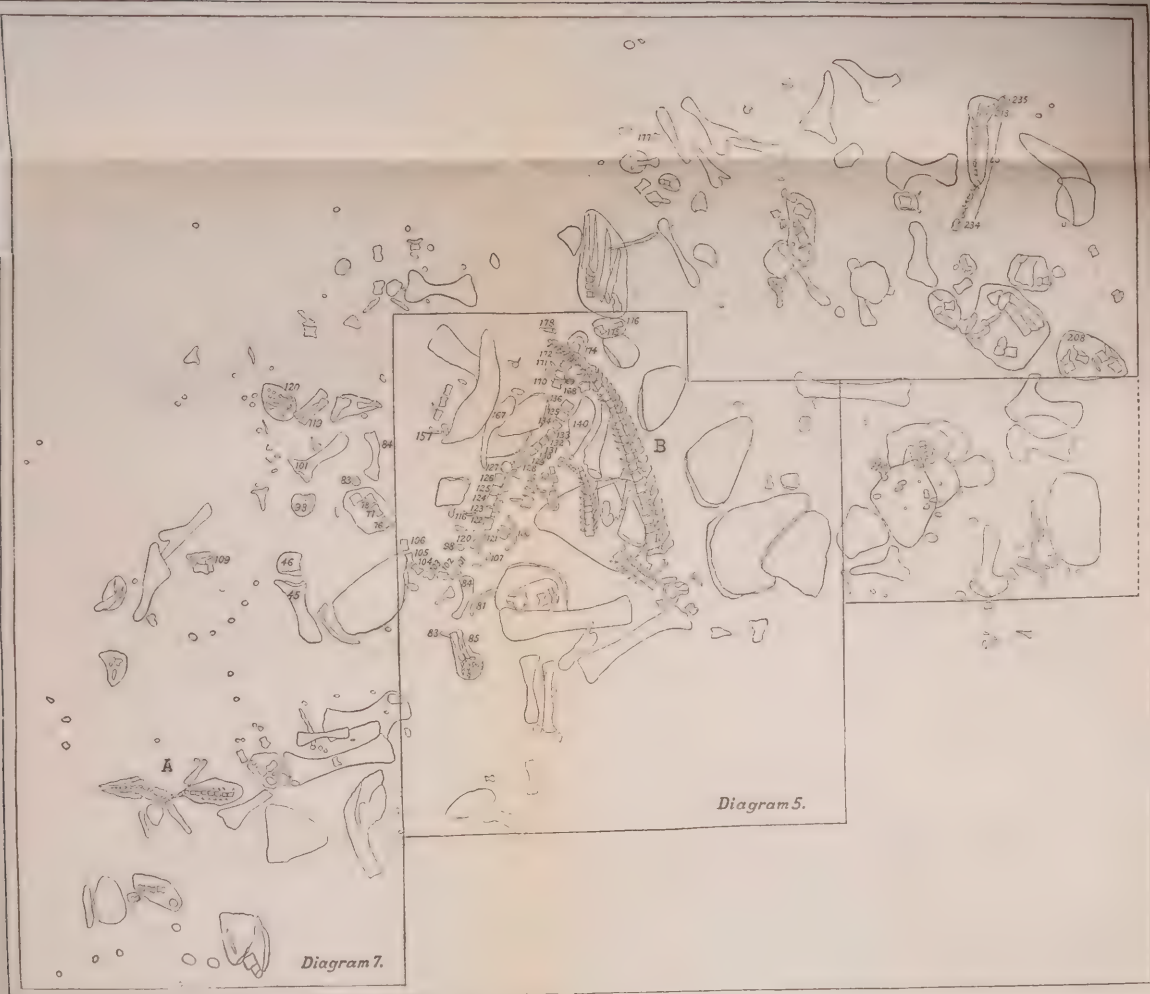
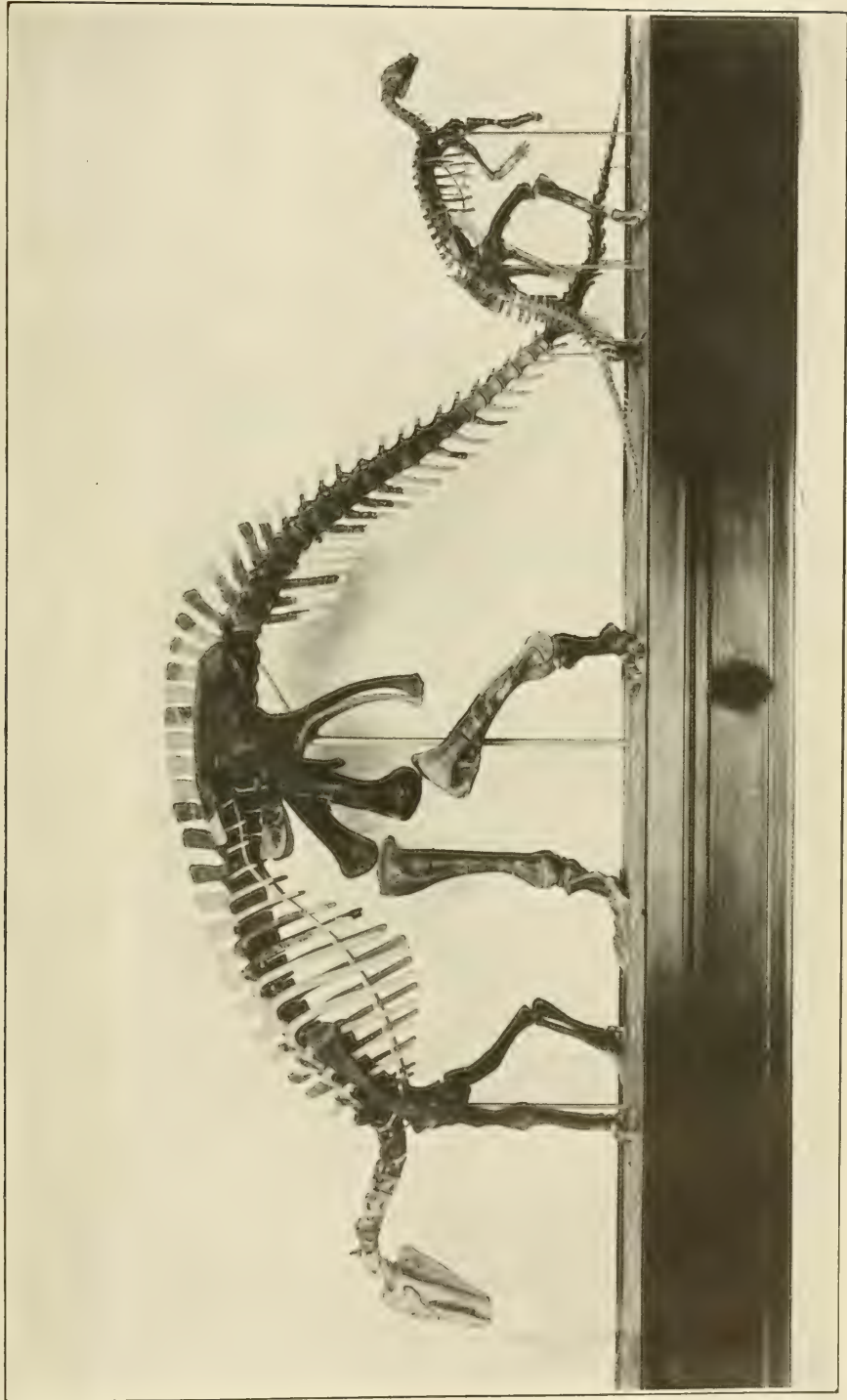
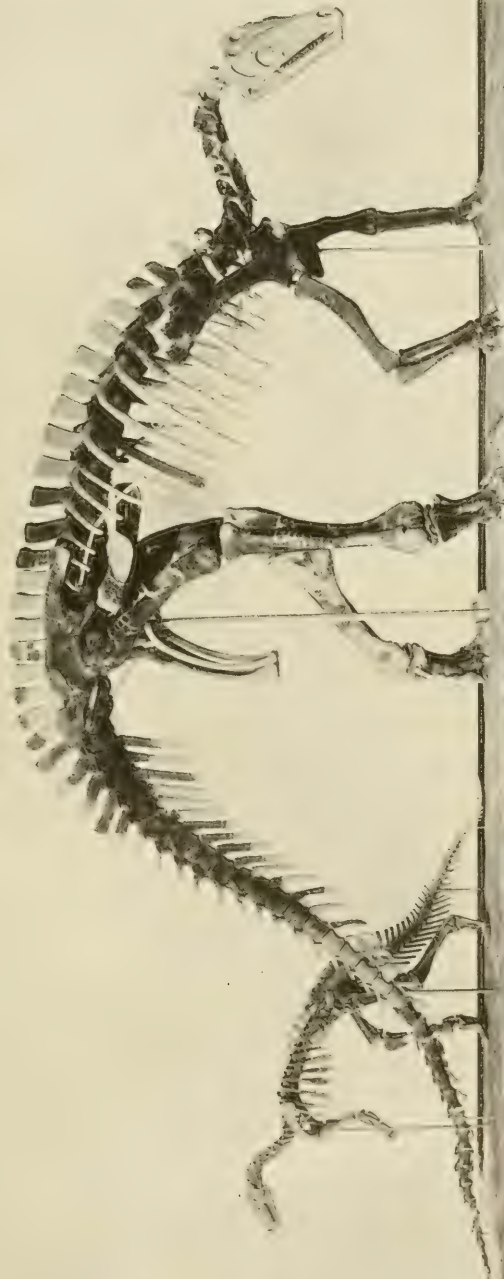


Diagram 7.



MOUNTED SKELETONS OF CAMPTOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 696.



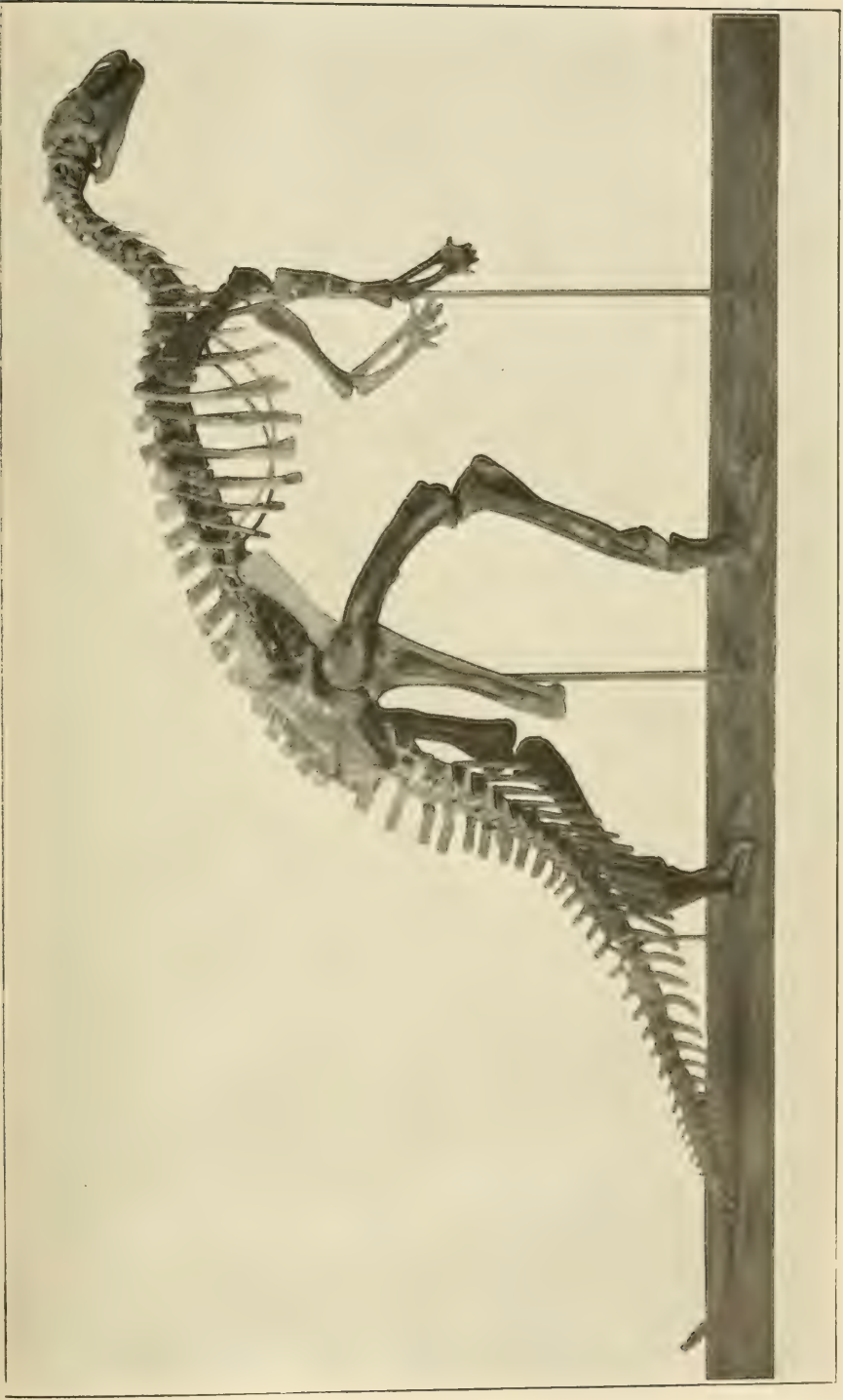
MOUNTED SKELETONS OF CAMPTOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 696.



SKELETON OF CAMPTOSAURUS BROWNI.

FOR EXPLANATION OF PLATE SEE PAGE 696.



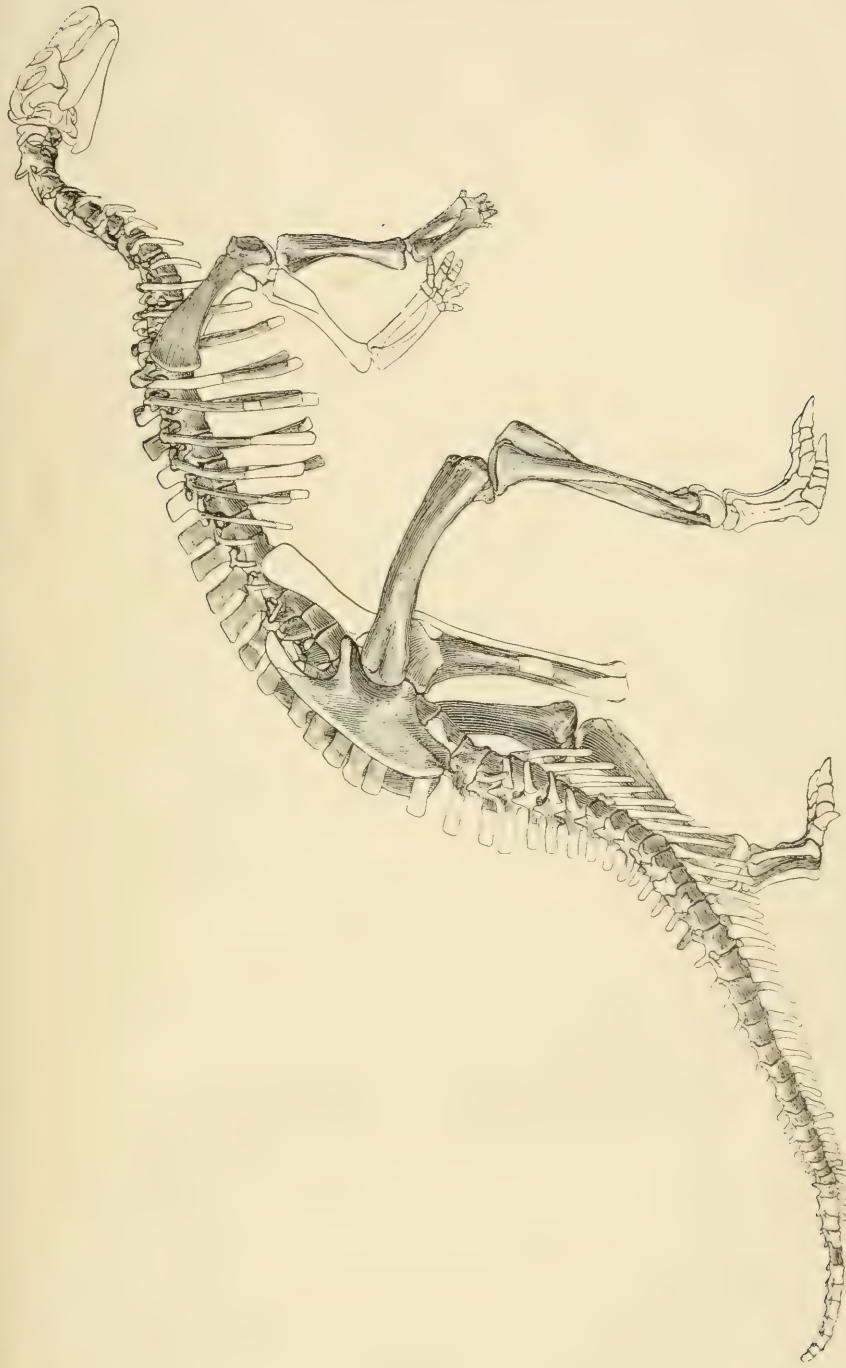
MOUNTED SKELETON OF CAMPTOSAURUS NANUS.

FOR EXPLANATION OF PLATE SEE PAGE 696.



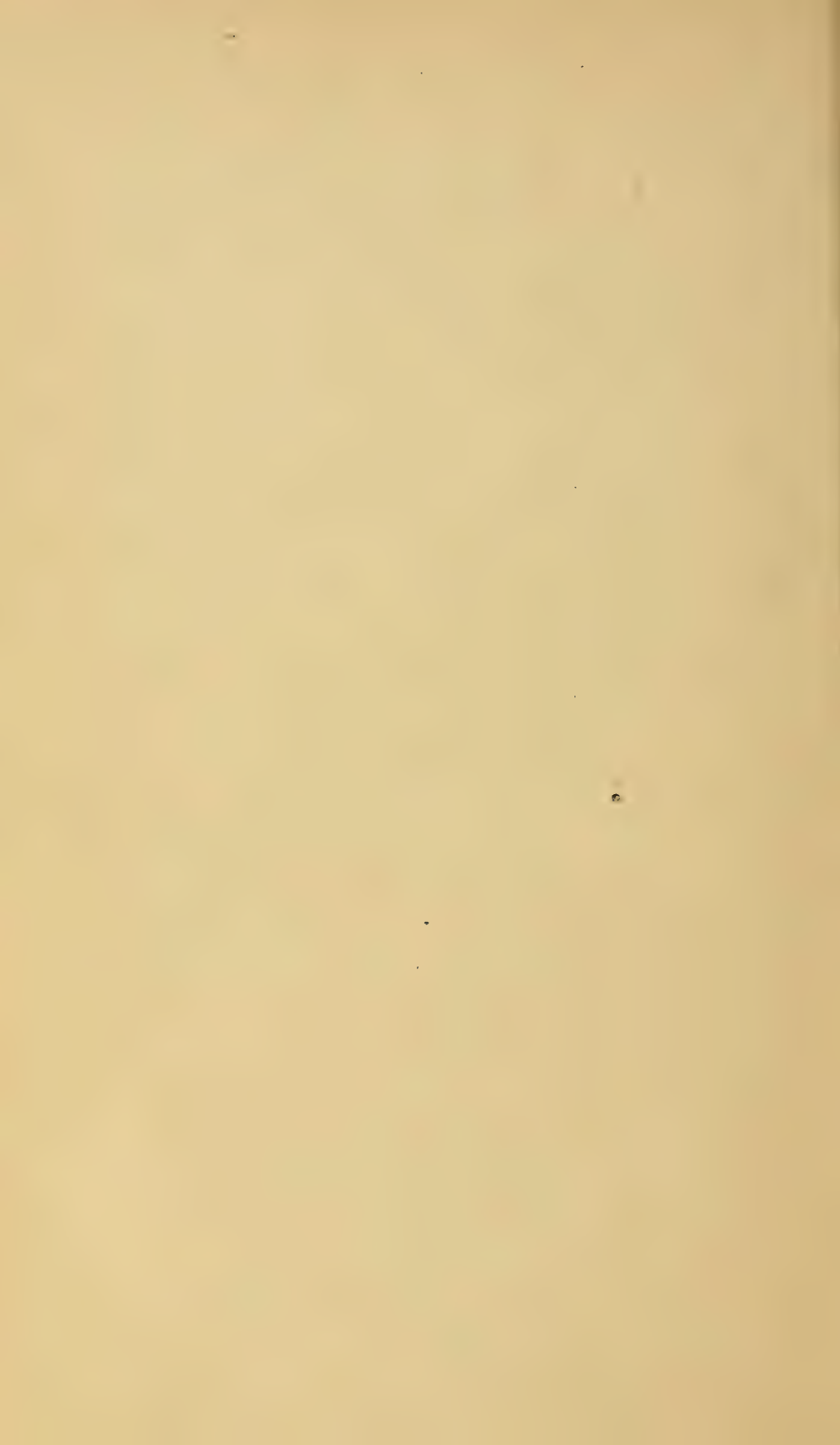
MOUNTED SKELETON OF CAMPTOSAURUS NANUS.

FOR EXPLANATION OF PLATE SEE PAGE 696.



SKELETON OF CAMPTOSAURUS NANUS.

FOR EXPLANATION OF PLATE SEE PAGE 696.



PRESERVATION OF OSSEOUS AND HORNY TISSUES.

By F. L. J. BOETTCHER,
Of Washington, District of Columbia.

INTRODUCTION.

During the winter of 1909-10 the large collection of hippopotamus skulls made by the Smithsonian African Expedition, under the direction of Col. Theodore Roosevelt, in British East Africa brought forcibly to notice the necessity of preventing the cracking, scaling, and rupture (at times explosive) of tusks, which within a month or two after their arrival often became badly disfigured.

Experiments for the accomplishment of the object soon showed the possibility of such a conservation. Acting upon the hypothesis that expansion and contraction are principally due to absorption and desiccation, a check to these, as complete as possible, seemed called for, and experiments were consequently conducted in accordance with such premises.

Under normal conditions during the life of the animal not even the enamel of the teeth shows signs of scaling. One and the same fluid permeates all their tissues, however different in density, chemical composition, and conductivity, forming one homogeneous unit, homogeneous to the active and normal forces of expansion and contraction.

To preserve natural objects successfully it is necessary to imitate the conservative forces of nature and meet their imperative demands. We must restore the homogeneity lost by desiccation, and to do so fully and permanently a medium must be found that will be sufficiently fluid to enter the most delicate capillaries and also sufficiently indestructible to resist normal chemical atmospheric changes, such as are likely to be found in a museum.

Various substances for this purpose have been considered. The retention of fats and of animal matter in skulls and bones, for example; the infiltration of oils, of glue, of shellac; but not one of these is satisfactory when one comes to consider its resistance to chemical changes or its ability to completely exclude the air.

Since it is the oxygen of the atmosphere and the accidental acids in the latter that attack the more complex molecules of matter, acting the more intensely the greater the humidity of the atmosphere, our aim, for the purpose of preservation, should be absolute exclusion of air and moisture. This atmospheric attack, combustion, or destructive metabolism, however it may be called, begins in organic life with the formation of the first cell and does not end until the last particle of bone has been disintegrated and oxidized into its component oxides. This is the course of nature, whatever the length of time, be it a few weeks or a million years. Silicification and carbonization as well as a complete replacement by calcium carbonate will, for the purpose of preservation, probably be always out of question. Infiltration of fluid calcium carbonate would be very slow and would probably change the external form while filling by accretion the cavities and capillaries, within and without, proving this method to be wholly unreliable.

There remains, therefore, as far as can be ascertained at the present time, only the one method, and that is the exclusion of air and humidity, and with it the forces of expansion and contraction. When life or vital forces no longer offset destructive metabolism, the latter will continue unchecked so long as external conditions promote the process. The same atmospheric air that consumes the worn-out tissues to furnish heat will continue to do so when heat is no longer necessary. As it is desirable to preserve museum specimens, our aim must be to check this combustion by the exclusion of the fuel necessary for its support.

That exclusion of air is an absolute preservative has been proven by the thousands of perfectly preserved insects and other animal inclusions in amber that have stood the test of thousands, if not of millions, of years. Of all the substances known and considered so far for the purpose of preserving bones and teeth not one is free from objections, not one even produces absolute homogeneity or absolutely excludes the air.

Among the expedients considered is the method of leaving within the bone a part of its organic and fatty substance as a preservative, a method that at first gives a better appearance as well as a substantiality to the delicate portions that are not evident when the full amount (50 per cent) of organic matter is withdrawn.

This might be satisfactory if it were possible to guard against changes of temperature and the entrance of air and moisture. This organic tissue within the pores of the bone, honeycombed (microscopically) by the taxidermic processes of treatment, offers ready admission to air and moisture, and as soaps or alkaline oxides, carbonates or borates, whatever may have been used, add nothing preservative in place of the substances removed, but rather assist

in removing bone tissue, it becomes quite evident that a core or skeleton of such material can not be long-lived.

If it is undesirable to leave organic tissue within the bone unprotected, it is still more so if fats remain there. In cleaning the same the process is one of saponification. Now, rancidity is partial saponification, whereby strong-smelling fatty acids have been set free. These fatty acids are unsaturated molecules and at once attack the lime salts of the bone, forming lime soap, so often observed in the use of hard waters. The bone is in a state of dry rot. The retention, therefore, of fats in the bone during cleaning, or the infiltration of similar easily decomposing substances, instead of being an advantage would soon lead to disaster.

Another point to be considered is the following: The greater the amount of animal matter retained the less will be space for the preservative to penetrate, and the thinner, therefore, the crust of the latter, the sooner it will be broken by the gases of decomposition formed within and destroyed through the entering air and moisture.

White shellac has been recommended as another preventative. Shellac, to be sufficiently fluid, must be dissolved in at least 10 times its volume of alcohol. This solution does not undergo any chemical change and contains, therefore, one molecule of unchanged shellac to every 10 molecules of unchanged alcohol. If we now suppose that an object such as a tusk or a bone had absorbed a sufficient quantity and then had been removed from the bath, the drying or hardening would begin at once on the exterior. Of this outside or superficial layer nearly 91 per cent would escape as alcohol, while the remaining 9 per cent of shellac would be attracted and adhere to its like in the next molecular surface below. This escape of alcohol and adhesion of the shellac molecules would continue until a pellicle was formed, continuous around the object if the porosity were microscopic, or continuous with the sinuosities or depressions if more coarsely porous. This pellicle would not prevent the evaporation of the underlying mixture of alcohol and shellac; indeed, it hardly retards it. It is simply a covering of loosely cohering plates, irregular and greatly disrupted, with air spaces greater than the solid material, and necessarily so, because as the evaporation proceeds inward the outside material grows firmer and more unyielding, thus leaving a loosely spongy mass even under the most favorable conditions. The evaporating molecules of alcohol need and find a vent from the innermost capillaries through all the successive layers of shellac varnish. It is certain that the pellicle always gives passage to the solvent beneath and that in such a case as the one here mentioned the shellac remaining behind is only one-eleventh of the material absorbed by the object. It is, moreover, very probable that the shellac has too much of a colloidal nature to even reach

the capillaries. What has been said of shellac applies equally well to all the colloids.

The same is true also of a varnish applied to a painting. It is a colloid substance inflated by a volatile liquid. The latter evaporates and leaves a thin porous crust of gum spread over the painting, uniting more or less with each superficial granule of pigment of the painting, which itself is a more or less porous layer on a ground composed of whiting and one of the ochers, united by a colloid. This in turn is necessarily porous, and is spread upon a very coarse, porous linen. Each layer penetrates and takes hold of the layer below. The porosity of such a varnish is proved by the dark tints of oxidation which it presents after the lapse of time and which are continuous throughout the thickness of the layer of varnish. It is further proven by the occasional oxidation of the oils used in the painting below the varnish, and the chemical change of the lead pigments into sulphides by the action of the sulphur dioxide contained in the contaminated atmosphere—all circumstances that make the restoration of a masterpiece a matter of great difficulty.

The use of gums and resins, or in fact any material that has a colloidal tendency, is wholly out of the question where absolute exclusion of air is demanded. Shellac is, however, a most excellent binder of decaying substances, and though the solution may not prevent air and moisture from penetrating, it is indispensable as a building or binding material.

The production of homogeneity would demand the infiltration of substances that would entirely fill up the interstitial spaces at ordinary temperatures and be as fluent as turpentine or benzine, so as to penetrate the most delicate capillaries. They should at the same time retain, if possible, some degree of firmness. To gain these qualities we are obliged to have recourse to various waxes, bitumens, or paraffins of the higher marsh-gas series. Stearin consists of stearic acid and glycerin and contains an unsaturated molecule that can not be depended upon.

Paraffin, as is well known, is fluid when heated, and will penetrate or dialyse, as it were, almost if not quite as readily as do lower members of the series, such as kerosene or benzine even when cold. The reason of this is that paraffin, according to Berlinerblau, contains as impurities products of the lower series, especially of a lower melting point, which, evaporating at or below 100° C., will work their way as vapor rapidly through the most delicate capillaries, then condense more or less upon the walls of the latter, and furnish points of attraction for products of a higher melting point, until finally the more slowly moving product of the highest point has penetrated the most deeply seated capillaries. The greater the volatility the greater also the diffusibility and power of penetration, and, on the con-

trary, the more a fluid approaches a colloidal condition the less it will penetrate.

Paraffin is not a perfect material for the preservation of objects, but it approaches perfection more nearly than any other substance known. It has the fault, however, of contracting upon cooling, and this contraction amounts to 14 per cent. Whenever an object has absorbed to saturation a fluid at 100° C., each capillary, at ordinary temperatures, will contain only 86 per cent of solid paraffin, crystallized, and 14 per cent interstitial spaces. These spaces may contain, besides the lower members of the series, also impurities, air, or even oxygen, according to Lippmann and Hawliczek, which has penetrated successively inward as contraction takes place, gradually following the cooling process. It is to be observed, however, that in a capillary or larger vessel the wall, rather than the intercellular lumen, attracts the layer. The slide test will prove this. Paraffin allowed to cool between a clean, dry slide and a cover glass will show a matted mass of fatty crystals arising from, or adhering to, a thin layer of the same on each glass.

Air, then, will filter through and approach the material which is to be protected, but does not reach it. These crystals act as a filter, like the cotton wad in a culture tube, only more thoroughly and on a more extended scale.

There is one danger, however, that is greater than the preceding. When by progressive inward cooling an inhalation of air takes place, impurities such as spores of fungi and bacteria may also penetrate one or two layers of crystals, and thus become embedded in the surface of the paraffin. These, if conditions are favorable, may attract moisture from the atmosphere, and according to Dr. O. Rahn,¹ grow and decompose the paraffin. If, as the above authority claims, paraffins of a lower melting point form better media for such growth than those of a higher melting point, the reason may be found in the more porous condition of the external layers owing to the greater evaporation of the lower series occurring as impurities in the grades of paraffins used. The growth of species of *Penicillium* and *Aspergillus* on the paraffin of fruit jars can be easily explained by the fact that the porosity of the crystallized paraffins, as well as the expansion and contraction of the preserved material closely below the paraffin, even if the latter does not become detached from the sides of the jar by this movement, causes an alternate pressure of liquid outward or a suction of spore-laden air inward, and the conditions for a growth of fungus are perfect, provided the layer of paraffin is not too thick. If it be too thick no mold will form, but the air will enter and cause a more or less advanced state of vinous fermentation.

¹ Centralbl. Bakt., Abth. 2, Jena. 1906, vol. 16, p. 382.

An interesting experience of this kind was observed at the writer's home in some jars of preserved pineapple, which had been covered after cooling by a layer of paraffin three-eighths of an inch thick, and by a double sheet of commercial paraffin paper, tied securely over the same. After the lapse of three or four months a jar was opened and it was found to have changed into a well-flavored wine. The air had filtered through the three different layers and caused a slow fermentation, resulting in pressure sufficient to squeeze a part of the fermenting liquid through the layer of paraffin and evaporate the same to such a degree that the remainder stood nearly one inch below the layer of paraffin, which, with all this powerful pressure from below, had held its place in all the jars of preserves. Part of the juice, or wine, which had been pressed through still stood on the top of the paraffin, furnishing proof of that action.

Berlinerblau considers paraffin as "highly resistant to chemical influences" and that it can be attacked only by strong reagents at high temperatures. Therefore, in spite of its contraction, crystallization, and other imperfections, including the possibility of decomposition by molds or bacteria, and in spite of the darkening effect and the greasy touch, paraffin is at present the only substance that approaches in any considerable degree the conditions necessary for a perfect medium for the preservation of organic substances, such as teeth, bones, etc. Still this substance can be employed successfully only in case it has been infiltrated in its pure and uncombined state at a sufficiently high temperature.

Paraffin has been infiltrated into shells in a chloroform solution, but as this, according to Pawlowski and Filemonowicz, means only 2.42 parts of paraffin in 97.58 parts of chloroform, the amount that reaches the interior capillaries, even if the material (owing to its viscosity) should penetrate so far, which is more than doubtful, would be only 2.42 per cent paraffin and 97.58 per cent air space after the escape of the chloroform. The slight benefit derived from so small an amount infiltrated is, however, increased to some extent by rubbing the shells and crushing the crystals, thus forcing them into the pores, thus forming an impervious coating on the outside of the shell. Carbon bisulphide and ligroin give better results. They absorb, according to the above-named authors, respectively, 13.16, and 10.76 per cent. Such a polishing process (without chloroform) on a somewhat thicker layer of paraffin on fruit jars might also solve the problem of excluding the air in the case of preserving.

An advantage not to be underestimated is the prevention of animal depredations on the objects treated. Paraffin is not absolutely innocuous. Its toxicity, even laetal, has been proven in numerous cases, and if the poisonous quality is due to chance ingredients in paraffin,

which can not be regarded as a chemical entity, the fact is not established. Kerosene, which differs from it only in the lower boiling point, is a recognized household insecticide. The fact that *Ascarides* and *Taenia serrata* are not affected by it does not disprove its poisonous qualities.

Experiments on herbarium specimens show an increase of flexibility, obtained by soaking in paraffin. The specimens are less brittle, will stand rougher handling, do not need to be poisoned and make a better appearance, although they lose their characteristic texture, which is often necessary in their determination.

WORKING METHODS.

The methods to be pursued in preserving osteological specimens necessarily vary according to their size, thickness, and purpose. If the object is merely to prevent cracking during prolonged overland transport, as in the case of tusks in Africa, it may suffice to carefully pour the melted paraffin of 80° to 90° C. into the open end of the tusk previously heated. In employing this process any sudden change of temperature should be avoided. After allowing the tusk to absorb the paraffin for a few minutes, the surplus material should be poured off. The outside of the tusk may then be treated with a benzine solution of paraffin, which should be well rubbed over every part of the surface, using as much as the same will absorb while exposed to the heat of the sun. If this has been well attended to, there is not much danger of longitudinal cracking, so undesirable in ivory intended for miniature painting, although it must be remembered at the same time the slow desiccation and gradual contraction are not checked altogether because of the tendency of the paraffin to liquify more or less in the heat of the sun during the day and to recrystallize as the temperature declines. This method will prove very satisfactory for tusks intended for industrial purposes, as it is undesirable to have the paraffin penetrate deeply.

If the purpose in view is permanent preservation, a large boiler of a sufficient size to allow the object to be immersed completely is heated in a water bath. In this boiler the object to be preserved is suspended by a wire from an hour or two for small skulls, such as those of rats and mice, to a week or more for tusks of a hippotamus. The heat in the experiments here described was turned on at 9 o'clock in the morning and turned off at half past 4 in the afternoon, and this alternation of heat and cold, in my opinion, proved beneficial, though at present I am not prepared to prove it.

To allow bubbles of air to escape from cul-de-sac hollows in the skulls, they were frequently shifted to different positions. When fully saturated, that is, when after long observation no more bub-

bles are found breaking above the object, it may be withdrawn from the paraffin and drained in various positions in the heat immediately above the surface of the paraffin. If too much paraffin has been removed, a rapid dip in the hot liquid, and subsequent draining in a hot place, or a rub, will quickly restore the deficiency.

Mr. G. S. Miller, in experimenting with weathered skulls, found that in five minutes—until bubbling ceased—the specimen had increased one-fifth in added substance and solidity to the fragile specimen.

NOTE.

Having after the lapse of 18 months reexamined 23 specimens treated in accordance with the foregoing method, I found:

First, that the tusks and some of the skulls were seriously disfigured by dust, but that a soft rag moistened with benzine restored the original color absolutely, a treatment that could only act beneficially to the specimens inasmuch as any chance outlet for decomposition gases is closed by this process.

Second, all the specimens examined were, without exception, intact. Not the faintest sign of disintegration was observable. This is nothing more than was to be expected. Paraffin from its very name, *parum affine*, denoting its chemical stability, neither attacks the calcium salts of the bone proper, nor does it permit its oxidation by the air, nor that of the animal matter still inclosed. Although the inevitable disorder connected with the transfer of specimens from one building to another subjected them to more than ordinary vicissitudes, there was, aside from dust, no damage apparent.

An interesting specimen well depicting the difference between a skull treated with paraffin and a jaw in its natural state is that of a leopard (Cat. No. 162927, U.S.N.M.), which was found on the ground in a considerably weathered condition. Here the jaw, with its countless cracks and crevices, worn more or less deep, with the bone surface here and there chipped off, exposing more and more the looser stratum within, and particularly the ragged, broken teeth, offers striking testimony in favor of the treatment.

The success being complete, it is not probable that an increase of the number of test specimens would have materially modified the results, especially as the experiment covered practically the whole ground of variation in size, condition, and age.

Another fact deserving attention is the displacement of animal matter and fats by paraffin. This vitiates the material infiltrated and impairs its stability. If rhigoline, petroleum ether, or benzine were used as a preliminary detergent, this waste of material would be obviated, since these can easily be distilled off from their impurities and used over again.

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