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The present volume is the hundred and second of this series.

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Remington Kellogg,
Director, U. S. National Museum.

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PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM

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CONTRIBUTIONS TO THE MORPHOLOGY AND TAXONOMY OF THE BRANCHIOPODA NOTOSTRACA, WITH SPECIAL REFERENCE TO THE NORTH AMERICAN SPECIES

By Folke Linder

INTRODUCTION

Since the days when Packard's "Monograph of the Phyllopod Crustacea of North America" was published (1883), the accessible material of notostracans has grown considerably, and the principles commonly used for the taxonomy have been discussed in several papers. Analyses of these characters, especially by Braem (1893), Gurney (1923, 1924), Sidorov (1927), Barnard (1929), and Gauthier (1934), have established a considerable variation in most of the characters of European, Asiatic, and African forms. This variation, of course, does not make a survey of the Notostraca of North America an easy task, and when I venture such a survey here, I wish to note that in some respects it is tentative only. It is based mainly upon a study of the collections of the U. S. National Museum, amounting to 109 lots and considerably more than 2,000 specimens. This study was performed during a 3 months' visit to the Museum in 1946, and was made possible by a grant from the Smithsonian Institution, to which my thanks are due for this generous support. I am also greatly indebted to Dr. Waldo L. Schmitt and other officials of the Museum for having most kindly facilitated my work. Also, Prof. J. E. Lynch, University of Washington, Seattle, kindly allowed me to examine some important material from the northwestern United States. For comparison I had specimens from other parts of the world, though this material, about 3,000 specimens from 71 localities, has not been as comprehensive as could be desired.

Gurney (1924, p. 559) says about the taxonomy of the Notostraca, "The separation of species within the genera *Apus* and *Lepidurus* is a matter of quite unusual difficulty, since there is much variation, and, as a rule, the only characters on which separation can be based are small and ill-defined." Barnard (1929, p. 230) agrees with him, and so do I.

As for other phyllopods, the females of the Anostraca present a similar difficulty, as, sometimes, if they occur without males, it is not even possible to say with certainty to what family they belong. But the males of this order give excellent specific characters in the genital organs and the second antennae—organs which display a striking uniformity in the Notostraca. In the Conchostraca, the structure of the head and the carapace provides rather good specific characters, but in these respects, too, the Notostraca are fairly consistent.

The characters actually employed—helpfully reviewed by Barnard (1929, pp. 230–234)—for the most part represent differences of degree only. A striking example of this is Packard's (1883, p. 319) key to the American species of *Apus;* a study of the type specimens of the species involved immediately reveals that the number of spines on the supra-anal plate, which seems to be the fixed point in this key, is not constant but overlaps the boundaries between his species. According to my experience, one seldom finds a specimen which is in complete accordance with the description of any of these species, and similar difficulties are met even when one goes to the type specimens. These are not numerous enough to cover the range of individual variation, nor are their descriptions extensive enough. Yet such variation is especially important when the characters involve differences of degree.

Of course, one can often compare material from neighboring localities in order to learn something of this variation, or, better still, one can try to get abundant material from the original locality. The first course is generally the only one practicable in museum work, and I have tried it here. It is not very satisfactory, though some results seem to be obtainable in this way.

Each sample of Notostraca ought to contain about 50 or more specimens in order to cover most of the variation. And, in my opinion, a new species should never be described from less than 100 specimens from the same district, preferably taken at varying times of the season. Paratypes are, in many respects, just as important as holotypes.

A special question arises when we try to interpret the variation. Ghighi (1924) suggests that the variation may sometimes be due to the presence of two species in the same pool. I think that this occurs only rarely, as in the Anostraca and in the Conchostraca, and if it should happen to occur in a particular sample, the fact would probably be readily revealed when all characters are considered. I have not found any indications of mixed populations in this sense in the samples I have examined, nor can I find any definite reference to it in the literature, with the exception that Lundblad (1920) noted that species of different genera sometimes have been found in the same pool. In these cases no intermediate forms are reported.

So far, I have considered only specific characters. Sidorov (1927) and Gauthier (1934) are convinced that there are geographical subspecies within *Apus cancriformis* of the Old World. I do not deny the possibility that there may be such taxonomic units in some North American species, most likely among the forms of *Apus*. Among the anostracans, which have similar habits, I have found some indications of geographical subspeciation in forms of the genera *Branchipus* and *Tanymastix* of the Old World. Smirnov (1931) seems to be of similar opinion with regard to some conchostracans.

However, I do not find it possible to separate geographical units out of the material to which I have had access. In my opinion the appropriate way of doing this would be to investigate thoroughly some limited areas, and to follow this with a comparison of samples from interspersed districts. The possible existence of clines (Huxley, 1942, and Margalef, 1948) might also be traced in this way.

During my work it appeared that a species from Asia and Europe, *Lepidurus macrurus*, is a synonym of the American species *L. couesii*. Further, I found that South American forms of *Apus* are the same species as the North American *Apus longicaudatus*. This may be significant. It is worth noting that no one since the days of Packard (1883) and Simon (1886) has tried to compare species from all over the world, and, with our present knowledge of the great latitude in variation of many characters, it does not seem at all improbable that additional species from different continents will be found synonymous.

The present tendency to reduce the number of species in the Notostraca (see Gurney, 1924, and Barnard, 1929) is, I think, sound, and is well supported by our present knowledge of variation. This paper follows the same line.

In the following pages I have tried to analyze, with the help of material from all continents, the commonly used taxonomic characters and, also, a character which has been very much neglected, the number of body-rings of different kinds. This character has proved quite useful. One of the results is a new grouping of the species of *Lepidurus* into what seems to be two natural groups; another, that lower taxonomic units begin to be revealed among parthenogenetic populations, although the real status of these cannot be determined from the accessible material. In connection with this analysis I have also considered polypody, and the peculiar phenomenon I have called spiral growth, both of which are problems of interest from a more strictly morphological point of view. Finally, I have applied to the North American material the results of this analysis of taxonomic characters.

TERMINOLOGY AND MEASUREMENTS

Instead of the term "segment," in referring to the postmaxillary part of the animal, I prefer the term "body-ring." The first 11 body-rings I call the thorax. This is followed by the abdomen, which is comprised of leg-bearing body-rings, legless body-rings, and the telson, which is not a true segment, and which should not be included in the number of body-rings. The series of legs does not always stop underneath a boundary between two body-rings; it may stop at any place quite independent of these boundaries (fig. 20). I have found it advisable to count half leg-bearing body-rings in those cases where the series stops approximately underneath the center of a ring, and a whole leg-bearing ring when the series covers almost the whole ring, disregarding those cases where the series only slightly surpasses a boundary. Incomplete rings (fig. 16) are often found at the anterior boundary of the telson, but very rarely within the series of rings.

It is useful to have a short formula when describing the numbers of the various kinds of body-rings in a specimen or in a species. In this paper, I have used such an arrangement. Thus, the formula $11+12+5=28$ body-rings indicates that there are 11 thoracic, 12 abdominal leg-bearing, and 5 abdominal legless rings, forming a total number of 28 rings (telson not included). For a species the formula is more complicated because there is a considerable variation of these numbers within the limits of a species (Linder, 1947). If the abdominal leg-bearing rings number from 16 to 18.5, the legless rings from 5 to 10, and the total from 35 to 38 rings, the formula would be, $11+(16–18.5)+(5–10)=35–38$ body-rings. If there is an incomplete ring, the abbreviation "i" is inserted, as in this example: $11+12+5+i=28+i$ body-rings. It is also possible to indicate the presence of the interesting abnormality, spiral growth, and its place within the series. If a spiral of 3 rounds appears after the 25th body-ring, immediately followed by the telson, in a specimen with 12 abdominal leg-bearing rings, the formula would run as follows: $11+12+2+\text{sp.3r.}=25+\text{sp.3r.}$

The telson bears a rather neglected structure, viz, a pair of dorsal sensory setae (fig. 28), surrounded by short spines, and a pair of caudal filaments. Between the latter there is, in the genus *Lepidurus,* the supra-anal plate. I measure the length of this plate from the most anterior point of the basis of the caudal filaments to its apex.

As Barnard (1929) and Sømme (1934) have pointed out, the total length of an animal cannot be measured with proper accuracy in preserved material. The reason is simple enough. Anteriorly and posteriorly, the integument of a ring is much softer than in the central part. This soft integument may form a fold directed inward and forward, and in such cases the rings appear short and the total length of the animal is relatively short, too. But other specimens from the same lot, which have a carapace of similar length, may show no deep fold in these places, the soft integument being more or less stretched out between the more highly chitinized parts of the rings (fig. 1). In

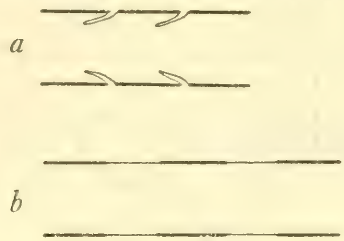

Figure 1.—Schematic diagram of the body-rings of a notostracan showing how the length is influenced by varying contraction. Highly chitinized parts of the integument indicated by heavy lines. *a*, Contracted; *b*, extended.

the latter case, of course, the rings appear longer and the total length of the animal may be considerably greater than in the former cases. It is quite usual to meet with both extremes and a more or less continuous series of intermediate cases in a lot containing a large number of specimens, as they may have been fixed in varying stages of contraction. Rosenberg (1947) noticed a considerable shrinking of the specimens when they were placed in preservation fluid. It is also obvious that preservation, after an indeterminable time, weakens the soft tissue in and between the body-rings and thus causes a lengthening of the body to a variable degree. In very old material maceration (and lengthening) may have gone rather far. It is, however, desirable to give an idea of the length even if it cannot be accurately stated. I measure the length on the midline from the apex of the head to the base of the caudal filaments. Thus, in *Lepidurus*, the length of the supra-anal plate is not included in the figure of the total length. This may seem a little odd, but in this way comparable figures for *Lepidurus* and *Apus* are obtained. The length of the supra-anal plate in the former genus may be up to 44 percent of the length of the carapace, and thus it would be quite misleading to include this plate, which has no counterpart within the genus *Apus*.

Barnard (1929) also points out that we cannot give an accurate count of the body-rings exposed behind the carapace. In order to give some, even if not an accurate, idea of this conspicuous feature I have mentioned the number in some specimens. But I give this number, as well as the figures of the total length, only with a stated reservation as to its accuracy.

As Sømme (1934) has shown for *Lepidurus arcticus*, the carapace is little affected by the preservation fluid and thus can give an idea of the size of the animal. This is only natural, because it is continuously and highly chitinized. Following the general custom, I measure its length along the mid-dorsal line. Of course, we cannot be sure that variations in this figure closely follow the variations of the real total length of the body; the relation may vary according to varying ages of the specimens, to say nothing of the varying contraction. To obtain the greatest width of the carapace, the usual method seems to have been to measure it in a straight line. This is not reasonably accurate, because the height of the carapace may vary, sometimes to a considerable degree. It is better to measure the greatest width from the carina to both sides (fig. 2). In cases of

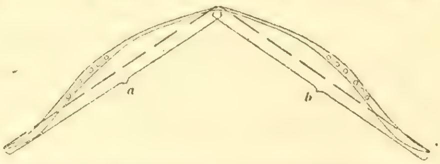

Figure 2.—Cross section of the carapace of a notostracan, showing how the width of the carapace is measured.

distortion, I have flattened the carapace to a shape similar to normal appearance before taking the measurement.

I count 5 endites on each leg (fig. 26). The coxal lobe is the first endite; it is essentially similar to the other endites in the arrangement of the setae and has on its margin similar small elevations covered with small needlelike structures. What Packard (1883) calls the sixth endite is quite dissimilar to the more basal, real endites; it has only a single row of setae and spines along its margin, and no trace of the small elevations mentioned above; I call it the endopodite, as many other authors do. Packard's "flabellum" is the exopodite, and his "gill" is called epipodite in this paper. Further, we sometimes find what may be the vestige of a preepipodite (fig. 22) in the form of a small elevation with a few setae (cf. Eriksson, 1934, p. 236).

Specimens from the following museums were examined:

Muséum National d'Histoire Naturelle, Paris (Paris Mus.).
Naturhistoriska Riksmuseet, Stockholm (Stockholm Mus.).
Zoologiska Museet, Kungl. Universitetet, Uppsala (Uppsala Mus.).
United States National Museum, Washington (U.S.N.M.).

BODY-RINGS AND POLYPODY

Following the usual custom, I consider the body proper to begin with the first postmaxillary ring, which is, however, strictly separated from the head only on the ventral side. Packard (1883) counts the first ten body-rings as the thorax, and the following ones as the abdomen. I include the eleventh body-ring in the thorax, as does Simon (1886) in his important revision of the phyllopods and as Sars does in his many descriptions of various notostracans. More than a hundred years ago Zaddach (1841) showed, in an admirable work now almost neglected, that the first 11 body-rings are essentially similar to each other in the equipment of muscles, while the following ones differ quite considerably from them. Further, the legs of this portion are different, though the boundary in this respect is usually not distinct. A boundary between different regions in this location is recognized in crustaceans of many orders—so many, in fact, that it is not likely to be a mere coincidence (Linder, 1941, p. 113).

I have abandoned the use of the term "segment," replacing it with the term "body-ring," when real rings or parts of rings are concerned. I do this for the reason that in the abdomen there are no complete, ordinary segments but two series of parts of segments, in some respects independent of each other—the series of rings and the series of legs. These are united to form a composite structure unique in appearance. This is the true meaning of the much discussed phenomenon, polypody. It is not an absolutely new view. Lankester (1904) expressed a similar view, but did not give evidence for his opinion. However, Zaddach (1841) had already supplied much evidence supporting that opinion, and the following facts, most of which have not been noticed by earlier authors, may give additional evidence:

1. The series of legs covers a varying number of body-rings in specimens from one locality. Zaddach (1841) has given an example of this. He also regards the number of pairs of legs as fixed; however, I have found that this number is subject to a considerable variation. The series of legs may stop at any place under a body-ring (fig. 20). If we choose a certain pair of legs in the caudal part of the series of legs, and determine its place under the series of body-rings, we shall find that it has varying positions in various specimens from the same locality (see table 2, p. 42). Thus, each body-ring in the abdomen does not have a fixed number of pairs of legs, and this means that there is no evident correlation, as is supposed by most authors, between the series of legs and the series of abdominal body-rings. Evidence for this fact from extra-American material is given in an earlier paper (Linder, 1947).

2. The boundaries between the body-rings in the leg-bearing part of the abdomen do not continue ventrally. They stop at a longitudi-

nal boundary, always well marked and often formed as a ridge in the integument (fig. 20), which delimits the leg-bearing area. This area may be divided into "segments" coinciding with the legs but totally independent of the boundaries between the body-rings. Zaddach (1841) has already described the ventral "segmentation" and the corresponding division of the longitudinal muscles in this area in *Apus cancriformis*.

3. In two cases of abnormal growth of the body-rings that I have found, the series of legs is not affected by the abnormal turns, or spiral growth, of the related body-rings (fig. 17).

The first two points hold good for each of the species of Notostraca that I have examined, though some of the details may be difficult to observe in specimens which have just molted or are badly preserved.

It is a well-known fact that the rate of production of new body-rings (in early postembryonic stages) is quite different from that of the legs, with their muscles and nerve-cord ganglions. From the caudal end of the series of legs there are produced, at an almost frantic rate and in considerable number, the elements of the leg-bearing area, but the body-rings, budding from the anterior margin of the telson, increase in number relatively slowly. The body-rings do not vary much in size, but the elements of the leg-bearing area grow smaller and smaller caudally, as if the animal meets the frantic activity of this part with something like starvation of its individual elements. We might assume a kind of organizer at the end of the series of legs (for what else could we assume?) that is, in some way or other, less favored than the ordinary organizers at the anterior boundary of the telson.

I have noticed in many specimens that this disproportionate development has continued during the further growth of the animal. Thus, we often notice that in a larger animal the series of legs covers a smaller number of body-rings than is the case in a smaller animal in the same lot (see table 2), indicating that the size of the body-rings, but not necessarily their number, increases faster than does the series of legs. Other facts also point to this conclusion: an oblique striation occurring at the area where the body-rings and the series of legs meet, explained as the mark of a tension between the two parts as they grow at dissimilar rates; and the moving forward of the fiftieth pair of legs, as observed in table 2 (we note that this moving forward does not exactly follow the changes in size, but individual variation in these complicated processes is to be expected).

NUMBER OF BODY-RINGS

It seems to be the rule that neither the total number of rings nor the number of abdominal leg-bearing rings is given in descriptions of North American Notostraca. There are few exceptions to this rule. Packard (1883) mentions the figures for one specimen of *Apus lucasanus* and Rosenberg (1947) quotes fixed figures characteristic of his species *A. oryzaphagus* and *A. biggsi*. The number of legless rings, on the other hand, is almost always recorded, and a slight variation in this respect is often noticed. Interesting information about *Lepidurus arcticus* is given, though only with some hesitation, by Chamberlin and Duncan (1924, p. 99): "The number of segments visible on the dorsal surface from the point of attachment of the carapace to the body seems to be either 26 or 27. . . . Behind the appendage bearing segments are five others, exclusive of the telson, which are without appendages of any sort." As the above-mentioned point of attachment stretches over the first body-ring, we may conclude that these authors found the number of body-rings to be $11+(11\text{–}12)+5=27\text{–}28$ (telson not counted).

Even in descriptions of species from other parts of the world we seldom get information about the number of leg-bearing abdominal rings; at times a fixed total number is given, together with the number of legless rings, but without any attention to a possible variation of the former figure. Zaddach (1841) provides an exception; he says that in *A. cancriformis* the number of leg-bearing abdominal rings (in "pars abdominis posterior," according to Zaddach) is 17 or 18, the number of legless rings 5 or 6, and the total number of body rings always 34.

All authors except Chamberlin and Duncan seem to take it for granted that the species of Notostraca are nomomeristic, but this is not true of any of the species examined by me.

From figures 14 and 31 it can be seen that a variation in number is found not only in the legless rings, but in the leg-bearing ones, too. These varying numbers, together with the 11 thoracic rings, are combined in different ways to give a total number varying within the limits of a species. This is true of every species of which I have seen a reasonable number of specimens.

When I now proceed to analyze what I have found concerning the variation of these figures—a preliminary analysis in some respects because the material is rather scanty—I shall begin, not in the traditional way, with a treatment of the legless rings, but with the total number of rings and the number of abdominal leg-bearing rings. These are the primary characters. The number of legless rings is not a simple character; it is the result of the varying interplay of the two other series.

As for the total number of body-rings, the range of variation may be quite considerable in specimens from the same locality. In a new species of *Lepidurus* from Grand Coulee, Wash. (see p 39), the males have 30–33+i and the females 30+i–34 rings (fig. 14). The range is also great in *A. longicaudatus* from Wyoming (U.S.N.M. No. 58766), where the males have 41–44 and the females 39+i–43 rings (fig. 31). These are relatively extensive samples, the former containing 54 males and 42 females, the latter 33 males and 98 females. In smaller samples the range of variation is not so great. The extremely high and low numbers of rings in one sample are usually represented by rather few specimens.

No doubt the average number differs in various samples of the same species. But we cannot reasonably compare samples with 1, 2, or 10 specimens with samples containing a hundred or more specimens. Small samples give very uncertain figures, and museum work, in this respect, is much hampered by the fact that the great majority of samples contain a very small number of specimens. Statistical calculations, however desirable, are thus rendered very difficult.

There seems to be a general rule that species with a large number of rings have a greater range of variation than species with few rings, both in *Lepidurus* and in *Apus*. There are some exceptions to this rule, but not many, in the material I have seen. The fewest rings in *Apus* occur in forms that have a clear parthenogenetic tendency and that show a very small range of variation. About these more will be said later on (see p. 12). Similar forms belonging to a group with relatively few body-rings are found among species of *Lepidurus*.

Body-rings in the species of *Lepidurus* range from 25 to 34, those of *Apus* from 30 to 44. In the former genus, the high numbers of 30–34 are represented by two species only, *L. bilobatus* and a new species described in this paper, both of which differ from the other species of the genus in the number of leg-bearing abdominal rings, and, most evidently, in the number of legs. Apart from this grouping, and from what has been mentioned about parthenogenetic forms, I cannot find clear correlations between the number of rings and other characters. I doubt the validity of Rosenberg's (1947) method of distinguishing taxonomic units—and not lesser units at that, but species—by associating a certain number of rings with a certain size of specimen, because I think that further research is necessary to establish the conditions of the variation in size, which in some lots is considerable, in others rather small.

It is usual for the males to have a higher total number of rings than the females of the same species, though the rule has many exceptions.

It is, of course, necessary to know whether the number of rings is really fixed in adult specimens—non-adult stages are not considered here—or whether it increases with an increase in size of the specimen. I have attacked this problem, which has never before been investigated, in two ways: first by comparing the number of rings in small and large specimens in the same sample, and second, by comparing the old and the new integument of specimens in molting. All my observations agree that there is no general rule that larger specimens have a higher total number of rings than smaller ones. On the contrary, I have not infrequently found relatively small specimens with a high number (see fig. 14). Also, I have thoroughly examined about a hundred molting specimens of various species, and in none of them have I found a new ring appearing from the telson in the underlying, new integument. Judging from this, I think I am entitled to assume a fixed total number of rings in an adult specimen.

As for the variation in the number of leg-bearing rings, I have found no clear rule when comparing larger and smaller specimens from the same lot. When examining molting specimens, however, I have found two cases where the number of pairs of legs is increased by one in the underlying, new integument. Thus we must reckon with the possibility of an increase in the number of legs, and, consequently, even a slight increase in the number of abdominal leg-bearing rings, with an increase in the size of the animal. However, I think we can be sure that this increase, if present, will not be great.

The usual range in the number of leg-bearing abdominal rings in the genus *Lepidurus* is 9.5–13. This applies to all extra-American species I have examined (*L. apus*, *L. kirkii*, *L. viridis*), and to most American species (*L. arcticus*, *L. packardi*, *L. couesii*). This condition, together with the similarly small number of legless rings, at least in some cases helps to explain the short abdomen commonly mentioned as a character separating *Lepidurus* from *Apus*. Packard (1883), however, mentions that *L. bilobatus* has an unusually long abdomen, with many body-rings exposed behind the carapace; and I found, when examining a specimen of this species marked "type" in the U. S. National Museum, that it has 16.5 leg-bearing abdominal rings. Further, in material consisting of more than a hundred specimens of a new species from the State of Washington, I found this number to be 14.5–18, while 12 specimens of a variety of this species had 16–17.5. Corresponding to the high number of leg-bearing abdominal rings we have a higher total number of body-rings here than in other species of the genus; there are more legs, and, generally, more rings exposed behind the carapace. In my opinion, these figures indicate that there are two groups of species within the genus *Lepidurus*, whatever the taxonomic category we choose for them.

In the American forms of *Apus*, the number of leg-bearing abdominal rings ranges between 16 and 21 (males 16–18.5, females 17.5–21). In one large lot I have seen every number in this range represented (see fig. 31). Usually, the females have more, sometimes many more, leg-bearing abdominal rings than the males of the same species.

The variation in the number of legless rings is often used as a taxonomic character. This appears to be a useful character in South African forms of *Apus* (Barnard, 1929), but in the North American forms I have not found it to be of much aid in separating species. In *Lepidurus*, the number varies within narrow limits (4–5.5 in the great majority of forms), with no specific differences corresponding to the differences in number; a few specimens having 3, 3.5, or 6 legless rings show no other essential differences. There is, of course, the possibility that *L. packardi* may have a high number and that this character may be of taxonomic importance, the type specimen having 6 legless rings. But I do not think this is probable. In two lots (5 specimens) that I consider belonging to this species I found 4.5–6 legless rings.

In *Apus*, the whole range in the American specimens I have seen is 4.5+i–13 in the females and 8–15+i in the males. It seems that this range of variation ought to be great enough to include several species (or subspecies, or forms) with varying ranges, and I will certainly not deny the possibility that lower taxonomic units than species may be separated. However, I have seen a single lot of *Apus* that covered much of this range (9+i–13 in the females and 12.5–15+i in the males, as shown in table 6). This is an extreme example, the range of variation being smaller in other samples, especially in those with only a few specimens.

As a rule, the males have more legless rings than the females of the same species because they usually have fewer leg-bearing rings but a higher total number of rings.

BODY-RINGS IN PARTHENOGENETIC POPULATIONS

It seems rather remarkable that an author like Zaddach (1841), extremely careful in so many details, gives a fixed number of 34 body-rings in *Apus cancriformis*. And Rosenberg (1947) definitely states that all specimens, several hundred in number, of his species *A. oryzaphagus* have 35 body-rings (36 including the telson, according to him). I have seen 6 of them (U.S.N.M. No. 88360) and found 5 to have 35 and 1 to have 34+i body-rings. Rosenberg describes another form, under the name of *A. biggsi*, where all specimens have 36 rings (37 including the telson), but here it seems uncertain whether he had enough specimens for comparison. I found 3 of them having 36 and 1 having 35+i rings (U.S.N.M. No. 88361). In these cases the statements of a fixed number may result from the counting of incomplete rings as ordinary rings. Even so, the range of variation is very small. A significant observation is that these authors had only females in their samples.

Populations without males, or with very few, have been known for a long time. A list of such cases in *A. cancriformis* from Europe is given by Gaschott (1928, p. 276), from whose paper the following examples may be cited: Schulze examined more than 1,000 specimens during 4 successive years from the vicinity of Dresden, Germany, and found no males; Siebold (1871) found only females among about 9,000 specimens from Franken, Germany, collected during the summers of 1857–1869, in the last 6 of which he tried to examine the whole population; less extensive samples without males (100–243 specimens) are reported from Munich and Erlangen, Germany, Prague, Czechoslovakia, and Pavia, Italy. Further proof of the existence of parthenogenesis in this species is given by Grasser (1933, pp. 319–320), who succeeded in rearing specimens from eggs laid in aquaria populated by females only. These females were taken from a population where no males were observed. Bisexual populations of the same species are also common (Gaschott, 1928).

Obviously, there are similar conditions in the American species *A. longicaudatus*. *A. oryzaphagus* and *A. biggsi* (Rosenberg, 1947) are probably parthenogenetic populations, and, on account of significant similarities with *A. longicaudatus*, ought to be included in this species (p. 64). Bisexual populations seem to be more common in this species than in *A. cancriformis*, and in them the males sometimes are almost as well represented as the females. In such populations there is a greater range of variation in the total number of body-rings.

I have seen a number of relatively extensive samples of *Lepidurus arcticus*, *L. apus*, *A. cancriformis*, and *A. longicaudatus* with no males. Even here, the variation in the total number of rings is always small. The following sample, a lot of 113 females of *L. arcticus* from Ooglamie, Alaska (U.S.N.M. No. 7903), is representative (no males were found in the sample):

Number of specimens	Series of body-rings
2	11+10.5+4.5+i=26+i
12	11+11 +4.i =26+i
2	11+10.5+5.5 =27
85	11+11 +5 =27
12	11+11.5+4.5 =27

Among these specimens the incomplete rings varied in size from a tiny piece to an almost complete ring. No correspondence with size, or with other characters, was observed in any of the groups. The specimens varied much in size. We find, also, that 99 specimens have 27 rings and 14 specimens 26+i rings. This is the whole variation in the total number, a striking contrast to the conditions in bisexual populations. If we count the incomplete rings as counterparts of whole rings we might say that the population is nomomeristic. But I will not go so far as that. We cannot say for certain how the incomplete rings are to be interpreted. In any case, this analysis shows that we must consider these structures. If they had not been counted here we would have obtained a wrong impression of the variation.

In small lots, of course, we shall not infrequently find all specimens to have the same number of rings. The largest lot in which I observed this fact is from St. Paul Island, Pribilof Group, and contains 20 females, all having 27 body-rings. The number of specimens is, however, too small to enable us to draw any conclusion.

A few specimens of *L. arcticus* with 26 or 28 rings have been observed by me, but only in samples with males. These, like the majority of those without males, contain only very few specimens, as may be seen from the following lot of 14 specimens of *L. arcticus* from Cambridge Bay, Canada (U.S.N.M. No. 180638):

Number of specimens	Sex	Series of body-rings
1	♀	11+10 +5 =26
2	♀	11+10.5+4.5 =26
1	♀	11+11 +5 =27
8	♀	11+11.5+4.5 =27
1	♀	11+11.5+4.5+i=27+i
1	♂	11+11 +5 =27

Of *L. apus*, I have had access only to samples with few specimens. A representative example is the following lot of 17 females from Malma at Uppsala, Sweden (Uppsala Museum) (no males were found in the sample):

Number of specimens	Series of body-rings
1	11+12 +4+i=27+i
1	11+12.5+4.5 =28
13	11+12 +5 =28
2	11+13 +5 =29

Here we probably have a parthenogenetic population, because males of this species have never been found in Sweden. The range of variation is greater than in the sample of *L. arcticus* from Alaska, but it is interesting to notice the predominant representation of specimens with 28 rings, 14 out of 17 having this number. Of course, many more specimens must be examined to get an idea of the variation in this species.

Of *A. cancriformis*, only samples with few specimens have been accessible. One of these is the following lot of 33 females from the vicinity of Skara, Sweden (Uppsala Museum). (No males were found in the sample):

Number of specimens	Series of body-rings
1	10+17 +5 =32
1	11+16.5+5.5 =33
26	11+17 +5 =33
1	11+17 +(sp. 2r.+3)=31+sp. 2r.
2	11+17 +5+i =33+i
1	11+17 +6 =34
1	11+18 +5+i =34+i

Of this species, also, no males have been found in Sweden, so it is fair to assume that the population is parthenogenetic.

The first specimen of *A. cancriformis* listed, with only 10 thoracic rings, is abnormal, the ninth, tenth, and eleventh pairs of legs coming from the ninth and tenth body rings, an interesting deviation, as it shows that the anterior boundary of the polypody sometimes can be displaced farther forward than the eleventh ring (it is a common occurrence to see it displaced backward). But, in the present case, I think we had better leave this aberrant specimen out of consideration. The specimen with spiral growth may be counted as having 33 rings, because the two rounds of a spiral probably represent two rings. Thus we have 28 specimens with 33 rings, 2 with 33+i, 1 with 34, and 1 with 34+i rings, which means a quite considerable predominance of specimens with 33 rings. In several smaller samples this tendency is still more pronounced; one lot from the same locality comprised 17 specimens, all with 11+17+5=33 body-rings.

Now, in parthenogenetic populations we naturally expect to find a smaller variation than in bisexual ones, if hereditary characters are considered. Thus we can conclude that the number of rings is predominantly due to hereditary influences.

This conclusion will be strengthened when we consider the environmental conditions of Rosenberg's find of populations with a nearly fixed number of rings in the rice districts of California. These conditions are probably similar to those of the localities of the same species in Texas and Oklahoma. But in the latter localities we have a wide range of variation in the number of rings, and both sexes are represented in about equal numbers.

There is a temptation to regard *A. oryzaphagus* and *A. biggsi* as two clones, one characterized by 35 or 34+i and the other by 36 or 35+i rings. In *A. cancriformis*, there might be clones with 33 and with 34 rings. But such conclusions would be premature. There is still the possibility that the small variation existing in a parthenogenetic population is due to environmental influences.

In both *Lepidurus* and *Apus*, parthenogenetic populations are characterized by a relatively small number of rings. But there are bisexual forms, too, with a similar number.

It would be interesting to make comparisons with other groups of many-segmented Arthropoda where parthenogenesis is known to occur. In the Conchostraca we may expect something of this kind. Species with a varying number of rings are known in the Conchostraca Spinicaudata (Linder, 1945); and there is a species where a fixed number is postulated and probable, though not definitely proved, viz., *Cyclestheria hislopi* Baird. The latter has both parthenogenetical and bisexual propagation in the same population, changing its mode of propagation according to the time of year; in other Spinicaudata, where males often are very rare, parthenogenesis is likely to be found in many populations (as in *Limnadia*). Further investigations are highly desirable.

Conditions of a similar kind occur in the Diplopoda, where they are a little better known, but detailed comparisons may have to be postponed until we know more of the variation in the Notostraca. I wish to point out one feature, however, that was brought to my attention by Dr. Hans Lohmander: in the Diplopoda the parthenogenetic forms are known to become sexually mature when having a smaller number of rings than the bisexual ones. This reminds us of the fact that parthenogenetic forms in *Lepidurus* and *Apus* also have relatively few rings, although likewise having bisexual forms with just as few or even fewer rings. Matters seem to be rather complicated here.

It has been maintained by Gaschott (1928, p. 277) that males are relatively rare in cold districts and increase in number in warmer parts of the world. It is, of course, a striking observation that *Lepidurus arcticus* has very few males, or none at all, in many populations, and that males are known to be common in tropical species. The present material no doubt gives the impression that the principle is acceptable, though with the reservation that we still know rather little of the tropical notostracans. Rosenberg's find of parthenogenetic populations in such a warm locality as California's rice fields clearly shows that a cold climate is not necessary for the development of parthenogenesis.

GROUPING SPECIES BY NUMBER OF BODY-RINGS

To sum up some of the facts I have observed about the number of rings in species from all over the world, we get the distribution shown in table 3, p. 42, in which I have included the number of pairs of legs. The range of variation given in this table applies to the group of species as a whole, each species usually covering only a part of the whole range. Several species of both genera are missing because I have not yet been able to get specimens, but there is strong reason to believe that the missing species are merely synonyms of those recorded. Even some of the listed species are probably synonyms.

I have not seen any specimens of *Lepidurus patagonicus* Berg, but judging from the description (Berg, 1900) and redescription (Birabén, 1945) we may assume that it belongs, with *L. arcticus*, to the first group in table 3. The author says that it has 29 segments, 5 of which are apodous. Nothing is mentioned about variation or about number of legs. Only two specimens seem to be known, the later report of Bruch (1916) about a new locality being very uncertain because the illustration of a specimen (op. cit., fig. 1) clearly shows a form of the genus *Apus*. Thus *L. patagonicus* seems to be closely related to *L. packardi* and is perhaps identical with this species. It should be added that I regard all North American forms of *Apus*, and at least some of the South American ones, too, as belonging to the species *A. longicaudatus*, and *L. macrurus* as a synonym of *L. couesii*.

There are strong reasons to consider the groups of species in *Lepidurus* (see table 3) to be just as homogeneous and well demarcated from each other as genera usually are. Further, *A. cancriformis* is in important respects well distinguished from the other species of *Apus*. However, I think it best to postpone the taxonomic alterations thus implied until more is known about the number of body rings and legs, an extensive field of investigation that has only recently been brought to our attention.

EXPOSED BODY-RINGS

In most descriptions the number of exposed rings is mentioned and is often stressed as an important character. Very small differences in number have been given the value of a specific character, as when Lilljeborg (1877) says that *L. macrurus* has six to eight exposed rings and *L. couesii* only five, but Gurney (1923) says he does not think that too much importance should be attached to this. Sars (1901) and Barnard (1929) doubt the importance of the differences, because the varying influences of preservation cause an artificial variation in this respect. I agree with them that this is obviously often the case (see p. 5).

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In samples of unusually well-preserved specimens I have observed a great range of variation in the number of exposed rings, particularly in *L. couesii* (2–8), in the new species of *Lepidurus* (10–19), and in *A. longicaudatus* (20–26). No correlation with other characters is noticed in these samples, with the exception that specimens with many exposed rings in most cases have longer rings than those with fewer exposed but with a carapace of about the same size. The appearance of the rings supports the idea that the variations are due to contraction.

Nevertheless, we must not altogether overlook this character. By their large number of exposed rings, *Lepidurus bilobatus* and the new species of *Lepidurus* (pls. 2, 3, and 4) are distinguished from the other species of the genus (though *L. arcticus*, too, sometimes may have a rather large number, as may be seen on plate 1), and suggest the genus *Apus*. It is quite a conspicuous character, and one that is easily explained by the great number of abdominal rings in these species. However, the variety of the new species described in this paper has just as many abdominal rings as do these forms, but only 7 to 10 exposed rings as against 10 to 19. Here the posterior emargination of the carapace is not nearly so deep as in the typical form, and this is certainly part of the explanation. However, the difference in number seems a little too great to be explained by this fact alone. One is tempted to say that the carapace is, relatively, a little larger here than in the typical form. Measurements confirm this; not only is it larger in relation to the total length but also in relation to length or width of separate body-rings. The body-rings are set just as closely together in the principal form as in the variety, and thus there appears to be a real difference in the relation between the length of carapace and of body in the two forms.

We see from the above that the number of exposed rings is not a simple character, but is the result of the combined action of several separate features, one of which is subject to variation caused by artificial means. Considerable caution is necessary when dealing with this as a taxonomic character.

The same thing may be said about the length of the carapace in relation to the length of the exposed part of the body. Packard (1883), when separating his species within the genus *Apus*, makes extensive use of this character. Because of the considerations noted, I do not think it advisable to pay much attention to this feature.

SIZE AND ARMATURE OF THE BODY-RINGS

As we have seen, the lengths of the individual body-rings, though not used as a separate character, influence two that are commonly used: the number of exposed body-rings, and the length of the carapace in relation to the total body length. It should be made clear, too, that these measurements are not easily determined with reasonable accuracy. They increase, of course, with increasing age, but to a degree that certainly varies.

The shape of the spines near the caudal border of the rings is rather uniform in each of the North American species. Accessory small spines sometimes occur on the ventral side of the legless rings, but this does not seem to be a specific character. In several species of *Lepidurus*, the ventral spines on the hind margin of the legless rings are smaller than the lateral and dorsal ones. The number of these

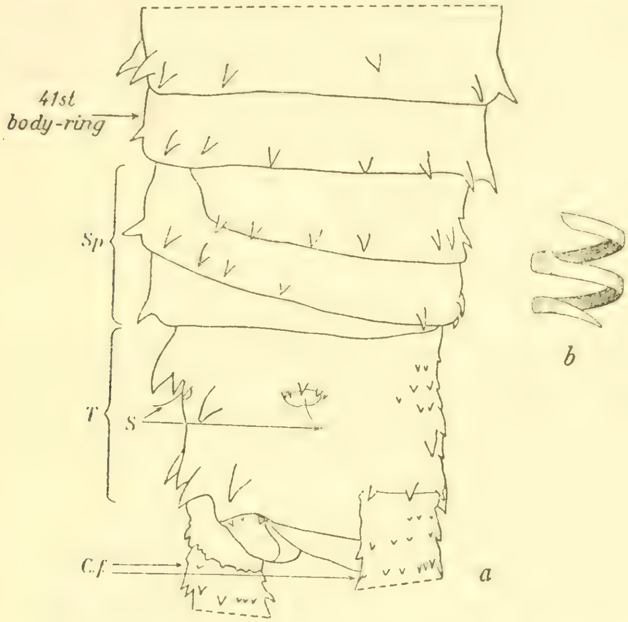

FIGURE 3.—*a*, Dorsolateral view of distal portion of abdomen of a male of *Apus longicaudatus* LeConte (U.S.N.M. No. 11602, type of *A. lucasanus* Packard) showing a right-handed spiral of a little more than two rounds, beginning in the middorsal line and evenly tapering at distal end, × 29. (*Sp*, spiral; *T*, telson; *S*, dorsal sensory setae; *C.f.*, caudal filaments.) *b*, Schematic drawing of the spiral.

spines, and of the other ones, too, is subject to considerable individual variation. Even in *Apus* the number of spines on each ring will not do as a specific character, though it is more constant in some lots than in others. Caution certainly is needed in dealing with this character, frequently used and much overrated in old descriptions.

INCOMPLETE BODY-RINGS

Barnard (1929, p. 232) seems to be the only author who has paid any attention to the interesting subject of incomplete body-rings. He states: "The interpolation of an incomplete segment immediately

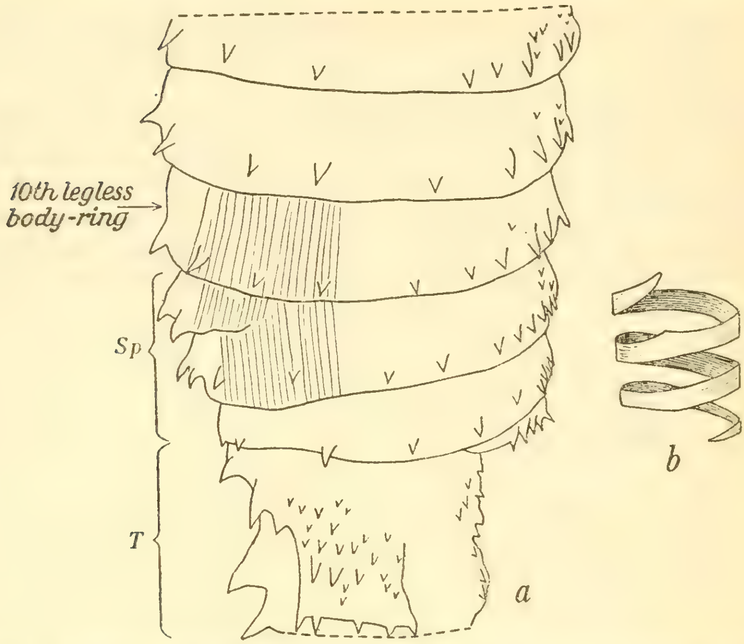

FIGURE 4.—*a*, Lateral view of portions of the abdomen and telson of a male of *Apus longicaudatus* LeConte (U.S.N.M. No. 11604) showing a left-handed spiral of about two and three-quarters rounds, beginning dorsolaterally and evenly tapering at distal end, × 28. Arrangement of muscle bundles indicated on the left side. (*Sp*, spiral; *T*, telson.) *b*, Schematic drawing of the spiral.

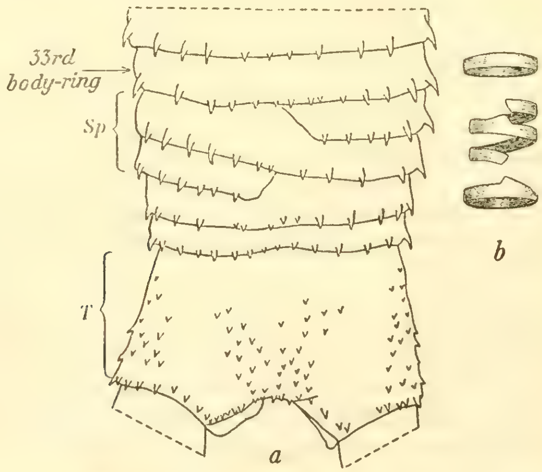

FIGURE 5.—*a*, Ventral view of portions of the abdomen and telson of a female of *Apus longicaudatus* LeConte (U.S.N.M. No. 82034) showing a right-handed spiral of two rounds placed within the series of normal rings and beginning and ending in the mid-ventral line, × 29. (*Sp*, spiral; *T*, telson.) *b*, Schematic drawing of the spiral and the rings immediately anterior and posterior to it.

preceding the telson occurs fairly often. This incomplete segment is visible on one or the other side, or only on the dorsal surface." He does not count it when giving the number of rings. Incomplete body-rings occur frequently; in one lot of the new species of *Lepidurus* described herein, for example, 10 out of 54 males and 7 out of 42 females show this structure in varying degrees of development. Nearly half the specimens in a lot of *A. longicaudatus* have incomplete rings: 14 out of 33 males, and 44 out of 98 females (fig. 31). These examples show that it is best not to omit them when counting the rings. They occur at any place around the front boundary of the telson (I have found, in two cases only, a piece of an incomplete ring in the middle of the series of abdominal rings) and may be of any size from a tiny piece to an almost but not quite complete ring. Two or even three of them may occur in the same specimen (fig. 16). Under their integument there is always a continuation of the longitudinal

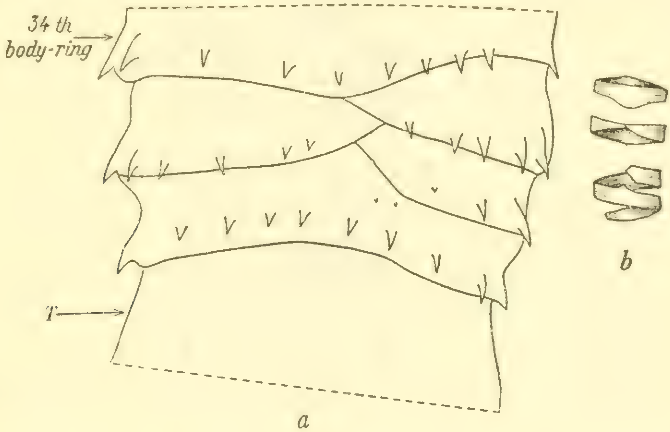

FIGURE 6.—*a*, Ventral view of portions of the abdomen and telson of a female of *Apus longicaudatus* LeConte (U.S.N.M. No. 18908) showing a right-handed spiral of a little more than one and one-half rounds, beginning in the midventral line, and preceded by a one-round structure similar to a spiral, × 29. (*T*, telson.) *b*, Schematic drawing.

muscles. I cannot say, as yet, whether such a piece sometimes grows to be a complete ring. The existence of a piece of an incomplete ring within the series of abdominal rings shows that they do not necessarily become complete rings and that they may be followed by a normal ring caudally.

SPIRAL GROWTH

Occasionally the regular growth is disturbed, and the rings in some part of the body are replaced by a real spiral (Linder, 1947). In more than 2,000 North American specimens I have found 15 cases of this, some of which are illustrated in figures 3 through 7, 17, and plate 7, figures 1 and 2. Most often the spiral ends at the front of the telson, but sometimes it appears in the midst of the series of abdominal rings, with normal rings following it caudally. There may be two spirals in one specimen (fig. 7 and pl. 7, figs. 1, 2), and they may be right-handed or left-handed. The largest spiral I have seen, consisting of a little more than 4 complete turns, was observed in a large female of the new species of *Lepidurus* (fig. 17), one of the two cases where the spiral was found to affect the leg-bearing part of the abdomen. It forms the whole legless part of the body, too. A spiral usually begins in the

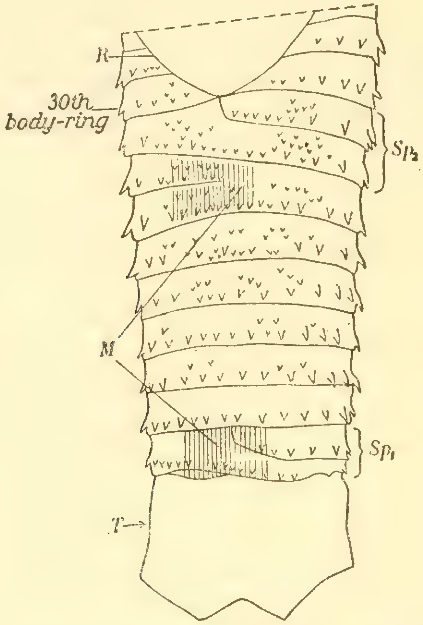

FIGURE 7.—Ventral view of abdomen of a female of *Apus granarius* (Lucas) from China (Stockholm Mus.) showing two right-handed spirals in the same specimen, both beginning in the midventral line, the anterior one (Sp_2) of two rounds and ending openly at the midventral line, the posterior one (Sp_1) of a little more than one and one-half rounds and with the distal end evenly tapering, $\times$ 14. (*M*, muscle bundles indicated in part of the body to show that their courses are not influenced by the spirals; *R*, ridge bordering the leg-bearing area; Sp_1, Sp_2, spirals; *T*, telson.)

midventral or middorsal line, but in one case (fig. 4) it begins dorsolaterally. The end of the spiral may be found in any place around the periphery of the anterior margin of the telson and is often tapered continuously for a rather considerable distance. If the spiral occurs within the series of normal rings, it ends only midventrally or middorsally, in the cases which I have seen, and no long tapering has been observed.

Though the occurrence of spiral growth and of incomplete body-rings has no significance at all for the taxonomy of the Notostraca, I think that both these kinds of abnormalities are of considerable interest, and I hope that others who come across cases of spiral growth will publish their findings.

THE TELSON AND SUPRA-ANAL PLATE

The telson is heavily chitinized and is thus very little subject to the influence of the preservation fluid. Disregarding the supra-anal plate, the telson is very short in *L. couesii* and *L. packardi*, and unusually long in the new species and variety of *Lepidurus* (figs. 9, 10,

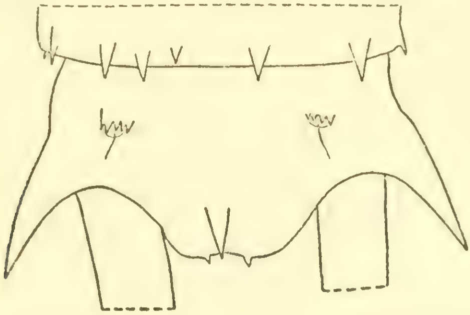

FIGURE 8.—Dorsal view of telson of a female of *Apus cancriformis* (Bosc) from Safi, French Morocco (U.S.N.M.), × 23.

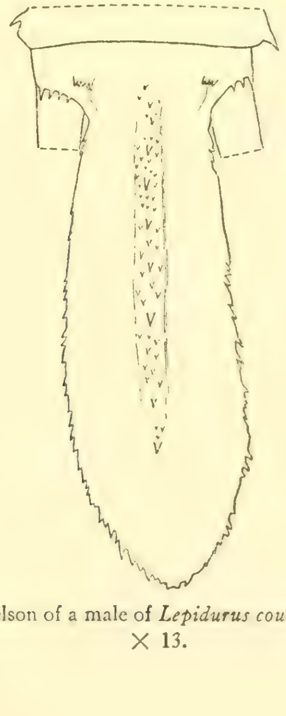

FIGURE 9.—Dorsal view of telson of a male of *Lepidurus couesii* Packard (Stockholm Mus.), × 13.

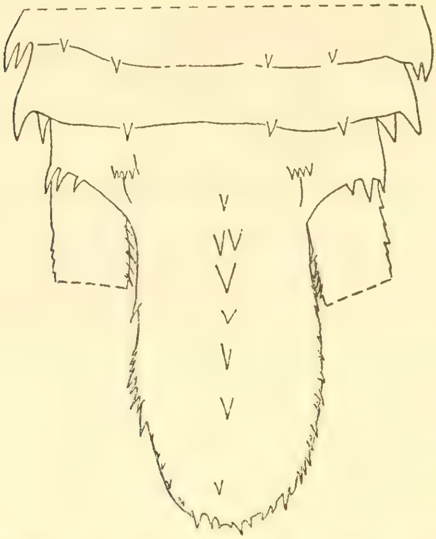

FIGURE 10.—Dorsal view of telson and last two body rings of female holotype of *Lepidurus packardi* Simon (Paris Mus.), × 19.5.

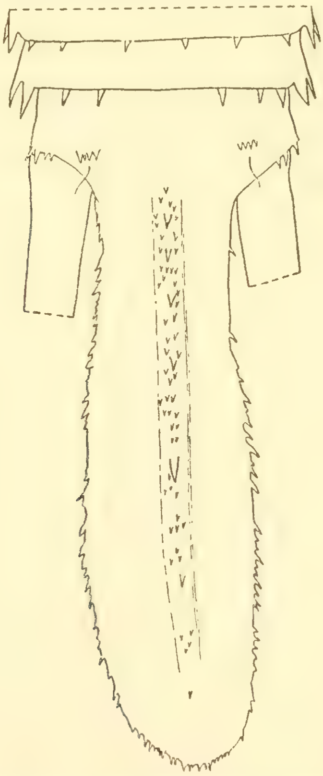

FIGURE 11.—Dorsal view of telson and last two body-rings of a female of *Lepidurus couesii* Packard from Jenissejsk (Stockholm Mus.; labeled *L. macrurus* by Lilljeborg), × 13.

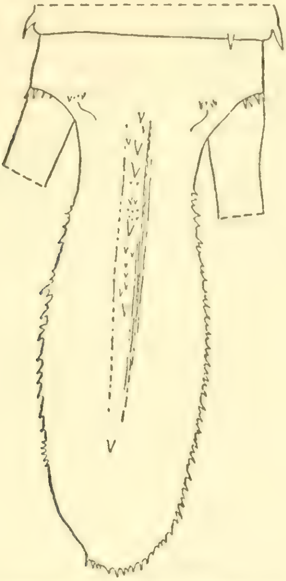

FIGURE 12.—Dorsal view of telson of a female cotype of *Lepidurus couesii* Packard (U.S.N.M. No. 11605), × 13.

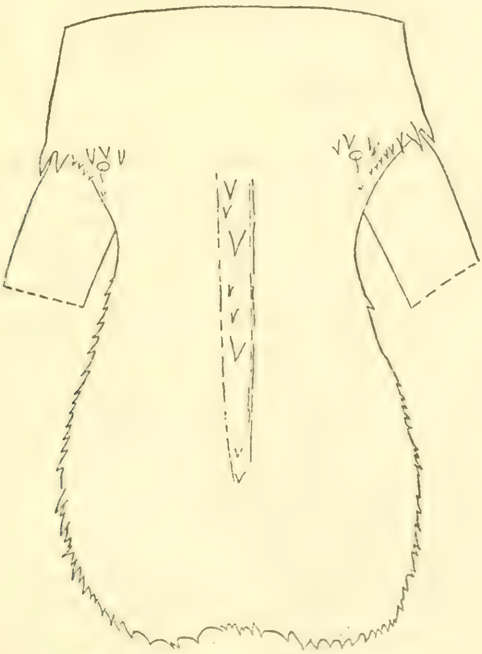

FIGURE 13.—Dorsal view of telson of a female of *Lepidurus bilobatus* Packard, from Utah (U.S.N.M. No. 11606; labeled "type"), × 20.

and 28). Its proportions do not vary much individually, at least not in the species of *Lepidurus*, and are well worth using as a taxonomic character, though they do not always separate species as well as in the case just mentioned.

The presence of a supra-anal plate has for a long time been the main character of the genus *Lepidurus*. Sometimes we meet forms of *Apus* (see fig. 8, and also Gauthier, 1934, pl. 2, fig. D) which show the appearance of such a plate not much smaller than that in some specimens of *L. arcticus*. However, for practical purposes the character seems to be quite acceptable.

The supra-anal plate has always been regarded as a useful taxonomic feature, and this course seems to be justified, provided we do not pay too much attention to its form. Holmes (1894, p. 586) has an extreme example of variation in this respect in a lot of only 5 specimens of *Lepidurus lemmoni*, in which it "may be rounded, truncated (obliquely so in some specimens), or, in some cases, bilobed." Bilobation of this plate is not a valid character. Sars (1896) figures such a condition in some specimens of *L. arcticus*, and Spandl (1925) the beginning of a bilobation in the European species *L. apus*. In the new species of *Lepidurus* from the State of Washington, I have observed varying bilobation, or none, in specimens of both sexes and of all sizes (figs. 15 and 24). Having found in several cases a variation in this respect within the limits of a species, I cannot, of course, follow Sidorov (1927) when he uses the bilobation as a generic character.

The largest supra-anal plate among all Notostraca is found in males of *L. couesii*, where its length can approach 44 percent of the length of the carapace (fig. 11). In *L. arcticus*, on the other hand, it is unusually small, being 7 to 13 percent of the length of the carapace.

The spines on the dorsal side of the supra-anal plate are sometimes valid characters, though their number is not fixed for each species but varies within certain limits. I have noticed 0–4 of them in *L. arcticus*, 4–19 in *L. packardi*, and 2–7 in the new species of *Lepidurus*. In these species they always occur in a reasonably straight row, but not on a keel, and they are rather similar in size. The two remaining North American species of *Lepidurus* are very different in this respect. In *L. couesii* there is a strong middorsal keel covered with very numerous spines (20–100) that vary considerably in size (figs. 9 and 11), most of which are very small and in this respect are similar to what I have called accessory small spines sometimes occurring on the ventral side of the legless body-rings in several species (p. 19). A varying number reach a size comparable with that found in other species of the genus, though not quite so large, and there are intermediate sizes, too. *L. bilobatus*, of which I have seen only a few specimens, has a supra-anal plate similar to that of *L. couesii*, though the keel is less well marked and the spines are fewer, 4–6 large ones and a trifling number of small ones (see fig. 13).

In *L. couesii*, the number of spines on the supra-anal plate obviously increases with the size of the animal, but in other species I cannot say that this is the rule.

The spines around the dorsal sensory setae and around the bases of the caudal filaments usually do not present valid characters in American forms, and as for the conspicuous spines placed more middorsally on the telson in the genus *Apus*, they vary in number in almost every sample. Later on (p. 59), I will give examples of this that may go to show that the number is not a reliable character. This variation also occurs in several extra-American species of *Apus* such as *A. numidicus* (Barnard, 1929, p. 234), *A. granarius*, and *A. australiensis*. The caudal filaments present good sexual characters in the armature of their basal parts (Gurney, 1924, 1925), because those of the female are bristly and those of the male armed, at least at the base, with rounded knobs. This, however, seems to apply to forms of *Apus* only. In other respects I have not found these filaments useful for taxonomic purposes.

THE CARAPACE

The carapace is more flattened in the male than in the female. The relation of its width to its length is, according to Barnard (1929), a valid character in some South African species of *Apus* (though not in all of them!). I have given this relation in the descriptions, but, at least in *Apus*, I have found no conspicuous differences in the American material. Many spines, which sometimes are very small, often occur in both genera on the dorsal surface, especially on the carina. The presence, absence, or number of these structures cannot, as it would seem, be used as a taxonomic character; many times I have found in a single lot great variation in this respect, without any correlation with other characters. Barnard (1929) found similar variation in South African material of *Apus* and he, too, rejects its taxonomic importance. The lateral margin of the carapace is regularly furnished with some very small spines, at least in its posterior part, and in the variety of the new species of *Lepidurus* described here, these spines are large and conspicuous around most of the margin (pl. 5, fig. 1). As for the posterior emargination of the carapace, early authors used to pay a great deal of attention to the number of spines found on it, and this character still appears in descriptions, sometimes with pretensions of separating species. However, Braem (1893) and many authors after him have found a great range of variation in this respect in many species, and so have I in the American material. On the other hand, the size and pattern of these spines in several cases may prove helpful to the taxonomist. In most forms the spines are fairly equal in size and regularly placed, but sometimes (in *L. packardi* and *L. bilobatus*) there are large spines interspersed between much smaller ones at fairly regular intervals, and this seems to be worth considering in the taxonomy, because the individual variation in this respect is very slight in the material I have examined. The depth of the posterior margination is also worth attention.

On the ventral side, just in front of the antennae, we find the supra-antennal crest. Simon (1886) attaches some importance to the appearance of this crest, which in some forms is quite smooth and in others is furnished with small tubercles or is almost serrated. As a taxonomic character, this seems to be well worth attention.

THE NUCHAL ORGAN

Barnard (1929) found that the height and location of the tubercle on which the nuchal organ is placed were very useful in distinguishing the South African species of *Apus*. The North American forms of the genus, however, are uniform in this respect. In *Lepidurus*, I have not observed any considerable differences in the height of it, and in almost all species its location is more or less uniform, that is, it occurs somewhat between the hind part of the eye-tubercles (fig. 19 and pl. 7, figs. 3–6). Aberrant in this respect is the new species from Washington, in which it occurs considerably behind the eye tubercles. The fact that the eyes are unusually small in this species may have some bearing on this, however. The same conditions occur in the variety of this species. According to Holmes (1894), the nuchal organ in *L. lemmoni* is "located considerably behind the posterior margin of the eyes." As the posterior margin of the eyes is situated in front of the posterior margin of the eye-tubercles, we cannot say for certain whether the organ is placed behind the latter margin or not.

THE SECOND MAXILLAE

Sars (1901) observed that the second maxillae are relatively larger in *Lepidurus* than in *Apus*, though "the exopodal part" may be much larger in *Apus*. What he calls "the exopodal part" is only the free end of the efferent duct of the maxillary gland. This is called "palpus" by Wolf (1911, p. 260), who made another important observation: "Vielleicht dürfte auch das von mir an vielen Arten beobachtete Unterscheidungsmerkmal allgemeine Geltung haben, dass nämlich bei Lepidurus die 2. Maxille seitlich einen Palpus trägt, während bei den Triops-Arten dieselbe vollständig rudimentär geworden, und der bedeutend vergrösserte Palpus frei zu stehen scheint." A similar reduction is mentioned by me in an earlier paper (1945, p. 13). I can now confirm that in most species of *Apus* (*A. australiensis*, *A. granarius*, *A. numidicus*, and *A. longicaudatus*) middle-sized and large specimens have only the free end of the efferent duct of the maxillary gland remaining. In small specimens of these species the reduction has not gone so far as that, the maxillae being similar to those of *Lepidurus*, but relatively smaller and pushed laterally, so that the median spines of the two limbs cannot possibly meet each other in the midline. In *A. cancriformis*, however, we find an exception. Here, as in the various forms of *Lepidurus*, I have observed no dwindling of these limbs in large specimens.

It remains a question whether or not the free end of the duct from the maxillary gland should be regarded as a constituent part of the maxilla. The above-mentioned authors obviously consider it a part of the limb, as do Cannon and Leak (1933).

It is easily observed that there is no intimate coalescence between the two parts in the Notostraca. In the Conchostraca, too, they are clearly separated from each other. From a theoretical point of view this seems peculiar, and may, of course, be taken as a secondary change. Claus (1873), however, says that the free end grows, in early post-embryonal stages of *A. cancriformis*, in a place clearly apart from "the masticatory part," and later comes closer to it. He gives his statement with some hesitation, but, so far as I can see, no one has since been able to verify or contradict it.

Grasser (1933) reveals many facts about the development of the excretory organs in early stages of *A. cancriformis*, but gives no clear information on this point, saying (p. 349): "Der Ausführzapfen . . . erhebt sich zu gleicher Höhe wie die . . . Anlagen des Maxillen—und des ersten Thorakalgliedpaares." Further examination of very young stages seems desirable.

THE LEGS

I have not paid much attention to variations of the proportions of the endites of the first pair of legs, because I have found, as did Barnard (1929), that individual variation is great in this respect. Nor have I measured the length or width of the stem, for similar reasons. In other respects the legs of various species are known to be very similar to each other, though it has been known for a long time that, as a rule, the endites of the first legs are longer in *Apus* than in *Lepidurus*. Perhaps we might be able to find some distinguishing characters in the structure of the endopodites of the first pair of legs, which are furnished with setae in some forms and without setae in others, and also, perhaps, in the preepipodites. However, the age variation in these respects is not yet known. Sometimes the epipodites and the exopodites are very much swollen, thus giving the legs a peculiar appearance, but, as the variation shows, this has no taxonomic significance.

The number of pairs of legs is seldom given in descriptions of notostracans. They are regarded as extremely difficult to count. I admit the difficulty, though with a pair of fine needles and a good binocular microscope the task is not at all impossible. Some training however, is highly advisable if one wants to get an accurate result with a minimum of effort.

When the number is actually mentioned in the literature, it appears that only one or two specimens have been counted, and a fixed number is given for each species. I have found only one exception to this: Chamberlin and Duncan (1924) noticed a variation in the number of leg-bearing rings (p. 9) and also mentioned that the number of pairs of legs in *L. arcticus* is 41–46.

In fact, the number is not constant in any of the species of which I have examined a reasonable number of specimens, though it seems to be fairly constant in parthenogenetic populations. The American species present the following figures: *L. arcticus* 41–46, *L. packardi* (1 specimen) about 35, *L. couesii* 35–40, *L. lemmoni* unknown, *L. bilobatus* (1 specimen) about 62, the new species of *Lepidurus* 60–71, the new variety of *Lepidurus* 67–68 (2 specimens), and *A. longicaudatus* 54–66. In two of the above species approximate figures are given because the specimens in question were not in a sufficiently good state of preservation to allow an accurate counting of the legs without causing some damage to the specimens, and, the specimens being unique, dissection did not seem advisable. In some species, at least, the females usually have a few more legs than the males.

We notice that the greatest number of legs is found not in *Apus*, where the leg-bearing abdominal rings may be as many as 21, but in a species of *Lepidurus*, where these rings do not number more than 18. Within the latter genus, however, all species with 14.5–18 leg-bearing rings have 60–71 pairs of legs, and the species with 9.5–13 leg-bearing rings have only 35–46 pairs. For counts of extra-American species, I refer readers to table 3, in which some small changes may be necessary when more specimens are counted.

It seems clear that the number of legs is a taxonomic character of no small importance in many cases, and that we have to take the trouble to count them.

NORTH AMERICAN SPECIES

Genus **LEPIDURUS** Leach

Lepidurus Leach, 1816, p. 259.—Simon, 1886, p. 428 (earlier synonymy).
Bilobus Sidorov, 1924; 1927.

The main character of the genus is the presence of a supra-anal plate on the telson, and this seems to be a reasonably good character for practical purposes (p. 26). Further, the first pair of legs have comparatively short endites, not much projecting beyond the margin of the carapace (in the new species from Washington, however, they are quite long), the legless rings are 3–8, mostly 4–6 in number, and the ova are reported as larger than in *Apus*.

The second maxillae are well developed, not reduced in size or absent as in most species of *Apus*.

It is often stressed that, in relation to the body, the carapace is larger than in *Apus*, thus leaving a smaller number of body-rings uncovered. This certainly is true of most species, but in *L. bilobatus* and the new species the number of such rings is quite as great as the usual number in *Apus*.

In the generic diagnosis we should include the numbers of body-rings and of pairs of legs. In these respects, there are two groups of species in the genus. *L. apus*, *L. arcticus*, *L. couesii*, *L. kirkii*, *L. packardi*, and *L. viridis* are characterized by fewer rings and legs: 9.5–13 abdominal leg-bearing body-rings, 25–29 body-rings in all, and 35–46 pairs of legs. The second group consists of *L. bilobatus* and the new species and variety of this genus. Here we find 14.5–18 abdominal leg-bearing body-rings, 30–34 body-rings in all, and 60–71 pairs of legs. These differences may be expressed by saying that the leg-bearing part of the abdomen is more developed in the last group than in that first mentioned.

This is not the place to give a world-wide enumeration of the species of *Lepidurus* described by various authors, or to give an account of their synonymy, but, as far as I can see, so many of these are synonyms only that I can maintain that I have examined specimens of all species except *L. patagonicus*, and that the above considerations apply to all species of the genus I have examined.

Sidorov (1927) refers to his paper (1924) in which he erects a new genus, *Bilobus*, for *L. bilobatus*. This genus is founded on minor characters, some of which are not even fit for specific demarcation (bilobation of the supra-anal plate, for example, is observed in many species). The 1924 paper, written in Russian, was not available for my inspection.

As for other characters, readers are referred to the descriptions in this paper.

About the distribution, I agree with Barnard (1929, p. 228): "*Lepidurus* is confined to the more boreal portions of the Palaearctic and Nearctic regions, New Zealand, Tasmania, the southwestern and southeastern coastal belts of Australia, and Patagonia. In regions of a hotter and more arid climate, subject to periodical droughts, it is replaced by *Apus*. The limits of distribution of the two genera overlap in places, but in general the above marked separation holds good."

In North America, members of the genus occur in the Arctic and in the western part of the continent: *L. arcticus* in northern Canada, Greenland, and Alaska; and the other species in Alberta and Saskatchewan, in Canada; and in Washington, Oregon, Montana, Idaho, North Dakota, California, Utah, Nevada, Arizona, and Colorado, in the United States. East of the Mississippi, *Lepidurus* is not recorded and east of the Missouri only once (Max, N. Dak.). It is, of course, possible that these animals really do not live in that area, but perhaps it would be premature to regard this as an established fact. We must not forget that notostracans are very easy to overlook even in places where much general collecting is done, and *Lepidurus* is found in other parts of the world, such as southeastern Australia and New Zealand, where the climatic conditions are similar to those in the eastern United States. The western part of North America, from Alberta in the north to Arizona in the south, in spite of the relative smallness of the area, and the comparatively few localities from which material is reported, presents a richness of forms unparalleled in other parts of the world. Four species are found here as against two in boreal Europe and Asia, one or possibly two (others are certainly synonyms only) in Australia, and one in South America. Species with a large number of leg-bearing rings (*L. bilobatus* and the new species of *Lepidurus*) have not been found anywhere else in the world.

It has been advanced that there is a biological difference between *Lepidurus* and *Apus*, the latter occurring in pools which regularly dry up, while the former are found in permanent waters (Brauer, 1878, and Barnard, 1929). However, I have observed *L. apus* in several ponds in Sweden which dry up every year. Further, Brauer states (p. 587) that species of both genera sometimes live in the same pool. Perhaps the eggs of *Lepidurus* may be able to stand some desiccation, though those of *Apus* certainly can stand more, or perhaps the different species of *Lepidurus* have varying abilities in this respect.

Both *Lepidurus* and *Apus* are recorded from Montana, Oregon, California, Nevada, Utah, Colorado, and Arizona, though they are not known to occur together in the same pool there. It is not known what differences there may be between the respective localities.

KEY TO THE NORTH AMERICAN SPECIES OF LEPIDURUS

A. Leg-bearing abdominal rings 9.5–13, inclusive, front part of nuchal organ between hind part of eye-tubercles, not far from hind margin of eyes.
- *a.* Endites 3–5 of first leg rather similar in size, very little or not at all projecting beyond margin of carapace ______________ **arcticus** (p. 33)
- *b.* Endites 3–5 of first leg much dissimilar in size, fifth endite of first leg clearly projecting beyond margin of carapace.
  1. Mediodorsal spines on supra-anal plate not on a keel, few in number, rather similar in size ______________ **packardi** (p. 33)
  2. Mediodorsal spines on supra-anal plate on a distinct keel, numerous (20–100), and highly variable in size ______________ **couesii** (p. 34)

B. Leg-bearing abdominal rings 14.5–18, inclusive.
- I. Front part of nuchal organ between hind parts of eye-tubercles, not far from hind margin of eyes ______________ **bilobatus** (p. 38)
- II. Nuchal organ considerably behind eye-tubercles.
  - *a.* Hind part of lateral margin of carapace with minute spines_ **lynchi** (p. 39)
  - *b.* Hind part of lateral margin of carapace with large spines, directed straight outward ______________ **lynchi var. echinatus** (p. 49)

L. lemmoni Holmes (p. 50) is regarded as insufficiently known to be included in the key.

LEPIDURUS ARCTICUS (Pallas)

PLATE 1 (FIGURE 1)

Monoculus arcticus PALLAS, 1793, pp. 39, 679.
Lepidurus glacialis PACKARD, 1883, p. 316.—SARS, 1896, p. 68, pls. 11–13.—CHAMBERLIN and DUNCAN, 1924, p. 101.
Lepidurus arcticus JOHANSEN, 1922, p. 4.—LINDER, 1932, p. 192.

Description.—For a detailed description readers are referred to Sars (1896). So far as I can see, there are no essential differences in structure between American and European or Asiatic specimens. Simon (1886, p. 429) says, "Lamina analis parva attenuata brevior quam telson (in speciminibus sibiricus) vel parum longior (in sp. americanis)," but he probably had too little material to cover the individual variations; in the extensive material I have seen I cannot find such a difference. Sømme (1934) noticed varying sizes of the spines on the dorsal side of the legless body-rings in specimens from various European localities, but it is uncertain whether these dissimilarities lie within the range of individual variation or characterize geographical races. In any case, I do not think they can be given specific value.

The number of body-rings is 11+(10–12)+(4–5)=26–28, and the number of legs is 41–46. Length of supra-anal plate is 7–13 percent of length of carapace.

Localities.—The localities in the collection of the U. S. National Museum are recorded by Johansen (1922).

Distribution.—For distribution, see Linder (1932).

LEPIDURUS PACKARDI Simon

FIGURES 10, 19, *a*; PLATES 2 (FIGURES 1, 2) AND 7 (FIGURE 6)

Lepidurus packardi SIMON, 1886, p. 448.

Description.—The principal points of the description are as follows: Carapace broadly oval, carina conspicuous in posterior third but disappearing anteriorly, posterior emargination with minute, numerous spines interspersed with slightly larger ones at regular intervals (8–9 on each side). Nuchal organ small, broadly oval. Abdomen short, hardly projecting behind carapace. Abdominal legless body-rings with 8 strong, sharp spines dorsally and 20–25 smaller ones ventrally. Supra-anal plate small, with parallel sides and rounded apex, and with 8 spines in the dorsal middle line. Endites 2, 3, and 4 of first leg rather thick and flattened and projecting beyond the margin of the carapace, endite 5 projecting beyond first third of carapace. Length of carapace 15.5 mm., width 14 mm.

Type locality.—California.

Type.—Type in Muséum d'Histoire Naturelle, Paris. Thanks to the courtesy of Dr. Marc André, of the Muséum d'Histoire Naturelle, I have had an opportunity to examine the type. The species does not seem to have been mentioned in the literature after its establishment, and a few supplementary notes about some details of its structure may be desirable. There is only one type, a female; number of body-rings: 11+10+6=27; telson (supra-anal plate not considered) very short; length of supra-anal plate 20 percent of length of carapace; width of carapace, as measured from the carina to both sides, 7.5+7.5 mm; nuchal organ oval, not so high as eye-tubercles, and placed between their hind parts, so that only a very small part of it reaches farther posteriorly than these; about 35 pairs of legs.

Localities.—I have examined a male and two females from Davis, Calif. (U.S.N.M. No. 82030), and a male and female from Lassen County, Calif. (U.S.N.M. No. 9377).

This species is not known from places other than those mentioned.

Remarks.—I have placed in this species some California specimens which belong to the group with 9.5–13 leg-bearing abdominal rings and which certainly are not *L. arcticus*, *L. couesii*, or *L. lemmoni*. Particulars are given in table 1. They agree well with *L. packardi* in the armature of spines on the posterior emargination of the carapace, and in having only large spines on the supra-anal plate. On the other hand, most of them have more spines on the supra-anal plate than the type specimen, and fewer teeth on the last legless ring, but, in these respects, individual variations may be expected. It is to be added that *L. patagonicus* Berg from South America (p. 17) obviously is nearly related to this species and possibly identical with it.

LEPIDURUS COUESII Packard

Figures 9; 11; 12; 19, *b*; Plates 1 (Figures 2, 3) and 7 (Figure 5)

Lepidurus couesii Packard, 1875, p. 311; 1883, p. 317.—Johansen, 1921, p. 29.
Lepidurus macrurus Lilljeborg, 1877, p. 9.—Simon, 1886, pp. 429, 448.—Sars, 1897, p. 464; 1901, p. 143.

Description.—I have examined two males and one female, marked "type" (U.S.N.M. No. 11605). According to the label, they were collected in Montana by E. Coues, as were Packard's type specimens, and I think there is no doubt about their being true types. Further, I have seen two males from Montana in the Stockholm Natural History Museum that were sent from Packard and thus, with some justification, ought to be regarded as types, too.

It appears from these specimens and from seven others from North America (table 1) that *L. couesii* is easily distinguished from other North American species of the genus. The number of rings is 11+(9.5–11.5)+(4–5.5)=25–27. The nuchal organ has its front part placed between the hind part of the eye-tubercles. The supra-antennal crest is quite smooth.

It is often mentioned as a good character of this species that the supra-anal plate is unusually long. This certainly is true of the males, where it can reach a length of 40–42 percent of the length of the carapace (in type specimens), thus by far exceeding the length in any other species of *Lepidurus* I have examined. In the females, however, we find quite an ordinary length of this plate to be 17–29 percent of that of the carapace. A reliable character, for both sexes, is that the supra-anal plate has a distinct keel middorsally, furnished with a large number of spines (from 20 up to more than a hundred). Most of these spines are minute, much smaller than in other species, but there are also larger ones interspersed at varying intervals, and intermediate sizes occur, too. However, the largest spines do not quite reach the size usual in other species. Another conspicuous character is the shortness of the telson. Its length, disregarding the supra-anal plate, is less than half of its width.

Packard (1883, p. 317) says about the spines on the posterior emargination of the carapace that they show a tendency to become obsolete on the lower part of the emargination, and that they are finer than in "the European species." I confirm this. They have a rather worn appearance, though variations occur.

So far as I can see, the number of pairs of legs is not given by earlier authors. I have found it to be 35 to 40.

For other particulars, see table 1.

Localities.—The following American localities are represented in the material examined by me: Montana, 2♂ and 1♀ (cotypes), U.S.N.M. No. 11605; 2♂ (cotypes), Stockholm Museum. Idaho, 25 miles north of Ashton, 2♂ and 2♀ (U.S.N.M. No. 55800); "Idaho," with no particulars, 1 specimen, badly preserved (U.S.N.M. No. 50569). Max, N. Dak., 1♀ (U.S.N.M. No. 67699). Rocky Point Pond, about 15 miles west of Klamath Falls, Klamath County, Oreg., elevation about 4,300 feet ("*L. lemmoni*," Coopey, 1946, p. 339), 3 specimens clearly belonging to this species. Canada, with no particulars, 1♂, typical (U.S.N.M. No. 49121). Medicine Hat, Alberta, 2♂ (U.S.N.M. No. 54814).

Of material from Europe and Asia I have seen specimens from the following localities. Northern Siberia, Nikoulina, 1♂, Stockholm Museum No. 561; Igarskoj, 1♂, Stockholm Museum No. 1433; Worogoba, 1♂ and 1♀, Stockholm Museum No. 549; Jenissejsk, 2♀, Uppsala Museum; Mellraddinka, Kulundinsk Steppe, 2 specimens, (U.S.N.M. No. 82060.)

The species is further reported in America from Smithfield, Cache Valley, Utah (Packard, 1883). From the following places in Canada: near Winnipeg, Manitoba; Dufton, Saskatchewan (Johansen, 1921). Outside America, it is given (as *L. macrurus*) from Arkhangel (Lilljeborg, 1877), Government of Wolodga (Decksbach, 1924), Koslow, in Government of Tambow (Decksbach, 1924), Government of Rjasan (Smirnov, 1936), Northern Caucasus (Smirnov, 1932), all in the

TABLE 1.—*Morphological characters of specimens of* Lepidurus packardi, L. couesii, *and* L. bilobatus

Species and locality	Sex	Body-rings	Leg-bearing abdominal rings	Legless abdominal rings	Teeth, ventral half, last body-ring	Dorsal spines on supra-anal plate	Total length (mm.), less supra-anal plate and caudal filaments	Length (mm.), supra-anal plate	Length (mm.), caudal filaments	Length (mm.), fifth endite of first leg	Length (mm.), carapace	Width (mm.), carapace	Length: width relation, carapace	Length supra-anal plate in % length of carapace
L. packardi from Davis, Calif., U.S.N.M. No. 82030	♂	28	12	5	13	4	20	6	--------	4. 5	18. 5	2 x 9. 5	1. 03	32
	♀	27	11. 5	4. 5	17	14	19. 5	5	16. 5	6	18	2 x 9	1. 00	28
	♀	28	12	5	20	19	35	8. 5	>27	10. 5	30. 5	2 x 15	. 99	28
L. packardi from Lassen County, Calif., U.S.N.M. No. 9377	♂	28	11	6	17	10	24. 5	5. 5	>19	6. 5	17. 5	2 x 10	1. 14	31
	♂	27	10. 5	5. 5	17	9	22	5. 5	>20	6	17	2 x 10	1. 18	32
L. couesii from Montana (cotypes), U.S.N.M. No. 11605	♂	25	9. 5	4. 5	15	51	------	>6	25	7	20. 5	2 x 10. 5	1. 02	>29
	♂	------	------	4	19	43	------	8	--------	5	20	2 x 10	1. 00	40
	♀	27	11. 5	4. 5	18	22	23	4	--------	4. 5	22	2 x 12	1. 09	18
L. couesii from Montana (cotypes), Stockholm Museum	♂	26	10. 5	4. 5	16	64	24	7	--------	7	18	2 x 10	1. 11	39
	♂	26	10. 5	4. 5	19	35	20	8	--------	7. 5	19	2 x 10	1. 05	42
L. couesii from Idaho, 25 miles north of Ashton, U.S.N.M. No. 55800	♂	27	10. 5	5. 5	28	>100	21	6. 5	22. 5	4. 6	17. 5	2 x 10	1. 14	37
	♂	26	10. 5	4. 5	20	60	17	5	18. 5	5	15	2 x 8. 5	1. 13	33
	♀	26	11	4	18	29	15	2. 5	--------	3. 2	15	2 x 8	1. 07	17
	♀	26	11	4	20	68	18. 5	4. 5	18. 5	4. 2	18	2 x 9. 5	1. 06	25
L. couesii from Medicine Hat, Alberta, U.S.N.M. No. 54814	♂	26	10	5	18	37	13	5	11. 5	3. 5	12. 5	2 x 7	1. 12	40
	♂	26	10. 5	4. 5	18	>30	11	------	> 7	3	10	2 x 5. 5	1. 10	----
L. couesii from Max, N. Dak., U.S.N.M. No. 67699	♀	26	10	5	19	>75	------	7. 5	21. 5	4. 5	25. 5	2 x 13. 5	1. 06	29

L. couesii from Nikoulina, N. Siberia, Stockholm Museum No. 561	♂	27	11	5	23	25	18	5	21	7	18	2 x 10. 5	1. 17	28
L. couesii from Igarskoj, N. Siberia, Stockholm Museum No. 1433	♂	26+i	10. 5	4. 5+i	22	20	18. 5	4. 5	17	6	19. 5	2 x 10. 5	1. 08	23
L. couesii from Worogoba, N. Siberia, Stockholm Museum No. 549	♂ ♀	26 27	10 11	5 5	20 21	58 42	23 19. 5	8 5. 2	21 >15	8 5. 5	18 19	2 x 10 2 x 10	1. 11 1. 05	44 27
L. couesii from Jenissejsk, N. Siberia, Uppsala Museum	♀ ♀	26 27	10 10. 5	5 5. 5	18 22	51 21	20 19	6. 4 4	27 16	8 5. 5	21. 5 16	2 x 12 2 x 9. 5	1. 12 1. 19	30 25
L. bilobatus from Utah, U.S.N.M. No. 11606	♀	32	16. 5	4. 5	19	------	24	3. 5	------	4. 5	15. 5	2 x 9	1. 16	23
L. bilobatus probably from Arizona, U.S.N.M. No. 82028	♀	32	16. 5	4. 5	28	------	38	7	------	--------	28	2 x 19	1. 36	25

European part of the U. S. S. R.; Jakutsk (Sars, 1897), several places in the territory of Akmolinsk (Sars, 1901, 1903), territory of Kokschetavsk (Sars, 1903), and Kasalinsk in Turkestan (Decksbach, 1924).

Remarks.—Outside America, there is a species with a similar telson and supra-anal plate, *L. macrurus* Lilljeborg. The general resemblance between this species and *L. couesii* was noted by Lilljeborg, who mentioned (1877, p. 14) one difference only, that the former has 6 to 8 rings exposed behind the carapace and the latter only 5. This character "is generally recognized to be somewhat unreliable" (Gurney, 1923, p. 502) because of the varying state of contraction of the specimens (p. 5), and I have seen American specimens of *L. couesii* with 7 exposed rings as well as specimens of *L. macrurus*, identified by Lilljeborg, with five exposed rings.

I have examined 25 Asiatic specimens identified as *L. macrurus* by Lilljeborg. They, as well as some specimens from a more southern locality, agree perfectly well with the American specimens of *L. couesii* as described, and ought to bear the same name, which is 2 years older than that given by Lilljeborg.

The relationship of this species to the European *L. apus*, to which it bears a certain resemblance, is in need of clarification, but I have not had enough material of the latter species to make a detailed comparison.

LEPIDURUS BILOBATUS Packard

FIGURE 13; PLATE 2 (FIGURES 3, 4)

Lepidurus bilobatus PACKARD, 1883, p. 318.

Description.—A supplementary description of a female labeled "Type, Utah, coll. Henshaw" (U.S.N.M. No. 11606) is given here. Body-rings $11+16.5+4.5=32$. Legless rings with many (19) densely crowded spines on the ventral side, dorsally 7 spines. Supra-anal plate slightly bilobed, with 8 dorsal spines, 4 of which are smaller than the others, all of them placed on a slightly marked keel. Nuchal organ oval, placed between hind parts of eye-tubercles. About 62 pairs of legs. In other respects there is reasonable agreement with Packard's description. Further particulars are given in table 1 (p. 36).

Remarks.—The real status of this type seems to be a little uncertain, because Packard's type locality was not Utah, but Po Cañon, Vermillion River, Colo. However, the specimen most probably comes from Packard's collection, and I feel reasonably certain that it belongs to this species. The large number of abdominal rings agrees well with Packard's statements that "the abdomen is longer than usual" and "there are about sixteen segments beyond the posterior edge of the carapace." Another species with many abdominal rings is described later on in this paper (p. 39), but *L. bilobatus* is easily distinguished by the position of the nuchal organ, the typical arrangement of the spines on the posterior emargination of the carapace, and by the varying sizes of the spines on the supra-anal plate. In the two last mentioned respects, there is good agreement with Packard's description. "Seven more or less well-marked median spines" on the telson, according to Packard, stands in sufficiently good accordance with the condition in this specimen. Bilobation of the supra-anal plate occurs here, in agreement with Packard's description, but it is to be remembered that this character is not an important one.

Tentatively, I have placed here another specimen (U.S.N.M. No. 82028) which bears only the label "Probably Arizona."

In a case like this, when there is a little uncertainty about the status of the single existing type specimen, and the original description is not very good, it may be questionable whether we ought to discard the species or keep it on record. In my opinion, the description is good enough to enable us to identify the species with reasonable accuracy. However, it seems desirable to search for more material from the type locality or its vicinity.

LEPIDURUS LYNCHI, new species

FIGURES 14–18; 19, *c;* 20–27; PLATES 3, 4, AND 7 (FIGURE 3)

Type specimens.—Holotype (1 ♀), allotype (1 ♂), and paratypes (Uppsala Mus.); paratypes also in U.S.N.M. (No. 82101); ponds in the upper Grand Coulee, Grant County, Wash; collector J. E. Lynch. Additional paratypes (6♀♀, 2♂♂, 5 juniors) from Fish Lake Valley, Nev.; collector, La Rivers.

FEMALES (52 specimens): Holotype 11+16.5+4.5=32 body-rings; paratypes 11+(15–18)+(3+i–5.5)=30+i–34 body-rings. Surface of all body-rings smooth, spines on dorsal and lateral quarters of caudal border of legless rings large, smaller on ventral quarter. On penultimate ring 9 large, 8 small spines; in paratypes 6–14 and 4–9, respectively, the boundary between large and small spines not always sharp, because they may diminish in size gradually. Telson (disregarding supra-anal plate) long, its length almost as great as its width, smooth except for small spines around dorsal sense organs and around bases of caudal filaments. Supra-anal plate 4 mm. in length (24 percent of carapace); in paratypes 0.6–8 mm. (7–30 percent of length of carapace, highest percentage being in large specimens). This plate irregularly tongue-shaped, with coarse, small spines on its margin, and 4 rather large spines dorsally in midline; in paratypes broadly triangular, tongue shaped or spatulate, often more or less bilobed, often irregular, with 2–7 dorsal spines. Caudal filaments 24 mm.; in paratypes 11–39 mm. 18 body-rings exposed beyond carapace; in paratypes 12–19. Color of preserved specimens greenish brown. Total length disregarding supra-anal plate and caudal filaments, 26 mm.; paratypes 12–45.5 mm. (preserved specimens!).

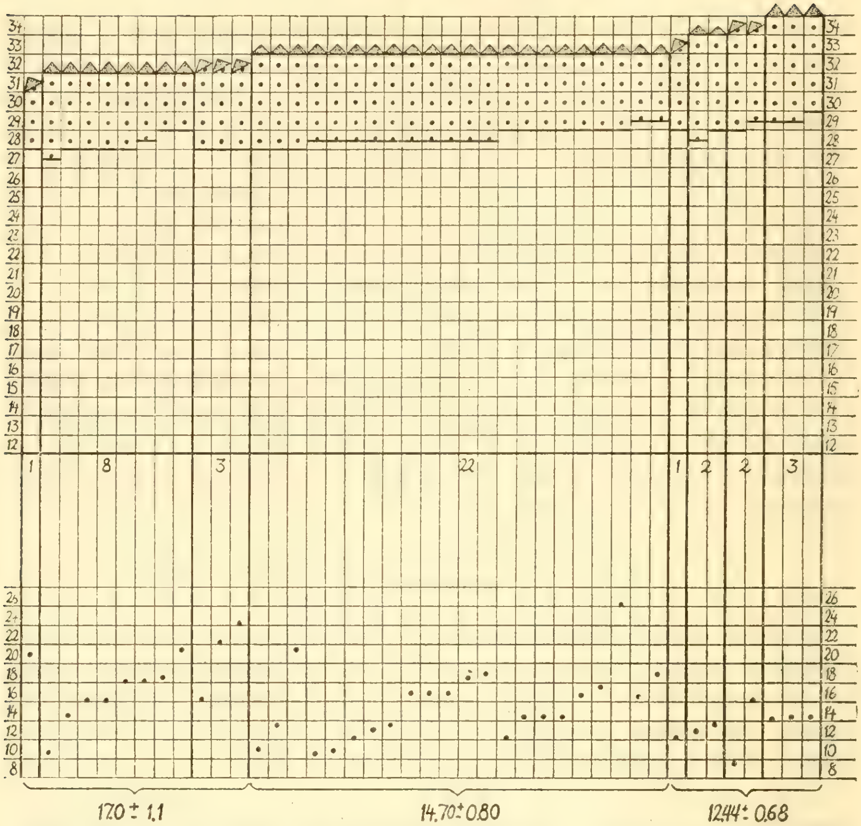

FIGURE 14.—Diagram indicating the number of body-rings in the abdomen and the length of the carapace in 42 female paratypes of *Lepidurus lynchi*, new species (males present in the sample not considered here). Each shaded triangle at the top of the diagram represents the telson of a specimen, below which are indicated the legless abdominal rings (dotted) and the leg-bearing rings. Incomplete rings at the anterior boundary of the telson are denoted by the oblique position of the triangle. Body-ring numbers are shown in the marginal columns at the left and right of this portion of the diagram. The carapace length of each specimen in mm. is indicated in the lower part of the figure, according to the scale in the left and right marginal columns. Correlations of various kinds are reserved for a later statistical report on more comprehensive material.

Carapace length 17.5 mm.; width 2 x 11.5 mm., width: length relation 1.22; in paratypes length 8.5–26 mm., width 2 x 5–2 x 15 mm., width: length relation 1.14–1.30. Caudal half of lateral margin serrated by numerous, minute, pointed spines. Dorsal carina slightly marked, with 19 short spines evenly scattered along whole carina; in paratypes carina often inconspicuous or wanting, with 0–20 spines. Posterior emargination rather deep, 5 mm., with 12 short spines on one side, 13 on the other, not quite similar in size and somewhat irregularly placed; in paratypes 7–17 spines on each side. Supra-antennal crest quite smooth.

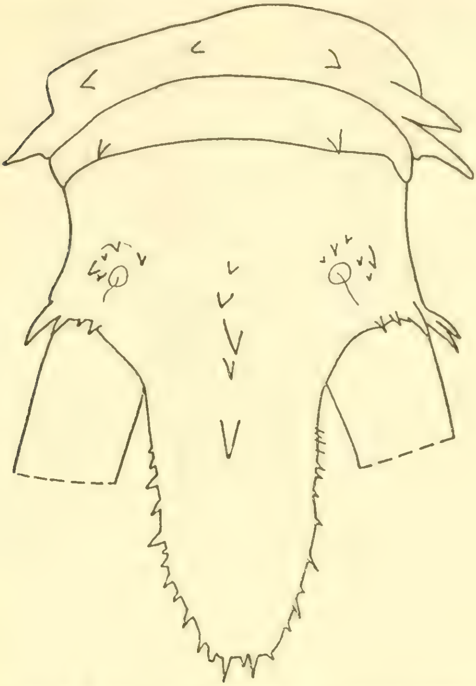

FIGURE 15.—Dorsal view of telson and last two body-rings of a female of *Lepidurus lynchi*, new species, × 18.

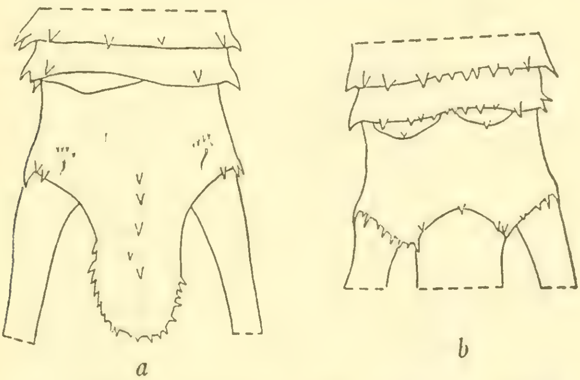

FIGURE 16.—Three pieces of an incomplete ring at the anterior margin of the telson in a female of *Lepidurus lynchi*, new species, × 11: *a*, Dorsal view; *b*, ventral view.

Eyes unusually small. Nuchal organ round, elevated to about same height as the small eye-tubercles, and placed clearly behind them; in paratypes more or less rounded form, rather varying height but always similar in position.

Antennae, mandibulae, and maxillae as usual in the genus.

Pairs of legs 61; in paratypes 60–71. Endites 2, 3, 4, 5 on first leg 1, 5, 3.4 and 8 mm., long, respectively; endopodite very short,

TABLE 2.—*Arrangement of legs in five females of* Lepidurus lynchi, *new species, and three males of* Apus longicaudatus *LeConte; each lot from a single locality.* (See p. 7.)

Item	*Lepidurus lynchi* (5 females)					*Apus longicaudatus* (3 males)		
Length carapace (mm.)	12	12	13	18	25. 5	14	14. 5	19
Number leg-bearing abdominal body-rings	16. 5	16. 5	17	16. 5	16	17	19	17
Number pairs legs	63	64	66	66	68	59	57	58
Leg-bearing abdominal body-ring on which 50th pair of legs is placed.	Beginning of 16th	Near end of 15th	Middle of 15th	End of 15th	End of 14th	Beginning of 17th	End of 18th	Beginning of 17th

TABLE 3.—*Numbers of legs and body-rings in the species of* Lepidurus *and* Apus. (See p. 17.)

Species	Total pairs of legs	Leg-bearing abdominal body-rings	Legless abdominal body-rings	Total body-rings
Lepidurus apus, arcticus, couesii, kirki, packardi, viridis, probably *patagonicus*	35–46	9.5–13	3.5–8	25–29
Lepidurus bilobatus, lynchi, lynchi var. *echinatus*	60–71	14.5–18	3–6	30–34
Apus australiensis, cancriformis, granarius, longicaudatus, namaquensis, numidicus, sudanicus (*A. cancriformis* may form a separate group, cf. p. 52).	50–66	12.5–21	4. 5+i–17	30–44

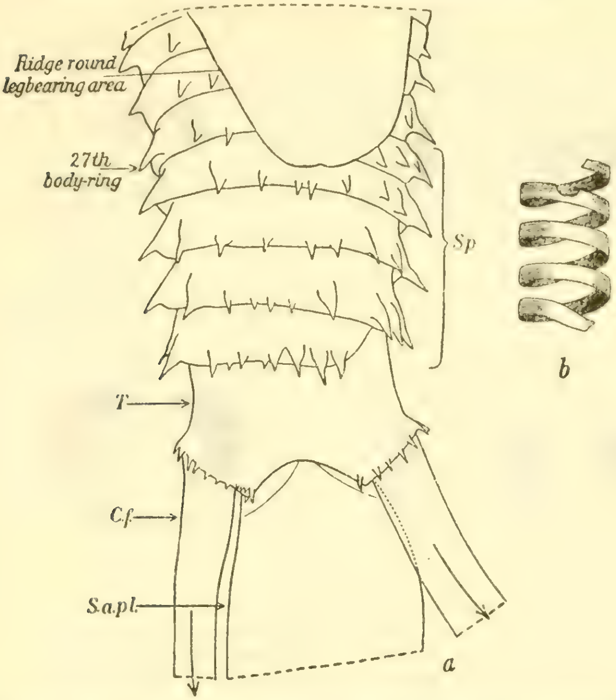

FIGURE 17.—*a*, Oblique ventral view of part of the abdomen and telson of the largest female; of *Lepidurus lynchi*, new species, showing a right-handed spiral of a little more than four rounds beginning in the leg-bearing part of the body and forming the entire legless part of it, × 8.5. The telson is shown in ventral view because of a slight natural torsion of the telson. Legs omitted, as well as spines on caudal filaments. Only basal parts of supra-anal plate and caudal filaments shown. (*C.f.*, caudal filaments; *S.A.pl.*, supra-anal plate; *Sp*, spiral; *T*, telson.) *b*, Schematic drawing of the spiral.

FIGURE 18.—Dorsal view of posterior emargination of the carapace of a female paratype of *Lepidurus lynchi*, new species (Uppsala Museum), × 7.

fringed with setae on its caudal margin; in paratypes (fig. 21) varying lengths, but fifth endite always at least double the length of fourth and reaches, when stretched backward, usually nearly to the posterior angle of carapace. On second leg endites 3, 4, and 5 rather similar in length, endopodite long, 2.2 mm., pointed, of about same length as fifth endite, fringed with setae on its caudal margin. Eleventh leg with a small epipodite, fringed with setae, and trace of a pre-

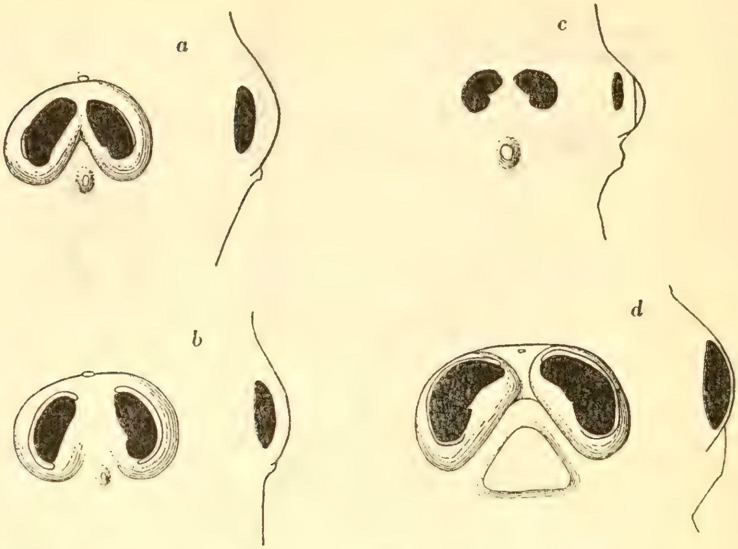

FIGURE 19.—Eyes and nuchal organ: *a*, Female holotype of *Lepidurus packardi* Simon (Paris Mus.), ×12; *b*, male paratype of *Lepidurus couesii* Packard from Montana (Stockholm Mus.), ×12; *c*, female paratype of *Lepidurus lynchi*, new species (Uppsala Mus.), ×8; *d*, male of *Apus longicaudatus* from Wyoming (U.S.N.M. No. 58766), × 8.

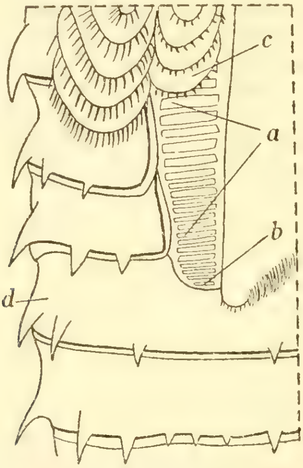

FIGURE 20.—Ventral view of a portion of the right side of a female of *Lepidurus lynchi*, new species, from which the last 25 legs have been removed, × 21. The specimen has 11+17.5+3.5=32 body-rings and 64 pairs of legs. *a*, Bases of legs; *b*, base of last (sixty-fourth) leg; *c*, endopodite of thirty-ninth leg; *d*, twenty-ninth body-ring.

epipodite in the form of an elevation with a few setae. Last leg very small.

MALES (55 specimens): Allotype 11+14.5+4.5+i=30+i body-rings; paratypes 11+(14.5–17)+(3.5–5.5)=30–33+i body-rings. Surface of body-rings smooth, spines on caudal border of legless rings about as numerous as in female. Telson, except supra-anal plate, as in female. Supra-anal plate 6.5 mm. in length, 35 percent of length of carapace; in paratypes 0.7–5 mm., 18–32 percent of length of carapace. This plate irregularly bilobed, with 2 rather large spines dorsally in midline; in paratypes form varying as in female, with 2–6 spines. Caudal filaments 23 mm.; in paratypes 14–25.5 mm. Body-rings exposed behind carapace 15+i; in paratypes 10–19. Color as in female.

Total length without supra-anal plate and without caudal filaments 29.5 mm.; paratypes 12–24 mm.

Carapace length 18.5 mm., width 2 x 11 mm., width: length relation 1.19; in paratypes length 11.5–16.5, width 2 x 7–2 x 10 mm., width: length relation 1.08–1.33. Anterior part broader than in females. Spines on lateral margin of carapace as in females. Carina missing; one short spine in midline; in paratypes sometimes trace of an inconspicuous carina at the places where there are spines, these ranging

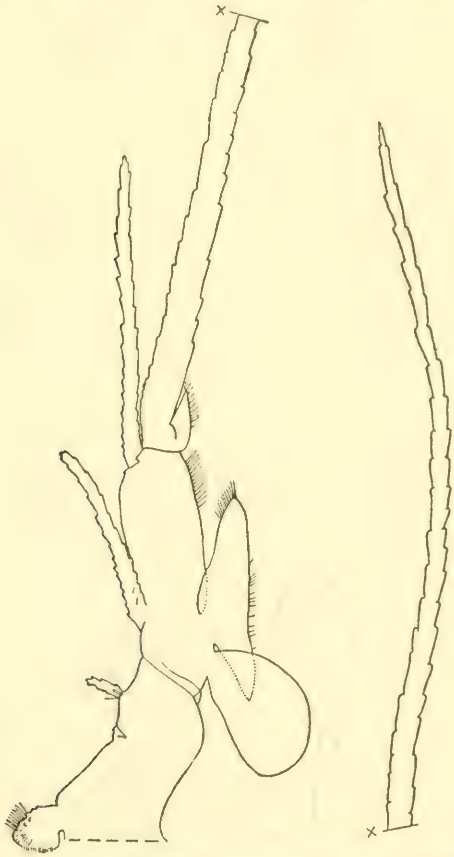

FIGURE 21.—First leg of a female paratype of *Lepidurus lynchi*, new species (Uppsala Mus.), × 6.

from 0–28 in number. Posterior emargination rather deep, 5 mm. in depth, with 13 rather conspicuous spines on one side, 14 on the other, a little irregularly placed and not quite similar in size; in paratypes rather deep, 7–16 spines on each side.

Eyes, nuchal organ, and supra-antennal crest as in female.

Antennae, mandibulae, and maxillae as in female.

Pairs of legs 60; in paratypes 60–67 (only 5 specimens counted). Length of endites 2, 3, 4, and 5 on first leg 0.8, 3.4, 4 and 10.2 mm., respectively; endopodite very short, fringed with setae on its caudal margin; in paratypes varying lengths, but fifth endite always more than double the length of fourth endite, reaching, when stretched backward, more than halfway to end of carapace. On second leg

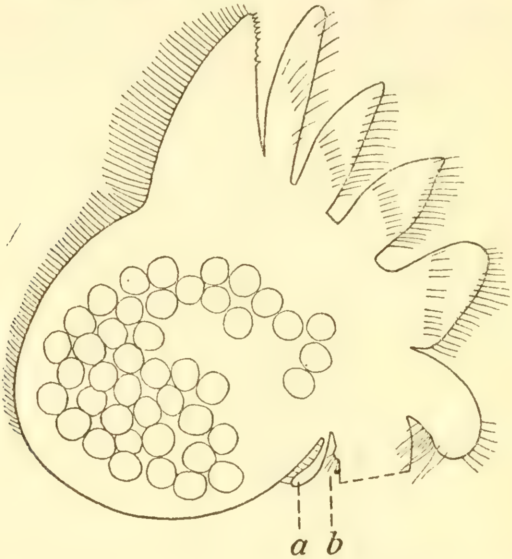

FIGURE 22. Eleventh leg of a female paratype of *Lepidurus lynchi*, new species (Uppsala (Mus.), × 12: *a*, Epipodite; *b*, pre-epidodite.

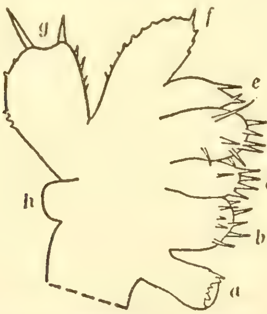

FIGURE 23.—Last (seventy-first) leg of a female paratype of *Lepidurus lynchi*, new species (Uppsala Mus.), × 200: *a-e*, First to fifth endite; *f*, endopodite; *g*, exopodite; *h*, epipodite.

FIGURE 24.—Dorsal view of supra-anal plate of a male paratype of *Lepidurus lynchi*, new species (Uppsala Mus.), × 10.5.

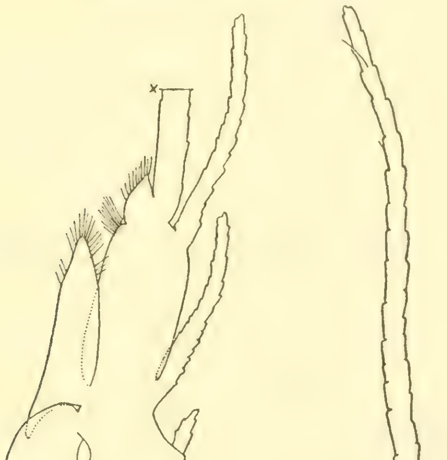

FIGURE 25.—First leg of a male paratype of *Lepidurus lynchi*, new species (Uppsala Mus.), × 7.

endites 3 and 4 of same length, 2.1 mm., endite 5, 4.2 mm., endopodite long and narrow, 2.2 mm., fringed with setae on its caudal margin;

in paratypes varying lengths, fifth endite sometimes not much longer than endopodite. Eleventh leg with trace of a pre-epipodite as in female.

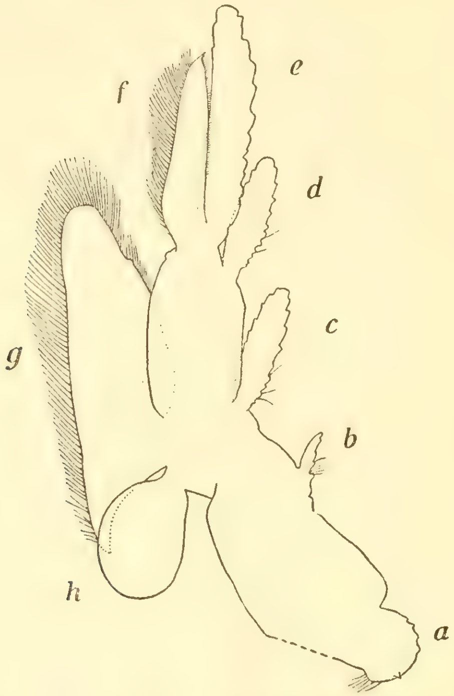

FIGURE 26.—Second leg of male paratype of *Lepidurus lynchi*, new species (Uppsala Mus.), × 7: *a-e*, First to fifth endite; *f*, endopodite; *g*, exopodite; *h*, epipodite.

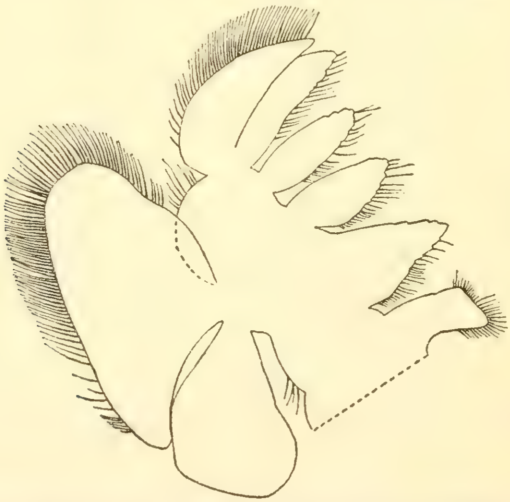

FIGURE 27.—Eleventh leg of a male paratype of *Lepidurus lynchi*, new species (Uppsala Mus.), × 13.

Remarks.—This new species is especially interesting, because it belongs (see table 3) with *L. bilobatus* in the group with many abdominal rings. The variation of the species, as limited above, may perhaps seem to be rather great. It includes forms with a very spiny carapace together with forms where the carapace is quite smooth; but intermediate forms occur in great numbers, and we find a similar variation in several species of the genus *Apus* (Barnard, 1929). Furthermore, the form of the supra-anal plate is highly variable; but, as I have shown previously (p. 26), this is true of many species. The great range of variation must be seen in connection with the fact that the species is described from such a great number of specimens from the same district.

The species is easily distinguished from *L. bilobatus* by the size and place of the nuchal organ and the eyes, characters to which I must ascribe great taxonomic importance. Its relation to the following form, however, I cannot regard as quite clear.

LEPIDURUS LYNCHI ECHINATUS, new variety

FIGURE 28; PLATES 5 (FIGURE 1), AND 7 (FIGURE 4)

Type specimens.—Holotype ♀ (U.S.N.M. No. 82068), allotype ♂ (U.S.N.M. No. 82069), paratypes 6 ♂ and 4 ♀ (U.S.N.M. No. 82070 and Uppsala Mus.). North end of Goose Lake, about 15 miles southwest of Lakeview, Lake County, Oreg.; altitude 4,700 feet; in water 2 feet deep, muddy; June 14, 1940; collector, J. E. Lynch.

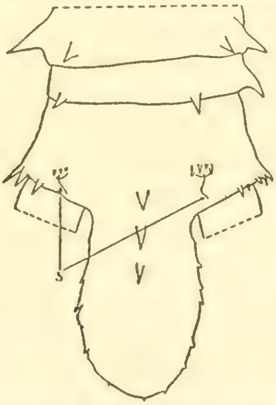

FIGURE 28.—Dorsal view of telson and last two body-rings of a female of *Lepidurus lynchi echinatus*, new variety, × 9. (*S*, dorsal sensory setae.)

Body-rings 11+(16–17.5)+(3.5–4.5)=31–33. Telson rather long. Always many large spines on carina of carapace. In females, 2–5 dorsal spines on supra-anal plate, in males, 3. Legs 67–68 in number (only two specimens). Total length, disregarding supra-anal plate and caudal filaments: Female 32–41 mm., male 22–30 mm. Length of carapace: Female 21–28 mm., male 17.5–21 mm. Width: length relation of carapace 1.21–1.29.

Very similar to the typical form. All characters lie within the range of variation mentioned for this form, except for some details of the carapace. On the middle and caudal part of its lateral margin there are numerous stout spines considerably larger than those in the principal form, though not so large as the spines at the posterior emargination. All the first-mentioned spines are directed straight outward. This is a very conspicuous feature and the explanation of the name *echinatus*. Furthermore, the carapace is more rounded and a little larger in relation to the body than in the typical form, and its posterior emargination is less deep, leaving a smaller number (7–10) of rings exposed behind the carapace.

Remarks.—It is regrettable that there are not more than 12 specimens of this variety, because this small lot cannot be expected to show much of the variation. As a provisional measure I have given it the rank of a variety within *L. lynchi*, because it shows a great similarity to this species in such important respects as the number of abdominal rings, the characteristic appearance of the eyes and the nuchal organ, and the array of spines on the lateral margins of the carapace. At the same time, there are clear differences between the two forms in the shape of the carapace.

There is a certain similarity between this variety and *L. lemmoni* Holmes, especially in the array of lateral spines on the carapace and, perhaps, also in the position of the nuchal organ.

But, as I will discuss in more detail later (p. 51), the similarities are more or less uncertain, and I consider *L. lemmoni* as an insufficiently known species. There are dissimilarities, in any event, among which the different shape of the posterior emargination of the carapace is the first to attract attention. I consider it better in this case to establish a new variety than to venture a highly dubious identification with an insufficiently described species.

LEPIDURUS LEMMONI Holmes

Lepidurus lemmoni Holmes, 1894, p. 585 (not Coopey, 1946, p. 338).

Description.—The principal points of the description of this insufficiently known species follow: About 4 body-rings exposed behind carapace, 4 or less legless body-rings (the author says 5 instead of 4, but in all probability he counts the telson as a ring). Number of spines on last body-ring never far from 12. Supra-anal plate rather long and may be rounded, truncated (obliquely so in some specimens), or, in some cases, bilobed, with 2–3 spines in midline, but no median carina except where the spines are situated. Carapace oval, carina with 10–15 teeth, posterior emargination with 5–7 teeth, sides with numerous small teeth. Nuchal organ round, small, considerably elevated, and located considerably behind the posterior margin of eyes. Length, 28 mm.

Type locality.—Honey Lake, Calif.

Types.—The type specimens (4 ♀, 1 ♂) are said to have been lost in the San Francisco fire.

Remarks.—Holmes' description is very good for its time, but naturally it does not mention the number of abdominal leg-bearing rings or the total number of rings. In these respects, there are two well demarcated groups within the genus, and these totals seem to be essential for a proper identification. Perhaps both were low, because he reports only 4 rings exposed behind the carapace; but we cannot be certain of this. Equivalent totals in *L. lynchi* var. *echinatus* are high even though as few as 7 rings are exposed. Only 12 specimens are known of the latter form, and only 5 of *L. lemmoni*. So few specimens cannot be expected to show a full range of variation; thus, it is possible that *L. lemmoni* may fall in within the upper limits of variation in this respect. And we must not forget that, in general, the number of exposed rings is shown to be an unreliable character, so its value as an indicator of the number of rings is very uncertain.

Other characters do not give clear indications, either. The nuchal organ is "located considerably behind the posterior margins of the eyes." Perhaps we have a condition here similar to that in *L. lynchi* and *L. lynchi* var. *echinatus*, but a precise comparison is impossible because Holmes does not mention the place of the organ in relation to the eye-tubercles, only to the eyes.

The very long caudal filaments present a character of doubtful significance. In each large lot of *Lepidurus* there is considerable variation in the length of these appendages.

The lateral spines on the carapace look quite conspicuous on Holmes' figure. Similar spines, or larger still, are found in *L. lynchi* var. *echinatus*, whereas in all other notostracans I have seen the corresponding structures are minute and inconspicuous. But *echinatus* differs clearly from *L. lemmoni* by its very shallow posterior emargination of the carapace as well as by the structure of its legs, and so an identification with this form seems highly improbable.

To sum up, the characters given for *L. lemmoni* cannot be regarded as sufficient for a proper identification. In my opinion, we had better not keep the species on record.

It can be abandoned without much trouble, because, as far as I can see, it has been recorded only once since its establishment, and in this case there is undoubtedly an error of identification. Coopey (1946) refers some specimens from Oregon to this species, though with the express reservation that they are only provisionally identified. Most kindly, he has given me the opportunity of examining 3 specimens from Rocky Point Pond, Klamath County. I find them to belong to *L. couesii*. The telson (without supra-anal plate) is short and broad, and on the conspicuous keel of the supra-anal plate there is a large number of spines of varying sizes (2–3 spines in *L. lemmoni*). Even the place of the nuchal organ is as in *L. couesii*. All characters considered, the specimens are quite typical representatives of this species.

Genus APUS Schaeffer

Apus SCHAEFFER, 1756, p. 131.—GURNEY, 1923, p. 497.—BARNARD, 1929, p. 229.[1]

The principal characters of the genus are, in my opinion, the absence of a supra-anal plate on the telson (p. 26), the relatively large number of body-rings, 30–44 as against 25–34 in *Lepidurus* (p. 42), and the reduction of the second maxillae in full-grown specimens (p. 28).

Even within these limits, however, the genus presents a unit that is not quite homogenous or well distinguished from the genus *Lepidurus*, because one species, *A. cancriformis*, is in several respects suggestive of the latter genus.

Absence of a supra-anal plate seems to be characteristic of all species except *A. cancriformis*, where we may find something rather similar to such a plate (fig. 8). It is very short, but we can only assume that it is essentially the same structure as the plate in *Lepidurus*, so that *A. cancriformis* may be regarded as an intermediate stage, in this respect, between *Lepidurus* and the remaining species of *Apus*.

In the reduction of the second maxillae, the same species forms an exception. I have found it to have, in full-grown specimens, just as well developed maxillae as in any species of *Lepidurus*.

It has very few body-rings as compared with almost all the other species of the genus that I have examined. There are a minimum of 30, and, generally, a maximum of 34. In only one sample of *A. cancriformis* have I found more, 35 in a female and 35 or 37 in the males (U.S.N.M. No. 58211, from Nanking, China). I have observed a similarly small number of rings in *A. sudanicus* from South Africa, identified by Barnard (U.S.N.M. No. 75749). The male in this sample has 32, the two females 33 and 33+i body-rings. All the other species of *Apus* have a larger number of body-rings. *A. longicaudatus* comes nearest with 34+i–44 rings (see table 4); however, I am fully aware that in many forms we know too little of the number to be able to make definite groupings of the species according to this character. Still, it may be considered significant that *A. cancriformis*, which comes close to Lepidurus in the structure of the telson and the second maxillae, also has a similar total number of body-rings. This is a further indication that the species is a sort of connecting link between the two genera.

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[1] I fully agree with Gurney and Barnard that the name of *Triops* Schrank, 1803, pp. 180, 251 (sometimes spelled *Triopes* or *Thriops*), ought to be rejected.

In its general appearance, also, this species is suggestive of the genus *Lepidurus.* The body, because of its small number of rings, may be almost completely covered by the carapace, which sometimes leaves only part of the telson exposed. Such proportions are unusual in the species of *Apus*, and it is interesting to notice that they occur, not in the species of *Lepidurus* that have a similar number of rings (*L. bilobatus, L. lynchi*), but in those that have the fewest rings.

The number of abdominal leg-bearing rings, a figure that proved helpful as a means of distinguishing groups within the genus *Lepidurus* (p. 31), gives no clear character in *Apus.* In the whole genus, it ranges from 12.5 to 20, figures that are generally higher than in *Lepidurus.* Im *A. cancriformis*, the range is usually 16 to 18, though I have occasionally observed either fewer or more of such rings (the fewest was noticed, not in this species, but in *A. sudanicus*, as noted above, where a male has 12.5 and two females 13.5 and 14 such rings).

The number of pairs of legs in various species is too little known to enable us to draw any conclusions about its taxonomic value.

On the whole, we must admit that much work remains to be done before we will be able to make a reasonably good arrangement of the species of *Apus.*

Distribution in America: Montana, Oregon, Wyoming, California, Nevada, Utah, Colorado, Nebraska, Arizona, New Mexico, Kansas, Oklahoma, Texas; Galápagos Islands; Hawaiian Islands; Mexico; Haiti; St. Vincent Island; Argentina.

APUS LONGICAUDATUS LeConte

FIGURES 3–6, 19, *d*, 29–31: PLATES 5 (FIGURES 2, 3), 6, and 7 (FIGURES 1, 2)

Apus longicaudatus LECONTE, 1846, p. 274.—PACKARD, 1883, p. 324.—MACKIN, 1939, p. 46.
Apus aequalis PACKARD, 1871, p. 3; 1883, p. 320.—PEARSE, 1912, p. 192; 1913, p. 2.
Apus newberryi PACKARD, 1871, p. 2; 1883, p. 321.
Apus lucasanus PACKARD, 1871, p. 2; 1883, p. 322.
Apus oryzaphagus ROSENBERG, 1947, p. 70.
Apus biggsi ROSENBERG, 1947, p. 72.

As far as I can see, the various species of *Apus* described from the North American continent must be united into one species, *A. longicaudatus.* A study of reasonably extensive material shows that the three species of Packard, enumerated above, cannot be properly demarcated from each other and from *A. longicaudatus*, and the same applies to Rosenberg's species.

Packard's material was probably too limited to enable him to detect the unbroken series of variation in most of the characters used by him. It was not so much that he had material from so few localities—4 species from 13 localities—as that only a few specimens were available from each locality. One of his species, *A. newberryi*, was based upon three females from two localities.

TABLE 4.—*Total number of body-rings observed in various species of* Apus

Species	Number of specimens	Males																										
		31	+i	32	+i	33	+i	34	+i	35	+i	36	+i	37	+i	38	+i	39	+i	40	+i	41	+i	42	+i	43	+i	44
cancriformis, South Africa, U.S.N.M. No. 75747	2	x																										
cancriformis, England, U.S.N.M. No. 5857																												
sudanicus, South Africa, U.S.N.M. No. 75749	1			x																								
cancriformis, Eritrea, Uppsala Mus.																												
cancriformis, Sweden, Uppsala Mus.																												
longicaudatus, many localities (table 8)	64															x	x	x		x	x	x	x	x	x	x	x	x
cancriformis, Nanking, China, U.S.N.M. No. 58211	2									x				x														
australiensis, Cowcowing, Western Australia, Uppsala Mus.	1																	x										
numidicus, South Africa, Stockholm Mus.	30																		1	6	1	12	5	3	2			
granarius, Kansu, China, Stockholm Mus.	13																		1		3	6	3					
australiensis, Lake Gidgee, Western Australia, Uppsala Mus.	7																	1				5		1				
granarius, Shansi, China, Stockholm Mus.	23																					5	9	8		1		
namaquensis, South Africa, U.S.N.M. No. 75748	1																										x	

Species	Number of specimens	Females 30	+i	31	+i	32	+i	33	+i	34	+i	35	+i	36	+i	37	+i	38	+i	39	+i	40	+i	41	+i	42	+i	43
cancriformis, South Africa, U.S.N.M. No. 75747	3	x		x		x																						
cancriformis, England, U.S.N.M. No. 5857	2							x																				
sudanicus, South Africa, U.S.N.M. No. 75749	2							x	x																			
cancriformis, Eritrea, Uppsala Mus.	10							x		x																		
cancriformis, Sweden, Uppsala Mus.	32							28	2	1	1																	
longicaudatus, many localities (table 8)	135										x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
cancriformis, Nanking, China, U.S.N.M. No. 58211	1											x																
australiensis, Cowcowing, Western Australia, Uppsala Mus.	2																	x										
numidicus, South Africa, Stockholm Mus.	30																	2	1	7	2	8	1	8		1		
granarius, Kansu, China, Stockholm Mus.	10																	1		2	4	3						
australiensis, Lake Gidgee, Western Australia, Uppsala Mus.	8																			3	1		3	1				
granarius, Shansi, China, Stockholm Mus.	29																			2	2	14	5	4		2		
namaquensis, South Africa, U.S.N.M. No. 75748	2																						x					

Table 5.—*Chief characters of the species of* Apus *recognized by Packard*

Species	Carapace	Exposed rings	Legless rings	Telson	Pattern of dorsal central spines on telson
A. aequalis	As long as abdominal portion behind it.	♂22 ♀24	♂10 ♀8	Short	
A. newberryi	Shorter than in *aequalis*	♀28	♀10	Longer than in *aequalis*	or
A. lucasanus	Shorter than in *newberryi*	♂32 ♀28	♂12 ♀10	Longer than in *longicaudatus*	
A. longicaudatus	Shortest of all American species	♂31 ♀27	♂13 ♀9	Very short	

I suspect that many carcinologists have had difficulties trying to identify species of *Apus* with the aid of Packard's descriptions. Pearse (1912) gives a good example. He had an unusually large number of specimens from one locality and found a remarkable variation in the number of dorsal spines on the telson, which Packard uses as one of the main characters: "The armature of the telson is somewhat variable; on the dorsal side there is commonly one median spine, but there are often two; there are usually two lateral spines at the proximal edge of the telson, but there are frequently more" (Pearse, 1912). Here is a mixture of characters from several species. *A. lucasanus* and *A. longicaudatus* are described with one median spine, *A. aequalis* with two, as is one of the specimens of *A. newberryi* mentioned by Packard. "Lateral spines at the proximal edge of the telson," probably means the spines around the dorsal sensory setae, of which one on each side is described as large in *A. lucasanus*. Thus most of Pearse's specimens ought to have agreed with *A. lucasanus*, but others not. Further, Pearse found the length of the carapace to be "about equal to the portion of the body exposed behind," as in *A. aequalis* according to Packard; it was obviously on these grounds that he identified his specimens with this species and dismissed the similarities with other species (especially *A. lucasanus*), which were observed on the telson of most specimens.

Mackin (1939) says that Packard's three species are synonyms of LeConte's species; his studies on material from Oklahoma and neighboring States showed that the characters used by Packard are of little value in taxonomics. However, he regards his conclusion as only tentative.

Packard's descriptions cover a lot of characters, but many of them are considered in only one species, so that comparisons in some respects are impossible. Those presented in table 5 are especially stressed by him. (In this table I have, in all cases, given one less ring than Packard, because he obviously counts the telson as a body ring, while I do not.)

The length of carapace in relation to length of body, and the number of body-rings exposed behind the carapace, vary according to the contraction of the rings, a condition itself highly variable. These characters are, of course, also influenced by the number of body rings, though in a rather erratic way on account of the variable contraction of the rings. These characters of Packard's are not simple characters, and generally they are more or less unreliable.

As for the number of legless rings, the examples in table 6 show how greatly this often varies in specimens from the same locality. The sample from Wyoming (columns a, c) is significant. It contains many more specimens than the others, and it covers the numbers given by Packard as characteristic of three species, *A. newberryi*

(10 in females), *A. lucasanus* (10 in females), and *A. longicaudatus* (9 in females, 13 in males). More than that, it presents an unbroken series beginning with a number of legless rings not much greater than that given for *A. aequalis* and ending with a number (15+i) considerably higher than those observed by Packard. No correlation with other characters has been found.

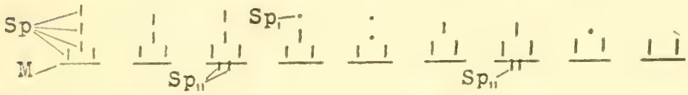
TABLE 6.—*Variation in the number of legless rings in populations of* Apus

Number of legless rings	Females		Males		
	U.S.N.M. No. 58766 (Wyoming) (a)	U.S.N.M. No. 61750 (Texas) (b)	U.S.N.M. No. 58766 (Wyoming) (c)	U.S.N.M. No. 61750 (Texas) (d)	Stockholm Mus. (Kansas) (e)
9+i 9.5	2				
9.5+i	1				
10	6	5			
10+i	8	3			
10.5	7	2			1
10.5+i	7				
11	23	1			2
11+i	21				1
11.5	8				1
11.5+i	2				
12	8				
12+i	3			1	
12.5	1		1		
12.5+i				1	
13	1		4	4	
13+i			3	4	
13.5			1	3	
13.5+i			2	2	
14			8	3	
14+i			7		
14.5			2		
14.5+i					
15			4		
15+i			1		
Total specimens	98	11	33	18	5

The other lots in this table are too small to enable us to make conclusions of a similar degree of probability, though it is noteworthy that they show a small average number of legless rings. The lot from Kansas (column e), however, is interesting for the reason that these specimens were sent from Packard and labeled by him *A. lucasanus*. Thus we may regard them as paratypes of this species. But they do not agree with his description, which claims 10 legless rings in the female, 12 in the male. Here we find only 9 such rings in the female (not shown in table 6), 10.5 to 11.5 in the males, to which must be added a male with spiral growth where there are 8 ordinary rings and 2 spirals of 2 rounds each in the legless part of the abdomen. This lack of agreement between the paratypes and the description is significant, and it will be stressed when we find that they do not agree with the description in another respect, either.

I have seen many small lots of *Apus* from North America, in which the number of legless rings varied considerably. The material gives the impression that different populations might be characterized by different numbers, but this is by no means statistically certain, and I am convinced that this problem can be solved only by studying large lots. Also, we must not forget that the number of legless rings is quite a dubious character: it is the result of the interaction of the number of leg-bearing rings and the total number of rings.

Size and form of the telson are worth attention because this has proved a reasonably good character in *Lepidurus*. As did Packard, I have found some variation in this structure. However, the various forms present a reasonably continuous series, and I have not been able to discover any correlation with other characters. As the specimens in one lot are usually similar to each other as far as the telson is concerned, perhaps it ought to be determined whether the differences can be of some use in distinguishing lower taxonomical units.



		a	b	c	d	e	f	g	h	i	Total	
1.	♂		5				34	1			40	154
	♀	1	12		1	1	92	1	1	5	114	
2.	♂		2				16	1		1	20	37
	♀		3				14				17	
3.	♂		1	1							2	2
	♀										–	
4.	♂	1	1				3				5	6
	♀						1				1	

FIGURE 29.—Patterns (a to i) of dorsal central spines on the telson in representative specimens of *Apus longicaudatus* LeConte from: (1) Near Aurora, Wyo. (U.S.N.M. No. 58766); (2) Moores Lake, Lubbock, Tex. (U.S.N.M. No. 61750); (3) Galápagos Islands (U.S.N.M. No. 84240); and (4) Kansas (Stockholm Mus., types of *A. lucasanus* Packard). M, dorsal hind margin of telson; Sp, well-developed spine; Sp_{I}, rudimentary spine; Sp_{II}, short spine.

Finally, in considering the pattern of the central dorsal spines on the telson, we must remember that Pearse found a considerable variation here, and that Rosenberg (1947) found the pattern variable in his material. My studies have shown that the variation presents a regular series with many intermediate patterns between the most common ones, so that in a sample with many specimens almost all patterns may be represented.

We see from figure 29 that some patterns are more common than others. These patterns were given the value of specific characters by Packard (1883); he assigned patterns a and b to *Apus newberryi*, pattern b to *A. aequalis*, pattern c to *A. longicaudatus*, and pattern f to *A. lucasanus*. Even in his small collection, however, significant variations must have been known to him. He gives two different patterns for *A. newberryi*, while the paratypes of *A. lucasanus* that

Table 7.—*Characteristics of type specimens of* Apus aequalis, A. newberryi, *and* A. lucasanus

Species	Sex	Series of body-rings	Remarks
A. aequalis, from Matamoros, Mexico (U.S.N.M. No. 11599).	♀	11+17+8=36	Carapace rough with small spines, spines on carina.
	♀	11+19+8=38	Carapace smooth, no spines on carina.
A. aequalis, from Matamoros, Mexico (U.S.N.M. No. 58769).	♂	11+16+11+i=38+i	Carapace smooth, no spines on carina. Two spines on hind margin of telson, as described for *A. longicaudatus*.
A. newberryi, from Utah (U.S.N.M. No. 11601).	♀	11+19+10=40	Carapace with few, very small spines. Five central spines on telson (*a*, fig. 29), some minute spines also.
Do	♀	11+19+10=40	Carapace rough, many small spines on carina. Four central spines on telson (*b*, fig. 29), minute spines also.
A. lucasanus, from Cape San Lucas, Baja California, Mexico (U.S.N.M. No. 11602).	♂	11+19.5+10.5+spiral of a little more than 2 rounds=41+sp.	Carapace smooth, no spines on carina.
A. lucasanus (paratypes), from Kansas (Stockholm Museum).	♀	11+19+9=39	All specimens—carapace smooth, no spines on carina.
	♂	11+16+11=38	
	♂	11+16+11+i=38+i	
	♂	11+16.5+11.5=39	
	♂	11+17.5+10.5=39	
	♂	11+18+11=40	
	♂	11+16+2+sp. 2r.+6+sp. 2r.=35+sp. (pl. 7, figs. 1, 2).	

were sent to the Stockholm Museum show the patterns of three of his species. I have not found any correlation between any one pattern and other characters.

One feature considered here, in a limited way only, is the presence of spines at the dorsal hind margin of the telson. Two spines should be characteristic of *A. longicaudatus*. Even in this respect there is often a great variation (fig. 30). Sometimes there are a number of small spines on this margin, sometimes only a few or none at all, and in some specimens we find two relatively large spines placed near the midline. We notice that such spines occur not only in the pattern said by Packard to be characteristic of *A. longicaudatus*, but also in one which, as far as the central spines are concerned, is given for *A. lucasanus*. Here, too, I have looked in vain for correlation with other characters.

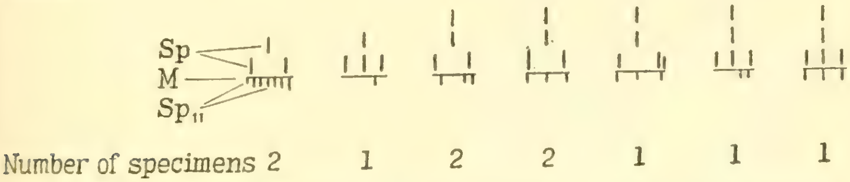


FIGURE 30.—Patterns of dorsal central spines and spines on dorsal hind margin of the telson in specimens of *Apus longicaudatus* LeConte, from California (*A. oryzaphagus* Rosenberg and *A. biggsi* Rosenberg). Abbreviations as in figure 29.

Extra-American species of the genus, too, present great variation in the spines on the telson. Often it is even greater than in American species, as I have found in *A. australiensis* and *A. granarius*. Barnard (1929) arrived at the conclusion that the presence, absence, or varying degree of development of the central spines is of no taxonomic significance in South African forms.

Summing up, I have found that the main characters used by Packard when describing his species of *Apus* are in part wholly unreliable and in part subject to considerable variation without any clear correspondence to other characters. Further, intermediate forms occur very often.

I have examined Packard's type specimens in the U. S. National Museum and also paratypes of *A. lucasanus* in the Stockholm Museum. Some of their characters are given in table 7. The variations in the number of legless rings and the armature of spines on the telson of *A. lucasanus* are already accounted for, and we learn from this that Packard did not pay any attention to the presence or absence of spines on the carapace and its carina. I quite agree with him that this character is of no taxonomic significance. Further, we notice from table 7 that the male of *A. aequalis* has two spines at the hind margin of the telson, a character given by him for *A. longicaudatus*.

TABLE 8.—*Total number of body-rings observed in specimens of* Apus longicaudatus *LeConte from various localities* [1]

Locality [1]	U.S.N.M. No.	Number of specimens	Males													Number of specimens	Females																		
			38	+i	39	+i	40	+i	41	+i	42	+i	43	+i	44		34	+i	35	+i	36	+i	37	+i	38	+i	39	+i	40	+i	41	+i	42	+i	43
California (Paratypes of *A. oryzaphagus*)	88360															6		x	x																
California (Paratypes of *A. biggsi*)	88361															4				x	x														
Galápagos Islands	84240															2				x			x												
Mexico (Types of *A. aequalis*)	11599															2					x				x										
New Mexico	41842															2								x				x							
General Acha, Argentina (Stockholm Mus.)																6										x	x								
Kansas (Paratypes of *A. lucasanus*, Stockholm Mus.)		6	x	x	x		x									1											x								
Nevada	85524	1	x																																
Mexico (Type of *A. aequalis*)	58769	1		x																															
Colorado	30576															2											x		x						
Texas	61750	20						x	x	x	x	x	x			12											x		x	x	x		x		
Oregon	41845															2												x	x						
Wyoming (?)	58766	33							x	x	x	x	x	x	x	98												x	x	x	x	x	x	x	x
Utah (Types of *A. newberryi*)	11601															2													x						
Texas	79027															1													x						
Montana	63289	1									x																								
Mexico (Type of *A. lucasanus* with spiral)	11602	1											x																						

[1] For details, see tables 6 and 7 (pp. 58, 60).

As I have said, the presence of such spines will not do as a specific character.

The total numbers of body-rings in table 7 might give the impression that we have, at last, found a distinguishing character for *A. aequalis* in its relatively low number. This would tally well with Packard's statement that this species has a short body in relation to the length of the carapace and that comparatively few rings are

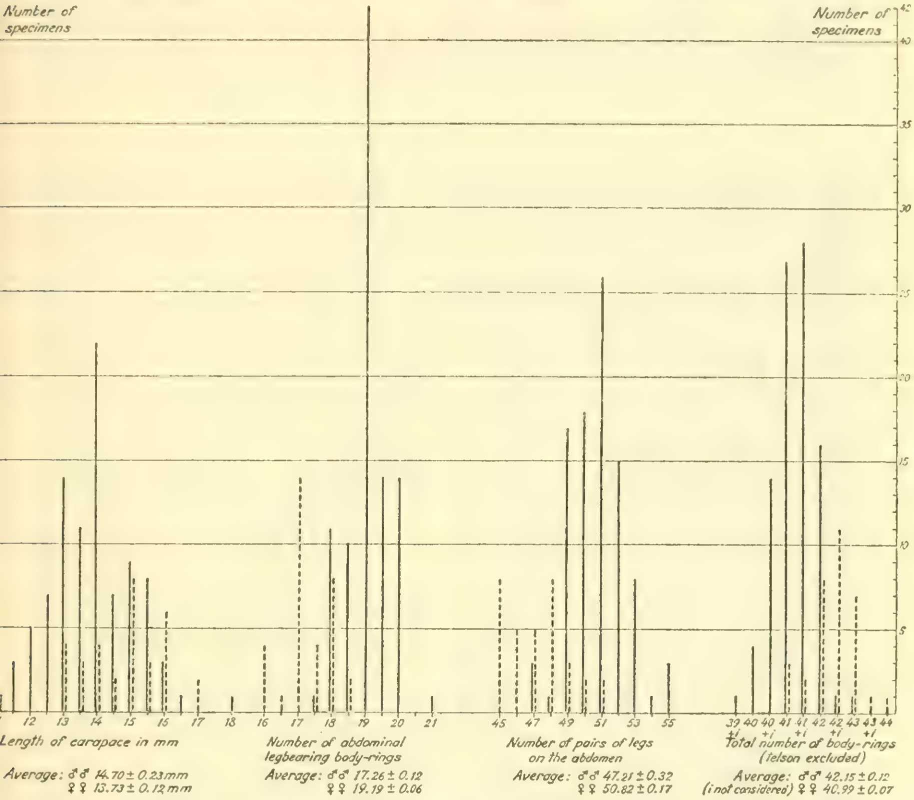


FIGURE 31.—Variations in the length of the carapace, number of legs, number of abdominal leg-bearing rings, and total number of rings in a population of 33 males and 98 females of *Apus longicaudatus* LeConte, from near Aurora, Wyo. (U.S.N.M. No. 58766). Males indicated by dashed lines, females by solid lines. Correlations of various kinds to be considered in a later paper.

exposed beyond the carapace. But a look at the paratypes of *A. lucasanus* contradicts this conclusion. There is a male with the same number as the type specimen of *aequalis* (38+i), and others with a little lower or higher number. The female has a number which is only slightly higher than that of the types of *A. aequalis*. As I have found (see table 8), the total number of rings in American forms of *Apus* present a continuous series from 34+i to 43 in the females and from 38 to 44 in the males. We cannot divide the series into species at some points arbitrarily chosen. And we know that the variation in this respect may be quite considerable.

It seems clear that Packard's species *A. aequalis*, *lucasanus*, and *newberryi* cannot be upheld. All these forms ought to be included in *A. longicaudatus*, which was described first.

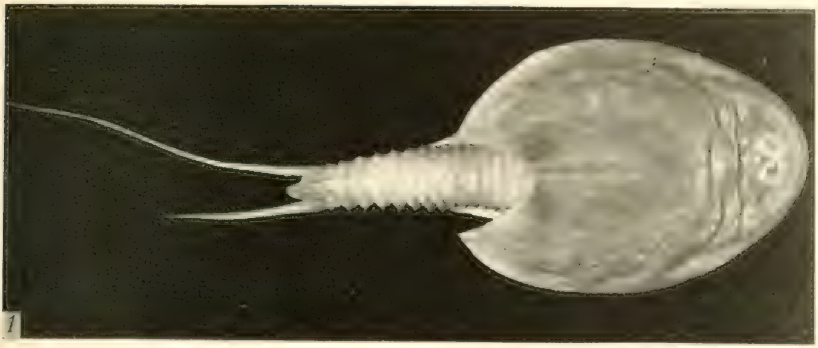
In this species I also include Rosenberg's species *A. oryzaphagus* and *biggsi*. These two forms differ from each other in two points, according to the description. The former species should have 35 body-rings (34+i or 35 in paratypes examined by me) and be small; the latter should have 36 rings (35+i or 36 in paratypes examined by me) and be larger. Considering the continuous series of variation of the number of rings in American forms it seems difficult to accept a certain number as a specific character. Similar numbers are observed, even in other samples, as table 8 demonstrates. One of the types of *A. aequalis* has exactly the same number as *A. biggsi* (table 8). The taxonomical value of the differences in size is doubtful. The forms in question are probably nothing more than populations with a pronounced parthenogenetic tendency, counterparts of which are to be found in the European species, *A. cancriformis*. In all respects, they join the series of variation in other American forms. Parthenogenetic populations probably also occur in the Galápagos Islands, from which locality I have seen lots (U. S. N. M. Nos. 83031, 82033–5, and 84240) totaling several hundred specimens, all female. Table 8 lists other localities from which only females have been found, but the material is too scanty to permit any conclusions about the possible existence of parthogenesis.

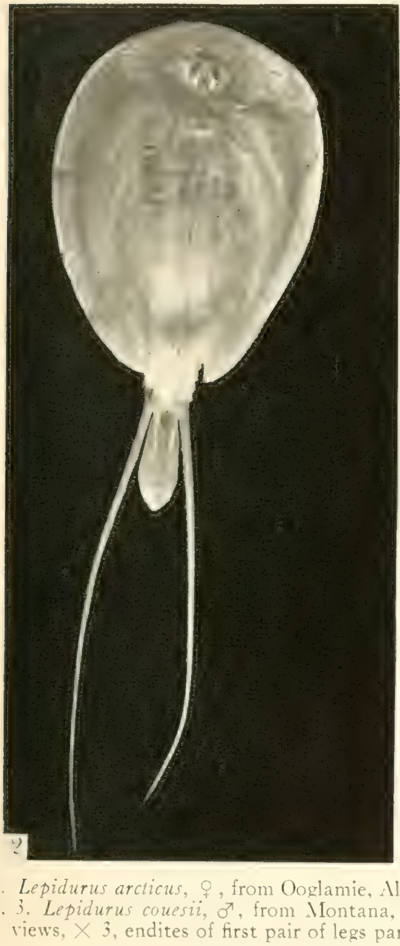
I have not had access to specimens of *A. domingensis* Baird from Haiti or *A. guildingi* Thompson from St. Vincent Island (Packard, 1883, p. 326), and so I cannot say anything of the taxonomic status of these forms except that no facts in the short descriptions contradict an assumption that they belong to *A. longicaudatus*.

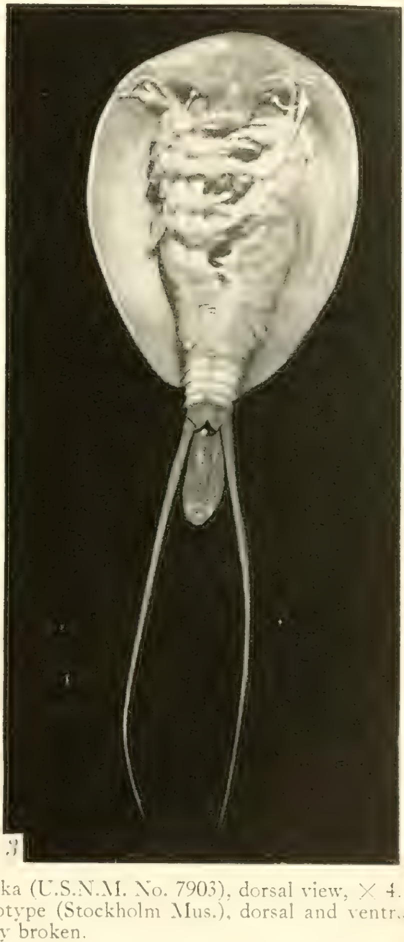
Apus longicaudatus, in this sense, is very variable. So are other species of the genus, too, according to my experience. In one respect the variation seems to be remarkably great here, and that is the total number of rings in the females (34+i to 43). It is true that I have not observed such a great range of variation in other species (see table 4), but we must not forget that only relatively limited material of the other species is considered here. How great a variation they really have remains an open question.

The future may show into what units *A. longicaudatus* can be divided. Not even their taxonomic value can be predicted, though, from the standpoint of our present knowledge, it seems unlikely that they will be species.

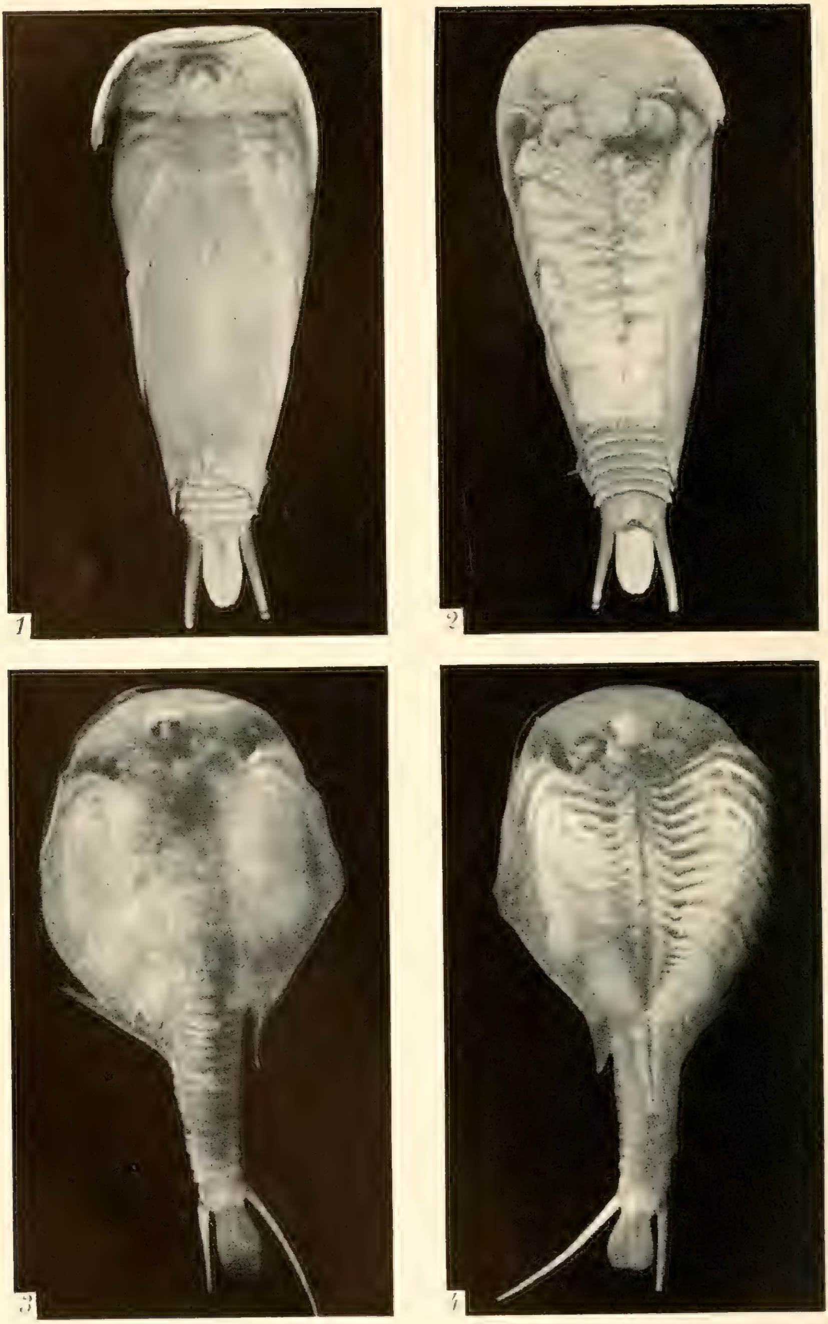
It seems clear that *A. longicaudatus* is closely related to several







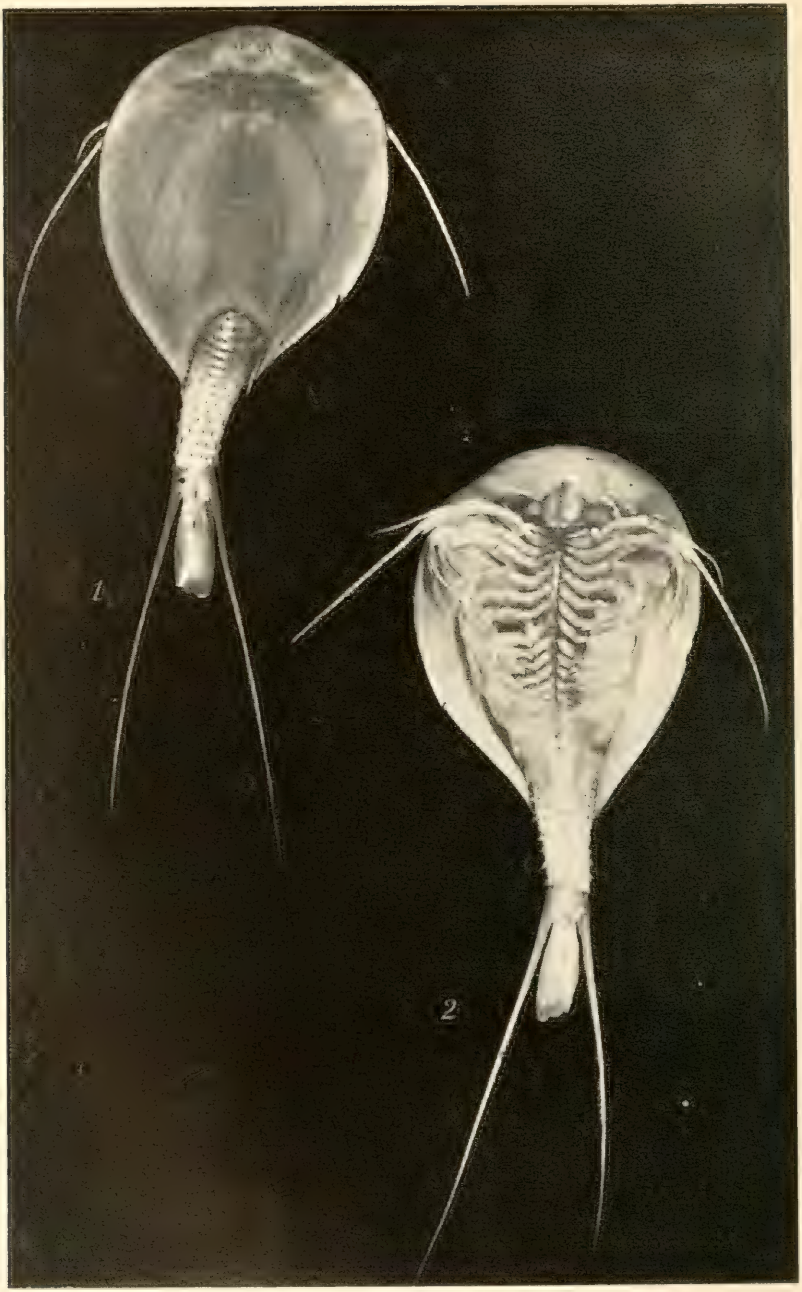
1. *Lepidurus arcticus*, ♀, from Ooglamie, Alaska (U.S.N.M. No. 7903), dorsal view, × 4.
2, 3. *Lepidurus couesii*, ♂, from Montana, cotype (Stockholm Mus.), dorsal and ventral views, × 3, endites of first pair of legs partly broken.



1, 2. *Lepidurus packardi*, ♀, from California, holotype (Paris Mus.), dorsal and ventral views, × 4.
3, 4. *Lepidurus bilobatus*, ♀, labeled "Type, Utah, coll. Henshaw" (U.S.N.M. No. 11606), dorsal and ventral views, × 3.

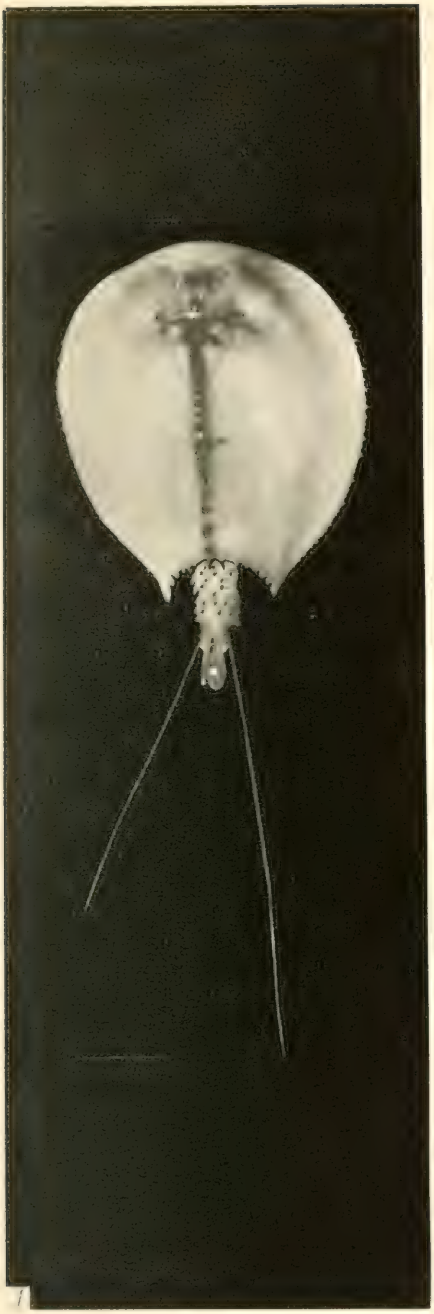
LEPIDURUS LYNCHI, NEW SPECIES.

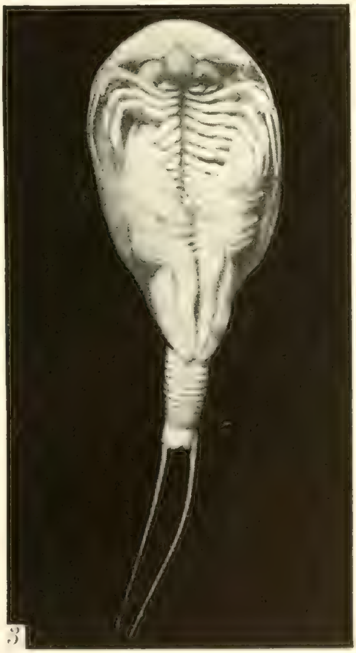
Female, from Upper Grand Coulee, Wash., holotype (Uppsala Mus.), dorsal and ventral views, × 2.



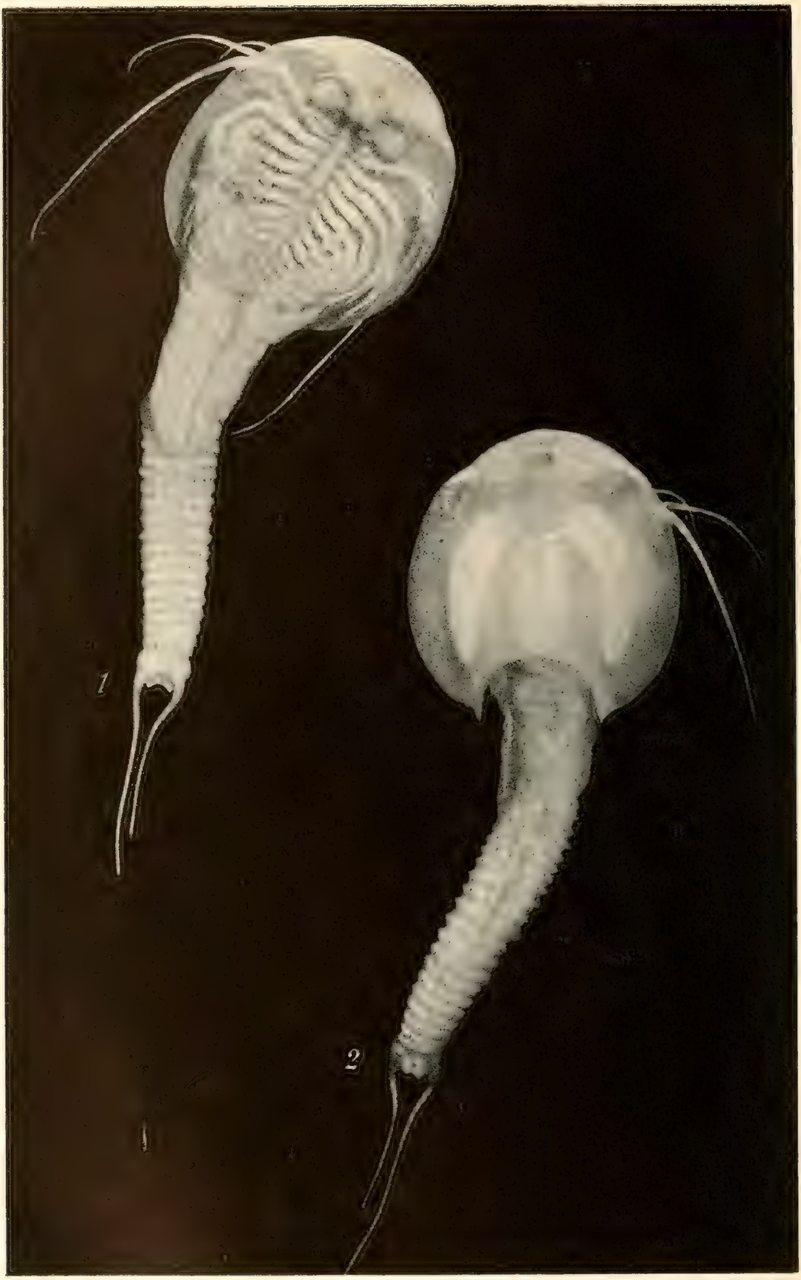
LEPIDURUS LYNCHI, NEW SPECIES.

Male, from Upper Grand Coulee, Wash., allotype (Uppsala Mus.), dorsal and ventral views, × 2.3.



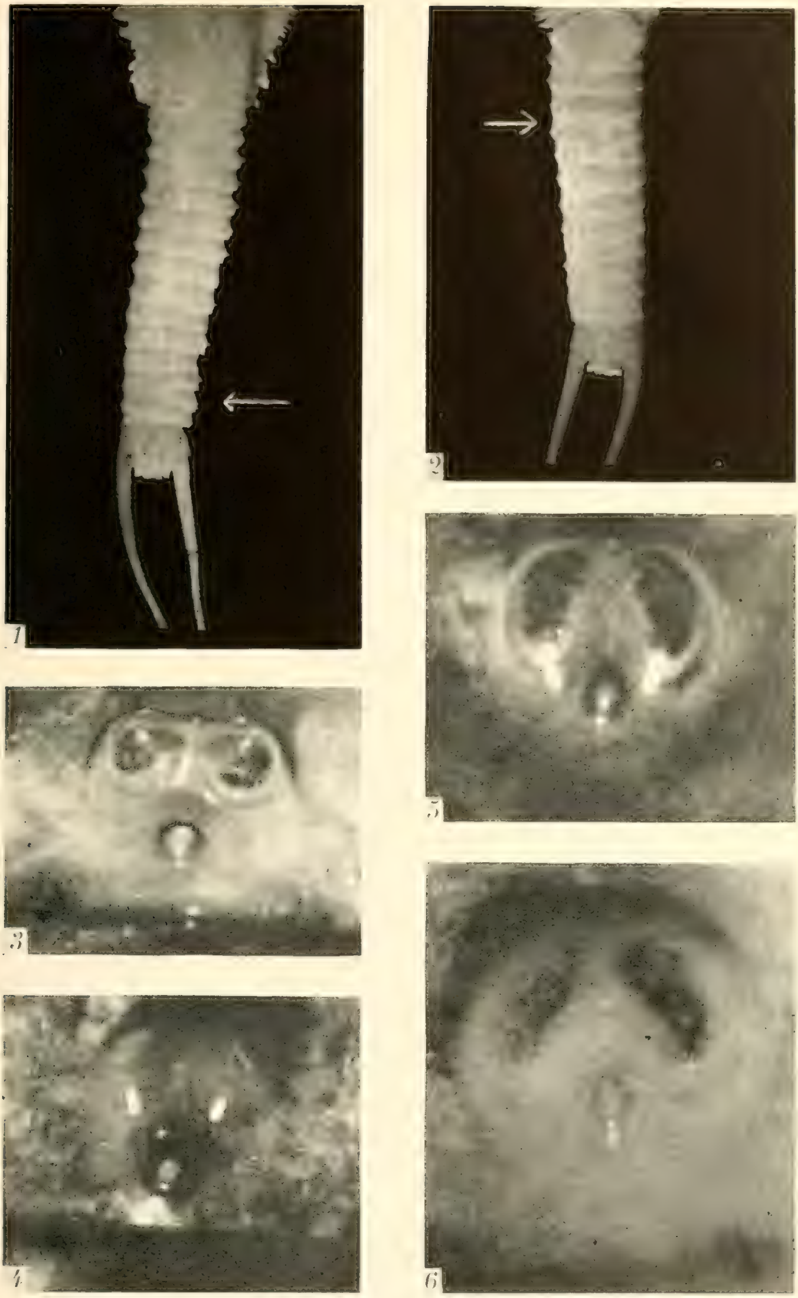


1. *Lepidurus lynchi echinatus*, new variety, , from Goose Lake, Lakeview, Oreg., paratype (Uppsala Mus.), dorsal view, 2.
2, 3. *Apus longicaudatus*, , from General Acha, Argentine (Stockholm Mus.), dorsal and ventral views, 2.



APUS LONGICAUDATUS.

Male, from Wyoming (U.S.N.M. No. 58766), ventral and dorsal views, × 2.



1, 2. Two spirals in legless part of abdomen of *Apus longicaudatus*, ♂, from Kansas (Stockholm Mus.), dorsal and ventral views, × 4 (this specimen was examined and described as *Apus lucasanus* by Packard).
3–6. Eyes and nuchal organs of, respectively, *Lepidurus lynchi*, new species, ♂, × 7; *L. lynchi echinatus*, new variety, ♀, × 6; *L. couesii*, ♂, × 9; and *L. packardi*, ♀, × 12.

species from other parts of the world, among which *A. australiensis* and *A. granarius* may be especially mentioned. Distinguishing characters are difficult to establish before the latter species have been subjected to a closer study. For the present, *A. longicaudatus* may be characterized by perhaps one outstanding feature—that the dorsal central spines on the telson are relatively large and are arranged in distinct patterns.

Localities.—Material from the following localities has been examined by me (samples with more than 50 specimens marked *):

Montana: 20 miles south of Malta (U.S.N.M. No. 53715); Malta (U.S.N.M. No. 63289); Billings (U.S.N.M. No. 82047). Oregon: without particulars (U.S.N.M. No. 41845). Wyoming: Cheyenne (U.S.N.M. No. 8298); "coll. A. Hyatt" without particulars (U.S.N.M. 58767); near Aurora (locality regarded as dubious), coll. Alpheus Hyatt (U.S.N.M. No. 58766*). California: Butte County, Richvale District (U.S.N.M. No. 82032); Butte and Sutter Counties (paratypes of *A. oryzaphagus*) (U.S.N.M. No. 88360); Biggs, Butte County, (paratypes of *A. biggsi*) (U.S.N.M. No. 88361). Nevada: dry lake near Boulder City (U.S.N.M. No. 82049); dry lake bed recently flooded by rain, near Boulder City (U.S.N.M. No. 85524). Utah: Delta (U.S.N.M. No. 61745); without particulars (types of *A. newberryi*) (U.S.N.M. No. 11601). Colorado: without particulars (U.S.N.M. No. 12419); University Park, Denver (U.S.N.M. No. 23550); Fort Collins (U.S.N.M. No. 29319); artificial lake on Pinyon Mesa, near Grand Junction, altitude 6,500 feet (U.S.N.M. No. 30576). Nebraska: Dewitt (U.S.N.M. Nos. 18812, 18908, 19489, 19691). Arizona: Anderson Mesa, 35 miles south of Flagstaff (U.S.N.M. Nos. 50559, 58770); Red Horse Tank, Grand Canyon (U.S.N.M. No. 81991); natural tank, south rim of the Grand Canyon (U.S.N.M. 82043); Haulpai Indian Reservation, T. 29 N., R. 6 W. (U.S.N.M. No. 82046*); east of Springerville, near Arizona–Mexico boundary, altitude about 7,000 feet (U.S.N.M. No. 82067); without particulars (U.S.N.M. No. 82051). New Mexico: Chaco Canyon (U.S.N.M. No. 19634); Eagle (U.S.N.M. No. 41842); Las Vegas (U.S.N.M. 82042). Kansas: without particulars (paratypes of *A. lucasanus*) (Stockholm Mus. and U.S.N.M. No. 11600); Ellis (U.S.N.M. Nos. 58768, 82054); Wallace County (U.S.N.M. No. 82057). Texas: without particulars (U.S.N.M. No. 11603); Goliad County (U.S.N.M. Nos. 26375, 26377); Moores Lake, Lubbock (U.S.N.M. No. 61750*); southeast of Groom, Carson County (U.S.N.M. No. 79027); Brownsville (U.S.N.M. No. 82041); Matagorda Bay (U.S.N.M. No 82045); near Odessa (U.S.N.M. No. 82048); 15 miles west of Ozona, Crockett County (U.S.N.M. No. 82052); 20 miles east of El Paso (U.S.N.M. No. 82056).

Mexico: Matamoros (types of *A. aequalis*) (U.S.N.M. Nos. 11599, 58769); Cape San Lucas, Baja California (type of *A. lucasanus*) (U.S.N.M. No. 11602); Municipality of Atzacoptzalco, Distrito Federal (U.S.N.M. No. 54160); valley of the Nasus River, Matamo, Coahuila (U.S.N.M. No. 82058); without particulars (U.S.N.M. Nos. 9102, 82050).

Galápagos Islands: Duncan Island (U.S.N.M. No. 82031*); inland from Iguana Beach, South Seymour Island (U.S.N.M. Nos. 82033*, 82034*, 82035); South Seymour Island (U.S.N.M. No. 84240).

Hawaiian Islands: Oahu; collector J. Theodore Reinhardt, *Galatea* Expeditions; October 1846; Zool. Mus. Univ. Copenhagen (1 ♀, quite typical, 11+19+7=37 body-rings).

Argentina: General Acha, Terr. de la Pampa (Stockholm Mus.).

The species is further reported from the United States. Utah and Colorado: Greeley (Dodds, 1915, *A. newberryi*). Colorado: La Junta (Dodds, 1915, *A. aequalis*); Montclair (Dodds, 1915, *A. lucasanus*); Rocky Mountains near Longs Peak (Packard, 1883, *A. longicaudatus*). Nebraska: Hyannis (Pearse, 1913, *A. aequalis*). Kansas: "Kansas No. 5," and Fort Wallace (Packard, 1883, *A. lucasanus*). Oklahoma: without particulars (Mackin, 1939). Texas: without particulars (Packard, 1883, *A. longicaudatus*); Bosque County (Packard, 1883, *A. aequalis*). Questionable States: "Plains of Rocky Mountains No. 390" (Packard, 1883, *A. aequalis*); "Pools near Yellowstone River" (Packard, 1883, *A. longicaudatus*); "Platte River, near the Rocky Mountains" (Packard, 1883, *A. obtusus* James).

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A STUDY OF AN INTERMEDIATE SNAIL HOST (THIARA GRANIFERA) OF THE ORIENTAL LUNG FLUKE (PARAGONIMUS)

By R. Tucker Abbott

In recent years there has been increasing interest in the Thiaridae, or "melaniid" snails, not only among students of mollusks but also among parasitologists, for numerous species in this family serve as the intermediate hosts of human trematode diseases. A few years ago *Thiara granifera* (Lamarck), an important intermediate snail host of the Oriental lung fluke (*Paragonimus westermani* Kerbert), was accidentally introduced and has established itself in Lithia Spring, Fla. As an aid to public-health workers and parasitologists, the anatomy, the bionomics, the manner of introduction, and the details of identifying characters of this species are given in this paper. There was also a need for a study of the gross morphological features of and ecological variations in *Thiara*, before an attempt could be made to solve the problems of speciation and systematic relationships of the genus.

This study was begun on Guam Island, the Marianas, and the Philippine Islands, where field observations and collecting were carried on from May 1945 to January 1946. Further field study was undertaken under the auspices of the Smithsonian Institution in January and February of 1948 at Lithia Spring, Hillsborough County, Fla., where bionomic studies were made on several introduced colonies of this species. Most of the anatomical work was done in the division of mollusks, United States National Museum, where these collections are now housed. Paraffin embedding and sectioning of animals was done in the Department of Zoology at George Washington University.

I wish to thank Albert Greenberg, of the Everglades Aquatic Nurseries in Tampa, for his many kindnesses in connection with the field work.

SYSTEMATIC POSITION

This paper is primarily a study of the anatomy and the life history of the fresh-water snail *Thiara granifera.* Although much material from all parts of the Pacific region has been critically examined, it is felt that a detailed analysis and presentation of the various subspecies and related species is a task at present beyond the scope of this study. However, a brief systematic orientation is included here for those wishing to use this anatomical study for comparative work:

Phylum:	MOLLUSCA
Class:	GASTROPODA
Order:	PROSOBRANCHIATA, Suborder TAENIOGLOSSA
Family:	THIARIDAE (=MELANIIDAE)
Subfamily:	THIARINAE
Genus:	*Thiara* Röding, 1798
Subgenus:	*Tarebia* H. and A. Adams, 1854
Species:	*granifera* Lamarck, 1816

The genus *Thiara* Röding, 1798, more familiarly known in older literature as *Melania* Lamarck, 1816, is represented by some fewer than 100 named species and forms, all of which are from the warmer regions of southern Asia, the East Indies, and the larger Pacific islands. As more and more species were described subgeneric names were proposed, such as *Plotiopsis*, *Tarebia*, *Melanoides*, and *Tiaropsis*, and these were later raised to generic standing. Recently there has been a tendency in the opposite direction, to recognize fewer species and to include these subgenera under the single genus *Thiara* (Abbott, 1948). The subgenus *Tarebia* H. and A. Adams, 1854, contains such species as *granifera* Lamarck, *rudis* Lea, and over two dozen names of subspecific or doubtful varietal rank. The specimens that have been used in this anatomical study came from Guam Island, in the Marianas, and are most likely members of a widespread race of *Thiara granifera*, which was given the name of *mauiensis* by Lea in 1856.

GENERAL DESCRIPTION

Thiara granifera is a relatively small gastropod, in which adults may vary in shell length from 6.0 to 40.0 mm., although the commonest size is approximately 25.0 mm. (one inch). The shell is rather elongate with a straight-sided, pointed spire and is sculptured with several spiral rows of beads or blunt tubercles. The aperture of the shell is obliquely ovate, and the apertural lip is sharp. The color of the shell and its thin periostracal covering is generally a light brown to yellowish brown, which sometimes is flecked with small, dark, red-brown color spots. The operculum is about two-thirds the size of the aperture, opaque, and colored a dark blackish brown. The animal and operculum may be withdrawn into the shell completely from view. When fully extended the head and foot are, together, about one-fourth the length of the shell. The foot is relatively small and square to oblong. The proboscis is rather large and flattened. The two tentacles are round and slender and extend slightly beyond the anterior limits of the proboscis. The mantle, which lines the interior of the last shell whorl, is bordered by several prominent, fleshy papillae, which may be seen projecting beyond the shell lip on the left (or outer lip) side. In mature and gravid specimens a brood pouch is present on the back of the animal just behind the head. In some individuals the shells of the small, living young may be seen through the thin dorsal wall of the pouch.

EXTERNAL ANATOMY

Shell (pl. 8, figs. 1, 2): Many minor geographical variations occur in the shell characters of this species, and since some confusion is apt to result if a composite description of the various races is presented, I have limited my remarks to a single colony, which was collected on October 8, 1945, near the reservoir dam, Geus River, Guam Island, Marianas (U.S.N.M. No. 590182). Supplementary remarks are appended concerning the shell differences between the Guam colonies and the population samples from Lithia Spring, Fla.

Shell elongate-turrite, from 15.0 to 25.0 mm. in length, relatively thin but strong. Color yellowish brown. From 7 to 11 whorls. First 3 or 4 whorls reddish brown with microscopic raised spiral threads and rather stronger, retractively slanting, axial riblets, which increase in strength on the succeeding whorls. Periphery of whorls nearly flat, but becoming slightly more rounded in last whorls of specimens over 20.0 mm. in length. Spire pointed and cast at an angle of from 31° to 35°. Suture well impressed, slightly irregular. Base of body whorl very slightly rounded and cast approximately 35° from the axis of the shell. Spiral sculpturing consists of 4 to 6, though most commonly 5, rows of round to squarish, small beads. In later whorls the lower 3 or 4 rows of beads become flattened and often fuse to form a single raised, smooth spiral band. Beads of top row have a tendency to become more pointed and tuberculate. Last whorl, including base of shell, bears 12 to 14 spiral rows, although the lower 10 are nearly always simple, raised bands without beads. Sharply incised, fine, spiral lines may be developed on any of the whorls and, when occurring on the tops of the beads, may in the following whorls become deeper and wider, and finally spread apart what was originally one row of beads into 2, 3, or rarely 4 rows. These incised lines occasionally disappear, allowing split beads to re-fuse into a single row. Many exceedingly fine, incised lines rarely may be present between the rows of beads. Axial sculpture consists of fine, irregular lines of growth which may be prominent, especially in last whorl, at various distances behind lip. Some specimens show a few rather regular, but very small pimplings. In general, the variations mentioned above may appear or disappear at random throughout ontogenetic development. Aperture oblique, moderately ovate to elongate, with a length about one-third that of entire shell. Parietal wall glazed with a transparent, thin covering of shell matter. Columella short, slightly arched, rounded within aperture but sharp on its outer and lower edge. Umbilicus absent. Outer lip thin, sharp, and projecting forward at its center portion. Interior of aperture glossy, chalky white. Periostracum covering entire outer shell (except for parietal wall and columella) thin, closely cemented to shell, yellowish brown. It is most frequently worn away at spire and regions overlying the more prominent beads. Inlaid in the shell itself there are a few small, squarish color-blotches of red-brown, which are usually more easily seen in younger specimens than in adults.

Description of a newly born specimen (pl. 9): Length 2.0 mm., width 1.0 mm. Nuclear whorls rosy pink, finely granulated. Total number of whorls 4.5. Spiral sculpturing in postnuclear whorls con-

TABLE 1.—*Measurements of shells from Geus River, Guam Island*

Entire shell		Aperture		Angle of spire
Length	Width	Length	Width	
Mm.	*Mm.*	*Mm.*	*Mm.*	°
25. 5	10. 8	11. 4	7. 3	30. 5
25. 2	10. 6	11. 0	7. 5	33. 0
24. 9	10. 6	10. 5	7. 5	30. 5
23. 7	10. 0	10. 4	7. 1	32. 0
24. 1	10. 4	10. 7	7. 0	35. 0
23. 6	9. 9	10. 6	7. 0	29. 5
21. 8	9. 1	9. 5	6. 0	29. 5
19. 3	8. 4	8. 8	5. 3	35. 0
19. 2	8. 4	8. 3	5. 9	29. 5
18. 0	8. 0	8. 0	5. 4	29. 0
16. 3	6. 8	6. 8	4. 9	28. 0
15. 8	6. 5	6. 8	4. 5	32. 5
15. 6	6. 4	7. 0	4. 7	30. 0
13. 5	5. 4	5. 5	4. 2	32. 0
12. 2	5. 0	5. 1	3. 5	33. 0
11. 6	4. 8	4. 9	3. 4	36. 5
10. 6	4. 5	4. 8	3. 2	34. 0
9. 5	4. 0	3. 9	2. 8	37. 0
8. 4	3. 5	3. 6	2. 4	33. 0
14. 8	6. 0	6. 4	4. 3	33. 0
24. 5	9. 7	9. 7	6. 3	29. 0
20. 6	8. 3	8. 8	5. 7	30. 0

sists at first of two minute, rough threads, increasing to 9 threads in fourth whorl. Axial sculpture on each whorl consists of 11 evenly spaced, raised ribs, which are slightly protractively slanting and are crossed by the spiral threads to form 5 rows of tiny beads on each rib. Ribs absent on lower half of whorl. Suture well indented. Whorls moderately rounded. Umbilicus absent. Columella slightly curved and thin. Outer lip thin and with a sharp, delicate edge. The spire is cast at an angle of 30°.

Measurements of a sample population from Geus River, Guam Island (U.S.N.M. 590182) are given in table 1.

A more detailed biometric treatment is presented in the section dealing with bionomics (p. 99), and figure 32 is a graphic representation. Total shell length has been arithmetically plotted against the

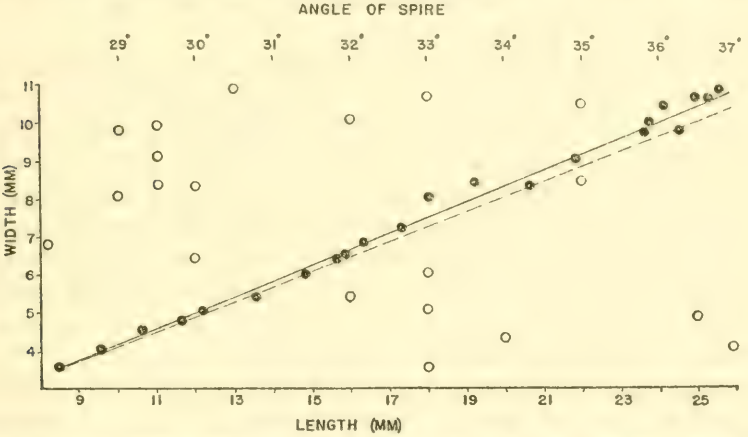

Figure 32.—Correlation between length and width of shell and between angle of spire and width.

width of the shell (solid circles). It will be seen from this graph that the proportion of shell length to width, or the obesity, remains essentially the same throughout life. The slightly more scattered results in larger specimens are probably accounted for by the fact that stream erosion has worn down the first one or two whorls. The unbroken line has been run through the mode of all the correlations. The course of the dotted line has been run through only the six youngest specimens, which showed little or no erosion, and has been protracted farther on to what should be the proper and theoretical ratio for older specimens. It will be noted that the majority of larger specimens are above this dotted line, a phenomenon that has resulted from the reduction of the total length of the older specimens by erosion. The two circles that rest on the dotted line in the larger brackets were not significantly eroded. A more detailed analysis of erosion and methods for its correction have been presented in the section on bionomics (p. 105).

As is shown on the graph by the open circles, which are plots of shell width against angle of spire, there is no correlation between the size, hence age, of individuals and the angle of the spire. Not only is there a marked variation in spire angles but there appears to be a minor, random fluctuation of this angle in the same individual during its life. When this occurs, the sides of the spire are not flat but are either slightly convex or concave. The mean angle of spire for 23 specimens was 31.93°. However, measurements of spire angles are difficult to make, and on the whole are not altogether reliable.

The shells of the Lithia Spring populations closely resemble those of Guam Island, except in being considerably smaller (see under bionomics, p. 104). The red spottings of the Lithia Spring populations are more pronounced and tend to amalgamate axially into small flammules. In larger specimens, however, the coloring is identical with that found in Guam individuals.

Operculum (fig. 33, D): The operculum is corneous, opaque, dark reddish brown, paucispiral with the nucleus placed in the far bottom right corner. In very old specimens the nucleus is sometimes chipped or worn off the operculum. Growth lines coarse and irregular. The inner side of the operculum glossy and smooth with a large elongate, depressed scar from the muscle of attachment. In very small specimens the operculum is transparent amber colored, with the nucleus less excentrically placed and usually less elongate in shape. In younger specimens the operculum is approximately two-thirds as wide as it is long, while in old individuals it is half as wide as long.

Foot (fig. 33, A, C): The foot is proportionately small in comparison with that of most gastropods. The flat, creeping surface is squarish, straight edged at its anterior end and slightly truncate posteriorly. The operculum is attached to the dorsal surface at the posterior end. Above this, and continuous with the general musculature of the foot, is the heavy, curved columellar muscle, which is attached to the inner columella of the shell. The anterior, leading edge of the foot bears across its entire width a narrow mucus slit. From this exudes a mucus, which aids the foot in sliding over sand or mud. Immediately above and continuous with the thick foot are the head and proboscis.

Head (fig. 33, A): The head is ill defined but may be said to include that region posterior to the proboscis that bears the two tentacles, and it contains the brain or central ganglia. Immediately posterior to it, in mature and gravid individuals, lies the brood pouch for the ovoviviparous young. The tentacles are a little longer than the proboscis, round, filiform, and very slightly swollen at the base, where the small black eye is located. The tentacles are capable of being swung in an arc of about 45° in any direction but are rarely bent, curved, or coiled to any great degree. Upon stimulation they may be shrunk to half

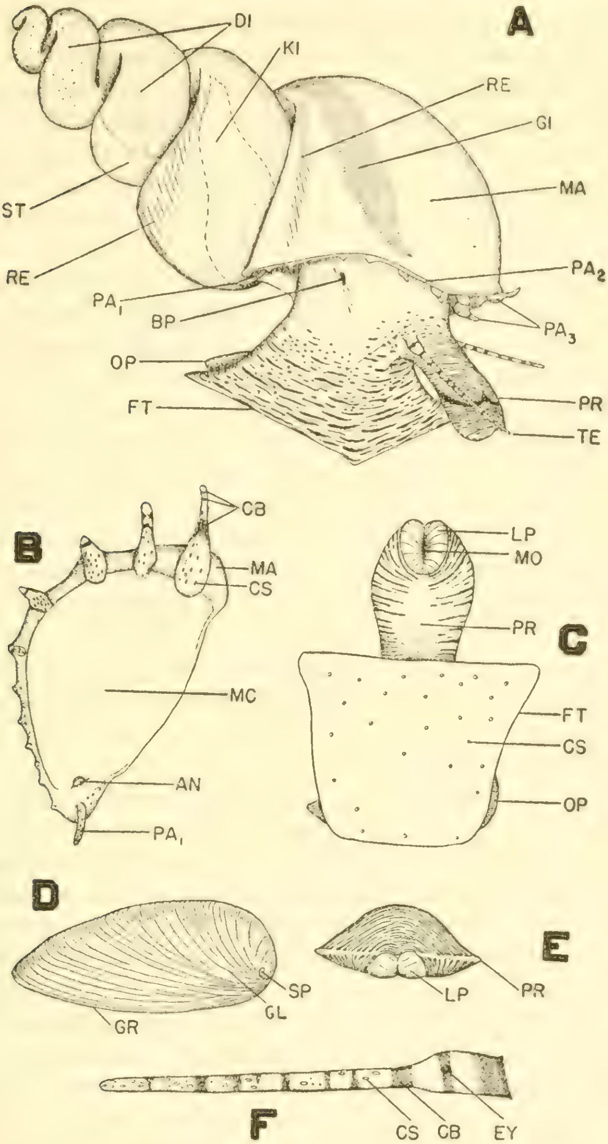

FIGURE 33.—EXTERNAL ANATOMY: A, Animal with shell removed to show areas of major organs (BP, birth pore; DI, digestive gland; FT, foot; GI, gills or ctenidium; KI, kidney; OP, operculum; PA_1, anal mantle papilla; PA_2, shell-forming edge of mantle; PA_3, mantle papillae; PR, proboscis; RE, intestine and rectum; ST, stomach; TE, tentacle). **B,** Edge of mantle looking into aperture with the body of the animal not shown (AN, anus; CB, grayish black color bands; CS, yellowish white color granules; MA, edge of mantle; MC, mantle cavity; PA_1, anal mantle papilla). **C,** View of underside of crawling animal (CS, yellowish color spots; FT, foot; LP, labial pads; MO, mouth; OP, operculum; PR, proboscis). **D,** Operculum, upper surface (GR, growth edge; GL, growth lines; SP, nucleus). **E,** Anterior view of proboscis (LP, labial pads; PR, carinate, lateral edge of proboscis). **F,** Dorsal view of right tentacle (CB, grayish black color bands; CS, yellowish color granules or spots; EY, eye).

their normal size but are incapable of being withdrawn within themselves, as is the case with many pulmonate gastropods.

The proboscis is rather large, with a length equal to that of the extended foot. Near the head it is round but becomes larger and flattened dorsoventrally toward the anterior end. On the ventral surface of the anterior end two oval labial pads flank the slitlike mouth. The proboscis is swung from side to side in elephantlike fashion when the animal is crawling.

Body (fig. 33, A): The external region posterior to the foot and head is sometimes referred to as the body, although it is merely a continuation of these. It is supported ventrally by the strong columellar muscle and dorsally bears the esophagus and brood pouch. The mantle is welded to it on each side. On the right side of the body the small pitlike opening to the brood pouch is sometimes conspicuous.

Mantle (fig. 33, A, B): The mantle is probably the most important and specialized organ of the gastropod, for it not only bears the glands that secrete the shell but it also serves as a base to which the ctenidium, osphradium, and several excretory and reproductive outlets are attached. Essentially the mantle is a thin, fleshy, cone-shaped cape that hangs over the body. It is appressed closely to the interior of the last half of the last whorl, and thus creates an open cavity into which water may enter freely to bathe the gills. The mantle is thicker at its lateral and anterior edges. Interlacing blood vessels and longitudinal muscle fibers are conspicuous.

The anterior border bears a series of large, projecting, fleshy papillae, the farthest to the left being the largest. The four papillae farthest to the left are bulbous at their basal attachment to the mantle and pointed at their distal ends, which may be seen projecting well beyond the edge of the shell. To the right of these are six to eight progressively smaller papillae that are not bulbous at their bases. To the far right and opposite the anal opening is a single, rather long, papilla. Seshaiya (1934, p. 191), in his work on *Paludomus tanschaurica*, was of the opinion that "the presence of definite sinuses in the processes in communication with the circumpallial vessel would show that the processes may function to some extent as accessory respiratory organs." I agree with him that in all likelihood such is the function of these papillae. It is significant to note that the largest ones are located on the left side where water flows into the mantle cavity. Seshaiya's contention that these papillae have little or nothing to do with the development of spiral sculpturing of the shell is further supported by the facts that: (1) The shell-producing area of the mantle is set posterior to the papillae, (2) there is no correlation between the position of the spiral rows of beads on the shell and that of the mantle papillae, and (3) *Hemisinus cubanianus* (Orbigny), from Cuba, bears papillae very similar to *Thiara*, yet its shell is smooth.

A comparative study of size and position of papillae was made in *Thiara* (*Plotiopsis*) *scabra* Müller, *Sermyla riquetii* Grateloup, and certain species of *Stenomelania*. While these mantle characters may be useful in generic determinations, it is felt that they are insufficiently distinct to separate species within the genus *Thiara*. Until now it was thought that the papillae-bearing Thiaridae were limited to the Old World, but examination of living specimens of *Hemisinus cubanianus* (Orbigny) from Cuba shows that this New World mollusk possesses mantle papillae very similar to those of *Thiara granifera*. The 7 papillae to the left are bulbous at their bases and extend beyond the edge of the shell. To the right of these are 13 to 14 small papillae. A solitary, long papilla to the far right is absent. Like *Thiara*, *Hemisinus* possesses a brood pouch on the back and a large birth pore on the right side.

Behind the row of papillae on the mantle of *T. granifera* there is a sharply impressed groove that runs parallel to and is superimposed on the edge of the shell. Posterior to this is the rather prominent circumpallial blood vessel. Welded to the inside of the mantle well within the mantle cavity are, from left to right, the osphradium, the ctenidium or gills, the urogenital ducts, and the rectum. A more detailed description of these organs is given under their respective systems, in the section on internal anatomy (p. 90).

Color of animal: Color of animal in general a dark yellowish gray. Underside of foot an opaque grayish white with 10 to 20 widely scattered, round, yellow dots. In some colonies the underside of the foot has an additional pinkish undertone. Side of foot speckled with clumps of tiny, black-gray spots, which anteriorly become thin, short, black irregular lines of color. Proboscis gray with transverse black, fine striations, which are more prominent dorsally but disappear on the ventral surface. Toward the anterior end and on the dorsal side is a prominent, inverted, V-shaped, black, transverse color band, which is characteristic of the genus *Thiara*. Anterior edge of proboscis with small, embedded, yellow color-granules. The labial pads are pinkish gray. Tentacles translucent gray to colorless with irregularly spaced, narrow, circular bands of blackish gray. One of these bands crosses the small, black eye. Relatively large, embedded, yellow color-spots are often present in the tentacle. The mantle papillae are colored similarly to the tentacles. Inside of mantle a brilliant copper-green. Birth pore usually tinted with pink.

INTERNAL ANATOMY

A general orientation is presented here as an aid to parasitologists who may wish to examine snails that have been experimentally infected with larval trematodes. In most instances only the digestive gland need be removed for gross examination or sectioning, but occasion may demand search in other organs in studies concerning the migratory paths of entering miricidia or escaping cercariae. Attention is drawn to the section on parasitology (p. 108).

The animal is held within in its protective shell by the strong, curved columellar muscle running posteriorly from the opercular region of the foot and curving around the inner columella. In material that has been preserved in formalin or 70 percent alcohol the columellar muscle loses its strength of attachment to the shell, and animals are usually easily drawn from their shell with the aid of a bent pin or sharp, curved probe. It is impossible to extract the animal of living specimens without seriously rupturing most of the organs. The shell must be cracked and picked away from the region of the penultimate whorl (the whorl above the aperture) to expose the area where the muscle is attached to the columella. A dissecting pin may be used to scrape away the attaching fibers. Living material has the additional disadvantage of becoming sticky from the exudation of mucus. However, certain organs are more easily found and studied in fresh material than in preserved specimens.

The general position of organs is shown in figure 33, A. The most conspicuous and most easily found organ is the "liver," or digestive gland, which in preserved material is a sandy brown and in fresh material is darkish green with numerous, small, embedded black spots. The digestive gland usually occupies the apical or top two or three whorls. Embedded in the columellar side or inside of the coil is the small, tubular-shaped gonad. Just below the digestive gland is found the rather large stomach, which may be easily found by tracing back along the easily seen feces-packed intestine. Between the stomach and the lower part of the intestine may be found the oval-shaped, sac-like kidney, which is conspicuous in its possession of internal fleshy septa or lamellae. Lying beside the kidney, and also just anterior to the stomach, is the pericardial sac, which contains the single auricle and one ventricle. The position of the heart may also be found by following back along the ctenidium, which arises at the base of the auricle. The esophagus is usually thin walled, small, and difficult to find at first, but may be more easily located at the point of its juncture with the posterior end of the stomach or where it emerges from between the brood pouch and the columellar muscle.

ALIMENTARY SYSTEM

FIGURES 34–36

PHARYNGEAL REGION: The mouth is a vertical, narrow slit located at the anterior end of the proboscis. It and the two labial pads that flank it on either side face slightly ventrally. The oral cavity is relatively short and round, although in preserved and shrunken material it is apt to become folded. Two ovoid, horny jaws are located on each side of the posterior region of the oral cavity. They are hinged together at their dorsal edges by a thin, transparent, hyaline sheath, which extends beyond the edges of the jaws slightly laterally and posteriorly. The anterior edge of these brown jaws is serrate. Small, polygonal platelets make up the anterior half of each jaw. The posterior region from which these platelets arise and are pushed forward is translucent-gray and smooth.

Just posterior to the jaws is found the large, bulbous buccal mass, which contains the radula ribbon and the two salivary glands. If the dorsal surface of the proboscis is slit open, the buccal mass is readily observed. Within the various muscles and ventral to the buccal cavity are found two pinkish, ovoid, translucent buccal cartilages. They are connected dorsally by a transverse muscle. Tensor superior muscles rise from the dorsolateral surfaces of the cartilages and run forward and inward to attach themselves to the hyaline sheath or elastic membrane of the radula ribbon. A number of other muscles, which aid in the manipulation of the radula, are present.

The salivary glands are two serpentine, thin-walled tubes, which enter the buccal mass slightly to either side of the median line on the dorsal surface. The glands coil posteriorly closely appressed to the esophagus as far back as the central ganglia of the brain. The number and nature of these glands is similar to those found in *Paludomus* (Seshaiya, 1934) and the Amnicolidae. Riech's (1937) observations on *Thiara scabra*, in which a dozen or so short salivary glands were noted, are not in conformity with what has been found in other gastropods in these families.

The radula ribbon, which the animal rolls back and forth to rasp at its food, is set in the center of the buccal mass. Its more highly developed anterior end lies exposed on the bottom of the buccal cavity. Posteriorly, where yet unused teeth are curled tightly together within a protecting tubular sheath, the radula descends through the buccal floor, runs slightly anterior within the buccal mass, and then turns posteriorly once more to leave the buccal mass. This free end is the swollen, rudimentary region where new teeth are being continually formed and pushed forward. Underlying the anterior section of the radula is a broad, winged hyaline sheath or elastic membrane, which on its dorsal side serves as anchorage for the individual teeth, and which on its ventral and lateral sides serves as a connecting base for muscles.

The radula is of the taenioglossate type, with the number of rows from rudiment to leading edge varying in adults from 60 to 115, although 85 to 95 appear most frequently. Each transverse row consists of 7 teeth. In the center is the smallest, the central or rachidian

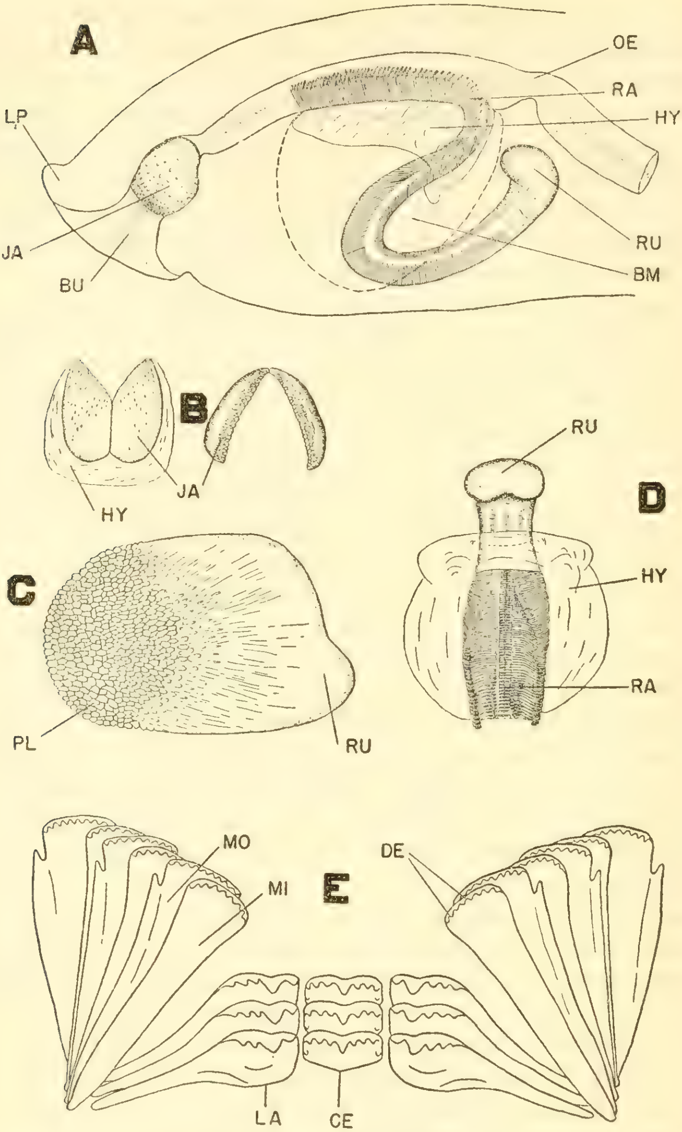

FIGURE 34.—PROBOSCIS AND ITS PARTS: **A,** Sagittal section (semidiagrammatic) of proboscis (BM, dotted line showing limits of buccal muscle and cartilage; BU, oral cavity; HY, hyaline sheath or basal membrane of radula; JA, left jaw; LP, labial pads; OE, esophagus; RA, radula or odontophore; RU, rudiment of radula). **B,** Dorsal (left) and anterior (right) view of paired jaws (HY, hyaline sheath; JA, jaws). **C,** Outer view of right jaw (PL, platelets; RU, rudiment of jaw). **D,** Dorsal view of exposed radula (HY, hyaline sheath or basal membrane; RA, teeth of radula; RU, rudiment). **E,** Three rows of radula teeth in their natural position (CE, central or rachidian tooth; DE, denticles found on leading edge of all teeth; LA, lateral tooth; MI, inner marginal; MO, outer marginal).

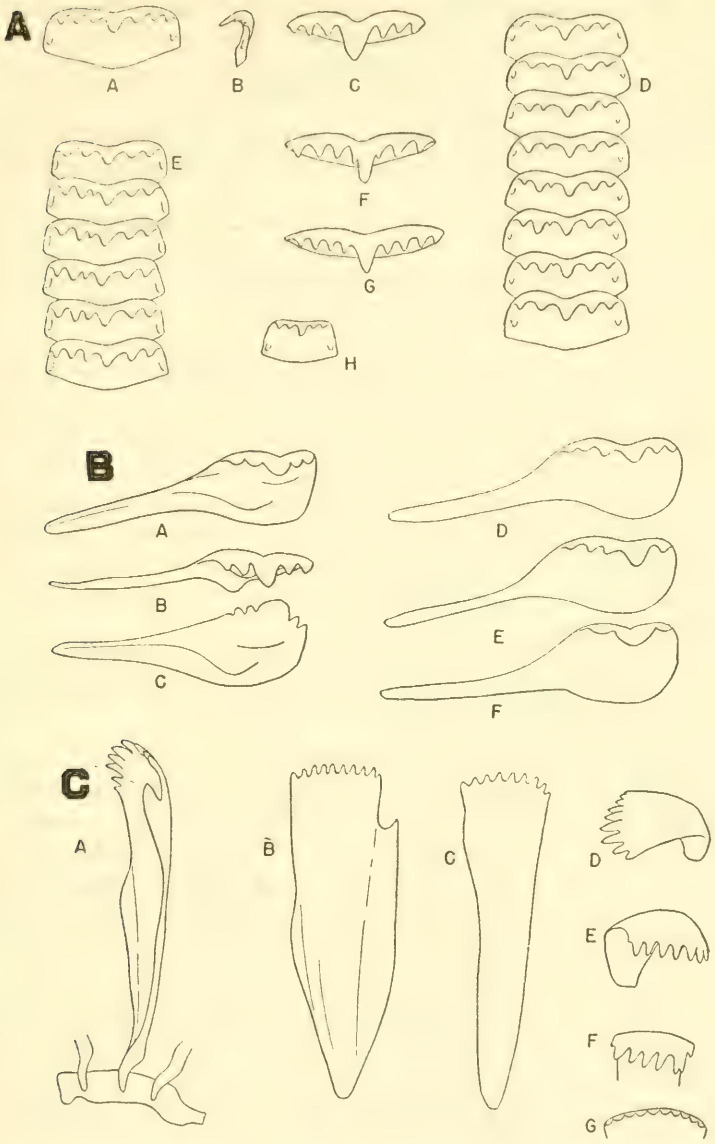

FIGURE 35.—DETAILS OF RADULA: **A,** Central teeth (A, anterior view; B, lateral view; C, dorsal view; D, row of 8 centrals showing variation in number of denticles; E, row of 6 centrals showing similar variation; F, G, dorsal view, showing denticle variation; H, central of young snail removed from parent's brood pouch, showing prominence of the two basal denticles in each lower corner). **B,** Lateral teeth (A, C to F, anterior view of 5 different laterals; B, dorsal view of lateral). **C,** Marginal teeth (A, side view of outer marginal, showing attachment to basal membrane; B, outer marginal; C, inner marginal; D to G, dorsal view of inner marginals, showing variations in number of denticles).

tooth. On each side of this is a larger lateral tooth. Two more pairs flank the laterals, first the inner marginals, and, lastly, the outer marginals. On the top and leading edge of each tooth are many small, pointed denticles that face anteriorly. These denticles are often used for identification purposes and are generally designated by numbers in malacological works. Hence the formula for the central tooth (fig. 34, E:CE) is $\frac{3\text{–}1\text{–}3}{1\text{–}1}$, indicating that the leading edge bears 1 large denticle in the center with 3 smaller ones on each side. Below these is a pair of basals, one situated at each bottom and outer corner of the tooth.

The teeth are transparent and of the consistency of very stiff rubber. They are best observed in water between a slide and coverslip. Staining by various conventional means does not appear to bring out any more detail, and, to the contrary, often obscures certain delicate features. Water mounts have the additional advantage of permitting a maximum of manipulation in which the teeth may be further separated, rolled, or flattened at will by nudging the coverslip back and forth. When dried, the radula may be covered with euparol and the coverslip replaced.

Observations on the radula and the illustrations in figures 34 and 35 are from a colony from Naujan River, Mindoro Island, Philippine Islands, P. Bartsch collector (U.S.N.M. No. 258890).

The central tooth is oblong and slightly more than twice as wide as high. The usual count on the leading edge is 3–1–3, although 2–1–2 is not uncommon. This variation may occur within one ribbon and appears to arise from the changing nature of the cells that form these teeth. Figure 35, A:E, shows a group of centrals, which anteriorly have a count of 3–1–2, but which progressively reduce the size of the extra denticle on the right side, until 5 teeth posterior to this the count becomes 2–1–2. Examples of additions of denticles were also noted. The maximum number of denticles seen was 4–1–4 but was noted only on one occasion. Not previously noted, and probably overlooked by other workers, are two small basals which are most prominent in centrals of very young individuals (fig. 35, A:H). In older specimens these basal denticles are formed nearer the sides and closer to the leading edge and likely have been misinterpreted as being abnormally placed denticles of the leading edge.

The lateral tooth is asymmetrical with the denticle-bearing oval section closest to the central. Lateral to this is the armlike extension, which is attached to the hyaline sheath. The denticle count is most frequently 1–1–2, quite often 2–1–2, and rarely 2–1–3. The counts appear to be more stable throughout the ribbon than is the case in the central, but occasionally the left lateral may differ consistently from the right lateral in the same animal.

The marginals are slightly spatulate and very similar in appearance. The inner marginal is always slightly shorter and narrower than the outer marginal. There is considerable variation in the number of denticles, with the counts of each often overlapping the other. The inner marginal has been observed to bear 9, 8, or 7 denticles, the outer marginal 12, 11, 10, or 9. The most important feature of the outer marginal is a small, sharp, thumblike protrusion on its outer edge. This feature has not been previously recorded in the literature, and has also been found by the author in other members of the Thiaridae. It is easily overlooked, and usually requires fresh material, which is observable in water mounts.

ESOPHAGUS: The thin-walled, rather narrow esophagus dips ventrally upon leaving the buccal mass and then passes through the brain, with the central ganglia dorsal to it, the pedal ganglia below, and the cerebro-pedal commissures on each side. It travels in a straight line posteriorly along the underside of the large brood pouch and emerges, with a slight twist to the right, over the end of the columellar muscle. It then passes up past the lower stomach and joins the posterior or upper stomach at its posterior and ventral end.

STOMACH: The stomach is a rather large sac located in about the second-to-the-last whorl and is bounded posteriorly by the large digestive gland and anteriorly by the heart and kidney. The stomach has a circular constriction at its center, which divides the lower stomach or crystalline sac from the upper stomach proper.

The esophagus enters the stomach at one corner at the posterior end. Below the esophageal entrance is a large, grooved, central mass, or core. The remainder of the sides of the stomach are lined with 40 to 50 raised, transverse lamellae or platelets. At the bottom of the stomach on the side opposite the central core is the small, circular opening from the crystalline style sac. The food passes slowly down the stomach, across this entrance and over to the corner, where it exits into the intestine.

The crystalline style sac is essentially a diverticulum of the stomach proper. It often appears as a transparent sac in fresh material. Within its thin walls is a round, folded hyaline sheath, iridescent, and open at its posterior end, which faces the stomach. Within this is the crystalline style itself, shaped like a dumbbell and jellylike in consistency.

Two rather large openings are present not far from the esophageal opening at the posterior end of the stomach proper, which constitute the connection with the hepatopancreas, or digestive gland. The top, or spire whorls, of the animal contain the digestive gland, which anteriorly partially enwraps the upper stomach.

INTESTINE: The intestine is thick walled, fairly large, and round. It passes downward in close contact with the crystalline style sac, on the outer surface of which it forms an S-shaped coil. Beyond this the intestine becomes thin walled and transparent. The long, round feces become packed in oblique rows as they pass toward the anus. The last section of the intestine is welded to the right side of the mantle. When feces pass from the small, round anus, they usually drop down the right side of the body. Their passing is facilitated by a shallow, ciliated groove, running from the region of the birth pore obliquely forward and downward toward the edge of the foot.

NERVOUS SYSTEM

FIGURE 37

The central ganglia of the nervous system are concentrated in the head region a little behind the proboscis. They may be reached easily by slitting open the dorsal side of the proboscis and head. The esophagus runs directly through the group, as described previously. The brood pouch borders the posterior regions of these ganglia remarkably closely, and on more than one occasion young snails have been found within 0.5 mm. of the central ganglia. The two large pedal ganglia are more difficult to reach, for they are set deeply in the fore regions of the foot directly below the other ganglia.

The central ganglia have a thick dorsal covering of connective tissue. The surfaces of these ganglia are colored a deep maroon in living specimens. In preserved material the color is waxy white. They are oval, with thicker and more rounded posterior ends, and with tapering, dorsoventrally flattened anterior ends, which give rise to six small nerves. The two ganglia are united by a very short, thick commissure. The number and size of the anterior nerves may vary, although the more important ocular and tentacular nerves, which are the most laterally placed, are constant. The inner four or five nerves run

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FIGURE 36.—ALIMENTARY SYSTEM: **A,** Dorsal view of buccal mass (semidiagrammatic) (BS, buccal sac; LC, left central ganglion; MO, mouth; OE, esophagus; RM, retractor muscle; SG, salivary gland). **B,** Sagittal section of esophagus (MO, mouth; OE, esophagus; SG, left salivary gland). **C,** Crystalline style; top figure from preserved specimen; bottom figure from life. **D,** Semidiagrammatic view of entire alimentary system (AN, anus; DD, digestive ducts coming from digestive gland; FE, feces in intestine; IN, intestine; OE, esophagus; RE, rectum or lower intestine; SS, lower stomach or crystalline style sac; ST, stomach). **E,** Dorsal view of esophagus as it passes posteriorly from beneath the edge of the brood pouch (LM, longitudinal muscles; OE, esophagus); PO, brood pouch. **F,** Left lateral view of stomach (IN, intestine; OE, esophagus; SS, crystalline style sac; ST, upper stomach). **G,** Interior of stomach; top left and bottom left, cross-sections; right figure, longitudinal section (CC, central column; CS, entrance of crystalline style sac; DD, ducts to and from digestive gland; HY, hyaline sheath surrounding style; IN, intestine; OE, esophagus; OS, outer wall of crystalline style sac; PL,plicae of stomach wall; SL, lumen of stomach).

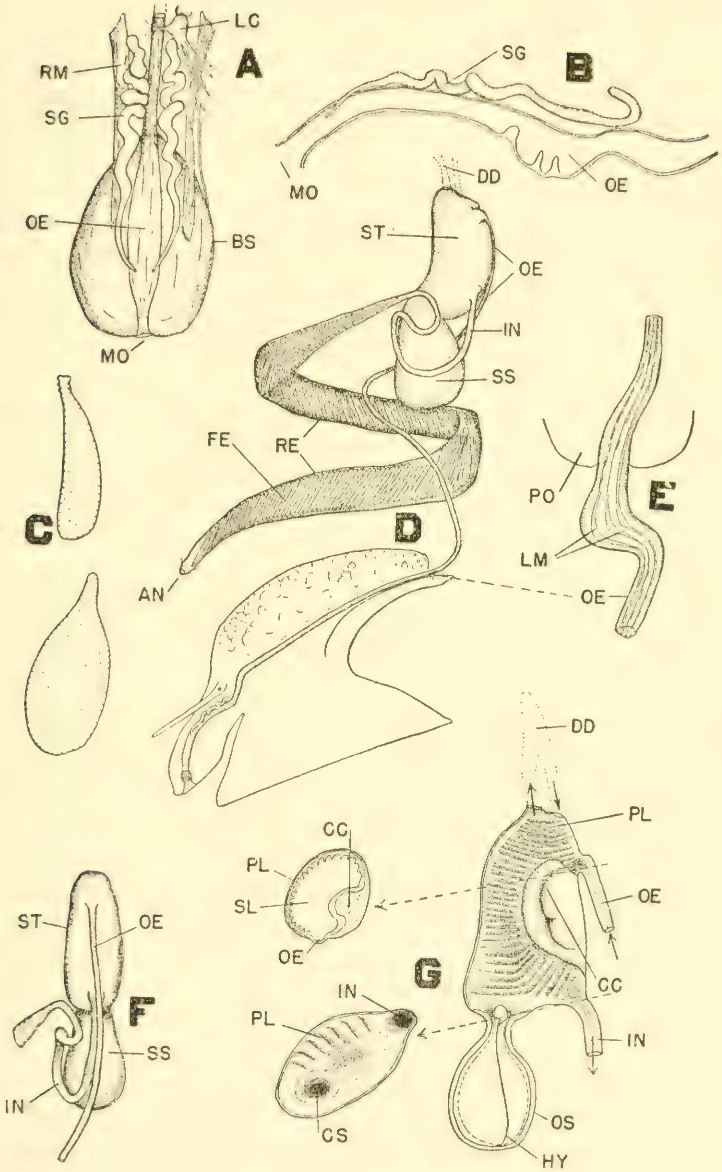

FIGURE 36.—(See opposite page for legend.)

anteriorly to supply the proboscis, the labial region, and the muscular elements of the buccal mass. The innermost nerve runs to the anterior region of the buccal mass, turns posteriorly, and runs back to join the buccal ganglia at the posterior end of the buccal mass.

Each cerebral ganglion gives rise ventrally to a stout commissure, which descends to the pedal ganglion below it. At a point on the pedal ganglion, just posterior to the entrance of the cerebro-pedal commissure, another large commissure enters from the pleural ganglion.

The pedal ganglia are larger than the cerebral ganglia and, in *Thiara*, are strikingly different from those in the Amnicolidae in being laterally rather than dorsoventrally compressed. They are closely connected at their inner surfaces and do not have what might be called a commissure. The ventral ends of these ganglia each give rise to two stout pedal nerves. Smaller offshoots of varying size may be present.

The statocysts are rather prominent in this species and are located on the upper ventral surface of each pedal ganglion. No prominent nerve running from the statocyst to the cerebral ganglion was observed, although there is one in *Paludomus* (Seshaiya, 1934), *Thiara* (*Thiara*) *amarula*, *Thiara* (*Melanoides*) *tuberculata*, and *Thiara* (*Melanoides*) *costata* (Bouvier, 1887). However, a rather prominent nerve is found descending ventrally from the statocyst. Each statocyst contains a single calcareous, disc-shaped statolith or otolith. Other members of the genus *Thiara* possess a similar otolith, but those of *Paludomus* (Seshaiya, 1934), *Nassopsis*, and *Bythoceros* (Moore, 1889) contain numerous small otocones.

The pleural ganglia are round and bulbous and closely appressed to the ventral and posterior end of the cerebral ganglia. They are connected to the latter by short commissures. The right pleural ganglion gives rise to the rather large supraintestinal nerve and the right pallial nerve. The former nerve joins the small supraintestinal ganglion on the left side of the body. The left pleural ganglion gives off on its left side a small nerve, which passes up to the left side of the mantle region. Just behind this ganglion is the equally large, oval, subintestinal ganglion. At its juncture with the pleural ganglion another thin nerve arises to the left and ascends toward the mantle.

The posterior end of the subintestinal ganglion gives rise to two prominent nerves: (1) A pallial nerve, which first makes a short, complete loop and then passes across the back of the animal to the right side, where it is joined by a similar nerve from the right pleural ganglion; and (2) the right visceral nerve, which proceeds posteriorly to join the small obscure visceral ganglion.

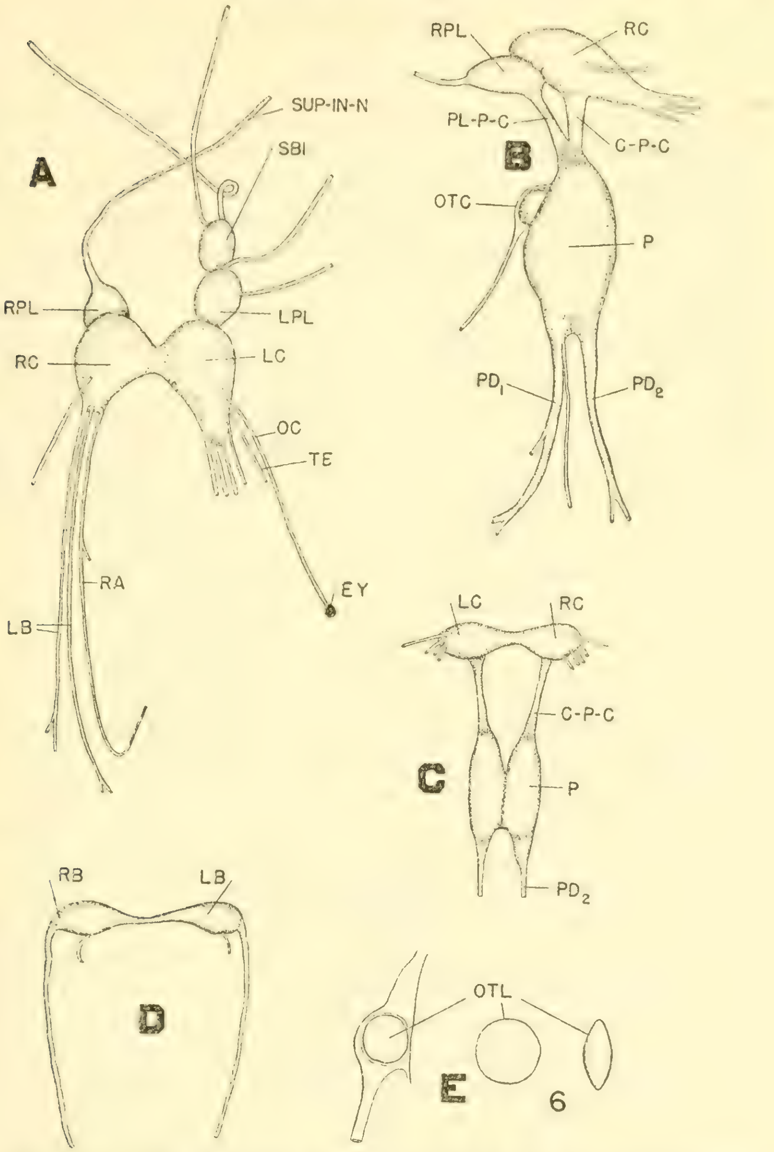

FIGURE 37.—CENTRAL NERVOUS SYSTEM: A, Dorsal view of central ganglia and its nerves (EY, eye; LB, labial nerves; LC, left cerebral ganglion; LPL, left pleural ganglion; OC, ocular nerve; RA, nerve to region of radula; RC, right cerebral ganglion; RPL, right pleural ganglion; SBI, subintestinal ganglion; SUP–IN–N, supraintestinal nerve; TE, tentacular nerve). **B,** Right lateral view of central ganglia (C–P–C, cerebro-pedal connective; OTC, otocyst; P, pedal ganglion; PD_1, posterior pedal nerve; PD_2, anterior pedal nerve; PL–P–C, pleuro-pedal connective; RC, right cerebral ganglion; RPL, right pleural ganglion). **C,** Anterior view of central ganglia (C–P–C, cerebro-pedal connective; LC, left cerebral ganglion; P, pedal ganglion; PD_2, anterior pedal nerve; RC, right cerebral ganglion). **D,** Dorsal view of left (LB) and right (RB) buccal ganglia. **E,** Otocyst and otolith (OTL).

CIRCULATORY SYSTEM

FIGURE 38

The small saclike pericardium is situated at the posterior end of the ctenidium in the region between the kidney and the lower stomach, or crystalline style sac. There is one auricle and posterior to it a single, smaller ventricle. The auricle is round and bulbous, with thin walls. In preserved material, "jellied" blood fills this organ. At its anterior end the large, efferent ctenidial vessel enters. At its posterior end it joins the ventricle. The ventricle is somewhat triangular with its broad base appressed to the auricle. It is relatively thick walled with a large number of separate, long muscle fibers running crisscross over the inner surface. Many of these fibers join at the anterior end to form a round valve, which prevents blood from reversing its course. On the ventral surface at the apical end of the ventricle there is another slitlike valve. At this point the blood enters the thin-walled transparent truncus arteriosus, which soon divides into an anterior and a posterior, or visceral, artery. The latter is round in cross-section in living material but collapses in preserved specimens. It runs posteriorly, first giving off a short artery to the left, which supplies the region of the crystalline style sac. It proceeds farther toward the apical whorls in close proximity to the stomach and then proceeds anteriorly to supply the anterior region of the foot and body.

The venous system has not been followed adequately in this species because of the difficulties in following the numerous sinuses. It appears that the sinuses that bathe the various organs are ill defined and have complex interconnections. The rectal sinus is the most easily found, and it is situated in the region of the lower part of the kidney and the intestine. The blood flows from this largest sinus into the ctenidial lamellae. Small sinuses have been noted in the region of the pedal ganglia, digestive gland, esophagus, and stomach. The complex of sinuses noted in the mantle of *Paludomus* by Seshaiya (1934) are similar, but are more highly developed than in *Thiara granifera*.

The bluish-green color of the mantle and other parts of the internal organs noted by Seshaiya (1934) is common not only to *Paludomus* and *Thiara* but also to a number of New World members of the Thiaridae. Seshaiya suggests that this is due to the presence of haemocyanin in the blood.

The ctenidium is long and narrow and is welded to the mantle. It extends from the apex of the mantle cavity in the region of the heart forward almost to the mantle edge. It bears approximately 190 to 200 separate gill lamellae, which are triangular, and which hang with their apices facing downward into the mantle cavity.

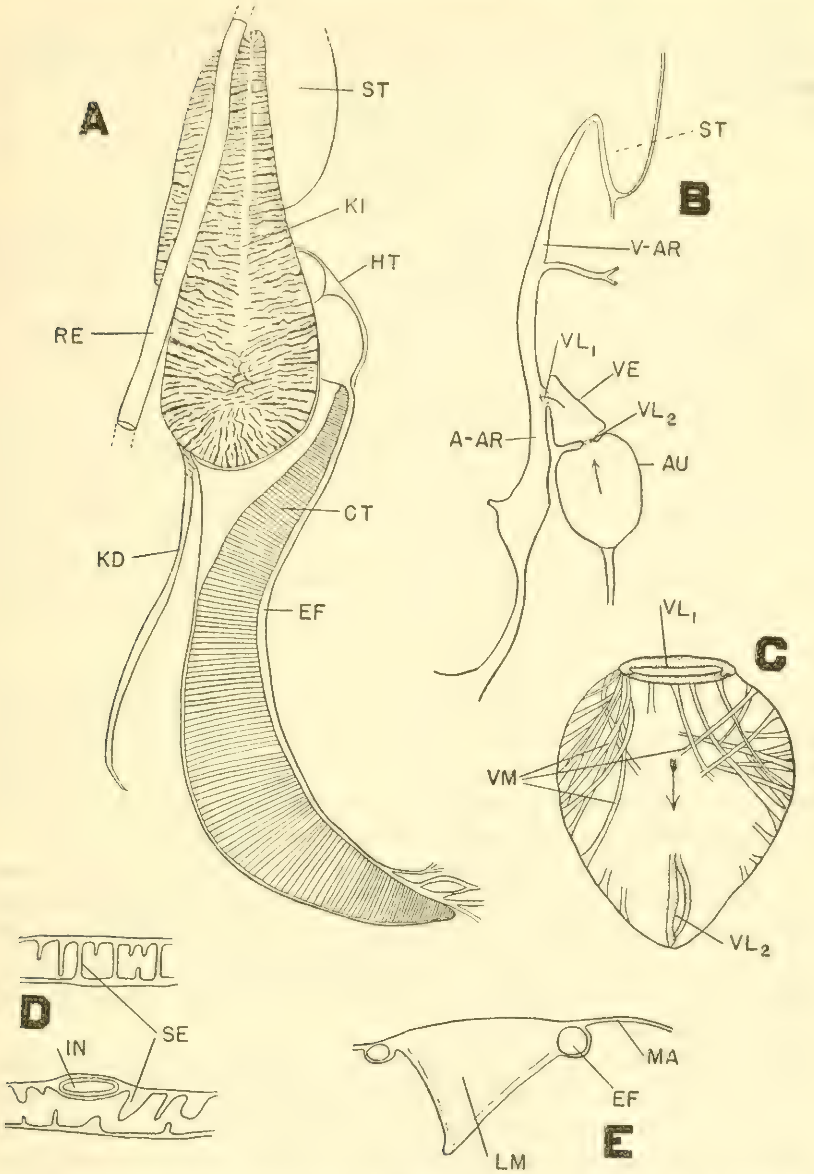

FIGURE 38.—EXCRETORY, CIRCULATORY, AND RESPIRATORY SYSTEMS: **A,** Kidney and ctenidium (CT, ctenidium or gills; EF, efferent vein from gills to heart; HT, pericardial sac containing auricle and ventricle; KD, kidney duct; KI, kidney; RE, rectum; ST, stomach). **B,** Heart (A-AR, anterior artery; AU, auricle; ST, stomach; V-AR, visceral artery; VE, ventricle; VL_1, posterior ventricular valve; VL_2, anterior ventricular valve). **C,** Dorsal view of heart (semidiagrammatic) showing the network of heart muscles (VM), the anterior ventricular valve (VL_1), and the posterior ventricular valve (VL_2). **D,** Cross-sectional views of kidney showing the septa (SE) and the embedded intestine (IN). **E,** Side view of a gill lamella (LM) attached to the mantle (MA) and showing the efferent artery (EF).

To the left of the ctenidium, and about half its length, is the narrow, tubular osphradium or "organ of smell." It is also closely welded to the mantle.

UROGENITAL SYSTEM

Figures 38, 39

Kidney: The renal organ is a rather large, easily seen, oval sac lying in the region between the stomach and the apex of the mantle cavity. At its posterior end, where it borders the right side of the crystalline style sac, it is narrow, but widens and flattens toward its anterior end. The intestine is partially encased by the right side of the kidney. Internally the kidney is made up of a network of thin lamellae or septa, between which are the blood spaces. The lamellae are arranged in a more or less regular pattern and all pointing toward the center of the kidney. This pattern is easily seen through the thin outer wall of the organ. No prominent renal aperture leading into the mantle cavity could be found. An obscure renal duct could be followed in a few specimens, which led down the right, lower side of the kidney and passed along the mantle wall to an exodus beside the genital orifice.

Gonads: The gonads in this species are small and lie on the inside of the whorls of the digestive gland in the spire. In living material they consist of a bright yellow tubule, which gives off numerous smaller branches. Eggs were observed by crushing small portions of the gonads on a slide. No sperm were observed in either living material or in histological sections made from preserved material.

The genital orifice is surrounded by a small, elongate, cup-shaped flap, the opening of which faces the entrance of the brood pouch a few millimeters away. Eggs have not been observed passing from the oviduct to the brood pouch, but it is possible that the flap of the genital orifice is pressed against the pouch entrance when the animal is completely withdrawn into its shell.

The brood pouch is not developed until the animal begins to reach maturity. In its early formation the pouch consists of an irregular, flattened hollow in the connective tissue of the back of the animal. As more eggs are added and the hatched young grow, the pouch is enlarged and becomes irregularly divided into small compartments. Thin, transparent walls of adventitious tissue separate the various groups of young, but all stages of development of the young may be represented in these compartments. The more advanced young either push or eat their way through these thin walls to other compartments. In a highly developed pouch the dorsal wall is thin enough to reveal the young crawling about inside. The pouch may extend from the region immediately behind the tentacles and central ganglia posteriorly to the very apex of the mantle cavity. Below it are the esophagus and the foot and columellar muscles. In one colony (Naujan, Mindoro Island, Philippine Islands) it was not uncommon to find in the more highly developed pouches an auxiliary pouch extending down the right side of the body below the right tentacle.

TABLE 2.—*Contents of brood pouches*

SPECIMEN No. 1

Number of young	Length of shell (mm.)	Number of whorls
1	1. 9	4. 5
1	1. 8	4. 2
2	1. 0	3. 8
2	. 8	3. 8
1	. 7	2. 8
1	. 5	2. 7
2	. 3	2. 1
2	. 2	1. 6
12	. 1	1. 2+
25	(Less than 1 whorl)	---
50 (Eggs)	---	---

SPECIMEN No. 2

1	2. 2	4. 5
1	1. 8	4. 3
1	1. 6	4. 0
1	1. 4	3. 5
1	1. 2	4. 0
2	. 9	3. 0
1	. 5	2. 5
2	. 2	2. 0
5	(Less than 1 whorl)	---
0 (Eggs)	---	---

SPECIMEN No. 3

1	1. 8	4. 8
1	1. 5	4. 5
1	1. 2	3. 5
1	1. 0	4. 0
6	. 9	3. 5
9	. 7	3. 0
5	. 2	2. 0
30	. 1	1. 5
20	(Less than 1 whorl)	---
50 (Eggs)	---	---

Young emerge from the pouch on the right side through the birth pore, which also serves as the egg entrance. The pore is bordered by a small, raised fleshy ridge. Young have been observed emerging spire first in living specimens (Agaña Spring Colony, Guam Island, Marianas). There appears to be no special order or time for leaving the pouch, and young of varying sizes have been observed being born from the same mother. In fresh specimens from Guam, numerous, irregularly shaped calcium-carbonate grains about 0.2 mm. in diameter have been found. It is possible that developing young feed on these concretions. Occasionally a young snail may fail to escape from the pouch, and in these cases no other young or eggs are found in the pouch. These giants often grow to one-fifth the size of the mother and probably rupture through the dorsal wall or cause the death of the parent.

Guam specimens kept in small vials of water gave birth to one young on an average of every 12 hours. Three mature individuals were dissected (Agaña Spring), with the brood pouch contents noted as in table 2.

Reproduction in related groups.—The family Thiaridae exhibits an interesting series of modifications within certain genera with regard to manner of reproduction. It is believed that the more primitive types are derivatives of the marine family Cerithiidae, a very similar group in shell, radula, and animal characters. A number of Cerithiidae are estuarine in habitat, and like their truly marine representatives possess a veliger larval phase. Seshaiya (1940) has made the remarkable discovery of a veliger stage in the fresh-water thiarid *Stenomelania crenulata* Deshayes, in India. He found that the breeding season commences about November and extends until the following April. During this period the brood pouch on the back of the animal contains thousands of developing eggs and a few veligers just escaped from the vitelline membrane, but no juvenile, shelled forms. The veliger stage, of about 2 weeks' duration, is spent in active swimming in the river water. The full-grown veliger has the typical form found in the life history of many marine gastropods and has two veliger lobes provided with long cilia, by means of which it propels itself. Seshaiya also noted the curious phenomenon found in many marine invertebrates, that of spawning on the day previous to the full moon and for the two succeeding days.

A more advanced type of brooding of young within a neck pouch is found in *Thiara* and *Brotia*. In the former there are fewer and much larger-shelled young retained for a number of weeks within the pouch.

A still more curious brooding modification is found in some other thiarids such as *Semisulcospira*, of Japan, and the African (Lake Tanganyika) genera *Tiphobia*, *Tanganyicia*, and *Nassopsis* (Moore, 1898). Brooding takes place in the enlarged oviduct, which is welded to the mantle. In the case of *Semisulcospira* the shelled young are rather small and all of the same size. Spermatozoa have been observed in male specimens.

The habit of laying eggs rather than brooding is considered to be a more nearly perfect adaptation to fresh-water conditions. *Paludomus*, of Ceylon, India, the Philippine Islands, and southern

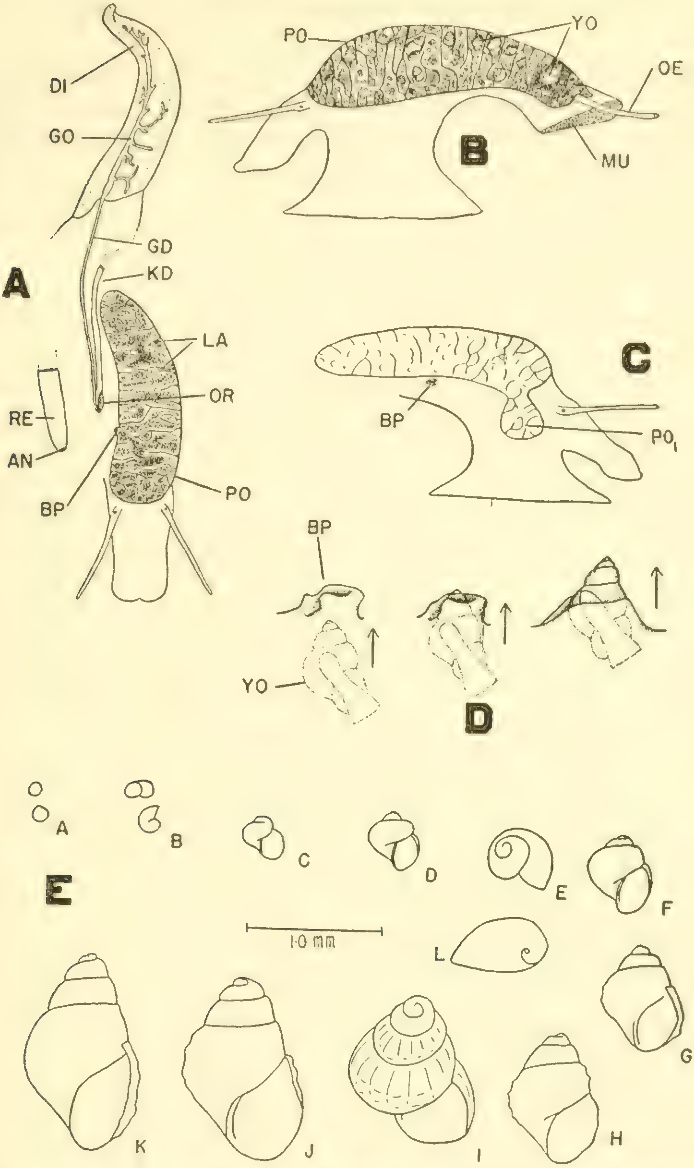

FIGURE 39.—REPRODUCTIVE SYSTEM: **A,** Dorsal view of reproductive system (semidiagrammatic) (AN, anus; BP, birth pore; DI, digestive gland; GD, gonoduct; GO, gonads; KD, kidney duct; LA, lamellae of adventitious tissue; OR, genital orifice; PO, brood pouch; RE, rectum). **B,** Side view of animal, showing young in brood pouch (MU, columellar muscle; OE, esophagus; PO, brood pouch; YO, young.) **C,** Side view of animal, showing abnormal extension (PO_1) of brood pouch on right side. **D,** Birth pores (BP), showing living young (YO) emerging. **E,** Selected individuals from brood pouch, showing development from egg (A) to young with four whorls (K) (sculpturing has been drawn only in figure I); (L, operculum of brood-pouch young).

China, and the several American genera of Pleurocerinae are among this type.

A completed study of the various reproductive modifications in this family on a world-wide basis should reveal a very interesting evolutionary pattern and should aid in solving many of the present phylogenetic problems in this group.

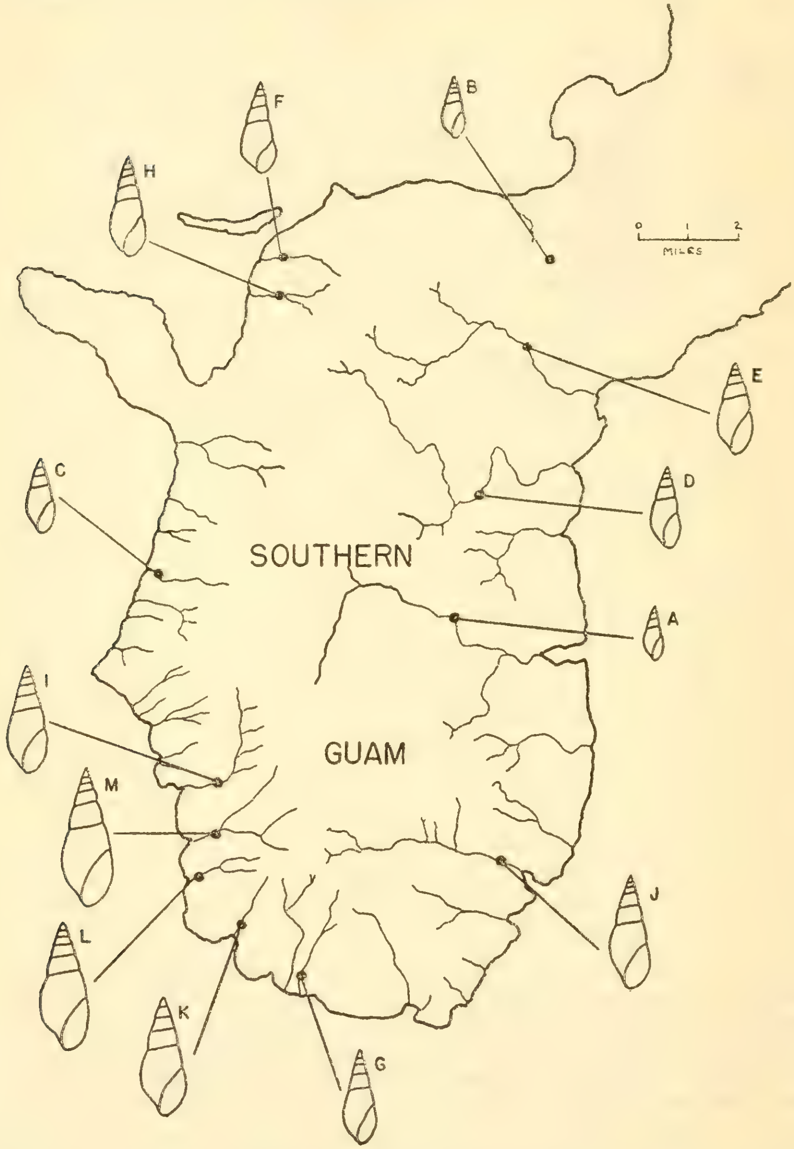

FIGURE 40.—Map of southern Guam Island, showing collecting localities and relative mean shell-size of colonies (see p. 103 for explanation).

LIFE HISTORY

HABITAT

As has been stated earlier, the various subspecies or geographical races of *Thiara granifera* have not been studied adequately, so that details of its geographical distribution cannot be presented at this time. However, the limits of its distribution as a whole are fairly well known. This species lives in fast-flowing fresh-water streams. Its most westerly limits include the Island of Ceylon and the eastern coast of India. Its range extends easterly to include the coasts of Siam and southern China, the East Indies, and the Philippine Islands. To the north it is found on Formosa (Taiwan) Island and the small islands south of Japan. Farther east, it is common in Melanesia, especially the Solomon Island Archipelago, the Marianas, and the Polynesian islands of the Hawaiian and the Society Islands. Undoubtedly the topography and nature of the areas in which this species is found varies from place to place, but it is highly likely that certain optimum environmental conditions are common to all its localities. Thus we may find this species in streams very near the sea in certain small islands, but considerably inland and at higher altitudes on such large islands as Luzon, Leyte, and Mindanao in the Philippine Islands.

In the isolated Micronesian islands of the Marianas only three islands are large enough to have permanent streams: Guam, Saipan, and Rota. All three support colonies of *Thiara* (*Plotiopsis*) *scabra*, but only the first possesses streams large enough to maintain populations of *Thiara* (*Tarebia*) *granifera*. Guam (Guajan) Island is 32 miles long by 4 to 10 miles wide and about 225 square miles in area. It is mountainous in the southern half, where a great number of small streams flow down to the sea. The northern half forms a low plateau, which is devoid of permanent streams.

The majority of the streams in the southern half of Guam are colonized by *Thiara granifera*. Collections were made at the localities listed. The number following each station record indicates the number of specimens collected (fig. 40).

A. Zadue Maagos River. 1945. D. Frey collector. 92.
B. Agaña Spring, 1½ miles southeast of Agaña. April 22, 1945. R. T. Abbott collector. 198.
C. Talisai stream, under bridge, 2 miles southeast of Agat. May 1, 1945. R. T. Abbott collector. 100.
D. Water Plant, 2 miles up Ylig River. April 26, 1945. R. T. Abbott collector. 65. Flow rapid, 6 feet wide, 6 inches deep.
E. 1 mile up Pago River. April 26, 1945. R. T. Abbott collector. 50. Flow rapid, 6 feet wide, 4 inches deep.
F. First stream 600 yards south of Piti. April 24, 1945. R. T. Abbott collector. 38. Flow sluggish, 3 feet wide, 1 inch deep; shady.
G. Geus River. 1945. D. Frey collector. 97.
H. 100 yards up Aguada Stream. April 24, 1945. R. T. Abbott collector. 127. Flow sluggish, 4 feet wide, 2 inches deep; shady.

I. 1 mile up La Sa Fua River. May 10, 1945. R. T. Abbott collector. 20. Flow sluggish, 4 feet wide, 2 inches deep; shady.

J. ½ mile up Inarajan River. May 2, 1945. R. T. Abbott collector. 43.

K. Merizo River. 1945. D. Frey collector. 245.

L. Small stream near Ajino Beach. 1945. D. Frey collector. 8.

M. ½ mile up Umatac River. May 10, 1945. R. T. Abbott collector. 36. Flow rapid. 30 feet wide, 8 inches deep; no shade.

The snails are most abundant in the shallow riffles where the flow of water is fairly rapid and where the bottom consists of a pavement of small stones. Occasionally the snails may be found congregated on firm sandy bottom provided there is a healthy flow of water. Waters of the stream that are exposed to direct sunlight during most of the day appear to attract this species. The upper reaches of the streams that have a very rapid flow of water are not favorable, although other mollusks such as *Neritina* and *Septaria* may be abundantly represented. The tiny flows of headwater tributaries, which are less than a foot in width and 2 inches in depth, will not support *T. granifera* but are favorable to *T. scabra.* The stream at Umatac, in the southwest end of Guam, has the colony with the greatest number of largest individuals. The maximum concentration of snails (about 10 per square foot) is found in the fairly level section of the stream, which is about 30 feet wide and half a foot deep. This area is only a few hundred feet from the high-tide mark of the ocean but is probably never diluted with salt water except perhaps during typhoons, which may come from the west.

Conditions at Agaña Spring, the most northerly located colony on the island, are interesting in the dwarfing effect on the size of the individuals. The spring is used as a source of water for nearby Agaña and at present has a pumping station located there. The spring proper is about 30 feet deep, with a diameter of about 60 feet. The upsurge of water is moderate, but the overflow is relatively fast, consisting of a 100-foot sluiceway about 3 or 4 feet wide. There are abundant algal growths in the spring. The shells and animals of this colony are similar to those of other Guam populations except in the reduction in size. No environmental cause for this could be found. Even more pronounced dwarfing is evident in specimens that were introduced to the large spring at Lithia, Fla.

On Leyte Island, Philippine Islands, where numerous collecting stations were made, *Thiara granifera* was found in large rivers and small streams. High in the central mountains, where large stream conditions duplicate those on Guam, colonies of this snail are rather common. In the extensive Leyte Valley, at the northeast end of the island, the larger rivers, with silty to sandy bottoms, meander; only rarely is *T. granifera* found along the very edges of the rivers, where the flow of water is moderately fast. However, smaller streams, which pass down from the foothills bordering the valley, are excellent habitats.

The water-temperature limits of this species were not appreciated until a survey was made of the Lithia Spring, Fla., populations. In aquaria and the spring, where the temperature remains around 76° F., the snails are able to maintain themselves in adequate numbers. However, just beyond the influence of the warm waters of the spring, where the cooler waters of the local river are about 50° F. or less, the snails are absent. The overflow ditch outside the extensive plant aquaria in Tampa is colonized by these snails during the warm summer months, but in winter, when the water temperature is as low as 50° F., these snails die off. The temperature recordings for Guam streams and even for the rivers at 3,000 feet altitude on Leyte Island were all above 75° F.

BIONOMICS

Growth and size.—The rate of growth of the shell has not been determined, although, from common experience in raising these snails in aquaria, it is assumed that adult size or maturity is reached within 6 to 12 months. Two preliminary studies were made of the character of shell size, one on the 13 colonies collected on Guam Island, the other on the populations of Lithia Spring. In the latter study, dissections were made to determine the size at which individuals become sexually mature, for there is no tell-tale flaring or thickening to the outer lip that often accompanies maturity in many other molluscan species.

The significant differences in the size of samples taken at various places in the spring, only a few dozen yards from each other, are extremely important in demonstrating the wide range in size exhibited by one species. The aquarial stock from which these snails originated grew to a size almost four times that of its offspring in the spring. Only in an isolated, subsidiary spring, a few yards from the main spring, did specimens reach a size comparable to the aquarial stock. In all likelihood the differences in size exhibited by the seven sample populations in the spring have been brought about by ecological and not genetic factors. Not only are the means of shell lengths and maximum sizes of shell considerably varied, but the points at which maturity is reached are correspondingly shifted. This latter fact excludes the premise that these colonies represent aggregates of smaller, younger individuals. No direct correlation between diminutive size and type of bottom, depth of water, temperature of water, amount of shade, or distance from source of spring could be found. The small colony in the adjacent subsidiary spring attained a shell size nearly three times that of colonies in the main spring. Relatively few specimens per square foot were found in the smaller spring, while in the main spring overcrowding was evident, sometimes reaching a population density of 400 specimens per square foot. It is likely that food availability is the most important factor, but controlled experiments alone will support this assumption.

TABLE 3.—*Data pertaining to collections from Lithia Spring, Fla.*

Station	Number of specimens	Mean shell length, mm.	Point of maturity	Type of bottom	Depth of water (ft.)	Distance from spring source (ft.)
1	437	7. 88	7. 0	Weed	1	25
2	368	7. 50	5. 5	Sand	1–3	25
3	442	6. 28	5. 5	Sand	4	25
4	352	5. 55	6. 5	Weed	3	100
5	487	6. 30	?	Sand	3	200
[1] 6	23	Insign.	?	Sand	10	500
7	676	9. 9	7. 0	Sand	2	30
[1] 8	5	Insign.	?	Weed	1	100
[1] 9	4	Insign.	?	Weed	2	250
10	105	5. 95	8. 0	Weed	1–4	Subsidiary spring
[1] 11	None	------	----	Weed	1	250

[1] Insufficient numbers of specimens to ascertain maturity point or significant mean of shell length.

Table 3 shows the results obtained from 11 sample collections taken from Lithia Spring, Hillsborough County, Fla., in February 1947. The stations are marked on the map of the spring (fig. 41). Stations 6, 8, 9, and 11 had insufficient numbers of specimens to ascertain a reliable point at which maturity is reached, or a significant mean of shell length.

The map has been marked with short arrows, which indicate the main flow of the current of water coming from the spring and with long, broken arrows, which indicate the flow of river water that breaks across the low land to the north of the spring during flood periods. The river water, which is 18° C. in contrast to the 25° C. of the spring water, is fatal to these snails and undoubtedly accounts for their absence or low numbers at stations 8, 9, and 11. These last-mentioned stations are well stocked with local Florida snails (pleurocerids, amnicolids, and planorbids).

The mean shell-length data given in table 3 is of little value in making a comparison of two populations, and, in fact, can be very misleading. A look at the population-growth curves of shell length (fig. 42) will reveal the fallacy of the mean shell length. Most of the populations give a bimodal curve, as accentuated in population 4. The first peak is simply an aggregation of immature specimens, a factor that will vary according to the reproductive cycle of that population and that will change in value as the young grow to an adult size. In population 4, maturity is reached at 6.5 mm. and extends up to 12.5 mm. The mean for these adults, which are continually growing, is about 7.5 mm., yet if the entire population, both immature and adult specimens, is averaged, the mean must be recorded as 5.5 mm. This difficulty may be avoided in great measure by comparing only adults,

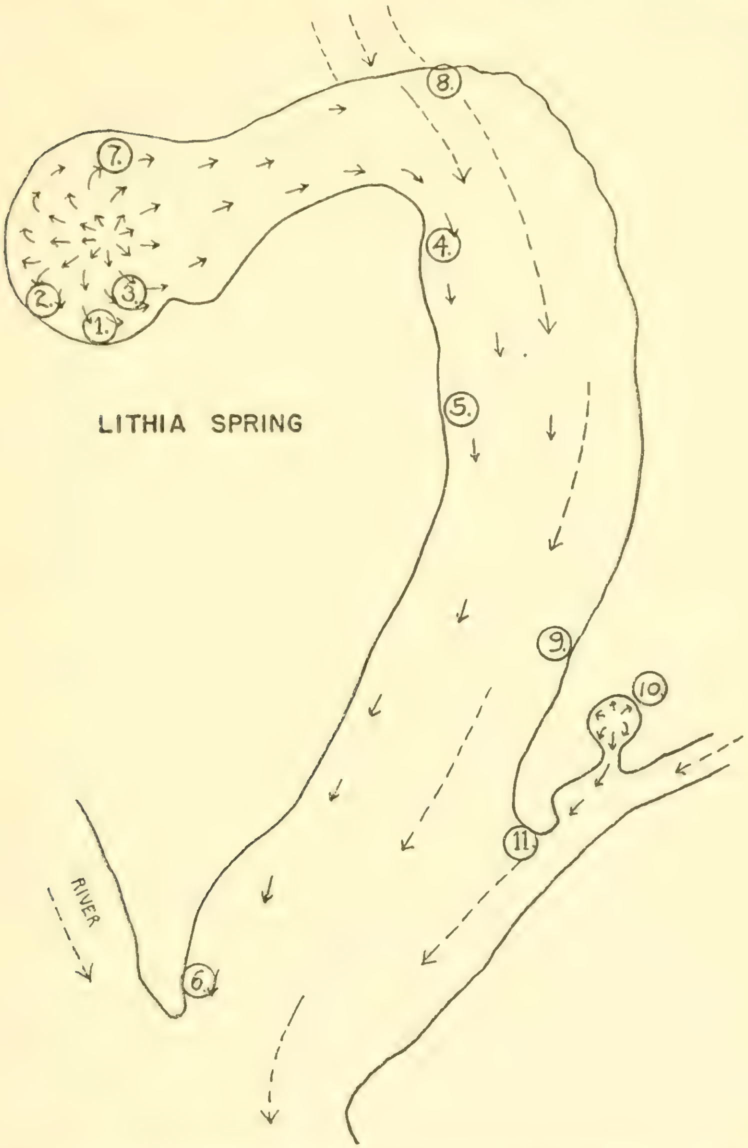

Figure 41.—Map of Lithia Spring, Fla., showing collecting stations (1 to 11) and water currents. Short arrows=spring water; long, broken arrows=river currents.

but, again, this is possible only if dissections can be made to determine whether the specimens in question are adult.

It is interesting to note the distance separating the mode of the immature curve and that of the adult curve in each population. Were these distances proportionately the same in each population, we could safely assume that the production of young was brought about simultaneously throughout the various populations of the spring and was

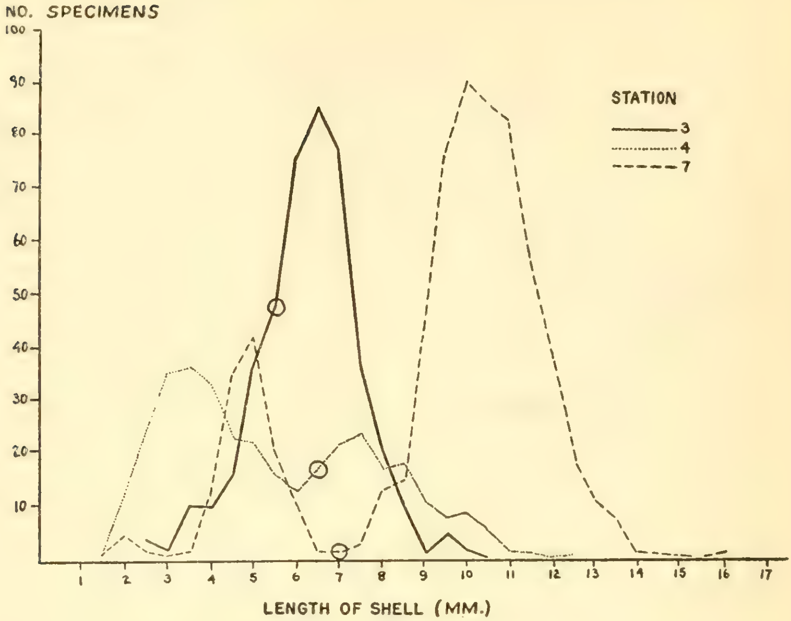

FIGURE 42.—Population curves based on shell length in three samples from Lithia Spring, Fla. Circles denote point at which maturity is reached.

due to a seasonal, environmental stimulus. However, the distance between the "wave" of young and the adults varies considerably from 6 mm. in population 7 to 0 mm. in population 3. The latter population, which is unimodal, may represent a population in which the "wave" of immature has grown into the mature class, and it is not unlikely that it was bimodal a few weeks before the date of collection, in the manner of the other populations.

The independent but pronounced production of young in the various populations suggests a cyclical activity in the physiology of the population itself, in which a fluctuation of sexual activity is present. How frequently these waves of young are produced could not be ascertained from data gathered on one visit to the spring.

McMullen (1947), in his studies on the growth rates of the freshwater snail *Oncomelania quadrasi* Moellendorff in the Philippine Islands, found similar smaller peaks or waves in the measurements of colonies. By revisiting his collecting areas periodically he was able to watch these waves of young move slowly toward the main peak of the adults. From his data he was able to ascertain that that species reaches maturity in 4 to 5 months. I have shown also (1946) that similar waves occur in the developmental stages of the eggs of *Oncomelania*, and that this was due to increased egg production brought about by the stimulus of rains and flood periods.

Bionomics of Guam colonies.—A natural sequence to the bionomic study of the Lithia Spring populations was an investigation of the same species living on Guam Island to see if similar environmental influences on size existed in areas natural to this species. In making a statistical study of the 13 colonies collected on Guam Island it was found that two serious drawbacks existed that, indeed, are common to any material of this nature. The first was that in most of the colonies an insufficient number of preserved animals were available to ascertain at what point maturity was reached. Secondly, the specimens were collected by hand and not in a strictly random fashion, as would be the case had a sieve or hand net been employed. The natural tendency of the collector is to choose the largest specimens first, then the smaller ones, until patience or time halts collecting.

Despite these handicaps, it was felt that a reliable index of size could be obtained by using the 10 percent of that part of the colony that represents the largest specimens. This method would be open to criticism were we dealing with animals which stopped growth at maturity, and which possessed some distinctive morphological adult character. When neither of these markers are present, as is the case with this genus of mollusks, we seek the maximum growth to which the snails grow and eliminate an abnormally low mean, owing to high percentage of young. The choice of the 10 percent figure is arbitrary, although, in population samples of 50 or more, the chances are that this will include only adults. It is unwise to choose simply the largest one or two specimens, for it is common knowledge that abnormal giants or perhaps polyploids are apt to be present in any population and will not serve as representatives. This is the reason why, in smaller samples, of 20 or less, it is best to choose the 20 or 30 percent representing the largest specimens, for comparative purposes.

What we are essentially seeking in a study of shell length is the largest size to which individuals will grow in any one population. Since growth is continuous throughout the life of the individual, two factors will delimit the length of shell—genetic and environmental. We have seen in our study of the Lithia Spring populations that some environmental factor is most likely responsible for length of shell, and it is not unreasonable to assume that such is the case in any differences found on Guam. On this island the streams are close to each other, and accidental dispersal by birds and other creatures is likely to keep the chances of a lengthy genetic isolation very low. To compare the 10 percent representing the largest specimens of each population is, in essence, to compare the ecologic conditions of each stream.

In order to test the validity of using the 10 percent referred to of each colony, histograms were made of the 13 colonies, and the means of shell length were calculated for the total population and for the top 10 percent. Figure 43 is a summation of this study from colonies A to

M, with the histograms in the right column and the means, to their left, represented by straight lines. The upper line is the mean for the entire population sample, and, the line below, the mean for the top 10 percent. These two lines could never have the same length, but the nearer they come together, the more natural will be the curve. Any preponderance of young would lower the mean for the entire population. It will be noticed, from a comparison of the proximity of the two means and the configuration of the histogram, that colonies such as A, B, E, and K, in which the two means are closest, have more compact histograms approaching the normal curve. (L is based on only 8 specimens and cannot be considered significant for this purpose.) On the other hand, samples D, F, and especially G and J, whose two means are relatively far apart, possess histograms that are considerably distorted and drawn out by a high percentage of young. A résumé of the statistics is given in table 4.

TABLE 4.—*Shell lengths of Guam colonies*

Colony	Number of specimens	Mean of colony	Mean of largest 10 percent	Largest specimen
A	92	13. 04	15. 3	16. 5
B	198	13. 44	16. 8	19. 0
C	100	15. 58	20. 1	23. 0
D	65	15. 10	22. 6	27. 0
E	50	19. 85	24. 0	26. 0
F	38	18. 44	25. 1	25. 5
G	97	15. 55	25. 4	27. 0
H	127	18. 33	27. 3	29. 0
I	20	22. 10	29. 2	30. 0
J	43	16. 09	31. 6	33. 5
K	245	24. 46	31. 7	34. 0
L	8	28. 68	34. 0	35. 5
M	36	26. 41	37. 1	40. 0

Although this method of comparing colonies lacks the usefulness and accuracy of presenting the true nature of each population, i. e., the percentage of young, the modes of one or more growth stages, and so forth, it seems to be the only recourse in problems confronting us in those invertebrates that show no morphological signs of maturity, and that grow throughout their life span. In reality, it answers only the question "how large does this species grow in this environment?"

A map of the southern half of Guam Island has been drawn and is presented in figure 40. The collecting localities for colonies A to M have been spotted, and the relative size of the top 10 percent of the individuals entered in the form of outlined shells. It will be noted that there is no geographical cline evident in their distribution. The only possible correlation noted is that between size of the large streams and size of large shells, but unfortunately insufficient studies of the

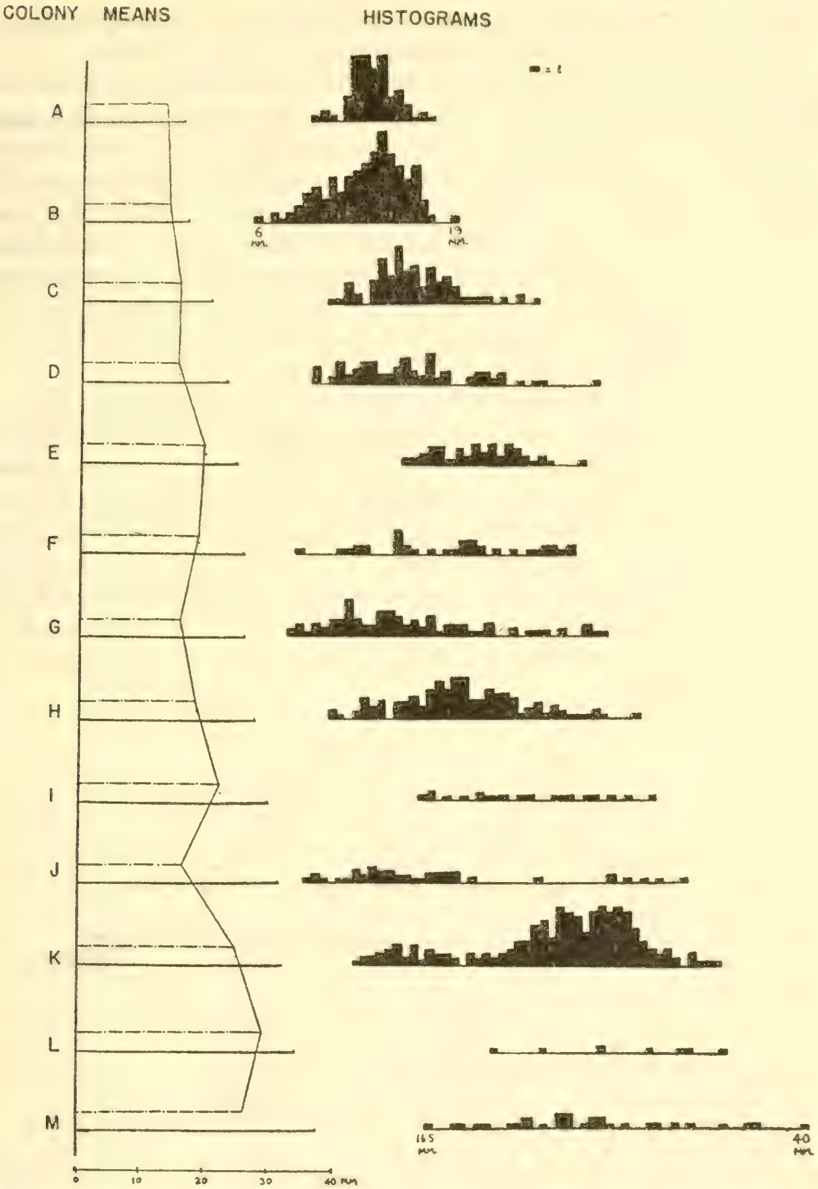

FIGURE 43.—Means and histograms of population samples from Guam Island (see p. 103 for explanation).

flow of these streams at various seasons were made. It would be interesting to mark and to transplant snails from, say, Agaña Spring to Umatac River to see if final growth conformed with the latter environment. A reciprocal transplant would be equally illuminating.

EFFECT OF EROSION ON SHELL LENGTH.—Whenever the water of the habitat of fresh-water mollusks becomes acid, there is apt to be a marked effect on the shells and, in cases where the pH is less than 6.0, sometimes the death of the entire colony results. Many mollusks have developed a chitinous periostracum that protects the shell from corrosion. However, the abrasive action of sand particles and the attachment by algae or egg cases of *Neritina* gastropods may break through this outer covering and expose the calcium carbonate of the shell to the acid waters. It is not uncommon for some colonies of *Thiara granifera* to be considerably eroded at their spires. Shell-length measurements, in these cases, can hardly serve as fair comparisons with colonies that have suffered no loss of shell. The effect of erosion may be avoided by comparing the width of shells or the height of the last two or three whorls that have not been affected.

However, it is of equal interest to learn exactly what amount of reduction in length has been brought about by stream action, for ecologists may wish to know not only the pH values of various streams but also what effect acidity is having on the animals. A study was made of a population sample of 257 specimens of *Thiara granifera* (Naujan River, Mindoro Island, Philippine Islands, U.S.N.M. 258890) which showed considerable erosion. It was found that adults were reduced in shell length by 11.6 percent. Since this type of study has not, to our knowledge, been previously used, we have gone into considerable detail.

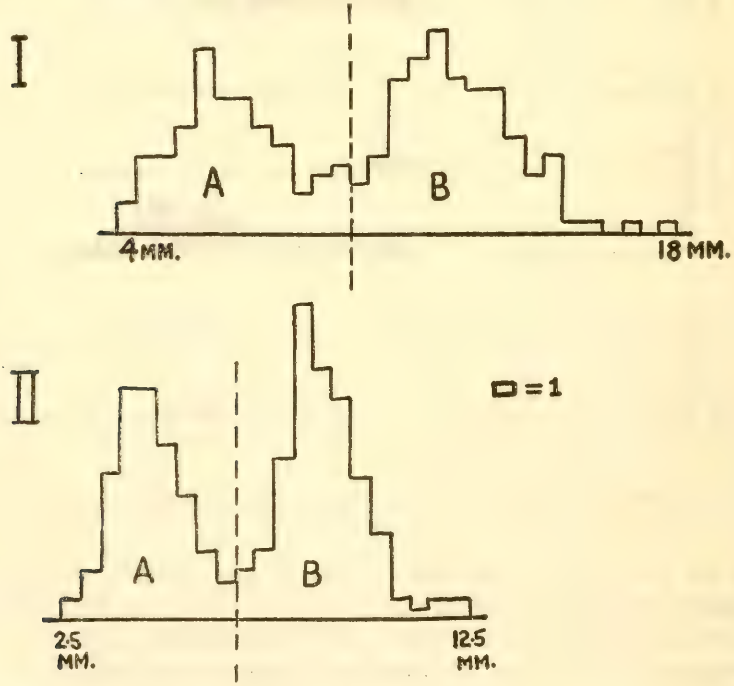

FIGURE 44.—I. Histogram of total shell length of sample from Mindoro colony. II. Histogram of same shells showing height of last whorl only.

Two histograms (fig. 44) are presented, with the upper one representing the distribution of individuals based on the measurements of total length of shell, and with the lower histogram representing the same individuals in which the height or length of the last whorl has been measured. Therefore, the upper histogram carries the effect of erosion, and the lower one is without it. Numerous small individuals were not worn away at their spires. These were measured for width and length to ascertain the ratio between these two figures (i. e., the obesity of the shell). The results are shown in table 5.

TABLE 5.—*Measurements of shells unaffected by erosion*

Total length (mm.)	Length of last whorl (mm.)	Total length÷length of last whorl
10. 5	6. 8	1. 55
9. 3	6. 0	1. 55
8. 5	5. 4	1. 56
8. 0	5. 4	1. 44
8. 0	5. 2	1. 53
7. 8	5. 2	1. 50
7. 0	4. 5	1. 55
6. 5	4. 6	1. 41
5. 8	3. 8	1. 52
5. 5	3. 6	1. 52
		Average ratio 1. 51

In a population sample, the distribution of which approaches the normal curve, or which consists of a uniform sample of adults, it would be necessary merely to multiply the mean of the last whorl measurements by 1.51 (total length/length of last whorl in perfect specimens) to arrive at a theoretical mean of the total shell length. Having obtained this figure, which would represent a population size unaffected by erosion, we need only to compare it with our actual measurements of eroded specimens to ascertain the amount of reduction.

This direct conversion could not be applied in this case, however, for the histogram is strikingly bimodal and in its lower peak possesses a number of young that were not worn away at the spires. The entire sample, therefore, was arbitrarily divided into groups A and B. As natural a midpoint as possible was chosen between the two peaks in the lower histogram at 6.75 mm. If the erosion-correction factor is applied to this (1.51 x 6.75), we obtain a theoretical equivalent total shell length of 10.19. It so happens that this figure divides the two groups in the upper histogram in exactly the same numerical proportion (i. e., 114 in group A and 142 group B) as we have in the lower histogram.

This division into two groups has put all the few perfect specimens in group A and has left us "adult" and all eroded specimens (except 1) in group B for comparative studies.

	Group A	*Group B*
Total number	114 (100%)	142 (100%)
Not eroded	31 (27.1%)	1 (0.7%)
Eroded	83 (72.9%)	141 (99.3%)

The means, their standard deviation, and the standard error of the means were calculated for the following:

TOTAL SHELL LENGTH

	Mean	δ	δ_m	*N*
Group A	6.59	1.42	0.13	114
Group B	12.46	1.47	.12	142

LENGTH OF LAST WHORL

Group A	4.40	0.29	0.02	114
Group B	9.03	1.04	.09	142

The correction factor (length/width of perfect specimens) of 1.51 was then applied to the measurements of the last whorls in each group to compare theoretical total shell length and actual total shell length.

	Total length	*Last whorl length*	*Last whorl × correction*	*Reduction caused by erosion*
A	6.59	4.40	6.64	0.03
B	12.46	9.03	13.63	1.17

It will be noted that the reduction caused by erosion in group A is extremely small. This is due to the youth of the group, which has been exposed to erosion for a relatively short time. In fact, 27.1 percent of these specimens were without a trace of spire erosion. In group B, representing adults that have been exposed to acid waters for considerable time, the reduction has been 1.17 mm., or 11.6 percent.

PARASITOLOGY

TREMATODE PARASITES.—This species of fresh-water snail is of particular interest to parasitologists because of its ability to serve as an intermediate host of numerous trematodes, three of which have been known, in their adult stages, to parasitize man. Other genera and species of the snail family Thiaridae also have this intermediate host ability, and their presence in the Orient is responsible for large endemic areas of the human lung fluke (*Paragonimus westermani*).

In the course of dissecting specimens from many localities, it was noted that some colonies in the Philippine Islands were infected as high as 20 percent with unidentified heterophyidlike cercariae. Dissection of specimens from the introduced colonies at Lithia Spring, Fla., failed to show any trematode infection.

A résumé of the parasites carried by this species is given here. Identification of the intermediate snail hosts as "*Melania obliquegranosa* Smith" is unquestionably referable to *Thiara granifera* (Lamarck). I have examined specimens with the above identification from Formosa Island and the illustrations published by Japanese parasitologists, and I find that the implicated Formosan species is a minor race of the widespread subspecies *T. g. mauiensis* Lea.

Family HETEROPHYIDAE

1. HAPLORCHIS TAICHUI (Nishigori, 1924).

Geographical distribution.—Northern and central Formosa.

Implicated by Faust, E. C. and M. Nishigori, 1926.

Intermediate snail hosts.—*Thiara granifera* (Lamarck) (+*Melania obliquegranosus* (Smith)) and *Semisulcospira libertina* Gould.

Second intermediate hosts.—Fishes: *Cyprinus*, *Gambusia*, *Carassius*, *Zacco*, *Pseudorasbora*, *Phodeus*, *Ctenopharyngodon*.

Definitive hosts.—Birds (?), mammals, including man (experimental infection). An intestinal parasite acquired by eating raw, infected fish.

"The miracidium which hatches from the egg penetrates the tissues of the snail to which it is adapted, as in the case of the miracidial larva of *M. taihokui*, and metamorphoses into a sporocyst. Rediae are produced parthenogenetically within these sporocysts, and after a period of five to six weeks mature cercariae develop within the rediae. These carcariae erupt from the snail tissues and are found freely swimming about in the water." (Faust and Nishigori, 1926.)

2. DIORCHITREMA FORMOSANUM Katsuta, 1932.

Geographical distribution.—Formosa.

Implicated by Katsuta, 1932.

Intermediate snail hosts.—*Thiara granifera* (Lamarck), and *Semisulcospira libertina* Gould.

Definitive hosts.—*Mammals.* An intestinal fluke acquired by eating raw, infected fish.

3. METAGONIMUS YOKOGAWAI Katsurada, 1912.

Geographical distribution.—Japan, Korea, Formosa, Rumania, Siberia, Dutch East Indies, Palestine, Russia, and Spain.

Intermediate snail hosts.—*Thiara granifera* (Lamarck), *Semisculcospira libertina* Gould, *Hua amurensis* Gerstfeld. The record of "*Melania ebenina*" in China is probably referable to *Hua toucheana* Heude. Unknown in the Philippine Islands and Eurasia.

Second intermediate hosts.—Fishes: the salmonoid *Plecoglossus altivelis* and the cyprinoid *Richardsonium.*

Family TROGLOTREMATIDAE

4. PARAGONIMUS WESTERMANI Kerbert, 1878.

Geographical distribution.—In the Orient, Japan, Korea, Manchuria, Formosa, China (especially Chekiang Province), French Indo-China, the Philippine Islands, Siam, the Malay Peninsula, Assam, India, New Guinea, Java, and Sumatra. Also South America, probably Africa, and one record for North America.

Intermediate snail hosts.—*Thiara granifera* (Lamarck) (Formosa), *Thiara* (*Melanoides*) *tuberculata* Müller (Formosa), *Semisulcospira libertina* Gould (Formosa and Japan), *Hua* species, and *Syncera lutea* A. Adams (China). Unknown elsewhere.

Second intermediate hosts.—The fresh-water crabs *Potamon* (*Geothelphusa*) *obtusipes* Stimpson, *P. dehaanii* White, and *Eriocheir japonicus* De Haan.

Definitive hosts.—Lungs of mammals, especially the felines and man.

The life cycle was first elucidated by K. Nakagawa in Formosa in 1917.

"When the snails are placed in water containing miracidia, the latter swarm around them and become attached to the heads, jaws and feet, but rarely to the tentacles and mantles. They cling with their suckers, insert proboscis into the tissue of the host and enter the body of the snail like the cercariae of Schistosomum [sic] japonicum, as described by Miyairi (1915). Unlike the miracidia of Schistosomum, those of the pulmonary distoma *Paragonimus* shed their cilia in this act.

"Besides the cercariae, sporocysts of various sizes are found abundantly in the liver of Melania [+*Thiara* and *Semisulcospira*]. They are sometimes found in the heart and kidneys." (Nakagawa, 1917, pp. 301–302).

Remarks on snail host specificity.—Gastropod mollusks serve as the obligatory first intermediate host of all digenetic trematodes or flukes. While in several cases the relationship between the parasitic fluke and the host snail is restricted to one species in certain areas, on the whole there does not appear to be any set pattern for certain snails to serve as hosts to any particular species or even genus of trematode.

Of the three important blood flukes that infect man, *Schistosoma japonicum* appears most restricted in its choice of only one genus of snails, *Oncomelania*. In the Philippine Islands, *Oncomelania quadrasi* Moellendorff is the only known carrier; in Japan, only *O. nosophora* Robson. This genus of snails is a gill-breathing amnicolid. Yet *Schistosoma mansoni* Sambon and *S. haematobium* Bilharz, of Africa and tropical America, are carried by the snails *Bulinus*, *Physopsis*, and *Australorbis*, all of which are lung-breathing Planortidae. The phylogenetic relationships of these two groups of gastropods could hardly be farther apart. In all likelihood the choice of mollusks is based on the physiological adaptations and ecological preferences of the snails in each case.

Thiara granifera serves as host for two different superfamilies of trematodes, the Heterophyoidea (*Metagonimus*, *Haplorchis*, and *Diorchitrema*) and the Troglotrematoidea (*Paragonimus*). These same trematode groups are also carried by other genera of Thiaridae (*Semisulcospira*, *Hua*, *Goniobasis*, and the subgenus of *Thiara* called *Melanoides*). In addition, however, members of the snail families Amnicolidae and Synceridae may also act as intermediate hosts, in some cases being the only snail hosts in the local endemic area.

In all likelihood *Thiara granifera* may be considered a potential host of the American *Paragonimus kellicottii* on epidemiological and ecological grounds.

An understanding of snail-host specificity will probably not arrive from a study of molluscan phylogeny, but rather will have to await an intensive study of the physiology of the many fresh-water species that serve as hosts. The seeming tendency for certain families of snails to serve as hosts to particular groups or species of flukes is probably merely an expression of a common physiological condition possessed by these snails.

INTRODUCTION INTO THE UNITED STATES

Thiara granifera has established itself some 5,000 miles east of its normal geographical limits in the Lithia Springs of Hillsborough County, Fla. The thriving American colonies should be considered as potential hosts for one or more of the trematodes that they are capable of carrying in their native habitats. (See under Parasitology, p. 109.) It appears, however, for the several reasons discussed subsequently, that no danger exists in the establishment of these snails in our country.

It appears from the information now at hand that there was only one introduction of the snail into the United States. On March 23, 1935, an aquarium dealer of San Francisco, Calif., sent four specimens to the United States National Museum for identification. In a letter (March 23, 1935) to Dr. G. S. Myers, then curator of the division of fishes, this dealer states, "I do not know just where their native habitat might be, because here and there, from different points, Australia, China, Hawaii, etc., where I get a small shipment, plant life comes along and some small ones [snails] may be adhering to it."

No further notice was taken of this species, since at that time the parasitological importance of this species was overlooked. It was not until 1947 that it reappeared, when Dr. C. Wythe Cooke, of the U. S. Geological Survey, collected a number of specimens in Lithia Spring, Fla., and kindly forwarded them to the United States National Museum. A few weeks later I was sent to this spring to determine its prevalence, manner of introduction, and its possible spread.

Thiara granifera is present in the main Lithia Spring in extraordinary numbers, sometimes as many as 400 specimens per square foot. A small, connecting subsidiary spring contains a few larger individuals. A fuller account of the spring condition appears in the section on bionomics (p. 100).

An aquatic-plant and fish dealer in Tampa related that he acquired specimens in 1937 while on a visit to California. Since that time, his plant vats have been stocked with this mollusk which, as an oddity, had been sold over a hundred times in a year as the "Philippine horn of plenty." It was his opinion that the snails were probably accidentally introduced to the spring around 1940, when improperly washed tubs were used to gather native plants. I have seen specimens in home aquaria in Silver Spring, Md., which had been acquired from Washington, D. C., dealers.

It will be seen by the above experiences that any foreign snail that has sales value because of its attractive appearance or peculiar habits will soon be distributed to many parts of the country and in many cases will be introduced purposely or accidentally to native waters. Probably the most likely solution to the problem of controlling introduced, dangerous mollusks lies in encouraging dealers, particularly the importers, to send their mollusks for identification to museums that have specialists in mollusks on the staff. The present programs of the Bureau of Plant Quarantine and Insect Control and the United States Public Health Service appear to be extensive enough for our protection. It must be realized that even the most stringent of laws prohibiting the import of foreign mollusks are not going to offer perfect screening, since accidental introductions by various means are likely to occur. In the past hundred years approximately 50 species of exotic species of land and fresh-water mollusks have established themselves in the United States and Canada.

The geographical origin of these snails will probably remain uncertain. From the condition and size of individuals in the Lithia Spring colonies, it appears that an abnormally stunted ecological form exists, which makes fair comparisons with races from endemic Pacific areas difficult. The more closely resembling lots in the United States National Museum are from the Hawaiian and Marianas Islands. They are possibly members of the subspecies or geographical race *Thiara granifera mauiensis* Lea, 1856.

It is highly unlikely that this snail will spread to many other sections of the United States, except in rare spring localities where water temperatures remain above 75° F. Its public health menace is negligible by virtue of the complex life cycle of the parasite that it is capable of carrying. A second intermediate host, usually a freshwater crayfish or crab, is a necessary part of the life cycle of *Paragonimus*. Furthermore, in order to accomplish infection of the definitive host the crayfish must be eaten raw, a custom which is infrequent or rare among our people.

IDENTIFICATION OF THIARA GRANIFERA AND CLOSELY RESEMBLING SPECIES IN THE UNITED STATES

In addition to a snail of similar appearance, which is native to Florida springs, there are two species of thiarid snails sometimes found in aquaria that are likely to be confused with *Thiara granifera*. *Pleurocera* (or *Ceriphasia?*) *catenaria* (Say) is found in the same habitat as *T. granifera* at Lithia Spring, but rarely succeeds in an aquarium. *Hemisinus cubanianus* (Orbigny), from Cuba, and *Pachychilus glaphyrus* (Morelet), from Central America (Honduras), have been raised by fish fanciers with moderate success. The synopses of distinguishing characters presented herewith will aid in identifying these species.

THIARA (TAREBIA) GRANIFERA (Lamarck)

FIGURE 45, *a*; PLATE 8, FIGURES 1, 2

At Lithia Spring: Shell 10 to 15 mm. (about ½ inch) in length, amber to reddish amber, rarely with green algal attachments. Sides of whorls in spire flat, without strong spiral cords.

In aquaria: Shell sometimes 20 mm. in length, and if in stagnant tank, heavily varnished with black coating. Animal with young in brood pouch under skin of back; mantle edge with tiny, fleshy fingers or papillae. Operculum with nucleus at one end.

PLEUROCERA CATENARIA (Say)

FIGURE 45, *c*; PLATE 8, FIGURES 3, 4

Shell 15 to 20 mm. (about ¾ inch) in length, amber brown to black-brown, often with green algal attachments. Sides of whorls in spire slightly rounded and carinate near the bottom, with strong spiral cords, which form well-developed tubercles as they cross the small axial ribs. Often with dark brown, spiral color band at base of shell. Mantle of animal wavy, but without papillae. No brood pouch. Operculum with nucleus near center.

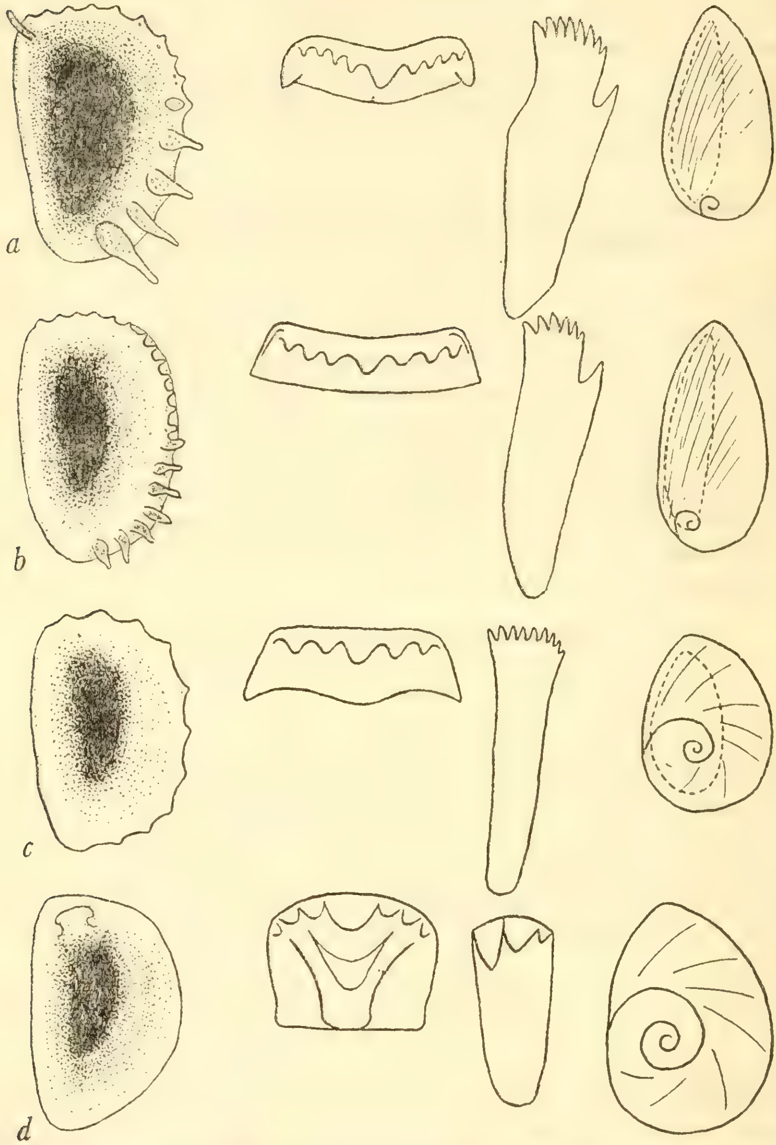

Figure 45.—Animal characters of four genera of Thiaridae: *a*, *Thiara* (*Tarebia*) *granifera* (Lamarck), from Lithia Spring, Fla., and the Orient; *b*, *Hemisinus cubanianus* (Orbigny), from Cuba; *c*, *Pleurocera catenaria* (Say), from Florida springs; *d*, *Pachychilus glaphyrus* (Morelet), from Honduras. (From left to right: Mantle edge, central radular tooth, outer marginal tooth, and operculum.)

HEMISINUS CUBANIANUS (Orbigny)

FIGURE 45, *b*

Shell 20 to 25 mm. (about 1 inch) in length, smooth, greenish brown, with many spiral rows of elongated, black-brown color spots. Animal with a few, large young in brood pouch under skin or back. Mantle edge with tiny, fleshy papillae. Operculum with nucleus at one end.

PACHYCHILUS GLAPHYRUS (Morelet)

FIGURE 45, *d*

Shell 35 to 45 mm. (about 1½ to 1¾ inches) in length, smooth, black-brown, and without spiral rows of color dots. Animal without brood pouch. Mantle edge smooth. Operculum with nucleus near center.

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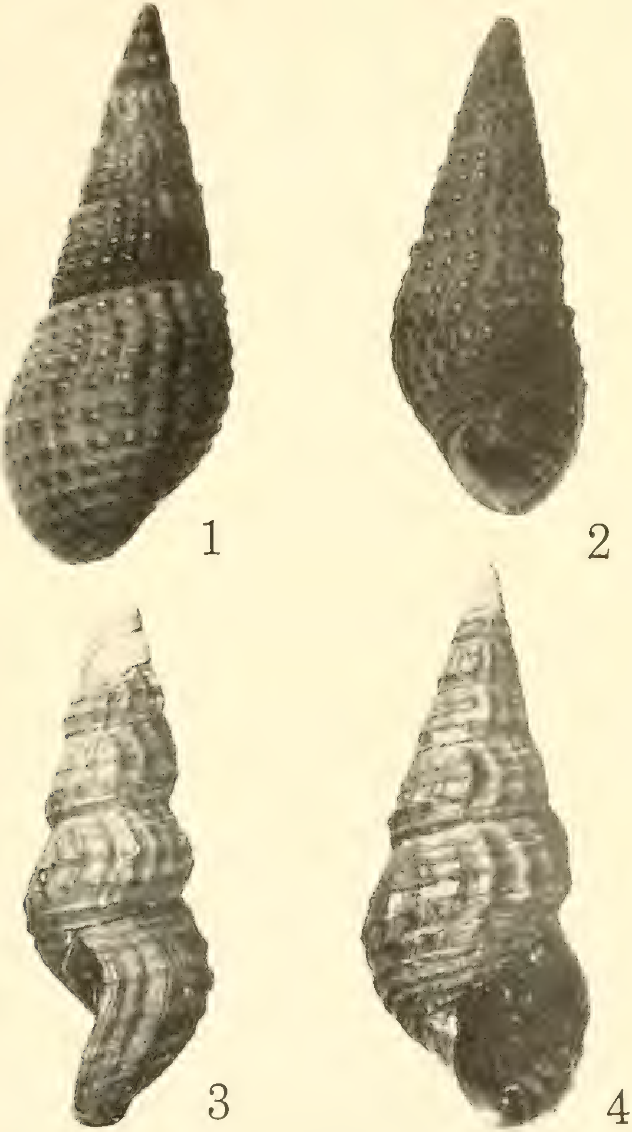

1, 2. Shells of *Thiara (Terebia) granifera* (Lamarck), from Lithia Springs, Fla. (× 5).
3, 4. Shells of *Pleurocera catenaria* (Say), from Lithia Spring, Fla. (× 4).

THIARA (TEREBIA) GRANIFERA (LAMARCK).
Contents of a brood pouch, showing development from egg to young ready to emerge.
(× 25).

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SOME MARINE ASELLOTE ISOPODS FROM NORTHERN CALIFORNIA, WITH DESCRIPTIONS OF NINE NEW SPECIES

By Robert J. Menzies

In this report certain of the species of the isopod families Munnidae and Janiridae from northern California are described. The recorded species were all collected from the intertidal zones, with the exception of *Ianiropsis magnocula*, which was taken from about 30 fathoms off the California coast. Hitherto only the genus *Ianiropsis*, represented by two (really one) species, had been known from the California coast.

In order to eliminate repetition, those characteristics mentioned in the family diagnoses are not mentioned in the generic diagnoses; furthermore, characteristics enumerated in the generic diagnoses apply to the specific diagnoses and descriptions as well.

In all instances, the width of specimens is taken at the widest part of the second peraeonal somite; the length is measured on the midline from the rostrum to the tip of the telson.

Dr. Fenner A. Chace, Jr., curator of the division of marine invertebrates, United States National Museum; Dr. Melville Hatch, Zoology Department, University of Washington; and Dr. Frank A. Pitelka, Zoology Department, University of California, have all assisted through the loan of certain specimens utilized in this report. Dr. Chace and Dr. Hatch kindly lent some type specimens, which proved very helpful in clearing up the confused concept concerning *Ianiropsis kincaidi kincaidi*. Most Monterey County specimens were lent by Dr. Pitelka. They form part of a fine collection

of isopods, made by John Davis, which was deposited in the University of California collections and subsequently lent me for study. To these gentlemen I extend my sincere thanks for their kind assistance.

Family MUNNIDAE

(Cf. Nierstrasz and Schuurmans Stekhoven, Jr., 1930, p. X, e 108)

Genus MUNNA Kroyer, 1839

Munna KRØYER, Naturh. Tidsskr., vol. 2, p. 612, 1839. (Genotype, *Munna boeckii* Krøyer, 1839.)

Generic diagnosis.—In general the generic diagnosis is modified after G. O. Sars (1897–99, p. 106). Body subpyriform, with dorsal surface somewhat vaulted; last three peraeonal somites small, with lateral parts directed somewhat posteriorly. Cephalon usually broad. Pleotelson consisting of two somites: A narrow, short, anterior somite and a pyriform last somite. Eyes distinct (G. O. Sars, 1897–99) or lacking (H. J. Hansen, 1916, p. 34). First antenna with a 3-jointed peduncle and a flagellum composed of only a few joints. Second antenna with a 6-jointed peduncle and a multiarticulate flagellum. Mandible with a well-developed molar process, palp 3-jointed. Maxilliped with a 5-jointed palp. Gnathopods of adult male subchelate, often enlarged and swollen. Remaining peraeopods ambulatory, not subchelate, increasing in length, with carpal and propodal joints much elongated and bordered with spinelike 2-pointed setae; dactylar joint small, biunguiculate. Uropods with one (?) or two branches.

Remarks.—Even today this genus remains inadequately understood and contains a vast number of species. The genotype, *Munna boeckii*, is still imperfectly known, especially in respect to the minute structure of the mouth parts, uropods, and pleopods. For that reason the diagnosis here given is very liberal, and I believe that once the genotype is better known it will be possible to divide the genus into at least two, and perhaps more, very distinct genera. It has been possible to detect on the species that I have examined a minute but clearly discernible dorsal (outer) uropodal branch, which usually has but a single seta at its apex, and which generally is concealed partly or totally by the edge of the pleotelson. This is a rather significant observation, in that the genus *Munna* has long been considered different from the other genera belonging to the family Munnidae in lacking biramous uropoda, e. g., "uropoda very small, simple" (G. O. Sars, 1897–99, p. 106); "uropoda small, simple" (Richardson, 1905, p. 480); "mit kurzen eingliedrigen uropoden" (Vanhöffen, 1914, p. 561); "uropoden einästig" Nierstrasz and Schuurmans Stekhoven, Jr. (1930, p. X, e 108); "uropoder enkla" (Hult, 1937, p. 9); et cetera.[1] It is believed

[1] After the preparation of this paper, Dr. Raymond Amar (1948) discovered an additional uropodal branch in *Munna petiti* Amar.

that the omission of reference to this minute dorsal uropodal branch has been due to its being overlooked by the several researchers who have worked on the genus, and that it will in all probability be found on the other species belonging to the genus. Of course this makes the differentiation of *Munna* from related genera a more difficult task, but at the same time it indicates closer affinities.

In three of the examined species a small but distinct squama was detected on the third joint of the peduncle of the second antenna. In a fourth species, *M. ubiquita*, there was only a slight indication of such a scale, in the form of a large seta. Reference to this observation, like that concerning the dorsal uropodal branch, appears to be lacking in the published description of species of *Munna* to which I have had access, and this character appears to have been overlooked. The squama also indicates a closer affinity between *Munna* and its related genera.

As mentioned, it is possible to divide *Munna* species into several groups, some of which may become recognized genera when *M. boeckii* is better known. The following attempt at a division of the genus, while obviously incomplete, seems none the less worthwhile:

A. Species having a leaflike, flattened, ventral uropodal branch lacking spinelike protuberances. Each male first pleopod not expanded laterally at apex, apex pointed. Gnathopods of adult male and female specimens similar. Male third pleopod with terminal joint of exopod not equal in width to width of terminal joint of endopod. Probably includes *Munna nana* Nordenstam, *Munna acarina* Miller, *Munna petiti* Amar, and *Munna ubiquita*, new species.

B. Species having rounded (in X-section) ventral uropodal branch bearing at least one large spinelike protuberance. Each male first pleopod expanded laterally at apex. Gnathopods of adult male enlarged and swollen, unlike those of adult females and subadult males. Male third pleopod with terminal joint exceeding in width the width of terminal joint of endopod. Probably includes *Munna avatshensis* Gurjanova, *M. krøyeri* Goodsir, *M. palmata* G. O. Sars, *M. stephenseni* Gurjanova, and *M. chromatocephala*, new species.

C. Species similar to those in B, except ventral uropodal branch appears to lack any large spinelike protuberance. A distinct, dorsally visible, dentate, suburopodal shelf is present, which structure is lacking in species mentioned in B. Probably includes *Munna minuta* Hansen and *Munna halei*, new species.

D. Species lacking eyes. Minute structure of mouth parts, pleopods, and uropods not known. Equals *Coecimunna* Richardson, 1908, and includes *Munna truncata* Richardson and *M. acanthifera* Hansen.

E. Species to which such assignments are impossible at the present time, owing to their being inadequately known. Includes a vast majority of the species.

The four species herein recorded, three of which are new, represent the first intertidal records for the genus from California.

KEY TO THE CALIFORNIA SPECIES OF MUNNA

a^1. Uropods small, leaflike, lacking spinelike protuberances. Male first pleopods apically pointed ________________ **M. ubiquita, new species**

a^2. Uropods round in X-section. Male first pleopods with apices laterally expanded.

b^1. Uropoda at least with one large spinelike protuberance. Dentate suburopodal shelf lacking.

c^1. Lateral borders of pleotelson smooth, devoid of large 2-pointed setae. **M. chromatocephala, new species**

c^2. Each lateral border of pleotelson with 2 to 3 large 2-pointed setae. **M. stephenseni Gurjanova**

b^2. Uropods lacking large spinelike protuberances. Dentate suburopodal shelf visible in dorsal view ________________ **M. halei, new species**

MUNNA UBIQUITA, new species

FIGURES 46–48

Munna minuta Hansen, HATCH, 1947, p. 173, not figs. 42–44.

Holotype.—Male, length 0.8 mm., width 0.4 mm.

Allotype.—Ovigerous female, length 1.2 mm., width 0.6 mm.

Diagnosis.—Eyes on fairly long immovable stalks, preorbital lobes well developed. Pleotelson with about six serrations on each ventrolateral margin. Flagellum of first antenna composed of three joints, last joint slightly shorter than second, which is about twice length of first, terminal joint with a single sensory filament at apex. Adult male and female gnathopods similar. Male first pleopod apically pointed, not laterally expanded. Second male pleopod with apex of exopod acutely pointed. Suburopodal shelf not evident. Uropodal ventral branch thin, leaflike, lacking spines.

Character of body.—Minute, mitelike, legs spindly. Patch of black chromatophores, above uropods and on male pleopods, distinctive. Antennae and body with scattered black chromatophores.

Cephalon.—Frontal margin slightly emarginate, devoid of spinelike setae.

Peraeon.—Epimeral plates evident in dorsal view on somites 2–7.

Pleon.—Pleotelson with few setae and no 2-pointed setae.

Second antenna.—As long as body. No squama observed, although a large seta occupies the place usually occupied by squama on third peduncular article. Flagellum with about 10 separate articles, first much longer than second.

Maxilliped.—With three coupling hooks.

First maxilla.—Outer lobe with about 11 apical setae, inner lobe with 3 apical setae.

Second maxilla.—Each of the two outer lobe lappets with 4 apical setae. Inner lobe with 11 apical setae and at least 4 pectinate scales along outer surface.

Mandibles.—Left mandible incisive part with 4 teeth, lacinia with 4 teeth, setal row with 3 setae, molar process expanded at denticulate

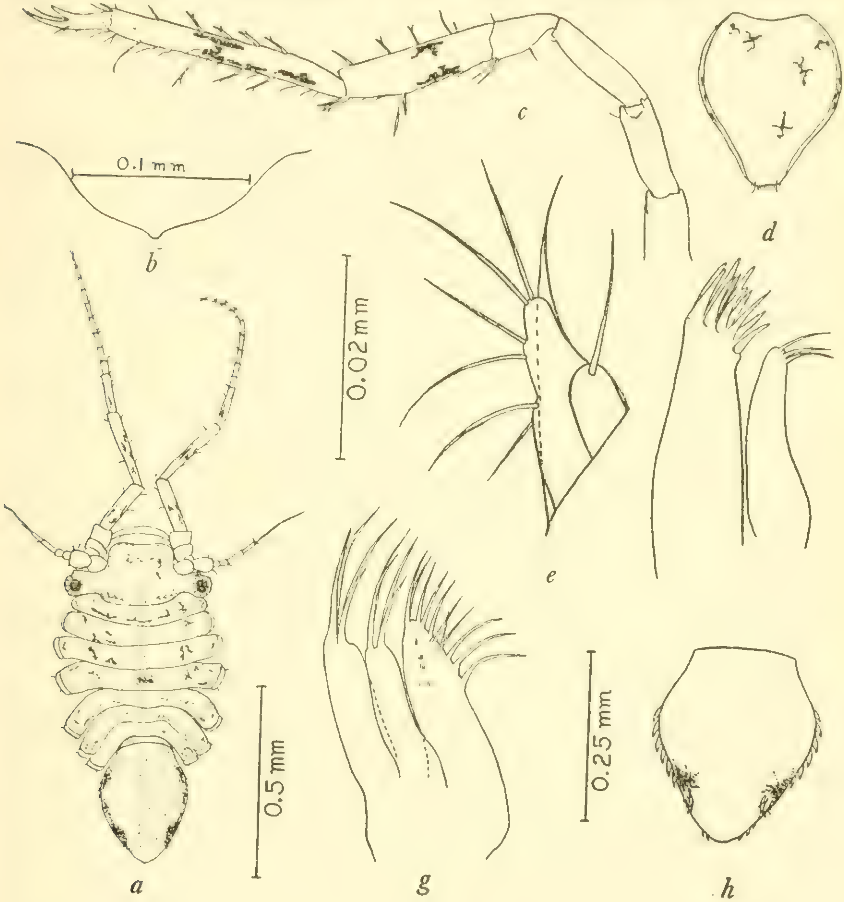

FIGURE 46.—*Munna ubiquita*, new species: *a*, Dorsal view, male paratype; *b*, apex of telson; *c*, seventh peraeopod; *d*, female operculum; *e*, uropods, left; *f*, first maxilla; *g*, second maxilla; *h*, pleotelson. (Magnification as indicated by scale: *f* and *g* same as *b*; *c* and *d* same as *h*.)

distal end. Right mandible lacking lacinia, incisor with 5 teeth, setal row with 4 setae. Terminal article of palp with two apical setae.

Gnathopod.—Carpus with three 2-pointed setae on inner distal angle, merus with a large 2-pointed seta at outer distal angle. Large black chromatophores on all articles except dactyl.

Seventh peraeopod.—Seven 2-pointed setae along inferior margin and four on superior margin of propodal joint. Other peraeopods similar in a general way to seventh.

Uropod.—Dorsal branch with a single seta, ventral branch with four setae on lateral margin and two apical setae.

Types.—Holotype, allotype, and 15 female paratypes, collected at the type locality, Marshalls, Tomales Bay, Marin County, Calif., in shoreline plankton haul, October 31, 1947, by R. J. Menzies. Type specimens have been deposited in the collections of the following institutions:

United States National Museum, holotype (No. 89520), allotype, and 16 paratypes; Allan Hancock Foundation, 6 paratypes; Rijksmuseum van Natuurlijke Historie, Leiden, Holland, 3 paratypes; Pacific Marine Station, 29 paratypes, accession numbers 1283–1290 Arth.

Geographical distribution.—Seattle, Wash., to Tomales Bay, Marin County, Calif.

Material examined.—Specimens examined were collected from the following localities:

WASHINGTON: *Seattle*, Carkeek Park, intertidal, on *Polysiphonia*.

CALIFORNIA: *Sonoma County*, Bodega Harbor, off Dusty's pier, November 29, 1947 (R. J. M.), 1 ovigerous female; Bodega Bay, whistle buoy, 40 feet, July 14, 1948 (R. J. M.), 1 male. *Marin County*, Dillon Beach, First Sled Road, January 21, 1948 (R. J. M.), 8 males, 13 females; Tomales Bluff, Tomales Point, bay side, August 18, 1947 (R. J. M.), 1 specimen; in tide-pool plankton haul, November 29, 1947 (R. J. M.), 3 specimens; Tomales Bay, Marshalls, shore-line plankton haul, November 13, 1947, 11 specimens, mostly ovigerous females (R. J. M.).

Ecology.—This species appears to be one of the most abundant species of intertidal marine isopods at localities near Dillon Beach, and because of its apparent ability to thrive in vastly different ecological conditions I have given it the name *ubiquita*. Specimens were found on the Bryozoa *Bugula pacifica* and *Tricellaria occidentalis* and in most tide pools and shore-line plankton hauls. The species appears intertidally abundant in both protected bay and exposed rock-coast localities. Specimens taken from Tomales Bay demonstrated a positive phototropism in the laboratory. Ovigerous specimens were noted during January, October, and November.

Remarks.—An examination of some paratypes of *Munna acarina* Miller (1941, pp. 311–313, fig. 2) indicates that the species is closely related to *M. ubiquita*. The specimens were kindly lent by Dr. Miller from his personal collection. *Munna nana* Nordenstam (1933, pp. 222–225, figs. 56–57) similarly appears closely related to *M. ubiquita;* however, in the paper cited Dr. Nordenstam makes no mention of the species having 2-branched uropods. In a letter recently received from Dr. Nordenstam he remarks that he has been unable to find a dorsal uropodal branch on specimens of *Munna nana*. *Munna ubi-*

FIGURE 47.—*Munna ubiquita*, new species: *a*, Terminal articles of seventh peraeopod; *b*, right mandible, distal end; *c*, maxilliped; *d*, first antenna; *e*, gnathopod; *f*, male first pleopods; *g*, distal end of left mandible. (Magnification adjacent to *a* applies to all figures.)

quita differs from both *acarina* and *nana* in having minute serrations along the ventrolateral borders of the pleotelson. Such serrations appear to be lacking in *acarina* and *nana*. I have examined the specimens recorded by Dr. Hatch (1947, p. 173) as *Munna minuta* Hansen, and in my opinion they belong to this species.

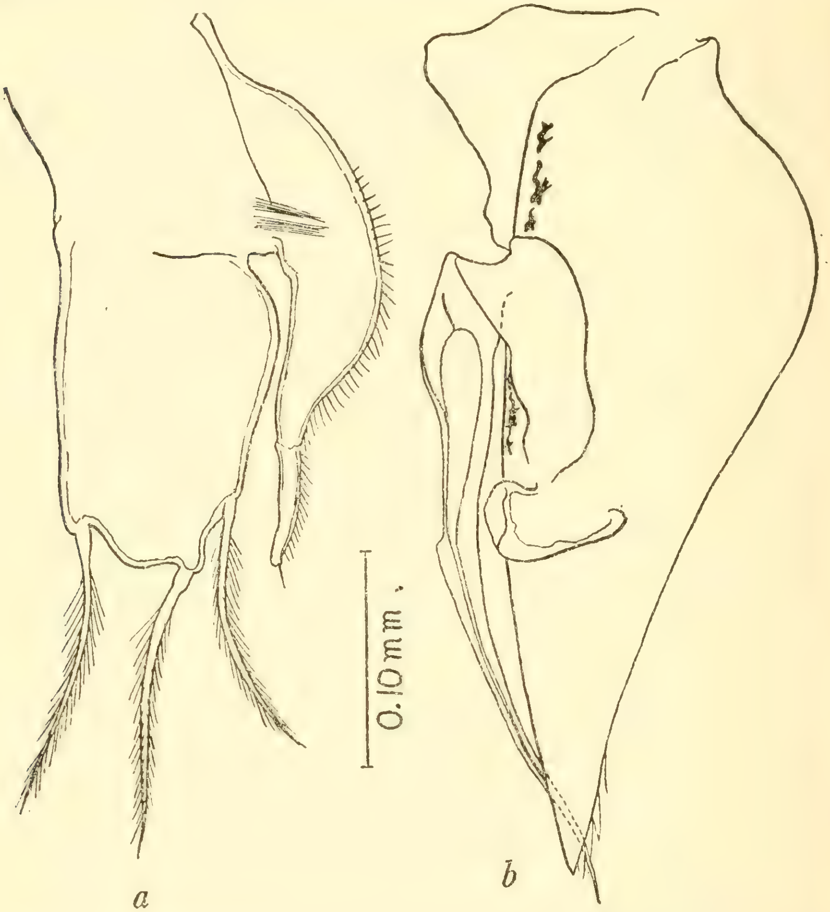

FIGURE 48.—*Munna ubiquita*, new species: *a*, Third pleopod, male; *b*, second pleopod, male.

MUNNA STEPHENSENI Gurjanova

FIGURES 49–51

Munna stephenseni GURJANOVA, 1933, p. 88 (in Russian), p. 91 (in English), fig. 15, *a–f*.

Munna krøyeri Goodsir, FEE, 1926, p. 22.—HATCH, 1947, p. 174 (not the figures given by Hatch).

The specimens taken in Marin County exhibit sufficient variation to make identification of them with Gurjanova's species seem quite reasonable. Those identified by Fee as *Munna krøyeri* Goodsir in all probability belong to this species, although the description given by Fee applies equally well to *M. krøyeri* or to *M. stephenseni* in most details. Fee's remark that there is one abdominal segment in the species is probably incorrect, because the genus is characterized in part by having two pleon somites.

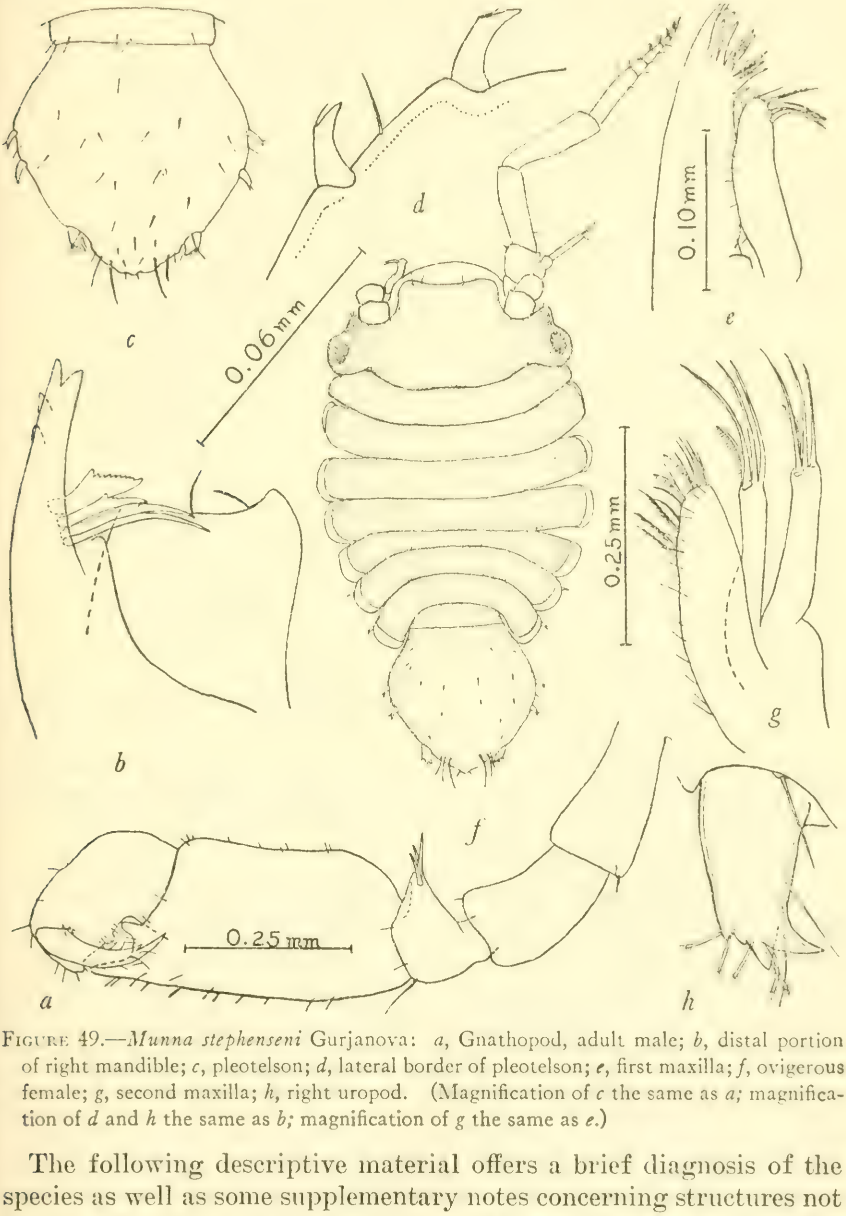

FIGURE 49.—*Munna stephenseni* Gurjanova: *a*, Gnathopod, adult male; *b*, distal portion of right mandible; *c*, pleotelson; *d*, lateral border of pleotelson; *e*, first maxilla; *f*, ovigerous female; *g*, second maxilla; *h*, right uropod. (Magnification of *c* the same as *a;* magnification of *d* and *h* the same as *b;* magnification of *g* the same as *e.*)

The following descriptive material offers a brief diagnosis of the species as well as some supplementary notes concerning structures not mentioned in the original description. The adult male gnathopod is figured for the first time.

Diagnosis.—Eyes on short immovable stalks, preorbital lobes strong. Pleotelson with two to three large 2-pointed setae on each side anterior to uropods. Body covered with setae, which are especially evident at posterior border of pleotelson. Flagellum of first antenna in adult composed of three articles, last article about one-eighth length of second and about two-thirds width of that article; second and third articles each with a sensory filament at apex. No suburopodal shelf

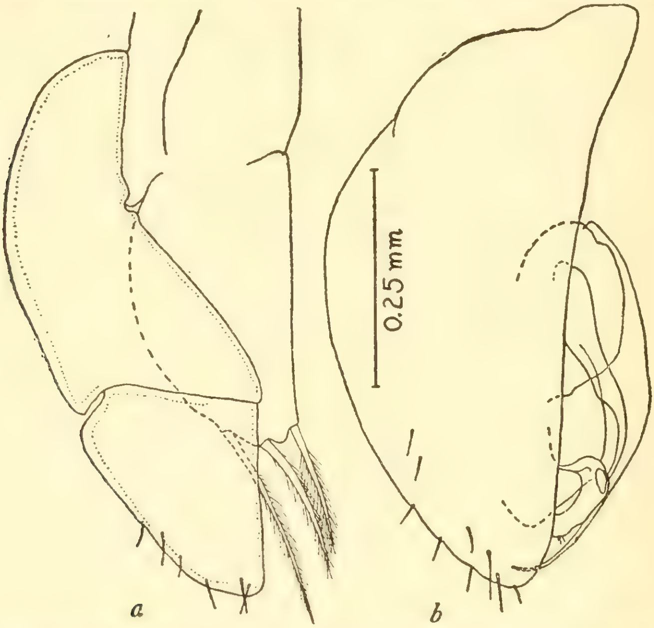

FIGURE 50.—*Munna stephenseni* Gurjanova: *a*, Third pleopod, male; *b*, second pleopod, male. (Magnification as indicated by scale.)

evident. Ventral uropodal branch with a strong posteromedially directed spinelike tooth at posteromedial angle, in addition to several smaller teeth.

Supplementary descriptive notes:

Pleon.—Small specimens with two spinelike 2-pointed setae on each side, large specimens with one more such seta on each side.

First antenna.—Gurjanova describes two flagellar segments,[2] the second of which is long, and figures (enlarged drawing) a flagellum composed of three segments (plus a very minute terminal article), the long last article of her description being figured as two subequal joints. In one of the specimens that I examined the flagellum of the left antenna was composed of two articles, much as Gurjanova describes (plus the minute terminal article, which Gurjanova did not consider a separate article), while the right antennal flagellum re-

[2] Antenna 1 has a 2-jointed flagellum, with a large long last joint" (Gurjanova, 1933, p. 91).

sembled that figured (enlarged drawing) by Gurjanova. All the other specimens that were examined had a flagellum similar to that shown in figure 51, *a*, that is, one consisting of three articles, including the minute terminal article.

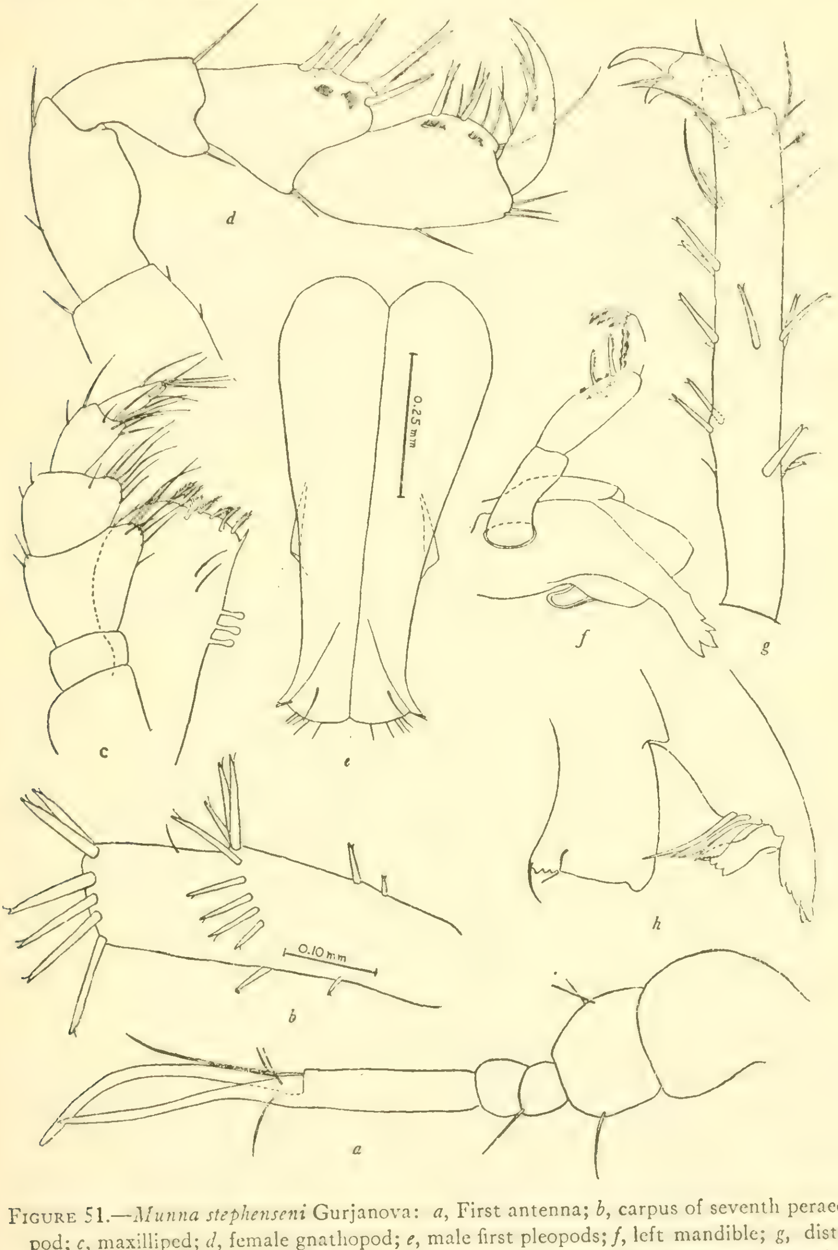

FIGURE 51.—*Munna stephenseni* Gurjanova: *a*, First antenna; *b*, carpus of seventh peraeopod; *c*, maxilliped; *d*, female gnathopod; *e*, male first pleopods; *f*, left mandible; *g*, distal articles of seventh peraeopod; *h*, left mandible. (Magnification as indicated by scales: *a*, *d*, *g*, and *h* same as *b*; *c* and *f* same as *e*.)

Second antenna.—Basal flagellar segments pink in life.

Maxilliped.—With three coupling hooks.

First maxilla.—Outer lobe with 12 setae, inner lobe with 4 apical setae.

Second maxilla.—Each of the two outer lobe lappets with 4 apical setae, inner lobe with about 13 large setae.

Mandible.—Left mandible incisor with five teeth, lacinia with four teeth, setal row with four setae. Right mandible lacking lacinia, incisor with four teeth, setal row with four setae. Terminal article of palp with three denticulate setae at apex. Molar process expanded at apex.

Adult male gnathopod.—With two blunt teeth on cutting edge of propodus and two longer teeth on cutting edge of carpus.

Subadult male gnathopod.—Resembles female gnathopod. A pair of pectinate scales present near inner margin of dactyl, propodus, and carpus. Number of 2-pointed setae appears variable, depending on size of specimen.

Types.—Type locality, Komandorskie Islands, seashore, Bering Sea. The types are located in the collections of the Zoological Museum of the Academy of Sciences, U. S. S. R.

Geographical distribution.—Bering Sea to Carmel Cove, Monterey, Calif.

Material examined.—Eleven male and 22 female specimens were examined that had been collected from various localities in Marin and Monterey Counties, Calif.

Remarks.—In juvenile specimens the very minute terminal article of the flagellum of the first antenna of the adult appears much longer and wider and is obviously a separate article (compare figs. 54, *a*, and 54, *b*). The aborted appearance of that article correlates with the development of a sensory filament at the apex of the penultimate flagellar article. This filament is lacking in very small specimens. As was earlier mentioned Gurjanova did not consider the minute article as a separate article in her description of *M. stephenseni.*

MUNNA CHROMATOCEPHALA, new species

FIGURES 52, 53

Holotype.—Adult male, length 2.2 mm., width 0.4 mm.

Allotype.—Ovigerous female, length 1.5 mm., width 0.7 mm.

Diagnosis.—Eyes bulging only very slightly, preorbital area almost contiguous with the lateral extent of eyes. Pleotelson smooth, lacking 2-pointed setae on lateral borders. Body covered with setae, especially on the dorsal surface of the pleotelson. Flagellum of first antenna composed of three articles, penultimate article scarcely exceeding twice the length of first article; last two flagellar articles each with a single sensory filament at apex. Dentate suburopodal shelf lacking. Ventral uropodal branch with conspicuous spinelike projections or teeth.

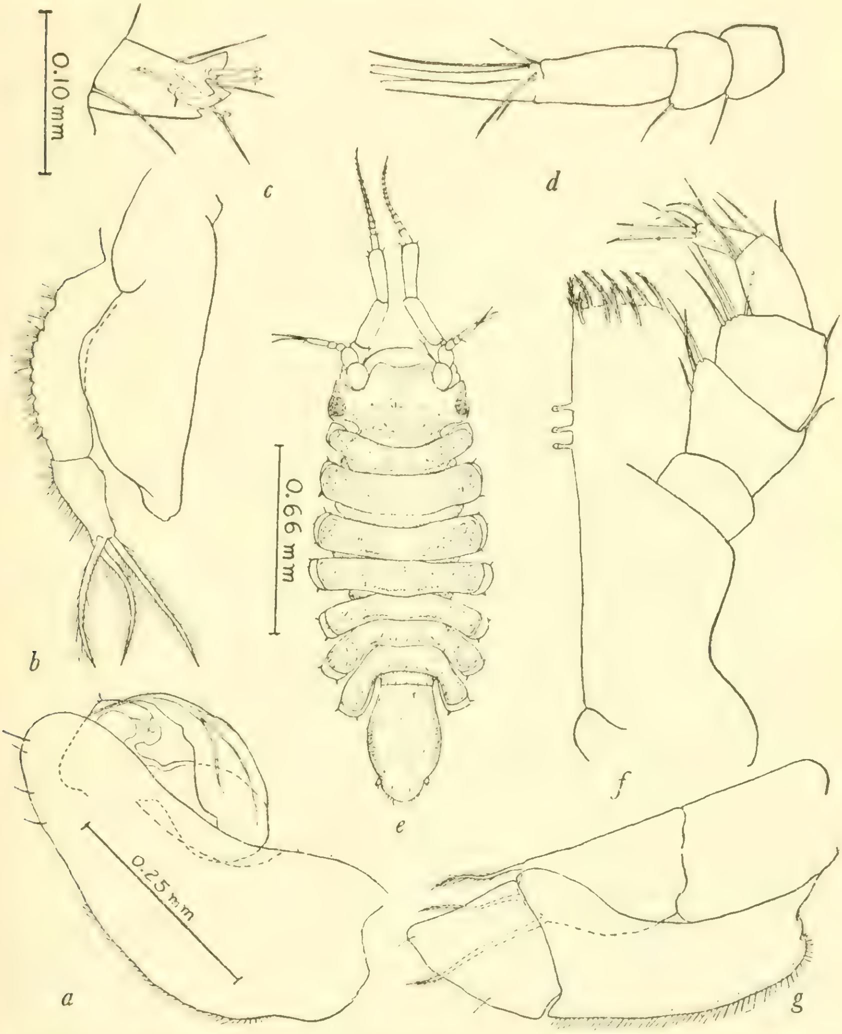

FIGURE 52.—*Munna chromatocephala*, new species: *a*, Second male pleopod; *b*, fourth male pleopod; *c*, right uropod; *d*, first antenna; *e*, male; *f*, maxilliped; *g*, third male pleopod. (Magnification as indicated by scales: *b* and *g* same as *a; d* and *f* unknown.)

Character of body.—Dark brown pigment patches on head and body distinctive.

Cephalon.—Frontal margin smooth, slightly concave in dorsal view.

Peracon.—Epimeral plates evident in dorsal view on somites 2 to 7.

Pleon.—Posterior margin of pleotelson with four to five narrow setae on each side at apex.

Second antenna.—Shorter than body. Peduncle with squama clearly visible. Flagellum shorter than peduncle, composed of about 14 articles.

Maxilliped.—With three coupling hooks.

First maxilla.—Outer lobe with 12 apical setae, inner lobe with 4 apical setae.

Second maxilla.—Each of the 2 inner lobe lappets with 4 apical setae, outer lobe with 10 setae.

Mandible.—Left mandible incisor with five teeth, lacinia with four teeth, setal row with four setae. Right mandible lacking lacinia, incisor with four teeth, setal row with five setae, the first two of which are apically expanded with numerous teeth on cutting edge. Molar process apically expanded.

Adult male gnathopod.—Propodal inferior margin smooth, beset with six small setae; carpal cutting edge with two teeth and a few setae.

Subadult male gnathopod.—Similar to female, having two pectinate scales near inferior margins of carpus and propodus.

Seventh peraeopod.—Nine 2-pointed setae on inferior margin and three similar setae on superior margin of propodus of small specimen. Other peraeopods similar in general to seventh.

Uropod.—Posteromedial apex of ventral uropodal branch with a distinct spinelike projection.

First male pleopods.—Tips laterally expanded. Posterior margins of each with six marginal setae in mature specimens.

Female operculum.—Apex setiferous, evenly rounded, and with a slight median emargination.

Types.—Holotype, allotype, and 35 paratypes (13 females, 4 males, and 18 juveniles) collected at the type locality, Dillon Beach, First Sled Road, Marin County, Calif., in *Mytilus* biotope, January 23, 1948, by R. J. Menzies. Type specimens have been deposited in the collections of the following institutions:

United States National Museum, holotype (No. 89530), allotype, and 6 paratypes; Allan Hancock Foundation, 4 female paratypes; Rijksmuseum Van Natuurlijke Historie, Leiden, Holland, 1 paratype; Pacific Marine Station, 25 paratypes, accession numbers 1299–1302 Arth.

Geographical distribution.—Marin County, Calif.

Material examined.—In addition to the type specimens the following from California localities were examined:

MARIN COUNTY: *Dillon Beach*, from holdfast of alga *Postelsia palmaeformis* washed onto beach, October 10, 1947, R. J. Menzies collector, two juvenile specimens; type locality, August 18, 1947, R. J. Menzies collector, 1 juvenile; *Tomales Point*, Tomales Bluff, May 23, 1948, 1 ovigerous female.

Ecology.—This species appears to be a prominent member of the *Mytilus-Mitella* biotope of exposed rocky coast localities. Ovigerous specimens were found during May.

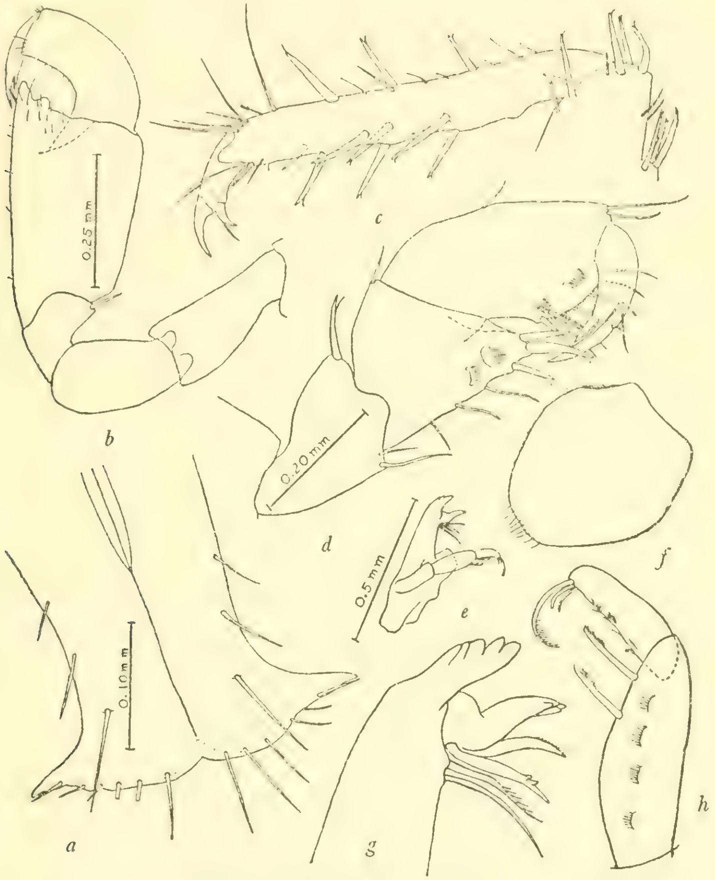

FIGURE 53.—*Munna chromatocephala*, new species: *a*, First male pleopods; *b*, mature male gnathopod; *c*, distal articles of seventh peraeopod; *d*, subadult male gnathopod; *e*, left mandible; *f*, female operculum; *g*, distal portion of left mandible; *h*, distal joints of mandibular palp. (Magnification as indicated by scales: *f* same as *b; g* and *h* same as *d; c* unknown.)

Remarks.—This species, although bearing a slight resemblance to *Munna subneglecta* Gurjanova (1936, pp. 254–255, abb. 3), can be distinguished from that species readily by the fact that the tips of the male first pleopods are considerably expanded laterally. In *subneglecta* such tips are scarcely expanded laterally. The eyes of *subneglecta* are on short but obvious stalks, which structures are almost lacking in *chromatocephala*.

MUNNA HALEI, new species

FIGURES 54, 55

Holotype.—Subadult male, length 1.3 mm., width 0.5 mm.

Allotype.—Ovaries swollen, length 1.5 mm., width 0.6 mm.

Diagnosis.—Eyes bulging slightly, preorbital lobes evident. Pleotelson with lateral borders smooth, lacking 2-pointed setae. Dentate suburopodal shelf visible in dorsal view. Flagellum of first antenna composed of three joints, penultimate joint twice the length of the first joint; last two articles each with a single sensory filament at apex. Each male first pleopod laterally drawn out into a long, nar-

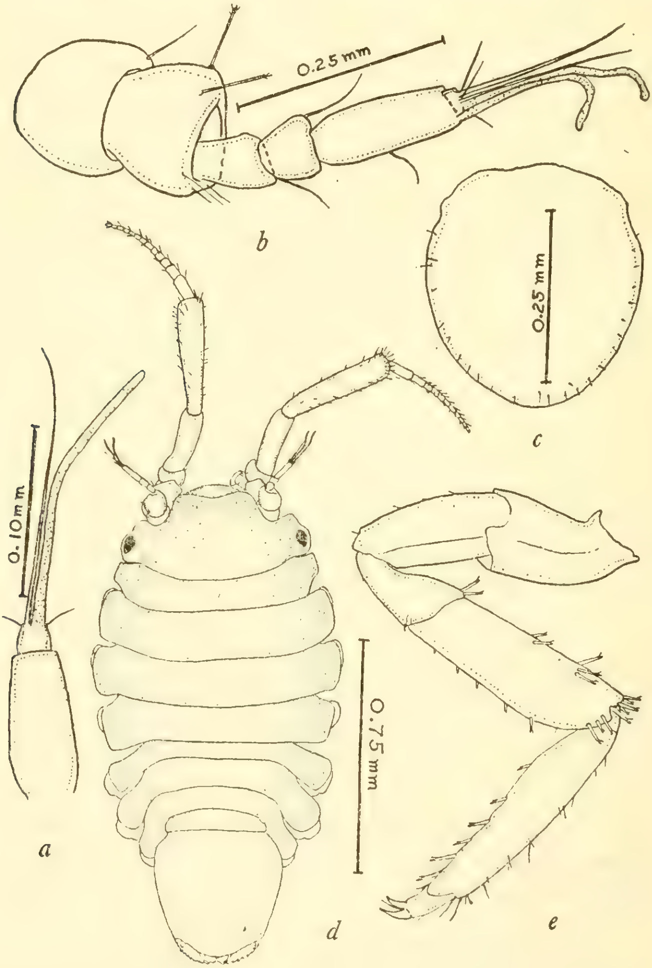

FIGURE 54.—*Munna halei*, new species: *a*, Distal articles, flagellum of first antenna, young specimen; *b*, first antenna, adult; *c*, female operculum; *d*, allotype; *e*, sixth peraeopod. (Magnification as indicated by scales: *e* same as *c*.)

row, pointed stylus. Uropod ventral branch lacking spinelike protuberances.

Character of body.—Body with few setae and a few dark pigments.

Second antenna.—Penduncle with squama. Flagellum as long as sixth article of penduncle. Antenna shorter than body length.

Maxilliped.—Endognath with apparently only two coupling hooks.

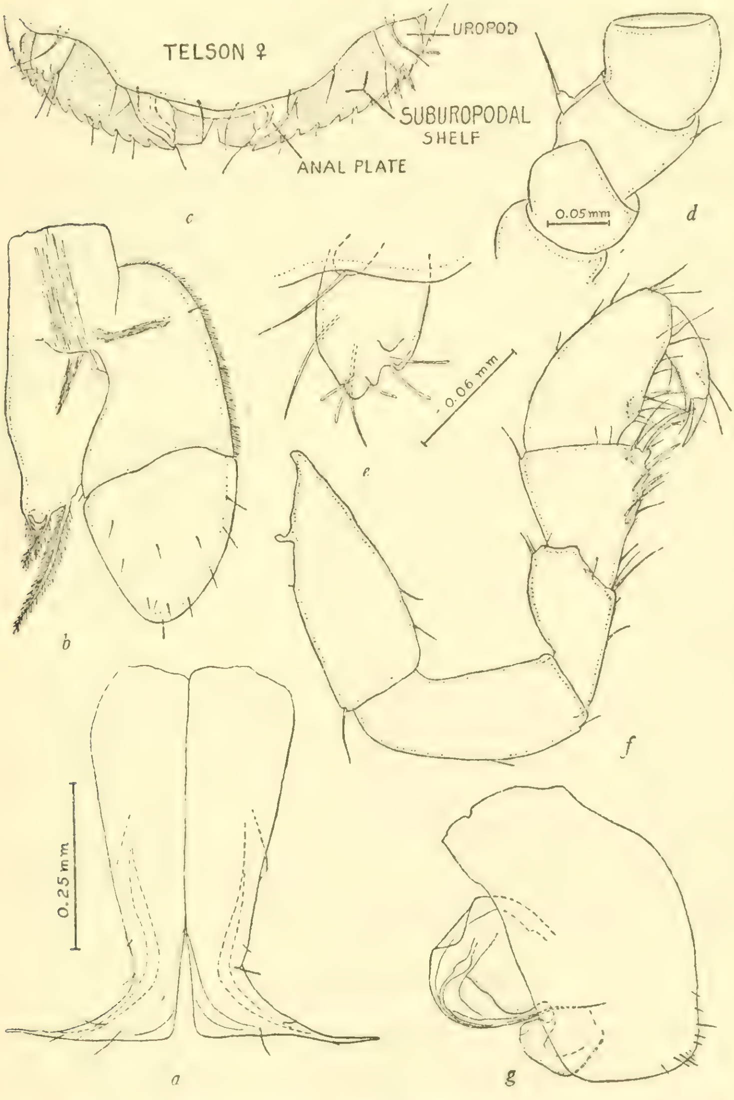

FIGURE 55.—*Munna halei*, new species: *a*, First male pleopods; *b*, third male pleopod; *c*, telson, posterior border; *d*, second antennal peduncle to show scale; *e*, right uropod; *f*, gnathopod, subadult male; *g*, male second pleopod. (Magnification as indicated by scales: *b*, *c*, *f*, and *g* same as *a*.)

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First maxilla.—Outer lobe with 10 apical setae, inner lobe with 4 apical setae.

Second maxilla.—Each of the two outer lobe lappets with 4 apical setae. Inner lobe with 10 apical setae and 3 marginal setae.

Mandibles.—Left mandible incisor with five teeth, lacinia with four teeth, setal row with four setae. Right mandible lacking lacinia, incisor with four teeth, setal row with five setae. Palp similar to that figured for *Munna stephenseni* (fig. 51, *f*).

Gnathopod.—Adult male gnathopods not observed. Subadult male and female gnathopods similar. Propodal inferior margin with one 2-pointed seta, carpal inferior margin with four 2-pointed setae.

Sixth peraeopod.—Propodus with six 2-pointed setae on inferior margin, none on superior margin. Other peraeopods similar to sixth.

Uropods.—Ventral branch cylindroid with six blunt projections at apex. Below uropods a suburopodal shelf, having a serrate outer margin, extends posteriorly beyond uropods and is thus visible in dorsal view.

First male pleopods.—Tips laterally expanded into narrow, elongate, styliform projections. Posterior margin of each pleopod with three marginal setae.

Female operculum.—Apex setiferous, evenly rounded.

Types.—Holotype (U.S.N.M. No. 89545), allotype, and one female paratype were collected at Tomales Bluff, Tomales Point, Marin County, Calif., bay side, May 23, 1948, by R. J. Menzies. The types, all in the collections of the United States National Museum, were collected in lowest intertidal zones under stones and in *Macrocystis* holdfast.

Geographical distribution.—Known only from the type locality.

Material examined.—Only the types have been examined.

Remarks.—This species, although resembling *Munna boeckii* in having a distinct dentate suburopodal shelf, differs from that species in lacking spines on the lateral borders of the pleotelson. The uropods and pleopods also differ in the two species.

This species is named in honor of Dr. Herbert M. Hale, director of the South Australian Museum, who has contributed so greatly to the knowledge of the marine Isopoda of Australia.

Family JANIRIDAE

(Cf. Nierstrasz and Schuurmans Stekhoven, Jr., 1930, p. X, e 116)

Genus IANIROPSIS G. O. Sars, 1897–99

Ianiropsis G. O. Sars, 1897–99, p. 102 (not *Janiropsis*, Sars' original spelling being *Ianiropsis*). (Genotype, *Ianiropsis breviremis* G. O. Sars, 1899.)

Diagnosis.—Cephalon, peraeon, and pleon lacking projecting lappets. Cephalon lacking a long rostrum. Epimeral plates visible in dorsal view on at least peraeon somites 2 to 7. Pleon composed of two somites. Uropods of variable length. Maxillipedal palp consisting of five segments, second and third segments expanded, being much wider than endognath. Maxilliped with two coupling hooks. Male first pleopods laterally expanded at apex. Female operculum with distal margin blunt or slightly concave. Dactyl of first peraeopods biunguiculate; those of peraeopods 2–7 all triunguiculate. Propodus of male first peraeopod smooth, lacking a series of serrations on inferior margin but usually bearing a variable number of 2-pointed setae. Mandibular molar process expanded at tip, apex truncate; second article of palp bearing two long, fairly straight denticulate setae, between which is a smaller strongly curved denticulate seta. In adult males the first pair of peraeopods are often almost as long as the body when expanded. First antenna with a 4-jointed peduncle. Second antenna with a 6-jointed peduncle bearing an obvious squama on the lateral border of the third joint.

Remarks.—The diagnosis given by G. O. Sars (1897–99, p. 102) for this genus appears incorrect in one important respect: the dactyls of the 2 to 7 peraeopods are triunguiculate and not biunguiculate, as one would gather from that diagnosis.

The species belonging to this genus that I have seen differ from one another only in a few respects. Some have spinelike serrations on the lateral edges of the pleotelson, while in others those borders are smooth. In certain species the general shape and relative length of the uropods are distinctive. The most reliable diagnostic features seem to be present on the male first pleopod, particularly at the lateral apex. Thus, in some the apex is entire, while in others it bifurcates; in some it is directed laterally, and in others it is directed abruptly posteriorly. Only a combination of the several features mentioned above provides a satisfactory means of separating the species.

From the northern California coast the detection of seven species has been possible. Previously only one valid species was known from that area. The species described by Richardson as *Janiropsis californica* probably belongs to *Iais* and not to *Ianiropsis*. One of the species, *Ianiropsis analoga*, is so very closely related to the genotype that it may later be found identical with that species. However, since real differences are apparent it seems best to keep the forms separate, at least for the present.

Eupraxia Gurjanova's *Janiropsis derjugini* is believed to be only a subspecies of Richardson's *Janiropsis kincaidi* and is herein called *Ianiropsis kincaidi derjugini* Gurjanova. The species *I. pugettensis* Hatch (1947, p. 172) is a synonym of *I. k. kincaidi* Richardson, as indicated by a comparison of paratypes of that species with cotypes of Richardson's species.

KEY TO THE NORTHERN CALIFORNIA SPECIES OF IANIROPSIS

a^1. Lateral borders of pleotelson with spinelike serrations.
b^1. Pleotelson with 4 to 7 spinelike serrations on each side. Lateral apex of each first male pleopod not directed abruptly posteriorly.
I. analoga, new species
b^2. Pleotelson with 2 spinelike serrations on each side. Lateral apex of each first male pleopod directed abruptly posteriorly.
I. epilittoralis, new species
b^3. Pleotelson with 3 spinelike serrations on each side. First male pleopods similar to but not identical with b^2 ______________ I. tridens, new species
a^2. Lateral borders of pleotelson lacking spinelike serrations.
b^1. Uropods half or less than half length of pleotelson.
c^1. Pleotelson with distinct posterolateral angles lateral to uropod insertions. Cephalon lacking anteriorly projecting anterolateral angles.
I. kincaidi derjugini, new combination
c^2. Pleotelson lacking posterolateral angles lateral to uropod insertions.
d^1. Cephalon with a distinct spinelike anterolateral projection on each side of frontal margin _________________ I. magnocula, new species
d^2. Cephalon with anterolateral margins evenly rounded.
I. minuta, new species
b^2. Uropods considerably exceeding half pleotelson length.
c^1. Uropods exceeding pleotelson length. Apex of each first male pleopod bifurcating__________________________I. montereyensis, new species
c^2. Uropods not exceeding pleotelson length. Apex of each male first pleopod not bifurcating___ I. kincaidi kincaidi Richardson, new combination

IANIROPSIS KINCAIDI KINCAIDI Richardson, new combination

FIGURES 56, *c*; 57, *a–e*

Janiropsis kincaidi RICHARDSON, 1904a, pp. 221–222, figs. 102–107; 1904b, pp. 665–666, figs. 7–12; 1905, pp. 456–457, figs. 509–514.
Ianiropsis pugettensis HATCH, 1947, p. 172, figs. 170–171.

Diagnosis.—Lateral borders of pleotelson smooth, lacking spinelike serrations, but bearing several setae; posterolateral angles acute but not projecting. Uropods not exceeding the pleotelson length. Each first male pleopod with lateral apex flattened, expanded, and directed laterally. First antennal articles considerably elongated compared with those of *I. kincaidi derjugini* (compare figs. 57, *e* and 57, *f*).

Types.—In the collection of the United States National Museum, No. 28717, from Yakutat, Alaska. Homoeotype male, length 3.8 mm., width 1.0 mm.

Geographical distribution.—Komandorskie Islands, Bering Sea, to Monterey County, Calif.

Material examined.—Specimens examined, 38 males and 50 females, were collected at various localities from the Komandorskie Islands, Bering Sea, to Monterey County, Calif.

Ecology.—See under *Remarks.* Ovigerous specimens were found during May and June.

Remarks.—In several significant respects the description given of this species by Harriet Richardson in her monograph (1905, pp, 456–457) is lacking or incorrect. The maxilliped has two coupling hooks; none were figured. The second and following peraeopods have triunguiculate dactyls, not biunguiculate as figured. The uropods do indeed slightly exceed half the abdomen length as is shown in the figures given by Miss Richardson and are "not longer than half the length of the terminal segment of the body" (Richardson, op. cit.).

This subspecies is identical in a number of important features with *I. kincaidi derjugini* Gurjanova. Of particular importance is the almost absolute similarity between the male first pleopods of the two subspecies. The subspecies differ from each other primarily only

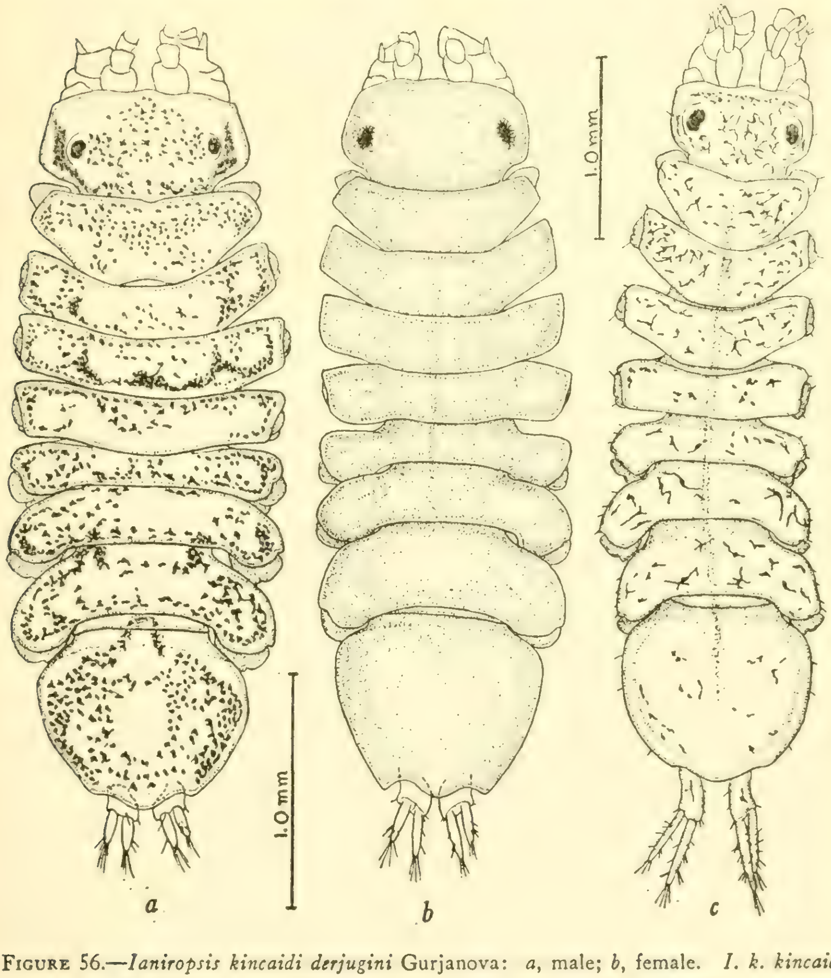

FIGURE 56.—*Ianiropsis kincaidi derjugini* Gurjanova: *a*, male; *b*, female. *I. k. kincaidi* Richardson: *c*, homoeotype male. (Magnification of *c* not known.)

in the morphology of the hinder margin of the pleotelson, in the relative length of the uropods compared with the pleotelson length, and

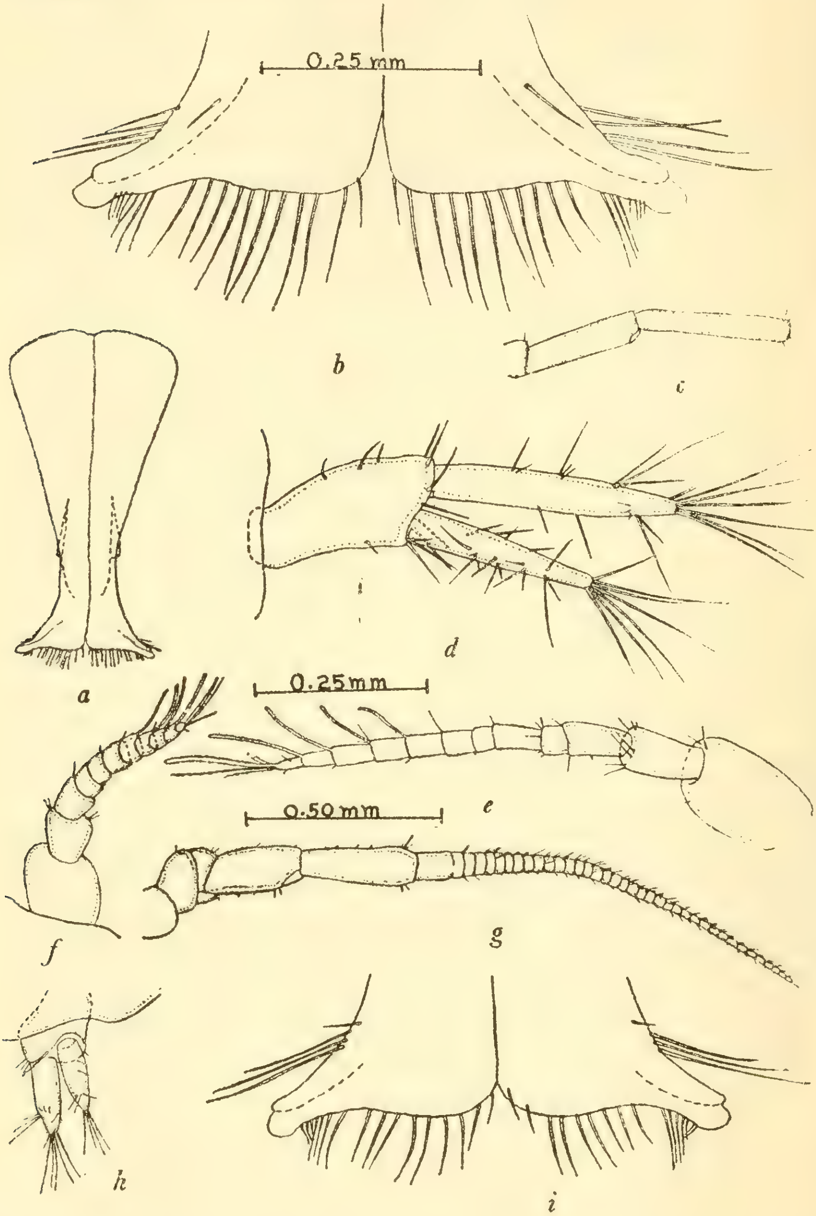

Figure 57.—*Ianiropsis kincaidi kincaidi* Richardson: *a*, Male pleopods; *b*, apex of male first pleopods; *c*, distal articles of peduncle of second antenna; *d*, uropod; *e*, first antenna. *I. k. derjugini* Gurjanova: *f*, first antenna; *g*, second antenna; *h*, uropod; *i*, apex of male first pleopods. (Magnifications as indicated by scales: *a* and *c* same as *g; i* same as *b; e, f,* and *h* same as *d.*)

in the relative lengths of the first and second antennal segments (compare diagnoses of the two subspecies).

Ecology.—Ecologically the two differ considerably. *I. k. kincaidi* is found in small pools on the surface of rocks where the water is supplied by wave splash and is subject to extremes in temperature. *I. k. derjugini*, on the other hand, is found under rocks in the middle and lower intertidal zones, often on and under rocks covered by the algae *Laminaria* and *Egregia*. Here of course the temperature is far less variable than that of the water of spray-filled tide pools.

A comparison of cotypes of *Janiropsis kincaidi* Richardson with paratypes of *Ianiropsis pugettensis* Hatch showed them to be identical.

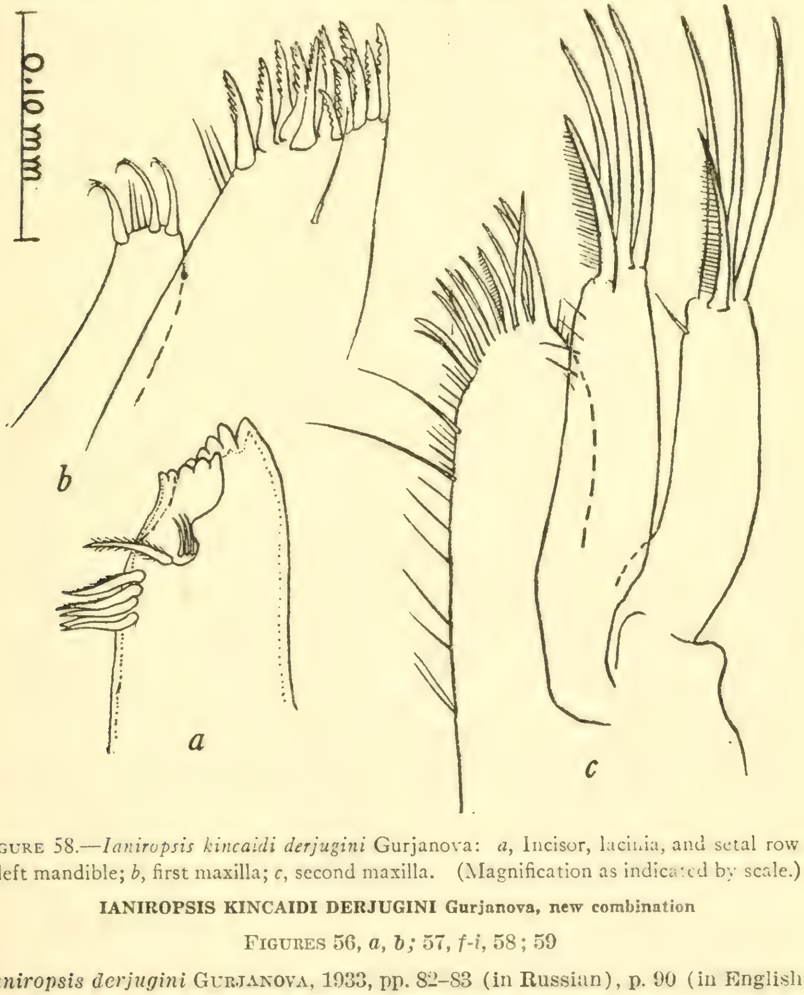

FIGURE 58.—*Ianiropsis kincaidi derjugini* Gurjanova: *a*, Incisor, lacinia, and setal row of left mandible; *b*, first maxilla; *c*, second maxilla. (Magnification as indicated by scale.)

IANIROPSIS KINCAIDI DERJUGINI Gurjanova, new combination

FIGURES 56, *a, b*; 57, *f-i*, 58; 59

Janiropsis derjugini GURJANOVA, 1933, pp. 82–83 (in Russian), p. 90 (in English), figs. 5, *a–c*, 6, *a–f*.

Diagnosis.—Lateral borders of pleotelson smooth, lacking setae and spinelike serrations; posterolateral angles acute and projecting. Uro-

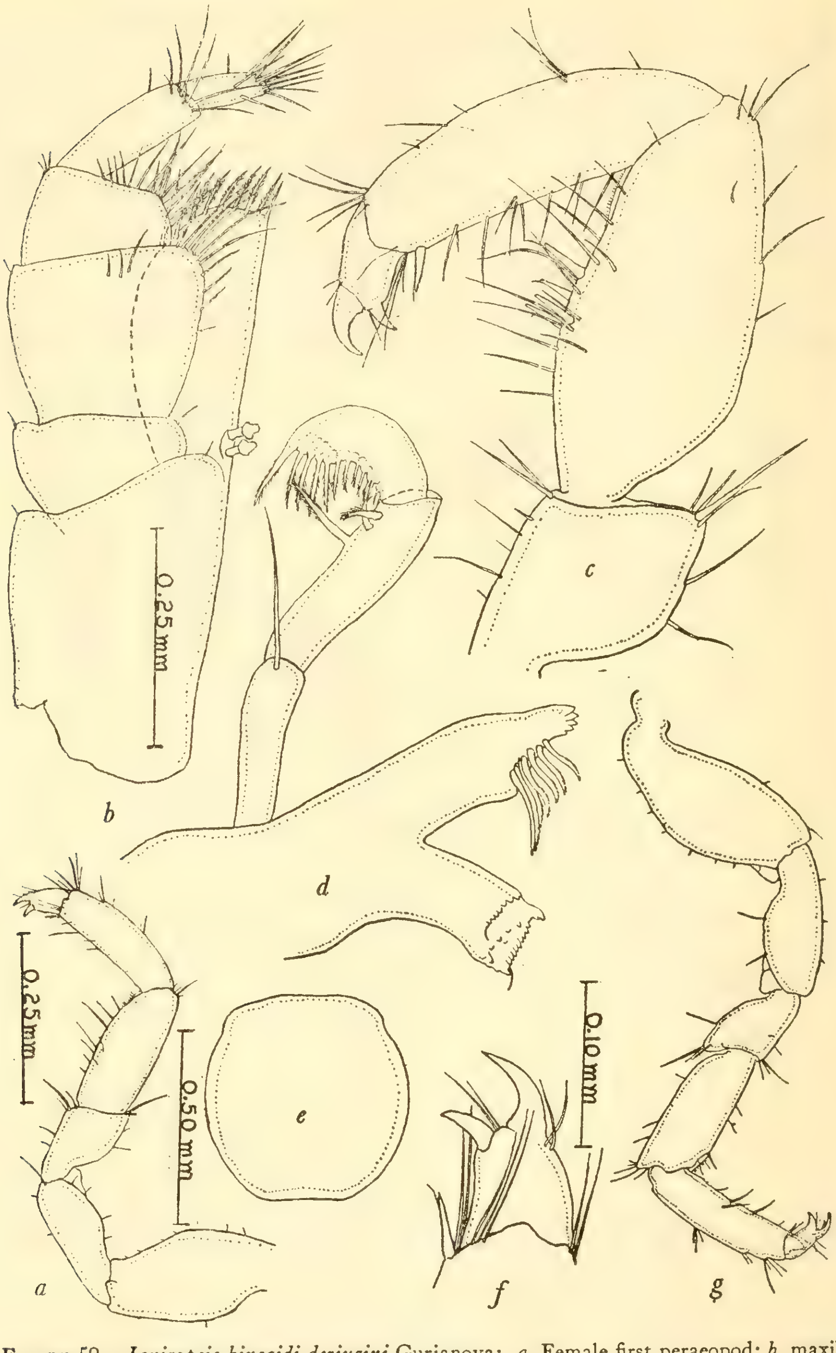

FIGURE 59.—*Ianiropsis kincaidi derjugini* Gurjanova: *a*, Female first peraeopod; *b*, maxilliped; *c*, male first peraeopod; *d*, right mandible; *e*, operculum, female; *f*, dactyl of first peraeopod; *g*, seventh peraeopod. (Magnification as indicated by scales: *g* same as *a*; *c* and *d* same as *b*.)

pods not exceeding half the pleotelson length. Male first pleopods as in *I. k. kincaidi*. First and second antennal articles considerably shortened compared with those of *I. k. kincaidi* (compare figures 57, *e*, and 57, *f*).

Types.—In the collections of the Zoological Museum of the Academy of Sciences, U. S. S. R., from Komandorskie Islands, Bering Sea. Male, length 2.5 mm., width 1.0 mm.

Geographical distribution.—Komandorskie Islands, Bering Sea, to Monterey County, Calif.

Material examined.—I have examined 47 male and 46 female specimens, from various localities in northern California.

Ecology.—See remarks for *I. k. kincaidi*. Ovigerous specimens were collected during February, May, and June.

Remarks.—Gurjanova makes no mention of the two coupling hooks present on each maxilliped. Her figures of the abdomen of the species do not compare favorably, the uropods shown in figure 5, *a*, being considerably longer than those shown in figure 5, *e*. Presumably both figures are of the same species. In most respects her description and figures indicate that the specimens I have seen are identical with her species. I consider this form a subspecies of *I. k. kincaidi* (see remarks concerning that subspecies).

IANIROPSIS ANALOGA, new species

FIGURES 60–62

Janira maculosa Leach, HATCH, 1947, p. 171, not figs. 37–38.

Holotype.—Male, length 3.7 mm., width 1.0 mm.

Allotype.—Length 2.5 mm., width 0.8 mm.

Diagnosis.—Cephalon with frontal margin slightly trilobed. Pleotelson with 4 (juvenile specimens) to 7 (adult specimens) spine-like serrations on either side above uropods. Uropods somewhat flattened, exceeding three-quarters the pleotelson length. Flagellum of first antenna composed of about 10 (average) subequal articles. Each male pleopod with expanded lateral apex pointed, posterior margin gently curving posteriorly.

Character of body.—Body speckled with numerous black chromatophores. Epimeral and pleotelsonal setae give borders of body a hirsute appearance. Eyes black in life.

Pleon.—Posterior margin lacking acute posterolateral angles.

First antenna.—Flagellum with 5 to 15 subequal articles.

Second antenna.—About as long as body. Flagellum with about 63 subequal segments.

Maxilliped.—Palp of male and female similar.

First maxilla.—Outer lobe with 12 setae, inner lobe with 4 apical setae.

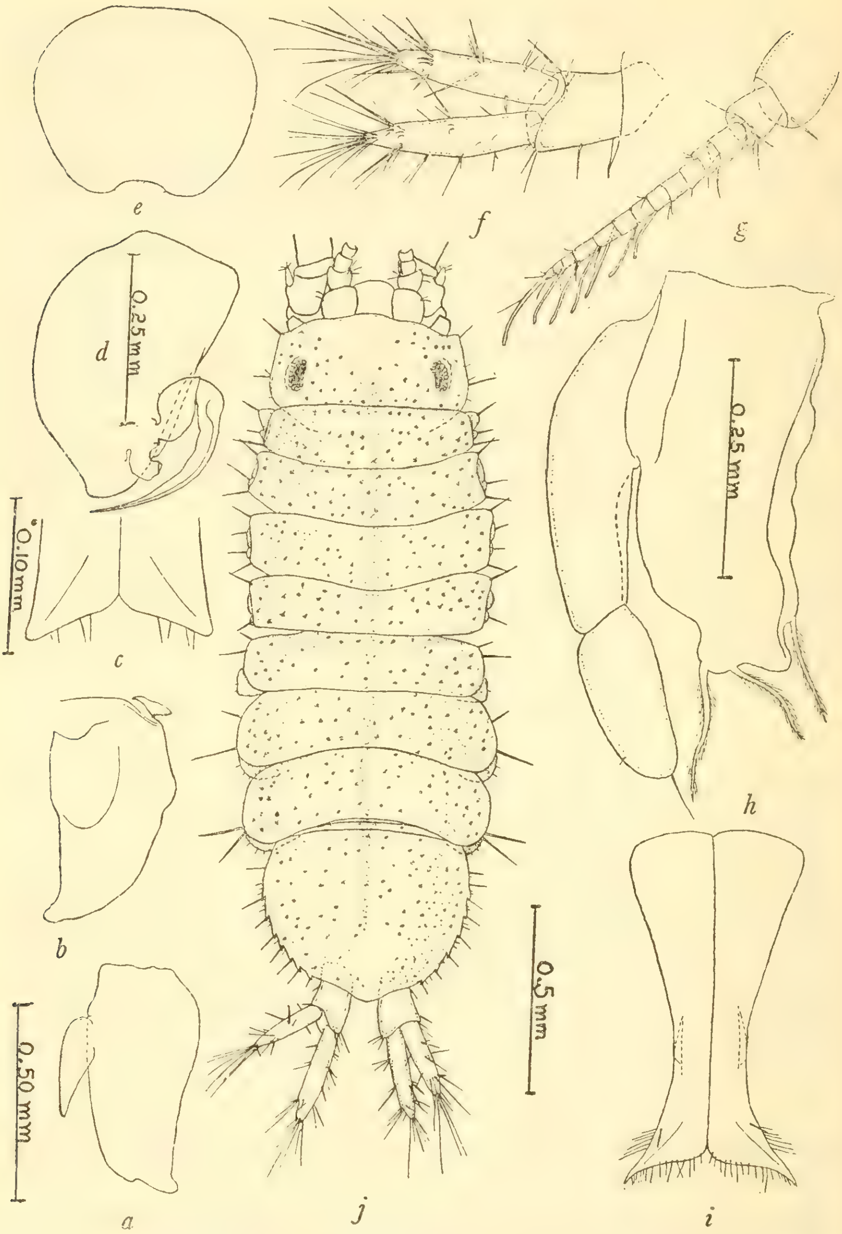

FIGURE 60.—*Ianiropsis analoga*, new species: *a*, Fourth male pleopod; *b*, fifth male pleopod; *c*, immature first male pleopods, apex; *d*, second male pleopod; *e*, female operculum; *f*, uropod; *g*, first antenna; *h*, third male pleopod; *i*, first male pleopods; *j*, paratype. (Magnifications as indicated by scales: *b*, *e*, and *i* same as *a*; *f* and *g* same as *d*.)

Second maxilla.—Each of the two outer lobe lappets with 4 apical setae, inner lobe with about 17 setae.

Mandible.—Left mandible incisor with five teeth, lacinia with five teeth, setal row with six setae in a row plus an isolated one between

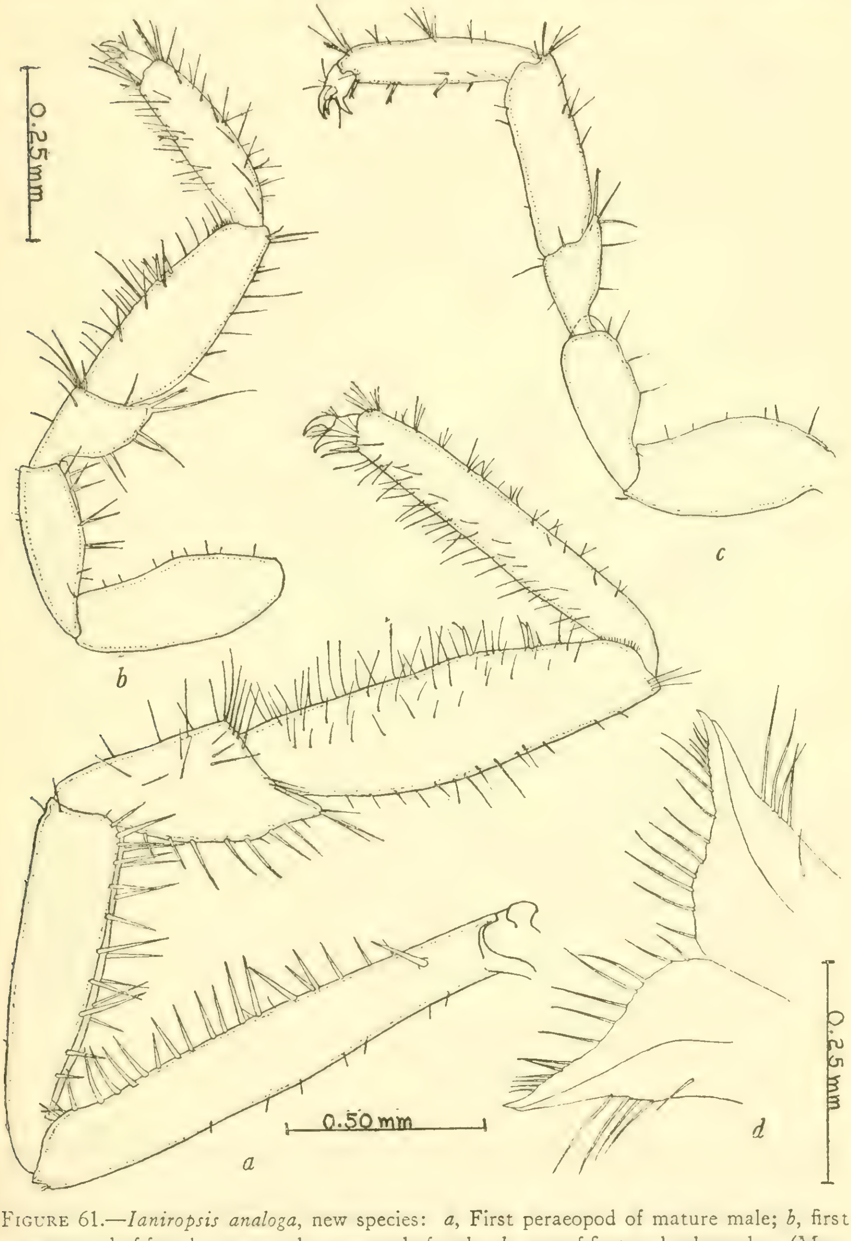

FIGURE 61.—*Ianiropsis analoga*, new species: *a*, First peraeopod of mature male; *b*, first peraeopod of female; *c*, seventh peraeopod of male; *d*, apex of first male pleopods. (Magnification as indicated by scales: *c* same as *b*.)

the row and lacinia. Right mandible incisor with five teeth, lacinia lacking, setal row with eight setae.

Mature male first peraeopod.—About as long as body when expanded.

FIGURE 62.—*Ianiropsis analoga*, new species: *a*, Maxilliped; *b*, left mandible; *c*, left mandible; *d*, right mandible; *e*, second maxilla; *f*, inner lobe of first maxilla; *g*, outer lobe of first maxilla; *h*, antennal scale. (Magnification as indicated by scales: *b* same as *a; c, e, f, g,* and *h* same as *d*.)

Uropods.—Inner branch as wide as and slightly longer than outer branch. Basal segment shorter than inner branch.

Types.—Holotype male collected at the type locality, Tomales Point, bay side near channel, Marin County, Calif., November 28, 1947, by R. J. Menzies; type found on *Macrocystis* holdfast. Type material has been deposited as follows:

United States National Museum, male holotype (No. 89535), allotype, and 15 paratypes. Allan Hancock Foundation, 6 paratypes. Universitets Zoologiske Museum, Oslo, Norway, 4 paratypes. Rijksmuseum Van Natuurlijke Historie, Leiden, Holland, 4 paratypes. Pacific Marine Station, 11 paratypes, accession numbers 1320–1322 Arth. University of Washington, 11 paratypes.

Geographical distribution.—Turn Island, Wash., to Marin County, Calif.

Material examined.—In addition to the holotype the following specimens were examined:

WASHINGTON: *Turn Island*, Turn Rock, under rock at low tide, July 17, 1940, 11 paratypes, F. A. Pitelka collector. CALIFORNIA: *Marin County*, Tomales Point, bay side, *Egregia* and *Laminaria* holdfasts, November 30, 1947, three males and one female, paratypes, collected by R. J. Menzies. Dillon Beach, Second Sled Road, under rocks, February 21, 1948, 13 paratypes, collected by R. J. Menzies; from *Laminaria* holdfast, March 22, 1948, 6 paratypes, R. J. Menzies, collector; under rocks and on *Laminaria* holdfasts, May 12, 1948, 16 paratypes, collected by R. J. Menzies.

Ecology.—Most specimens were found under rocks in the lower intertidal zones and among holdfasts of the algae *Macrocystis*, *Laminaria*, and *Egregia*. Ovigerous specimens were observed during February and May.

Remarks.—The specimens reported by Dr. Melville Hatch from Washington as *Janira maculosa* have been examined and in my opinion they belong to this species. *Ianiropsis analoga* differs from *I. breviremis* (G. O. Sars) in the following features: 1, Posterior margin of male first pleopods distinctly curving posteriorly, lateral apices pointed, not minutely bifid; 2, cephalon frontal margin slightly trilobate, not transverse.

IANIROPSIS MAGNOCULA, new species

FIGURES 63–65

Holotype.—Female with partly developed oostegites, length 2.2 mm., width 0.8 mm.

Diagnosis.—Cephalon with conspicuous frontally projecting anterolateral angles; frontal margin with a very short, yet evident, rostrum.

Eyes large, globose, situated less than half the width of eyes from shelflike lateral borders. Pleotelson subcircular in outline, with a very small posteromedial lobe and lateral borders that are smooth except for a very few setae. Uropods flattened, length slightly less than half the pleotelson length. First antenna flagellum with first article exceeding two times the length of second article.

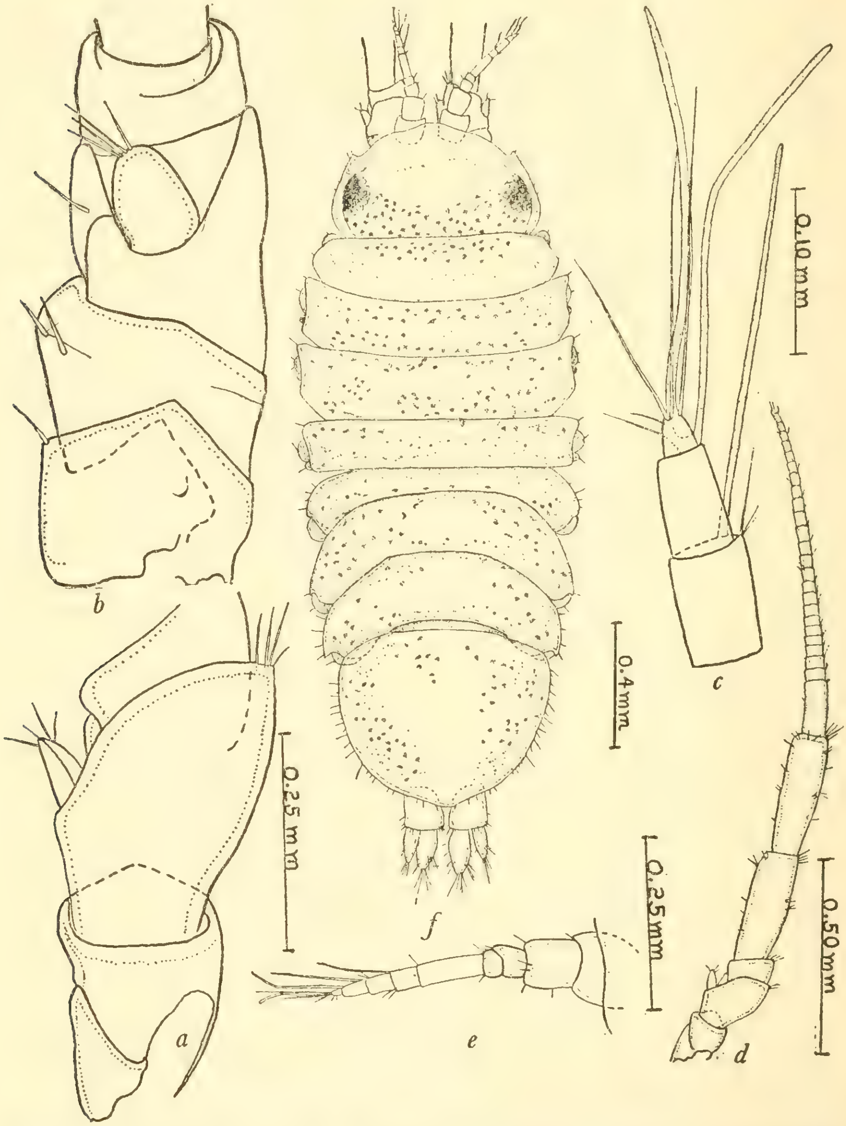

FIGURE 63.—*Ianiropsis magnocula*, new species: *a*, Proximal articles of second antenna peduncle; *b*, proximal articles of second antenna peduncle; *c*, distal joints of flagellum of first antenna; *d*, second antenna; *e*, first antenna; *f*, holotype. (Magnification as indicated by scales: *b* same as *a*.)

Character of body.—Entire animal appears very flattened. Color white with numerous scattered black chromatophores.

Second antenna.—About as long as body, reaching near middle of pleotelson when retracted. Flagellum composed of about 23 subequal articles.

First maxilla.—Outer lobe with 11 setae, inner lobe with 5 setae.

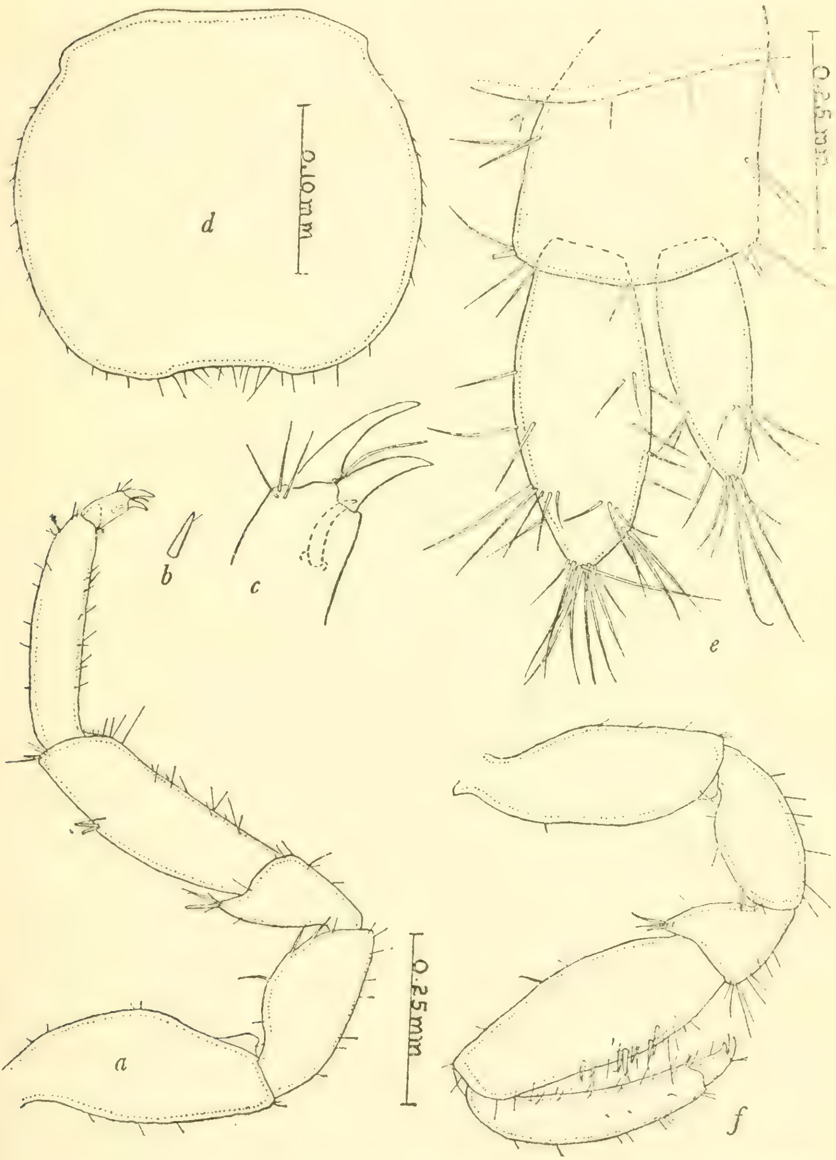

FIGURE 64.—*Ianiropsis magnocula*, new species: *a*, Seventh peraeopod; *b*, 2-pointed seta on seventh peraeopod; *c*, dactyl of seventh peraeopod; *d*, female operculum; *e*, uropod; *f*, first peraeopod. (Magnification as indicated by scales: *f* same as *a; b* and *c* same as *d*.)

Second maxillae.—Each of the two outer lobe lappets with four apical setae, inner lobe with about eight setae.

Mandible.—Left mandible incisor with five teeth, lacinia with four teeth, setal row with four plus one setae. Right mandible incisor with five teeth, lacinia lacking, setae not counted (mandible not dissected out).

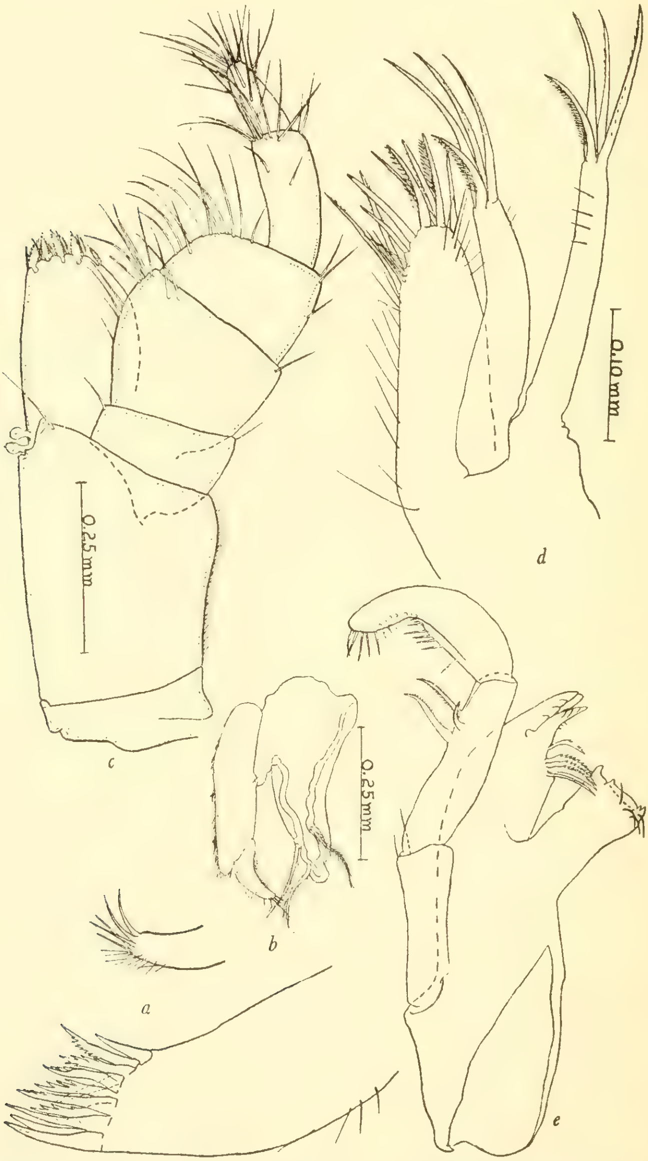

FIGURE 65.—*Ianiropsis magnocula*, new species: *a*, First maxilla; *b*, third (?) pleopod; *c*, maxilliped; *d*, second maxilla; *e*, left mandible. (Magnification as indicated by scales: *a* and *e* same as *c*.)

Female operculum.—Wider than long, beset with marginal setae and bearing a distinct wide median emargination on posterior border.

Type.—The holotype, the only specimen known, is in the collection of the United States National Museum (No. 89538). It was collected in the Pacific Ocean, 3 miles off the mouth of Russian River, Calif., 31 fathoms depth, from fine green mud, July 13, 1947, Paul Quyle and Richard J. Waidzunas collectors; found with the sea star *Luidia foliolata* Grube and the isopod *Pleurogonium californiense* Menzies, taken from mud brought to the surface in a fisherman's net.

Geographical distribution.—Known only from the type locality.

Remarks.—This specimen to a considerable extent resembles *Janira japonica* Richardson (1909, pp. 114–115). It appears to differ from that species in having much shorter uropods and in having the dactyls of peraeopods 2–7 triunguiculate, not biunguiculate.

IANIROPSIS EPILITTORALIS, new species

Figures 66, 67

Holotype.—Male, length 3.8 mm., width 1.1 mm.

Allotype.—Ovigerous, length 2.5 mm., width 0.6 mm.

Diagnosis.—Frontal margin of cephalon very slightly concave, but having a short medial rostrum. Lateral borders of pleotelson each with two very inconspicuous spinelike serrations; a long seta located at posterior base of each serration. Uropods exceed three-fourths length of pleotelson. First antennal flagellum composed of nine (average) articles. Lateral apex of each first male pleopod pointed and directed abruptly posteriorly.

Character of body.—Usual color green with numerous scattered black chromatophores. Eyes black in life.

Pleotelson.—Posterior margin with only a slight indication of a wide median lobe; acute posterolateral angles lacking.

Second antenna.—Flagellum with about 66 segments in adult specimens. Antenna longer than body.

Maxilliped.—Palp of male and female similar.

First maxilla.—Outer lobe with 12 setae, inner lobe with 4 setae.

Second maxilla.—Each of the 2 outer lobe lappets with 4 setae, inner lobe with about 12 setae.

Mandible.—Left mandible incisor with five teeth, lacinia with five teeth, setal row with four plus one setae. Right mandible incisor with five teeth, lacinia lacking, setal row with eight setae.

Types.—The holotype, allotype, and eight paratypes were collected at the type locality, Dillon Beach, First Sled Road, Marin County, Calif., May 2, 1948, by R. J. Menzies; types found in tide pool on top of *Mytilus*-covered rock. Additional type material has been deposited in the following institutions:

United States National Museum, holotype (No. 89539); allotype, and 10 paratypes. Allan Hancock Foundation, 4 paratypes. Universitets Zoologiske Museum, Oslo, Norway, 4 paratypes. Rijksmuseum Van Natuurlijke Historie, Leiden, Holland, 4 paratypes. Pacific Marine Station, 12 paratypes, accession numbers 1323–1324 Arth.

Geographical distribution.—Marin County to Monterey County, Calif.

Material examined.—In addition to the above-mentioned specimens the following were examined from California localities:

MARIN COUNTY: Type locality, May 16, 1948, R. J. Menzies, collector,

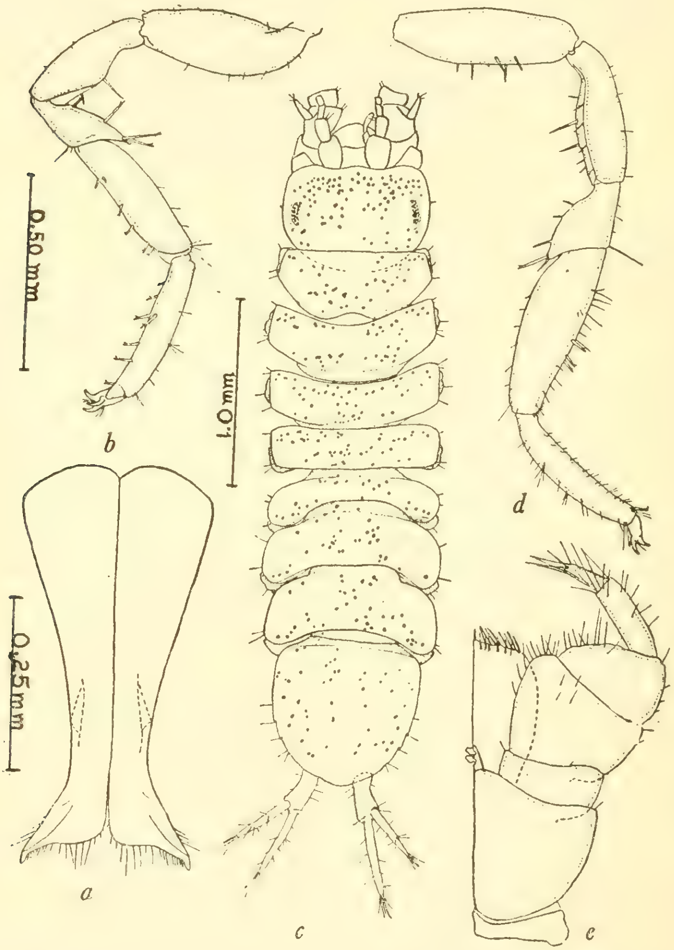

FIGURE 66.—*Ianiropsis epilittoralis*, new species: *a*, Male first pleopods; *b*, seventh peraeopod; *c*, male; *d*, male first peraeopod; *e*, maxilliped. (Magnifications as indicated by scales: *e* same as *a*; *d* same as *b*.)

24 paratypes. MONTEREY COUNTY: *Pacific Grove*, from elevated tide pools, date?, H. Heath collector, 5 paratypes.

Ecology.—Found in elevated, spray-filled tide pools, often with specimens of *Ianiropsis kincaidi kincaidi* Richardson. Ovigerous specimens were found in May.

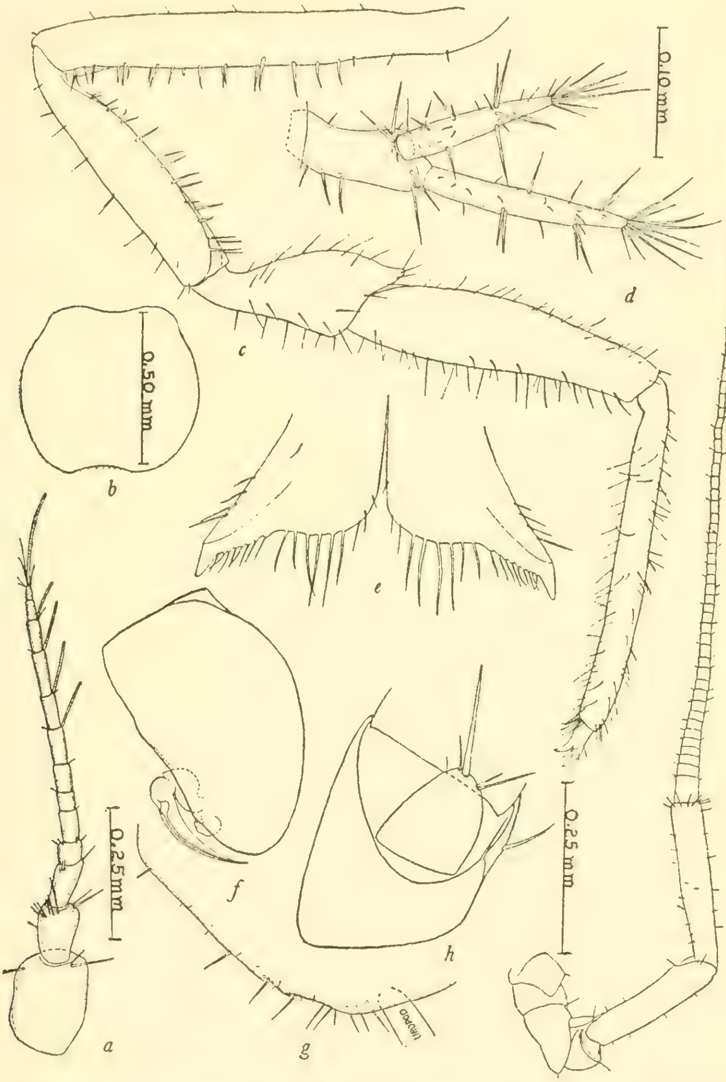

FIGURE 67.—*Ianiropsis epilittoralis*, new species: *a*, First antenna; *b*, female operculum; *c*, adult male first peraeopod; *d*, uropod; *e*, first male pleopods; *f*, second male pleopod; *g*, posterolateral margin of pleotelson; *h*, antennal scale; *i*, second antenna. (Magnifications as indicated by scales: *f* and *g* same as *a; c* and *i* same as *b; e* same as *h.*)

IANIROPSIS MONTEREYENSIS, new species

FIGURES 68, 69

Holotype.—Male, length 3.3 mm., width 1.0 mm.

Allotype.—Ovigerous, length 3.6 mm., width 1.2 mm.

Diagnosis.—Cephalon with a short conspicuous triangulate rostrum. Eyes red in life. Pleotelson ovate, lacking lateral spinelike serrations but bearing several long setae. Uropods elongate, as long as or slightly longer than pleotelson. First antennal flagellar articles subequal in length. Each male first pleopod bifurcating at lateral apex.

Character of body.—Covered with scattered black chromatophores.

Second antenna.—Flagellum with about 91 articles. Length slightly exceding body length.

First maxilla.—Outer lobe with 12 setae, inner lobe with 5 setae.

Second maxilla.—Each of the 2 outer lobe lappets with 4 apical setae, inner lobe with about 14 setae.

Mandible.—Left mandible incisor with five teeth, lacinia with five teeth, setal row with three plus one setae. Right mandible incisor with five teeth, lacinia lacking, setal row with six setae.

Uropods.—Very elongate, peduncle about as long as inner branch.

Types.—The holotype, allotype, and 18 paratypes were collected at the type locality, Pescadero Point, Monterey County, Calif., July 19, 1947, by John Davis; lowest intertidal zone under sponge-encrusted rock. Type specimens have been deposited in the following institutions:

United States National Museum, holotype (No. 89551); allotype and 35 paratypes. Allan Hancock Foundation, 2 paratypes. Universitets Zoologiske Museum, Oslo, Norway, 2 paratypes. Rijksmuseum Van Natuurlijke Historie, Leiden, Holland, 2 paratypes. Pacific Marine Station, 12 paratypes, accession numbers 1325–1326 Arth.

Geograpical distribution.—Marin to Monterey Counties, Calif.

Material examined.—In addition to the above-mentioned specimens the following were examined, all from California localities:

MARIN COUNTY: *Dillon Beach*, on beach in *Macrocystis* holdfast, October 10, 1947, R. J. Menzies collector, 1 paratype. MONTEREY COUNTY: *Carmel Cove*, under rocks, lower zones, July 6, 1947, John Davis collector, 5 paratypes; July 1947, T. E. Bowman collector, 5 paratypes; *Point Pinos*, zones 3–4, July 4 and 12, 1947, John Davis collector, 4 specimens, 3 of them paratypes; *Asilomar*, lower zones under rocks, July 16, 17, and 21, 1947, John Davis collector, 21 paratypes.

Ecology.—Most of the specimens were found under rocks in the lower intertidal zones of exposed rocky coast localities. Ovigerous specimens were found during July and October.

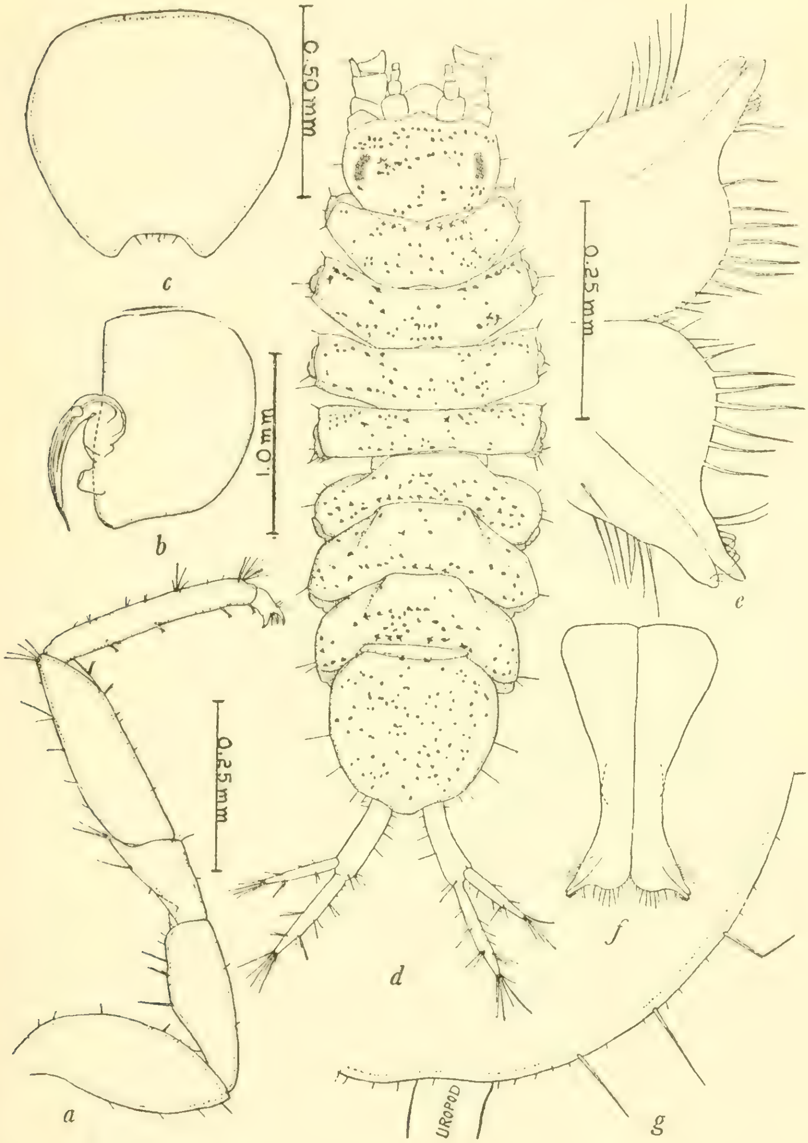

FIGURE 68.—*Ianiropsis montereyensis*, new species: *a*, Seventh peraeopod; *b*, second male pleopod; *c*, female operculum; *d*, male; *e*, male first pleopods; *f*, male first pleopods; *g*, posterolateral pleotelson margin. (Magnifications as indicated by scales: *g* same as *a*: *c* and *f* same as *b*.)

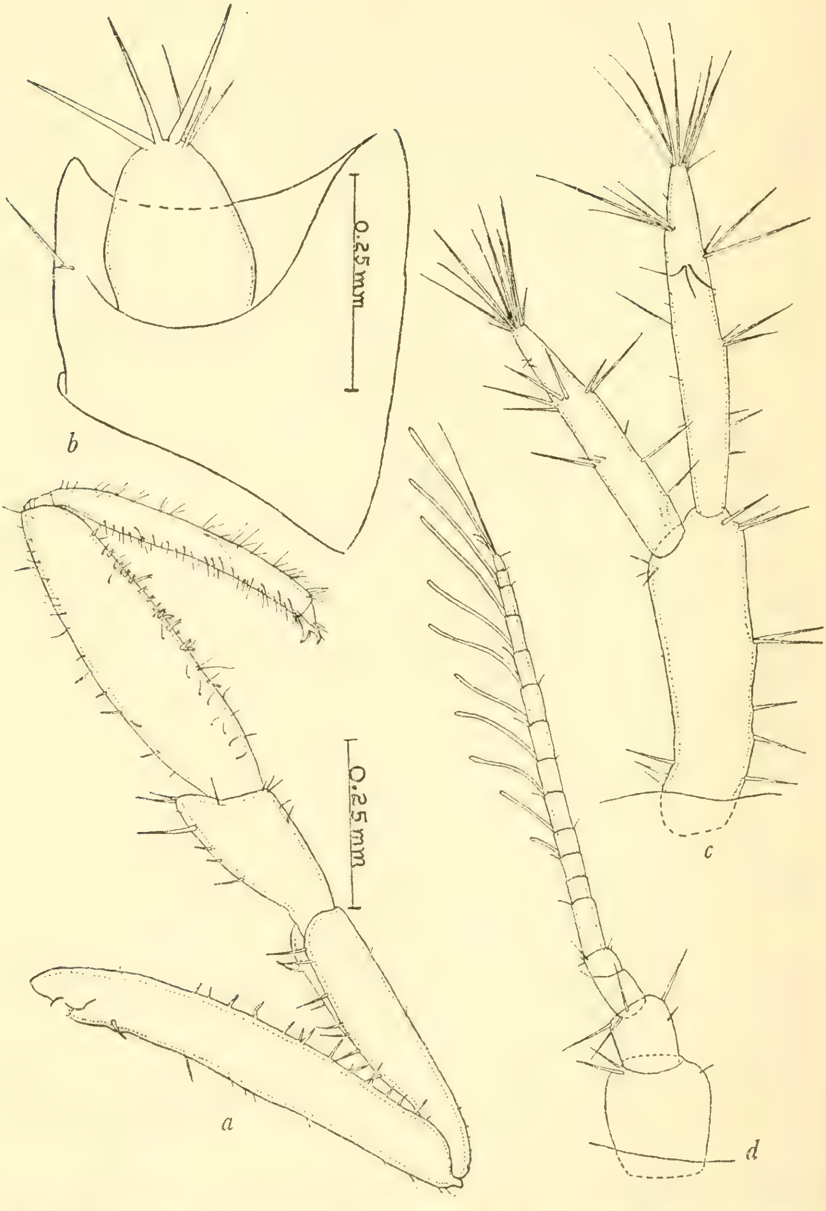

FIGURE 69.—*Ianiropsis montereyensis*, new species: *a*, Adult first peraeopod, male; *b*, antennal scale; *c*, uropod; *d*, first antenna. (Magnification of *a*, *c*, and *d* not known.)

IANIROPSIS MINUTA, new species

FIGURE 70

Holotype.—Male, length 1.3 mm., width 0.3 mm.

Allotype.—Ovigerous, length 1.3 mm., width 0.35 mm.

Diagnosis.—Frontal margin of cephalon almost transverse. Lateral pleotelson borders smooth, with a few small setae. Uropods about half the pleotelson length. First antennal flagellum with five articles (adult). Lateral apex of each first male pleopod irregular (fig.

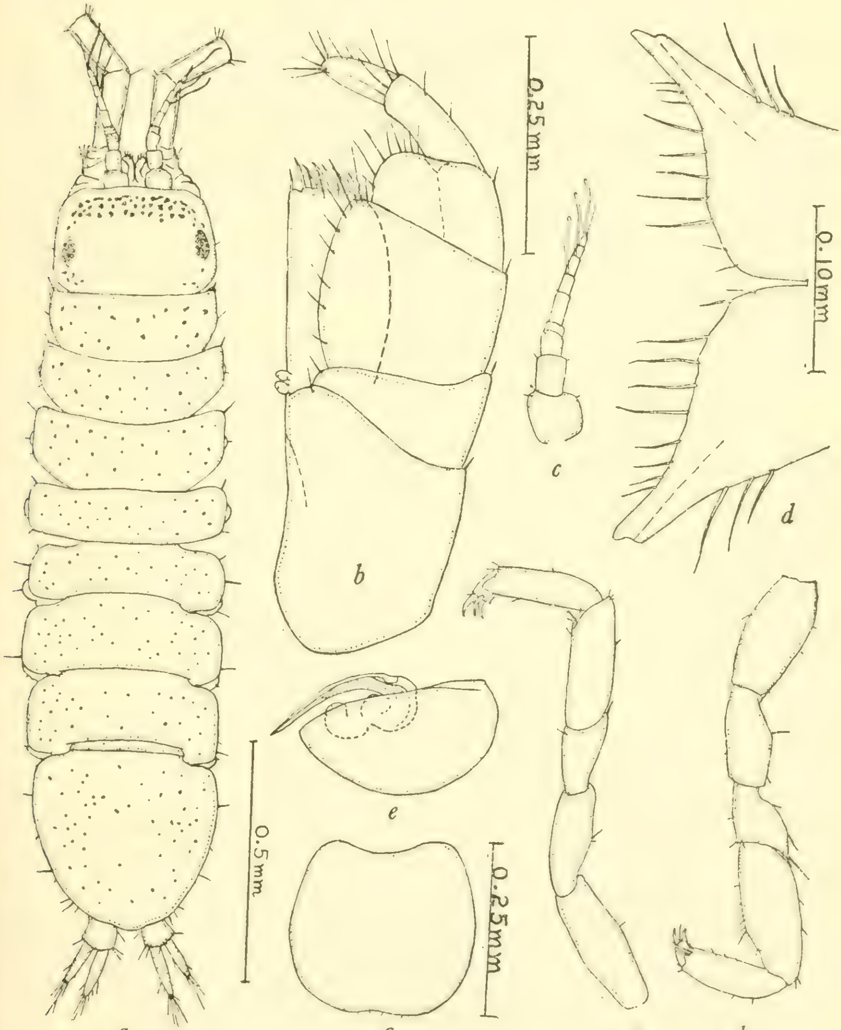

FIGURE 70.—*Ianiropsis minuta*, new species: *a*, Holotype; *b*, maxilliped; *c*, first antenna; *d*, male first pleopods; *e*, male second pleopod; *f*, female operculum; *g*, seventh peraeopod; *h*, first peraeopod. (Magnifications as indicated by scales: *c*, *e*, *g*, and *h* same as *f*.)

70, *c*), not directed abruptly posteriorly. A very small species, the adults being only slightly longer than postembryonic larvae of most species (e. g., specimens lacking developed seventh pair of peraeopods).

Character of body.—Small, with few scattered black chromatophores. Anterior part of cephalon with many black chromatophores.

Pleotelson.—Ovoid, with evident anterolateral angles, posterolateral angles lacking. Posterior border with short median convexity.

Second antennae.—Not so long as body. Flagellum with 27–32 subequal articles.

Maxilliped.—Those of male and female similar.

First maxilla.—Outer lobe with 13 setae, inner lobe with 3 setae.

Second maxilla.—Each of the two outer lobe lappets with four setae, inner lobe with about eight setae.

Mandible.—Left mandible incisor with five teeth, lacinia with five teeth, setal row with five setae. Right mandible incisor with five teeth, lacinia lacking, setal row with five setae. Second joint of palp with only two denticulate setae near distal end on inner margin.

Peraeopods.—Similar to those of *I. k. kincaidi* but sparsely setose in comparison.

Types.—The holotype (U.S.N.M. No. 89522), allotype, and 2 paratypes were collected at the type locality, Dillon Beach, Second Sled Road, Marin County, Calif., October 6, 1948, by R. J. Menzies; mid-intertidal, under rock. All are in the collection of the United States National Museum.

Geographical distribution.—Known only from Marin County, Calif.

Material examined.—Tomales Point reef, Marin County, Calif., 1 male paratype June 9, 1949, R. J. Menzies, collector, mid-intertidal zone among rock and sand.

Ecology.—Mid-intertidal, under rock and sand.

IANIROPSIS TRIDENS, new species

FIGURE 71

Holotype.—Male, length 2.5 mm., width 0.6 mm.

Allotype.—Not ovigerous, length 1.5 mm., width 0.5 mm.

Diagnosis.—Frontal margin of cephalon with a very slight median convexity. Each lateral (posterior half) border of pleotelson with three spinelike serrations. First antennal flagellum with nine articles (adult). Each lateral apex of first male pleopod directed posteriorly but apparently not as abruptly as in *I. epilittoralis* (compare figs. 67, *e* and 71, *e*). Uropods exceeding half the pleotelson length.

Character of body.—Chromatophores scattered irregularly over body. Eyes red in life.

Pleotelson.—Posterior border with an evident median lobe.

Maxilliped.—Those of male and female similar. Compares favorably with that figured for *I. minuta* and thus is not figured.

First maxilla.—Outer lobe with 13 setae, inner lobe 4 large setae plus several small setae.

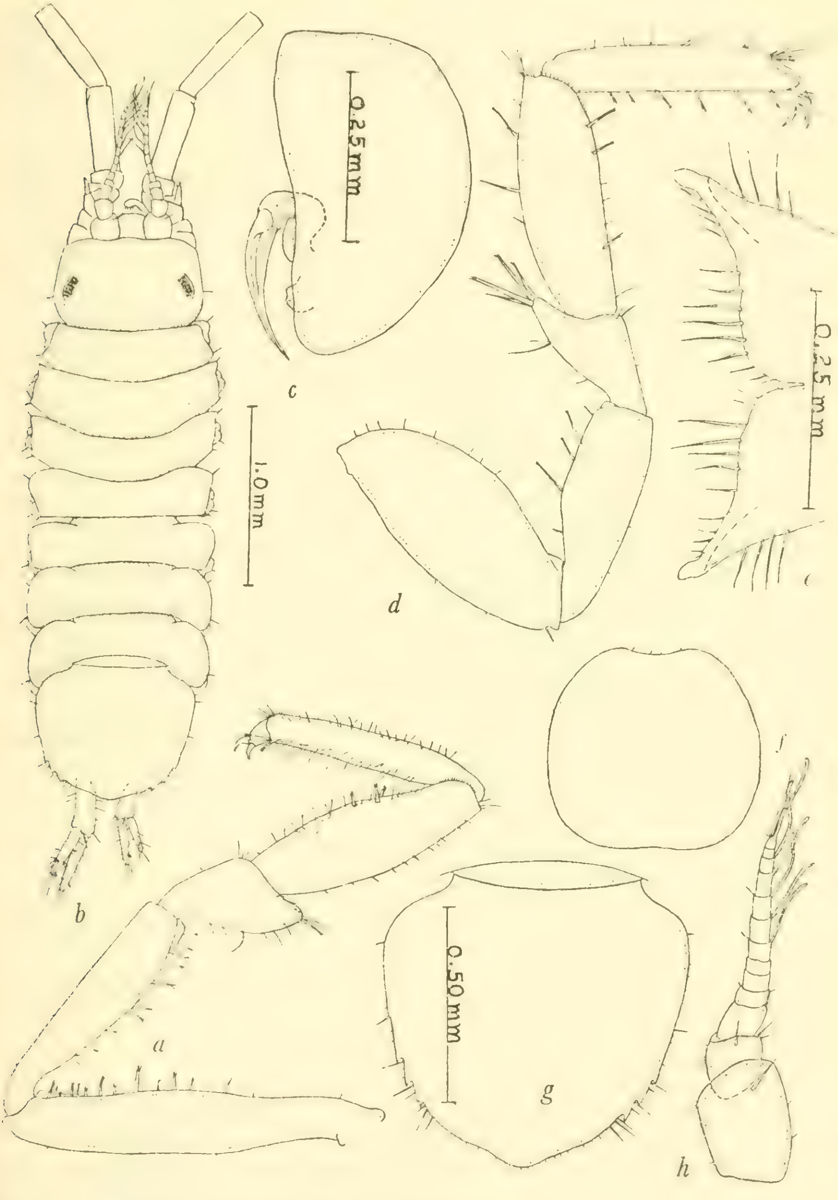

FIGURE 71.—*Ianiropsis tridens*, new species: *a*, First peraeopod of adult male; *b*, male; *c*, second male pleopod; *d*, seventh peraeopod; *e*, male first pleopods; *f*, female operculum; *g*, pleotelson; *h*, first antenna. (Magnifications as indicated by scales: *a* and *f* same as *g*; *d* and *h* same as *c*.

Second maxilla.—Each of the 2 outer lobe lappets with 4 setae, inner lobe with about 8 setae.

Mandible.—Left mandible incisor with five teeth, lacinia with five teeth, setal row with five plus one setae. Right mandible incisor with 5 teeth, lacinia lacking, setal row with nine setae.

Types.—The holotype was collected at Tomales Point, bay side, Marin County, Calif., May 23, 1948, by R. J. Menzies; lower intertidal zone, with calcareous algae. Type specimens have been deposited in the following institutions:

United States National Museum, holotype (No. 89528); allotype and 1 paratype. Allan Hancock Foundation, 2 paratypes. Universitets Zoologiske Museum, Oslo, Norway, 1 paratype. Rijksmuseum Van Natuurlijke Historie, Leiden, Holland, 2 paratypes. Pacific Marine Station, 9 paratypes, accession numbers 1327–1329 Arth.

Geographical distribution.—Marin to Monterey Counties, Calif.

Material examined.—In addition to the holotype the following California material was examined:

MARIN COUNTY: *Tomales Point*, ocean side with *Scrupocellaria*, August 18, 1947, R. J. Menzies collector, 1 paratype; reef, with *Laminaria*, June 9, 1948, 6 paratypes; *Dillon Beach*, First Sled Road, on hydroids, August 14, 1947, 1 paratype. SAN MATEO COUNTY: *Moss Beach*, in algal clump, December 26, 1947, Miss Margaret Barr collector, 2 paratypes. MONTEREY COUNTY: *Asilomar*, from surface with *Amaroucium californica*, July 17, 1947, University of California collection, 6 paratypes. *Pacific Grove*, Aumentos Rocks, in algae, May 20, 1930, 1 paratype; from a sponge, November 7, 1942, E. C. Dougherty, collector, 3 paratypes.

Ecology.—A mid-intertidal form, some specimens found with specimens of *I. montereyensis*. Ovigerous specimens were found during July.

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AUSTRALASIAN STILT-LEGGED FLIES (DIPTERA: TYLIDAE) IN THE UNITED STATES NATIONAL MUSEUM

By George C. Steyskal

Collections made during recent years by members of the armed forces in the course of malaria-control work and similar activities have added materially to our knowledge concerning the flies of the family Tylidae in areas not covered in Hennig's recent (1935–1936) monograph. This and other material in the United States National Museum were made available to me through the kindness of the authorities of the Smithsonian Institution, and study has led to the following results:

Eleven new forms are described, for one of which a new genus is erected. The genus *Mimomyrmecia* is transferred from the subfamily Trepidariinae to the Taeniapterinae, and descriptive notes are given. Examination of material determined as *Eurybata hexapla* has revealed a compact group of species around that form and the fact that other species placed in the genus are abundantly distinct. A new genus, based upon the second species referred to *Eurybata*, *E. semilauta* Osten-Sacken, has been set up for the latter group. Sufficient material was examined to make possible a preliminary study of the subspecies of *Mimegralla albimana*, a "Formenkreis" widespread in the East and Oceania.

Geographical spellings are taken from maps of the National Geographic Society, especially those of the Pacific Ocean (December 1936) and southeast Asia (October 1944), except that Japanese forms of names for islands formerly under Japanese mandate are not used.

956650—52——1

Family TYLIDAE

Subfamily TAENIAPTERINAE

Genus GRAMMICOMYIA Bigot

1. GRAMMICOMYIA HALLI, new species

FIGURE 72, *a*

Male.—Length 8.5–9.5 mm., exclusive of ensiform hypopygial process. Very similar to *G. bergi* Steyskal (1947, p. 7), differing as follows: Anterior part of frons bright creamy yellow, somewhat wider than in *G. bergi*, pale centrally back to ocellar region; third antennal joint largely blackish, but brown basally; anterior hump of mesonotum rather flatter than in *G. bergi*, not rugulose, brown pruinose anteromedianly. Pruinosity of venter and pleura rather thin. Middle and hind femora very little swollen centrally, tapering to each end, dark brown in middle. Hind tibiae black at base, grading into brown in apical half; middle tibiae wholly black. Copulatory fork as figured. Wings as in *G. bergi*. Palpi flat, elongate-oval, with small hairs only, dark brown, somewhat paler apically.

Types.—Holotype, male, U.S.N.M. No. 58304, and two male paratypes, NEW GUINEA: Finschhafen, November 9, 1944 (David G. Hall).

Remarks.—The hind femora, swollen *centrally*, place this form intermediate between *G. bergi*, in which the femora are swollen basally, and the more typical forms from farther west, which have the hind femora strongly swollen distad of the middle.

2. GRAMMICOMYIA SONDAICA Hennig

Grammicomyia sondaica HENNIG, Konowia, vol. 14, p. 80, 1935 (Siam, Sumatra, Java).

MALAY STATES: Singapore, 1 specimen.

Genus MIMEGRALLA Rondani

3. MIMEGRALLA ALBIMANA (Doleschall)

Taeniaptera albimana DOLESCHALL, Nat. Tijdschr. Nederl. Ind., vol. 10, p. 413, pl. 10, fig. 4, 1856.

Mimegralla albimana (Doleschall) HENNIG, Konowia, vol. 14, p. 198, 1935.

The various subspecies of *M. albimana* may be rather easily distinguished from other species by the following combination of characters: First posterior cell narrowly open; postvertical bristles lacking; front wholly black (except frequently reddish anteriorly in *M. a. contraria*); antennae reddish yellow, brownish apically or dorsally only; hind basitarsi (except extreme base) whitish.

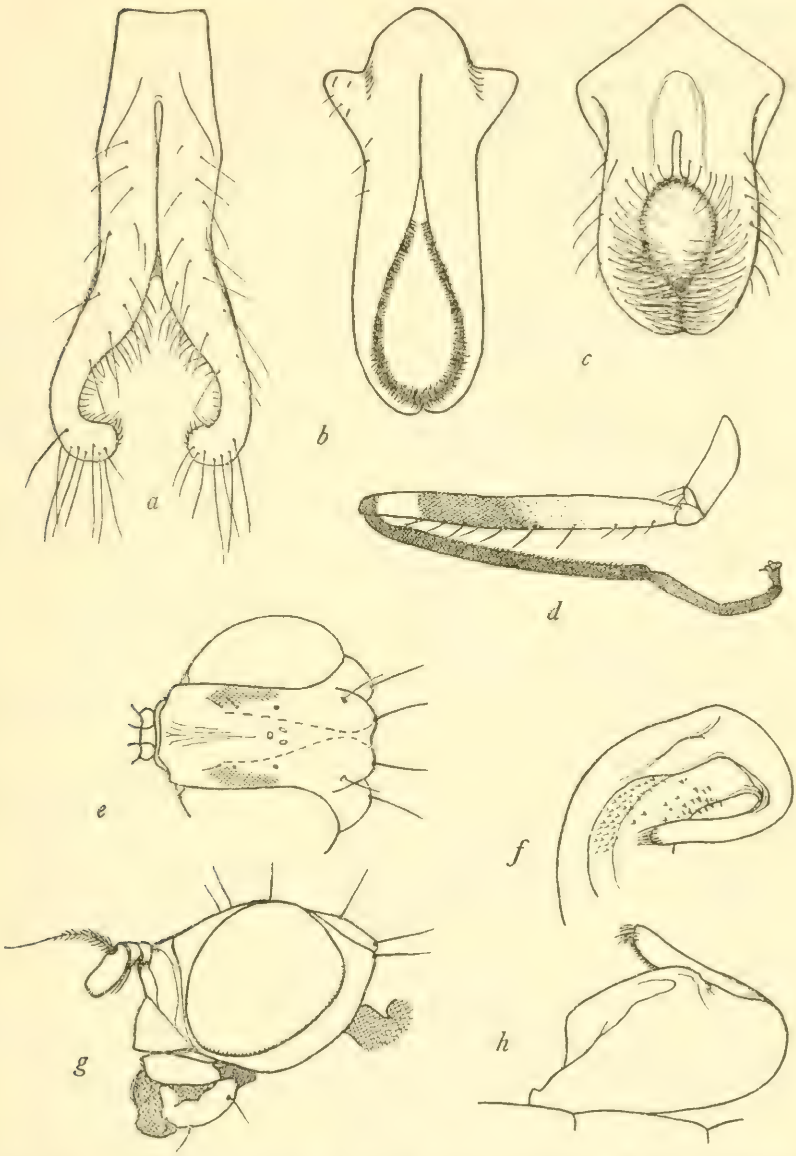

FIGURE 72.—*a*, *Grammicomyia halli*, new species, copulatory fork. *b*, *Mimegralla perfulva*, new species, copulatory fork. *c*, *d*, *Townesa spinosa*, new species: *c*, Copulatory fork, *d*, posterior aspect of left fore leg of male. *e-h*, *Mimomyrmecia tessellata* Frey: *e*, Dorsal aspect of head, *f*, ventral aspect of half of copulatory fork, *g*, lateral aspect of head, *h*, lateral aspect of copulatory fork.

The examination of a considerable amount of material has enabled me to construct a key, which is presented here in the hope that it will be found to be an improvement over Hennig's rather sketchy one, wherein the subspecies are brought out in several different places among other species. A map (fig. 73), based upon Hennig's data and material examined by me, is also offered as a graphic résumé of the distribution of the various races.

KEY TO THE SUBSPECIES OF MIMEGRALLA ALBIMANA [1]

1. Hind femora yellow, with three or less brown or blackish rings, the third ring always clearly subapical, the tip of the femora yellow; when the rings are of some length: Brown with four yellow rings, the fourth covering the tip ---------- 2

   Hind femora brown or blackish, with 0 to 3 yellowish rings: Basal, distomedian, and apical when complete (sometimes a nerrow proximomedian ring divides the median black section in M. a. striatofasciata) ---------- 4

2. Mesopleura with brassy pruinose area posteriorly, which is part of a sterno-mesopleural band; mesonotum posteriorly usually with a pair of similar but less distinct longitudinal stripes (Philippine Islands: Taiwan; Ryukyu Islands; Marianas Islands; Caroline Islands; Palau Islands).
   3c. **M. a. galbula** (Osten-Sacken)

   Pruinosity of mesopleura indistinct, not sharply delimited, less distinct than that of sternopleura ---------- 3

3. A reddish interantennal spot present; palpi wholly yellow (Malay States: Borneo; Java) ---------- 3a. **M. a. albimana** (Doleschall)

   Interantennal spot lacking; tip of palpi black; femoral rings strong (Celebes, Halmahera, Amboina, Aroe Islands; ? Ternate).
   3b. **M. a. sepsoides** (Walker)

4. Hind femora unicolorous black (New Hebrides) ---- 3f. **M. a. extrema** Hennig

   Hind femora with yellow rings ---------- 5

5. Basal hind femoral ring about four times width of femur, the rings well-defined; wings dilute brownish, with a single more distinct crossband in middle; anterior margin of front frequently reddish (New Guinea).
   3d. **M. a. contraria** (Walker)

   Basal hind femoral ring twice or less width of femur ---------- 6

6. Wings hyaline with 2 well-defined crossbands (Admiralty Islands; Bismarck Islands; Solomon Islands) ---------- 3e. **M. a. striatofasciata** (Enderlein)

   Wings dilute brownish with a single more distinct crossband in middle ---- 7

7. Middle and hind femora with a distinct subapical ring, also yellow at tip below; thorax rather shining above (Samoa; ? Fiji).
   3g. **M. a. samoana** (Czerny)

   Middle and hind femora without distinct subapical ring; thoracic dorsum grayish centrally (Tonga Islands) ---------- 3h. **M. a. tongana** (Czerny)

3a. MIMEGRALLA ALBIMANA ALBIMANA (Doleschall)

Hennig adduces from a study of type material that this, the typical subspecies, was first described from Java. It is also known from the Malay States and Borneo. I have not seen specimens.

[1] *M. a. keiensis* Hennig is not included; see discussion under *M. a. keiensis* (p. 167).

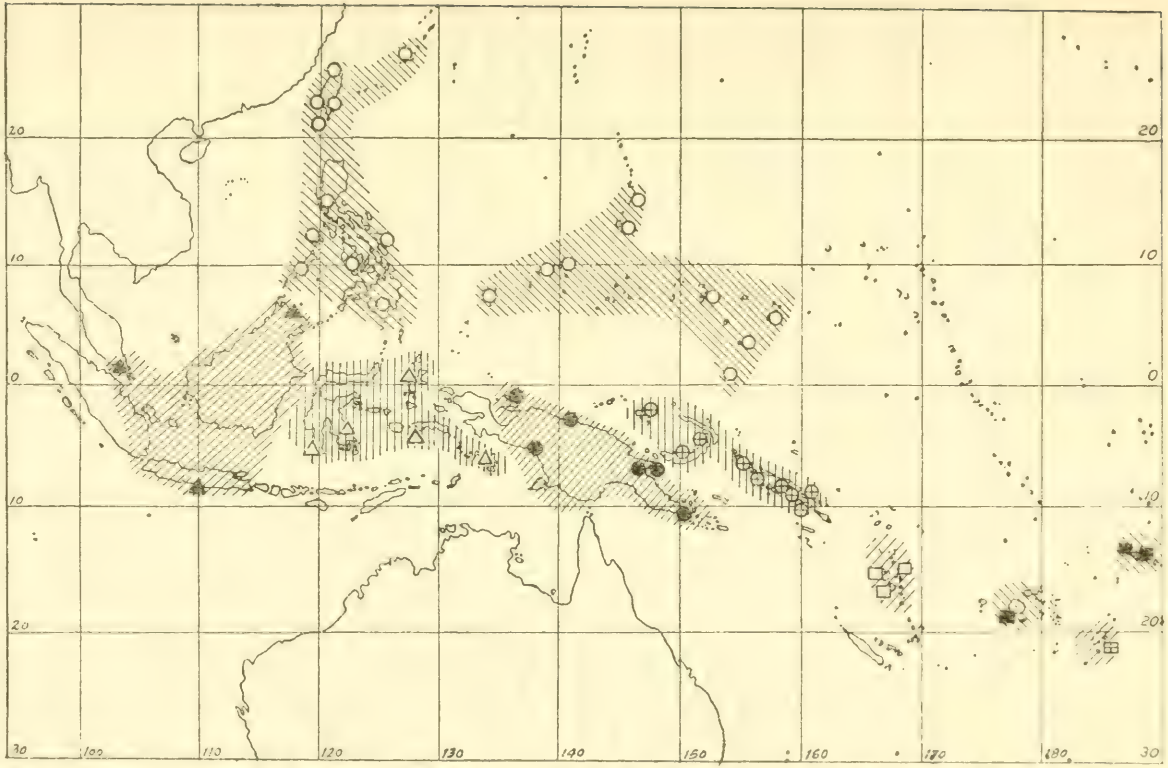

FIGURE 73.—Map showing distribution of the subspecies of *Mimegralla albimana* (Doleschall): ▲ *M. a. albimana* (Doleschall); △ *M. a. sepsoides* (Walker); ○ *M. a. galbula* (Osten-Sacken); ● *M. a. contraria* (Walker); ⊕ *M. a. striatofasciata* (Enderlein); □ *M. a. extrema* Hennig; ■ *M. a. samoana* (Czerny); ⊞ *M. a. tongana* (Czerny).

3b. MIMEGRALLA ALBIMANA SEPSOIDES (Walker)

Calobata sepsoides WALKER, Proc. Zool. Soc. London, vol. 3, p. 124, 1859.
Mimegralla albimana sepsoides (Walker) HENNIG, Konowia, vol. 14, p. 200, 1935.

I have not seen material referable to the subspecies, but Hennig cites records from Celebes, Amboina, Halmahera, Aroe Islands and Ternate (?).

3c. MIMEGRALLA ALBIMANA GALBULA (Osten-Sacken)

Calobata galbula OSTEN-SACKEN, Berliner Ent. Zeitschr., vol. 26, p. 202, 1882.—SWEZEY, Bernice P. Bishop Mus. Bull. No. 189, p. 198, 1946.
Mimegralla albimana galbula (Osten-Sacken) HENNIG, Konowia, vol. 14, p. 200.
Mimegralla albimana palauensis HENNIG, Konowia, vol. 14, p. 201, 1935 (new synonym).

RYUKYU ISLANDS: Okinawa, 12 specimens. TAIWAN: Hokuto, 1 specimen. PHILIPPINE ISLANDS: Luzon, 10 specimens; Samar, 1 specimen; Negros, 1 specimen; Palawan, 2 specimens; Calamian group (Culion Island), 1 specimen. MARIANAS ISLANDS: Guam, 9 specimens; Saipan, 1 specimen. CAROLINE ISLANDS: Yap, 1 specimen; Ulithi Atoll, 7 specimens; Truk, 7 specimens; Nukuoro Atoll, 2 specimens; Ponape, 2 specimens. KAPINGAMARANGI, 1 specimen. PALAU ISLANDS: Peleliu, 1 specimen; Koror, 5 specimens; Babelthuap, 3 specimens.

Hennig (1935, p. 200) cites *M. a. galbula* from the Philippine Islands (Palawan, Mindanao, Luzon) and Taiwan (several localities, including Lambe Island). Our extra-Philippine material is generally a little smaller and paler; the dark femoral bands are narrower or reduced to indistinct spots on the dorsal side of the femora and the wing pattern is very indistinct; but the Philippine specimens also vary in these respects and it is deemed unwise to recognize any distinctions. The Palau Islands material varies enough to bring it well within the limits of *galbula*.

3d. MIMEGRALLA ALBIMANA CONTRARIA (Walker)

Calobata contraria WALKER, Proc. Linn. Soc. London, vol. 5, p. 253, 1861.
Mimegralla albimana contraria (Walker) HENNIG, Konowia, vol. 14, p. 201, 1935.

NEW GUINEA: Cyclops Mountains, 5 specimens; Finschhafen, 20 specimens; Hollandia, 4 specimens; Milne Bay, 2 specimens; Nadzab, Markham River Valley, 3 specimens; Toem, 2 specimens.

The type was from Dorey, and Hennig cites the following localities, also all in New Guinea: Ramoi; Soron; Lorentz River; Alkmaar; Biak Island; Rivier Kamp; Simpsonhafen. This large form is one of the more distinct ones. Most specimens have the anterior margin of the front reddish, an exceptional character in the *M. albimana* circle.

3e. MIMEGRALLA ALBIMANA STRIATOFASCIATA (Enderlein)

Calobata striatofasciata Enderlein, Arch. für Naturg., vol. 88 (A5), p. 184, 1922.
Mimegralla albimana striatofasciata (Enderlein) Hennig, Konowia, vol. 14, p. 202, 1935; Stettiner Ent. Zeit., vol. 98, p. 49, 1937.—Steyskal, Occas. Pap. Mus. Zool. Univ. Michigan, No. 502, p. 9, 1947.—Berg, Occas. Pap. Mus. Zool. Univ. Michigan, No. 503, pp. 3–8, pls. 1–2, 1947.

Admiralty Islands: 2 specimens; Los Negros, 1 specimen. Solomon Islands: Guadalcanal, 17 specimens; Russell Island, 1 specimen; New Georgia, 3 specimens: Florida Island, 4 specimens; Treasury Island, 1 specimen; Bougainville Island, 7 specimens.

The type of *M. a. striatofasciata* was from Ralum, in the Bismarck Islands, and Hennig reports the subspecies from Mioko (Duke of York Island, 1935) and New Britain (1937). Our Admiralty Islands material is most nearly typical, with distinct wing bands and a strong hind femoral pattern, including a distinct preapical dark band.

A wide variation exists, however, in the coloration of this form and although some evidence of a cline toward the east is present, some of the specimens from Bougainville, Florida, and New Georgia approach those from the Admiralties.

3f. MIMEGRALLA ALBIMANA EXTREMA Hennig

Mimegralla albimana extrema Hennig, Konowia, vol. 14, p. 203, 1935.

New Hebrides: Espíritu Santo (Turtle Bay and Segond Channel) 29 specimens.

This form was described from Pentecost Island and Malekula Island, also in the New Hebrides. It is a large and distinct form.

3g. Mimegralla ALBIMANA SAMOANA (Czerny)

Cyclosphen samoanus Czerny, Stettiner Ent. Zeit., vol. 93, p. 271, 1932.
Mimegralla albimana samoana (Czerny) Hennig, Konowia, vol. 14, p. 202, 1935.
Calobata (Neocalobata) deferens Malloch, Insects of Samoa (British Mus. Nat. Hist.), pt. 6, fasc. 9, p. 346, Feb. 23, 1935 (new synonym).

Samoa: Tutuila, October 26, 1946, D. G. Hall collector, 1 specimen.

3h. MIMEGRALLA ALBIMANA TONGANA (Czerny)

Cyclosphen tonganus Czerny, Stettiner Ent. Zeit., vol. 93, p. 272, 1932.
Mimegralla albimana tongana (Czerny) Hennig, Konowia, vol. 14, p. 203, 1935.

I have not seen specimens of this form, which was described from the Tonga Islands.

3k. MIMEGRALLA ALBIMANA KEIENSIS Hennig

Mimegralla albimana keiensis Hennig, Konowia, vol. 14, p. 201, 1935.

Not seen by me. It was described from three female specimens from the Kai (Kei or Key) Islands. It is likely that it is but a variant of *M. a. sepsoides*, which is known from the neighboring Aroe (Aru) Islands.

4. MIMEGRALLA BINGHAMI (Enderlein)

Calobata binghami ENDERLEIN, Arch. für Naturg., vol. 88, ser. A5, p. 186, 1922.
Mimegralla binghami (Enderlein) HENNIG, Konowia, vol. 14, p. 210, 1935.

INDIA: Assam (Hellgate), September 22, 1943, D. E. Hardy collector, 3 specimens.

Described from Sikkim.

5. MIMEGRALLA COERULEIFRONS (Macquart)

Calobata coeruleifrons MACQUART, Diptères exotique nouveaux ou peu connus, vol. 2, No. 3, p. 24, pl. 33, fig. 2, 1843.
Mimegralla coeruleifrons (Macquart) HENNIG, Konowia, vol. 14, p. 193, 1935.

MALAY STATES: Singapore, 5 specimens. INDIA: Bengal, Tezgaon, 1 specimen.

A widely distributed species from India and South China to the Sunda Islands.

6. MIMEGRALLA CEDENS CHRYSOPLEURA (Osten-Sacken)

Calobata cedens WALKER, Proc. Linn. Soc. London, vol. 1, p. 135, 1857.
Calobata chrysopleura OSTEN-SACKEN, Berliner Ent. Zeitschr., vol. 26, p. 201, 1882.
Mimegralla cedens chrysopleura (Osten-Sacken) HENNIG, Konowia, vol. 14, p. 205, 1935.

PHILIPPINE ISLANDS: Luzon, Mount Maquiling, 3 specimens.

Known only from the Philippine Islands; the typical subspecies is from Borneo.

6a. MIMEGRALLA CEDENS THAIENSIS Cresson

Mimegralla thaiensis CRESSON, Trans. Amer. Ent. Soc., vol. 52, p. 269, 1926.
Mimegralla niveimana CRESSON, Trans. Amer. Ent. Soc., vol. 52, p. 269, 1926.
Mimegralla cedens thaiensis Cresson, HENNIG, Konowia, vol. 14, p. 204, 1935.

Hennig lists the above synonymy of *M. niveimana* with a query. I have compared male paratypes of *M. thaiensis* with the male type of *M. niveimana*, and I feel that I can confirm the synonymy. All the specimens are from the same locality in lower Siam. The copulatory fork of this form differs somewhat from that of *M. cedens chrysopleura.*

7. MIMEGRALLA CONFINIS (Walker)

Calobata confinis WALKER, Proc. Linn. Soc. London, vol. 1, p. 37, 1857.
Mimegralla confinis (Walker) HENNIG, Konowia, vol. 14, p. 211, 1935.

PHILIPPINE ISLANDS: Luzon (Mount Maquiling) 3 specimens; Mindanao (Davao), 1 specimen.

A widely distributed species already known in the Philippines from Luzon and Basilan Island.

8. MIMEGRALLA CONTINGENS CONTINGENS (Walker)

Calobata contingens Walker, Proc. Linn. Soc. London, vol. 7, p. 221, 1864.
Mimegralla contingens (Walker) Enderlein, Arch. für Naturg., vol. 88 (A5), p. 195, 1922.—Hennig, Konowia, vol. 14, p. 90, 1935.

New Guinea: Nadzab, 2 specimens.

Already known from several localities in New Guinea, as well as from Misoöl and Halmahera. Other subspecies are known from Ternate (*M. c. lunaria*), northern Australia (*M. c. australica*), and the Solomon Islands (*M. c. solomonis*).

8a. MIMEGRALLA CONTINGENS NOVAEHEBRIDEANA, new subspecies

Female.—Length 10 mm. Preapical white fascia of wing very broad, in middle a little wider than first posterior cell; wing veins R_2 and R_3 ending slightly apicad of *tp;* mesofrons with distinct tomentum; base and apex of middle and hind femora yellowish, apex of hind femora for about one-fifth length of femora with traces of a preapical dark ring, but yellowish color is rather dark and not sharply delimited; middle and hind tibiae and tarsi wholly black.

Remarks.—This race has the tomentose mesofrons of *M. c. lunaria* and *M. c. salomonis.* The former, however, has a very narrow preapical wing fascia and the tips of the middle and hind femora but little paler, while from the latter it may be distinguished by the wholly black middle and hind tibae and strong dark wing fascia.

Types.—Holotype and one paratype, U.S.N.M. No. 58305, New Hebrides: Espíritu Santo Island, Nav. Med. School Ser. No. 18/34, sp. 20; two paratypes, same locality, Segond Channel, August 29, 1943, Laffoon collector.

9. MIMEGRALLA PERFULVA, new species

Figure 72, *b*

Male and female.—Length of body 8–10 mm.; length of wings 6.6–7.7 mm. Color brownish yellow, except as further noted. Head of general body color, including mesofrons; ocellar triangle blackish; third antennal joint, except at extreme base, black; antennal grooves shining black with whitish pruinose patch below; palpi black in apical third. Posterior frontal bristle anterior to anterior ocellus by length of ocellar triangle; two well-developed anterior frontals; arista blackish, brown at base, toward base with a few short hairs. Postvertical bristles lacking.

Thorax with presutural lateral border of mesonotum rather broadly dark brown, pruinose, and with traces of median longitudinal dark margins postsuturally; only one notopleural bristle, situated in posterior corner of notopleural area; scutellum dark brown laterally.

Abdomen very dark brown, but somewhat paler basally and apically. Copulatory fork figured is yellowish with black mesal spinules.

Legs of general body color; tips of femora black, on fore femora for distance equal to twice the width, on middle and hind femora for distance equal to width, an indistinct darker ring at apical third of femora. Fore tibiae black except at base, middle and hind tibiae dark brown. Fore tarsi black, except apical half of basitarsi and basal two-thirds of second joint, which parts are pale yellow; middle and hind tarsi brown, blackish apically, the hairs black, except part of the plantar brush.

Wings uniformly tinged with light brown; the basal crossvein its own length apicad of vein closing the anal cell; first posterior cell narrowly open; second vein ending 0.36 to nearly 0.5 the distance from *tp* to apex of wing. Knobs of halteres gray-brown.

Types.—Holotype, male, U.S.N.M. No. 58981, Caroline Islands: Ponape (Mount Dolennankap), 1,700 to 2,000 feet, August 10, 1946 (H. K. Townes No. 1648); allotype, female, same locality, 1,800 feet, August 11, 1946 (H. K. Townes No. 1651); paratypes, four males, five females, same data as allotype; one female, same data as holotype.

Remarks.—Since this species runs in Hennig's key (1935, p. 83) to *Mimegralla leucopeza*, it may be a subspecies of that form. However, the general yellowish color is more extensive than in any race of *M. leucopeza*, and the wide separation from the nearest station of that species (*M. l. albitarsis*, Manila, Philippine Islands) also makes doubtful its identity with *leucopeza*.

10. MIMEGRALLA PONAPENSIS PONAPENSIS Hennig

Mimegralla ponapensis Hennig, Konowia, vol. 14, p. 207, 1935.

Caroline Islands: Ponape Island, Colonia, 29 specimens.

10a. MIMEGRALLA PONAPENSIS KUSAIEANA, new subspecies

Male and female.—Middle femora yellow at base for distance equal to twice the diameter of the part, then black to 0.6 the whole length, then yellow for about 1.5 times the diameter and finally brown, but yellow again apicoventrally. The hind femora are yellow for 3.5 diameters, then black to 0.6 the whole length, the yellow portion with a preapical brown section.

The middle and hind tibiae, which in *M. p. ponapensis* are practically wholly black or sometimes a little brownish distomedially, in *M. p. kusaieana* are yellowish except at each end.

The whole insect is otherwise as in the typical race, the thoracic dorsum of both races largely brownish pruinose, the antennae and palpi blackish apically, and the frons reddish anteriorly.

Types.—Holotype male, allotype female, and three each male and female paratypes, U.S.N.M. No. 58982, CAROLINE ISLANDS: Kusaie Island (Lele), August 21, 1946 (H. K. Townes No. 1815); paratypes, four each males and females, same locality, August 19, 1946 (Oakley No. 1726); four females, Kusaie Island (Mount Tafeyät), 500 to 800 feet, August 2, 1946 (H. K. Townes No. 1812); five males, three females, Majuro Atoll (Majuro Village), August 28, 1946 (H. K. Townes Nos. 1989, 1992).

Genus MIMOMYRMECIA Frey

11. MIMOMYRMECIA TESSELLATA Frey

FIGURE 72, *e–h*

Mimomyrmecia tessellata FREY, Not. Ent., vol. 7, p. 75, 1927.—BRYAN, Proc. Hawaiian Ent. Soc., vol. 8, p. 34, 1932.—HENNIG, Konowia, vol. 14, p. 309, 1935.

PHILIPPINE ISLANDS: Luzon (Mount Maquiling), 7 specimens; (Mount Banahao), 2 specimens; (Los Banos), 2 specimens; (Limay, Bataan), 1 specimen; (Manila), 1 specimen; Negros Occidentale (Victoria) 1 specimen.

Examination of the above material has revealed that the genus is definitely taeniapterine, rather than trepidariine, as Hennig, in the lack of material, presumed it to be. It will run in my key to the genera of African and Oriental Taeniapterinae (1947, p. 6) to couplet 3, the first three characters of the first alternative suit. The arista, however, is plumose. The affinities seem to lie definitely with *Grammicomyia*, but the development of the back of the head into three protuberances distinguishes *Mimomyrmecia* from any other Paleotropical genus.

TOWNESA, new genus

Genotype.—*Townesa spinosa*, new species.

Very similar to *Mimegralla*, to which genus it will run in my key (1947, p. 6), agreeing in all particulars. The type of *Mimegralla*, *M. coeruleifrons* (Macquart), as well as all other species of *Mimegralla* known to me, has no armature of any kind on the fore femora. *Townesa*, however, has a row of 8 to 12 strong bristles nearly as long as the diameter of the femora along the whole length of each lower side of the fore femora of the male, and 3 to 5 similar but somewhat smaller bristles on each side of the apical half of the fore femora of the female. The legs are very long and uniformly slender; the first posterior cell of the wing is very narrow apically but not closed; the second vein exceeds the level of *tp* by the length of *tp;* postvertical bristles are lacking; two well-developed anterior frontals are present definitely within the tomentose mesofrontal area; the posterior frontals are about opposite the anterior ocellus; and the bristles of the mesonotum include 1 *dc*, 2 *sa*, and 2 strong *ntpl*. The arista is distinctly and abundantly short plumose.

Remarks.—I take pleasure in naming this genus in honor of the discoverer of its type species, Dr. H. K. Townes.

12. TOWNESA SPINOSA, new species

FIGURE 72, *c*, *d*

Male and female.—Length of body 8 to 9 mm.; length of wings 6 to 6.8 mm. Color of body black.

Head with mesofrons black-tomentose; parafrontals shining black with bluish reflection; medifacies brown with black lower margin; clypeus, palpi, and antennae brown, the antennae with third joint black above and in apical half and with arista black apically, brown at base, and furnished with short plumosity.

Thorax lightly greenish-brown-pruinose on pleura and sternum, dark-brown-pruinose on notum, except broad sublateral greenish subshining stripes, which meet anteriorly across the anterior hump. Postalar calli shining brownish.

Abdomen black, dark-brown-pruinose with gray incisures, except segment bearing the copulatory fork and those posterior to it, which are shining. Copulatory fork as figured (fig. 72, *c*), bearing dense, rather long dark brown hairs ventrally and mesally, also with denser and shorter black bristles mesally.

Legs brownish yellow; fore femora of male as in figure 72, *d*, the shaded parts black, in female similar but with fewer bristles (cf. generic diagnosis above); fore tibiae black; fore tarsi light brown basally, apically blackish; middle and hind femora with extreme apex black, preapical narrow ring of black, and indistinct distomedian ring or dorsal spot; middle and hind tibiae dark brown, their tarsi yellow basally, brown apically.

Wings evenly light brown; *ta* interstitial with vein closing anal cell. Halteres with yellow stem, blackish knob.

Types.—Holotype and four paratypes, males, U.S.N.M. No. 58983, CAROLINE ISLANDS: Kusaie Island (Mount Tafeyät), 500 to 800 feet, August 20, 1946 (H. K. Townes No. 1810); allotype and one paratype, females, same locality, August 2, 1946 (H. K. Townes No. 1812); paratypes, three males, Kusaie (Lele Island), August 19, 1946 (Oakley No. 1726).

Subfamily TREPIDARIINAE

KEY TO THE AUSTRALASIAN GENERA OF TREPIDARIINAE [2]

1. Upper part of metanotum conical and surpassing scutellum. **Nestima Osten-Sacken**
   Metanotum of ordinary form ____ 2
2. Middle and hind femora on lower side before the tip with a series of spinules ____ 3
   Middle and hind femora unarmed below ____ 4
3. Wings strongly fasciate or tessellate with dark brown; mesofrons shining medially, flat and strongly angulate apically ____ **Eurybata Osten-Sacken**
   Wings with but indistinct pattern; mesofrons tomentose, strongly convex in front and truncate ____ **Crosa, new genus**
4. Scutellum turned upward; head spheroidal; three fronto-orbital bristles. **Gongylocephala Czerny**
   Scutellum horizontal above; head somewhat depressed; wing with third costal division more than half as long as ultimate section of fourth vein ____ 5
5. Middle and hind femora thickened basally; arista plumose. **Crepidochaetus Enderlein**
   Middle and hind femora slender; arista bare to plumose.
   Trepidarioides Frey
   Cothornobata Czerny
   Metopochetus Enderlein

Of the last three genera I have seen only one representative, *Trepidarioides territa* Osten-Sacken, and I am unable to find good distinctive characters in the literature.

Genus EURYBATA Osten-Sacken

On examining a series of specimens included in *Eurybata hexapla* it became evident to me that Osten-Sacken was correct when, in describing the second species of *Eurybata*, *E. semilauta*, he stated that later authors might see fit to place it in another genus. *Eurybata* may be distinguished from *Crosa*, new genus (p. 176), which is based upon *E. semilauta*, as in the foregoing key, by the characters of the head represented in figure 74, *a*, *b*, and in the male by a lack of long hairs on the basal ventral side of the fore femora. The abdomen is shining apically and near the segmental sutures.

It was also evident that two new species were included with *E. hexapla*. These species are included in the following key to the species of the restricted genus *Eurybata*. All species are known only from the Philippine Islands.

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[2] The genus *Mimomyrmecia* Frey has been removed from this subfamily (see p. 171). The genera *Formicosepsis* De Meijere and *Cypselosoma* Hendel have been referred here by Hennig (1941), although Hennig has later (*in litt.* Sabrosky, 1949) indicated that *Cypselosoma* is a clusiid. These two genera may be distinguished from all other Tylidae by the possession of strong vibrissae and ocellar bristles. *Calycopteryx* Eaton, from the Kerguelen and Heard Islands, a fly with rudimentary wings, has also been referred here by Hennig (1934).

KEY TO SPECIES OF THE GENUS EURYBATA OSTEN-SACKEN

1. Dark fasciae of wing uniform and straight; fore tibiae whitish; mesonotum wholly shining or very indistinctly pruinose; *male:* copulatory fork with two long divergent prongs (fig. 74, *e*) ____________ **E. hexapla Osten-Sacken**
   The wing fascia distad of *tp* (fifth from base of wing) projecting basad between third and fourth veins or all fasciae broken, forming a checkered pattern ____________ 2
2. Only the fifth fascia uneven; fore tibiae blackish except at tips; mesonotum with distinct prescutellar brown-pruinose spot; *male:* copulatory fork with short arms inflexed at ends (figs. 74 *f, g*) 15______ **E. nigritibia, new species**
   Wings with checkered pattern; fore tibiae only a little brownish distomedially; mesonotum wholly shining; *male:* copulatory fork with short arms, knobbed at tip and slightly convergent (fig. 74, *h*) __ **E. tessellata, new species**

13. EURYBATA HEXAPLA Osten-Sacken

FIGURE 74, *a, b, e*

Eurybata hexapla OSTEN-SACKEN, Berliner Ent. Zeitschr., vol. 26, p. 206, 1882.—BEZZI, Philippine Journ. Sci., vol. 2, ser. 3D, p. 155, 1917.—FREY, Not. Ent., vol. 7, p. 7, 1927.

PHILIPPINE ISLANDS: Luzon (Mount Maquiling), Baker collector, 12 specimens; (Ube Laguna), May 12, 1924, R. C. McGregor collector, 2 specimens; Tayabas (Malinao), Baker collector, 1 specimen.

Bezzi lists Los Baños and Mount Maquiling as localities, probably from part of the same material that is still in the Museum, but I saw no specimens from Los Baños, a town at the foot of Mount Maquiling; Frey lists (Mount) Banahao (Tayabas) and Surigao in Mindanao. The latter locality is the source of the type of *E. tessellata*, new species. Hennig did not see specimens.

The following characters will assist in distinguishing *E. hexapla* from the new species: Arista short plumose on barely the basal half; third antennal joint 2.5 times as long as broad, blackish except at base; fore legs yellow, except apical half of femur and apical joints of tarsi; middle and hind femora with brownish preapical band; one sternopleural bristle; one posterior notopleural bristle; one dorsocentral bristle; wing fasciae all even and straight; pterostigma very small; apical wing spot as long as width of first posterior cell at base of spot; copulatory fork as figured (fig. 74, *e*).

14. EURYBATA NIGRITIBIA, new species

FIGURE 74, *f. g*

Male.—Length, 10 mm. Differs from *E. hexapla* in having yellowish brown antennae, the third joint only about 1.5 times as long as broad; the shining mesofrontal wedge extending as a narrow strip all the way to the anterior ocellus; fore femora colored similarly to

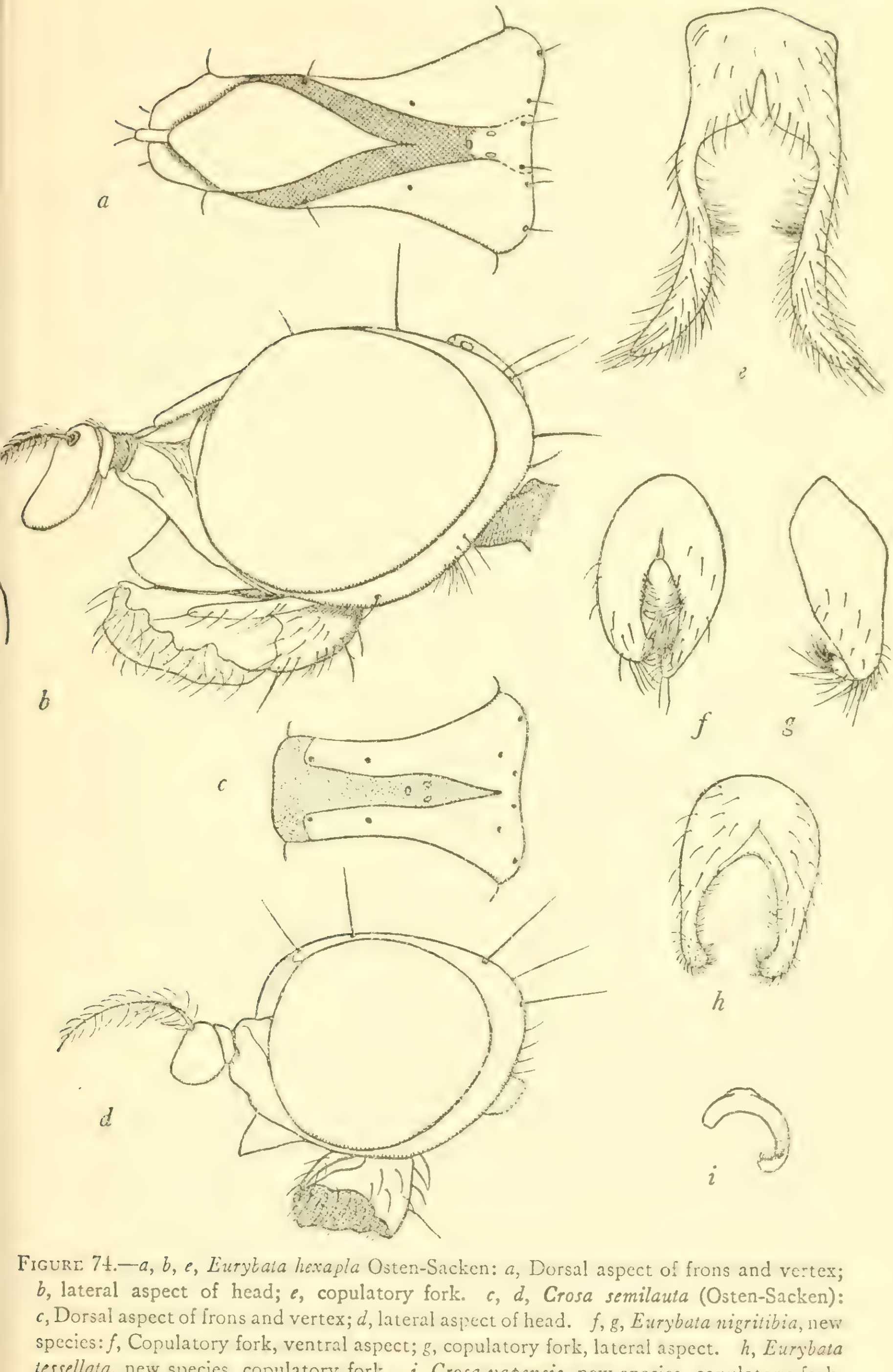

FIGURE 74.—*a*, *b*, *e*, *Eurybata hexapla* Osten-Sacken: *a*, Dorsal aspect of frons and vertex; *b*, lateral aspect of head; *e*, copulatory fork. *c*, *d*, *Crosa semilauta* (Osten-Sacken): *c*, Dorsal aspect of frons and vertex; *d*, lateral aspect of head. *f*, *g*, *Eurybata nigritibia*, new species: *f*, Copulatory fork, ventral aspect; *g*, copulatory fork, lateral aspect. *h*, *Eurybata tessellata*, new species, copulatory fork. *i*, *Crosa yapensis*, new species, copulatory fork.

E. hexapla, but the tibiae are blackish except for a short distance at tip and the tarsi are brown from tip of basitarsi; all tarsi apically darkened; mesonotum with a heavily brown-pruinose roundish patch behind transverse suture, a band before scutellum, and one at mesal corner of notopleural area.

Wing fascia beyond *tp* (fifth from base of wing) extending basad between third and fourth veins, making the band twice as wide at this point; two sternopleurals; one strong posterior and one small anterior notopleural bristle; apical wing spot longer than width of first posterior cell at base of spot; copulatory fork as in figures 74, *f*, *g*.

Type.—Holotype, male, U.S.N.M. No. 58302, Philippine Islands: Luzon (Ube Laguna), May 12, 1929, R. C. McGregor collector.

15. EURYBATA TESSELLATA, new species

Figure 74, *h*

Male and female.—Length, 10 mm. (exclusive of ovipositor in female). Antennae blackish except at base, twice as long as wide; the shining mesofrontal wedge very rapidly running out into a short point not more than halfway to ocellus; fore femora blackish except short distance at base; fore tibiae a little brownish apically; all tarsi light brown apically; mesonotum without distinctly set-off pruinose areas; wings with the transverse fasciae, especially in middle of wing, broken into a series of alternating squarish blotches; a hyaline spot anterior to *tp* lying directly posterior to a brown blotch in submarginal cell; marginal cell wholly brown; apical wing spot indistinct; two subequal notopleural bristles; two sternopleurals; copulatory fork of male as in figure 74, *h*.

Types.—Holotype, male, U.S.N.M. No. 58303, Philippine Islands: Mindanao (Surigao), Baker collector; allotype, female, Island of Basilan, Baker collector.

CROSA, new genus

Genotype.—*Eurybata semilauta* Osten-Sacken.

Distinguished from related genera as in the foregoing key, as well as by the following characters: Mesofrons (fig. 74, *c*) wholly dull, vertical in front, not projecting, parafrontals ending bluntly; ocelli well foreward; one dorsocentral bristle; pterostigma very small; abdomen wholly pruinose; male fore femora with many long loose hairs on basal ventral side.

It is possible that with the exception of the preceding three species all those heretofore included in *Eurybata* should find their place here.

Crosa is dedicated to that master dipterologist, Carl Robert von Osten-Sacken, and the name is formed from the initial letters of his name.

16. CROSA SEMILAUTA (Osten-Sacken), new combination

FIGURE 74, *c*, *d*

Eurybata semilauta OSTEN-SACKEN, Berliner Ent. Zeitschr., vol. 26, p. 207, 1882.—FREY, Not. Ent., vol. 7, p. 76, 1927.—HENNIG, Konowia, vol. 14, p. 302, 1935.

PHILIPPINE ISLANDS: Luzon (Los Baños; Mount Maquiling) ; Mindanao (Zamboanga) ; Tayabas (Lucban) ; Samar (Osmeña).

Previously recorded from localities in Luzon, Mindanao, and Samar.

17. CROSA TETRAS (Steyskal), new combination

Eurybata tetras STEYSKAL, Occas. Pap. Mus. Zool. Univ. Michigan, No. 502, p. 2, 1947.

The type material, from the Solomon Islands, is evidently congeneric with *C. semilauta.*

18. CROSA YAPENSIS, new species

FIGURE 74, *i*

Male.—Length of body, 6.5 mm.; length of wings, 4.5 mm. Color yellow, except extreme tip of femora and tibiae, dorsum of abdomen and anterior part of parafrontal stripes, which parts are brown. There is a faint preapical band of brown on fore femora and the apical tarsal joints are a little darkened. Mesofrons golden brown, becoming blackish in ocellar region.

The entire insect is shining or subshining except mesofrons, frontal orbits anterior to parafrontal stripes, antennae, and a heavily tomentose pleural stripe. Anterior frontal orbits narrowly golden tomentose. Pleural stripe bright white when viewed very obliquely, but otherwise dull lead colored; it covers the narrow lower margin of propleura and continues across mesopleura as a stripe as wide as fore tibiae. The stripe, were it to continue across the sternopleura, would run into the uppermost two posterior sternopleural setae. Parafrontal stripes with a bluish reflection.

Head very similar to that of *C. semilauta* (fig. 74, c, *d*), but aristal hairs only half as long as in that species.

Wings clear hyaline with brownish-yellow veins. Third and fourth veins converge to within a distance equal to length of *ta.* Pterostigma obsolete.

Fore femora furnished below with loose yellowish hairs, at base of femora twice as long as width of femur, but rapidly becoming shorter until they give out at mid-femur.

Copulatory fork in figure 74, *i*, the right arm apparently broken off.

Type.—Holotype, male, U. S. N. M. No. 58984, Caroline Islands: Yap Island, near Yaptown, July 14, 1946 (H. K. Townes No. 1239).

Remarks.—This species is apparently near *Eurybata cuneifrons* De Meijere and *E. petasibarba* Enderlein, as keyed in Hennig (1935, p. 301), but the "wedge-shaped spot on the hind margin of the mesopleura" is here a slender stripe. The pale general color and the wholly hyaline wings are distinctive.

Genus GONGYLOCEPHALA Czerny

19. GONGYLOCEPHALA PALLIDA LUZONICA, new subspecies

Gongylocephala pallida Steyskal, Occas. Pap. Mus. Zool. Univ. Michigan, No. 502, p. 4, 1947.

Male and female.—Subspecies agrees with *G. pallida* (Guadalcanal, Solomon Islands), except that base of fore tibiae is not brownish, but tibiae are uniformly yellow; middle tibiae are uniformly dark brown, not grading to yellow basally; fore femora are a little darker than tibiae in well-preserved specimens and hind tibiae are a little darkened basally; whitish fascia of wing is quite straight; male copulatory fork as in *G. pallida.*

Types.—Holotype male, allotype, female, and four male and two female paratypes, U.S.N.M. No. 58306, Philippine Islands: Luzon (Mount Maquiling), Baker collector.

Genus NESTIMA Osten-Sacken

20. NESTIMA POLITA Osten-Sacken

Nestima polita Osten-Sacken, Ann. Mus. Genova, vol. 16, p. 458, 1880.—Hennig, Konowia, vol. 14, p. 308, 1935.

New Guinea: Nadzab (Markham River Valley), May 4, 1944 (K. V. Krombein), one female.

Although the two known species of *Nestima*, *N. polita* Osten-Sacken, and *N. prolixa* (Walker), are both inadequately described, I believe that the above specimen agrees well enough with Osten-Sacken's description to make the determination. There must remain some doubt as to the identity of the following forms, described as new, but I feel certain that they are specifically distinct.

21. NESTIMA PLEURALIS, new species

Female.—Length 10 mm., exclusive of ovipositor. Similar to Osten-Sacken's description of *N. polita*, although the thorax is not "uniformly dark brown, shining," but moderately pruinose on dorsum with a pitchy brown, largely polished band of equal width extending all around thorax, including entire pteropleura, crossing notopleural suture, and including neck, humeri, and anterior face of anterior hump of mesonotum. Below this band on pleura of each side is a heavy stripe of appressed white hair, very narrow above fore coxae and gradually widening to include entire hypopleura from middle coxal to pteropleural sutures. There are several whitish sternopleural bristles and 1+2 notopleurals. Lower part of thorax is yellow.

Fore trochanters are black; fore femora yellow at base and at tip for a distance equal to three times the width, preceded by a blackish band of approximately same length; fore tibiae blackish except at extreme base; and fore tarsi whitish except two brown apical joints. Middle and hind legs have tips of tibiae and entire tarsi black. Halteres with brown stem and yellow knob.

Type.—Holotype, female, U.S.N.M. No. 58308, New Guinea: Nadzab (Markham River Valley), May 14, 1944 (K. V. Krombein).

22. NESTIMA VIRIDINSULA, new species

Female.—Length 10 mm., exclusive of ovipositor. Very similar to *N. polita* and *N. pleuralis*. Thorax dark brown, moderately pruinose on dorsum, blackish in a humeral stripe on each side of anterior hump. Mesopleura with pitchy, shining stripe in upper part, tapering and becoming evanescent forward. No trace of pruinosity or hair on pleura anterior to hyposternopleural suture. Several whitish sternopleural bristles and 1+2 notopleurals.

Fore legs yellow; tibiae light brown on most of length, yellow basally and whitish apically; tarsi whitish, but brownish on apical two or three joints; middle and hind legs yellow, except black tips of tibiae and entire tarsi.

Halteres with brown stem and yellow knob.

Type.—Holotype, female, U.S.N.M. No. 58307, Bismarck Islands: Green Island, 1944 (W. G. Downs).

Genus TREPIDARIOIDES Frey

23. TREPIDARIOIDES TERRITA (Osten-Sacken)

Calobata territa Osten-Sacken, Berliner Ent. Zeitschr., vol. 26, p. 203, 1882.
Trepidarioides territa (Osten-Sacken) Frey, Not. Ent., vol. 7, p. 76, 1927.—Hennig, Konowia, vol. 14, p. 307, 1935.

PHILIPPINE ISLANDS: Mindanao (Surigao); Luzon (Mount Maquiling; Laguna).

The copulatory fork of the male of this species, type of the genus *Trepidarioides* Frey, is a simple U-shaped organ, as narrow at base as the arms are wide, unadorned, and quite different from the organ figured by Hennig (1935, p. 306) for *T. cyanea* (Hendel).

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APHOTAENIUS, A NEW GENUS OF DUNG BEETLE (COLEOPTERA: SCARABAEIDAE)

By O. L. Cartwright

A new South American beetle, which I discovered as I studied the collection of Aphodiinae (Coleoptera: Scarabaeidae) in the United States National Museum, has certain characters, especially those of the hind tibiae, that are shared by *Ataenius carolinus* Van Dyke. These peculiar characters, which have precluded the satisfactory inclusion of *carolinus* in any known genus of the Aphodiinae, would seem to indicate the advisability of setting up a new genus for the reception of both species.

APHOTAENIUS, new genus

General shape elongate oval, very convex, lateral edges of elytra and pronotum posteriorly not visible from directly above. Head moderately large, smooth except for a band of coarse punctures across occiput. Clypeus shallowly emarginate, finely reflexed margin flattened and dorsally angulately widened between two widely placed marginal teeth or denticles, when viewed from directly above the widened margin appearing as an angulate carina and hiding extreme lower edge, which has a much smaller median angulation directed in the opposite direction. Genae bent downward as in *Ataenius*. Pronotum not crenate, not fimbriate, posterior angles truncate-obtuse, slightly depressed. Pygidium as in *Ataenius*, the anterior basal portion with a longitudinal groove receiving the ventrally dentate tips of the elytra, the exposed apical portion with a depressed central area. Middle and posterior tibiae with distinct oblique carinae as in *Apho-*

dius but without the apical fringe of spinules, the apical margin ventrally with two well-separated triangular teeth, each tooth with a very fine hairlike seta basally on each side, the outer apical angle spinelike as in *Ataenius*. Mouthparts as in *Ataenius*.

Genotype.—Ataenius carolinus Van Dyke=*Aphotaenius carolinus* (Van Dyke).

Aphotaenius, though having distinct oblique carinae on the middle and hind tibiae as in *Aphodius*, should be placed in the tribe Eupariina, since the head, genae, pygidium, and other parts are much closer to *Ataenius* and allied genera than to *Aphodius*. The middle and hind tibiae are unique.

APHOTAENIUS CAROLINUS (Van Dyke)

Ataenius carolinus Van Dyke, Pan-Pacific Ent., vol. 14, p. 157, 1928.
Aphodius carolinus Hinton, Ann. Mag. Nat. Hist., ser. 10, vol. 20, p. 196, 1937.

Piceous black, shining, head anteriorly and legs reddish, antennae and palpi testaceous. Head three-fourths as wide as pronotum, strongly convex, basally with a band of coarse punctures, front finely punctate, anterior smooth, impunctate; clypeus with finely reflexed margin, bidentate, teeth strongly developed, acutely pointed and widely separated, slightly emarginate between teeth, margin flattened and dorsally angulately widened, this appearing as an angulate carina from directly above, the extreme ventral margin, invisible from above, with a small median angulation directed in the opposite direction. Pronotum convex, margined basally and laterally, surface with mixed coarse and very fine punctures, coarse punctures uniformly distributed, separated by less than one to two diameters. Elytra convex, coarsely striate, striae strongly crenate punctate, intervals moderately convex, minutely punctate. Covered basal portion of pygidium deeply grooved under tips of elytra, exposed portion with depressed eroded area divided by a longitudinal carina. Posterior prosternal spine strongly developed, laterally compressed. Mesosternum closely moderately punctate. Metasternum quite closely coarsely punctate, median longitudinal line deep. Second abdominal segment closely shallowly setigerously punctate along anterior margin, carinate between the coxae; remaining segments smooth, coarsely deeply crenate in front. Posterior femoral line obsolete, only faintly indicated, middle femoral line and anterior ventral line of profemur wide, deep, and noticeably alutaceous. Anterior tibiae tridentate externally. Middle and posterior tibiae with oblique carinae as in *Aphodius*, without fringe of spicules apically but with two well-separated triangular teeth, each tooth with a fine hairlike seta basally on each side, the outer apical angles prolonged, spinelike as in *Ataenius*, long spur, first tarsal joint, and three following tarsal joints combined equal in length. Terminal tarsal joint about as long as two preceding combined, claws minute. Length, 2.75 mm.

Holotype.—In California Academy of Sciences, No. 2549.

Type locality.—Black Mountains, N. C.

Remarks.—*Aphotaenius carolinus* is a common species in deer droppings in June in Pisgah Forest, near Brevard, N. C., and was taken there as early as April 29 and as late as September 10. It has been taken in sheep droppings on Sassafras Mountain, S. C.; in rather old cow dung in woods near Pine Mountain, Ga.; and in the same in I'On Swamp, Fair Lawn Plantation, 7 miles from Awendaw, near Charleston, S. C. Mark Robinson and I collected several specimens at the last-named place on June 4, 1948. These were the first seen from other than mountain localities, except possibly a single specimen in the M. A. Cazier collection bearing an old and very doubtful label, "Key West, Fla." Recently a single specimen was found in an early private collection of H. S. Barber, which had been determined by E. A. Schwarz as "Aphodius n. sp." This specimen bears label data as follows: "Marlboro, Md. May 13. Collection H. S. Barber." It was probably collected between 1898 and 1901.

Still more recently I found a specimen in the Blatchley collection at Purdue University. This specimen of *Aphotaenius carolinus* was collected in Crawford County, Ind., May 19, 1903, by W. S. Blatchley and was erroneously reported as *Ataenius lecontei* Harold in his "Catalogue of the Coleoptera in Indiana."

APHOTAENIUS COLOMBIENSIS, new species

Piceous black, shining, anterior margin of head and thorax and legs reddish, antennae and palpi testaceous. Head about three-fourths as wide as pronotum, strongly convex, basally with a band of close moderate punctures, front with more widely spaced fine to minute punctures; clypeus slightly depressed and emarginate at middle with a low angulation or denticle each side, lateral margins finely reflexed, genae bent down as in *Ataenius*, margin between denticles flattened and dorsally angulately widened to twice the height of the denticles, this appearing as a carina from directly above, lower edge of widened margin, invisible from above, with a small median angulation in the opposite direction. Pronotum convex, laterally and basally margined, not fimbriate, anterior angles obtusely rounded, posterior angles truncate-obtuse, slightly depressed, base distinctly lobed medially, surface with mixed fine and coarse punctures, the latter generally distributed but closer laterally, separated by one to four or five diameters on the disc. Elytra convex, deeply striate, striae coarsely crenately punctate, intervals weakly convex, with scattered minute punctures. Mesosternum closely moderately punctate. Metasternum with scattered very fine punctures at middle, a few coarse shallow punctures and alutaceous sculpture at sides, median longitudinal line moderately impressed. Second abdominal segment carinate between coxae, closely, shallowly, setigerously punctate anteriorly, remaining segments smooth, coarsely deeply crenate anteriorly. Covered portion of pygidium longitudinally grooved to receive tips of elytra, which lock together with tongue-and-groove sutural edges, disc of exposed portion depressed but smooth, with a few scattered very small low tubercles basally. Anterior ventral profemoral line and posterior femoral line of middle femurs entire, wide, moderately deep and alutaceous. Posterior femurs smooth, with scattered minute punctures, without femoral line. Anterior tibiae externally tridentate. Middle and hind tibiae with well-developed oblique carinae as in *Aphodius*, terminally without fringe of spinules but with two widely separated triangular teeth on ventral apical edge, each tooth with a fine hairlike seta basally on each side, outer apical angle prolonged, spinelike as in *Ataenius*. Long spur slightly shorter than first tarsal joint, which is as long as the three following joints combined, tarsal claws minute. Sex not determined but probably a male. Length 4 mm.; width 1.75 mm.

Holotype.—U. S. N. M. No. 59444.

The unique specimen of *colombiensis* was collected at 2,900 meters, above Guasca, Cundinamarca, Colombia, March 10, 1942, by Dr. E. A. Chapin.

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PRELIMINARY ANALYSIS OF THE VERTEBRATE FOSSIL FAUNA OF THE BOYSEN RESERVOIR AREA

By Theodore E. White

As a part of the salvage program of the River Basin Surveys, a cooperative project between the Smithsonian Institution, the National Park Service, the Bureau of Reclamation, and the Corps of Engineers, Department of the Army, in the prospective reservoir sites in the Missouri Valley, the Boysen Reservoir area near Shoshoni, Wyo., has been prospected for vertebrate fossils for parts of two seasons. During the first period, from October 23 to November 7, 1947, I worked alone, and considerable time was lost because of early snows. The area was again worked, with the aid of John C. Donohoe, a student at Montana State College, and Ernest L. Lundelius, a student at the University of Texas, from June 4 to July 12, 1948. Although the specimens have not been credited to individuals, I wish to state that these men have proved themselves competent collectors, and we three found about equal amounts of material. Although it is planned to visit this area for as many seasons as possible before the reservoir is flooded, it seems desirable to make the information gathered to date available to other paleontologists.

956647—52——1

SYSTEMATIC DESCRIPTION OF FOSSIL VERTEBRATES

Class REPTILIA

Order SQUAMATA

Suborder SERPENTES

Family BOIDAE

Genus BOAVUS Marsh

BOAVUS cf. OCCIDENTALIS Marsh

About 30 associated thoracic vertebrae (loc. No. 48FR78);[1] 2 thoracic vertebrae (loc. No. 48FR80).

Although there is considerable difference in size between the two specimens, I am inclined to be extremely cautious about differentiating species of snakes on the size of the vertebrae only, since age is not readily reflected in the surface texture of the bone. Consequently, the principal importance of this material is the presence of this genus in the Lost Cabin faunal zone of the Wind River formation.

Suborder SAURIA

Family VARANIDAE

Genus SANIWA Leidy

SANIWA sp.

One dorsal and five caudal vertebrae (loc. No. 48FR65); two dorsal vertebrae of presumably a young individual (loc. No. 48FR78); one caudal vertebra (loc. No. 48FR80).

This material is too imperfect for more than generic identification and its value is only that it establishes this genus in these deposits.

Family ANGUIDAE

Genus GLYPTOSAURUS Marsh

GLYPTOSAURUS DONOHOEI, new species

FIGURE 75

Type.—U.S.N.M. No. 18316 (fig. 75), a badly damaged skull lacking the tip of the snout, both maxillae, and the right temporal region (loc. No. 48FR65).

Referred material.—U.S.N.M. No. 18317, skull and jaw fragments with scutes (loc. No. 48FR65).

[1] For a description of localities see pp. 203–206.

Horizon and locality.—Lower Eocene, Lost Cabin, NE¼SW¼ sec. 5, T. 4 N., R. 6 E., of Wind River meridian; White Hill, south side of Cottonwood (Dry Muddy) Creek, 11 miles north-northwest (air line) of Shoshoni, Fremont County, Wyo.

Diagnosis.—A medium-sized species; interorbital breadth 33 percent less than in *G. hillsi* Gilmore; interorbital area with 5 regular alternating rows of bony scutes, supraorbital and median rows larger

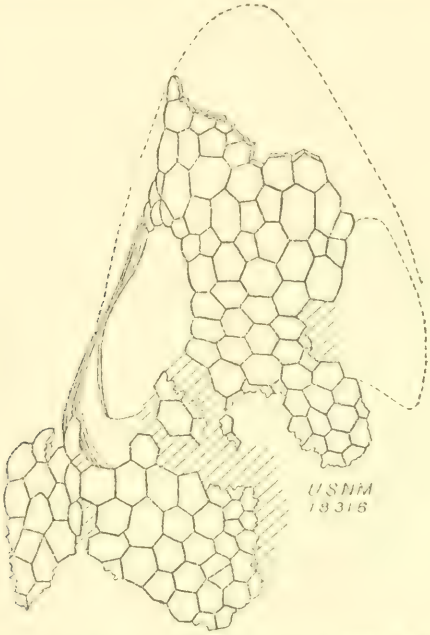

FIGURE 75.—*Glyptosaurus donohoei*, new species, type, U.S.N.M. No. 18316; squamation of dorsal surface of skull, ×1.

than second and fourth rows; scutes raised into a boss as in *rugosus* and *nodosus;* vertical diameter of orbit equal to interorbital breadth: scutes of the temporal region less regular in outline and about twice the diameter of those of the interorbital area.

Discussion.—This specimen, in conjunction with a braincase from Pipestone Springs (U.S.N.M. No. 13805), permits a few additions to Gilmore's (1928, 1938) discussions of the genus.

The various elements that make up the braincase are securely fused, as in *Peltosaurus.* The former location of some of the sutures can be made out by lines of roughened bone. The condyle is elongate-oval in outline, twice as broad as deep. The tubera basioccipitalia project ventrolaterally from the basicranial axis and are expanded anteriorly and posteriorly at their bases as though reinforced by flying buttresses. These expansions are thickened along their edges so that the tubera are triradiate from their terminations, with the median portion the heaviest. The foramen for the twelfth cranial nerve is located beside the condyle and below the paroccipital process, at the termination of the posterior wing of the tubera basioccipitalia. The ninth and tenth nerves exit through a dorsoventrally elongated foramen at the ventral side of the jugular groove a little posterior to the median portion of the tubera basioccipitalia. The fenestra ovale lies just above this foramen. The foramen for the exit of the *venus capitis lateralis* lies just above the anterior termination of the anterior wing of the tubera at the bottom of the jugular groove. The foramen for the hyoid branch of the seventh nerve lies at the top of the jugular groove slightly posterior to the foramen for the *venus capitis lateralis*. A thin, fairly deep ridge of bone extends downward from the paroccipital process of the proötic so that the jugular groove is partially enclosed laterally.

The region of the hypophyseal fontanelle is so badly damaged in both specimens that reliable data cannot be obtained. The basipterygoid processes of the basisphenoid are elongate and flattened as in most *Sauria*. They are separated from the tubera basioccipitalia by a deep notch, which extends to the main body of the basisphenoid.

The anterior edge of the proötic is damaged in both specimens, but enough of this region is preserved in U.S.N.M. No. 18316 to indicate that the ossification of the prefacial commissure very nearly or entirely encircled the facialis branch of the seventh nerve as it left the braincase.

A fragment of the maxilla in U.S.N.M. No. 18317 shows that the anterior maxillary teeth are much smaller than the posterior teeth. They increase rapidly in size to the fifth tooth, which is as large as the remainder.

The collection of *Glyptosaurus* material in the United States National Museum, which contains most of the types, was examined in connection with this material. Many of the species were founded on the characters of the frontal and interorbital regions only, and as yet some of the species are known only from the type specimens. Although the taxonomy of a genus based on such a limited portion of an animal leaves much to be desired, it is possible to make a morphological grouping of the species of this genus by means of the characters presented by this region of the skull. Only with the aid of better material can the validity of this grouping be determined. The known species are tentatively grouped as follows:

I. Interorbital region with four rows of osseus scutes with one or two odd scutes interpolated between the median rows___________G. montanus group

II. Interorbital region with five regular, alternating rows of osseus scutes. G. hillsi group

III. Interorbital region with six irregular rows of scutes; odd scutes may or may not be present between the median rows............G. giganteus group
IV. Frontal region unknown..G. sphenodon

TABLE 1.—*Stratigraphical distribution of the* Glyptosaurus montanus, G. hillsi, *and* G. giganteus *groups*

Periods	Stages	*montanus* group	*hillsi* group	*giganteus* group
Oligocene	Whitneyian			
	Orellan			*giganteus*
	Chadronian	*montanus*		*tuberculatus*
Eocene	Duchesnian			
	Uintan			
	Bridgerian		*brevidens* *princeps*	*nodosus* *sylvestris* *rugosus*
	Huerfano B		*hillsi*	
	Huerfano A		*hillsi?*	
	Wasatchian	*obtusidens*	*donohoei*	

Class MAMMALIA

Order INSECTIVORA

Family DELTATHERIDIIDAE

Genus DIDELPHODUS Cope

DIDELPHODUS VENTANUS Matthew

FIGURE 76

U.S.N.M. No. 18369 (fig. 76), a badly crushed skull with left P^2 to M^3 and both lower jaws from which all the teeth have been broken (loc. No. 48FR65); U.S.N.M. No. 18433, fragment of left mandible with M_2 (loc. No. 48FR80).

If the skull is correctly referred to this form its characters are sufficiently distinctive to warrant designation as a separate species, rather than citation as a mutation of *D. absarokae.* The distinctive characters presented by the teeth of this specimen are : P^2 two-rooted, anterior and posterior cingula well developed and with minute crenulations; P^3 submolariform and differs from P^4 only in being slightly smaller; M^1 exhibits several minute tubercles on the external cingulum between the parastyles and metastyles. Other characters of the teeth agree with Matthew's (1918, p. 583) figures of *D. absarokae.*

Although this skull is very badly broken and crushed, it adds a few details to our knowledge of the genus. Because *Ictops* is relatively well known, comparisons will be made with it, although the two forms are not closely related:

(1) The frontonasal suture lies a short distance in front of the orbit. (2) The zygoma is a little heavier than in *Ictops.* (3) Postorbital process is short but very well defined. A companion process was not observed on the fragment of the zygoma preserved. (4) The orbit appears to be as large relatively as in *Ictops.* (5) The sagittal crest is single and moderately high. (6) The parietal foramen appears to lie closer to the crest than to the squamosal. (7) Squamosoparietal

FIGURE 76.—*Didelphodus ventanus* Matthew, U.S.N.M. No. 18369; occlusal view of left P^2–M^3, ×4.

foramina were not observed. (8) The union of the mastoid portion of the petrosal and the squamosal appears to have been similar to that in *Ictops.* (9) The mastoid appears to form as much of the occiput as in *Ictops.* (10) The relationship of the glenoid to the periotic suggests that the postglenoid and posttympanic processes of the squamosal were separated by a meatal notch, although these processes were broken away. (11) The tympanic ridge of the alisphenoid is lacking, but there is a short one on the glenoid portion of the squamosal. (12) The foramina in the alisphenoid appear to have been much the same as in *Ictops*, but this region is badly crushed and difficult of interpretation. (13) The alisphenoid appears to be fused to the basisphenoid. (14) The periotic appears to be rather large judged by the dimensions of the skull that can be observed. (15) The inferior border of the massateric fossa is sharply defined by an abrupt indentation as in *Deltatheridium.*

MEASUREMENTS OF TEETH OF DIDELPHODUS VENTANUS (IN MILLIMETERS)

	Length	*Width*
P^3–M^3	13. 5	------
M^{1-3}	8. 0	------
Diastema P^{2-3}	1. 6	------
P^2	2. 1	1. 2
P^3	2. 8	3. 2
P^4	2. 6	3. 4
M^1	3. 0	3. 5
M^2	2. 4	3. 5
M^3	1. 7	3. 0

The dentition of this specimen is distinctly more advanced than that of *D. absarokae* of the Gray Bull. Unfortunately the upper dentition of this genus is unknown from the Alkalai Creek exposures. Consequently it is impossible to evaluate the stratigraphic significance of this specimen.

Family MIXODECTIDAE

Genus CYNODONTOMYS Cope

CYNODONTOMYS SCOTTIANUS COPE

U.S.N.M. No. 18436, fragment of left mandible with posterior half of P_4 and M_{1-3} (loc. No. 48FR76); U.S.N.M. No. 18434, fragment of right mandible with M_{2-3} (loc. No. 48FR80).

The limited material pertaining to this species does not permit any additions to Matthew's (1915c, pp. 470–477) discussion of the genus.

CYNODONTOMYS LUNDELIUSI, new species

FIGURE 77

Holotype.—U.S.N.M. No. 18371 (fig. 77), fragment of a right mandible with posterior half of M_1, M_2, posterior half of M_3, and the roots of P_{3-4} (loc. No. 48FR65).

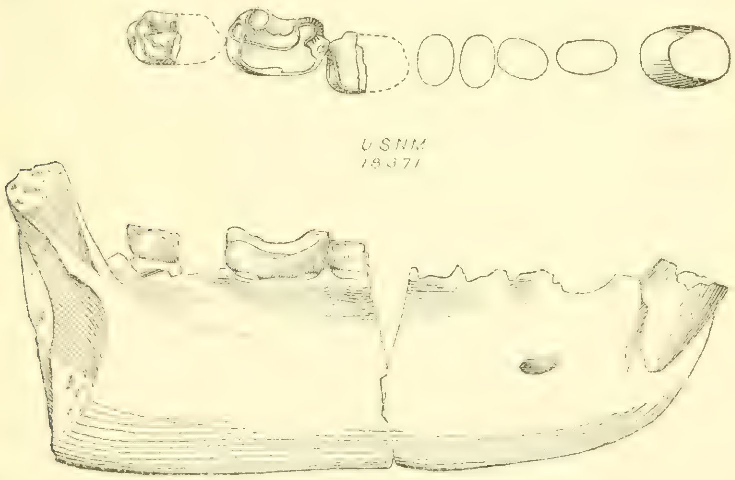

FIGURE 77.—*Cynodontomys lundeliusi*, new species, type, U.S.N.M. No. 18371; occlusal view of teeth and lateral view of right mandible, ×2.

Horizon and locality.—Lower Eocene, Lost Cabin. NW¼SW¼, sec. 5, T. 4 N., R. 6 E. of Wind River meridian, south side of Cottonwood (Dry Muddy) Creek, 11 miles (air line) north-northwest of Shoshoni, Fremont County, Wyo.

Diagnosis.—Size large, 33 percent larger than the average for *C. scottianus* (Matthew, 1915c, p. 471); M_3 relatively shorter than in that species; heel of M_3 narrower than on M_2; paraconid on M_2 distinct; external and posterior cingula as in *C. scottianus*.

Discussion.—Although the teeth in this specimen are broken and badly worn, the characters presented, especially the size, are distinct enough for the species to be easily recognized.

MEASUREMENTS OF TEETH OF CYNODONTOMYS LUNDELIUSI (IN MILLIMETERS)

	Length
P_3–M_3	30.7
P_4–M_3	22.3
M_1 (estimated)	5.0
M_2	5.5
M_3	6.5
Depth of jaw at M_1	12.8
Depth of jaw at M_3	13.7

Order TILLODONTIA

Family TILLOTHERIIDAE

Genus ESTHONYX Cope

ESTHONYX ACUTIDENS Cope

U.S.N.M. No. 18267, fragment of right mandible with I_{2-3} and P_3–M_2 (loc. No. 48FR78); U.S.N.M. No. 18470, fragments of both mandibles (loc. No. 48FR65); U.S.N.M. No. 18469, skull and jaw fragments (loc. No. 48FR80).

This material is being studied by Dr. C. L. Gazin and will be discussed in his revision of the order.

Order PRIMATES

Family ADAPIDAE

Genus NOTHARCTUS Leidy

NOTHARCTUS VENTICOLUS Osborn

U.S.N.M. No. 18437, left mandible with M_{1-3}, roots of P_{3-4}, and alveoli of P_{1-2} (loc. No. 48FR77).

This specimen does not add anything to our knowledge of the species.

Family APATEMYIDAE

Genus TEILHARDELLA Jepson

TEILHARDELLA sp.

U.S.N.M. No. 18438, right mandible with only the incisor (loc. No. 48FR80).

This specimen is provisionally referred to this genus on the characters of the mandible, which exhibit a number of differences from the genotype, but these differences cannot be properly appraised until the dentition is known. The characters exhibited by this specimen are:

P_3 procumbent; P_4 with a single large root; M_1 and M_2 with posterior root the larger; posterior root of M_3 very long and narrow; massateric fossa very deep and broad.

MEASUREMENTS OF ALVEOLI OF TEILHARDELLA sp. (IN MILLIMETERS)

	Length
P_3–M_3	7.8
M_{1-3}	5.7
M_1	1.7
M_2	1.7
M_3	2.0

Family ANAPTOMORPHIDAE

Genus LOVEINA Simpson

LOVEINA ZEPHYRI Simpson

U.S.N.M. No. 18439, portion of a left mandible with part of P_4, the base of M_1, and M_2 and M_3 (loc. No. 48FR76).

This specimen is provisionally referred to this species on the basis that M_2 and M_3 agree with those of ? *L. vespertina* (Matthew) better than with those of any other genus. It differs from that species in the proportionally shorter M_1 and M_2, in the broader trigonid, and in the presence of a minute entoconid on the heel of M_3. Since M_2 and M_3 are unknown in the genotype any attempt at comparison of the two specimens would be futile.

MEASURMENTS OF TEETH OF LOVEINA ZEPHYRI (IN MILLIMETERS)

	Length	*Width (at base)* *Trigonid*	*Heel*
M_{1-3}	7.4	------	------
M_1	2.3	?	1.8
M_2	2.3	2.0	2.2
M_3	2.7	1.8	1.6

Order TAENIODONTA

Family STYLINODONTIDAE

Genus STYLINODON Marsh

STYLINODON CYLINDRIFER (Cope)

U.S.N.M. No. 18440, portion of right canine (loc. No. 48FR76).

This specimen is referred to *S. cylindrifer* on the basis of the distribution of the enamel, which is in two bands, one on each side of the tooth. It is of uniform thickness and width and shows the obsolete vertical striation and the stronger transverse growth lines which Cope (1884, p. 192) describes for the type of the species. The cement, which covers the areas between the enamel bands, overlaps the enamel for a short distance on each side, but there is no evidence that the bands were covered.

MEASUREMENTS OF CANINE OF STYLINODON CYLINDRIFER (IN MILLIMETERS)

Diameter (transverse)	10.5
Diameter (anteroposterior)	11.5
Width between enamel bands:	
Anterior	2.8
Posterior	4.8

Order RODENTIA

Family ISCHYROMYIDAE

Genus PARAMYS Leidy

PARAMYS MAJOR Loomis

U.S.N.M. No. 18442, right mandibular fragment with M_{1-2} and roots of M_3 (loc. No. 48FR76); U.S.N.M. No. 18441, left mandibular fragment with P_4–M_2 (loc. No. 48FR80).

This material does not permit anything to be added to Matthew's (1918, p. 614) discussion of the species.

PARAMYS MURINUS Matthew

U.S.N.M. No. 18443, right mandible with M_{1-2} and roots of P_4 (loc. No. 48FR80).

This specimen does not agree with the figures (Matthew, 1918, p. 617) of the type in that the enamel is entirely smooth and not rugose. Consequently, it is only provisionally referred to this species pending the acquisition of better material.

Order CARNIVORA

Family HYAENODONTIDAE

Genus PROLIMNOCYON Matthew

PROLIMNOCYON ANTIQUUS Matthew

U.S.N.M. No. 18444, left mandible with P_{3-4} and roots of M_{2-3} (loc. No. 48FR76); U.S.N.M. No. 19445, both mandibles with only roots of teeth preserved (loc. No. 48FR65).

This material does not permit anything to be added to Matthew's (1915a, p. 70) discussion of the species.

Genus SINOPA Leidy

SINOPA STRENUA (Cope)

U.S.N.M. No. 18446, mandibular fragments with M_{1-3} of both sides and associated skeletal fragments (loc. No. 48FR77).

This specimen does not permit the addition of anything to Matthew's (1915a, p. 74) discussion of the species.

Genus DIDYMICTIS Cope

DIDYMICTIS ALTIDENS Cope

U.S.N.M. No. 18447, skull with calvarium and occiput eroded away, right and left P^1–M^2 present (loc. No. 48FR75).

This specimen differs from the one figured by Matthew (1915a, p. 23) in that P^1 is 2-rooted, and there is no diastema between it and the canine. The parastyle on M^1 is better developed and the internal cingulum is continuous. M^2 has a greater transverse diameter for its length and is more advanced.

MEASUREMENTS OF TEETH OF DIDYMICTIS ALTIDENS (IN MILLIMETERS)

	Length	*Width*
P^1–M^2	58.5	------
P^4–M^2	29.5	------
M^1	9.0	17.0
M^2	5.0	9.0

Genus MIACIS Cope

MIACIS cf. LATIDENS Matthew

U.S.N.M. No. 18448, right maxillary fragment with M^{1-2}, roots of P^4, and associated skull fragments (loc. No. 48FR80).

This specimen is intermediate in size between the types of *M. exiguus* and *latidens* (Matthew, 1915a, p. 33–35). It agrees with the former in the extended parastyle on the upper molars and with the latter in that the paracone is much larger than the metacone. The internal cingulum is interrupted medially below the protocone. Matthew (1915a, p. 33) states that it is continuous in both species but the illustrations show it to be the same as in this specimen. Although M^1 shows considerable wear, there is a suggestion of a small hypocone, and this specimen may be prophetic of *M. parvivorus* of the Lower Bridger.

MEASUREMENT OF TEETH OF MIACIS CF. LATIDENS (IN MILLIMETERS)

	Length	*Width*
P^4–M^2	16.5	------
P^4	7.7	------
M^1	6.0	8.4
M^2	4.0	8.0

Genus VULPAVUS Marsh

VULPAVUS AUSTRALIS Matthew

U.S.N.M. No. 18449, left mandibular fragment with M_{1-2} (loc. No. 48FR76).

This specimen does not permit anything to be added to Matthew's (1915a, p. 39) discussion of the species.

MEASUREMENTS OF TEETH OF VULPAVUS AUSTRALIS (IN MILLIMETERS)

	Length	*Width trigonid*	*Heel*
M_{1-2}	11.7	------	------
M_1	6.9	4.5	4.0
M_2	4.8	3.9	3.3

Order CONDYLARTHRA

Family MENISCOTHERIIDAE

Genus MENISCOTHERIUM Cope

MENISCOTHERIUM TERRARUBAE Cope

U.S.N.M. No. 18451, fragment of right mandible with P_4–M_3 (loc. No. 48FR80) : U.S.M.N. No. 18450, fragment of left mandible with P_4–M_3 (loc. No. 48FR80).

The limited material of this form is uniform in size and is larger than the material from Alkalai Creek listed by Granger (1915, p. 359). On the basis of size the material agrees better with *terrarubae* than with *chamense*, but whether these should receive full specific status or be considered as varieties will not be considered here.

Although the genus was identified with certainty from one locality, it would be premature to attempt any discussion of the paleoecology of the Boysen Reservoir area on the basis of such limited data.

Family HYOPSODONTIDAE

Genus HYOPSODUS Leidy

HYOPSODUS POWELLIANUS Cope

U.S.N.M. No. 18452, right mandible with P_1–M_3 and right maxilla with P^{2-3} (loc. No. 48FR75).

This specimen is referred to *H. powellianus* on the basis of size and the position of the mental foramina, both of them lying below P_4. The teeth are so badly worn that certain identification is impossible.

MEASUREMENTS OF TEETH OF HYOPSODUS POWELLIANUS (IN MILLIMETERS)

	Length
P_4–M_3	23.5
M_{1-3}	18.5
P_4	5.0
M_1	5.5
M_2	6.0
M_3	7.0

HYOPSODUS WORTMANI Osborn

U.S.N.M. Nos. 18453, 18454, two specimens, one with upper and lower molars associated (loc. No. 48FR78); U.S.N.M. Nos. 18455–18460, six specimens, including one maxilla with M^{2-3} (loc. No. 48FR80).

There appears to be some confusion in the literature concerning the size range of the lower molars of this species. Osborn (1902, p. 185) in the original description gives the size range from 11 to 13 millimeters. Loomis (1905, p. 422) found that his material exhibited a uniform measurement of 12 mm. Matthew (1915b, p. 317), in his key to the species of the genus, gives the length of the lower molars as 10 mm. In the material from the Boysen Reservoir area, the two specimens with M_{1-3} have a molar length of 13 mm. In all the specimens the length of M_{2-3} varies between 8.0 and 9.0 mm. Van Houten (1945, p. 425) pointed out that most of the Lower Eocene genera could be revised profitably. This is certainly true of *Hyopsodus.*

Hyopsodus wortmani has never been adequately characterized in the literature, and if this material is correctly referred, the lower dentition may be characterized as follows: P_4 submolariform, anterointernal style well developed and joined to the protoconid by a distinct crest; deuteroconid well developed; anterointernal style, protoconid, and deuteroconid forming a distinct trigonid; heel well developed and trenchant, hypoconid centrally placed and prominent, entoconid small and indistinct from posterior cingulum; M_1 with metaconid distinctly twinned, crescents on protoconid well developed, hyopoconulid and entoconid distinct, anterior and posterior cingula present; M_2 similar to M_1 except that metaconid is indistinctly twinned; M_3 long and narrow, narrowing rapidly from in front posteriorly, hypoconulid as large as, or larger than, hypoconid and forming a distinct heel; entoconid small but distinct, metaconid may or may not be indistinctly twinned.

This material is not readily distinguishable from *H. paulus* Leidy, of the Lower Bridger, by size, but the teeth of the type are so badly worn that their characters cannot be properly evaluated.

Order PANTODONTA

Family CORYPHODONTIDAE

Genus CORYPHODON Duméril and Bibron

CORYPHODON sp.

Right P^{3-4} (loc. No. 48FR65).

This material is inadequate for more than generic identification.

Order PERISSODACTYLA

Family EQUIDAE

Genus HYRACOTHERIUM Owen

HYRACOTHERIUM VENTICOLUM Cope

FIGURE 78

U.S.N.M. No. 18368, left mandibular fragment with Dp_4 (fig. 78) (loc. No. 48FR65); U.S.N.M. No. 18462, right mandibular fragment with the heel of Dp_3 and Dp_4 (loc. No. 48FR76); U.S.N.M. No. 18461, right mandibular fragment with P_{2-4} and M_3 (loc. No. 48FR78).

Although this material is very fragmentary, it shows the character of the lower deciduous premolars, which was not treated in Granger's (1908) revision. Unfortunately, only the heel of Dp_3 is preserved.

FIGURE 78.—*Hyracotherium venticolum* Cope, U.S.N.M. No. 18368; lateral and occlusal views of right DP_4, $\times 1\frac{1}{2}$.

The characters that this limited material presents are as follows: Dp_3 with posteroexternal crescent well developed, cross-crest between hypoconid and entoconid well developed, hypoconulid small but distinct, external and posterior cingula present; Dp_4 with anterior and posterior external crescents well defined, metaconid distinctly twinned and higher than protoconid, cross-crest between hypoconid and entoconid well developed, entoconid higher than hypoconid, hypoconulid small but well defined, well developed anterior, external, and posterior cingula.

The deciduous teeth described here are somewhat higher crowned than the permanent teeth, and can be distinguished from the permanent dentition of *Orohippus* only with difficulty. In fact, these teeth were originally referred to that genus and it was only after Dr. C. L. Gazin and I spent some time comparing them with the material in the U. S. National Museum that their true identity was learned.

I have been told by Morris Skinner that this characteristic—the deciduous teeth of horses being more advanced than the permanent teeth—has been observed in the later Tertiary horses. In view of the growth processes involved in the formation of horse teeth (White, 1942, p. 26) it is logical to correlate the above phenomenon with the activities of the endocrine glands, which stimulate and regulate growth, during the period of postnatal development (ibid., p. 45). That the thyroid (Goldzieher, 1939, p. 83) plays an important role in influencing the morphogenic processes, particularly in the ossification of the skeleton and in the growth of the teeth, has been demonstrated by the administration of thyroid extract to hypothyroid children and by thyroidectomy of normal laboratory animals. Its action is by no means independent but is closely integrated with that of the pituitary, parathyroid, and adrenals. Nor do these glands function only in combination with each other but in combination with the other glands of the system to maintain an endocrine balance and a favorable "internal environment" or *homeostasis* (ibid., p. 11).

In order to maintain homeostasis the endocrine glands must respond to external factors. The changes in external environment that are accompanied by changes in the activity of the glands are: Altitude, temperature, climate, quantity and type of food, and accessory foodstuffs such as mineral salts and vitamins. The data on the responses to these factors are limited almost entirely to the clinical observations on man and laboratory animals. These data indicate that when less than radical changes in the external factors prove deleterious there is a strong probability that an endocrine imbalance already existed (Goldzieher, 1939, pp. 11–13).

Of equal importance to the activities of the endocrine glands are the responses of the receptor tissues to the stimuli of the hormones. These responses may be affected by a variety of factors, such as: The condition of the tissues, ennervation, chemicals, and the age and stage of development of the individual. With regard to the two last-mentioned factors, which are probaby the most fundamental, little is known except that the responses of the tissues are characteristic of the stage of development. Thus, in a young and growing individual, the response to hormones is growth and maturation, while in the adult the hormones are capable only of maintaining the orderly function of the tissues (Goldzieher, 1939, p. 6). It is a well-known fact that in animals there is a noticeable slowing down of growth soon after puberty, though the postpubertal growth period may be as long as the prepubertal. However, this may be due to the interaction of the endocrine glands.

In regard to the environment offered by this region during Lower Eocene time, Van Houten (1945, pp. 442–444) characterizes it as a humid lowland with a warm-temperate to subtropical climate supporting a luxuriant vegetation of both woodland and savannah types.

As to the soils, the parent rocks from which they were derived were igneous (extrusives and intrusives) and sedimentary (limestones, dolomites, shales, and sandstones). Weathering processes would make available phosphorus, potassium, calcium, and some sodium from the igneous rocks and calcium and magnesium from the limestones and dolomites. The result would be a very fertile soil containing an ample supply of all the minerals necessary for a luxuriant and nutritious vegetation. In view of the above considerations, it can be concluded that this region offered a very nearly optimum environment for herbivorous animals, and that factors which would seriously disturb the endocrine balance were absent.

The estrogens and androgens (sex hormones) (Goldzieher, 1939, p. 289) and the hormone of the adrenal cortex (ibid., p. 93) have an inhibitory effect on the thyrotropic hormone of the anterior lobe of the pituitary, which results in decreased activity of the thyroid. Although estrogens and androgens are present in nearly all foods (ibid., p. 743) and growing plants, and do not appear to be altered by the processes of digestion, they are not secreted in quantity by the gonads till a short period before puberty. It is believed that only a portion of these hormones taken with food find their way into the blood stream. It has been shown that these hormones are inactivated in the liver and are rapidly destroyed by oxidation in the lungs (ibid., p. 748), which greatly reduces their effectiveness when administered by mouth.

In view of the role played by the thyroid in the formation of the teeth by its effect on metabolism and growth, the low estrogen and androgen content of the blood while the deciduous teeth were being formed could result in the advanced type of teeth. That the third permanent premolar is more advanced than the fourth in some species of *Hyracotherium* (Granger, 1908) may be due to the sudden increase in the estrogen and androgen content of the blood during the interval between the formation of these two teeth. If the appearance of the physiological brake on the thyroid furnished by the secretions of the gonads and the adrenal cortex were postponed until after the determination of the form of the permanent teeth by the growth of the tooth germ, it is conceivable that the advanced type of tooth would result. In view of the antagonism between the gonads and the thyroid (Goldzieher, 1939, p. 94), such a deferment could be the result of mild hyperthyroidism.

Family BRONTOTHERIIDAE

Genus LAMBDOTHERIUM Cope

LAMBDOTHERIUM POPOAGICUM Cope

U.S.N.M. No. 18464, right P^3–M^3 (loc. No. 48FR76); U.S.N.M. 18463, right P^2–M^1 (Shoshoni Reservoir); U.S.N.M. No. 18465, loose upper teeth (loc. No. 48FR75).

This genus is generally accepted as the index fossil for the Lost Cabin faunal zone of the Wasatchian, Lower Eocene. Unfortunately, this material is too fragmentary to add anything to our knowledge of this species. Bonillas (1936) has given very good reasons for concluding that only one species existed in the Wind River Basin.

Genus EOTITANOPS Osborn

EOTITANOPS sp.

U.S.N.M. No. 18466, fragment of a right mandible with M_1–M_2 (loc. No. 48FR65); U.S.N.M. No. 19104, loose teeth including P_{3-4} and part of M_1 (loc. No. 48FR79).

This material is too fragmentary to add anything to our knowledge of the genus.

Family ISECTILOPHIDAE

Genus HEPTODON Cope

HEPTODON BROWNORUM Seton

U.S.N.M. No. 18467, badly broken right mandible with P_4–M_3 and portions of the left mandible (loc. No. 48FR65); U.S.N.M. No. 18468, right mandible with P_3–M_2 (loc. No. 48FR80); U.S.N.M. No. 18471, badly crushed skull and jaws with associated skeletal fragments (loc. No. 48FR75).

This material is referred to *Heptodon brownorum* on the basis of size, but it is too fragmentary to add anything to our knowledge of the species.

Order ARTIODACTYLA

Family DICHOBUNIDAE

Genus BUNOPHORUS Sinclair

BUNOPHORUS ETSAGICUS (Cope)

FIGURE 79

U.S.N.M. No. 18370, left mandibular fragment with P_4–M_3 and alveolae for P_{2-3} (loc. No. 48FR76).

This specimen is a younger individual than the type (Sinclair, 1914, p. 273) and shows the characters of the teeth much better. While there are some differences the material is not adequate for specific separation. Anterior mental foramen between P_1 and P_2 and the posterior below the posterior root of P_3; very short diastema between P_2 and P_3, both double rooted; P_4 with a small anterior tubercle, protoconid and deuteroconid well developed, deuteroconid nearly as high as protoconid (Cope, 1884, pl. 25e, fig. 24a, and Sinclair, 1914, fig. 7, indicate that a deuteroconid may have been present but was obliterated by wear), posterior cingulum with tubercle just lateral to median line; paraconid appears to be absent on all of the molars, a faint, discontinuous cingulum present on anterior, external, and posterior borders; hypoconulid on M_3 larger than entoconid and forming a distinct heel.

MEASUREMENTS OF MANDIBULAR FRAGMENT OF BUNOPHORUS ETSAGICUS (IN MILLIMETERS)

	Length	*Width*
P_4–M_3	31.5	------
M_{1-3}	23.3	------
P_4	7.5	4.4
M_1	7.0	6.0
M_2	7.4	6.5
M_3	9.0	7.0

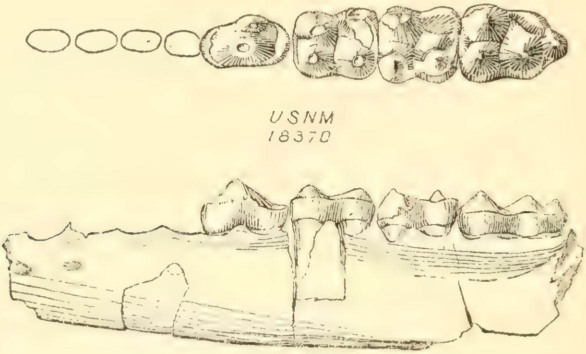

FIGURE 79.—*Bunophorus etsagicus* (Cope), U.S.N.M. No. 18370; occlusal view of teeth and lateral view of left mandible, ×1½.

Genus DIACODEXIS Cope

DIACODEXIS OLSENI Sinclair

U.S.N.M. No. 18472, left mandibular fragment with P_4–M_2 (loc. No. 48FR78).

This material does not permit anything to be added to Sinclair's (1914, p. 292) discussion of the species.

SUMMARY

Since Tertiary reptiles are yet too poorly known to be useful as horizon markers, they will be omitted from the summary. From the Boysen Reservoir area 23 species of fossil mammals have been identified; 14 of them (see Table 2) are common to the Lost Cabin faunal zone of the Lower Eocene, 2 of them to the Gray Bull, and 2 others are common to both the Gray Bull and the Lysite. Consequently, there can be little doubt that these deposits must be referred to the Lost Cabin faunal zone. However, on structural grounds these beds may be somewhat younger than the type section on Alkalai Creek.

There are about 250 feet of the Wind River formation exposed in the Boysen Reservoir area. For the most part the formation consists of drab greenish-gray gypsiferous clays with yellowish, usually fine-grained, channel sandstones forming nearly vertical cliffs. While most of the gypsum is probably secondary there are numerous areas of local concentration caused by seepage of ground water or by capillary

TABLE 2.—*Species of fossil mammals identified from the Boysen Reservoir area*

	Gray Bull	Lysite	Lost Cabin
Didelphodus ventanus			x
Cynodontomys scottianus			x
Cynodontomys lundeliusi, new species			
Esthonyx acutidens			x
Notharctus venticolus			x
Teilhardella sp			
Loveina zephyri [1]			x
Stylinodon cylindrifer			x
Paramys major [1]	x		x
Paramys murinus [1]	x		x
Prolimnocyon antiquus			x
Sinopa strenua	x	x	x
Didymictis altidens			x
Vulpavus australis	x	x	x
Miacis latidens [1]	x		x
Meniscotherium terrarubae			x
Hyopsodus powellianus		x	x
Hyopsodus wortmani			x
Hyracotherium venticolum			x
Lambdotherium popoagicum			x
Eotitanops borealis			x
Heptodon brownorum			x
Bunophorus etsagicus	x		x
Diacodexis olseni			x
Coryphodon sp			

[1] Specimens referred provisionally to this species.

action in poorly drained areas. These areas are just as hazardous to motor vehicles when dry as when wet. Local areas of banded red and greenish clays occur in several places in the Reservoir area, but are usually not more than 50 or 60 acres in extent and grade laterally into the drab-colored clays. Associated with the variegated beds there are usually one or more zones of small calcareous nodules. Nearly all the fossils collected were found in the areas of the banded clays and the best preserved ones were in the nodular zones. The few fossils that were found in the drab clays were usually so badly disintegrated by crystallization of gypsum that they were not worth collecting. Neither the field observations nor the study of the fauna give any indication of a difference in stratigraphic level between the localities. Following is a list of the localities, from which vertebrate fossils were obtained, coded according to the practice of the Smithsonian River Basin Surveys:

48FR65. NE¼SW¼ sec. 5, T. 4 N., R. 6 E., of Wind River meridian. Two prominent buttes, locally known as White Butte, or White Hill, on the south side of Cottonwood (Dry Muddy) Creek at the junction of its valley with that of the Big Horn River. The sediments consist of banded red and greenish clays with local concretionary zones, and are fossiliferous throughout the thickness of the exposure. Probably some of the material collected by J. L. Wortman in 1880, 1891.

and 1896 came from this locality, though most of his localities are rather vague, owing to the absence of cultural landmarks.

48FR75. An area of badlands centering around the corners of secs. 2, 3, 10, and 11, T. 4 N., R. 5 E., of the Wind River meridian on the south side of Cottonwood (Dry Muddy) Creek about 7 miles above the mouth. The sediments here consist of drab greenish-gray shaly clays, which are highly gypsiferous throughout. Yellowish channel sandstones play an important role in the physical features. Fossils are rare in this area and are often so badly rotted with gypsum that they are not worth collecting.

48FR76. SW¼ sec. 5, T. 39 N., R. 94 W., of the 6th principal meridian, on the east side of the Big Horn River and on the north side of Birdseye Creek. A small area of banded red and greenish clays with local concretionary zones. These banded beds grade laterally into the drab gray clays. This locality is one of the most productive in quantity and variety of fossils.

48FR77. NW¼ sec. 1 and NE¼ sec. 2, T. 4 N., R. 5 E., of the Wind River meridian, on the north side of Cottonwood (Dry Muddy) Creek about 4 miles above the mouth. A small area of banded red and greenish clays with considerable gypsum, and local nodular zones. Crossbedded channel sandstones make up a greater part of the sediments here than in any of the other localities. Fossils are rare in this locality and are usually rather badly damaged by gypsum.

48FR78. NE¼NW¼ sec. 32, T. 5 N., R. 6 E., of the Wind River meridian on the north side of Cottonwood (Dry Muddy) Creek near the mouth. A rather large area of banded red and greenish clays with considerable gypsum, and local nodular zones. The fossils were associated with the latter and were usually rather well preserved, though fragmentary. Fossils are scarce in this area and only a small fauna was obtained.

48FR79. SW¼ sec. 29, T. 5 N., R. 6 E., of Wind River meridian. On the west side of Big Horn River about 1 mile north of Cottonwood (Dry Muddy) Creek, north of a fault of unknown displacement which extends across this area about 2 miles south of the mountains. A small area of banded red, yellow, and greenish sandy clay with abundant small calcareous nodules. The only fossils obtained from this locality were broken mammal teeth and fresh-water gastropods.

48FR80. SW¼ sec. 2, T. 4 N., R. 4 E., of Wind River meridian, south side of Cottonwood (Dry Muddy) Creek about 14 miles above the mouth, west side of trail which crosses creek. A small area of banded red and greenish clays with local nodular zones. Channel sandstones are prominent in the upper portion of the exposures.

FIGURE 80.—Map of Boysen Reservoir area showing localities from which vertebrates were obtained.

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There appears to be less gypsum in this locality than in the others. This locality was the most productive in both quantity and variety of fossil mammals.

Table 3 shows the species obtained at each locality.

TABLE 3.—*Distribution of forms by localities*

Mammals recognized from the Boysen Reservoir area	Locality number						
	65	75	76	77	78	79	80
Didelphodus ventanus	x						x
Cynodontomys scottianus			x				x
Cynodontomys lundeliusi	x						
Esthonyx acutidens	x		x		x		x
Notharctus venticolus				x			
Teilhardella sp.							x
Loveina zephyri			x				
Stylinodon cylindrifer			x				
Paramys major			x				x
Paramys murinus							x
Prolimnocyon antiquus	x		x				
Sinopa strenua				x			
Didymictis altidens		x	x				x
Miacis latidens							x
Vulpavus australis			x				
Meniscotherium terrarubae							x
Hyopsodus powellianus		x					
Hyopsodus wortmani	x				x		x
Hyracotherium venticolum	x		x		x		
Lambdotherium popoagicum		x	x		x		
Eotitanops sp.	x		x			x	
Heptodon brownorum	x	x	x				x
Bunophorus etsagicus			x				
Diacodexis olseni					x		x
Coryphodon sp	x						

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A NEW CRAYFISH FROM ALABAMA, WITH NOTES ON PROCAMBARUS LECONTEI (HAGEN)

By Horton H. Hobbs, Jr.

The combined ranges of the members of the Blandingii section of the genus *Procambarus*, excluding mountainous areas, extend from Mexico to Massachusetts, and from Florida to Ohio and Minnesota. The new species described herein is found in a region in which the members of this section have shown the greatest degree of speciation (i. e., in the southeastern part of the United States). Since the species is represented in my collection by only six specimens, taken from the type locality, little is known of its habits and variation, and its range can be postulated only in terms of the known distribution of its close relatives, which presumably have similar habitat preferences. On the basis of the latter it seems probable that it is confined to the Tallapoosa River and its tributaries.

Procambarus lecontei (Hagen, 1870, p. 47) has never been adequately diagnosed, and the published figures (first pleopods, antennal scale, and epistome by Hagen, 1870, and dorsal aspect by Faxon, 1885a) are inadequate and not entirely accurate. Furthermore, since its original description there has been considerable confusion as to its range. In addition to presenting a revised diagnosis of *P. lecontei* and illustrating the diagnostic features, I am including a bibliography of the species and summarizing its known range.

I wish to express my gratitude to Dr. E. C. Raney, R. D. Suttkus, and J. Kezer, of Cornell University, for the gift of the specimens on which the new species is based, as well as to others, mentioned in connection with collection data, who have assisted in collecting specimens of *P. lecontei*.

Abbreviations used to indicate repositories of specimens are as follows:

HHH, my personal collection at the University of Virginia. Note that the date collected may be obtained from the catalog number—6–1649–2a, specimens were collected on June 16, 1949.

MCZ, Museum of Comparative Zoology.

TU, Tulane University.

U.S.N.M., United States National Museum.

Genus PROCAMBARUS Ortmann

Cambarus Ortmann, 1905b, p. 437.

PROCAMBARUS LECONTEI (Hagen)

Figure 81

Cambarus lecontei Hagen, 1870, pp. 10, 45–47, 48,[1] 52, 97,[1] 106,[1] 107 (pp. 100, 101, and 106 not *lecontei*), figs. 15, 18, 145.—Creaser, 1934, p. 4.—Faxon, 1884, pp. 110, 137; 1885a, pp. 17, 19, 22, 24, 29–30,[1] 31, 32, 33, 158,[1] 167,[1] 168,[1] 173, pl. 2, fig. 2; 1885b, p. 358; 1914, p. 413.—Harris, 1903, pp. 58,[1] 107,[1] 138,[1] 144, 151 (pp. 143 and 152 not *lecontei*).—Hay, 1899, pp. 959, 963.—Ortmann, 1902, p. 277; 1905a, pp. 102, 129.

Procambarus lecontei Hobbs, 1942b, p. 342 (by implication); 1942c, pp. 94, 95, 98.

Diagnosis.—Rostrum with lateral spines; areola moderately broad with four or five punctations in narrowest part; cephalothorax granulate laterally, punctate dorsally; a single lateral spine present on each side of carapace. Male with hooks on ischiopodites of third and fourth pereiopods; palm of chela of first-form male not bearded but bearing a row of seven to nine tubercles on inner margin; postorbital ridges terminating cephalad in spines. First pleopod of first-form male with no marked hump on cephalic surface but with a noticeable "knob" on lateral surface opposite the caudal process; tip terminates in four distinct parts (of which all except caudal process are directed caudad at approximately a right angle to main shaft of appendage): mesial process long, slender, subcylindrical, noncorneous, lies considerably proximad of and extends much farther caudad than the other terminal elements; cephalic process moderately short, compressed, corneous, and somewhat hoods the more prominent central projection; caudal process slender, somewhat flattened, corneous, lies proximad of the central projection, and is directed at about a 45° angle to the main shaft of the appendage; central projection compressed, corneous, beaklike, and extends slightly farther caudad than either cephalic or caudal processes. Annulus ventralis as in fig. 81, *d*, decidedly broader than long with a prominent raised area on cephalolateral (dextral or sinistral) side of sinus; sternum immediately cephalad of annulus with multituberculate prominences which extend caudad to cover a portion of annulus.

[1] In part, excluding records from Georgia, Florida, Mississippi, and North Carolina.

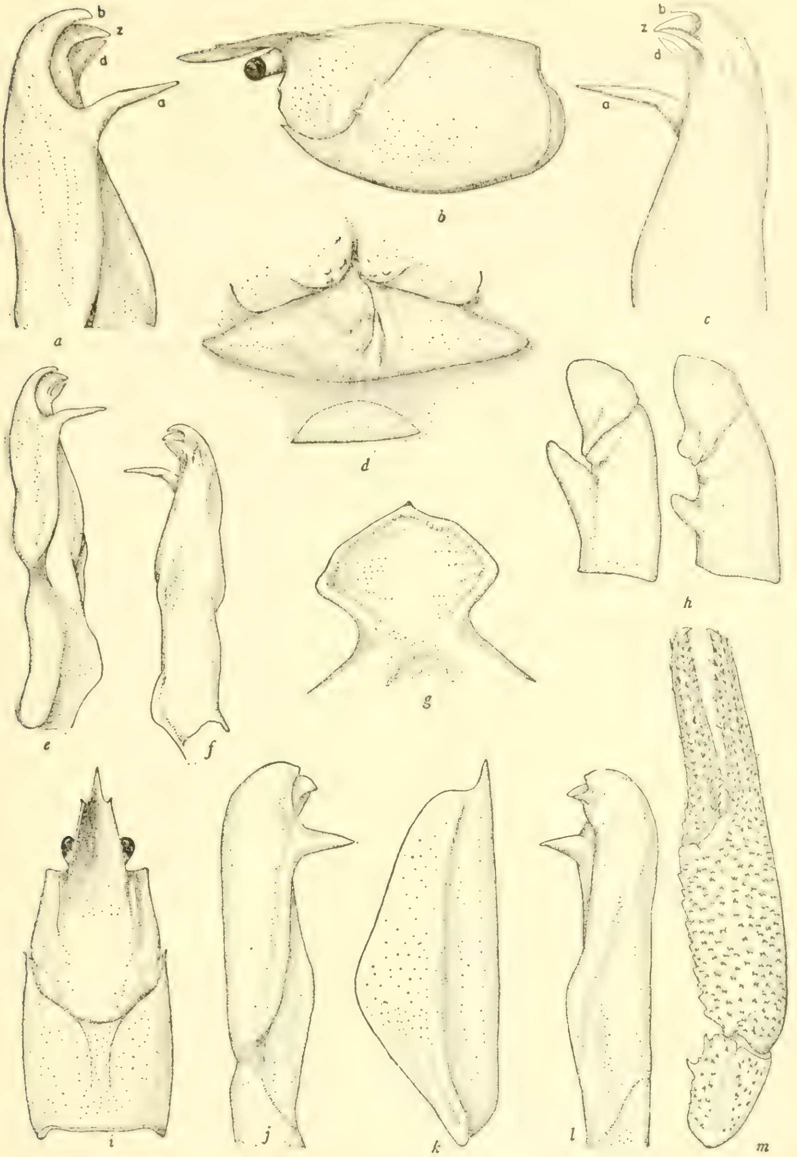

FIGURE 81.—*Procambarus lecontei* (Hagen), from Moores Creek, 8 miles southwest of Mobile on United States Highway 90, Mobile County, Ala.: *a*, Mesial view of first pleopod of male, form I; *b*, lateral view of carapace of male, form I; *c*, lateral view of first pleopod of male, form I; *d*, annulus ventralis; *e*, mesial view of first pleopod of male, form I; *f*, lateral view of first pleopod of male, form I; *g*, epistome of male, form I; *h*, basipodites and ischiopodites of third and fourth pereiopods of male, form I; *i*, dorsal view of carapace of male, form I; *j*, mesial view of first pleopod of male, form II; *k*, antennal scale of male, form I; *l*, lateral view of first pleopod of male, form II; *m*, upper view of chela of male, form I. a=Mesial process; b=cephalic process; d=caudal process; z=central projection. Pubescence removed from all structures illustrated except *m*.

Specimens examined.—ALABAMA: *Mobile County*, MCZ No. 217, Mobile (types) (1 ♂ I, 2 ♂ ♂ II, 7 ♀ ♀); MCZ No. 4958, Mobile (types) (1 ♂ I); HHH No. 6–1649–2a, Clear Creek, 4.7 miles east of Semmes [R. D. Suttkus, C. F. Cole, and R. H. Gibbs] (1 ♂ I, 1 ♀); HHH No. 6–340–1b, 5.6 miles east of Irvington [L. Berner, C. Benton, and HHH] (1 ♂ I, 1 ♂ II, 1 ♀); HHH No. 6–340–9c, 2.5 miles south of Bucks [LB, CB, and HHH] (1 ♀); HHH No. 6–240–5b, 3.5 miles south of Irvington [LB, CB, and HHH] (2 ♂ ♂ I, 2 ♂ ♂ II, 1 ♂ imm.); HHH No. 6–240–2a, 3.8 miles west of Grand Bay [LB, CB, and HHH] (1 ♂ I); HHH No. 6–140–9a, 15 miles southwest of Mobile [LB, CB, and HHH] (1 ♂ I); HHH No. 6–140–8a, 8 miles southwest of Mobile [LB, CB, and HHH] (2 ♂ ♂ I, 1 ♂ II, 2 ♀ ♀, 2 ♀ ♀ imm.); MCZ (no number), Mobile (1 ♂ I dry).

MISSISSIPPI: *Stone County*, HHH No. 6–1649–1, 16.6 miles east of Wiggins [RDS, CFC, and RHG] (1 ♂ II, 2 ♀ ♀); in collection of George H. Penn, Jr., Tulane University, TU. No. 1233, 16 miles east of Wiggins (6/8/49) (2 ♂ ♂ II, 1 ♀).

Remarks.—Faxon (1885a, p. 30) has discussed the locality records cited by Hagen (1870, p. 48), and has indicated that only the specimens mentioned by the latter that were collected from Mobile, Ala., belong to *Procambarus lecontei*.[2] Following his discussion of Hagen's locality records he stated that "besides the Mobile types, I have found but one other specimen of this species in the Museum, a young female in a jar with *C. spiculifer* (Cat. No. 172), from Athens, Ga." I have examined this specimen, which is in a poor state of preservation, and am uncertain as to its identity, but even if it should prove to be *lecontei* there is every reason to doubt the reliability of the label. I have collected on several occasions in the vicinity of Athens, and have received numerous collections made by Dr. Donald C. Scott from that region, and neither of us has found *P. lecontei*. In fact, only two species belonging to the genus *Procambarus* have been found in the Athens region: *P. spiculifer* (LeConte, 1856, p. 401) and *P. pubescens* (Faxon, 1884, p. 109). Furthermore, no other specimen of *lecontei* has been reported east of Mobile County, Ala. Thus *P. lecontei* is known only from the southwestern part of Alabama and the southeastern part of Mississippi, where it is found in tributaries of the Mobile and Pascagoula Rivers.

PROCAMBARUS VERRUCOSUS, new species

FIGURE 82

Diagnosis.—Rostrum with small lateral spines or tubercles, which set off the acumen from basal portion; areola moderately narrow with

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[2] I may add that the specimens from Pensacola, Fla., which Faxon stated were not *lecontei* but of which he made no specific determination, are *Procambarus evermanni* (Faxon, 1890, p. 620) [MCZ No. 249].

three punctations in narrowest part; cephalothorax markedly granulate laterally and in the caudal portion of the areola; a single lateral spine present on each side of carapace. Male with hooks on ischiopodites of third and fourth pereiopods; palm of chela of first-form male not bearded but bearing a row of seven to nine tubercles along inner margin; postorbital ridges terminating cephalad in spines. First pleopod of first-form male with a rounded hump on cephalic margin near distal end, and terminating in four distinct parts: The noncorneous mesial process prominent, acute, and extends caudodistad, and laterad of the other terminal elements; the small, corneous, acutely triangular cephalic process arises from middistal end of appendage; caudal process corneous, and flattened cephalocaudad, corneous, subtriangular, and concave in caudal aspect, and closely applied to caudolateral surface of central projection; central projection corneous, slender, and terminating bluntly, directed caudodistad as are cephalic and caudal processes. Annulus ventralis as in figure 82, *d*, and sternum immediately cephalad of annulus with multituberculate prominences, which extend caudad to cover portion of annulus.

Holotypic male, form I.—Body subovate, somewhat compressed laterally; abdomen narrower than thorax (12.9–14.6 mm. in widest parts, respectively); width of carapace slightly less than depth in region of caudodorsal margin of cervical groove (14.6–15.0 mm.).

Areola moderately narrow, about 7.3 times longer than broad with three punctations in narrowest part, caudal third granulate; cephalic section of carapace about 2.1 times as long as areola (length of areola about 31.9 percent of entire length of carapace).

Margins of rostrum gently converging cephalad, and terminating at base of acumen in a small acute tubercle on each side; acumen not upturned; rostrum excavate above and without swollen margins, and studded with many inconspicuous setae arising from very minute punctations.

Postorbital ridges grooved laterally, and terminating cephalad in acute spines; subrostral ridges moderately well developed, but evident in dorsal aspect only at base; suborbital angle small and obtuse; branchiostegal spine well defined and acute; sides of carapace with an acute spine on each side. Surface of carapace granulate except for cephalodorsal portion of carapace and cephalic two-thirds of areola which are punctate.

Abdomen longer than thorax (34.7–31.9 mm.).

Cephalic section of telson with two spines in each caudolateral corner. Outer dextral spine bidentate.

Epistome semiovate with a distinct cephalomedian projection; entire margin bearing plumose setae.

Antennule with a strong spine on ventral surface of basal segment.

Antenna broken, but in other specimens extends caudad to fourth abdominal segment; antennal scale broad with a well-developed spine on outer distal margin; lamellar portion rounded mesially, and broadest proximad of middle (fig. 82, *k*).

Right chela slender, with inflated palm; palm studded with setiferous tubercles on all surfaces. Inner margin of palm with a row of nine tubercles which are only slightly more prominent than others flanking this row. In addition to squamous tubercles on lower surface of palm a distinctly larger tubercle present near base of dactyl. Fingers not gaping. Opposable margin of immovable finger with a row of three small tubercles on basal fifth, the distal one largest; a strong tubercle extends mesiad from lower opposable margin near midlength of finger; otherwise opposable margin with crowded minute denticles. Opposable margin of dactyl with 2 proximal rows of rounded tubercles: an upper row of 10 and a lower one of 6; between and distad of these 2 rows are crowded minute denticles. A low longitudinal ridge present on upper surface of both fingers; all surfaces of fingers with setiferous punctations except along proximomesial portion of dactyl where squamous tubercles occur in basal sixth.

Carpus of first right pereiopod about 1.7 times longer than broad with the usual oblique furrow on upper surface represented by a broad shallow depression; all surfaces with squamous tubercles, more abundant in mesial half of segment; mesial surface with an oblique row of three spikelike tubercles. Lower mesiodistal margin with a strong acute tubercle, and a similar one on lower laterodistal margin.

Merus of first right pereiopod with 2 irregular rows of tubercles on upper margin and a few scattered ones between; 2 strong acute tubercles in distal portion; lateral surface with scattered punctations; lower surface with two rows of tubercles: lateral row of 14 and mesial row of 16, and in addition a few tubercles on both sides of these 2 rows.

Ischiopodites of third and fourth pereiopods with hooks; hooks simple, that on third extending proximad of ischiopodite, and that on fourth opposed by a tubercle on basipodite. Coxopodites of fourth and fifth pereiopods with ventrally projecting prominences: those on fourth swollen, and those on fifth smaller and less bulbiform.

First pleopods symmetrical and reaching coxopodite of third pereiopod when abdomen is flexed. (See description of pleopod under *Diagnosis.*)

Morphotypic male, Form II.—Differs from the holotype in the following respects: Rostrum more contracted distally; caudal portion of areola punctate; all spines on telson simple; mesial row of tubercles on

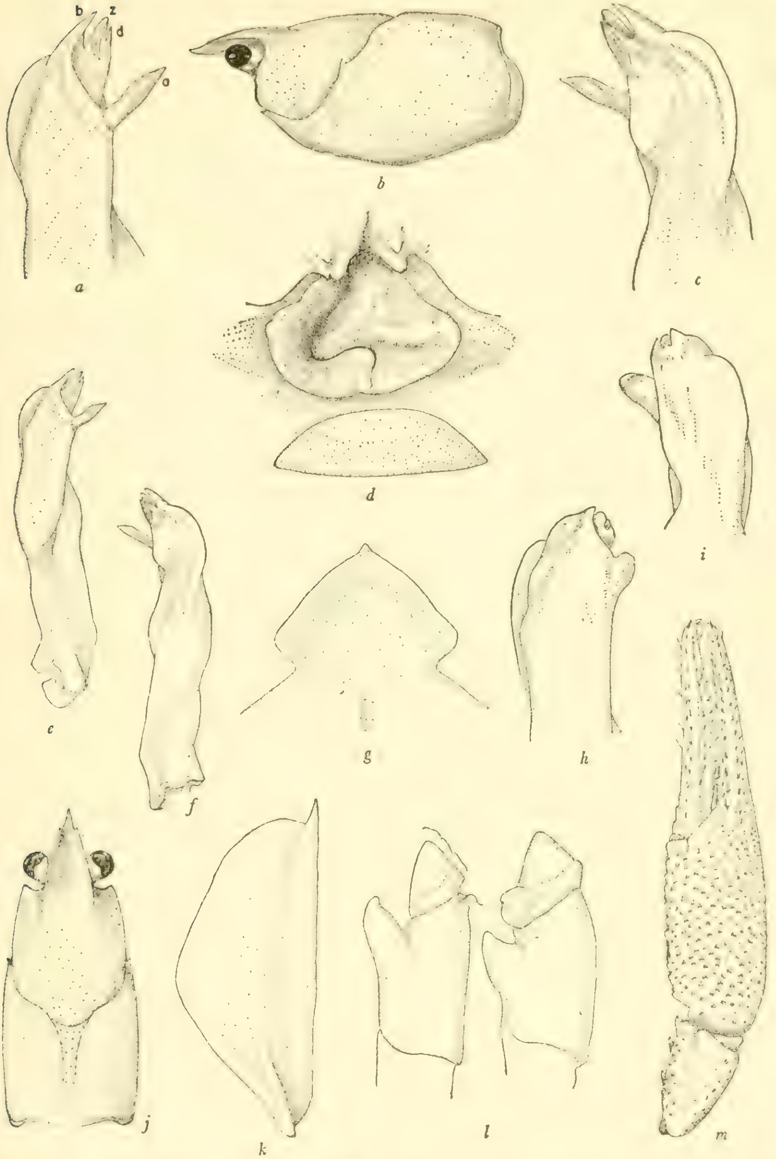

FIGURE 82.—*Procambarus verrucosus*, new species: *a*, Mesial view of first pleopod of holotype; *b*, lateral view of carapace of holotype; *c*, lateral view of first pleopod of holotype; *d*, annulus ventralis of allotype; *e*, mesial view of first pleopod of holotype; *f*, lateral view of first pleopod of holotype; *g*, epistome of holotype; *h*, mesial view of first pleopod of morphotype; *i*, lateral view of first pleopod of morphotype; *j*, dorsal view of carapace of holotype; *k*, antennal scale of holotype; *l*, basipodites and ischiopodites of third and fourth pereiopods of holotype; *m*, upper view of chela of holotype. a = Mesial process; b = cephalic process; d = caudal process; z = central projection. Pubescence removed from all structures illustrated except *m*.

carpus of cheliped consisting of 4 instead of 3; only 1 acute tubercle (spine) present near upper distal end of merus of cheliped, and lower surface of same podomere with 14 tubercles in mesial row. The usual secondary sexual differences occur with smaller hooks on ischiopodites of third and fourth pereiopods and less well-developed armature of the coxae of the fourth and fifth pereiopods. First pleopod with all terminal elements represented and disposed as illustrated (fig. 82, *h*, *i*). Accessory shoulder, typical of the group of which this species is a member, lies more laterad in the second-form male. (See *Measurements.*)

Allotypic female.—Differs from the holotype in the following respects: Caudal portion of areola punctate; sinistral outer spine of telson broken but was bidentate; chela comparatively broader and shorter with upper opposable margin of immovable finger bearing a row of 5 tubercles, of which the second from base is largest, and lower opposable margin with 1 large tubercle at base of distal two-fifths; opposable margin of dactyl with a row of 7 tubercles, of which third from base is largest; lower mesial row of 14 tubercles on merus of cheliped.

Sternum immediately cephalad of annulus ventralis with paired caudally projecting tuberculate prominences which extend over (ventrally) the cephalic margin of the latter. Annulus ventralis (fig. 82, *d*) irregularly shaped with its greatest length in the transverse axis. Dextral wall very high and relatively thin; cephalosinistral wall much thicker and of more irregular contour. Sinus originates near cephalic margin of annulus and extends caudodextrad slightly caudad of midlength; here it makes an S-curve just crossing the median line and turns caudad and slightly dextrad almost to caudal margin of annulus.

Measurements (in millimeters).—

	Holotype	*Allotype*	*Morphotype*
Carapace:			
Height	15. 0	15. 9	14. 2
Width	14. 6	15. 8	15. 1
Length	31. 9	33. 2	30. 6
Areola:			
Length	10. 1	10. 4	9. 9
Width	1. 5	1. 5	1. 4
Rostrum:			
Length	9. 0	9. 2	8. 6
Width	6. 4	5. 6	5. 3
Right chela:			
Length, inner margin of palm	10. 9	6. 1	7. 3
Width of palm	6. 9	6. 0	4. 6
Length, outer margin of hand	28. 2	17. 0	19. 2
Length of dactyl	15. 3	10. 1	10. 5

Type locality.— A tributary of Calebea Creek [Alabama River system], 3.9 miles south of Tuskegee, Macon County, Ala., on United States Highway 29. The specimens on which this description is based were collected by Dr. E. C. Raney, of Cornell University, on March 24, 1948, and he has kindly furnished me with the following data: At this locality the stream is clear, about 10 feet wide and 3 feet deep, sandy-bottomed, and with a volume flow of 5 cubic feet per second. The stream flows through an open pasture, and at the time the collection was made the temperature of the air was 80° F., and that of the water 65° F.

Disposition of types.—The holotypic male, form I, allotypic female, and morphotypic male are deposited in the United States National Museum (No. 90743). The paratypes, consisting of one male, form I, one male, form II, and one female, are in my personal collection at the University of Virginia (No. 3–2448–3b).

Relationships.—*Procambarus verrucosus*, a member of the Blandingii group (Hobbs, 1942b, p. 341), has its closest affinities with *Procambarus blandingii acutus* (Girard, 1852, p. 91). However, it may readily be distinguished from it by the more complexly appearing annulus ventralis of the female, and the structure of the first pleopod of the male. The *caudal knob* of the first pleopod has assumed a markedly different position in *P. verrucosus* from that in some of the other species of this group, in which this knob more closely resembles that of the hypothetical generalized pleopod (Hobbs, 1942a, p. 58). In *P. hayi* (Faxon, 1884, p. 108) the caudal knob (which has been prolonged proximally into a long irregular fold) lies on the caudolateral face of the appendage at the base of the caudal process; in *P. blandingii acutus*, while the caudal knob is distinctly knoblike, it has shifted caudolaterad and lies at the cephalolateral base of the cephalic process; in *P. verrucosus* there has been a still stronger degree of shifting in a cephalic direction so that it forms a rounded shoulder on the cephalic border of the appendage. Were it not for the intermediate stages of shifting of the "caudal knob" which have been observed in specimens tentatively identified as *P. blandingii acutus* (a subspecies that has never been clearly defined) one would hardly suspect that the "shoulder" on the pleopod of *P. verrucosus* had any relationship to that of the more "typical" caudal knob as occurs in *P. pictus* (Hobbs, 1940, p. 419) and the "less typical" one in *P. hayi*.

Remarks.—The annulus ventralis of the allotype contains a sperm plug, which indicates that this species breeds in the early spring; however, it should be pointed out that this does not mean that this species does not breed during summer, fall, or winter.

Collected with *P. verrucosus* in the type locality were five specimens of *P. versutus* (Hagen, 1870, p. 51).

The name *verrucosus* refers to the granulate condition of the carapace.

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MOTHS OF THE GENERA MULONA WALKER AND LOMUNA, A NEW AND CLOSELY RELATED GENUS (ARCTIIDAE: LITHOSIINAE)

By William D. Field

The two genera of moths [1] treated in this paper are found only in the Greater Antilles and the Bahama Islands. Until the present time they have been treated as a single genus with three species, *Mulona lapidaria* Walker, *Mulona nigripuncta* Hampson, and *Mulona grisea* Hampson.[1] A careful study of the 47 known specimens from the collections of the United States National Museum, the British Museum (Natural History), the American Museum of Natural History, the Carnegie Museum, and Cornell University, disclosed two genera and six species involved in the complex.

Palpal, antennal, and venational characters are identical in the two genera treated in this paper and are given here to avoid repetition in the generic descriptions. Labial palpus upturned, reaching middle or slightly above middle of frons. Antenna of male and female filiform and gradually more slender to the tip; each subsegment with two pairs of bristles, one from near or above middle of ventrolateral margin of subsegment, the second much smaller and just behind the first; subsegments pubescent. Venation of forewing with vein 2 from middle of cell or from just before or after middle, downward curved at base; vein 3 from just below lower angle of cell; veins 4 and 5 separate, 4 from lower angle, 5 from slightly above lower angle (in one of the 5 specimens of *Lomuna nigripuncta* Hampson, 4 and 5 are connate or extremely short stalked); vein 6 from below upper angle of cell; vein 9 from stalk of 7 and 8 or rarely 7 from stalk of 8 and 9;

[1] The species *Autoceras phelina* Druce was placed in *Mulona* by Hampson (Catalogue of the Lepidoptera Phalaenae in the British Museum, vol. 2, p. 387, 1900). It does not belong in *Mulona* and was transferred to the genus *Gaudeator* Dyar by Forbes (Bull. Mus. Comp. Zool., vol. 85, No. 4, p. 183, 1939).

veins 10 and 11 free; vein 10 from middle or nearer stem 7, 8, and 9 than to 11; vein 11 from beyond middle of cell and curved toward 12, distally coincident with 12. Venation of hindwing with vein 2 from outer third of cell or beyond; vein 3 stalked with 4 from lower angle of cell; vein 5 absent; vein 6 separate from 7 or sometimes connate or stalked with 7 (in the single female specimen of *Mulona manni*), 6 from upper angle, 7 from before upper angle of cell; vein 8 from before middle of cell.

KEY TO THE INCLUDED GENERA, BASED UPON GENITALIA

1. Male with uncus short and broadly bilobed; gnathos absent; anellus bifurcate with arms weakly sclerotized and short, one-eighth or less the length of harpes; female with ductus bursa cylindrical, not at all flattened; posterior genital plates absent------------------------**Lomuna,** new genus

   Male with uncus long, not bilobed, either slender, curved and hooklike, or broad and hoodlike; gnathos present; anellus bifurcate with arms strongly sclerotized and with arms long, nearly as long or longer than harpes; female with ductus bursa flat, not sclerotized or only partially sclerotized; posterior genital plate present-------------------------**Mulona** Walker

Genus MULONA Walker

Mulona Walker, List of specimens of lepidopterous insects in the collection of the British Museum, vol. 35, p. 1896, 1866.—Hampson, Catalogue of the Lepidoptera Phalaenae in the British Museum, vol. 2, pp. 386–388, 1900.—Draudt, *in* Seitz, Gross-schmetterlinge der Erde, vol. 6, p. 252, 1918.—Forbes, Scientific survey of Porto Rico and the Virgin Islands, vol. 12, pt. 1, p. 33, 1930.—Strand, *in* Wagner, Lepidopterorum catalogus, pars 26, p. 732, 1922.

Genotype.—Mulona lapidaria Walker. Monobasic.

Labial palpus, antenna, and venation as described on page 221.

Male genitalia (pl. 10, figs. 2–6) with uncus slender, curved and hooklike in some species and broad and hoodlike in others, terminating in a short constricted point in all species, this point usually blunt; gnathos weakly sclerotized and divided, forming two broad short lobes; anellus bifurcate with stongly sclerotized arms and these arms nearly as long or longer than harpes; transtilla present and wholly or partially fused; vinculum triangular to nearly round; aedeagus thick throughout, distally broad and blunt and armed with various broad, sometimes dentate lobes; ductus ejaculatorius entering anterior end of aedeagus; vesica with numerous scobinations; harpe with an apical lobe or arm (the cuiller) and with a clavus and with a third arm from base of costa (except in *M. schausi* where apex of harpe is a broad rounded lobe and clavus is greatly reduced).

Female genitalia (pl. 11, figs. 8–11) with ductus bursa nearly flat and only partially sclerotized, with two separate sclerotized latero-ventral plates near ostium bursae or with ductus bursae flat and almost entirely sclerotized, triangular or subtriangular; bursa copulatrix obpyriform or subspherical, longer than broad and heavily and completely serratulate through middle two-thirds or more; seventh sternum not modified, weakly sclerotized; eighth sternum with sclerotized bilobed lip at posterior margin (the posterior genital plate), each lobe with sclerotized arm extending anteriorly to ductus bursa; with bilobed invaginated sac on dorsal surface immediately before ovipositor.

Remarks.—As defined above *Mulona* contains five species and is confined to the Greater Antilles and the Bahama Islands.

KEY TO THE SPECIES OF MULONA

1. Males 2
   Females 6
2. Uncus broad and hoodlike (pl. 10, figs. 5, 6) 3
   Uncus slender, curved and hooklike (pl. 10, figs. 2, 3, 4) 4
3. Apex of harpe pointed and sharply bent back; clavus as broad as long; harpe without long sharp arm from base of costa (pl. 10, fig. 5) ...**manni**, new species
   Apex of harpe rounded and recurved but not sharply bent back; clavus longer than broad; harpe with a long sharp arm from base of costa (pl. 10, fig. 6) ....**barnesi**, new species
4. Anellus with arms of equal length; harpe with costal arm absent (pl. 10, figs. 3, 4) 5
   Anellus with arms subequal in length; harpe with costal arm nearly equal in length and subparallel to apical arm (pl. 10, fig. 2) ......**grisea** Hampson
5. Harpe with apical arm present, about four times as long as broad, recurved; arms of anellus divergent at free end (pl. 10, fig. 3) ..**lapidaria** Walker
   Harpe without apical arm, apex broadly rounded; arms of anellus directed toward each other at free end (pl. 10, fig. 4) ....**schausi**, new species
6. Ductus bursa partially sclerotized with two separate, sclerotized lateroventral bilobed plates near ostium bursae (pl. 11, figs. 10, 11) 7
   Ductus bursa almost entirely sclerotized and without separate sclerotized plates (pl. 11, figs. 8, 9) 8
7. These plates nearly flat and only slightly upturned anteriorly (pl. 11, fig. 11). **barnesi**, new species
   These plates distinctly curved and greatly upturned anteriorly (pl. 11, fig. 10) ....**manni**, new species
8. Ductus bursae with sclerotized plate nearly triangular (pl. 11, fig. 9). **schausi**, new species
   Ductus bursae with sclerotized plate bilobed near entrance to bursa copulatrix (pl. 11, fig. 8) ....**grisea** Hampson

1. MULONA GRISEA Hampson

PLATE 10, FIGURES 2, 2A; PLATE 11, FIGURE 8

Mulona grisea HAMPSON, Catalogue of the Lepidoptera Phalaenae in the British Museum, vol. 2, p. 388, pl. 29, fig. 30, 1900.—DRAUDT, *in* Seitz, Grossschmetterlinge der Erde, vol. 6, p. 252, pl. 32, fig. L 8, 1918.—STRAND, *in* Wagner, Lepidopterorum catalogus, pars 26, p. 732, 1922.

Male.—Palpus light gray or white below, dark fuscous above. Antenna and head white or light gray tinged with yellow or brown, sometimes darker. Mesoscutum, patagium, tegula, and mesoscutellum white or light gray, sprinkled with brownish scales. A light brown spot at center of hind margin of mesoscutellum. Legs dirty white to pale yellow or brown, fuscous along inner sides of foreleg and with midlegs and hindlegs sometimes faintly banded. Abdomen dirty white. Forewing above gray or grayish white, heavily irrorated with light brown and with the following small dark brown or black spots: one at costa near base of wing; one just below cell and at about the basal one-fourth of cell; a row of four, crossing wing just before middle, the first of these on costal margin, the third just below middle of cell, and the fourth immediately below the third and on the anal vein, the second out of line with the other three and located below front margin of cell near origin of subcosta. There are three of these spots just beyond end of cell, one near lower angle of cell at the base of veins 3, 4, 5, one near upper angle of cell at the base of veins 6 and 7+8+9 and the third just above these on costal margin; three or four submarginal spots cross the wing from costa to hind margin, these usually very indistinct. In the middle of cell near the outer end is a minute orange or orange-yellow spot. Forewing below pale brown, whitish along middle of costa, fringe dirty white above and below. Hindwing above and below pale brown or light fuscous, base much lighter, sometimes dirty white. A large patch of white or grayish white specialized scales along middle of costa covered by forewing.

Length of forewing, 8–9.5 mm.

Male genitalia as illustrated (pl. 10, fig. 2) and with characters as given in the key.

Female.—Habitus entirely like the male.

Length of forewing, 10 mm.

Female genitalia as illustrated (pl. 11, fig. 8) and with characters as given in the key.

Type locality.—Jamaica.

Additional type data.—Described from the holotype (as type), female (Jamaica; J. J. Bowry; ♀ genitalia preparation, British Museum No. 1947–272) and from a male (same locality as female) not designated type in original description.

Location of type.—In the British Museum (Natural History.)

Distribution.—JAMAICA: *St. Andrew Parish,* Kingston, Mount Mansfield House, Gordon Town (July); *Clarendon Parish,* Milk River (August); *Manchester Parish,* Mandeville (June, July, November), Newport (February); *St. Elizabeth Parish,* Balaclava (June). Locality in Jamaica for which the parish is uncertain: May Hill (July).

Twenty-six specimens examined.

Remarks.—The genitalia of the type of *M. grisea* was compared with the figure of the female of this species (pl. 11, fig. 8) by D. S. Fletcher, of the Department of Entomology, British Museum (Natural History). He found the type of *grisea* to be the species I have illustrated.

2. MULONA SCHAUSI, new species

PLATE 10, FIGURES 4, 4A; PLATE 11, FIGURE 9

Male.—Habitus very much like that of *Mulona grisea* Hampson. All dark spots on forewing above slightly more indistinct, orange spot as in *grisea.* Hindwing above paler, nearly white, slightly darker along outer angle and with a large dark brown patch of specialized scales along middle of costal margin, extending to below front margin of cell, this area covered by the forewing. Abdomen white above, darker, more brownish below.

Length of forewing, 10–11 mm.

Male genitalia as illustrated (pl. 10, fig. 4) and with characters as given in the key.

Female.—Habitus similar to that of male, forewing above suffused with a dirty yellowish color, particularly along outer margin. Hindwing above and below entirely light fuscous with white fringes.

Length of forewing 10 mm.

Female genitalia as illustrated (pl. 11, fig. 9) and with characters as given in the key.

Type locality.—Matanzas, Province of Matanzas, Cuba.

Additional type data.—Described from the holotype, male (locality as listed above, type U. S. N. M. No. 34830; collection William Schaus; ♂ genitalia slide W. D. F. No. 1655, 1941); allotype, female (Santiago de las Vegas, Province of Habana, Cuba; January 24, 1933; A. Otero; ♀ genitalia slide W. D. F. No. 1661, 1941) and one paratype, male (Province of Habana, Cuba; Father Roberto; ♂ genitalia preparation, British Museum No. 88–1949).

Location of types.—Holotype and allotype in the United States National Museum. Paratype in the British Museum of Natural History.

Distribution.—CUBA: *Province of Habana,* Habana, Santiago de las Vegas (January); *Province of Matanzas,* Matanzas.

Three specimens (all known) examined.

Remarks.—Species named for the late William Schaus.

3. MULONA MANNI, new species

PLATE 10, FIGURES 5, 5A; PLATE 11, FIGURE 10

Male.—Very similar to *Mulona grisea* but smaller, usually with a dark spot along middle of outer margin of patagium. Forewing above with a marginal row of small dark spots not found in *M. grisea* or *M. schausi,* orange spot absent. Hindwing above and below somewhat paler than in *grisea* and about as in *schausi.* Specialized scales near base at costa and pale in color. Abdomen white to pale brown.

Length of forewing, 6.5–8 mm.

Male genitalia as illustrated (pl. 10, fig. 5) and with characters as given in the key.

Female.—Habitus very much like the male, hindwing above entirely white.

Length of forewing, 7 mm.

Female genitalia as illustrated (pl 11, fig. 10) and with characters as given in the key.

Type locality.—Mangrove Cay, Andros Island, Bahamas.

Additional type data.—Described from the holotype, male (locality as listed above; type U. S. N. M. No. 34831; William M. Mann; ♂ genitalia slide W. D. F. No. 1663, 1941); allotype, female (same locality and data as holotype; ♀ genitalia slide W. D. F. No. 1664, 1941); paratypes Nos. 1–4, males (same locality as holotype; January 11, 1902; J. L. Bonhote), paratype No. 5, male (Bahamas; Carter; Walsingham collection), and paratype No. 6, male (Little Abaco, Bahamas; March 1902; J. L. Bonhote; ♂ genitalia preparation, British Museum No. 274–1947).

Location of types.—Holotype and allotype in the United States National Museum. Paratypes Nos. 1–6 in the British Museum (Natural History).

Distribution.—BAHAMAS: Andros Island, Mangrove Cay (January), Little Abaco (March).

Eight specimens (all known) studied.

Remarks.—Species named for Dr. William M. Mann, who collected the holotype and allotype.

4. MULONA LAPIDARIA Walker

PLATE 10, FIGURES 3, 3A

Mulona lapidaria WALKER, List of specimens of lepidopterous insects in the British Museum, vol. 35 (supplement part 5), p. 1,896, 1866.—KIRBY, Synonymic catalogue of Lepidoptera Heterocera, vol. 1, p. 366, 1892.—HAMPSON, Catalogue of the Lepidoptera Phalaenae in the British Museum, vol. 2, p. 287, 1900.—DRAUDT, *in* Seitz, Gross-schmetterlinge der Erde, vol. 6, p. 252, pl. 34, figure D 9, 1918.—STRAND, *in* Wagner, Lepidopterorum catalogus, pars 26, p. 732, 1922.

Male.—This species is closely related to *Mulona manni*. Head and thorax white tinged with pale brown. Forewing above white irrorated with brown, with marginal row of small dark spots as in *manni*. The row of four small dark-brown spots crossing wing just before middle are faintly connected, forming a zigzag line. There is a faint black submarginal streak in lower half of wing nearly parallel to outer margin and a similar streak starting at costa from just before middle of wing, bending down from costa and continuing parallel to costa to near apex, where it is bent upward to costa. With a minute pale yellow spot in middle of cell near outer end. Hindwing above white, outer margin and apex tinged with brown.

Length of forewing, 9 mm.

Male genitalia as illustrated (pl. 10, fig. 3) and with characters as given in the key.

Female.—Unknown.

Type locality.—Santo Domingo ("St. Domingo").

Additional type data.—Described from a single male specimen, the holotype (St. Domingo; Tweedie; genitalia preparation, British Museum No. 1947–275).

Location of type.—In the British Museum (Natural History).

Distribution.—SANTO DOMINGO.

Remarks.—D. S. Fletcher, of the Department of Entomology, British Museum (Natural History), was kind enough to dissect this holotype and send me a photograph of the genitalia. A drawing was made from this photograph and this drawing was checked by Mr. Fletcher for accuracy.

5. MULONA BARNESI, new species

PLATE 10, FIGURES 6, 6A; PLATE 11, FIGURE 11

Male.—Similar to the other species of *Mulona*. Forewing above white, the small dark spots usually found in species of this genus are greatly reduced and are missing in the lower half of the wing. Small orange spot in middle of cell near outer end as in *M. grisea* and *M. schausi*. Forewing below white suffused with pale brown. Hindwing above and below slightly brownish along outer margin.

Length of forewing, 8.5–10 mm.

Male genitalia as illustrated (pl. 10, fig. 6) and with characters as given in the key.

Female.—Habitus similar to that of male. Dark spots on forewing above more abundant than in male and hindwing above light brown, paler and whitish at base.

Length of forewing, 9 mm.

Female genitalia as illustrated (pl. 11, fig. 11) and with characters as given in the key.

Type locality.—Santiago de Cuba, Province of Oriente, Cuba.

Additional type data.—Described from the holotype, male (locality as given above; type U. S. N. M. No. 34832; William Schaus; ♂ genitalia slide W. D. F. No. 1657, 1941); allotype, female (same locality as holotype; collection Schaus and Barnes; September; ♀ genitalia slide W. D. F. No. 1660, 1941); paratype No. 1, male (same data as holotype, ♂ genitalia slide W. D. F. No. 1656, 1941) and paratype No. 2, male (Holguin, Province of Oriente, Cuba; H. S. Parish; ♂ genitalia preparation, British Museum No. 1949–89).

Location of types.—Holotype, allotype, and paratype No. 1 in the United States National Museum. Paratype No. 2 in the British Museum (Natural History).

Distribution.—CUBA: *Province of Oriente,* Santiago de Cuba (September), Holguin.

Four specimens (all known) studied.

Remarks.—Species named for the late John T. Barnes, old friend, constant companion, and assistant to the late William Schaus.

LOMUNA, new genus

Genotype.—*Mulona nigripuncta* Hampson.

Labial palpus, antenna, and venation as described in the introduction.

Male genitalia (pl. 10, fig. 1) with uncus very short and broadly bilobed; gnathos absent; anellus with ventrobasal plate broad and rectangular, entirely fused to harpes and bifurcate at posterior end and with arms very weakly sclerotized and very short, one-eighth or less the length of harpes; transtilla present and partially fused across middle; vinculum with saccus expanded, almost as long as broad and rounded below; aedeagus thick throughout, distally broad and bilobed; ductus ejaculatorius entering anterior end of aedeagus; vesica with numerous scobinations; harpe deeply divided apically into three long and slender arms.

Female genitalia (pl. 11, fig. 7) with ductus bursa sclerotized, cylindrical, not at all flattened; bursa copulatrix subspherical, slightly longer than broad and heavily and completely serratulate through middle two-thirds; seventh and eighth sternae not modified and weakly sclerotized (without anterior and posterior genital plates); with bilobed invaginated sac on dorsal surface immediately before ovipositor.

Remarks.—As defined above *Lomuna* contains a single species known only from Puerto Rico (see remarks on type locality under *L. nigripuncta* Hampson).

LOMUNA NIGRIPUNCTA (Hampson)

PLATE 10, FIGURE 1, 1A; PLATE 11, FIGURE 7

Mulona nigripuncta HAMPSON, Catalogue of the Lepidoptera Phalaenae in the British Museum, vol. 2, pp. 387, 388, pl. 29, fig. 6, 1900.—DRAUDT, *in* Seitz, Gross-schmetterlinge der Erde, vol. 6, p. 252, pl. 29, fig. L 9, 1918.—STRAND, *in* Wagner, Lepidopterorum catalogus, pars 26, p. 732, 1922.—FORBES, Scientific survey of Porto Rico and the Virgin Islands, vol. 12, pt. 1, p. 33, 1930.—WOLCOTT, Journ. Agr., University of Puerto Rico, vol. 20, No. 1, p. 415, 1936.

Male.—Habitus somewhat like that of *Mulona grisea* Hampson but with black spots on forewing more distinct and more nearly round. Palpi dark fuscous except along ventral surface, where color is white. Head, antenna, and thorax white, sometimes pale yellow or brown on thorax. Forewing above white with black spots arranged as in *grisea* but with an additional black spot in base of wing on the base of anal vein. The orange or yellow spot found in the middle of the cell near the outer end in *M. grisea*, *M. schausi*, *M. barnesi*, and *M. lapidaria* is present in *M. nigripuncta* and is orange or yellowish orange. Forewing below nearly white along hind and outer margins, pale brown over rest of wing. Hindwing above and below entirely white. Specialized scales found in *grisea* near costal margin of hindwing are absent in *nigripuncta*. Legs as in *grisea*.

Length of forewing, 8–8.5 mm.

Male genitalia as illustrated (pl. 10, fig. 1).

Female.—Habitus similar to that of the male. Forewings above irrorated with black scales. This irroration sometimes heavy and therefore habitus sometimes much darker than male. Forewing below entirely light fuscous, sometimes paler along hind margin. Hindwing above and below pale fuscous, nearly white or pale gray in base of wing.

Length of forewing, 8–9 mm.

Female genitalia as illustrated (pl. 11, fig. 7).

Type locality.—Probably Puerto Rico. NOTE: Hampson cites the type locality as "Colombia" and his type is labeled "nigripuncta, Z., Columb., M. Ber." in Zeller's own handwriting. It is a specimen that Zeller intended to describe and the specimen came originally from the Berlin Museum. This species is known only from Puerto Rico and is not known from Colombia. The species of this group and other closely related groups are very limited in their distribution and hence it is extremely doubtful that the type of *nigripuncta* came from Colombia.

Additional type data.—Described from a single specimen, the holotype, female (locality cited as Colombia but probably is Puerto Rico; collection Zeller; Berlin Museum; ♀ genitalia preparation, British Museum No. 1947–273). Hampson also cites Puerto Rico as a habitat for *nigripuncta* but he does not list number of specimens or sexes for this locality. He had evidently seen specimens other than the type from Puerto Rico; however these were not before him at the time he wrote his original description, hence the single specimen mentioned above is indeed the holotype.

Distribution.—PUERTO RICO: *District of Guayama*, Palmas Abajas, near Guayama (June); *District of San Juan*, Manati (June), Bayamon (July); *District of Aguadilla*, Lares (July); *District of Mayagüez*, San German (April).

Five specimens examined.

Remarks.—The genitalia of the type of *nigripuncta* was compared with the figure of the female of this species (pl. 11, fig. 7) by D. S. Fletcher of the Department of Entomology, British Museum (Natural History). He found the type of *nigripuncta* to be the species there illustrated.

PLATES

The drawings for figures 3 and 3A were made by the author from a photograph of the genitalia of the type. These two drawings were corrected and modified by D. S. Fletcher, of the Department of Entomology, British Museum (Natural History), by comparison with the actual type preparation. Arthur D. Cushman, of the U. S. Bureau of Entomology and Plant Quarantine, made the drawing of the bursa copulatrix and ductus bursae in figure 8 (from an imperfect specimen in the Carnegie Museum) and the drawings of the remaining figures. The rest of figure 8 was drawn from the type by Mr. Fletcher. The following figures were based upon the preparations of the holotypes of the respective species: 3, 3A, 4, 4A, 5, 5A, 6 and 6A. Figures 9, 10, and 11 were drawn from the allotypes of the respective species. Figures 1 and 1A were drawn from slide W. D. F. No. 1651, 1941. Figures 2 and 2A were drawn from slide W. D. F. No. 1658, 1941. Figure 7 was drawn from slide W. D. F. No. 1662, 1941. These three slides were all compared with the genitalia preparations of the types in the British Museum (Natural History).

The size of the genitalia on these plates is indicated by the straight lines placed near the figures. These lines indicate 1 mm.

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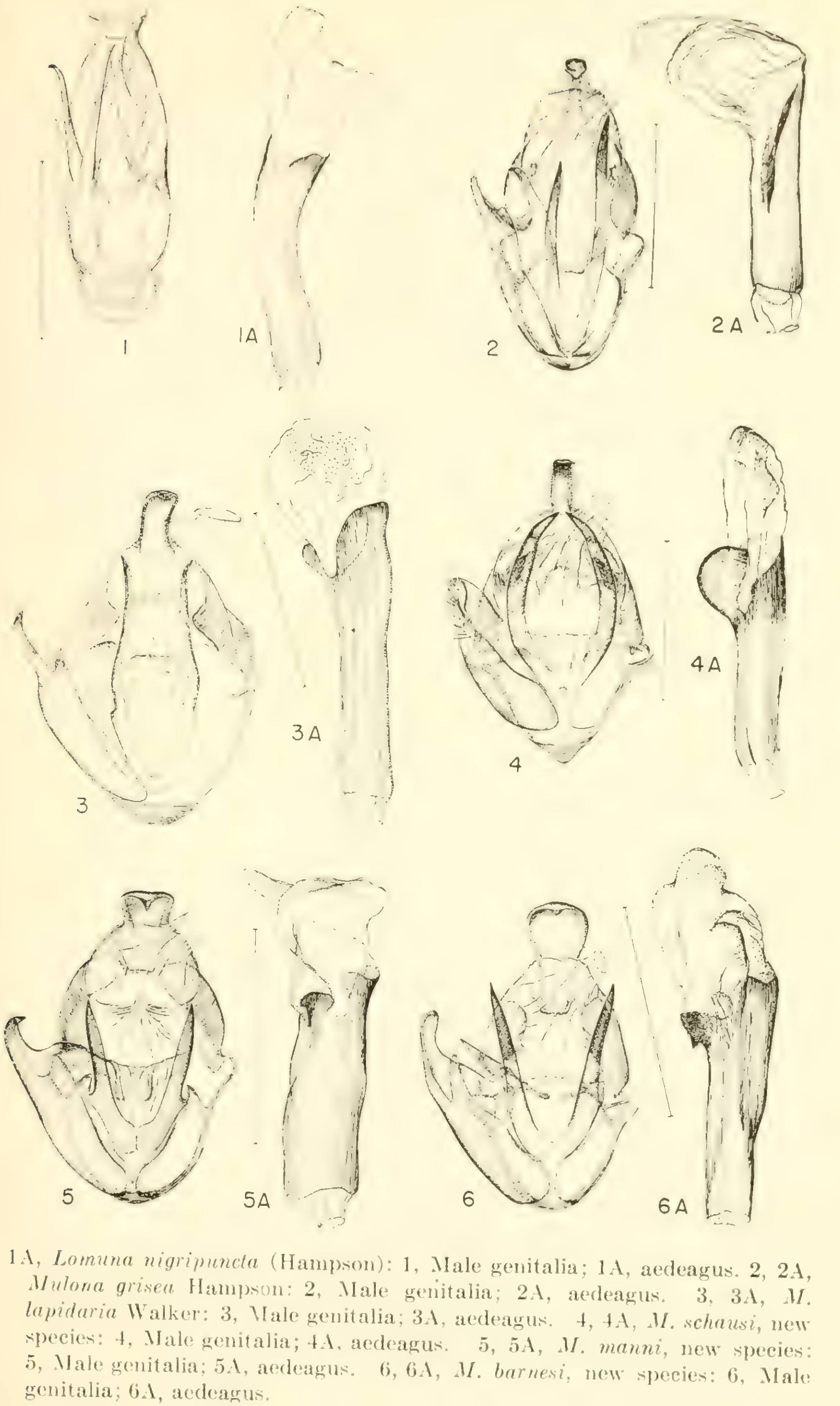
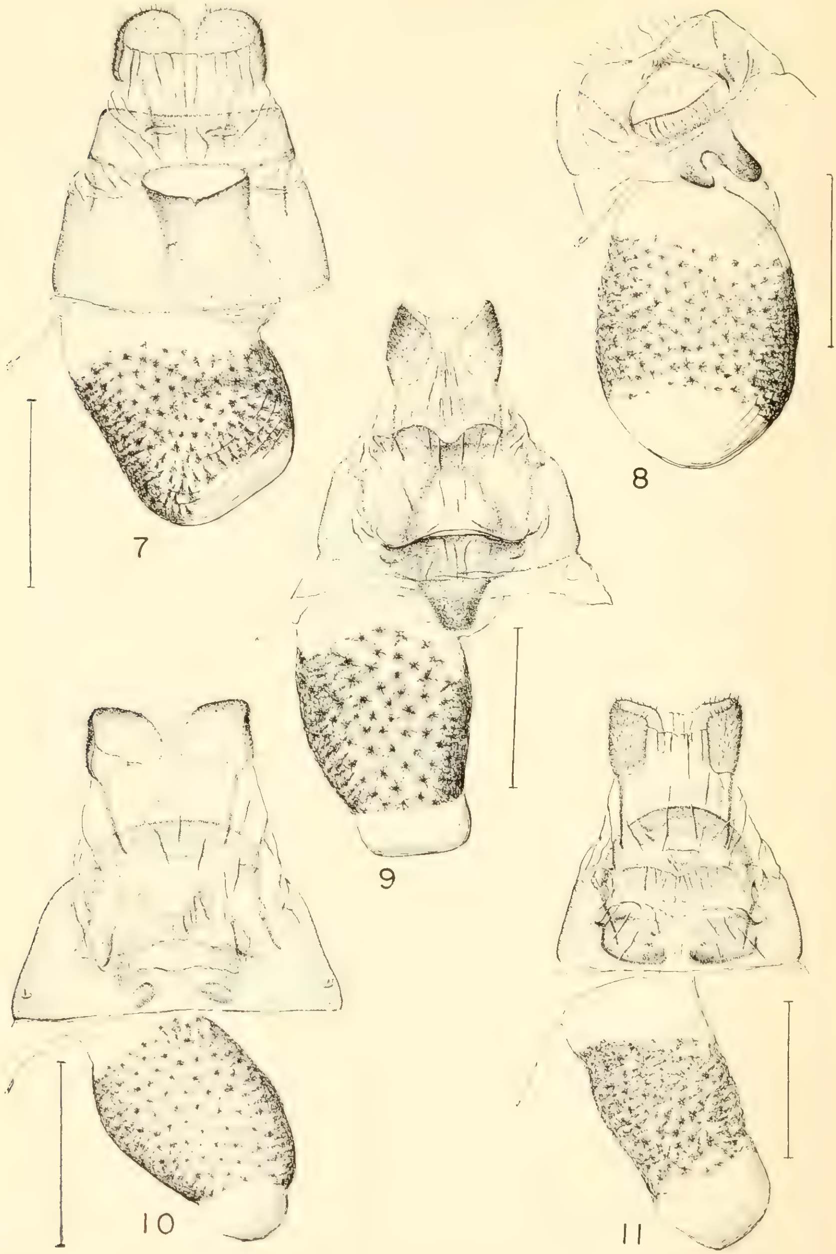


1, 1A, *Lomuna nigripuncta* (Hampson): 1, Male genitalia; 1A, aedeagus. 2, 2A, *Mulona grisea* Hampson: 2, Male genitalia; 2A, aedeagus. 3, 3A, *M. lapidaria* Walker: 3, Male genitalia; 3A, aedeagus. 4, 4A, *M. schausi*, new species: 4, Male genitalia; 4A, aedeagus. 5, 5A, *M. manni*, new species: 5, Male genitalia; 5A, aedeagus. 6, 6A, *M. barnesi*, new species: 6, Male genitalia; 6A, aedeagus.



Female genitalia of: 7, *Lomuna nigripuncta* (Hampson); 8, *Mulona grisea* Hampson; 9, *M. schausi*, new species; 10, *M. manni*, new species; 11, *M. barnesi*, new species.

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A NEW SPECIES OF COMMENSAL AMPHIPOD FROM A SPINY LOBSTER

By Clarence R. Shoemaker

In January 1942 the late E. F. Ricketts, in connection with the work of his Pacific Biological Laboratory, at Pacific Grove, Calif., examined a living spiny lobster *Panulirus interruptus* (Randall) at the local fish market. The lobster, which was presumably sent from Santa Barbara, had some amphipods adhering to its pleopods, and six of these were sent to me for identification. I find that these specimens represent a new species. The structure of the peraeopods indicates that they were modified and developed for the purpose of grasping, and the animals appear to have been living commensally upon the pleopods of the lobster. The mouthparts are of the normal type and are not modified in any way, thus indicating that the animal is not parasitic. The specimens are all females possessing partially developed marsupial plates.

PARAPLEUSTES COMMENSALIS, new species

Figure 83

Female.—Head with rostrum rather short and blunt; lateral lobes rounding; eye rather large, black, and reniform. Antenna 1: Peduncular joints short; first joint not twice as long as second; second joint not twice as long as third; flagellum about twice as long as peduncle and containing 14 joints (an unknown number of terminal joints are missing). Antenna 2: Peduncle short; fourth joint about twice as long as third and equal in length to the fifth; flagellum a little longer than peduncle and consisting of 13 joints.

Right mandible with 10 or 11 teeth in cutting plate; no accessory plate; molar conical with very small triturating surface; 12 spines in spine-row; palp with third joint slightly longer than second and not apically produced. Maxilla 1: Inner plate small with one plumose apical seta; outer plate with nine spine-teeth; palp with eight apical spines, and three submarginal setae on the outer surface. Maxilla 2: Inner plate with one long plumose seta on inner margin. Maxilliped: Inner plate reaching to the base of the first joint of palp, armed distally with four or five very short spine-teeth and two slender spines, and on the inner margin with one long spine; outer plate reaching a little beyond the base of the second joint of palp, armed on inner edge with eight slender submarginal spine-teeth and on the outer surface with six small submarginal spinules; palp with first three joints subequal in length.

First four coxal plates a little deeper than their respective body segments. Gnathopod 1 as shown in fig. 83, *F;* sixth joint with palm oblique, convex, armed with a row of submarginal spinules, and defined by two spines, below which on the hind margin of joint is another pair of spines; seventh joint fitting palm. Gnathopod 2, like gnathopod 1, but a little longer. Peraeopods 1 and 2 alike; sixth joint strongly developed, hind margin armed with seven pairs of stout spines against the distal four of which the seventh joint closes, forming a grasping organ. Peraeopods 3 to 5 are alike, but the fourth is somewhat the longest; second joint well expanded; sixth joint strongly developed and armed on the front margin with groups of stout spines, which together with the seventh joint form an effective grasping organ.

The lower posterior angle of the metasome segments minutely and sharply produced. Uropods as shown by Sars for *Stenopleustes malmgreni* (Crustacea of Norway, 1893, vol. 1, pl. 125, fig. 1) except that the outer ramus of uropod 3 is proportionately shorter in Sars' figure. Uropod 1 reaching a little farther back than uropod 2. Uropod 3 reaching back about as far as uropod 2. Telson reaching to the distal end of peduncle of uropod 3, three-fourths as wide as long with the convex sides converging to the evenly rounding extremity. Length from front of head to end of uropods 5.5 mm.

Type.—A female, U.S.N.M. No. 85260, taken from the pleopods of a spiny lobster *Panulirus interruptus*, from Santa Barbara, Calif., January 22, 1948, by E. F. Ricketts.

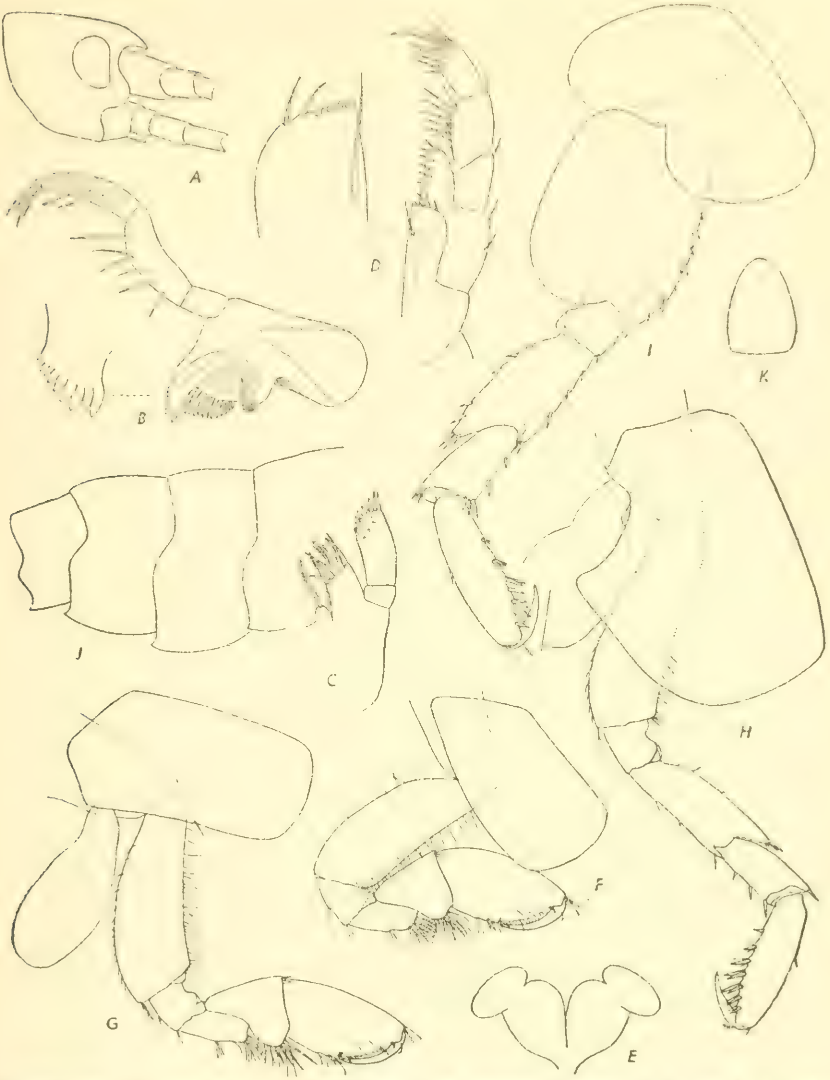

FIGURE 83.—*Parapleustes commensalis*, new species, female: *A*, Head; *B*, mandible; *C*, maxilla 1; *D*, maxilliped; *E*, lower lip; *F*, gnathopod 1; *G*, gnathopod 2; *H*, peraeopod 2; *I*, peraeopod 3; *J*, metasome; *K*, telson.

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A NEW GENUS OF CENTRAL AMERICAN MILLIPED (FAMILY EURYURIDAE), WITH NOTES ON THE AMERICAN GENERA.

By Richard L. Hoffman

While sorting out unidentified millipeds in the collection of the United States National Museum, I encountered a single male specimen that represents an unnamed genus (here described) of the family Euryuridae. Investigation of pertinent literature has revealed several taxonomic errors that may be corrected at this time, and it appears that at least one genus (*Polylepiscus*) is readily separable into two more natural groups.

Together with these various additions and emendations, I include new distributional records for two species of *Amplinus*, and a consideration of the known American euryurid genera with reference to some diagnostic characters whose value seems questionable. A tentative key to the genera is provided.

The Euryuridae is a small family (12 genera and about 50 species) with many of the characters of the Platyrrhacidae and with nearly the same distribution. Both families are represented in the Indo-Australian region and in tropical America; species of *Euryurus* and *Auturus* also invade the North Temperate Zone as far as Ohio and Minnesota.

The most recent, and only complete, account of the Euryuridae is to be found in Attems' monumental Polydesmoidea monograph (Das Tierreich, Lief. 68–70, 1937–1940). This manual lists all known species and because of its conservatism affords an excellent starting point for taxonomic studies. Attems combines the Euryuridae and

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Platyrrhacidae (Lief. 69, p. 202), the latter being represented in his arrangement by the single genus *Platyrhacus*. Seven other genera of Attems' "Platyrrhacidae" have the characters of the Euryuridae as here understood.[1] Since the appearance of Attems' work, Chamberlin has described a number of species and genera from northeastern Peru (1941, Bull. Amer. Mus. Nat. Hist., pp. 498 et seq.).

I wish to express my indebtedness to Dr. E. A. Chapin, curator, division of insects, United States National Museum, who has greatly facilitated my work at that institution; to R. L. Wenzel, division of insects, Chicago Natural History Museum, for the loan of many specimens from collections under his charge; and to Dr. Clarence J. Goodnight, department of biological sciences, Purdue University, who has kindly given me valuable material from his Central American collecting.

REMARKS ON TAXONOMIC CHARACTERS

Attems' key to the five American genera recognized by him is based to a considerable extent upon sculpture of the dorsum. *Euryurus* and *Pycnotropis* are separated off in couplet 4 by the statement "Metazoniten glatt oder nur mit Spuren einer polygonalen Felder," as opposed to "Metazoniten mit Querreihen grosser Tuberkeln," which leads to *Polylepiscus* and *Amplinus*.

This reliance upon tergite modification leads to considerable difficulty. Even in the four genera mentioned, one finds smooth species in "tuberculate" genera, and vice versa. The issue is complicated by the addition of Chamberlin's four Peruvian genera and one from Panama to be described herein. There seems to be such variability in the development of polygonal areas on the dorsum that its practical value is largely negated. The new Panamanian form keys out to *Pycnotropis*, and the gonopods are of the type found in that genus, but other characters are those of *Phinotropis* (*Polylepiscus*, in part, of Attems). Because of the difficulty attendant upon the use of sculpture, I believe it advisable to appeal to other characters, such as subantennal swellings, anal sternite, and male gonopods, for generic diagnosis.

The following key appears to be satisfactory at present for the recognition of American genera:

---

[1] The genus *Aphelidesmus* has been placed in the Euryuridae by recent American workers at one time or another, since the time of Cook (1895) and Pocock (1909). Despite its somewhat truncate terminal segment, *Aphelidesmus* properly belongs in the family Strongylosomidae, a group with somewhat distant affinities.

TENTATIVE KEY TO THE AMERICAN GENERA OF EURYURIDAE

1. Anal sternite distally truncate, with two large setiferous tubercules. Amplinus
   Anal sternite semicircular, with very small tubercules or none 2
2. Male gonopod without solenomerite; tibiotarsus, if present, not set off from femur 3
   Male gonopod with a definite solenomerite branch 4
3. Gonopod without perceptible tibiotarsus .... Auturus
   Gonopod with a long slender tibiotarsal portion .... Euryurus
4. Gonopod with two tibiotarsal branches .... Polylepiscus
   Gonopod with a single tibiotarsal process 5
5. Tibiotarsal portion of gonopod broad, short, laminate, solenomerite very short 6
   Tibiotarsus long, slender, usually terete in cross-section, solenomerite typically long 7
6. Tergites with three transverse rows of large tubercules .... Protaphelidesmus
   Tergites completely smooth .... Ptyxogon
7. A large ovoid swelling below each antenna 8
   No swellings under the antennae .... Pycnotropis
8. Distal end of tibiotarsus of gonopod pointed, or at least unbranched. Phinotropis
   Distal end of tibiotarsus variously modified 9
9. Tibiotarsus straight or simply curved, parallel sided, distally bifid. Thrinoxethus
   Tibiotarsus long and slender, bent into a sigmoid curve, with the terminal end trifid .... Sigmogonotropis

Family EURYURIDAE Pocock

Euryurinae Pocock, Biologia Centrali-Americana, Diplopoda, p. 147, 1909.

Genus AMPLINUS Attems

Pachyurus (*Amplinus*) Attems, Denkschr. Akad. Wiss. Wien, vol. 68, p. 281, 1899. (Genotype: *Polydesmus klugi* Brandt.)

Range.—Mexico (Veracruz and Hidalgo) south to Costa Rica.

Species.—*Amplinus abtrusus* (Karsch), *arcatus* Pocock, *armatus* Pocock, *crenus* Chamberlin, *convexus* (Carl), *erichsoni* (Brandt), *flavicornis* Pocock, *klugi* (Brandt), *manni* Chamberlin, *niteus* Chamberlin, *nitidus* (Brölemann), *orphinus* Chamberlin, *palicaudatus* (Attems), *tapachulae* Chamberlin, *triramus* Pocock, *vergelanus* Chamberlin, and *xelitlus* Chamberlin.

AMPLINUS FLAVICORNIS Pocock

Amplinus flavicornis Pocock, Biologia Centrali-Americana, Diplopoda, p. 151, pl. 11, fig. 2, 1909.

Chiapas: Palenque Ruins, near Palenque, July 8, 1949, C. J. Goodnight collector.

This is the first definite locality for the species, which was described from "Central America." The specimens at hand match the original description closely. The prozonites are very dark brown, the metazonites light brown or tan; keels, antennae, legs, and last tergite yellow. In the male the apical prongs of the gonopod are not bent to the extent shown in Pocock's figure, but the difference in this respect is hardly significant.

AMPLINUS ORPHINUS Chamberlin

Amplinus orphinus CHAMBERIN, Proc. U. S. Nat. Mus., vol. 60, art. 8, p. 42, pl. 16, fig. 8, 1922.

BRITISH HONDURAS: Middlesex, February 1, 1923, K. P. Schmidt and L. Walters collectors. A single female tentatively referred to this species (Chicago Natural History Museum).

GUATEMALA: Chimaltenango, La Jolla Grande (Finca Monserrat), northwest slope of Volcán de Fuego, 5,700 feet, May 3, 1948, R. L. Wenzel and R. D. Mitchell collectors (Chicago Natural History Museum).

HONDURAS: Río Santa Ana, 2,500 feet, March 21, 1923, Schmidt and Walters collectors (Chicago Natural History Museum).

This species has previously been recorded from La Ceiba, Honduras (the type locality) and Livingston, Guatemala. The following localities represent considerable range extensions for *orphinus*, which appears to be one of the most abundant and widespread members of the genus. The record from Chimaltenango, Guatemala, is of especial interest in carrying the range up into the high mountains.

Genus AUTURUS Chamberlin

Auturus CHAMBERLIN, Bull. Univ. Utah, biol. ser., vol. 6, No. 8, p. 7, 1942. (Genotype: *Auturus phanus* Chamberlin.)

Range.—Eastern United States. Mississippi Valley from Minnesota to Louisiana, east to Georgia.

Species.—*Auturus dixianus* Chamberlin, *evides* (Bollman), *georgianus* Chamberlin, *louisianus* (Chamberlin), *mimetes* Chamberlin, *phanus* Chamberlin, *scotius* Chamberlin.

Genus EURYURUS Koch

Euryurus KOCH, Krit. Rev. Insectf. Deutschl., vol. 3, p. 59, 1847. (Genotype: *Polydesmus erythropygus* Brandt.)

Range.—Southeastern United States, north as far as Ohio.

Species.—*Euryurus australis* Bollman, *erythropygus* (Brandt).

EURYURUS AUSTRALIS Bollman

Euryurus erythropygus australis BOLLMAN, Proc. U. S. Nat. Mus., vol. 11, p. 346, 1889.

Euryurus falcipes LOOMIS, Bull. Mus. Comp. Zool., vol. 92, p. 403, fig. 15, 1943 (type locality: Torreya State Park, Liberty County, Fla.).

Range.—The species is known to occur from west Florida north through Georgia (Indian Springs), Alabama (Auburn), and Tennessee to extreme northern Kentucky (Crittenden).

Loomis was misled into describing *falcipes* by a misunderstanding of Bollman's statement that the upper branch of the male gonopod of *australis* is five times as long as the lower. This refers to the branches in their position on the living animal. In Loomis' description and figure, the gonopod is reoriented so that the actual position is reversed. Bollman's type of *australis* has been discovered at the National Museum and its gonopods verify this idea, matching perfectly with the figure of *falcipes*.

Genus PHINOTROPIS Chamberlin

Phinotropis CHAMBERLIN, Bull. Amer. Mus. Nat. Hist., vol. 78, p. 499, 1941. (Genotype: *P. tidus* Chamberlin.)

Range.—Northwestern Brazil, northeastern Peru, Ecuador.

Species.—*Phinotropis acuticollis* (Attems), *braueri* (Carl), *kalonotus* (Attems), *mammatus* (Attems), ?*roreri* (Chamberlin), *tidus* Chamberlin.

The original description of *Phinotropis* is as follows: "This genus is erected for the species described below in which the male gonopods differ from those of *Thrinoxethus* in having the major distal branch entire and distally acute like the minor branch."

Thrinoxethus was characterized as follows: "Agreeing in general structure with *Polylepiscus* but differing in the form of the gonopods of the male. In these there are two distal branches of which one is distally acute and the other, larger one, furcate at its distal end . . ."

Insofar as these two diagnoses alone go, it is obvious that *Phinotropis* is identical with *Polylepiscus* as used by Attems and others. However, with the restriction of the latter name to Guatemalan species having three terminal processes on the male gonopod, Chamberlin's name becomes available for the South American forms and must be used, although originally a synonym.

Polylepiscus roreri Chamberlin, from Trinidad, is known only from the female type specimen, and probably pertains to another, possibly new, genus.

Genus POLYLEPISCUS Pocock

Polylepiscus POCOCK, Biologia Centrali-Americana, Diplopoda, p. 154, 1909. (Genotype: *Polylepiscus stolli* Pocock.)

Range.—Guatemala.

Species.—*Polylepiscus actaeon* Pocock, *furcifer* Pocock, *heterosculptus* (Carl), *stolli* Pocock.

The considerable distance separating the ranges of the Guatemalan and upper Amazonian species hitherto referred to *Polylepiscus* further serves to emphasize the lack of any close affinity between the two groups.

Genus PROTAPHELIDESMUS Brölemann

Protaphelidesmus Brölemann, Ann. Soc. Ent. France, vol. 84, p. 559, 1916. (Genotype: *Platyrrhacus ligula* Brölemann.)

Range.—Venezuela.

Species.—*Protaphelidesmus ligula* Brölemann, *levigatus* Attems.

Genus PTYXOGON Chamberlin

Ptyxogon Chamberlin, Bull. Amer. Mus. Nat. Hist., vol. 78, p. 500, 1941. (Genotype: *Ptyxogon incus* Chamberlin.)

Range.—Northeastern Peru.

Species.—*Ptyxogon incus* Chamberlin.

Genus PYCNOTROPIS Carl

Pycnotropis Carl, Mem. Soc. Sci. Nat. Neuchatel, vol. 5, p. 932, 1914. (Genotype: *Polydesmus* (*Euryurus*) *taenia* Peters.)

Amydrinus Chamberlin, Bull. Amer. Mus. Nat. Hist., vol. 78, p. 500, 1941. (Genotype: *Amydrinus pongus* Chamberlin.)

Range.—Northeastern Peru, Ecuador, Colombia, Panama.

Species.—*Pycnotropis devillei* (Silvestri), *flavocarinata* (Silvestri), *haenschi* Carl, *latzeli* Attems, *polygonata* (Gervais), *pongus* (Chamberlin), *taenia* (Peters).

SIGMOGONOTROPIS, new genus

Genotype.—*Sigmogonotropis serratus*, new species.

Diagnosis.—Head smooth, clypeal furrow distinct, a prominent ovoid swelling under each antennal socket. Collum and other tergites smooth, underparts without tubercules or bristles. Anal sternite semicircular, without enlarged tubercules. Gonopod of male as follows: Coxa small, without hairs; prefemur and femur coalesced, straight, setose. Distally, set off by a definite constriction, are a long tubular solenomerite and a long, slender, sigmoidally curved tibiotarsus, terminally trifid and with a broad subterminal toothed lamina.

This genus seems to be intermediate between *Pycnotropis* and *Phinotropis.*

SIGMOGONOTROPIS SERRATUS, new species

Figure 84

Type specimen.—Male holotype, U.S.N.M. No. 1900, collected at Cana, east Panama, by E. A. Goldman, June 1912.

Diagnosis.—Characterized by the configuration of the male gonopod as represented in figure 84.

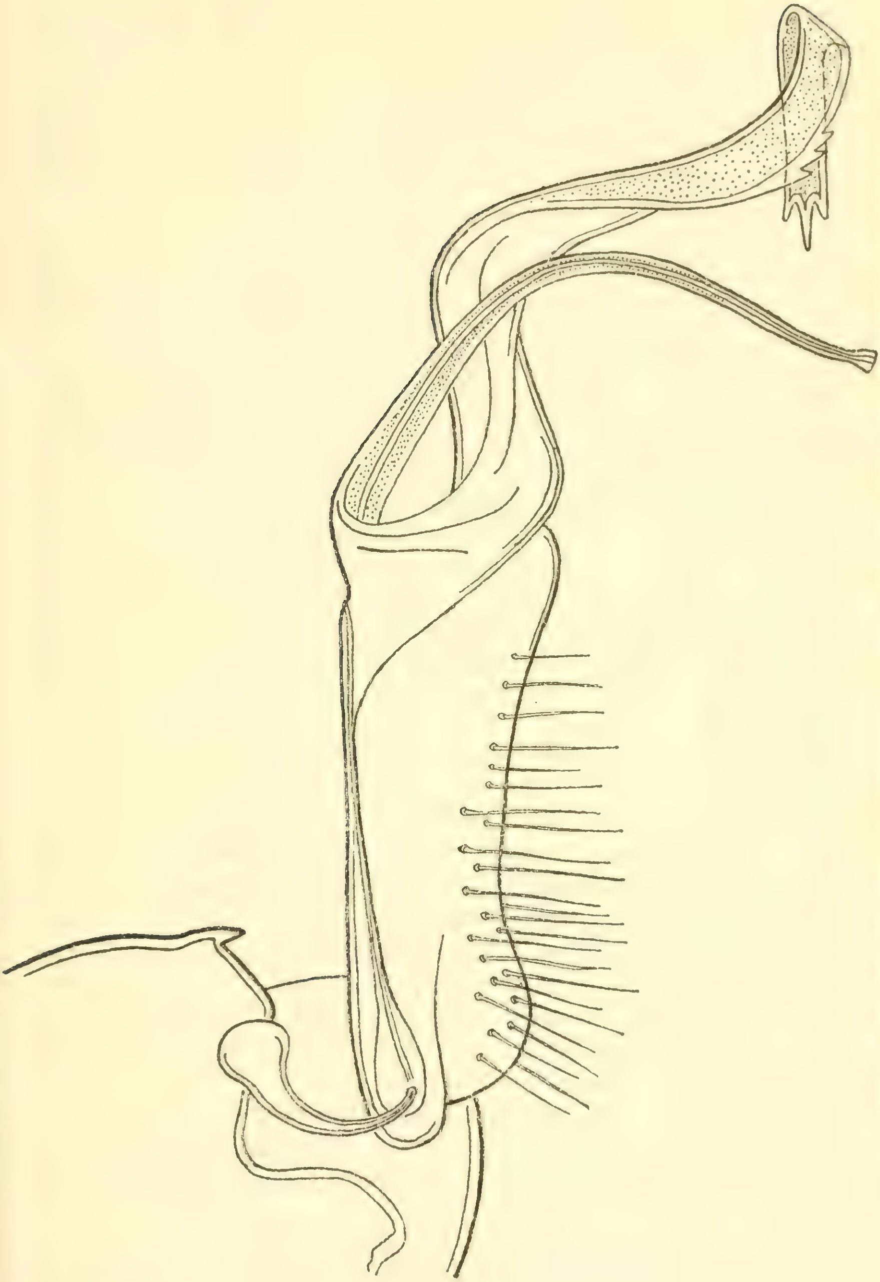

Figure 84.—Left male gonopod of *Sigmogonotropis serratus*, cephalic aspect (not all setae on prefemur shown).

Description of holotype.—Specimen much broken. Approximate length, 51 mm.; greatest width, 6.9 mm.

Head entirely smooth, glabrous except for a few fine hairs near labral margin. Clypeal furrow very distinct. A prominent transverse ovoid swelling directly below each antennal socket. Antennae rather stout, short, reaching back to anterior margin of third tergite; articles 2–6 of nearly equal size.

Collum perfectly smooth, with a fine but distinct margining ridge except on caudal edge. Anterior edge nearly straight, caudal edge bent forward laterally. Lateral ends slightly truncate and marginal ridges more prominent than across back. Second tergite wider than collum and third tergite, its keels pronouncedly swept forward.

Tergites completely smooth, except for extremely faint suggestions of polygonal areas on the keels, to be seen when the dorsum is dry. Keels of moderate width and length, never overlapping, set above middle of body and nearly horizontal, thus interrupting slope of the rather convex dorsum; anterior corners rounded off, posterior corners produced caudad into a point on all keels back of third segment. Both anterior and posterior edges are set off by a marginal ridge. Lateral edges inflated and smooth but for a slight notch on the anterior shoulder. On poriferous keels the pores are lateral in a large swelling. On the 19th segment pores are definitely inferior on the small, distally rounded keel. Last tergite broadly truncate, nearly tongue shaped, lateral edges almost parallel. A small median terminal lobe.

Anal valves smooth, with well-defined median ridges. Preanal sternite nearly semicircular without lateral setiferous tubercules. Last pair of legs separated by a distance equal to diameter of their coxae; penultimate pair slightly farther apart. Bases of all legs fused into a raised area very distinct from and higher than the prosternites. Legs long and slender, end of third joint visible past keels in dorsal aspect. Lengths of joints of legs, in order of decreasing length, 3, 6, 5, 2, 4, 1. Terminal claw slender and nearly straight. No special processes associated with any of the legs.

Sides and underparts all smooth and glabrous. A deep constriction between prozonite and metazonite. In going toward the head, the sternites tend to develop a small conical tubercle at base of each leg.

Gonopod aperture of medium size, oval, with caudal and lateral raised edges. Pregenital legs unmodified. Seminal apertures small, in end of coxae of second pair of legs, no special processes for them.

Gonopods: Coxa short with a long slender trachial process and a small hook just above exsertion of solenite. Prefemur and femur fused into a straight, heavy, upright trunk, somewhat concave on one side and densely setose; the opposite side is traversed by the seminal groove. Terminal elements of gonopod (solenomerite and tibiotarsus) set off by a distinct joint. Solenomerite long, gently curved across tibiotarsus, with a small distal expansion. Tibiotarsus sigmoidally curved, with a subterminal lateral lamination, the outer edge of which bears three teeth; distally trifurcate with the median tooth the longest.

Original color completely lost through preservation.

Genus THRINOXETHUS Chamberlin

Thrinoxethus CHAMBERLIN, Bull. Amer. Mus. Nat. Hist., vol. 78, p. 498, 1941. (Genotype: *Thrinoxethus hermosus Chamberlin.*)

Range.—Northeastern Peru (Department of Loreto).

Species.—Thrinoxethus bombonus Chamberlin, *cainarachus* Chamberlin, *hermosus* Chamberlin, *iquitus* Chamberlin, *lamprus* Chamberlin, *nitens* Chamberlin, *phanotypus* Chamberlin, *ucayalus* Chamberlin.

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AN EMENDED DIAGNOSIS OF THE COPEPOD GENUS PUPULINA (CALIGOIDA), WITH DESCRIPTIONS OF NEW SPECIES AND A REDESCRIPTION OF THE GENOTYPE

By Mildred Stratton Wilson

The caligoid copepod parasite *Pupulina* has been an imperfectly known genus since its discovery in 1892. The original description by van Beneden was incomplete, and attached to it, as the description of the male, was the diagnosis of an immature female of another genus. Not until 1935 was its validity definitely established, by Dr. Charles Branch Wilson, through the description of both sexes of the genotype, *Pupulina flores*. One subsequent record of the species has been made, that of Bere (1936).

This seeming rarity and the incompleteness of knowledge that always results when but a single member of a genus is known add interest to the recent discovery of two new species. These occurred together on a specimen of the giant ray *Mobula lucasana* Beebe and TeeVan, taken off the coast of California. The copepods were removed from its surface by Prof. G. E. MacGinitie, who referred them to the United States National Museum for identification. The host, the second of its kind to be drawn to the attention of science, was also of particular interest, and salient facts concerning it have already been noted in a publication by MacGinitie (1947).

The collections of both Wilson and Bere are in the United States National Museum and thus, fortunately, available for study. A direct comparison of the new species with *Pupulina flores* has made possible a new, nearly more complete diagnosis of the genus; especially has it indicated the importance of certain characters hitherto not stressed or noted. In addition, it has been found that some of the specimens identified by Bere as *Pupulina flores* are referable to the smaller of the two new species.

A new description, based on the Wilson and Bere specimens, has been prepared for the genotype, as much detail having specific value has been previously omitted. Development forms, present in his material and not mentioned by Wilson, are also described.

For critical readings of the manuscript I am indebted to Dr. Charles H. Martin, of Oregon State College, and to Paul L. Illg, of the United States National Museum.

HOST RECORDS

According to each of the three published instances of the occurrence of *Pupulina*, it has been found on a species of large ray belonging to the family Mobulidae. From this fact and MacGinitie's discovery it would appear that the genus may be a specific parasite of this group of rays. It seems very probable that records of its occurrence have been infrequent because the hosts themselves are seldom caught.

In this connection, it is necessary to qualify Wilson's statement (1935a, p. 593) that his specimens, taken near the Galápagos Islands, were from "*Manta birostris*, the same species of fish as that from which Beneden's specimens were collected." Van Beneden did not so name the species of the host, merely alluding to it as *Ceraptopterus*. The latter is a genus of Coleoptera, and so far as is known to me, the name has not been used in the fishes. From van Beneden's description of the size of the host, it is probably safe to assume that he had confused the name with *Ceratoptera* Müller and Henle, a synonym of *Manta*. Van Beneden's specimens occurred off the Azores, a locality considerably removed from the Galápagos, and whether the host was the identical species of *Manta* is certainly open to question.

Genus PUPULINA P. J. van Beneden

Pupulina van Beneden, 1892, p. 254.—C. B. Wilson, 1935a, p. 593.

Diagnosis (emended).—Body form of more or less specific variability in females; strikingly similar in males.

Frontal plates well defined, without lunules. First three thoracic segments fused with head; fourth segment free, without dorsal plates. Lateral, cephalic, and thoracic areas of carapace demarcated dorsally by well-defined grooves; ventral supporting ribs of lateral areas stout, the posterior of double rods, their outlines usually conspicuous dorsally.

Genital segment of female moderately enlarged, its width greater than that of free segment, about one-half to three-fifths that of carapace; the posterior corners produced into backwardly directed lobes; dorsal surface with a large medial clear area in which the integument is considerably thinner than that surrounding it, creating in the mature forms a characteristic design for each species. Abdomen narrow and elongate in both sexes, 3-segmented in the female, the division between the first two segments sometimes indistinct; 2-segmented in the male. Caudal rami linear in male; either linear or short and broad in female; terminal setae very short, sparsely plumose or naked.

Second antenna of female with either two or three segments well defined, apical claw stout, basal segment with a strong, posteriorly directed spinous process; that of male 3-segmented, tipped with a stout claw and armed variously with laminae and spines. Prehensile lateral hooks present, the basal portion bearing posteriorly two papillae armed with branched or simple setae.

Oral appendages similar to those of the Caliginae. Mouth tube in female constricted near the middle, its greatest width a little more than half the length of the entire tube; the whole more slender and hardly constricted in the male; opening subterminal. Mandible 4-segmented, segments 2 and 3 imperfectly defined, claw heavily chitinized, with teeth on the inside margin only.

First maxilla consisting of two heavily chitinized pieces and a very small, membranous papilla, the outer chitin piece having its outside edge more or less produced distally, being extended in the genotype into an elongated process; the inner piece (usually referred to as endopod by recent writers) extended posteriorly into a slender spinelike process, in the male either branched distally or bearing an articulated spine. The papilla (the exopod of recent writers) arising from the ventral face between the basal portions of the two chitin structures; bearing three comparatively short setae which exhibit sexual as well as pronounced specific differences. Second maxilla elongated; first segment imperfectly defined, represented by a slightly enlarged basal portion; third segment very slender, with two thin, curving, terminal claws, the posterior of which is much shorter than the other. Maxilliped of female with short terminal claw, not more than half the length of basal segment; male having claw a little longer and the basal segment variously armed.

Two pairs of accessory processes arising from the ventral face, sexually similar. The anterior pair spinelike, situated near distal end of the inner chitin piece of the first maxilla. The posterior pair heavily chitinized or membranous, shape specifically variable, located behind the base of the maxilliped, directly opposite the posterior supporting lateral ribs of the carapace, but in nowise connected with them or with the central area usually occupied by the furca, which is lacking.

Legs 1–3 biramose. Leg 1 with both rami 2-segmented, the endopod well developed; the inside spine of the second exopod segment characteristically branched in each species. Curved chitin rods, sometimes armed with spines or spinous processes, between bases of legs 1 and 2. Leg 2 with trimerous rami; outer spines of exopod 1 and 2 only moderately developed; endopod 1 and 2 with outer marginal laminae.

Leg 3 having both rami 3-segmented, their bases set closely together. Exopod well developed, the first segment elongate as in the second leg, outer spines weaker. Endopod 1 and 2 with outer laminae, that of segment 1 greatly enlarged and overlying the exopod, that of segment 2 much smaller; the second segment the longest, with two inner setae arranged like those of the second leg; third segment approximately the same size as the first segment, with four terminal setae.

Leg 4 uniramose and stout; 4-segmented, the basal segment greatly broadened; somewhat sexually dimorphic in armature; some species having short spines on the inner margins of segments 2–4; the sutures between these segments transverse. No rudiments of legs 5 and 6 visible on genital segment of adult, but present on the ventral side in female chalimi; condition in immature male not observed.

Length of known females, 6–15 mm.; of males, 4.8–12 mm.

Parasites of giant rays.

Genotype.—Pupulina flores P. J. van Beneden.

PUPULINA FLORES van Beneden, new description

PLATE 12; PLATE 14, FIGURES 8–11

Pupulina flores VAN BENEDEN, 1892, p. 254, pl. 3, figs. 6–8, female.
Lepeophtheirus flores, BASSETT-SMITH, 1899, p. 455.
Lepeophtheirus flores, C. B. WILSON, 1905, pp. 617, 618, in key.
Pupulina flores, C. B. WILSON, 1935a, p. 594, figs. 1–13, female and male.
Pupulina flores, C. B. WILSON, 1935b, p. 331, refers van Beneden's male to *Paralebion elongatus* female.
Pupulina flores, BERE, 1936, p. 590, the "large female."

Specimens examined.—Six mature, two immature females; two mature males, U.S.N.M. No. 60439. Host: *Manta birostris* (Walbaum). Locality: near the Galápagos Islands. Identified by Charles Branch Wilson.

One female, U.S.N.M. No. 79150. Host: "probably *Mobula hypostoma* (Bancroft)." Locality: Lemon Bay, Fla., Gulf of Mexico. Identified by Ruby Bere.

Diagnosis.—Anterior (cephalothorax) and posterior parts of body approximately equal in length in both sexes. Processes of female genital segment reaching a little beyond the middle of the abdomen. Caudal rami attached terminally, linear; those of female only a little shorter than the abdomen; those of male longer. Outer chitin piece of first maxilla extended distally almost to tip of the process of the inner piece; the latter bifurcate in male. Maxilliped of male with a short papillalike process on the basal segment. Posterior ventral accessory processes large, heavily chitinized, triangular spines. Leg 4 without inside spines on segments 2–4, but with a cuticular process on 4.

Description.—FEMALE (pl. 12, fig. 1): Galápagos specimens: Total length 13.9–15.0 mm. Carapace about 6 mm. long, 5.8–6.0 mm. wide. Gulf of Mexico specimen: The single, nonovigerous female only 10 mm. in length, but otherwise like the Galápagos specimens.

Anterior margin of carapace curved, median sinus slitlike; posterior margin nearly straight. Grooving of carapace as in pl. 12, fig. 1; lateral lobes with long slender hairs dorsally; each side of distal edge of thoracic area set with four or five spines. Free segment about three times wider than long, with short dorsal spines posteriorly.

Genital segment joined by short neck to the free segment, rounded anteriorly; posterior processes reaching slightly beyond midpoint of second segment of abdomen, ending in slender, rounded tips, diverging inside directly from the base of the abdomen. Sides of segment and parts of dorsal surface set with very short spinules. Design on dorsal surface sloping in a wavy line from the rather straight top to the widened central area; the posterior part narrowed with a marked central incision of the entire bottom margin.

Abdomen narrow and elongate, a little longer than the genital segment in midline; the first segment very short and indistinctly defined; the second and anal segments plainly demarcated from each other, the second twice the length of the anal; both distal segments with a midline of long, coarse hairs and scattered surface spinules; anal segment with a pair of dorsal longitudinal ridges distally.

Caudal rami a little shorter than the abdomen, flattened laterally, proximally with a raised longitudinal ridge; dorsal margins set with coarse hairs; terminal setae very short and nonplumose, three in number. Ovisacs slender, longer than the caudal rami.

The first antenna (pl. 14, fig. 9) with a double row of stout plumose setae on the upper side of the first segment and two short spines distad on the lower side; the narrowed terminal segment having a slender seta midway on the lower margin, and the apex set with numerous short spines and varied setae (pl. 14, fig. 8).

Second antenna (pl. 12, fig. 4) 2-segmented, basal spinous process very slender, terminal claw curved inwardly, only moderately elongated. Lateral prehensile hooks (pl. 14, fig. 5) comparatively long and strongly curved, setae of basal papillae branched. Mouth tube as described for the genus; mandible with 12 teeth.

The anterior accessory process of the ventral face (pl. 14, fig. 7) located near the distal inner side of the inner piece of the first maxilla; consisting of a very stout spine about one-fourth as long as this portion of the maxilla. The outer piece of the first maxilla (pl. 12, fig. 8) well developed, its outer edge elongated and spinelike distally, reaching beyond the middle of the inner piece; the papilla seemingly closely associated with the tissue of its inner basal portion. The three papillary setae unequal and unlike (pl. 12, fig. 15), the shortest having an accessory spine near its midline. The inner piece of the maxilla longer than the extension of the outer piece, ending in a similar stout, slightly curved spine.

The second maxilla (pl. 12, fig. 9) of the long slender form characteristic of the genus, tipped with two slender, unequal claws with marginal hyaline flanges, the posterior about half the length of the other. The claw of the maxilliped (pl. 12, fig. 10) slender, about half the length of the basal segment, bearing a stalked seta on its posterior side. The accessory process just posterior to the base of the maxilliped (pl. 12, fig. 11) a very broad, stout, chitinous spine, irregularly triangular, with the distal point somewhat attenuated. (The basal part of this spine is probably a bar corresponding to that found in the other species, but the main body is so strongly chitinized that any division between the two is obscured.)

Chitin rod between legs 1 and 2 narrow, curved backward, each side armed with a stout upwardly directed spine. Form of leg 1 as shown in plate 15, figure 14; endopod reaching to distal third of basal exopod segment; terminal exopod segment with the upper two spines stout and dentate on both margins, the modified inner spine and accompanying seta as shown in plate 12, figure 16.

Basal segment of leg 2 armed inside with a plumose seta and a triangular lamina. Exopod (pl. 12, fig. 18) with outer spine of first segment reaching to distal end of third; spine of third segment with smooth margins, reaching considerably beyond distal edge of segment; second spine about one-third the length of the first, smooth and slightly curved. Laminae on outer margins of endopod segments 1 and 2 similar to those shown in plate 15, figure 12, except that the edges are more rounded. (There is no lamina on the inner edge of the second segment as stated by C. B. Wilson, 1935a. As is usual, the margin of the segment is extended beyond the point of attachment of the succeeding segment, and bears two long setae at the distal terminus of the extension.) The third segment rounded and very short, bearing six setae.

The exopod of leg 3 having the basal segment as long as the two succeeding segments, the outer spines of segments 1 and 2 smooth, slender, and scarcely longer than the following segment. The inner setae not so long as those of leg 2. Segment 3 (pl. 12, fig. 14) with three outer unequal spines. The laminae of the outer margins of the endopod attached as shown in plate 12, figure 17; that of segment 1 very large and overlying the first two segments of the exopod. The inner margin of segment 2 expanded as in leg 2.

As my findings disagree with some of those of C. B. Wilson (1935a), the following summary of the armature of legs 1–3 is given (sp=spine; se=seta; lam=lamina):

	Exopod		Endopod	
Leg 1	sp		0	
	3sp	4se	3se	
Leg 2	sp	se	lam	se
	sp	se	lam	2se
	2sp	6se	6se	
Leg 3	sp	se	lam	0
	sp	se	lam	2se
	3sp	4se	4se	

Basal segment of leg 4 (pl. 12, fig. 20) with small spines on anterior and posterior margins; second segment with similar spines along outer margin; none on margins of segments 3 and 4. Terminal outer spines of segments 2 and 3 about as long as the succeeding segment, inner spines lacking. Distal end of fourth segment with three stout spines and one slender spine, the outermost shorter than the segment, the next as long as, and the third a little longer than the segment; the inner spine attached laterally, slender, curved, reaching beyond the end of the segment by one-half its own length; a thin, cuticular process, spinelike distally, present at about the middle of the inner margin. All large major spines of the leg coarsely toothed, the longest of the terminal segment having some of the teeth considerably enlarged on the inner margin, with three stout additional teeth on the outer side.

Male (pl. 12, fig. 3): Total length 11.4–12.1 mm. Carapace about equal in length and greatest width, 5.1–5.4 mm.; cephalothorax about 5.8–6.0 mm. long. Posterior part of body averaging 5.8 mm. in length; of this the approximate divisions are: genital segment, 1.3 mm.; abdomen, 1.9 mm.; caudal rami (exclusive of setae), 2.6 mm. The caudal rami are therefore longer than the abdomen, but are shorter than the genital segment and abdomen combined. None of the specimens, including the allotype (kindly measured for me by Paul Illg, of the United States National Museum), exhibit the condition described and figured by C. B. Wilson (1935a, p. 597) in which "the caudal rami are as long as the entire body behind the carapace."

Carapace similar to that of female except that the medial posterior edge is somewhat curved. Free thoracic segment little more than twice as wide as long; posterior part considerably widened at midline, with long, stiff marginal hairs.

Genital segment with sides slightly rounded, set with conspicuous spinules, both marginally and on dorsal and ventral surfaces; four-fifths as wide as long; posterior corners produced dorsally, well rounded ventrally. Basal segment of abdomen distinctly set off;

anal segment not demarcated by discernible transverse grooving either dorsally or ventrally in specimens examined, but with a pair of raised longitudinal dorsal ridges as in female, particularly noticeable in stained specimens. Both ventral and dorsal surfaces covered with scattered spinules. Caudal rami slightly less than one-third longer than the abdomen, flattened laterally as in female, with proximal dorsal ridges, inside margins with long hairs, outside with spinules.

Second antenna (pl. 14, fig. 10) reduced in size but very stout; basal segment unarmed, strongly united to ventral face of carapace (this segment is apparently omitted in C. B. Wilson's illustration, 1935a); second segment stout and well rounded, projecting upward, armed below with a broad but rather short spine, and a comparatively large, 2-layered, fringed lamina placed distad to the spine. Third segment with a stalked spine, segmented near its tip, and a stalked seta at the base of the claw. Claw short, but very strongly curved, with a rounded projection at its inner base. (The illustration of this appendage, pl. 14, fig. 10, is a flattened, semidiagrammatic view, turned so as to include detail of all the armature.)

Lateral prehensile hooks scarcely larger than those of female, but much more strongly curved, papillary setae unbranched. Anterior accessory process like that of female, but comparatively smaller. Inner piece of first maxilla (pl. 12, fig. 12) bifurcate at tip, inner branch the longer; basal portion of the outer piece broad, extended distally into a long spine as in female; setae of papilla unequal (pl. 12, fig. 15). Maxilla 2 as in female. Maxilliped (pl. 14, fig. 11) about twice the length of the second antenna, with a stout claw bearing a stalked seta; basal segment with a short, rounded process whose tip is more or less demarcated by a roughened area. Posterior accessory process behind maxilliped a stout triangular spine like that of female. Chitin rod between legs 1 and 2 also resembling that of female.

Legs 1–3 with setal formula and laminae like female. Basal segment of leg 4 (pl. 12, fig. 19) armed marginally with spinules; more spinules scattered over the upper part of the dorsal surface, and the lower part with a patch of long, stiff hairs running crosswise. The large spines of segments 2–4 more slender and comparatively longer than those of female; all having toothed margins, that of the longest terminal spine with the proximal teeth enlarged on the inner margin. Length of the shorter inner spine not known, as it is unfortunately broken off in all the specimens, including the allotype.

Development Stages: Two female chalimi, not mentioned by C. B. Wilson in his report, are present in the Galápagos collection. In the following descriptions, they are referred to as Stages *a* and *b*.

Stage *a* (pl. 12, fig. 2): Total length, 4.2 mm. All the first three thoracic segments incorporated in the carapace, which is as wide as long. Frontal plates indistinct. Free thoracic segment only slightly wider than long, with small distal lobes; fourth legs attached near the middle of the segment. Genital segment separate from abdomen, widened anteriorly, narrowed posteriorly, with cuticular lobes on the sides at the midpoint; behind these, another pair of lobes that represent the beginnings of the posterior processes. Ventrally, these latter lobes carry the rudiments of leg 5, consisting of a small, rounded flap hardly differentiated from the surface and bearing terminally two short plumose setae; leg 6 not discernible in this specimen. Abdomen and caudal rami together only a little longer than the genital segment. Abdomen showing no segmentation. Caudal rami flattened dorsoventrally, with the plumose terminal setae longer than in the adult.

Ventrally, the fore part of the body showing the distinguishing characters of the species already developed. The outer piece of the first maxilla well extended distally; both anterior and posterior ventral accessory processes large and of distinctive shape, the posterior process more membranous than in the adult, with the distal attenuated point sharper. A pair of spinous processes between legs 1 and 2, the connecting rod between them scarcely discernible.

The second antenna segmented like that of the adult, but more slender, the terminal claw very strongly bent as in adult; prehensile lateral hook comparatively shorter. The second maxilla not at all strongly developed, the basal segment being shortened and not extending outward beyond the maxilliped as in the adult; the terminal claws (pl. 12, fig. 2, *a*) not demarcated basally from the apex, the posterior claw very short, broad and dentate.

Leg 1 with both rami 2-segmented and all setae present, the branching of the modified spine of the exopod incomplete. Rami of legs 2 and 3 only 2-segmented, the laminae not developed. Leg 4 relatively small, consisting of the basal and two other smaller segments.

Stage *b* (pl. 12, fig. 13): Total length about 9.3 mm. Metasome a little longer than urosome. Carapace slightly longer than wide. Fourth legs attached near the distal end of free segment, the widened area behind having disappeared; distal edges of segment somewhat angular.

Genital segment with processes reaching to about the proximal third of abdomen; rudiments of leg 5 on the ventral side having three setae, one lateral, two terminal, all shorter than the two setae of the preceding stage. Rudiments of leg 6, consisting of a very much abbreviated lobe and a single seta, located outside and slightly anterior to leg 5.

Abdomen 2-segmented dorsally, the short basal segment of the adult indistinctly demarcated ventrally; the anal segment distally with a pair of dorsal longitudinal lines, undoubtedly the beginnings of the prominent ridges of the adult. Caudal rami a little shorter than the abdomen, terminal setae shorter than in Stage *a*.

All appendages considerably larger and more chitinized than in Stage *a*. Outer piece of maxilla 1 a more slender spine than in adult; claws of second maxilla longer, but of same general shape as in Stage *a*. Rod between legs 1 and 2 well developed. All legs with rami completely segmented; leg 4, however, not large, and its spines weak and flattened.

This chalimus is almost as long as Bere's specimen from the Gulf of Mexico which, however, is as completely developed as the adult.

Hosts and distribution.—*Manta* sp., Atlantic Ocean, near the Azores (van Beneden); *Manta birostris* (Walbaum), Pacific Ocean, near the Galápagos Islands (C. B. Wilson); "probably" *Mobula hypostoma* (Bancroft), Gulf of Mexico, in Lemon Bay, Fla. (Bere).

Remarks.—The identification of these Pacific and Gulf of Mexico specimens with the female of the type species from the Atlantic would seem from a comparison with van Beneden's original description and illustrations to be correct. His drawing of the female shows the same general shape of the various parts of the body, and the dorsal design on the genital segment is closely similar, the midinvagination of the posterior margin being characteristic of the species. His illustration differs in that the anterior lobe of this design is considerably narrower and the sides longer. In his figure, also, the posterior inside margins of the genital segment are more rounded with the corners less produced, and the abdomen is unsegmented and longer in proportion to the genital segment.

The only illustrations van Beneden gave of the appendages are some very incomplete figures of those of the cephalic area. These, however, show two important characteristics of the species: The extension of the outer portion of the first maxilla into a slender spine, and the triangular shape of the posterior ventral accessory processes. As these are distinctive features of the Pacific and Gulf of Mexico specimens it seems reasonable to assume that they are identical with those of van Beneden.

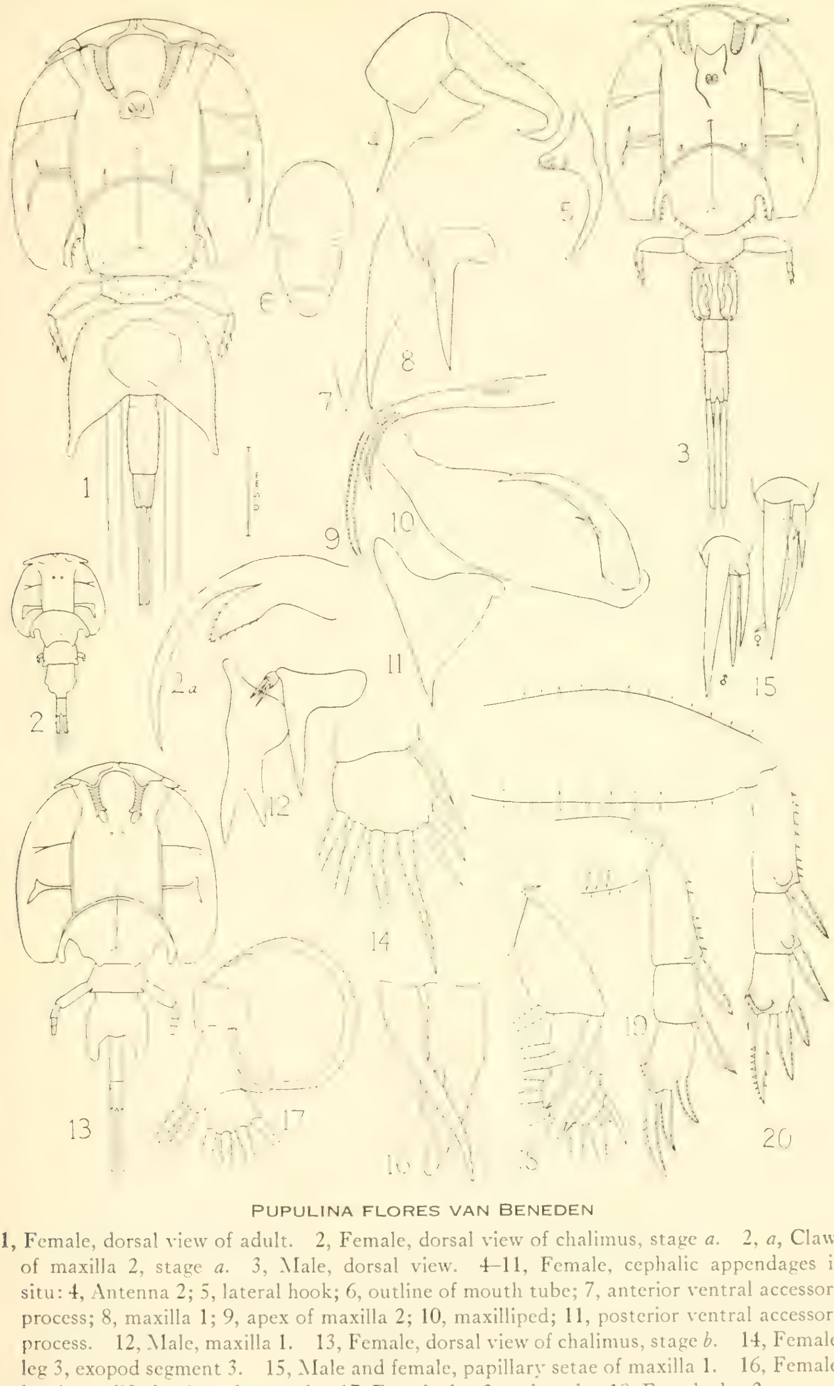
The form described by van Beneden as the male of *Pupulina flores* has been stated by C. B. Wilson (1935a, 1935b) to be an immature female of *Paralebion elongatus* C. B. Wilson.

PUPULINA MINOR, new species

PLATE 13

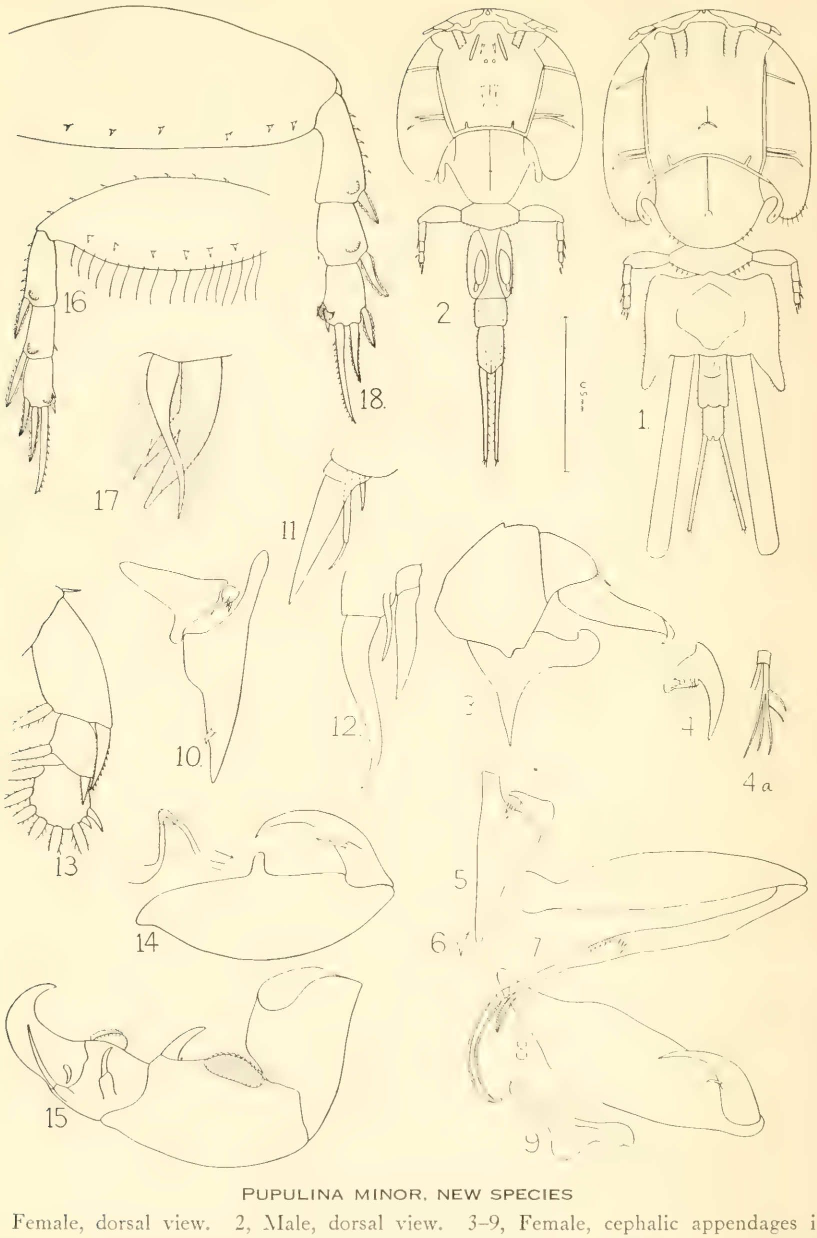
Pupulina flores, in part, BERE, 1936, p. 590, the "smaller" specimens.

Specimens examined.—Two females, one ovigerous; two males; collected by G. E. MacGinitie, from the giant ray *Mobula lucasana* Beebe



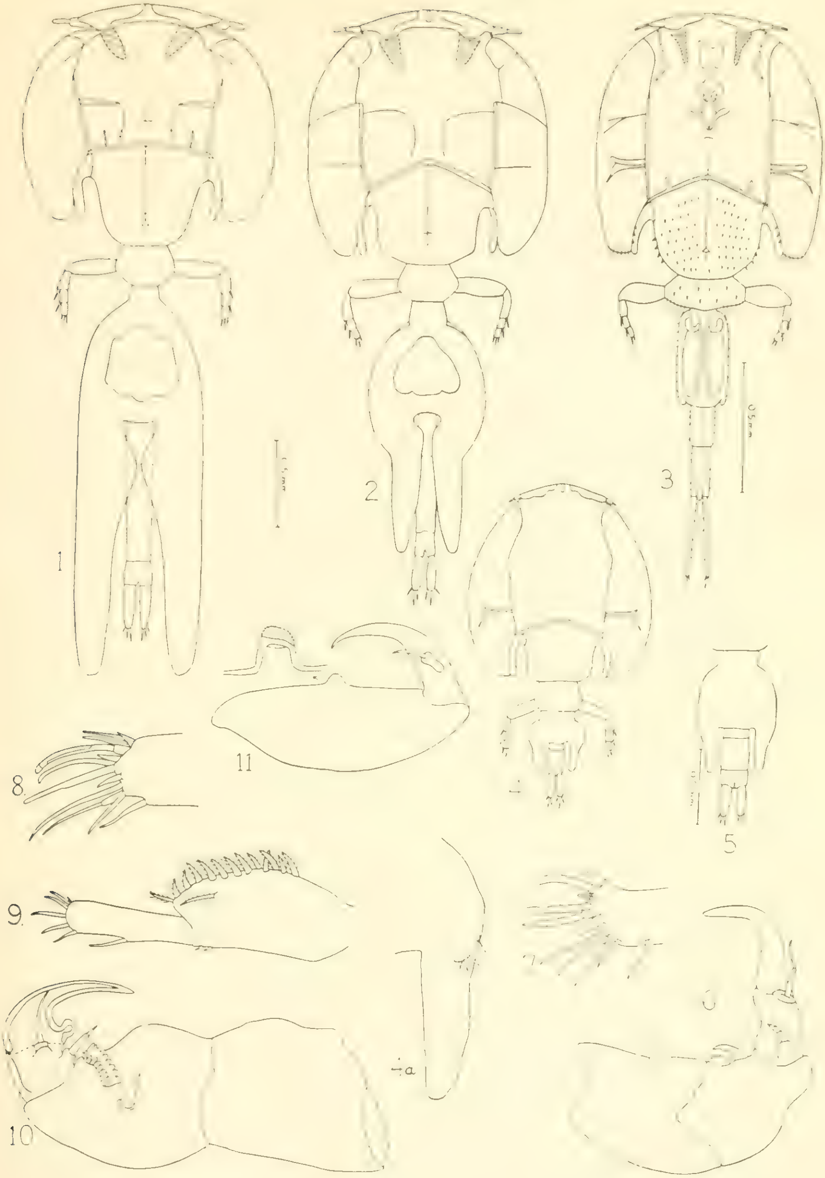
PUPULINA FLORES VAN BENEDEN

1, Female, dorsal view of adult. 2, Female, dorsal view of chalimus, stage *a*. 2, *a*, Claws of maxilla 2, stage *a*. 3, Male, dorsal view. 4–11, Female, cephalic appendages in situ: 4, Antenna 2; 5, lateral hook; 6, outline of mouth tube; 7, anterior ventral accessory process; 8, maxilla 1; 9, apex of maxilla 2; 10, maxilliped; 11, posterior ventral accessory process. 12, Male, maxilla 1. 13, Female, dorsal view of chalimus, stage *b*. 14, Female, leg 3, exopod segment 3. 15, Male and female, papillary setae of maxilla 1. 16, Female, leg 1, modified spine of exopod. 17, Female, leg 3, endopod. 18, Female, leg 2, exopod. 19, Male, leg 4. 20, Female, leg 4. (Scale applies to figures 1–3 and 13.)



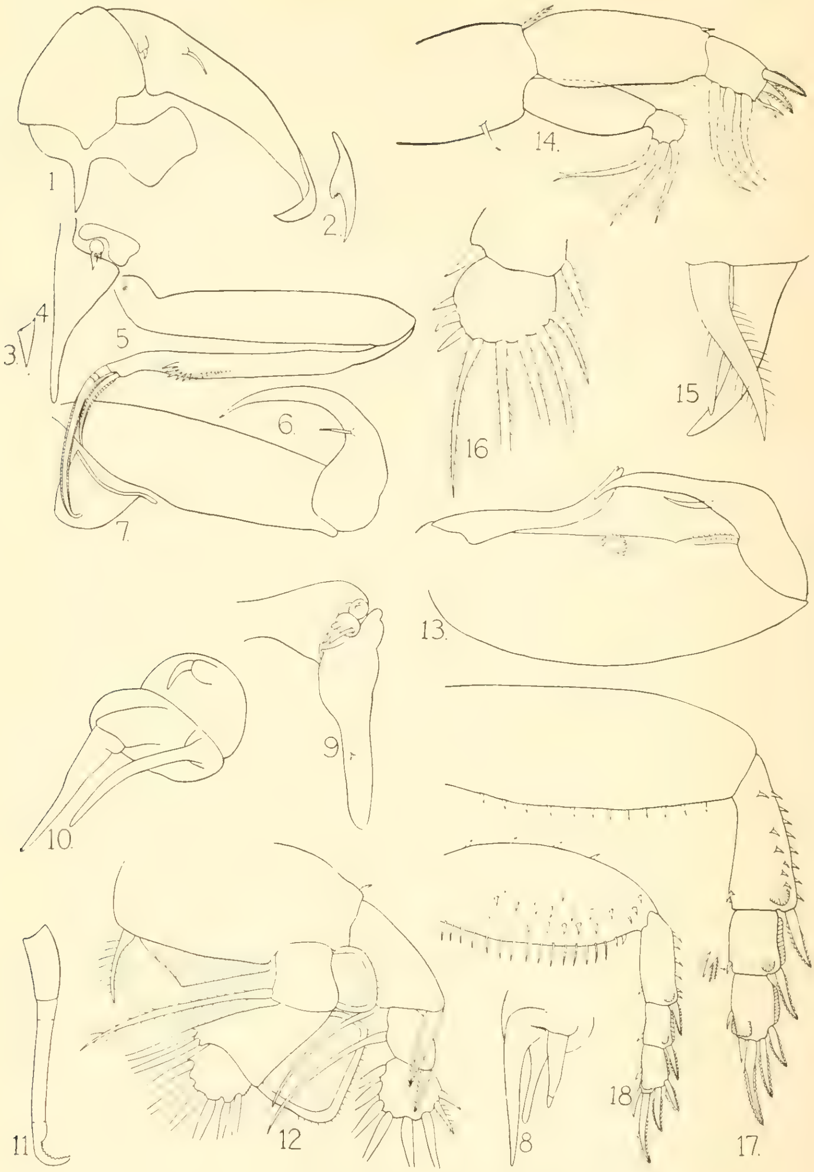
PUPULINA MINOR, NEW SPECIES

1, Female, dorsal view. 2, Male, dorsal view. 3–9, Female, cephalic appendages in situ: 3, Antenna 2; 4, lateral hook; 4, *a*, papillary seta of hook; 5, maxilla 1; 6, anterior ventral accessory process; 7, maxilla 2; 8, maxilliped; 9, posterior ventral accessory process. 10, Male, maxilla 1. 11, Female, papillary setae of maxilla 1. 12, Male, papillary setae of maxilla 1. 13, Female, leg 2, exopod. 14, Male, maxilliped, with detail of papilla. 15, Male, antenna 2, greatly enlarged. 16, Male, leg 4. 17, Female, leg 1, modified spine of exopod. 18, Female, leg 4. (Scale applies to figures 1 and 2.)



PUPULINA BREVICAUDA, NEW SPECIES, AND P. FLORES VAN BENEDEN

Pupulina brevicauda: 1, Female, dorsal view of adult; 2, young female, dorsal view; 3, male, dorsal view; 4, female, dorsal view of chalimus, stage *b;* 4, *a*, ventral view of genital segment, stage *b*, with legs 5 and 6; 5, female, stage *c*, posterior part of body, dorsal view; 6, male, antenna 2, greatly enlarged; 7, female, terminal portion of antenna 1. *P. flores:* 8, Female, enlarged terminal portion of antenna 1; 9, female, antenna 1; 10, male, antenna 2, greatly enlarged; 11, male, maxilliped, with detail of papilla. (Scale between figures 1 and 2 applies to figures 1, 2, and 4; scales at figures 3 and 5 apply to those figures only.)



PUPULINA BREVICAUDA, NEW SPECIES

1–7, Female, cephalic appendages in situ: 1, Antenna 2; 2, lateral hook; 3, anterior ventral accessory process; 4, maxilla 1; 5, maxilla 2; 6, maxilliped; 7, posterior ventral accessory process. 8, Female, papillary setae of maxilla 1. 9, Male, maxilla 1. 10, Male, papillary setae of maxilla 1. 11, Female, mandible. 12, Female, leg 2. 13, Male, maxilliped, greatly enlarged. 14, Female, leg 1. 15, Female, leg 1, modified spine of exopod. 16, Female, leg 3, exopod segment 3. 17, Female, leg 4. 18, Male, leg 4.

and TeeVan; off Santa Catalina Island, Calif.: October 3, 1946.

Three females, two ovigerous; three males; collected by Ruby Bere, "around the mouth of a devilfish (probably *Mobula hypostoma*)," Lemon Bay, Fla., Gulf of Mexico. Identified and reported as *Pupulina flores* by Bere (1936).

Types.—Holotype female, U.S.N.M. No. 85973; allotype male, U.S.N.M. No. 85972; Gulf of Mexico specimens.

Diagnosis.—Length of anterior and posterior parts of body approximately equal in both sexes. Processes of genital segment of female reaching to near the middle of the abdomen. Caudal rami linear and a little longer than abdomen in both sexes, attached laterally, divergent in female. Outer piece of first maxilla not produced distally in female, only slightly so in male; inner piece in male with small spine near distal outer margin. Male maxilliped with process of basal segment elongated. Posterior ventral accessory processes with small lobed membranous extension distally. Leg 4 with inside spine on segment 3, cuticular process on segment 4.

Description.—Female (pl. 13, fig. 1): Gulf of Mexico specimens: Total length, 6.8–7.0 mm.; average length and width of carapace, 3.2 mm. California specimens: Total length 5.9 mm.; length and width of carapace, 2.5 mm.

Anterior and posterior margins of carapace curved; sides slightly rounded. Median sinus a small rounded pit; posterior sinuses rather shallow. Distal edges of lateral area set thickly with long hairs, edge of thoracic area with a few spinules. Main lines of dorsal grooving well defined, that of central cephalic area not distinct in available specimens.

Free thoracic segment almost three times as wide as long; posterior margin set with very minute spinules. Genital segment two-thirds wider than long at middorsal line; sides tapering gradually, armed marginally with short spinules. Processes with rounded points, extending nearly to the middle of the abdomen; inside, the processes not arising on either side of the base of the abdomen as in *P. flores*, the posterior margin of the genital segment being extended beyond this point. Design on dorsal surface of genital segment with rounded peak at top, and single lobes at side and bottom; this pattern identical in the two lots of specimens. Ovisacs reaching slightly beyond end of caudal rami in all specimens.

Abdomen slender, indistinctly 3-segmented; a dorsal inflation of the anterior portion of the proximal part the only indication of its division into two joints; this basal portion almost twice the length of the anal segment; both set with marginal spinules, dorsal surface with long slender hairs. Caudal rami slender, a little longer than abdomen; attached to the anal segment laterally, and divergent from one another; inner and outer margins set with very short, scattered spinules. End of rami bearing terminally a short, broad, spiniform seta and three longer, nonplumose setae, one lateral and one short ventral seta.

Second antenna (pl. 13, fig. 3) with spinous process of basal segment well developed; third segment more or less distinct; terminal claw comparatively weak and little curved, with a slender seta at its base. Prehensile lateral hook (pl. 13, fig. 4) short, with broadened base, not strongly curved; setae of papillae branched (pl. 13, fig. 4, *a*). Mouth tube as described for the genus, well developed and seeming large in proportion to the comparatively small size of the copepod.

First maxilla (pl. 13, fig. 5) having the inner piece well extended distally and the outer portion with a small posterior extension not reaching beyond the curved basal part of the inner piece; the longest of the three papillary setae (pl. 13, fig. 11) very broad and partially divided near its base, the other two very slender, the longer consisting of two unequal segments. The anterior ventral accessory process (pl. 13, fig. 6) located near the distal inside end of the inner piece of the first maxilla, a small spine terminating a membranous fold that runs backward about half the length of the maxilla (this membrane not shown in pl. 13, fig. 6).

Posterior claw of second maxilla (pl. 13, fig. 7) only one-third the length of the anterior. Claw of maxilliped (pl. 13, fig. 8) very short, with an accessory seta. Posterior ventral accessory process (pl. 13, fig. 9) consisting of a stout curved chitin rod and a membranous extension with a small distal lobe. Rod between the bases of legs 1 and 2 broadened, unarmed, curved backwardly.

Legs 1–3 of the same form as in other species of the genus; modified spine of leg 1 as illustrated in plate 13, figure 17. Exopod of leg 2 (pl. 13, fig. 13) with outer spine of first segment very stout, reaching only a little beyond the second segment; that of segment 2 reaching to about the middle of the third segment. First spine of third segment curved downward, reaching only a little beyond distal margin of the segment; second spine straight, about half the length of the first. Leg 3 similar to that of *P. flores*.

Leg 4 (pl. 13, fig. 18) with the basal segment broadened and armed with scattered spines; segment 2 having marginal outer spinelets and a thin ventral lamina distally. All the major spines with toothed margins. The terminal spines of segment 4 considerably elongated, the longest being about twice the length of the segment; the innermost spine attached laterally and unusually short. Segment 3 with a short lateral spine inside; the fourth segment with a curved cuticular process (or imperfectly separated spine), covered ventrally by the lamina which extends outward from the distal edge of the segment.

MALE: Gulf of Mexico specimens: Total length, 5.7–6.1 mm.; width of carapace, 2.2–2.5 mm.; length of carapace, 2.3–2.8 mm. California specimens: Total length, 4.8 mm.; width of carapace, 2.0 mm.; length of carapace, 2.1 mm.

Carapace suborbicular, longer than wide; posterior sinuses shallow; thoracic area somewhat elongated and narrowed behind the sinuses. Pattern of cephalic area not distinct in specimens available, except for two anterior ridges, between which are a pair of rather stout spines; another pair of spines located a short distance posterior to the eyes; these spines apparently easily broken off, as in no single specimen are they all intact.

Free segment about two and one-half times wider than long, with long dorsal hairs posteriorly. Distal corners of genital segment hardly produced. Abdomen about as long as genital segment, 2-segmented, set marginally and dorsally with fine spinules. Caudal rami one-fourth longer than abdomen, attached laterally as in female, but not divergent; not twisted and flattened laterally to such an extent as those of *P. flores*, but with similar long hairs inside. Caudal setae as in female.

Prehensile lateral hook hardly stouter than that of female, setae of papillae unbranched. Second antenna (pl. 13, fig. 15) comparatively stout; basal segment well differentiated from ventral surface, second segment armed with a large, ridged lamina and a stout spine; the third with a 2-layered lamina, a spine and a seta, both of which arise from large stalks; claw short but strongly curved.

First maxilla (pl. 13, fig. 10) with inner piece elongated distally as in female, but bearing at outer distal third a stout recurved spine; basal outer piece with distal outer lobe larger than in female and extended slightly beyond the curved basal part of the inner piece; papilla (pl. 13, fig. 12) with the three usual setae, the medial being very slender.

Maxilliped (pl. 13, fig. 14) with stout terminal claw, armed with a seta on a long stalk; basal segment having a prominent process similar to that of *P. flores*, but more elongated. Anterior ventral accessory process with smaller spine than in the female; posterior process like that of female.

Rod between legs 1 and 2 with posterior, upwardly directed lobes, apparently unarmed. Legs 1–3 like female; leg 4 (pl. 13, fig. 16) like female except that in addition to scattered spines, the basal segment is set dorsally with very long slender hairs.

Color.—MacGinitie (1947) has recorded the following notes on the color of the California specimens: "The smaller of the two new species of copepods had a wine-colored eyespot. The body and tail were transparent, with wine and blue lines and patches over the body. The eggs were salmon colored." Bere (1936) referred to the "smaller females" (Gulf of Mexico specimens) which are here designated as belonging to this species, as having the carapace "creamy with much branched reddish purple pigment spots; genital segment and egg strings rose colored; eyes black."

Remarks.—The only noticeable differences between the Gulf of Mexico specimens and those from the Pacific are in the larger size of the former and in the thicker integument of the latter.

It is interesting to note that this species occurred in both collections with another species of the genus, in the Gulf of Mexico with *Pupulina flores* and in the Pacific with the other new species herein described.

The name *minor* refers to the notably small size of this species, compared with that of the other known species.

PUPULINA BREVICAUDA, new species

PLATE 14, FIGURES 1–7; PLATE 15

Specimens examined.—Eight females, 2 adult, nonovigerous, others in various development stages; 16 males, 2 attached to immature females; collected by G. E. MacGinitie, from around the mouth and anterior end of the giant ray *Mobula lucasana* Beebe and TeeVan; off Santa Catalina Island, Calif.; October 3, 1946; occurring with *Pupulina minor.*

Types.—Holotype female, U.S.N.M. No. 85977; allotype male, U.S.N.M. No. 85976.

Diagnosis.—Posterior part of body in female longer than the anterior; a little shorter in the male. Both abdomen and processes of the genital segment of female greatly elongated, the latter reaching a little beyond distal end of caudal rami. Caudal rami of female short and broad, only about one-fifth of the total length of the abdomen; linear in male, almost as long as abdomen. Basal portion of outer piece of first maxilla not produced distally in female, hardly so in male; inner piece of male with minute spine near distal outer margin. Male maxilliped with large curved, clawlike process at its base. Posterior ventral accessory processes large membranous lobes in female, not so well developed in male. Leg 4 with inside spines on segments 2–4.

Description.—FEMALE (pl. 14, fig. 1): Measurements of holotype: Total length about 14.8 mm.; length of cephalothorax, 6 mm.; posterior part of body, 8.8 mm.; length of carapace, 5.2 mm.; width of carapace, 6.0 mm. Total length of paratype, 14.5 mm.; width of carapace, 6.0 mm.

Carapace a little wider than long; anterior and posterior margins only slightly curved, sides well rounded. Anterior sinus hardly distinguishable; posterior sinuses deep. Dorsal pattern of carapace uniquely distinguished by the pair of transverse lines of the midcephalic area, these carried backward by curved lines ending in small loops; midanterior portion with a design similar to that of the male (pl. 14, fig. 3), but not entirely clear in available specimens. Ventral supporting ribs of the lateral area not visible dorsally in holotype, partially so in paratype.

Free segment about one-fourth wider than long, posterior edge straight. Genital segment with a narrow neck, anterior portion (exclusive of neck and processes) a little longer than wide; sides rounding out from neck and extending straight backward in long, narrow processes, almost twice as long as the main portion of the segment and reaching a little beyond the tip of the caudal rami; in the paratype female, the processes slightly shorter than the rami. Processes well rounded apically, partially covering the abdomen in the proximal inner area; sides curved under and more or less grooved ventrally; the surface integument relatively thin and lacking hairs or spinules. Top of dorsal pattern of segment with well-rounded lobe in middle, slanting sides, and five posterior lobes, of which the central is the longest.

Abdomen slender, elongate, with three distinct segments; the middle the longest, the anal the shortest; the first two segments together six times the length of the anal; margin set with very fine short hairs. Caudal rami about one-fourth as broad as long; differing from those of other females of the genus in being somewhat flattened, very short and broad; equaling only a little more than a fourth of the total length of the abdominal segments; slightly less than twice the length of the anal segment; tipped with three very short setae.

First antenna with fewer plumose setae on the basal segment than in *P. flores*, armed terminally as in plate 14, figure 7. Second antenna (pl. 15, fig. 1) with a stout basal spinous process, terminal claw exceptionally long, armed proximally with a stalked spine and a long seta. Lateral hook (pl. 15, fig. 2) very short, hardly curved, setae of basal papillae little developed. Mouth tube as for the genus; claw of mandible (pl. 15, fig. 11) with 12 teeth. Anterior ventral accessory processes short, narrow, membranous spines (pl. 15, fig. 3), larger than those of *minor*, smaller than those of *flores*.

First maxilla (pl. 15, fig. 4) with posterior lobe of outer portion not extended beyond base of inner piece; setae of papilla subequal (pl. 15, fig. 8), the shortest divided near the tip, the middle one with the basal part rounded and swollen; inner piece with distal extension very slender. Posterior claw of second maxilla (pl. 15, fig. 5) about half the length of the anterior. Maxilliped (pl. 15, fig. 6) with moderately strong claw, set with a slender seta. Posterior ventral accessory process (pl. 15, fig. 7) a somewhat large, membranous, rounded flap attached to a narrow chitinous bar.

Rod between legs 1 and 2 narrow, unarmed. Legs 1–3 of the usual form for the genus. Leg 1 (pl. 15, fig. 14) with endopod reaching to distal end of first exopod segment; modified spine and seta of exopod 2 as in plate 15, figure 15.

Leg 2 (pl. 15, fig. 12) with the outer spine of first exopod segment reaching to the proximal third of segment 3; that of segment 2 reaching a little beyond the middle of the third segment. First spine of third segment curved downward, shorter than the second, which is setiform and sparsely plumose. Laminae of endopod with somewhat straight outer edges.

Exopod of leg 3 with outer spine of segment 2 reaching to about middle of third segment; outer spines of segment 3 (pl. 15, fig. 16) all very short, subequal; differing from *flores* and *minor* in the presence of a fifth plumose seta inside, this seta shorter and more slender than the others. Endopod like that of *flores* except that the lower part of the lamellar expansion of segment 2 is much larger, extending distally almost to the end of the third segment.

Leg 4 (pl. 15, fig. 17) with the basal segment comparatively narrow, set with short spines posteriorly. Segments 2–4 bearing short spinules inside, that of segment 4 the longest, placed just below the middle of the segment; this latter spinule apparently homologous to the imperfectly separated cuticular process of the other two species. Second segment with an irregular double row of outer marginal spinelets; segments 3 and 4 with narrow marginal laminae. Major spines of all segments stout and comparatively short, the longest of the terminal spines being only a little longer than its segment. The distal portion of segment 4 almost squarely truncated, with the inner spine thus placed in a terminal position; this spine straight and stout, a little less than one-third the length of the longest terminal spine.

Male (pl. 14, fig. 3): Average total length, 8.7 mm.; length of cephalothorax, 4.7 mm.; width of carapace, 3.7 mm. Carapace longer than wide, anterior and posterior margins rounded, sides nearly straight. Cephalic area with well-defined dorsal patterns, transverse lines more or less distinct as in female. Spinules set thickly on dorsal surface of thoracic area, thinly scattered over the rest of the carapace. Free thoracic segment almost three times wider than long, set dorsally with spinelets and posteriorly with long hairs.

Genital segment and abdomen approximately equal in length. Genital segment about twice as long as broad, with small distal processes; surface covered dorsally and ventrally with minute spines. Anal segment a little longer than the basal segment of the abdomen; caudal rami slightly shorter than the abdomen, linear as in other males of the genus. Abdomen with center line of long coarse hairs; caudal rami with similar coarse hairs on inside margins.

Lateral prehensile hook stouter than that of female, about as long as terminal claw of second antenna; the setae of basal papillae long, slender, and unbranched. Antenna 2 (pl. 14, fig. 6) with a cuticular process on basal segment; a stout, curved spine and small laminate process on segment 2; a 4-jointed, broadly stalked seta on segment 3; terminal claw stout and strongly curved, though relatively short, the seta at its base long and 2-jointed. First maxilla (pl. 15, fig. 9) having the basal outside portion of the outer piece widened transversely with a slight distal extension inside; papilla (pl. 15, fig. 10) of two parts, the upper with a very short spine, the lower with two subequal setae, the outer seta very broad and set on a stout basal stalk; inner piece slender throughout, having at its distal outer third a very small curved spine. Maxilliped (pl. 15, fig. 13) with a small lamina at the middle of the basal segment, and an unusual clawlike process with a divided tip, attached basally.

Leg 4 (pl. 15, fig. 18) with broad basal segment set with stout spinules and long coarse hairs. Segments 2–4 with inside spines and outer marginal laminae as in female; apex of segment 4 not so squarely truncated, terminal inside spine slender and curved, comparatively longer than that of the female.

Development Stages: Three development stages of the female are represented in the collection. None is so immature as the earliest stage (*a*) described for *Pupulina flores*. The youngest, however, corresponds very closely to stage *b* of *P. flores*, and so is likewise designated as stage *b*. Stage *c* is probably the one immediately following this in natural development. Other forms designated as *young females* are considered to represent early growth stages of the adult copepod.

No filament was ascertained to have been present in any of the specimens, but there is a small ventral structure that is interpreted as being a filament gland.

Stage *b* (pl. 14, fig. 4): Two specimens, to one of which a male is attached to the dorsal neck of the genital segment, clinging by means of the claws of its second antennae.

Total length, 7.8 mm.; cephalothorax, 5.5 mm.; posterior part of body, including caudal rami, 2.3 mm. All the first three thoracic segments incorporated in the carapace, which is a little longer than wide; frontal plates distinct.

Processes of genital segment reaching almost to the end of abdomen. Abdomen 2-segmented, the anal segment not being differentiated. Caudal rami having the short, broad form characteristic of the species; in this stage they are almost as long as the abdomen.

All of the appendages completely segmented, but not so strongly developed as those of the adults. The inner piece of the first maxilla not reaching beyond the tip of the anterior ventral process; maxillae and maxilliped crowded together as in adult. Claws of second maxilla short and weak, as noted for immature forms of *P. flores.* Anterior ventral accessory processes very small spines; the membranous flap of the posterior process hardly separated from the tissue of the ventral face, but the outline discernible.

Legs 1–3 completely segmented, with the laminae also well developed. Leg 4 with all the segments indicated, but very short, the whole structure appearing thin; all the spines, including the inside marginal ones, present but very short and weak. Rudiment of leg 5, a lobe hardly differentiated from the surface and bearing three short setae, present ventrally on the proximal surface of the genital process near the outer edge (pl. 14, fig. 4, *a*); leg 6, represented by a single seta attached to a minute lobe, located anterior to the fifth pair, the seta projecting beyond the margin of the genital segment.

This form is closely similar to that described as stage *b* for *P. flores*, and undoubtedly represents the same period in development. That it can properly be interpreted as a chalimus stage, though a very late one, can be seen not only from the shape and size of the genital segment and abdomen, but by the incompleteness of segmentation of the latter. The appendages, though completely segmented, are thin and weak, and the claws of the second maxillae have not assumed the adult form. In addition, legs 5 and 6 are at the height of their development, requiring passage through another stage before disappearing.

Stage *c* (pl. 14, fig. 5): One specimen, male attached. Total length, 11.0 mm.; cephalothorax, 6.5 mm.; posterior part of body, including caudal rami, 4.5 mm.; width of carapace, 6.5 mm.

Genital processes only slightly longer than in stage *b*, but abdomen considerably longer, showing division into three segments.

All appendages more strongly developed than in preceding stage. Distal extension of inner piece of first maxilla reaching well beyond the tip of the anterior ventral process. Claws of maxilla 2 as in the adult. Spines of leg 4 considerably longer and thicker. Ventral accessory processes as in stage *b*. Legs 5 and 6 still present, but the setae much shorter than in preceding stage.

Whether this stage is to be interpreted as a chalimus or a growth form of the adult is not clear. Although the appendages are more strongly developed than in Stage *b*, they are still thin and weak compared to the young or adult female. In addition to the comparatively short abdomen and the small genital segment, there are still present the rudiments of legs 5 and 6.

Young female (pl. 14, fig. 2): Three females, measuring between 13.1 and 13.5 mm., show differences in the length of the processes of the genital segment: Slightly shorter than the anal segment (as figured); slightly shorter than the caudal rami; as long as the caudal rami. These must represent different growth stages of the mature copepod; they differ from the adult only in their lesser length, in having the anterior and posterior parts of the body approximately equal in length, the carapace not so wide, and in very slight differences in the dorsal pattern of the genital segment.

Color.—MacGinitie (1947) has recorded this species as being transparent and without colored markings; eyespot black.

Remarks.—MacGinitie has further noted that this species was parasitized by a trematode, the egg cases being attached mainly to the abdominal area. It may or may not be of significance that the right caudal ramus of the holotype female, which is a little shorter than the left, and the left genital process of the paratype female, which is a little shorter than the right, are each much more heavily infested by the trematode egg cases than any other area.

The name *brevicauda* refers to the very shortened caudal rami, particularly conspicuous in the female, though it is to be noted that those of the male are comparatively much shorter than those of other species.

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ECHINODERMS FROM THE MARSHALL ISLANDS

By Austin H. Clark

The echinoderms from the Marshall Islands recorded in this report were collected during Operation Crossroads by the Oceanographic Section of Joint Task Force One under the direction of Commander Roger Revelle in 1946, and by the Bikini Scientific Resurvey under the direction of Capt. Christian L. Engleman in 1947. The number of species of echinoderms, exclusive of holothurians, in these two collections is 80, represented by 2,674 specimens. Although many of these have not previously been recorded from these islands, a number known from the group were not found, while others that certainly occur there still remain undiscovered.

Of the 80 species collected, 22 were found only in 1946 and 24 only in 1947; only 34, about 40 percent, were found in both years. It is therefore impossible to appraise the effects, if any, of the explosion of the atomic bombs. But the specimens of the 54 species collected in 1947 are all quite normal. On the basis of the scanty and inadequate data available it would seem that the bombs had no appreciable effect on the echinoderms.

Some of the species are represented by young individuals only. This is always the case in any survey of the echinoderm fauna of any tropical region. A few localities are found to yield nothing but young individuals of certain species at a given time, or possibly unless collections are made over a series of years.

A few of the records are from depths greater than any heretofore recorded for the species. These records are based mostly on dead material, which may have washed down from the shallower water of the reefs, though there is no reason to believe that the animals could not have lived at the depths given.

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The echinoderms represented in the collections, with the year or years in which they were found, are listed on page 299. Subsequent to the completion of this report some specimens collected in 1948 have come to hand. They have been noted in the text under Localities, and for convenience they have been included with the entries for 1947 in the list just mentioned.

This collection, unusually extensive for any region in the Polynesian area, was assembled by 16 members of the expeditions, none of whom had a special interest in the echinoderms. These were: Capt. R. H. Draeger, M. C., U. S. Navy; Lt. Comdr. Fred C. Ziesenhenne, U. S. N. R.; Capt. Earl S. Herald, U. S. Army; and Frederick M. Bayer; Vernon E. Brock; Frank Cali; Martin W. Johnson; Thomas F. Kohler; Harry S. Ladd; Joseph P. E. Morrison; R. Dana Russell; Leonard P. Schultz; William Randolph Taylor; Joshua R. Tracey; Douglas M. Whitaker; and Fred C. Zimmerman. It is a pleasure to thank these gentlemen and to congratulate them on the notable contribution they have made to our knowledge of the echinoderms of Polynesia.

Class CRINOIDEA

Family COMASTERIDAE

Genus COMASTER L. Agassiz

COMASTER GRACILIS (Hartlaub)

Actinometra gracilis Hartlaub, Nachr. Ges. Göttingen, May 1890, pp. 170, 187 (description; Pulo Edam, near Batavia, Java).

Locality.—Bikini Atoll; 150–265 feet; August 7, 1947. One specimen, U.S.N.M. No. E. 7236.

Notes.—This specimen has 8 arms on each of the 5 rays, making 40 arms in all. In recording 11 specimens of *Comaster multifida* (J. Müller) from the Gilbert Islands Prof. Torsten Gislén expresses doubt in regard to the specific distinctness of *C. gracilis.* It is quite possible that *gracilis* will prove to be a synonym of *multifida.*

Genus COMANTHUS A. H. Clark

COMANTHUS BENNETTI (J. Müller)

Alecto bennetti J. Müller, Monatsb. preuss. Akad. Wiss., 1841, p. 187 (description; locality unknown).

Locality.—Rongelap Atoll; Kieshiechi Island, lagoon side; Morrison, July 24, 1946. Two large specimens, U.S.N.M. Nos. E. 6995, E. 6996.

Family MARIAMETRIDAE

Genus STEPHANOMETRA A. H. Clark

STEPHANOMETRA INDICA PROTECTUS (Lütken)

Antedon protectus LÜTKEN, Mus. Godeffroy Cat., vol. 5, p. 190, 1874 (Tonga Islands; nomen nudum); *in* P. H. CARPENTER, Trans. Linn. Soc. (Zool.), ser. 2, vol. 2, p. 19, 1897 (character of the oral pinnules).

Localities.—Rongerik Atoll; Latoback Island; Bayer, Zimmerman, and Morrison, August 18, 20, 21, 1947; shallow water, the only depth given being 5 feet. Seven specimens, U.S.N.M. Nos. E. 7232–E. 7235, E. 7240, E. 7241.

Rongelap Atoll; on a coral head on the sandy bottom of the lagoon off the center of Tufa Island; 10 feet; Morrison, July 18, 1946. One large specimen, U.S.N.M. No. E. 7559.

Class ECHINOIDEA

Family CIDARIDAE

Genus EUCIDARIS Pomel

EUCIDARIS METULARIA (Lamarck)

Cidarites metularia LAMARCK, Histoire naturelle des animaux sans vertèbres, vol. 3, p. 56, 1816 (Ocean of the Great Indies, Mauritius, and Santo Domingo).

Localities.—Bikini Atoll; 200–290 feet; August 6, 1947. One small specimen, U.S.N.M. No. E. 7341.

Bikini Atoll; seaward side of Bikini Island; 150–275 feet; August 7, 1947. Two worn spines, slightly fusiform, the longest 31 mm. long, U.S.N.M. No. E. 7375.

Bikini Atoll; 800–900 feet; August 7, 1947. One small spine, slightly fusiform, 15 mm. long, U.S.N.M. No. E. 7376.

Bikini Atoll; Namu Island; outside reef; Johnson, April 4, 1946. One specimen, U.S.N.M. No. E. 7609.

Eniwetok Atoll; lagoon; Bogon Island, intertidal; Johnson, June 1, 1946. One specimen, U.S.N.M. No. E. 7614.

Rongerik Atoll; Rongerik Island; under rock in shallow water; Whitaker, August 20, 1947. One specimen, U.S.N.M. No. E. 7242.

Genus CHONDROCIDARIS A. Agassiz

CHONDROCIDARIS GIGANTEA A. Agassiz

Chondrocidaris gigantea A. AGASSIZ, Bull. Mus. Comp. Zool., vol. 1, No. 2, p. 18, 1863 (Hawaiian Islands).

Locality.—Bikini Atoll; 800–900 feet; August 7, 1947. A perfectly clean subambital spine, U.S.N.M. No. E. 7372.

Notes.—This spine agrees fairly well with some of the subambital spines in a specimen of *Chondrocidaris gigantea* at hand from the Hawaiian Islands, and I have little hesitation in referring it to that species. It is 37 mm. long and 4 mm. thick without the winglike processes. The wings are in seven rows along the lateral and aboral side of the spine, those of one row alternating with those of the rows on either side. The adoral side of the spine is flattened and is without processes. The processes begin 3 mm. from the base. There are three or four in each row. Those nearest the base are high conical tubercles. From the base outward they become progressively elongated and flattened, the outermost being high thin ridges 4–6 mm. long with a slightly convex crest. The terminal 7–12 mm. on the spine carries five high thin ridges about 2 mm. high, highest at the proximal end, thence curving downward to the apex. The color is white with streaks and spots of light pink.

The spine resembles in a general way that from Lau, Fiji, figured by Dr. H. L. Clark under the name of *Chondrocidaris problepteryx* (Bernice P. Bishop Mus. Bull. 181, p. 314, pl. 41, fig. E, 1945), but the wings are more numerous, are not truncated distally, and are continued downward to the base.

Genus PHYLLACANTHUS Brandt

PHYLLACANTHUS IMPERIALIS (Lamarck)

Cidarites imperialis LAMARCK, Histoire naturelle des animaux sans vertèbres, vol. 3, p. 54, 1816 (Red Sea).

Locality.—Bikini Atoll; west end of the target area, 3 miles southwest by south of Bikini Island, in the lagoon; 150 feet; broken coral bottom; Morrison, August 26, 1947. Four spines, U.S.N.M. No. E. 7397.

Note.—These spines are of the typical form with three narrow evenly spaced white bands; the largest (broken) is 9 mm. in diameter.

The fact that the detached spines of this species and of *Chondrocidaris gigantea* and *Eucidaris metularia* were dredged in deep water does not necessarily indicate that the individuals from which these spines came lived at these depths. Although this condition is possible, it is more likely that they lived in shallower water and that after their death the spines were washed into the localities in which they were found.

Family ARBACIIDAE

Genus COELOPLEURUS L. Agassiz

COELOPLEURUS, sp.

Locality.—Bikini Atoll; 800–900 feet; August 7, 1947. Portion of a spine, U.S.N.M. No. E. 7370.

Note.—The spine fragment is 31 mm. long, 1.3 mm. in diameter at the larger end, and 1 mm. at the smaller. It is rounded triangular in section, smooth and polished, bright scarlet above, white below. The lower side has five equally spaced fine longitudinal ridges.

Family DIADEMATIDAE

Genus ECHINOTHRIX Peters

ECHINOTHRIX DIADEMA (Linné)

Echinus diadema LINNÉ, Systema naturae, ed. 10, vol. 1, p. 664, No. 7, 1758 (Indian Sea).

Localities.—Bikini Atoll; Namu Island, flats a little west of the northern point, under loose flat coral heads; Morrison, April 4, 1946. Two specimens, U.S.N.M. No. E. 7143.

Bikini Atoll; Bokonfuaaku Island, on ocean side of reef; Schultz, April 15, 1946. Four specimens, U.S.N.M. Nos. E. 7222, E. 7223, E. 7969, E. 7970.

Bikini Atoll; southeast corner of Bikini Island, lower intertidal zone, near outer reef, under rocks; Morrison, March 7, 1946. One specimen, U.S.N.M. No. E. 7006.

Eniwetok Atoll; Ziesenhenne, February 1, 2, 1946. One specimen, U.S.N.M. No. E. 7285.

Eniwetok Atoll; Arambiru Island, ocean reef; Schultz, June 3, 1946. Two specimens, U.S.N.M. Nos. E. 7224, E. 7225.

Eniwetok Atoll; outer reef at east end of Bogen Island; Morrison, May 21, 1946. Three specimens, U.S.N.M. No. E. 7536.

Eniwetok Atoll; outer reef flats, Pujiyoru Island; Morrison, June 2, 1946. One small specimen, U.S.N.M. No. E. 7546.

Johnston Island, outer reef; Bayer, August 28, 1947. Three specimens U.S.N.M. Nos. E. 7387, E. 7388.

ECHINOTHRIX CALAMARIS (Pallas)

Echinus calamaris PALLAS, Spicilegia zoologica, . . ., vol. 1, fasc. 10, p. 31, pl. 2, figs. 4–8, 1774.

Localities.—Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. One specimen, U.S.N.M. No. E. 7583.

Rongelap Atoll; intertidal; Johnson, July 1946. One small specimen, U.S.N.M. No. E. 7611.

Johnston Island, outer reef; Bayer, August 28, 1947. Two specimens, U.S.N.M. Nos. E. 7220, E. 7389.

Family TEMNOPLEURIDAE

Genus TEMNOPLEURUS L. Agassiz

TEMNOPLEURUS TOREUMATICUS (Leske)

Cidaris toreumatica LESKE, Additamenta ad Jacobi Theodori Klein . . ., p. 155, pl. 10, fig. E, 1778.

Locality.—Rongelap lagoon; 23+ fathoms; Johnson, June 16, 1946. One small specimen, U.S.N.M. No. E. 7607.

Genus MESPILIA Desor

MESPILIA GLOBULUS (Linné)

Echinus globulus LINNÉ, Systema naturae, ed. 10, vol. 1, p. 664, No. 2, 1758 (Indian Ocean).

Localities.—Bikini Atoll; lagoon; Schultz, March 29, 1946. Two specimens, U.S.N.M., No. E. 7276.

Eniwetok Atoll; Lidilbut Island, lagoon reef; Schultz, June 1, 1946. Two fragments, U.S.N.M. No. E. 7137.

Bikini Atoll: 3 miles off Bikini Island, in lagoon; 150 feet; *Halimeda* bottom; Morrison, July 11, 1946. One specimen, U.S.N.M. No. E. 7299.

Bikini Atoll; about one-third of a mile southwest of the southeast point of Bikini Island; 27 feet; April 25, 1946. Two specimens, U.S.N.M. No. E. 7532.

Bikini Atoll; Namu Island, outer reef; Johnson, April 4, 1946. One specimen, U.S.N.M. No. E. 7604.

Bikini Atoll; Enirik Island; intertidal; Johnson, 1946. One specimen, U.S.N.M. No. E. 7623.

Eniwetok Atoll; south end of Rigili Island; Morrison; May 26, 1946. Two dead tests, U.S.N.M. No. E. 7558.

Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. Three specimens, U.S.N.M. No. E. 7530.

Rongelap Atoll; lagoon, 2 miles west of Busch Island; 120 feet; Morrison, June 21, 1946. One specimen, U.S.N.M. No. E. 7531.

Rongelap Atoll; lagoon; 23+ fathoms; Johnson, June 16, 1946. One small specimen U.S.N.M. No. E. 7605.

Genus DESMECHINUS H. L. Clark

DESMECHINUS RUFUS (Bell)

Salmacis rufa BELL, Proc. Zool. Soc. London, 1894, p. 411, pl. 26, figs. 2, 3, (Macclesfield Bank 30–44 fathoms).

Locality—Bikini Atoll; 800–900 feet; August 7, 1947. One specimen, U.S.N.M. No. E. 7371.

Notes—The specimen is a bare test 9 mm. in diameter and 4 mm. high. The sculpture is strongly marked. The color is bright orange red fading to white on the oral surface. The region around the periproct is white, the white color running in a broad wedge down the interambulacral areas about halfway to the ambitus, and in narrower wedges about two-thirds as far down the midambulacral areas. There is a yellow-green spot in the middle of each genital. The interior of the test is white with a tapering red stripe running along each outer border of the interambulacral areas as far as the coronal ring. The lower half of the test is lighter and mottled red.

Family TOXOPNEUSTIDAE

Genus CYRTECHINUS Mortensen

CYRTECHINUS VERRUCULATUS (Lütken)

Psammechinus verruculatus LÜTKEN, Vid. Medd. Naturh. Foren. København, 1864, p. 166, 1865.

Localities.—Bikini Atoll; lagoon; 180–200 feet; Schultz, March 29, 1946. One specimen, U.S.N.M. No. E. 7286.

Bikini Atoll; in the lagoon, dredged about 3 miles off Bikini Island; 150 feet; *Halimeda* bottom; Morrison, July 11, 1946. Six specimens, U.S.N.M. No. E. 7300.

Bikini Atoll; lagoon; Morrison, August 26, 1947. Seven specimens, U.S.N.M. No. E. 7275.

Rongelap Atoll; lagoon; 23+ fathoms; Johnson, June 16, 1946. One specimen, U.S.N.M. No. E. 7606.

Genus TRIPNEUSTES L. Agassiz

TRIPNEUSTES GRATILLA (Linné)

Echinus gratilla LINNÉ, Systema naturae, ed. 10, vol. 1, p. 664, No. 4, 1758 (Indian Ocean).

Localities.—Eniwetok Atoll; Ziesenhenne, February 1, 2, 1946. One specimen, U.S.N.M. No. E. 7282.

Eniwetok Atoll; Arambiru Island, ocean reef; Schultz, June 3, 1946. Fifteen specimens, U.S.N.M. Nos. E. 7971, E. 7972.

Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. One specimen, U.S.N.M. No. E. 6998.

Eniwetok Atoll; Pujiyoru Island, ocean reef; Morrison and Cali, June 2, 1946. Eleven specimens, U.S.N.M. No. E. 7308.

Johnston Island; through Dr. David Starr Jordan. One specimen, U.S.N.M. No. 5948.

Johnston Island, outer reef; Bayer, August 28, 1947. Three specimens, U.S.N.M. No. E. 7390.

Family PARASALENIIDAE

Genus PARASALENIA A. Agassiz

PARASALENIA GRATIOSA A. Agassiz

Parasalenia gratiosa A. AGASSIZ, Bull. Mus. Comp. Zool., vol. 1, p. 22, 1863 Kingsmill [Gilbert] and Society Islands).

Localities.—Bikini Atoll; lagoon; 180–200 feet; Schultz, March 29, 1946. Two specimens, U.S.N.M. No. E. 7263.

Bikini Atoll; lagoon, from staghorn coral at anchorage about 1 mile inside Bikini Island; July 16, 1947. One specimen, U.S.N.M. No. E. 7213.

Bikini Atoll; lagoon; 40–80 feet; Bayer, August 8, 1947. Fourteen specimens, U.S.N.M. No. E. 7219.

Bikini Atoll; lagoon; 30–75 feet; Bayer, August 15, 1947. Two specimens, U.S.N.M. No. E. 7216.

Bikini Atoll; lagoon; 50–140 feet; Bayer, August 15, 1947. One specimen, U.S.N.M. No. E. 7215.

Bikini Atoll; Bikini Island, lagoon reef; Bayer, August 24, 1947. One specimen, U.S.N.M. No. E. 7214.

Bikini Atoll; Bikini Island; Whitaker, August 1947. Nine specimens, U.S.N.M. No. E. 7163.

Eniwetok Atoll; lagoon; approximately 5 miles north of anchorage, about 3 miles west of Bogen Island; 90–120 feet; Taylor. One specimen, U.S.N.M. No. E. 7246.

Family ECHINOMETRIDAE

Genus ECHINOMETRA Gray

ECHINOMETRA MATHAEI (de Blainville)

Echinus mathaei DE BLAINVILLE, Dict. sci. nat., vol. 37, Oursin, p. 94, 1825.

Localities.—Bikini Atoll; Bikini Island, lower intertidal zone near outer reefs, under rocks; Morrison, March 7, 1946. Three specimens, U.S.N.M. No. E. 7005.

Bikini Atoll; Bikini Island, under loose flat coral heads on flat inside of outer reefs near north point, at about low tide level; Morrison, April 4, 1948. Three specimens, U.S.N.M. No. E. 7003.

Bikini Atoll; outer reef at the north end of Bikini Island; Whitaker, July 1947. Seven specimens, U.S.N.M. No. E. 7406.

Bikini Atoll; drift at the south end of Bikini Island; Morrison, April 9, 1946. One dead test, U.S.N.M. No. E. 7297.

Bikini Atoll; flats inside outer reef, southeast side of Bikini Island; Morrison, April 5, 1946. One small specimen, U.S.N.M. No. E. 7572.

Bikini Atoll; outer reefs, south end of Bikini Island; Morrison, July 3, 1946. Two specimens, U.S.N.M. No. E. 7553.

Bikini Atoll; southeast corner of Enyu Island, flats inside outer reef above low tide line; Morrison, March 16, 1946. Two specimens, U.S.N.M. No. E. 7541.

Bikini Atoll; southeast corner of Enyu Island, rocky flats inside outer reef; Morrison, March 16, 1946. One specimen, U.S.N.M. No. E. 7579.

Bikini Atoll; Ourukaen Island, narrow reef on northeast side; Ladd and Tracey, May 3, 1946. Three specimens, U.S.N.M. Nos. E. 7580, E. 7581.

Bikini Atoll; outer reef, south (ocean) side of Bokororyuru Island; Morrison, April 30, 1946. One specimen, U.S.N.M. No. E. 7582.

Bikini Atoll; outer reef at south end of Bokororyuru Island; Ladd and Tracey, April 29, 1946. Sixteen specimens, U.S.N.M. Nos. E. 7548, E. 7549, E. 7550.

Bikini Atoll; east end of Namu Island, ocean drift; Morrison, April 14, 1946. Fragments, U.S.N.M. No. E. 7298.

Bikini Atoll; Eninman Island, outer reef flats; Morrison, July 17, 1947. Three specimens, U.S.N.M. No. E. 7274.

Eniwetok Atoll; Ziesenhenne, February 1, 2, 1946. Ten specimens, U.S.N.M. No. E. 7284.

Eniwetok Atoll; Arambiru Island; Schultz, June 3, 1946. Five specimens, U.S.N.M. No. E. 7260.

Eniwetok Atoll; outer reef flats, northeast side of Arambiru Island; Morrison, June 3, 1946. Nine specimens, U.S.N.M. Nos. E. 7560, E. 7561.

Eniwetok Island; south end of Rigili Island; Morrison, May 26, 1946. One dead test, U.S.N.M. No. E. 7555.

Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. Twelve specimens, U.S.N.M. No. E. 7565.

Eniwetok Atoll; outer reef, east end of Bogen Island; Morrison, May 21, 1946. One specimen, U.S.N.M. No. E. 7554.

Eniwetok Atoll; outer reef flats, Pujiyoru Island; Morrison, June 2, 1946. Six specimens, U.S.N.M. No. E. 7547.

Eniwetok Atoll; outer reef, southwest side of Grinem Island; Morrison, May 29, 1946. Four specimens, U.S.N.M. No. E. 7551.

Eniwetok Atoll; flats on outer reef, southwest side of Buganegan Island; Morrison, May 28, 1946. Two specimens, U.S.N.M. No. E. 7552.

Kwajalein Atoll; Draeger, July 1946. Nine bare tests, U.S.N.M. No. E. 7244.

Rongerik Atoll; Eniwetak Island, under rocks on reef flat; Morrison, June 29, 1946. Two specimens, U.S.N.M. No. E. 7569.

Rongelap Atoll; Rongelap Island, outer reef flats; Morrison, June 17, 1946. One specimen, U.S.N.M. No. E. 7004.

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Rongelap Atoll; Rongelap Island, intertidal; Johnson, July 1946. One specimen, U.S.N.M. No. E. 7610.

Johnston Island, outer reef; Bayer, August 28, 1947. Four specimens, U.S.N.M. No. E. 7217.

Note.—These specimens are all small or medium sized. The largest, from the outer reef flats on the northeast side of Arambiru Island, Eniwetok Atoll, is 51 mm. in length, 40 mm. broad, and 32 mm. high (E. 7561).

ECHINOMETRA MATHAEI var. OBLONGA (de Blainville)

Echinus oblongus DE BLAINVILLE, Dict. sci. nat., vol. 37, Oursin, p. 95, 1825.

Localities.—Bikini Atoll; Bikini Island, from borings in coralline rock at and just behind the edge of the outer reef on the southeast side of the island; Morrison, April 5, 1948. Twenty-eight specimens, U.S.N.M. No. E. 7001.

Bikini Atoll; Bikini Island, outer reef opposite the center of the island; Ladd, April 17, 1946. Three specimens, U.S.N.M. No. E. 6700.

Bikini Atoll; Bikini Island, outer edge of reef opposite the east central part; Morrison, April 18, 1946. One specimen, U.S.N.M. No. E. 7002.

Bikini Atoll; Bikini Island; Herald, July 15, 1946. Two specimens, U.S.N.M. No. E. 7259.

Eniwetok Atoll; Lidilbut Island, near outer reef edge; Morrison, May 1, 1946. Five specimens, U.S.N.M. No. E. 7568.

Rongelap Atoll; Rongelap Island, outer reef flats; Johnson, July 1946. One specimen, U.S.N.M. No. E.7281.

Johnston Island, outer reef; Bayer, August 28, 1947. One specimen, U.S.N.M. No. E.7218.

Genus ECHINOSTREPHUS A. Agassiz

ECHINOSTREPHUS ACICULATUS A. Agassiz

Echinostrephus aciculatus A. AGASSIZ, Bull. Mus. Comp. Zool., vol. 1, p. 20, 1863 (Kingsmill [Gilbert] and Hawaiian Islands).

Localities.—Bikini Atoll; Eniairo Island; Bayer, July 21, 1947. One specimen, U.S.N.M. No. E. 7228.

Bikini Atoll; Namu Island, outer reef; Bayer, August 25, 1947. Four specimens, two in their excavations in coral rock, U.S.N.M. Nos. E. 7226, E. 7368, E. 7369.

Eniwetok Atoll; Arambiru Island, ocean reef; Schultz, June 3, 1946. Two specimens, U.S.N.M. Nos. E. 7227, E. 7266.

Eniwetok Atoll; south end of Rigili Island; Morrison, May 26, 1946. One dead test, U.S.N.M. No. E. 7556.

Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. One specimen, U.S.N.M. No. E. 7529.

Eniwetok Atoll; Pujiyoru Island, outer reef flats; Morrison, June 2, 1946. One specimen, U.S.N.M. No. E. 7544.

Rongerik Atoll: Bock Island, outer reef; Bayer and Zimmerman, August 19, 1947. One specimen.

Note.—One of the specimens from Namu Island is at the bottom of a cylindrical hole with perfectly smooth sides, 80 mm. deep and 30 mm. in diameter (E. 7368).

Genus HETEROCENTROTUS Brandt

HETEROCENTROTUS TRIGONARIUS (Lamarck)

Echinus trigonarius Lamarck, Histoire naturelle des animaux sans vertèbres, vol. 3, p. 51, 1816 (?Mediterranean).

Localities.—Bikini Atoll; reef off the southeast corner of Bikini Island; Morrison, March 7, 1946. Four specimens, U.S.N.M. Nos. E. 7007, E. 7008, E. 7533.

Bikini Atoll; outer reef, southern end of Bikini Island; Morrison, July 3, 1946. One specimen, U.S.N.M. No. E. 7534.

Bikini Atoll; Enyu Island, southeast corner, outer reef; Morrison, March 16, 1946. Five specimens, U.S.N.M. No. E. 6988.

Bikini Atoll; Namu Island, edge of outer reef; Morrison, April 4, 1946. Three specimens, U.S.N.M. Nos. E. 6992, E. 6993.

Bikini Atoll; Bikini Island, outer reef opposite the center of the island; Ladd, April 17, 1946. One specimen, U.S.N.M. No. E. 6991.

Bikini Atoll; Bikini Island, edge of reef opposite the east central part of the island; Morrison, April 18, 1946. Two specimens, U.S.N.M., No. E. 6989.

Bikini Atoll; Enyu Island, outer reef, south point of the island; Bayer, August 1, 1947. Two specimens, U.S.N.M., Nos. E. 7183, E. 7184.

Bikini Atoll; Namu Island, outer reef; Morrison, August 7, 1947. One specimen, U.S.N.M., No. E. 7207.

Bikini Atoll; Namu Island, outer reef; Bayer, August 25, 1947. Two specimens, U.S.N.M., Nos. E. 7179, E. 7180.

Eniwetok Atoll; Ziesenhenne, February 1, 2, 1946. One specimen, U.S.N.M., No. E. 7283.

Eniwetok Atoll: Arambiru Island, ocean reef; Schultz, June 3, 1946. Two specimens, U.S.N.M., Nos. E. 7967, E. 7968.

Eniwetok Atoll; Pujiyoru Island, ocean reef; Morrison, June 2, 1946. Two specimens, U.S.N.M., Nos. E. 7965, E. 7966.

Eniwetok Atoll: flats on east side near south end of Eniwetok Island; Morrison, May 20, 1946. One specimen, U.S.N.M., No. E. 7535.

Eniwetok Island; Grinem Island, outer reef on southwest side; Morrison, May 29, 1946. Seven specimens, U.S.N.M., Nos. E. 6990, E. 6994.

Eniwetok Atoll; Lidilbut Island, near outer reef edge; Morrison, May 1, 1946. Two small specimens, U.S.N.M., No. E. 7557.

Rongelap Atoll; 2 miles west of Busch Island; 120 feet; Taylor, June 21, 1946. One small dead test, U.S.N.M., No. E. 7564.

Rongelap Atoll; Kabelle Island; lithothamnion ridge, intertidal; Johnson, July 28, 1946. One small specimen, U.S.N.M., No. E. 7603.

Johnston Island; outer reef edge, northwest side; Bayer, August 28, 29, 1947. Two specimens, U.S.N.M., Nos. E. 7181, E. 7182.

HETEROCENTROTUS MAMMILLATUS (Linné)

Echinus mamillatus Linné, Systema naturae, ed. 10, vol. 1, p. 664, No. 9, 1758 (no locality).

Localities.—Johnston Island; through David Starr Jordan. One specimen, U.S.N.M., No. E. 5949.

Johnston Island, outer reef edge on the northwest side of the island; Bayer, August 28, 1947. Twenty-four specimens, U.S.N.M., Nos. E. 7185–E. 7206, E. 7237, E. 7316.

Family CLYPEASTRIDAE

Genus CLYPEASTER Lamarck

CLYPEASTER RETICULATUS (Linné)

Echinus reticulatus Linné, Systema naturae, ed. 10, vol. 1, p. 666, No. 15, 1758 (American Ocean).

Locality.—Bikini Atoll; Bikini Island; 150–265 feet; August 7, 1947. One specimen, U.S.N.M. No. E. 7262.

Family LAGANIDAE

Genus LAGANUM Linck

LAGANUM DEPRESSUM L. Agassiz

Laganum depressum L. Agassiz, Monographie des Scutellidae, p. 110, pl. 23, figs. 1–7, 1841 (Moluccas).

Localities.—Bikini Atoll; about one-fourth mile southwest of the southeast point of Bikini Island; 21 feet; sandy bottom with Foraminifera; Morrison, April 25, 1946. Thirty-two specimens, U.S.N.M., Nos. E. 7505, E. 7508, E. 7294.

Bikini Atoll; one-third of a mile southwest of the southeast point of Bikini Island; 21 feet; Morrison, April 25, 1946. Three specimens, U.S.N.M., No. E. 7291.

Bikini Atoll; one-third of a mile west of the southeast point of Bikini Island; 24 feet; sandy bottom; Morrison, April 23, 1946. Two specimens, U.S.N.M., No. E. 7507.

Bikini Atoll; one-third of a mile southwest of the southeast point of Bikini Island; 27 feet; sandy bottom; Morrison, April 25, 1946. Five specimens, U.S.N.M., Nos. E. 7510, E. 7577.

Bikini Atoll; one-third of a mile west of the southeast point of Bikini Island; 30 feet; coral and foraminiferal sand; Morrison, April 23, 1946. Seventeen specimens, U.S.N.M., Nos. E. 6999, E. 7511.

Bikini Atoll; one-third of a mile west of the southeast point of Bikini Island; 36–42 feet; Morrison, April 23, 1946. Four specimens.

Bikini Atoll; one-half mile south of the west end of Bikini Island, in the lagoon; 150 feet; sandy bottom with *Halimeda;* Morrison, August 7, 1946. One specimen, U.S.N.M., No. E. 7293.

Bikini Atoll; three-fourths of a mile south of the west end of Bikini Island; 90 feet; sandy bottom; Morrison, August 26, 1947. Two specimens, U.S.N.M., No. E. 7238.

Bikini Atoll; south of the west end of Bikini Island; coral-algae bottom; Morrison, April 23, 1946. Two specimens, U.S.N.M., No. E. 7292.

Bikini Atoll; in the lagoon 3 miles off Bikini Island; 150 feet; *Halimeda* bottom; Morrison, July 11, 1946. Four specimens, U.S.N.M. Nos. E. 7295, E. 7296.

Bikini Atoll; 4 miles south of the west end of Bikini Island; 168 feet; Morrison, April 25, 1946. One specimen, U.S.N.M. No. E. 7265.

Bikini Atoll; in the lagoon one-eighth to one-fourth mile offshore inside Bokonfuaaku Island; 18–30 feet; foraminiferal sand covering rock bottom; Morrison, July 11, 1946. Eleven small specimens, U.S.N.M. No. E. 7509.

Eniwetok Atoll; Pujiyoru Island, lagoon reef; Schultz, June 2, 1946. Fragments, U.S.N.M. No. E. 7512.

Eniwetok Atoll; in the lagoon approximately 5 miles north of the anchorage, about 3 miles west of Bogen Island; 90–120 feet; Taylor. Six specimens, U.S.N.M. No. E. 7247.

Rongerik Atoll; ocean side of Rongerik Island; August 13, 1947. Two specimens, U.S.N.M. No. E. 7239.

Rongelap Atoll; lagoon; 23+ fathoms; Johnson, June 16, 1946. One specimen, U.S.N.M. No. E. 7608.

Note.—One of the specimens from about one-fourth mile southwest of the southeast point of Bikini Island has the petals broadly outlined in purple.

Family FIBULARIIDAE

Genus FIBULARIA Lamarck

FIBULARIA AUSTRALIS Desmoulins

Fibularia australis DESMOULINS, Études sur les Échinides, p. 240, 1837 (southern seas).

Localities.—Bikini Atoll; 3 miles off Bikini Island, in the lagoon; 150 feet; *Halimeda* bottom; Morrison, July 11, 1946. Four specimens, U.S.N.M. No. E. 7303.

Eniwetok Atoll; north end of Bogon Island; Draeger, 1948. Eighteen specimens, U.S.N.M. No. E. 7814.

Eniwetok Atoll; south end of Rigili Island; Morrison, May 25, 1946. Eleven specimens, U.S.N.M. No. E. 7495.

Rongerik Atoll; in drift on the sandy beach at the north end of Bock Island; Morrison, August 19, 1947. Twenty specimens, U.S.N.M. Nos. E. 7587, 7816.

Rongelap Atoll; sandy flats on the lagoon side of Kabelle Island; Morrison, June 20, 1946. One specimen, U.S.N.M. No. E. 7496.

FIBULARIA OVULUM (Linné)

Echinus ovulum LINNÉ, Systema naturae, ed. 13, vol. 1, pt. 6. p. 3194, No. 83, 1788 (no locality).

Localities.—Bikini Atoll; in the lagoon, one-half mile south of the west end of Bikini Island; 150 feet; sandy bottom with *Halimeda;* Morrison, August 7, 1946. One specimen, U.S.N.M. No. E. 7304.

Bikini Atoll; a mile and a half south of the west end of Bikini Island; 72 feet; coral and sand bottom; Morrison, April 4, 1946. Two specimens, U.S.N.M. No. E. 7305.

Bikini Atoll; west side of Arriikan Island; Morrison, May 14, 1946. One specimen, U.S.N.M. No. E. 7503.

Eniwetok Atoll; north side of Pujiyoru Island, at high tide line; Morrison, June 2, 1946. One specimen, U.S.N.M. No. E. 7306.

Eniwetok Atoll; south end of Rigili Island; Morrison, May 25, 1946. Thirty specimens, U.S.N.M. Nos. E. 7497, E. 7500, E. 7829.

Eniwetok Atoll; in the lagoon approximately 5 miles north of the anchorage, about 3 miles west of Bogen Island; 90–120 feet; Taylor. Three specimens, U.S.N.M. No. E. 7249.

Eniwetok Atoll; north end of Bogen Island; Draeger, 1948. One specimen, U.S.N.M. No. E. 7815.

Eniwetok Atoll; islet west of Elugelab Island; Draeger, 1948. Eleven specimens, U.S.N.M. No. E. 7826.

Rongerik Atoll; lagoon side of Bock Island; Morrison, June 27, 1946. Two specimens, U.S.N.M. No. E. 7303.

Rongerik Atoll; in drift on the sandy beach at the north end of Bock Island; Morrison, August 19, 1947. One thousand six hundred and two specimens, U.S.N.M. Nos. E. 7586, E. 7813, E. 7824.

FIBULARIA VOLVA L. Agassiz and Desor

Fibularia volva L. AGASSIZ and DESOR, Ann. Sci. Nat., ser. 3, vol. 7, p. 142, 1847 (Red Sea).

Localities.—Bikini Atoll; in the lagoon; Morrison, August 26, 1947. Two specimens, U.S.N.M. No. E. 7277.

Eniwetok Atoll; islet west of Elugelab Island; Draeger, 1948. One specimen, U.S.N.M. No. E. 7830.

Rongelap Atoll; sandy flats on the lagoon side of Kabelle Island; Morrison, June 20, 1946. Seven specimens, U.S.N.M. No. E. 7498.

Rongerik Atoll; in drift on the sandy beach at the north end of Bock Island; Morrison, August 19, 1946. Sixteen specimens, U.S.N.M. Nos. E. 7589, E. 7817, E. 7821.

FIBULARIA ACUTA Yoshiwara

Fibularia acuta YOSHIWARA, Annot. Zool. Japon., vol. 2, p. 60, 1898.

Rongerik Atoll; north end of Bock Island; Morrison, August 19, 1948. Two specimens, U.S.N.M. No. E. 7818.

Genus ECHINOCYAMUS van Phelsum

ECHINOCYAMUS INCERTUS H. L. Clark

Echinocyamus incertus H. L. CLARK, Mem. Mus. Comp. Zool., vol. 46, No. 1, p. 64, pl. 128, figs. 1–3, 1914 (*Albatross* station 4045, off Kawaihae Light, Hawaii, 147–198 fathoms).

Locality.—Bikini Atoll; 800–900 feet; August 7, 1947. One specimen, U.S.N.M. No. E. 7374.

Note.—This specimen is 7 mm. long, 5 mm. in maximum width, and 2.5 mm. high, a little larger than the type specimen.

ECHINOCYAMUS MEGAPETALUS H. L. Clark

Echinocyamus megapetalus H. L. CLARK, Mem. Mus. Comp. Zool., vol. 46, No. 1, p. 60, pl. 128, figs. 5–8, 1914 (Mauritius).

Localities.—Eniwetok Atoll; south end of Rigili Island; Morrison, May 25, 1946. One specimen, U.S.N.M. No. E. 7501.

Eniwetok Atoll; Chinieero Island; Draeger, 1948. Six specimens, U.S.N.M. No. E. 7827.

Bikini Atoll; Namu Island; Morrison, March 1, 1946. One specimen, U.S.N.M. No. E. 7828.

Rongerik Atoll; in drift on the sandy beach at the north end of Bock Island; Morrison, August 19, 1947. One hundred thirty-four specimens, U.S.N.M. Nos. E. 7590, E. 7819, E. 7825.

Rongerik Atoll; Latoback Island, northeast side, just above the high-tide line; Morrison, June 28, 1946. One specimen, U.S.N.M. No. E. 7499.

Note.—The specimen from Latoback Island, Rongerik Atoll, is 6 mm. long, 4 mm. wide, and 2.5 mm. high.

ECHINOCYAMUS ELONGATUS H. L. Clark

Echinocyamus elongatus H. L. CLARK, Mem. Mus. Comp. Zool., vol. 46, No. 1, p. 61, pl. 126, figs. 9–11, 1914 (*Albatross* station 3846, south coast of Molokai, Hawaiian Islands, 117–110 meters).

Locality.—Bikini Atoll; west side of Arriikan Island; Morrison, May 14, 1946. Eight specimens, U.S.N.M. No. E. 7502.

Family ECHINONEIDAE

Genus ECHINONEUS van Phelsum

ECHINONEUS ABNORMALIS de Loriol

Echinoneus abnormalis DE LORIOL, Mém. soc. phys. nat. hist. Genève, vol. 28, No. 8, p. 41, 1883 (Mauritius).

Locality.—Eniwetok Atoll; east side of Rigili Island; Morrison, May 30, 1946. One specimen, U.S.N.M. No. E. 7488.

Note.—This specimen is large, 50 mm. long, 42 mm. wide, and 28 mm. high.

ECHINONEUS CYCLOSTOMUS Leske

Echinoneus cyclostomus LESKE, Additamenta ad Jacobi Theodori Klein, p. 173, pl. 37, figs. 4, 5, 1778.

Localities.—Bikini Atoll; Eniairo Island; Bayer, July 21, 1947. One specimen, U.S.N.M. No. E. 7267.

Bikini Atoll; ocean drift on the west part of the north side of Namu Island; Morrison, March 30, 1946. One specimen, U.S.N.M. No. E. 7302.

Bikini Atoll; drift on the ocean side of Namu Island; Morrison, April 14, 1946. One specimen, U.S.N.M. No. E. 7301.

Bikini Atoll; rocky flats inside the outer reef, southeast corner of Enyu Island, near low tide line; Morrison, March 16, 1946. One specimen, U.S.N.M. No. E. 7493.

Eniwetok Atoll; east side of Rigili Island; Morrison, May 30, 1946. One specimen, U.S.N.M. No. E. 7489.

Eniwetok Atoll; south end of Rigili Island; Morrison, May 25, 1946. One specimen, U.S.N.M. No. E. 7494.

Rongelap Atoll; outer reef flat of Rongelap Island; Johnson, July 1946. Two large specimens, U.S.N.M. No. E. 7280.

Rongerik Atoll; in drift on sandy beach at the north end of Bock Island; Morrison, August 19, 1947. Eighteen specimens, U.S.N.M. Nos. E. 7589, E. 7820.

Family NUCLEOLITIDAE

Genus ECHINOLAMPAS Gray

ECHINOLAMPAS ALEXANDRI de Loriol

Echinolampas alexandri DE LORIOL, Mém. soc. phys. nat. hist. Genève, vol. 24, p. 660, 1876 (Mauritius).

Localities.—Bikini Atoll; in the lagoon; 180–200 feet; Schultz, March 29, 1946. One specimen, U.S.N.M. No. E. 7279.

Bikini Atoll; 4 miles south of the west end of Bikini Island; 180 feet; Morrison, April 4, 1946. One specimen, U.S.N.M. No. E. 7278.

Bikini Atoll; one-third of a mile west of the southeast point of

Bikini Island; 30 feet; coral and foraminiferal sand bottom; Morrison, April 23, 1947. One very young specimen, U.S.N.M. No. E. 7506.

Notes.—The very small specimen (E. 7506) bears little resemblance to the adult, but instead suggests a small slender spined *Echinometra*. It is slightly oval, two-thirds as broad as long, and twice as long as high, with the aboral surface gently convex. It measures 7 mm. in length, 5.5 mm. in width, and 3.5 mm. in height.

The genitals are fused into a somewhat irregular five-sided plate 1.5 mm. long and 1 mm. broad. The posterior genital appears to be much larger than the others and bears a large perforated tubercle surrounded by a broad areole. Numerous other tubercles about half as large are scattered over the surface of the combined genitals. There are four large madreporic pores, each on the summit of a short tube, the four tubes crowded into a square with rounded angles and slight notches on the sides. No pores are visible in the genital plates.

The triangular oculars are very small, each situated on one of the sides of the combined genitals.

There are from 10 to 12 large interambulacrals in each column. These are at first hexagonal, toward the ambitus gradually becoming transversely elongated, and at the ambitus about twice as broad as long; below the ambitus they gradually become shorter again. Aborally each interambulacral plate bears a large central perforated tubercle surrounded by a broad areole margined by a circlet of small and glassy, usually contiguous, tubercles. On the broad interambulacral plates at and below the ambitus there are commonly two tubercles to a plate.

The ambulacrals are at first minute. After a series varying from 12 to 19, much larger ones, each with a large central tubercle, appear, and soon all are large with usually three pores in a slightly curved line along the outer border. At the ambitus the ambulacrals are hexagonal and about as high as the much broader interambulacrals, with central tubercles about as broad as those of the latter. On the aboral surface the very small ambulacrals always extend farther down on one side of the ambulacral areas than on the other.

There is a single glassy spheridium situated in a deep and capacious pit at the adoral end of each ambulacrum.

The peristome is circular, 2 mm. in diameter, densely and evenly covered with very minute spinous plates. The mouth is closed and no teeth are visible.

The periproct is large, situated just below the ambitus and sloping slightly inward, diamond shaped with rounded angles, transversely elongated, 2.3 mm. wide and 1.4 mm. high. Most of its surface is covered by three large plates of which the two outer reach halfway from the lateral apices to the anterior angle. The remaining area, from the anterior angle about halfway to the posterior, and halfway to the lateral apices, is covered by several much smaller plates.

The primary spines are 2 mm. long, cylindrical or slightly tapering, with eight high and rounded longitudinal ridges. In section they resemble the spine of *Echinolampas alexandri* var. *sibogae* figured by Mortensen (Monograph of the Echinoidea, vol. 4, part 1, p. 281, fig. 272, c. 1948). The secondary spines are very fine, 0.7 mm. long and cylindrical.

The ophicephalous pedicellariae resemble the one from *E. a. sibogae* figured by Mortensen (pl. 14, figs. 5, 6).

The color is light olive-green. The test is yellowish white with some olive-green patches and a purple patch on the genitals.

This little specimen bears a close resemblance to the young *Echinolampas depressa* figured by Agassiz (Revision of the Echini, pl. 16, figs. 1, 2, 3, 1872), but it is much lower than is shown in figure 3, in lateral view being more like the larger specimen shown in figure 10. The periproctal structure is as shown in figure 14, but the three large plates are smaller.

Dr. Morrison's specimen (E. 7278) is 77 mm. long, 69 mm. in maximum width, 35 mm. high at the apical system, and 36 mm. high at the posterior end. It agrees well with a specimen from Tavoy figured and described by Koehler, but is slightly larger and more depressed.

Dr. Schultz's specimen (E. 7279) agrees with the preceding, but is somewhat smaller.

This species has heretofore been reported only from Mauritius, Ceylon, and the Bay of Bengal.

Family SPATANGIDAE

Genus METALIA Gray

METALIA DICRANA H. L. Clark

Metalia dicrana H. L. Clark, Mem. Mus. Comp. Zool., vol. 46, No. 2, p. 211, pl. 146, fig. 16, pl. 160, figs. 1–4, 1917 (Panglao, Bohol Province, Philippines).

Localities.—Bikini Atoll; in the lagoon, about one-eighth to one-fourth mile offshore inside Bokonfuaaku Island; 18–30 feet; Morrison, July 11, 1946. One specimen, U.S.N.M. No. E. 7487.

Eniwetok Atoll; in the lagoon, approximately 5 miles north of the south anchorage, about 3 miles west of Bogen Island; 90–120 feet; Taylor. Seven specimens, U.S.N.M. No. E. 7245.

Notes.—The specimen from Bikini is 26 mm. long, 23 mm. wide, and 17 mm. high. The seven specimens from Eniwetok are small, about 17 mm. long, and are very variable in shape.

Genus BRISSUS Leske

BRISSUS LATECARINATUS (Leske)

Spatangus brissus var. *latecarinatus* LESKE, Additamenta ad Jacobi Theodori Klein, pp. XX, 185, 1778.

Localities.—Bikini Atoll; Namu Island; drift on the north side of the east end; Morrison, April 14, 1946. Two bare tests, U.S.N.M. No. E. 7258.

Bikini Atoll; blasted out of a coral head in making a channel across the flats just west of the beach on the west side of Bokororyuru Island; Morrison, August 12, 1946. Fragments, U.S.N.M. No. E. 7290.

Rongelap Atoll; lagoon side of Eniaetok Island; 12 feet; Brock and Herald, July 20, 1946. One specimen, U.S.N.M. No. E. 7492.

Note.—The two specimens from Namu Island (E. 7258) are 110 and 115 mm. in length.

Genus MARETIA Gray

MARETIA OVATA (Leske)

Spatangus ovatus LESKE, Additamenta ad Jacobi Theodori Klein, p. 188, pl. 49, figs. 12, 13, 1778.

Localities.—Bikini Atoll; 50–80 feet; August 15, 1947. One specimen, U.S.N.M. No. E. 7256.

Bikini Atoll; in the lagoon; 100–140 feet; August 6, 1947. Three small broken specimens, U.S.N.M. No. E. 7373.

Eniwetok Atoll; Lidilbut Island, north side, outer reef flats, under sand; Morrison, June 1, 1946. One specimen with parasitic gastropods, U.S.N.M. No. E. 7504.

Class ASTEROIDEA

Family ASTROPECTINIDAE

Genus ASTROPECTEN Schultze

ASTROPECTEN POLYACANTHUS Müller and Troschel

Astropecten polyacanthus MÜLLER and TROSCHEL, System der Asteriden, p. 69, 1842 (Red Sea).

Locality.—Eniwetok Atoll; in the lagoon approximately 5 miles north of the anchorage and about 3 miles west of Bogen Island; Taylor, 1947. One small specimen, U.S.N.M. No. E. 7248.

Family LUIDIIDAE

Genus LUIDIA Forbes

LUIDIA MASCARENA Döderlein

Luidia mascarena DÖDERLIEN, Die Asteriden der *Siboga*-Expedition, pt. 2, p. 261, fig. 5, 1920 (Mauritius).

Locality.—Bikini Atoll; in the lagoon; Morrison, August 26, 1947. One specimen, U.S.N.M. No. E. 7255.

Note.—This specimen was kindly identified by Prof. Walter K. Fisher.

Family GONIASTERIDAE

Genus CALLIASTER Gray

CALLIASTER ELEGANS Döderlein

Calliaster elegans DÖDERLIEN, Bijdragen tot de Dierkunde, Amsterdam, Afl. 22, p. 49, pl. 1, figs. 1–1*b*, 1922 (Solor Strait, 113 meters).

Locality.—Bikini Atoll; off Bikini Island; 400–450 feet; Russell, August 14, 1947. One specimen, U.S.N.M. No. E. 7365.

Notes.—R=45 mm., r=18 mm.; R=2.4 r. This specimen agrees fairly well with Döderlein's type specimen, which was dredged by the *Siboga* in the Solor Strait near Flores in 113 meters, though it is rather more than twice as large. The plates of the disk agree with those of the type. The innermost spines of the carinal row are 6 mm. high, those following decreasing rapidly in height and disappearing at the level of the third superomarginal. The plates of the disk, except for those of the two rows adjoining the superomarginals, each have a prominent central tubercle. There are no pedicellariae.

There are eight superomarginals of which the outer five are in contact in the midradial line. The two interradial superomarginals each bear a prominent spine 2 mm. high on the inner edge, a shorter spine or tubercle in the middle, and usually one or two tubercles near the outer edge. The next two superomarginals on each side bear similar but smaller spines. The following superomarginals bear usually two or three tubercles near the inner edge, one in the middle, and from one to three near the lower edge.

The inferomarginals bear a group of from two to four tubercles near the upper edge, or sometimes a group of three long spines.

Each actinal plate bears a short stout spine.

The adambulacral plates bear two large stout spines on the outer surface and a comb of usually seven subequal furrow spines.

The slight differences between this specimen and the type, the only other specimen known, are probably due chiefly to size and age.

Family OREASTERIDAE

Genus CULCITA L. Agassiz

CULCITA NOVAE-GUINEAE Müller and Troschel

Culcita novae-guineae Müller and Troschel, System der Asteriden, p. 38, 1842.

Localities.—Bikini Atoll; north side of the lagoon, by diving to a depth of 15 feet; March 11, 1946. Three specimens, U.S.N.M. Nos. E. 7960, E. 7961, E. 7962. The diameter of the largest (in alcohol) is 225 mm.

Bikini Atoll; Bokororyuru Island, west side; Morrison, August 12, 1948. One specimen, U.S.N.M. No. E. 6997.

Eniwetok Atoll; Arambiru Island, ocean reef; Schultz, June 3, 1946. One specimen, U.S.N.M. No. E. 7964.

Eniwetok Atoll; Pujiyoru Island, ocean reef; Schultz, June 2, 1946. One specimen, U.S.N.M. No. E. 7963.

Family LINCKIIDAE

Genus NEOFERDINA Livingstone

NEOFERDINA OCELLATA (H. L. Clark)

Ferdina ocellata H. L. Clark, The Echinoderm fauna of Torres Strait, p. 60, pl. 6, fig. 5 (colored), pl. 31, figs. 1, 2, 1921 (Mer, Murray Islands, Torres Strait).

Locality.—Bikini Atoll; Namu Island, ocean drift on the north side; Morrison, March 30, 1946. One beach-worn specimen, U.S.N.M. No. E. 7364.

Notes.—R = 33 mm., r = 10 mm.; width of rays at base 12 mm. This specimen agrees well with Dr. H. L. Clark's original description and figures, based upon a single specimen from Mer, Murray Islands, Torres Strait. Since the species was originally described two additional specimens have been recorded, another from Mer and one from Northwest Islet.

Neoferdina ocellata is probably conspecific with *N. cancellata* (Grube), described from a specimen without locality and later recorded from Fiji.

Genus FROMIA Gray

FROMIA BALANSAE E. Perrier

Fromia balansae E. Perrier, Arch. zool. experim., vol. 4, p. 178, 1875 (New Caledonia).

Locality.—Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. One specimen, U.S.N.M. No. E. 7524.

Notes.—R = 25 mm., r = 7 mm. This specimen agrees well with the figure of the type specimen published by Koehler (Echinoderma of the Indian Museum, Part vi, Asteroidea II, pl. 18, figs. 7, 8, 1910).

FROMIA HEMIOPLA Fisher

Fromia hemiopla FISHER, Proc. U. S. Nat. Mus., vol. 46, p. 213, 1913 (Tonquil Island, Gumila Reef, south of Mindanao, Philippine Islands).

Localities.—Bikini Atoll; in the lagoon; Schultz, March 29, 1946. One specimen, U.S.N.M. No. E. 7264.

Bikini Atoll; 150–180 feet; Schultz, April 13, 1946. One small specimen, U.S.N.M. No. E. 7288.

Notes.—The specimen from the Bikini lagoon has R=16 mm., r=4 mm. In the specimen from 150–180 feet R=5 mm.

FROMIA EUSTICHA Fisher

Fromia eusticha FISHER, Proc. U. S. Nat. Mus., vol. 46, p. 213, 1913 (*Albatross* station 5146, in the vicinity of Siasi, Tapul group, Jolo Archipelago; 24 fathoms).

Locality.—Bikini Atoll (lat. 11°34′30″ N., long. 165°30′30″ E.); 180 feet; August 22, 1947. One specimen, U.S.N.M. No. E. 7287.

Genus DACTYLOSASTER Gray

DACTYLOSASTER CYLINDRICUS PACIFICUS Fisher

Dactylosaster cylindricus pacificus FISHER, Bernice P. Bishop Mus. Bull. No. 27, p. 75, pl. 8, *b*. 1925 (Laysan Island).

Locality.—Bikini Atoll; Schultz, April 13, 1946. One specimen, U.S.N.M. No. E. 7271.

Notes.—R=11 mm. The animal is completely covered with small granules, with one large pointed granule on the summit of each plate.

Genus OPHIDIASTER L. Agassiz

OPHIDIASTER GRANIFER Lütken

Ophidiaster granifer LÜTKEN, Vid. Med., vol. 23, p. 276, 1871 (Tonga Islands).

Localities.—Bikini Atoll; Eniuman Island, outer reef flats; Bayer, July 17, 1947. One specimen, U.S.N.M. No. E. 7289.

Bikini Atoll; Bikini Island, lagoon reef; Bayer, August 24, 1947. Two specimens, U.S.N.M. No. E. 7270.

Bikini Atoll. One specimen, U.S.N.M. No. E. 7269.

Bikini Atoll; Draeger, 1946. Five specimens, U.S.N.M. No. E. 7822.

Bikini Atoll; Johnson, May 1946. One specimen, U.S.N.M. No. E. 7621.

Eniwetok Atoll; outer reef, southwest side of Grinem Island; Morrison, May 29, 1946. Two specimens, U.S.N.M. No. E. 7513.

Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. Two specimens, U.S.N.M. No. E. 7514.

Rongelap Atoll; outer reef flats of Mellu Island; Morrison, June 19, 1946. One specimen, U.S.N.M. No. E. 7515.

Notes.—In the largest specimen R=33 mm. One of the specimens from Grinem Island is four-rayed.

OPHIDIASTER SQUAMEUS Fisher

Ophidiaster squameus FISHER, U. S. Fish Comm. Bull. for 1903, pt. 3, p. 1,079, pl. 31, figs. 6, 6*a*, 6*b*, pl. 37, fig. 4, 1906 (*Albatross* station 4100, Pailolo Channel, between Maui and Molokai, Hawaiian Islands, 130–151 fathoms).

Locality.—Rongelap Atoll; outer reef flats on the ocean side of Enybarbar Island; Morrison, June 18, 1946. One specimen, U.S.N.M. No. E. 7516.

Notes.—R=40–45 mm. Pedicellariae with straight alveolae are rather numerous on the abactinal surface, some of them raised on smooth elongate elevations. The color is bright red and yellow in broad irregular bands.

OPHIDIASTER LORIOLI Fisher

Ophidiaster lorioli FISHER, U. S. Fish Comm. Bull. for 1903, pt. 3, p. 1,077, pl. 31, figs. 4, 4*a–d*, pl. 39, fig. 3, 1906 (*Albatross* station 3834, south coast of Molokai, Hawaiian Islands, on reefs).

Locality.—Eniwetok Atoll; outer reef, east end of Bogen Island; Morrison, May 21, 1946. One specimen, U.S.N.M. No. E. 7517.

Notes.—All the rays are of different lengths, up to 25 mm. long. Only a single pedicellaria is present, in the center of an interbrachial area on the oral side. There are two small madreporites.

OPHIDIASTER PUSILLUS Müller and Troschel

Ophidiaster pusillus MÜLLER and TROSCHEL, Arch. für Naturg., Jahrg. 10, vol. 1, p. 180, 1844 (Philippines).

Localitiy.—Bikini Atoll; Bokororyuru Island; Morrison, April 30, 1946. One specimen, U.S.N.M. No. E. 7518.

Notes.—R=20 mm. There are seven pedicellariae, each situated on a second superomarginal, two in two of the interbrachial areas, and one in each of the other three.

Genus LINCKIA Forbes

LINCKIA MULTIFORA (Lamarck)

Asterias multifora LAMARCK, Histoire naturelle des animaux sans vertèbres, vol. 2, p. 565, 1816 (?Seas of Europe).

Localities.—Bikini Atoll; in the lagoon; 40–80 feet; August 6, 1947. One specimen, U.S.N.M. No. E. 7272.

Bikini Atoll; Draeger, 1946. Two specimens, U.S.N.M. No. E. 7833.

Bikini Atoll; sandy reef flats behind the outer reef, opposite the center of Bikini Island; Ladd, April 17, 1946. One comet, U.S.N.M. No. E. 7539.

Bikini Atoll; Romurikku Island, reef; Schultz, May 13, 1946. One specimen, U.S.N.M., No. E. 7273.

Bikini Atoll; rocky flats inside outer reef, southeast corner of Enyu Island; Morrison, March 16, 1946. One small specimen, U.S.N.M., No. E. 7566.

Bikini Atoll; lagoon side of Yurochi Island, under rock in tide pool; Morrison, March 22, 1946. One comet, U.S.N.M., No. E. 7542.

Bikini Atoll; outer reef, south (ocean) end of Bokororyuru Island; Morrison, April 30, 1946. One specimen, U.S.N.M., No. E. 7541.

Bikini Atoll; Enirik Island, lagoon tide pool; Schultz and Brock, March 20, 1946. Three specimens, U.S.N.M., No. E. 7486.

Bikini Atoll; Enirik Island; Johnson, 1946. One specimen, U.S.N.M., No. E. 7619.

Bikini Atoll; Johnson, 1946. Two specimens, U.S.N.M., No. E. 7615.

Eniwetok Atoll; Bogombogo Island; Johnson, May 31, 1946. One specimen, U.S.N.M., No. E. 7616.

Eniwetok Atoll; outer reef flats, Pujiyoru Island; Morrison, June 2, 1946. One six-rayed comet, U.S.N.M., No. E. 7545.

Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. Thirteen small specimens, of which nine are comets; one comet has six rays and three madreporites, U. S. N. M., No. E. 7537.

Rongelap Atoll; inner reef flats, sandy and rocky, of Burok Island; 1–2 feet; Morrison, July 24, 1946. One specimen, U.S.N.M., No. E. 7540.

Rongelap Atoll; 2 miles west of Busch Island; 120 feet; Taylor, June 20, 1946. One comet, U.S.N.M., No. E. 7538.

Rongelap Atoll; Kabelle Island, lithothamnion ridge, intertidal; Johnson, July 28, 1946. One specimen, U.S.N.M., No. E. 7617.

Rongerik Atoll; Latoback Island, lagoon reef; Bayer and Zimmerman, August 20, 1947. One specimen, U.S.N.M., No. E. 7338.

Johnston Island, outer reef on the northwest side; Bayer, August 28, 1947. One specimen, U.S.N.M., No. E. 7339.

LINCKIA GUILDINGII Gray

Linckia guildingii GRAY, Ann. Mag. Nat. Hist., vol. 6, p. 285, December 1840 (St. Vincent, West Indies).

Localities.—Bikini Atoll; Johnson, May 16, 1946. One specimen, U.S.N.M., No. E. 7612.

Rongelap Atoll; lagoon; Johnson, June 16, 1946. Two specimens, U.S.N.M., Nos. E. 7618, E. 7620.

Notes.—In the specimen from Bikini Atoll one ray is about 35 mm. long, and the other four are 9–10 mm. The color is purple blotched with yellowish white.

LINCKIA LAEVIGATA (Linné)

Asterias laevigata LINNÉ, Systema naturae, ed. 10, vol. 1, p. 662, No. 8, 1758 (Mediterranean and Indian Seas).

Localities.—Eniwetok Atoll; Chinieero Island, reef on outer side of island, close to island but in water on bottom not likely to be exposed at low tide; Taylor and Schultz, May 25, 1946. One specimen, U.S.N.M., No. E. 7775.

Rongelap Atoll; west side of Naen Island; Herald, July 30, 1946. One specimen, U.S.N.M., No. E. 7776.

Notes.—Dr. Schultz recorded the color of the specimen from Chinierro Island as a "bright grayish blue or delft blue." In this specimen R=132 mm., r=23 mm. In the one from Naen Island R=177 mm., r=25 mm.

Family ASTERINIDAE

Genus ASTERINA Nardo

ASTERINA CEPHEA (Müller and Troschel)

Asteriscus cephus (Valenciennes, MS.) MÜLLER and TROSCHEL, System der Asteriden, p. 41, 1842 (Batavia, Java).

Locality.—Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. One specimen, U.S.N.M. No. E. 7528.

ASTERINA CORONATA CRISTATA Fisher

Asterina cristata FISHER, Proc. Biol. Soc. Washington, vol. 29, p. 27, 1916 (Ponapé, Caroline Islands).

Localities.—Bikini Atoll; lagoon; 180–200 feet; Schultz, March 29, 1946. One specimen, U.S.N.M. No. E. 7361.

Bikini Atoll; Johnson, May 1946. One specimen, U.S.N.M. No. E. 7622.

Rongerik Atoll; Latoback Island; lagoon reef, from a clump of *Stylophora mardax;* Bayer and Zimmerman, August 20, 1947. One specimen, U.S.N.M. No. E. 7362.

Notes.—The specimen collected by Dr. Schultz at Bikini is 9 mm. in diameter and has two regenerating rays. Dr. Johnson's specimen from Bikini has seven rays, the two longest 12 mm. long, the other five, 9 mm. The specimen from Latoback Island, Rongerik Atoll, has seven rays and is 6.5 mm. in diameter.

ASTERINA ANOMALA H. L. Clark

Asterina anomala H. L. CLARK, The Echinoderm fauna of Torres Strait, p. 95, pl. 7, fig. 8 (colored), pl. 23, fig. 5, pl. 26, figs. 2, 3, 1921 (reef flat, Mer, Murray Islands, Torres Strait).

Locality.—Bikini Atoll; lagoon, about 1 mile inside Bikini Island;

picked off staghorn coral; Bayer, July 16, 1947. One specimen, U.S.N.M. No. E. 7363.

Notes.—R = 11 mm., r = 5 mm. There are seven rays of nearly equal length. This specimen agrees well with Dr. H. L. Clark's original description. The form, size, and proportions are the same as those of the specimen shown in his colored figure. This species is known from Mer and Lord Howe Islands, from Cape Leveque, Western Australia, and from the Hawaiian Islands. It is abundant at Lord Howe Island.

Family ECHINASTERIDAE

Genus OTHILIA Gray

OTHILIA LUZONICA Gray

Othilia luzonica GRAY, Ann. Mag. Nat. Hist., vol. 6, p. 282, December 1840 (Isle of Luzon, Philippine Islands).

Localities.—Bikini Atoll; lagoon, off western end of Bikini Island; Cali, April 29, 1946. One specimen, U.S.N.M. No. E. 7521.

Bikini Atoll; Bikini Island, drift; Morrison, April 5, 1946. One specimen, U.S.N.M. No. E. 7520.

Bikini Atoll; drift from south side of Uorikku Island; Morrison, March 23, 1946. One small specimen.

Bikini Atoll; Airukiraru Island, lagoon side; Schultz, April 17, 1946. Three specimens, U.S.N.M. No. E. 7483.

Bikini Atoll; narrow outer reef on southwest (ocean) side of Ourukaen Island; Ladd, May 2, 1946. One specimen, U.S.N.M. No. E. 7523.

Bikini Atoll; lagoon reef, a poor narrow reef on the northeast side of Ourukaen Island; Ladd and Tracey, May 3, 1946. Two small specimens, U.S.N.M. No. E. 7567.

Bikini Atoll; east side of Chieerete Island, under rocks in tide pools; March 20, 1946. Two specimens, U.S.N.M. No. E. 7139.

Bikini Atoll; Bokororyuru Island, flats inside outer reef on south (ocean) end; Morrison, April 30, 1946. Two specimens, U.S.N.M. No. E. 7519.

Eniwetok Atoll; Rigili Island; Morrison, May 25, 1946. One specimen, U.S.N.M. No. E. 7522.

Eniwetok Atoll; east side of Rigili Island; Morrison, May 30, 1946. Seven specimens, U.S.N.M. No. E. 7490.

Eniwetok Atoll; Lidilbut Island, lagoon reef; Schultz, June 1, 1946. One specimen, U.S.N.M. No. E. 7484.

Eniwetok Atoll; outer reef, east end of Bogen Island; Morrison, May 21, 1946. One specimen, U.S.N.M. No. E. 7491.

Family ACANTHASTERIDAE

Genus ACANTHASTER Gervais

ACANTHASTER PLANCI (Linné)

Asterias planci LINNÉ, Systema naturae, ed. 10, p. 823, Appendix, 1758 (Goa [Portuguese India]).

Locality.—Bikini Atoll; Eninman Island; Bayer, July 17, 1947. One specimen, U.S.N.M. No. E. 7391.

Class OPHIUROIDEA

Family OPHIOMYXIDAE

Genus OPHIOMYXA Müller and Troschel

OPHIOMYXA AUSTRALIS Lütken

Ophiomyxa australis LÜTKEN, Additamenta ad historiam Ophiuridarum, part 3, p. 99, 1869 (Bass Strait, between Australia and Tasmania).

Localities.—Bikini Atoll; one-half mile from Aomoen Island, in the lagoon, in coral at 42 feet; Brock, Kohler, and Herald, July 10, 1946. Four specimens, U.S.N.M. No. E. 7350.

Rongerik Atoll; Latoback Island, lagoon reef; Bayer and Zimmerman, August 18, 20, 21, 1947. Four specimens, U.S.N.M. Nos. E. 7351–E. 7354.

Genus OPHIODERA Verrill

OPHIODERA PUNCTATA, new species

Description.—The disk is stellate with evenly rounded interbrachial borders (dried), and is 27 mm. in diameter; the arms are 160 mm. long.

The disk is thickly studded with minute oval concretions uniformly distributed over the surface but becoming smaller toward the interradial borders; these do not extend out onto the arms, though there may be a few just beyond the ends of the radial shields. The disk thus resembles that of *Ophiomyxa bengalensis* Koehler, but the concretions are smaller and end abruptly at the arm bases. The radial shields are conspicuous, 5 mm. long and about 1.5 mm. broad. Their distal ends are connected across the arm bases by a row of six small rounded contiguous plates.

There are no upper arm plates, but there are a few scattered rounded plates on the aboral side of the first two arm segments.

The interbrachial areas below are naked. The genital slits are long, reaching nearly to the sixth spine-bearing side arm plates. Parallel to the genital slits and near them is a row of eight or nine short black lines at right angles to the slits, the outermost about 2 mm. long and the following regularly decreasing in length to that just beyond the oral shield, which is merely a dot.

The oral shields are reniform, nearly twice as broad as long. The adoral shields are broad, outwardly adjoining the first under arm plates; they do not quite meet beneath the oral shields. The jaw plates are narrow with parallel sides, so that there is a long triangle of membrane between them. There are four mouth papillae. The outermost is narrow, conical, and sharply pointed. The next is conical, but stouter. The third is broader with almost or quite parallel sides and a broad chisellike tip. The innermost is broadly fan shaped with a curved and finely serrate outer edge and resembles the teeth.

The under arm plates are large and well developed with a sharp angle proximally and a deep distal notch; at the arm bases they are almost in contact; distally they become narrower and somewhat more separated, and the distal notch becomes deeper. At the arm tips they are small and widely separated, the side arm plates almost meeting between them.

The side arm plates beyond the disk bear four, rarely five, subequal spines of which the uppermost is slightly longer and considerably stouter than the others, and the two lowest are the most slender. Toward the arm tips the number of spines becomes reduced to three, and the upper transforms into a stout hook with three or four teeth. Later the middle spine also becomes hooklike. At the end of the arms there are only two spines, both in the form of hooks.

The disk is rather dark brown with numerous white specks and conspicuous dull yellow radial shields. The arms and the oral surface are brownish yellow, with a conspicuous row of short black lines along the genital slits.

Locality.—Bikini Atoll; off Enyu Pass, 700–725 feet; August 22, 1947. One specimen, the type, U.S.N.M. No. E. 7367.

Family OPHIACTIDAE

Genus OPHIACTIS Lütken

OPHIACTIS SAVIGNYI (Müller and Troschel)

Ophiolepis savignyi Müller and Troschel, System der Asteriden, p. 95, Species 12, 1842 (Egypt).

Localities.—Eniwetok Atoll; in the lagoon, approximately 5 miles north of the anchorage, about 3 miles west of Bogen Island; 90–120 feet; Taylor. Five specimens, U.S.N.M. No. E. 7250.

Rongerik Atoll; Bock Island; Bayer and Zimmerman, August 19, 1947. One specimen, U.S.N.M. No. E. 7252.

Rongerik Atoll; Latoback Island, lagoon reef, from a sponge; Bayer and Zimmerman, August 21, 1947. Twenty-one specimens, U.S.N.M. No. E. 7251.

Family OPHIOTRICHIDAE

Genus OPHIOTHRIX Müller and Troschel

OPHIOTHRIX LONGIPEDA (Lamarck)

Ophiura longipeda LAMARCK, Histoire naturelle des animaux sans vertèbres, vol. 2, p. 544, 1816 (Mauritius).

Locality.—Bikini Atoll; Bikini Island, under rocks on the outer reef flat; Bayer, August 8, 1947. One specimen, U.S.N.M. No. E. 7342.

OPHIOTHRIX ELEGANS Lütken

Ophiothrix elegans LÜTKEN, Additamenta ad historiam Ophiuridarum, part 3, pp. 57, 99, 1869 (China Sea).

Locality.—Rongelap Atoll; lagoon, 2 miles west of Busch Island; 120 feet; Taylor, June 21, 1946. Three specimens, U.S.N.M. No. E. 7584.

OPHIOTHRIX VIRGATA Lyman

Ophiothrix virgata LYMAN, Proc. Boston Soc. Nat. Hist., vol. 8, p. 82, 1861 (Kingsmill [Gilbert] Islands).

Localities.—Bikini Atoll; Bikini; Schultz, April 13, 1948. Three specimens, U.S.N.M. No. E. 7345.

Bikini Atoll; in the lagoon; Morrison, August 26, 1947. One specimen, U.S.N.M. No. E. 7344.

Bikini Atoll; Johnson, May 1946. Six specimens, U.S.N.M. No. E. 7625.

OPHIOTHRIX TRILINEATA Lütken

Ophiothrix trilineata LÜTKEN, Additamenta ad historiam Ophiuridarum, part 3, pp. 58, 100, 1869 (Samoan Islands).

Locality.—Bikini Atoll; Bikini Island, lagoon reef; Bayer, August 24, 1947. One specimen.

OPHIOTHRIX EXIGUA Lyman

Ophiothrix exigua LYMAN, Bull. Mus. Comp. Zool., vol. 3, part 10, p. 236, pl. 4, figs. 14–26, 1874 (Philippine Islands).

Locality.—Eniwetok Atoll; in the lagoon approximately 5 miles north of the anchorage, about 3 miles west of Bogen Island; 90–120 feet; Taylor, 1947. One specimen, U.S.N.M. No. E. 7329.

OPHIOTHRIX LEPIDA de Loriol

Ophiothrix lepida DE LORIOL, Mém. soc. phys. nat. hist. Genève, vol. 32, part 1, No. 3, p. 45, pl. 25, figs. 1–1*f*, 1893 (Mauritius).

Locality.—Bikini Atoll; off Bikini Island; 400–550 feet; August 6, 1947. One specimen, U.S.N.M. No. E. 7340.

Note.—This specimen is of the typical form, not the Hawaiian subspecies (*hawaiiensis* A. H. Clark). It was taken from a muriciid alcyonarian.

Family OPHIOCHITONIDAE

Genus OPHIODESMUS Ziesenhenne

OPHIODESMUS DEGENERI A. H. Clark

Ophiodesmus degeneri A. H. Clark, Bernice P. Bishop Mus. Bull. 195, p. 46, fig. 17, a, b, p. 47, 1949 (*Albatross* station 4160, in the vicinity of Moku Manu [Bird Island], Hawaiian Islands, 57–71 meters).

Localities.—Bikini Atoll; in the lagoon, 180–200 feet; Schultz, March 29, 1946. Two small specimens, U.S.N.M. No. E. 7357.

Bikini Atoll; in the lagoon, 150–180 feet; Schultz, April 13, 1948. Two specimens, U.S.N.M. No. E. 7358.

Family OPHIOCOMIDAE

Genus OPHIOCOMA L. Agassiz

OPHIOCOMA ANAGLYPTICA Ely

Ophiocoma anaglyptica Ely, Journ. Washington Acad. Sci., vol. 34, No. 11, p. 373, fig. 1, p. 374, 1944 (Canton Island, reef).

Localities.—Bikini Atoll; Namu Island, west of the north point, under loose flat coral heads; Morrison, April 4, 1946. One specimen, U.S.N.M. No. E. 7141.

Eniwetok Atoll; reef on the ocean side of Pujiyoru Island; Morrison and Cali, June 2, 1946. Six specimens, U.S.N.M. No. E. 7309.

Eniwetok Atoll; under rocks on rocky shore, south end of Rigili Island; Morrison, May 25, 1946. Two specimens, U.S.N.M. No. E. 7574.

Notes.—The apparently quite distinct and easily recognized *Ophiocoma anaglyptica* was described in 1944 from Canton Island in the Phoenix group and has not since been reported. The granules on the disk are lower and broader than those of *O. scolopendrina*, a point not mentioned in the original description.

Mr. Ely has kindly presented his type specimen to the National Museum (No. E. 6847). The National Museum also possesses specimens from Asor Island, Ulithi Atoll, Caroline Islands, collected and presented by Lt. Comdr. F. C. Ziesenhenne, U. S. N. R.

OPHIOCOMA SCOLOPENDRINA (Lamarck)

Ophiura scolopendrina Lamarck, Histoire naturelle des animaux sans vertèbres, vol. 2, p. 544, 1816 (Mauritius).

Localities.—Bikini Atoll; Bikini Island, under rocks in the lower intertidal zone near the outer reef; Morrison, March 7, 1946. Three specimens, U.S.N.M. No. E. 7138.

Bikini Atoll; Namu Island, under loose flat coral heads a little west of the north point; Morrison, April 4, 1946. One specimen, U.S.N.M. No. E. 7142.

Bikini Atoll; Enyu Island, ocean reef; Schultz, May 8, 1946. One specimen, U.S.N.M. No. E. 7348.

Bikini Atoll; rocky flats inside outer reef, southeast corner of Enyu Island; Morrison, March 16, 1946. Five specimens, U.S.N.M. No. E. 7573.

Bikini Atoll; Eninman Island, outer reef flats; Bayer, July 17, 1947. One specimen, U.S.N.M. No. E. 7312.

Bikini Atoll; east side of Yomyaran Island; Morrison, April 10, 1946. Two specimens, U.S.N.M. No. E. 7576.

Eniwetok Atoll; Eniwetok Island, reef at low tide; Ziesenhenne, February 1, 2, 1946. Twenty-two specimens, U.S.N.M. Nos. E. 7333, E. 7334, E. 7335.

Eniwetok Atoll; Arambiru Island, ocean reef; Schultz, June 3, 1946. Three specimens, U.S.N.M. Nos. E. 7328, E. 7329.

Rongerik Atoll; outer reef flats of Latoback Island; Morrison, June 28, 1946. One specimen, U.S.N.M. No. E. 7575.

Rongelap Atoll; Enybarbar Island, northeast end; Schultz, June 18, 1946. Thirteen specimens, U.S.N.M. Nos. E. 7310, E. 7311.

Kwajalein Atoll; Gugegwe Island; Ziesenhenne, February 9, 1946. Thirteen specimens, U.S.N.M. No. E. 7337.

OPHIOCOMA ERINACEUS Müller and Troschel

Ophiocoma erinaceus Müller and Troschel, System der Asteriden, p. 98, 1842 (Red Sea; Indian Ocean).

Localities.—Bikini Atoll; outer reef flats of Bokonfuaaku Island; Morrison, July 3, 1946. One specimen, U.S.N.M. No. E. 7570.

Bikini Atoll; outer reef, south (ocean) end of Bokororyuru Island; Morrison, April 30, 1946. One specimen, U.S.N.M. No. E. 7571.

Eniwetok Atoll; Eniwetok Island; Morrison, June 17, 1946. One specimen, U.S.N.M. No. E. 7140.

Johnston Island, outer reef on northwest side; Bayer, August 28, 1947. Three specimens, U.S.N.M. Nos. E. 7313, E. 7314.

OPHIOCOMA PICA Müller and Troschel

Ophiocoma pica Müller and Troschel, System der Asteriden, p. 101, 1842 (locality unknown).

Localities.—Bikini Atoll; Bikini Island; Bayer, 1947. One specimen, U.S.N.M. No. E. 7563.

Bikini Atoll; Eniairo Island; Bayer, July 21, 1947. One specimen.

Eniwetok Atoll; outer reef flats, northeast side of Arambiru Island; Morrison, June 3, 1946. One specimen, U.S.N.M. No. E. 7562.

Rongerik Atoll; Latoback Island, lagoon reef, from a clump of *Stylophora mordax;* Bayer and Zimmerman, August 18, 1947. One specimen, U.S.N.M. No. E. 7356.

Johnston Island; outer reef on northwest side; Bayer, August 29, 1947. One specimen, U.S.N.M. No. E. 7315.

OPHIOCOMA BREVIPES Peters

Ophiocoma brevipes PETERS, Monatsb, preuss. Akad. Wiss., 1851, p. 465.

Localities.—Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. One specimen, U.S.N.M. No. E. 7578.

Rongerik Atoll; outer reef flats on the north side of Bigonattam Island; Morrison, August 21, 1947. One specimen, U.S.N.M., No. E. 7330.

OPHIOCOMA, sp.

Locality.—Bikini Atoll; lagoon; Morrison, August 26, 1947. Six very small specimens, U.S.N.M. No. E. 7355.

Genus OPHIOCOMELLA A. H. Clark

OPHIOCOMELLA CLIPPERTONI A. H. Clark

Ophiocomella clippertoni A. H. CLARK, Smithsonian Misc. Coll., vol. 98, No. 11, p. 7, pl. 1, figs. 1, 2 (as *O. parva*), June 2, 1939 (Clipperton Island).

Localities.—Bikini Atoll; Bikini Island, outer reef; Bayer, July 25, 1947. One specimen, U.S.N.M. No. E. 7347.

Eniwetok Atoll; East Rigili Island; Morrison, May 30, 1946. Two specimens, U.S.N.M. No. E. 7585.

Rongerik Atoll; Bock Island, in algae on the outer reef flats; Taylor, June 27, 1946. One specimen, U.S.N.M. No. E. 7346.

Genus OPHIOMASTIX Müller and Troschel

OPHIOMASTIX MIXTA Lütken

Ophiomastix mixta LÜTKEN, Additamenta ad historiam Ophiuridarum, pt. 3, pp. 42, 99, 1869 (Samoa and Fiji).

Locality.—Eniwetok Atoll; Pujiyoru Island, ocean reef; Morrison and Cali, June 2, 1946. Two specimens, U.S.N.M. No. E. 7321.

OPHIOMASTIX BISPINOSA H. L. Clark

Ophiomastix bispinosa H. L. CLARK, Bull. Mus. Comp. Zool., vol. 61, No. 12, p. 442, pl. 2, figs. 1, 2, 1917 (Paumotu [Tuamotus] Islands, Makemo).

Localities.—Bikini Atoll; Bikini Island; Schultz, April 13, 1946. One specimen, U.S.N.M. No. E. 7324.

Bikini Atoll; in the lagoon; Schultz, March 29, 1946. One specimen, U.S.N.M. No. E. 7326.

Bikini Atoll; Johnson, May 1946. One specimen, U.S.N.M. No. E. 7624.

Bikini Atoll; Bikini Island; Schultz, April 13, 1946. Two specimens, U.S.N.M. No. E. 7327.

Bikini Atoll; one-half mile north of Aomoen Island, in the lagoon; 42 feet, in coral; Brock, Kohler, and Herald, July 10, 1946. Two specimens, U.S.N.M. No. E. 7323.

Bikini Atoll; 30–75 feet; August 15, 1947. One specimen, U.S.N.M. No. E. 7322.

Notes.—In the last-mentioned specimen (E. 7322) the stellate disk is 13 mm. in diameter and the arms are 70 mm. long. The disk is thickly covered with short sharp spinules. There are two tentacle scales on the first four or six pores. The arm spines are usually three, sometimes four; the enlarged uppermost arm spines are 5 mm. long, usually slender, occasionally thickened. The color (as in E. 7324) is olive-brown with the arms obscurely banded.

Specimen No. E. 7323 has the disk 9 mm. in diameter and the arms 50 mm. long. The disk is thickly beset with very small sharp spinules. There are two tentacle scales on the first three, sometimes four, pores. The color is uniform olive-brown, the spines lighter.

Specimen No. E. 7326 has the disk 5 mm. in diameter, and beset with scattered sharp spinelets. There are two tentacle scales on the first two or three pores. There are three arm spines. This specimen agrees well with the type as described and figured by Dr. H. L. Clark.

Dr. Johnson's specimen (No. E. 7624) has the disk 8 mm. in diameter and the arms 50 mm. long. The disk is rather thickly beset with short spines. The arm spines are usually three, occasionally two.

OPHIOMASTIX SEXRADIATA, new species

Description.—The disk is 3 mm. in diameter and the six arms are 14 mm. long. The disk is covered with small imbricating scales and studded with numerous short stout conical spinelets resembling those on the disk of *Ophiocomella clippertoni.*

The general structure is similar to that of *O. clippertoni*, but there are only three arm spines—four on the first three or four side arm plates beyond the disk—and the uppermost arm spine is from half again to twice as long as the others, slender and tapering gradually to a sharp tip; near the arm bases it may be considerably longer than an arm segment. The middle spine is shorter, but usually stouter. The lowest spine is about as long as the middle spine, and usually somewhat more slender.

The disk is light brown, the spinules white. The upper arm plates are light brown with a narrow white border and a narrow white curved band extending across the plates from the spines on one side to those on the other. The under arm plates are light brown with a narrow distal white border. The oral and adoral shields have a dark center and broad white borders.

In two of the specimens all six arms are of the same size. In the remainder, three of the arms are much smaller than the others, indicating autotomous division.

Locality.—Bikini Atoll; in the lagoon; Morrison, August 26, 1947. Four specimens, U.S.N.M. Nos. E. 7359 (type), E. 7360.

Notes.—In spite of the close agreement in the form of the arm plates and the plates of the oral surface, and in the number of arms, with the species of *Ophiocomella*, this little species should be referred to *Ophiomastix*, with which it agrees in the relations of its arm spines and in the general scheme of its color pattern. It does not agree with any of the known species of *Ophiomastix*, none of which are six-rayed in any stage. The color pattern also is unique.

Family OPHIODERMATIDAE

Genus OPHIOPEZELLA Ljungman

OPHIOPEZELLA SPINOSA (Ljungman)

Ophiaracna spinosa Ljungman, Öfv. K. Vet.-Akad. Förh., vol. 23, pt. 6, p. 305, 1867 (Foua).

Localities.—Bikini Atoll; Eninman Island, outer reef flat; Bayer, July 17, 1947. One specimen, U.S.N.M. No. E. 7210.

Rongerik Atoll; Bock Island; Bayer and Zimmerman, August 19, 1947. One specimen, U.S.N.M. No. E. 7212.

Rongerik Atoll; Latoback Island, lagoon reef; Bayer and Zimmerman, August 20, 1947. One specimen, U.S.N.M. No. E. 7211.

Family OPHIOLEPIDIDAE

Genus OPHIURA Lamarck

OPHIURA KINBERGI Ljungman

Ophiura (vel *Ophioglypha*) *kinbergi* Ljungman, Öfv. K. Vet.-Akad. Förh., vol. 23, p. 166, 1866 (Sydney, New South Wales, Australia).

Locality.—Rongelap Atoll; lagoon; 23+ fathoms; Johnson, June 16, 1946. One specimen, U.S.N.M. No. E. 7613.

Genus OPHIOLEPIS Müller and Troschel

OPHIOLEPIS CINCTA Müller and Troschel

Ophiolepis cincta Müller and Troschel, System der Asteriden, p. 90, 1842 (Red Sea).

Locality.—Rongerik Atoll; Latoback Island, lagoon reef; Bayer and Zimmerman, August 21, 1947. Two specimens, U.S.N.M. Nos. E. 7253, E. 7254.

Genus OPHIOPLOCUS Lyman

OPHIOPLOCUS IMBRICATUS (Müller and Troschel)

Ophiolepis imbricata Müller and Troschel, System der Asteriden, p. 93, 1842 (Mauritius; Timor).

Localities.—Bikini Atoll; Eninman Island, outer reef flats; Bayer, July 17, 1947. One specimen, U.S.N.M. No. E. 7209.

Bikini Atoll; Namu Island, outer reef; Morrison, August 7, 1947. One specimen, U.S.N.M. No. E. 7208.

ECHINODERMS FROM OPERATION CROSSROADS, 1946, AND THE BIKINI SCIENTIFIC RESURVEY, 1947

Species	1946	1947
Crinoidea		
Comaster gracilis	----	x
Comanthus bennetti	x	----
Stephanometra indica protectus	x	x
Echinoidea		
Eucidaris metularia	x	x
Chondrocidaris gigantea	----	x
Phyllacanthus imperialis	----	x
Coelopleurus sp	----	x
Echinothrix diadema	x	x
Echinothrix calamaris	x	[1] x
Temnopleurus toreumaticus	x	----
Mespilia globulus	x	----
Desmechinus rufus	----	x
Cyrtechinus verruculatus	x	x
Tripneustes gratilla	x	[1] x
Parasalenia gratiosa	x	x
Echinometra mathaei	x	[3] x
Echinometra mathaei oblonga	x	[2] x
Echinostrephus aciculatus	x	x
Heterocentrotus trigonarius	x	x
Heterocentrotus mammillatus	----	[1] x
Clypeaster reticulatus	----	x
Laganum depressum	x	x
Fibularia australis	x	[2] x
Fibularia ovulum	x	[2] x
Fibularia volva	x	[2] x
Fibularia acuta	----	[2] x
Echinocyamus incertus	----	x
Echinocyamus megapetalus	x	[2] x
Echinocyamus elongatus	x	----
Echinoneus abnormalis	x	----
Echinoneus cyclostomus	x	x
Echinolampas alexandri	x	x
Metalia dicrana	x	----
Brissus latecarinatus	x	----
Maretia ovata	x	x
Asteroidea		
Astropecten polyacanthus	----	x
Luidia mascarena	----	x
Calliaster elegans	----	x
Culcita novae-guineae	x	[3] x
Neoferdina ocellata	x	----

Species	1946	1947
Asteroidea—Continued		
Fromia balansae	x	----
Fromia hemiopla	x	----
Fromia eusticha	----	x
Dactylosaster cylindricus pacificus	x	----
Ophidiaster granifer	x	x
Ophidiaster squameus	x	----
Ophidiaster lorioli	x	----
Ophidiaster pusillus	x	----
Linckia multifora	x	x
Linckia guildingii	x	----
Linckia laevigata	x	----
Asterina cephea	x	----
Asterina coronata cristata	x	x
Asterina anomala	----	x
Othilia luzonica	x	----
Acanthaster planci	----	x
Ophiuroidea		
Ophiomyxa australis	x	x
Ophiodera punctata, new species	----	x
Ophiactis savignyi	----	x
Ophiothrix longipeda	----	x
Ophiothrix elegans	x	----
Ophiothrix virgata	x	[2] x
Ophiothrix trilineata	----	x
Ophiothrix exigua	----	x
Ophiothrix lepida	----	x
Ophiodesmus degeneri	x	[3] x
Ophiocoma anaglyptica	x	----
Ophiocoma scolopendrina	x	x
Ophiocoma erinaceus	x	x
Ophiocoma pica	x	x
Ophiocoma brevipes	x	x
Ophiocoma sp	----	x
Ophiocomella clippertoni	x	x
Ophiomastix mixta	x	----
Ophiomastix bispinosa	x	x
Ophiomastix sexradiata, new species	----	x
Ophiopezella spinosa	----	x
Ophiura kinbergi	x	----
Ophiolepis cincta	----	x
Ophioplocus imbricatus	----	x

[1] Johnston Island only.
[2] Collected in 1947 and 1948 (See text, p. 266).
[3] Collected in 1948 only (See text, p. 266).

ISLANDS ON WHICH COLLECTIONS WERE MADE, WITH THE SPECIES COLLECTED ON EACH

BIKINI ATOLL

AIRUKIRARU ISLAND: *Othilia luzonica.*

AOMOEN ISLAND: *Ophiomyxa australis; Ophiomastix bispinosa*, 42 feet.

ARRIIKAN ISLAND: *Fibularia ovulum; Echinocyamus elongatus.*

BIKINI ISLAND and VICINITY: *Comaster gracilis*, 150–265 feet; *Eucidaris metularia*, 150–275, 200–290, 800–900 feet; *Chondrocidaris gigantea*, 800–900 feet; *Phyllacanthus imperialis*, 150 feet; *Coelopleurus*, sp., 800–900 feet; *Echinothrix diadema; Mespilia globulus, Desmechinus rufus*, 800–900 feet; *Cyrtechinus verruculatus*, littoral, 138+, 150, 180–200 feet; *Parasalenia gratiosa*, littoral, 30–75, 40–80, 50–140, 180–200 feet; *Echinometra mathaei; Echinometra mathaei* var. *oblonga; Heterocentrotus trigonarius; Clypeaster reticulatus*, 150–265 feet; *Laganum depressum*, littoral, 21, 24, 27, 30, 36–42, 90, 150, 168 feet; *Fibularia australis; Fibularia ovulum; Fibularia volva; Echinocyamus incertus*, 800–900 feet; *Echinolampas alexandri*, 180, 180–200 feet; *Maretia ovata*, 50–80, 100–140 feet; *Luidia mascarena; Calliaster elegans*, 400–450 feet; *Culcita novae-guineae; Fromia hemiopla*, littoral, 150–180 feet; *Fromia eusticha*, 180 feet; *Dactylosaster cylindricus pacificus; Ophidiaster granifer; Linckia multifora*, littoral, 40–80 feet; *Linckia guildingii; Asterina coronata cristata*, littoral, 180–200 feet; *Asterina anomala; Othilia luzonica; Ophiothrix longipeda; Ophiothrix virgata, Ophiothrix trilineata, Ophiothrix lepida*, 400–550 feet; *Ophiodesmus degeneri*, 150–180, 180–200 feet; *Ophiocoma scolopendrina; Ophiocoma pica; Ophiocoma*, sp.: *Ophiocomella clippertoni; Ophiomastix bispinosa*, littoral, 30–75 feet; *Ophiomastix sexradiata.*

BOKONFUAAKU ISLAND: *Echinothrix diadema; Laganum depressum; Metalia dicrana; Ophiocoma erinaceus.*

BOKORORYURU ISLAND: *Echinometra mathaei; Brissus latecarinatus; Culcita novae-guineae; Ophidiaster pusillus; Linckia multifora; Othilia luzonica; Ophiocoma erinaceus.*

CHIEERETE ISLAND: *Othilia luzonica.*

ENIAIRO ISLAND: *Echinostrephus aciculatus; Echinoneus cyclostomus; Ophiocoma pica.*

ENIRIK ISLAND: *Mespilia globulus; Linckia multifora.*

ENINMAN ISLAND: *Echinometra mathaei; Ophidiaster granifer; Acanthaster planci; Ophiocoma scolopendrina; Ophiopezella spinosa; Ophioplocus imbricatus.*

ENYU ISLAND: *Echinometra mathaei; Heterocentrotus trigonarius; Echinoneus cyclostomus; Linckia multifora; Ophiodera punctata; Ophiocoma scolopendrina.*

NAMU ISLAND: *Eucidaris metularia; Echinothrix diadema; Mespilia globulus; Echinometra mathaei; Echinostrephus aciculatus, Heterocentrotus trigonarius; Echinocyamus megapetalus; Echinoneus cyclostomus; Brissus latecarinatus; Neoferdina ocellata; Ophiocoma anaglyptica; Ophiocoma scolopendrina; Ophioplocus imbricatus.*

OURUKAEN ISLAND: *Echinometra mathaei; Othilia luzonica.*

ROMURIKKU ISLAND: *Linckia multifora.*

UORIKKU ISLAND: *Othilia luzonica.*

YOMYARAN ISLAND: *Ophiocoma scolopendrina.*

YUROCHI ISLAND: *Linckia multifora.*

ENIWETOK ATOLL

ARAMBIRU ISLAND: *Echinothrix diadema; Tripneustes gratilla; Echinometra mathaei; Echinostrephus aciculatus; Heterocentrotus trigonarius; Culcita novae-guineae; Ophiocoma scolopendrina; Ophiocoma pica.*

BOGEN (JIERORU) ISLAND: *Echinothrix diadema; Parasalenia gratiosa; Echinometra mathaei; Laganum depressum; Fibularia ovulum; Metalia dicrana; Astropecten polyacanthus; Ophidiaster lorioli; Othilia luzonica; Ophiothrix exigua; Ophiactis savignyi.*

BOGOMBOGO ISLAND: *Linckia multifora.*

BOGON ISLAND: *Eudicaris metularia; Fibularia australis.*

BUGANEGAN (MUI) ISLAND: *Echinometra mathaei.*

CHINIEERO ISLAND: *Echinocyamus megapetalus; Linckia laevigata.*

EAST RIGILI ISLAND (a rock just east of Rigili Island): *Echinothrix calamaris; Mespilia globulus; Tripneustes gratilla; Echinometra mathaei; Echinostrephus aciculatus; Fromia balansae; Ophidiaster granifer; Linckia multifora; Asterina cephea; Ophiocoma brevipes; Ophiocomella clippertoni.*

ELUGELAB ISLAND: *Fibularia ovulum; Fibularia volva.*

ENIWETOK ISLAND: *Echinothrix diadema; Tripneustes gratilla; Echinometra mathaei; Heterocentrotus trigonarius; Ophiocoma scolopendrina; Ophiocoma erinaceus.*

GRINEM ISLAND: *Echinometra mathaei; Heterocentrotus trigonarius; Ophidiaster granifer.*

LIDILBUT (TEITEIRIPUCCHI) ISLAND: *Mespilia globulus; Echinometra mathaei* var. *oblonga; Heterocentrotus trigonarius; Maretia ovata; Othilia luzonica.*

PUJIYORU (RUJORU) ISLAND: *Echinothrix diadema; Tripneustes gratilla; Echinometra mathaei; Echinostrephus aciculatus; Heterocentrotus trigonarius; Culcita novae-guineae; Laganum depressum; Fibularia ovulum; Linckia multifora; Ophiocoma anaglyptica; Ophiomastix mixta.*

RIGILI ISLAND (southwestern or seaward end): *Mespilia globulus; Echinometra mathaei; Echinostrephus aciculatus; Fibularia australis; Fibularia ovulum; Echinocyamus megapetalus; Echinoneus abnormalis; Echinoneus cyclostomus; Othilia luzonica; Ophiocoma anaglyptica.*

JOHNSTON ATOLL

JOHNSTON ISLAND (F. M. Bayer): *Echinothrix diadema; Echinothrix calamaris; Tripneustus gratilla; Echinometra mathaei; Echinometra mathaei* var. *oblonga; Heterocentrotus trigonarius; Heterocentrotus mammillatus; Linckia multifora; Ophiocoma erinaceus; Ophiocoma pica.*

KWAJALEIN ATOLL

GUGEGWE (BERLIN) ISLAND: *Ophiocoma scolopendrina.*

KWAJALEIN ISLAND: *Echinometra mathaei.*

RONGELAP ATOLL

BUROK ISLAND: *Linckia multifora.*

BUSCH ISLAND: *Mespilia globulus; Heterocentrotus trigonarius; Linckia multifora; Ophiothrix elegans.*

ENIAETOK ISLAND: *Brissus latecarinatus.*

ENYBARBAR ISLAND: *Ophidiaster squameus; Ophiocoma scolopendrina.*

KABELLE ISLAND: *Heterocentrotus trigonarius; Fibularia australis; Fibularia volva; Linckia multifora.*

KIESHIECHI ISLAND: *Comanthus bennetti.*

MELLU ISLAND: *Ophidiaster granifer.*

NAEN ISLAND: *Linckia laevigata.*

RONGELAP ISLAND: *Echinothrix calamaris; Temnopleurus toreumaticus; Mespilia globulus*, 138+ feet; *Cyrtechinus verruculatus*, 138+ feet; *Echinometra mathaei; Echinometra mathaei* var. *oblonga; Laganum depressum*, 138+ feet; *Echinoneus cyclostomus; Linckia guildingii; Ophiura kinbergi*, 138+ feet.

TUFA ISLAND: *Stephanometra indica protectus.*

RONGERIK ATOLL

BIGONATTAM ISLAND: *Ophiocoma brevipes.*

BOCK ISLAND: *Echinostrephus aciculatus; Fibularia australis; Fibularia ovulum; Fibularia volva; Fibularia acuta; Echinocyamus megapetalus; Echinoneus cyclostomus; Ophiactis savignyi; Ophiocomella clippertoni; Ophiopezella spinosa.*

ENIWETAK (ENYVERTOK) ISLAND: *Echinometra mathaei.*

LATOBACK ISLAND: *Stephanometra indica protectus; Echinocyamus megapetalus; Linckia multifora; Asterina coronata cristata; Ophiomyxa australis; Ophiactis savignyi; Ophiocoma scolopendrina; Ophiocoma pica; Ophiopezella spinosa; Ophiolepis cincta.*

RONGERIK ISLAND: *Eucidaris metularia; Laganum depressum.*

ADDITIONAL RECORDS OF ECHINODERMS FROM THE MARSHALL ISLANDS

From time to time scattered references to specimens from the Marshall Islands have appeared in the literature, based upon material that has found its way into museums from various sources, much of it from the Reverend B. G. Snow, a resident missionary. Most of the specimens are from Ebon (Boston Island), with some from Jaluit (Bonham Island), both in the extreme south of the Marshall group.

The only systematic collecting that has been done in the Marshalls was by the Swedish expedition to the South Sea Islands under the leadership of Dr. Sixten Bock in 1917. A report on the Ophiuroidea of this collection was published by Prof. René Koehler in 1927 (Göteborgs Kungl. Vet. Vitt. sam. Handl., vol. 33, No. 3), which lists 16 species, mostly from Jaluit and Ebon, of which the following are not represented in the present collection.

Ophiomyxa brevispina von Martens (Jaluit)
Amphilimna sexradiata (Duncan) (Jaluit)
Ophionereis porrecta Lyman (Ebon)
Ophiothrix demessa Lyman (Jaluit)
Ophiothrix galatheae Lütken (Jaluit)
Ophiothrix triloba von Martens (Jaluit)
Ophiopezella dubiosa de Loriol (Jaluit)

It is probable that Professor Koehler's *Ophiothrix galatheae* is the same as *O. longipeda* of the present list.

The Crinoidea of this expedition, all collected by Dr. Chr. Hessle, were described by Professor Torsten Gislén in 1940 (Kungl. Svenska Vetenskapsakademiens Handlingar, ser. 3, vol. 18, No. 10). He recorded five species of which four are not represented in the present collection. These are:

Eudiocrinus tenuissimus Gislén (Jaluit)
Lamprometra palmata (J. Müller) (Ebon; Jaluit)
Cenometra bella var. *magnifica* Gislén (Jaluit)
Dorometra nana (Hartlaub) (Ebon; Jaluit)

Earlier records of crinoids from the Marshall Islands are *Stephanometra protectus* from Ebon, collected by the Reverend B. G. Snow in 1877 (A. H. Clark, Bull. Mus. Comp. Zool., vol. 51, p. 242, 1908, as *Himerometra heliaster*), recorded also by Gislén and represented in the present collection; and *Lamprometra palmata*, also collected by Mr. Snow at the same time (Hartlaub, Mem. Mus. Comp. Zool., vol. 27, No. 4, p. 409, 1912, as *Antedon brevicuneata*).

Dr. Hubert Lyman Clark in 1915 (Mem. Mus. Comp. Zool., vol. 25, No. 4, p. 343, No. 1368) recorded *Ophiolepis superba* from Ebon, where it had been collected by Mr. Snow in 1877. It has not since been reported from the Marshall Islands.

Additional species known from Johnston Island (A. H. Clark, Bernice P. Bishop Mus. Bull. 195, p. 119, 1949) are: *Echinostrephus aciculatus*, *E. molaris*, *Brissus latecarinatus*, *Culcita novae-guineae* forma *novae-guineae*, *Acanthaster planci*, *Mithrodia fisheri*, and *Ophiactis savignyi.*

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A NEW SPECIES OF INSECT OF THE ORDER PROTURA

By Grace Glance

The members of the order Protura, usually placed in the class Insecta, are considered the most primitive members of the class. In 1938, Silvestri described the first South American proturan, *Acerentulus iravassosi*, of the family Acerentomidae, from Brazil. The new species described in this paper seems to be the second proturan to be described from South America.

In 1948, Dr. F. Bonet, of the Escuela Nacional de Ciencias Biológicas, Mexico City, spent several months at the United States National Museum studying the Protura collection. I wish to acknowledge with much gratitude the help and suggestions he gave me in beginning work on this order.

I made the drawings for figures 85 and 86 with camera lucida. They were transferred and inked by Mrs. Aime M. Awl.

FAMILY EOSENTOMIDAE

EOSENTOMON VENEZUELENSE, new species

Figures 85, 86

The adults are dark yellow and well chitinized; the maturus junior is much less chitinized and the thorax and abdomen I–IV are white. An unexpanded female is 797μ long; the completely expanded male, holotype, is 1,243μ long. The head (fig. 85, *a*), is 132–136μ long; at its greatest width 89–100μ. In one female specimen, the head is subspherical, 107μ long by 96μ wide. The pseudoculi are oval, 9–12μ long.

THORAX

The first pair of legs is longest, the second pair shortest. Tarsus I (fig. 85, *e*) is 98–107μ long; claw 17–18.5μ long. From the dorsal, median, club-shaped sensilla to the base of the tarsus is 52–57μ. In addition to the seven blunt sensillae shown on the outer face of the tarsus in figure 85, *e*, there are three more on the inner face, their positions indicated by x. Tarsus III (fig. 85, *b*) with a large, heavy, subapical spine.

The anterior and posterior transverse apodemes and the median apodeme of the mesonotum are shown in figure 86, *b*. They were drawn from the stained specimen, and can be seen vaguely on the unstained specimens.

On the metanotum, the anterior transverse apodeme is more strongly developed than on the mesonotum and is bowed. From it, the median apodeme runs two-thirds the length of the metanotum, and is more noticeable than on the mesonotum, even on the unstained specimens. The posterior transverse apodeme is slightly more developed than the mesonotal one.

CHAETOTAXY OF THORAX

PRONOTUM: With two pairs of setae; median pair 46μ apart, 17μ long; outer pair 20μ long, near the lateral border.

MESONOTUM (fig. 86, *b*): From median anterior to posterior margin 76μ. Anterior setae (1a–4a): At the middle, setae 1 are 14μ apart, 9μ long; setae 2 are 22μ from setae 1, and are 9μ long; setae 3 are 23μ anteriolateral from setae 2, and are 12μ long; setae 4 are on the anteriolateral margin, 17μ long. Posterior setae (1p–5p): At the posterior margin, setae 1 are 25μ apart, 15μ long; setae 2, slightly posterior of the chitinized margin, 14μ long; setae 3 are 22μ long; setae 4 are anterior to setae 3, near the lateral border, 9μ long; setae 5 are anterior to setae 4, and are 29μ long. Near or on the peritreme of the spiracle are two setae; the anterior is 15μ long, the posterior is 11μ long.

The number of setae and their approximate position correspond with that figured for *E. ribagai* Berlese (1909, pl. 3, fig. 22), and with that figured for *E. armatum* Stach by Tuxen (1949, Abb. 66). In *E. germanicum* Prell as figured by Prell (1913, pl. 3, fig. 11), the same condition prevails, except that setae 5p are missing. Gisin's figure of *E. armatum* Stach (1945, fig. 1) shows the same number of setae, but the position of the anterior setae is quite different. I have examined the holotype slides of E. *rostratum* Ewing (1940) and of *E. pallidum* Ewing (1921), and the number and approximate position of the setae are the same as for *E. venezuelense*.

METANOTUM: Same length as mesonotum. Anterior setae 1 are 34μ from anterior transverse apodeme, 17μ apart, 11μ long; setae 2 are 11μ long; setae 3 are 15μ long; setae 4 are on the anteriolateral margin, 8μ long, and close to each one is a microchaeta. Posterior setae 1 are on the transverse apodeme, 28μ apart, 17μ long; setae 2

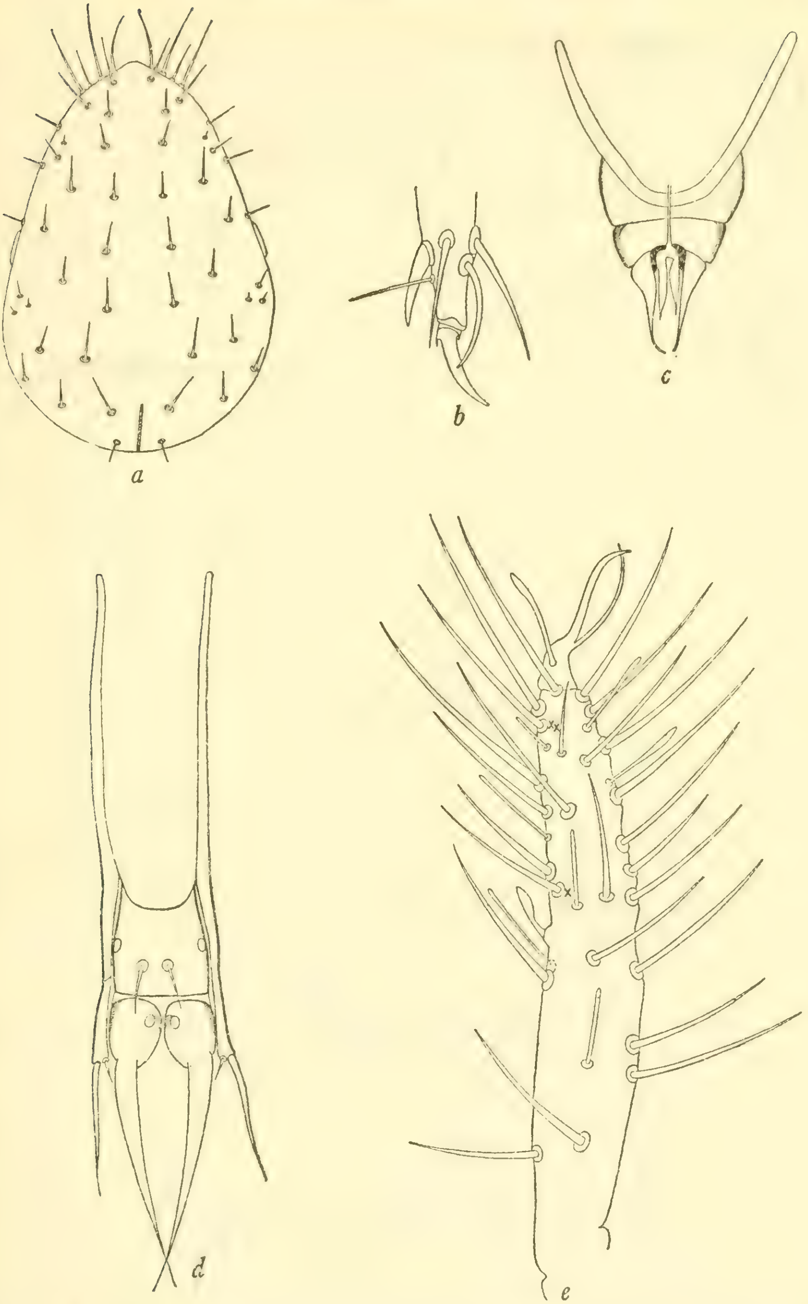

FIGURE 85.—*a*, Head of female (dorsal), × 200; *b*, claw and part of tarsus of leg III of maturus junior, × 450; *c*, female genitalia, × 450; *d*, male genitalia, × 450; *e*, tarsus and claw of leg I (outer face) of maturus junior, × 450 (x = position of additional sensillae on inner face).

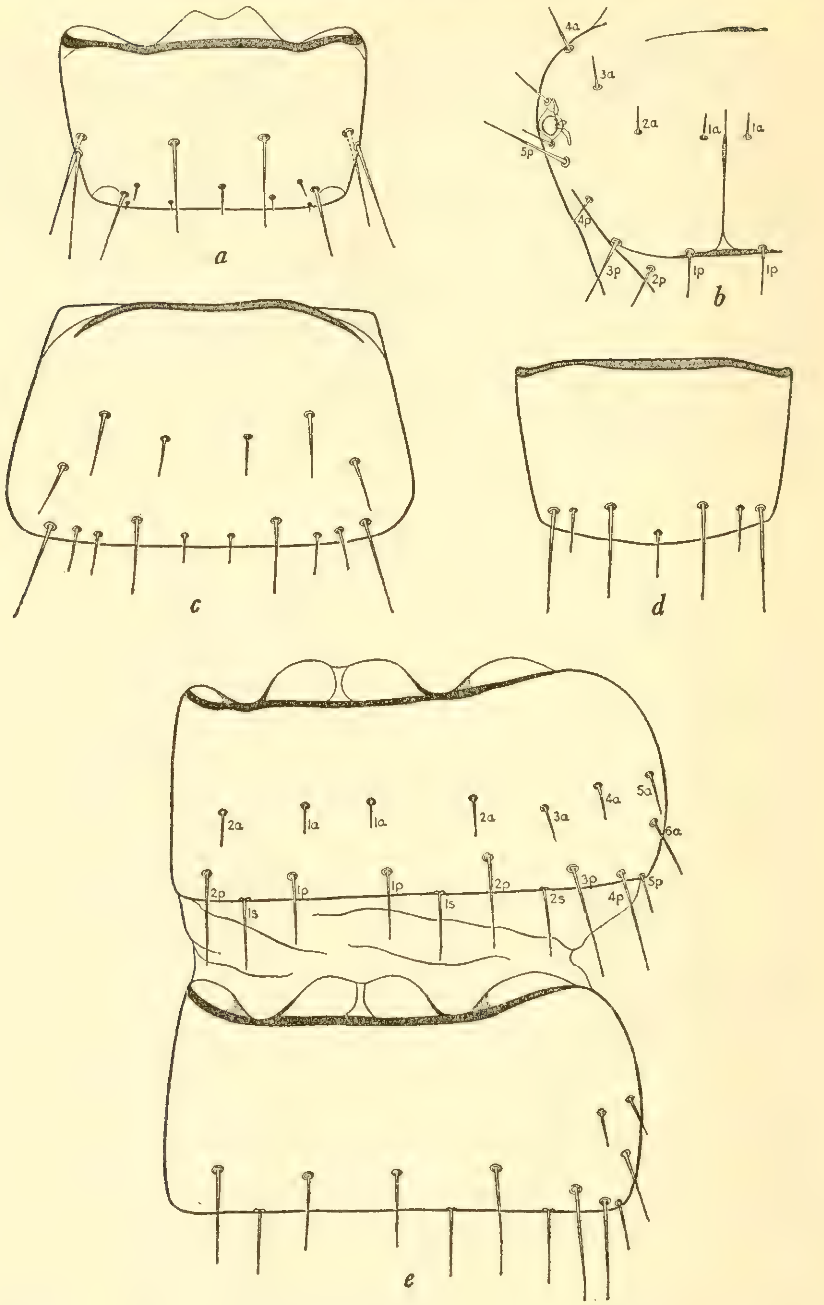

FIGURE 86.—*a*, Tergite VIII, holotype, × 200; *b*, mesonotum, holotype, × 200 (1a–4a = anterior pairs of setae; 1p–5p = posterior pairs of setae); *c*, sternite IV, holotype, × 200; *d*, sternite VIII, holotype, × 200; *e*, tergites IV and V, holotype, × 200 (1a–6a = anterior pairs of setae; 1p–5p = posterior pairs of setae; 1s–2s = supplementary pairs of setae).

are 14μ long; setae 3 are 25μ long; setae 4 are 11μ long; setae 5 are 34μ long. The anterior spiracular seta is 14μ long; the posterior 9μ.

The position of these setae approximates that given for *E. ribagai* Berlese (1909, pl. 3, fig. 22), except that the anteriolateral setae 4 with the microchaetae are missing. Berlese (1909, pl. 8, fig. 80), figures the tergite of the metathorax for *E. transitorium* Berlese on which anterior setae 4 with the microchaetae are missing as also are posterior setae 4. In *E. germanicum* Prell as figured by Prell (1913, pl. 3, fig. 11), anterior setae 4 with the microchaetae are missing as are posterior setae 5. Gisin's figure of *E. armatum* Stach (1945, fig. 1) lacks the anterior microchaetae and the postion of the anterior setae is quite different; the same condition prevails in this same species as figured by Tuxen (1949, Abb. 66). I have examined the holotype slides of *E. rostratum* Ewing (1940) and of *E. pallidum* Ewing (1921); the number and approximate position of the setae are the same as for *E. venezuelense.*

ABDOMEN

Transverse apodemes present on tergites and sternites (fig. 86, *a, c–e*) of abdomen I–IX, but slightly developed on abdomen I; unbranched laterally. A pair of vestigial appendages ventrally on abdomen I–III, conspicuous, two-segmented.

CHAETOTAXY OF THE ABDOMEN

Tergites and Pleurites: The tergites and the pleurites are fused on all abdominal segments except abdomen IX, X, and XI. In giving the arrangement and number of setae, I shall include all setae present on both. The setae are arranged more or less in one or two transverse rows on the most heavily chitinized portion; in all the following description I refer only to this chitinized portion. The rows are usually not straight, but slant posteriorly in the pleural region where the setae in the anterior row are not at all in alinement. Most of the setae are what I shall call primary ones, which vary greatly in length but are well chitinized, and their sockets are deep and heavy. In the posterior row there are also present what I shall call supplementary setae; these are usually not in alinement with the primaries, and are placed at the extreme posterior margin. They are long, slender, and slightly chitinized, about the same length, and their sockets are shallow and delicate. Also present in the posterior row are occasional microchaetae. The primary and supplementary setae are duplicated on the right and left sides except for an occasional single one, placed exactly in the middle. In referring to the setae, I shall call the median pair setae 1; then the one to the right and the one to the left of them, setae 2; et cetera. Wherever possible, the measurements have been taken from the holotype.

Tergite I: The anterior row of setae is slightly posterior of the middle of the tergite. Setae 1 are 23μ apart, 9μ long; setae 2 are equidistant from setae 1 and are 12μ long. In the posterior row, setae 1 are 6μ from the posterior margin, 37μ apart, 25μ long; setae 2 are 29μ from setae 1 and are 28μ long; setae 3 are on the margin, 17μ from setae 2 and are 22μ long. Very close and exterior to setae 3 are microchaetae. Between setae 1 and 2 on the margin are supplementary setae 22μ long. A formula for tergite I would be: Anterior row 2–2; posterior row 3–3+1–1 supplementaries +1–1 microchaetae.

The number of setae agrees with that given by Ionesco (1935) for the genus, and by Gisin (1945) and Tuxen (1949) for *E. armatum* Stach, except that none mentions the microchaetae.

Tergite II: The anterior row is at the middle of the tergite. Setae 1 are 22μ apart; setae 2 are 28μ from setae 1; setae 3 are 31μ from setae 2; setae 6 are posterior to setae 5; all are 8–11μ long. In the posterior row, setae 1 are 32μ apart, 19μ long and 6μ from the margin; setae 2 are 35μ from setae 1 and are 28μ long; setae 3 are on the margin, 26μ from setae 2 and are 32μ long; setae 4 are 14μ long; setae 5 are 9μ long. Between setae 1 and 2, and 2 and 3, are supplementary setae 22 and 23μ long. Formula: Anterior row 6–6; posterior row 5–5+2–2 supplementaries.

The number of setae differs from that given by Ionesco (1935) for the genus, and by Gisin (1945) and Tuxen (1949) for *E. armatum* Stach, in that there is an additional pair in the posterior row.

Tergite III: In the anterior row, the arrangement and number of the setae are the same as for tergite II; all are 9–12μ long. The same condition exists in the posterior row; the setae are the same length as, or slightly longer than, those on tergite II, except that setae 4 are 29μ long. Formula: Same as tergite II.

As noted on tergite II, there is one more pair of setae in the posterior row than is given by Ionesco (1935) for the genus, and by Gisin (1945) and Tuxen (1949) for *E. armatum* Stach.

Tergite IV (fig. 86, *e*): Anterior row (1a–6a) in middle of tergite. Setae 1 are 23μ apart; setae 2 are 34μ from setae 1; setae 3 are 25μ from setae 2; they increase in length from 9–12μ, except that setae 6 are 20μ long. The setae of the posterior row are spaced slightly closer to one another than on tergite II; primaries (1p–5p) slightly longer than on tergite III, except that setae 4 are 32μ long; supplementaries (1s–2s) same as on tergite II. The posterior row is not so close to the margin. Formula: Same as tergite II.

The number of setae agrees with that given by Ionesco (1935) for the genus, and by Gisin (1945) and Tuxen (1949) for *E. armatum* Stach.

Tergite V (fig. 86, *c*): In the anterior row, setae corresponding to 1, 2, and 3 of tergite IV are absent; setae 4 are 12μ long; setae 5 are 14μ long; setae 6 are 23μ long, posterior to setae 5; these are all in the pleural region. The posterior row is slightly more anterior from the margin, setae 1 being 9μ distant; the setae are spaced about as on tergite IV; primary setae mostly slightly longer than on tergite IV; setae 1 are 23μ long; setae 2 are 31μ long; setae 3 are 35μ long, setae 4 are 31μ long; setae 5 are 15μ long; supplementaries same as on tergite II. Formula: Anterior row 3–3; posterior row 5–5+2–2 supplementaries.

The absence of the three pairs of setae in the anterior row differentiates this species from all others of the genus The number of setae in the posterior row agrees with that given for the genus by Ionesco (1935), and by Gisin (1945) for *E. armatum* Stach. See tergite VI for comment on *E. transitorium* Berlese.

Tergite VI: Anterior row same as tergite V. Posterior row is one-fourth distant from the margin; setae are spaced closer together than on tergite V; setae 1 are 29μ apart, 29μ long; setae 2 are 31μ from setae 1, and are 35μ long; setae 3 are 23μ from setae 2, and are 39μ long; setae 4 are 34μ long; setae 5 are 12μ long; supplementaries 23μ long. Formula: Same as tergite V.

The absence of the three pairs of setae in the anterior row differentiates this from all other species of the genus. The number of setae in the posterior row agrees with that given for the genus by Ionesco (1935) and by Gisin (1945) for *E. armatum* Stach. Berlese (1909, pl. 8, fig. 83), figures tergites V and VI for *E. transitorium* Berlese, but he has not shown all the pleural setae; however, on tergite VI, it appears that anterior setae 3 are absent. In *E. armatum delicatum* Gisin (1945), anterior setae 3 are absent. In the descriptions given by Ewing (1940), for tergite VI he does not mention any of the pleural setae; but for *E. pallidum* Ewing (1921), he notes that anterior setae 3 are absent, and that anterior setae 2 and 3 are absent in *E. yosemitense* Ewing (1927).

Tergite VII: Anterior row same as tergite V in only one female specimen; in the other four specimens, setae 4 are absent. Posterior row is placed a little more anteriorly than on tergite VI; setae 1 are 28μ apart, 32μ long; setae 2 are 26μ from setae 1, and are 37μ long; setae 3 are 39μ long; setae 4 are 35μ long; setae 5 are 12μ long. Instead of the usual supplementaries between setae 1 and 2, there are microchaetae; supplementaries between setae 2 and 3 are 22μ long. Formula: Anterior row 2–2 or 3–3; posterior row 5–5+1–1 supplementaries +1–1 microchaetae.

The number of setae in the anterior row differs from that given by Ionesco (1935) for the genus, and for *E. armatum* Stach by Gisin

(1945). In *E. armatum* subsp. *delicatum* Gisin (1945), one pair of setae in the anterior row is absent. The number of setae in the posterior row agrees with that given by Ionesco (1935) for the genus, and for *E. armatum* Stach by Gisin (1945).

Tergite VIII (fig. 86, *a*): In the anterior row, only the last two setae in the pleural region are present, 35 and 34μ long. The other setae present I call posterior only because of their length; setae 1 are slightly posterior of the middle, 29μ apart, 29μ long; setae 2 are 23μ diagonally from setae 1, near the glandular opening, 22μ long; near setae 2 are three microchaetae. Near the posterior margin in the middle is a single seta 9μ long. Formula: Anterior row 2–2; posterior row 2–1–2+3–3 microchaetae.

The number of setae does not agree with that given by Ionesco (1935) for the genus. The same number of setae is given by Gisin (1945) and Tuxen (1949) for *E. armatum* Stach, but the size of the setae differs greatly.

Tergite and pleurite IX: Near the posterior margin, setae 1 are 22μ apart, and are 11μ long; setae 2 are 9μ from setae 1, and are 9μ long; setae 3 are 8μ long, in the posterior lateral corner. Formula: 3–3+1–1 on the pleurite at the posterior tergal corner, 32μ long. (See comment for tergite XI.)

Tergite and pleurite X: The row is nearer the margin than on tergite IX; setae 1 are 14μ apart, and are 8μ long; setae 2 are 9μ from setae 1, and are 6μ long; setae 3 are 5μ long, in the posterior lateral corner. Formula: 3–3+1–1 on pleurite, 8μ long. (See comment for tergite XI.)

Tergite and pleurite XI: The row is on the margin; setae 1 are 8μ apart, 6μ long; setae 2 are 19μ from setae 1, and are 4μ long; setae 3 are 9μ long. Formula: 3–3+1–1 on pleurite, 26μ long.

The number of setae on tergites and pleurites IX–XI is the same as that given for the genus by Ionesco (1935), and for *E. armatum* Stach by Gisin (1945) and Tuxen (1949).

Tergite XII: Near the middle, a pair of setae 12μ apart, 31μ long; near the anterior lateral corners, setae 28μ long; two setae posterior to the latter, 8μ and 6μ long; a microchaeta at the posterior tip. Formula: 4–4+1 microchaeta.

The number of setae differs from that given by Ionesco (1935) for the genus. It agrees with *E. armatum* Stach as given by Gisin (1945).

STERNITES: Here again, the setae are on the most heavily chitinized portion, and I shall refer to that part only in the description. The number of setae on sternites I–XI agrees with that given for the genus by Ionesco (1935), and for *E. armatum* Stach by Gisin (1945) and Tuxen (1949).

Sternite I: Anterior row about one-third from the anterior margin, setae equidistant, 20μ; setae 1 are 11μ long; setae 2 are 20μ long. Posterior row at margin; setae 1 are 15μ apart; setae 2 are 12μ from setae 1; all are 11μ long. Formula: Anterior row 2–2; posterior row 2–2.

Sternite II: Anterior row; setae 1 slightly anterior of the middle, 19μ apart, 11μ long; much anteriolateral of setae 1 are setae 2, which are 19μ long; near the lateral margin, 31μ from setae 1 are setae 3, which are 20μ long, somewhat posterior to setae 1. Posterior row at margin, setae equidistant, 17μ; setae 1 are 9μ long; setae 2 are 20μ long, at the lateral corner. Formula: Anterior row 3–3; posterior row 2–2.

Sternite III: Anterior setae 1 are slightly posterior of the middle; setae 3 are more posterior on the lateral margin. The spacing of the setae is almost the same as on sternite II; the setae are slightly longer except that setae 2 of the posterior row are 25μ long. Formula: Same as sternite II.

Sternite IV (fig. 86, *c*): Anterior row; setae 1 are slightly posterior of the middle, 28μ apart, 12μ long; setae 2, anterior to setae 1 are 22μ long; setae 3, posterior to, and 34μ from, setae 1 are 19μ long. Posterior row; 8μ from the margin, 43μ apart are setae 2, which are 25μ long; at the margin, between setae 2 and 15μ apart, are setae 1, which are 9μ long; at the margin, 26μ from setae 2, are setae 5, which are 31μ long; between setae 2 and 5, are setae 3 and 4, which are 8μ apart and 12μ long. Formula: Anterior row 3–3; posterior row 5–5.

Sternite V: The arrangement of the setae is practically identical with sternite IV. Anterior setae 1 are 32μ apart, 31μ from setae 3; setae 2 are 26μ long. All the other setae are the same length as, or slightly longer than, on sternite IV. Anterior setae 2 and 3, and posterior setae 5 are in a diagonal row. Formula: Same as sternite IV.

Sternite VI: The arrangement of the setae is the same as on sternite V. The setae are the same length or slightly shorter. Formula: Same as sternite IV.

Sternite VII: The arrangement and size of the setae are about the same as on sternite VI except that the setae are spaced closer together. Formula: Same as sternite IV.

Sternite VIII (fig. 86, *d*): Setae 1 are 29μ apart, 32μ long, and 9μ from the posterior margin; between them near the margin is a single seta 15μ long; setae 2 are 14μ long; setae 3 are 34μ long. Formula: 3–1–3.

Sternite IX: Near the posterior margin 28μ apart are setae 1, which are 31μ long; setae 2 are 12μ long. Formula: 2–2.

Sternite X: At the posterior margin about equidistant; setae 1 are 12μ long; setae 2 are 14μ long. Formula: 2–2.

Sternite XI: On the posterior margin, setae 1 are 12μ long; setae 2 are 25μ long; somewhat anterior on the sternite, setae 3 are 29μ long; setae 4 are 11μ long. Formula: 4–4.

Sternite XII: Near the anterior margin 15μ apart, a pair of setae 9μ long; on or near the lateral border, a group of three setae on each side, two are 34μ long, the third is 46μ long; at the posterior tip, a group of four setae 9μ long. Formula: 6–6.

The number of setae agrees with that given by Ionesco (1935) for the genus, and by Gisin (1945) for *E. armatum* Stach.

Type.—U.S.N.M. No. 59913.

Remarks.—The species is described from two males, two females, and one maturus junior, collected by A. W. Rakosy, at 3,000 feet elevation, Sierra del Avila, Los Chorros, Estado Miranda, Venezuela, in 1947. Each specimen is on a slide. The holotype, male, has been completely cleared in lactic acid, stained with fuchsin, and mounted in damar; the four paratypes have been mounted in Hoyer solution (Faure).

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NEW AMERICAN CYNIPID WASPS FROM GALLS

By Lewis H. Weld

Twenty-four new species of cynipids and their galls and two inquilines are described herein, together with some notes on biology and synonymy. One new generic name is proposed for three described gall-making species from the Pacific coast.

Types of the new species are in the United States National Museum (U.S.N.M.). Paratypes are deposited in institutions that are indicated by the following abbreviations: the American Museum of Natural History (A.M.N.H.), the Chicago Museum of Natural History (C.M.N.H.), the Academy of Natural Sciences of Philadelphia (A.N.S.P.), the California Academy of Sciences (C.A.S.), the Museum of Comparative Zoology (M.C.Z), Cornell University (C.U.), the Illinois Natural History Survey (I.N.H.S.), and the University of Utah Museum (U.U.M.).

Genus SAPHONECRUS Dalla Torre and Kieffer

SAPHONECRUS BREVICORNIS (Ashmead), new combination

Synergus brevicornis Ashmead, Trans. Amer. Ent. Soc., vol. 23, p. 189, 1896.

The types have the radial cell open; hence the species belongs in *Saphonecrus*.

Genus SYNOPHRUS Hartig

SYNOPHRUS MEXICANUS (Gillette)

Synergus mexicana Gillette, Trans. Amer. Ent. Soc., vol. 23, pp. 90, 96, 1896.

The type, in the U. S. National Museum, has the petiole smooth and

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the radial cell open; hence the species belongs in *Synophrus* and was transferred in "Hymenoptera of America North of Mexico," p. 613, 1951.

Genus SYNOPHROMORPHA Ashmead

Synophromorpha ASHMEAD, Psyche, vol. 10, p. 45, 1903.

Ashmead, in his key to genera, designated *Synophromorpha salicis* as the type of this genus, but no further description of it was ever published, and no specimen so labeled was found in the Ashmead collection. It was supposed to have been reared from a dipterous gall on willow and considered to be a guest fly. He characterized the genus as having an open radial cell, the petiole not longitudinally striate, and separable from *Synophrus* Hartig by having a coriaceous instead of transversely sculptured mesoscutum with more or less distinct parapsidal grooves, smaller foveae, incomplete areolet, and the third segment of the antenna longer than the fourth in the male.

SYNOPHROMORPHA SYLVESTRIS (Osten Sacken), new combination

Synophrus (?) *sylvestris* OSTEN SACKEN, Ent. Zeit. Stettin, vol. 22, p. 415, 1861.

This species agrees with the diagnosis of *Synophromorpha* and is here transferred to that genus, and as the original spelling is permissible Latin it is retained. It was reared from the gall of *Diastrophus nebulosus* Osten Sacken on blackberry in the Washington, D. C., area. Adults agreeing with paratypes of this species have often been reared from this gall in this, the type, area and in many other localities. Range in length of females 2.1–3.25 mm. Average of 31 specimens 2.86 mm. Males 1.8–2.65 mm. Average 2.25 mm. Similar adults have been reared from galls of *Diplolepis ignota* (Osten Sacken) in the Washington area.

Two new species are described in the present paper. Like *sylvestris* they have the face striate, antennae and legs straw yellow, antennae 12-segmented in the female, mesoscutum broader than long, parapsidal grooves percurrent and broadened posteriorly, foveae smooth, carinae on propodeum straight, diverging above, abdomen with a hairy ring at base and a faint indication of a suture between tergites II and III as in *Ceroptres*.

SYNOPHROMORPHA TERRICOLA, new species

Differs from *sylvestris* in having the mesopleuron smooth instead of finely aciculate and a fainter coriaceous sculpture on mesoscutum. The parapsidal grooves closely approach each other at scutellum where they are separated only by a distinct median groove. Length of females 2.2–2.9 mm. Average of 32 specimens 2.57 mm. Males have 14-

segmented antennae. Length 1.8–2.7 mm. Average of 20 specimens 2.42 mm.

Types.—U.S.N.M. No. 60105: Type female, allotype, and six paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.[1]

Habitat.—Emerged early in May from galls of *Diastrophus radicum* Bassett at East Falls Church, Va. Part of the paratypes are from galls of *D. bassettii* Beutenmueller, from Washington, D. C.

SYNOPHROMORPHA RUBI, new species

Differs from *S. terricola* in having the parapsidal grooves widely separated behind with a median groove wanting or a mere notch. Females measure 2.2–2.9 mm. Average of 15 specimens 2.46 mm. Males 1.6–2.2 mm. Average of six specimens 1.77 mm.

Types.—U.S.N.M. No. 60106: Type female, allotype, and four paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

Habitat.—The types emerged in July from galls of *Diastrophus cuscutaeformis* Osten Sacken collected at Winnetka, Ill.

Genus CEROPTRES Hartig

CEROPTRES OBTUSILOBENSIS Weld

Diplolepis q.-obtusilobae Karsch, Zeitschr. für Ges. Naturw., vol. 53, pp. 292, 293, pl. 6, figs. 3, 3a, 3b, 1880.

Cynips obtusilobae Dalla Torre, Catalogus hymenopterorum, vol. 2, p. 47, 1893 (cites Karsch).

The Karsch gall in Berlin is an abrupt terminal stem swelling on *Quercus stellata*, from Texas, labeled *Cynips quercus obtusilobae*. The three type adults reared from it, which Karsch considered to be the makers of the gall and related to *Neroterus*, are all guest flies of the genus *Ceroptres*. Dalla Torre was the first to apply a binomial designation to the species. As *obtusilobae* was preoccupied in *Ceroptres* in 1885 by Ashmead (Trans. Amer. Ent. Soc., vol. 12, p. 300) the name *obtusilobensis* was proposed in the "Hymenoptera of America North of Mexico," p. 614, 1951, for the Karsch species.

Genus LIPOSTHENES Foerster

LIPOSTHENES GLECHOMAE (Linnaeus)

Cynips glechomae Linnaeus, Systema naturae, ed. 10, p. 553, 1758.

Aulax latreillei Kieffer, Ent. Zeit. Wien., vol. 17, p. 257, 1898.

Linnaeus did not describe his species, but he cited seven references; six of these refer to galls only. However, in one, Reaumur (Memoirs,

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[1] See p. 315 for explanation of abbreviations used throughout this paper.

vol. 3, pp. 460–462, figs. 1–5, 1737) says he reared a brown fly with four wings, similar to those he had reared from oak but with slight and sufficient differences to indicate it is a distinct species. This brief characterization of the maker of the gall validates the name that Linnaeus gave to the species in 1758. He himself evidently had not seen the maker, for in Fauna Suecica, p. 386, No. 1520, 1761, he says of the gall "insectum tamen non dum vidi" (however, I have not yet seen the insect).

Kieffer makes two misstatements when he writes (loc. cit.): "Linné hat zuerst aus den Galläpfeln von *Glechoma hederacea* den Erzeuger erhalten, und denselben *Cynips glechomae* genannt; die Beschreibung lautet: '*fusca thorace villoso.*' Fauna Suecica 1761, pag. 386, Nr. 1520." Reaumur, in France, was the first to rear the maker. The phrase "fusca thorace villoso" does not occur in the reference that Kieffer cites. There is in Geoffroy (Histoire abregée des insectes qui se trouvent aux environs de Paris . . ., vol. 2, p. 203, No. 20, 1762), the statement, "Cynips totus fuscus, thorace subvillosus. Sa coleur est brun et noiratre; son corcelet est un peu velu." Then, in 1787, Fabricius (Mantissa insectorum . . . , vol. 1, p. 252), in what is merely a key to species in each genus, shortens this to "fusca thorace villoso," to distinguish *glechomae* from the preceding species in his key.

The sides of the pronotum are pubescent and the mesoscutum is bare. In 1841 Hartig described adults he had from Foerster as having a shining mesonotum and makes the comment that "*Cynips glechomae* Lin. (fusca thorace villoso) muss notwandig ein andere Insect gewesen sein, da die Brust nichtsweniger als behaart ist." He does not name it, however. He takes the three Latin words to be a condensed *description* instead of a mere phrase to separate it from another species. This Hartig-Foerster material is what Foerster in 1869 made the type of his genus *Liposthenes.*

Latreille also (Histoire naturelle générale et particulière, des crustacés et des insectes . . . , vol. 13, p. 207, 1803) reared the maker and described it as very black, smooth, shining—the same insect that Hartig and Foerster examined. In 1898 Kieffer gave a new name to this species, calling it *Aulax latreillei*, and in 1910 (Das Tierreich, Lief. 24, p. 668) it appeared as a species distinct from *glechomae* Linnaeus from Sweden (sic), its gall not distinguishable from that of *glechomae. Aulax latreillei* is listed as from Britain, Germany, France, Austria, Italy, and North America.

If the above reasoning about the Latin phrase is correct, then Kieffer was not justified in giving a new name to the Hartig-Foerster-Latreille material, and the name *latreillei* should go into synonymy. There is only one species making the characteristic gall on *Nepeta* in

Europe and this species was introduced, together with its host plant, into the eastern United States. It should be known by the specific name that Linnaeus gave to it. Taylor (Amer. Journn. Botany, vol. 36, pp. 222–230, February 1949) published an excellent study of the early stages of this gall.

Genus DIPLOLEPIS Geoffroy

Rhodites Hartig, 1840, was founded on three species and Foerster in 1869 designated *Cynips rosae* Linnaeus as the type. The name is transliterated from a Greek word meaning "pertaining to a rose." Thus the name when applied to an insect implies an association with rose. In both the American and European literature up to 1917 the maker of a rose gall has been placed consistently in *Rhodites*.

Neither Hartig nor Foerster seems to have consulted the old literature. Geoffroy in 1762 (Histoire abregée des insectes, vol. 2, p. 308) proposed the genus *Diplolepis* for six species of gall makers, which he designated simply by number. Under No. 1 he cites Rösel, ins. vol. 3, suppl., plates 35, 36, and 53, figs. 10, 11, where he describes and figures an insect and gall on the leaf of oak without name. (Fourcroy in 1785 gave the name *Diplolepis quercus* to Geoffroy's No. 1.) In the bibliography of his No. 2 he cites among others Systema Naturae, ed. 10, p. 553, No. 1, 1758, which is *Cynips rosae* Linnaeus. The other numbered species lack a bibliography and have no standing. Thus by a reference the genus is established on one named species, and the definite designation of *Cynips rosae* as the type by Rohwer and Fagan in 1917 (Proc. U. S. Nat. Mus., vol. 53, p. 365) was unnecessary. They seem to feel that there is some slight doubt about the supposed designation of *C. rosae* as type by Geoffroy. The genus is monobasic. It is next-to-the-oldest name in the Cynipidae and was plainly intended to apply to a gall maker. And yet it does not appear in the key to genera in Foerster (1869), Mayr (1881), or Ashmead (1903), either as a valid name or a synonym. It was used erroneously in 1910 by Dalla Torre and Kieffer in Das Tierreich, Lief. 24, Cynipidae.

As *Rhodites* and *Diplolepis* are isogenotypic, *Rhodites* disappears in synonymy, although there is sentiment for having it placed on the conservanda list. Kinsey and Ayres (Indiana University Studies, vol. 9, Study 53, 1922) were the first to adopt *Diplolepis* in place of *Rhodites*, and Felt in 1940 (Plant galls and gall makers) followed their example. The name is coming into increased use among American authors. Europeans still use *Rhodites*. It is a case of an appropriate name made familiar by a century of usage against the plain intent of an older author. The establishment of a name by a reference is not an unusual or doubtful procedure. Linnaeus thus established his *Cynips glechomae*. Whether plenary power should be exercised in a case where the obvious intent of an author is so evident and his procedure so little open to question is a matter for discussion.

DIPLOLEPIS LENS, new species

Female.—Head and thorax black, abdomen and legs red. Vertex coriaceous. Antennae 14-segmented. Mesoscutum almost shining but not smooth, slightly rugose behind; parapsidal grooves percurrent with a median groove posteriorly. Scutellum rugose, longer than broad. Mesopleuron with a smooth and shining spot above and a larger one below. Wing pubescent and ciliate, clouded on radial and part of cubital cells as in *rosae*. Abdomen not so long as head plus thorax. Length 1.9–2.6 mm. Average of 23 specimens 2.24 mm. Smaller than *D. bicolor* (Harris), whose mesoscutum is more coarsely rugose behind, without a median groove.

Types.—U.S.N.M. No. 60107: Type and 4 paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

Host.—Rosa nutkana.

Gall.—A lentil-shaped thickening, up to 3.2 mm. in diameter by 1.7 mm. thick, in the parenchyma of the leaf in the fall. Single or several on a leaf. Similar to the gall of *D. rosaefolii* Cockerell in the eastern United States.

Habitat.—The types are from galls collected at Corvallis, Oreg., on October 16, 1939, along a road northwest of the university campus. Adults emerged June 7–14, 1940. Similar galls were seen at Holland, Siskiyou, and Klamath Falls, Oreg.; Chelan and Waitsburg, Wash., and Walnut Creek, Calif.

DIPLOLEPIS TERRIGENA, new species

Female.—Head and thorax variegated, red and black, abdomen and legs red. Antennae 14-segmented, three basal segments slightly reddish. Mesoscutum shining, smooth, with scattered punctures; parapsidal grooves broad, rugose, percurrent, ending in a rugose area at pronotum, median groove represented posteriorly by confluent punctures and continued forward by a dark median line. Scutellum rugose, less coarsely so in center. Wing not clouded, areolet reaching one-fifth way to basal. Propodeum with a smooth median groove. Abdomen nearly as long as head plus thorax, exposed parts of tergites back of II finely coriaceous, tergites IV–VII knife-edged dorsally. Using width of the head as a base the length of mesonotum ratio is 1.27; antenna 2.4; wing 3.0; ovipositor 3.3. Length 3.45–5.0 mm. Average of 65 specimens 3.99 mm.

Male.—Head and thorax black, abdomen red under black, legs beyond coxae red. Antennae 15-segmented, third bent. Abdomen shorter than thorax, twice as long as high. Length 2.25–3.25 mm. Average of 43 specimens 2.92 mm.

Differs from *D. fulgens* (Gillette), the median groove of which is as distinct as a parapsidal in posterior third and whose propodeum is rugose medially.

Types.—U.S.N.M. No. 60108: Type female, allotype, and 20 paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., M.C.Z., and C.U.

Host—*Rosa* sp.

Gall (pl. 17, fig. 17).—A large abrupt "root" gall at the crown, up to 50 mm. in diameter, surface somewhat botryoidal.

Habitat.—The types are from galls collected at Ojai, Calif., on April 6, 1922. They contained pupae at that time. Adults emerged April 26 to May 20. Galls were seen also at St. Helena and Los Gatos, Calif.

DIPLOLEPIS POLITA (Ashmead)

Rhodites polita Ashmead, Colorado Biol. Assoc. Bull. 1, pp. 14, 38, 1890.
Rhodites occidentalis Beutenmueller, Brooklyn Ent. Soc., vol. 17, p. 45, 1922 (new synonymy).

Ashmead described *polita* from a gall similar to the eastern *Diplolepsis bicolor* (Harris), found on *Rosa californica*, but adds the statement that he has seen galls from Dakota and Colorado also. As the types in the U. S. National Museum are from Marin County, Calif., and bear Koebele's label with No. 70 in red ink, the type locality is California, and the Dakota and Colorado material was misdetermined. There are males of this species in collections from Los Angeles but not marked as types.

Fullaway reared adults, which he determined to be *Rhodites bicolor* (Harris), from Cupertino (Stevens Creek), Calif., and described them in 1911 (Ann. Ent. Soc. Amer., vol. 4, p. 377). In 1922 Beutenmueller gave this *bicolor* Fullaway the name of *Rhoditis occidentalis*. The U. S. National Museum has a female specimen from Cupertino (Stevens Creek) which must be a type of the Fullaway description. It agrees with types of *R. polita* Ashmead. It measures 3.1 mm. The 5 mm. measurement in the description must be a misprint for 3 mm.

Genus NEUROTERUS Hartig

NEUROTERUS TANTULUS, new species

Female.—Black. Head from above about twice as wide as long, broader than thorax, cheeks slightly broadened behind eyes; from in front broader than high, malar space one-third eye with a faint groove, interocular space broader than high. Antennae 12-segmented, lengths as (scape) 25(12) : 18(14) : 25(6) : 17 : 16 : 16 : 16 : 16 : 15 : 14 : 12 : 22

(9). Mesoscutum without trace of parapsidal grooves. Wing pubescent and ciliate, second cross-vein at angle of 55 degrees with basal, areolet reaching one-fourth way to basal. Claw with a weak tooth. Abdomen higher than long, ovipositor often extruded. Using width of the head as a base the length of mesonotum ratio is 1.17; antenna 1.8; wing 4.3; ovipositor 3.3. Range in length of 100 measured specimens 1.75–2.05 mm. Average 1.91 mm.

Types.—U.S.N.M. No. 60109: Type and 20 paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., M.C.Z., I.N.H.S., and C.U. A gall is on each pin.

Host.—*Quercus alba.*

Gall (pl. 16, fig. 1).—Small saucer-shaped galls occurring in large numbers attached by a broad base on under side of leaf in early summer. Individual galls measure .9–1.6 mm. in diameter by .6–.7 mm. high, with an elevation in center of the concave free surface, brown, almost bare, dropping off when mature and leaving a scar .7 mm. in diameter on the gall and a brown spot on the leaf.

Habitat.—Type locality, College Park, Md. On May 24, 1948, W. H. Anderson swept up a tablespoonful of the galls, which had fallen on a table under a heavily infested white oak tree. These were placed in a breeding cage on the ground outdoors and when examined on April 1, 1949, scores of adults had emerged and many had already died.

Genus TRICHOTERAS Ashmead

TRICHOTERAS PERFULVUM, new species

Female.—Piceous; mandibles, parts of scutellum and legs, brown. Head coriaceous, pubescent; from above transverse, as broad as thorax, cheeks not broadened behind eyes; from in front almost circular, malar space one-third eye, without groove, antennae filiform, 12-segmented, lengths as (scape) 16 : 11 : 20 : 19 : 17 : 17 : 15 : 11 : 10 : 9 : 8 : 18. Pronotum and mesonotum somewhat shining with uniformly distributed appressed hairs from prominent punctures. Mesoscutum broader than long, parapsidal grooves percurrent. Scutellum rugose posteriorly, with two widely separated smooth pits at base. Wing pubescent and ciliate, veins brown, third abscissa of subcosta almost parallel with second abscissa of radius, radial cell five times as long as broad, areolet present. Mesopleuron largely bare, smooth, polished. Tarsal claws with a strong tooth. Carinae on propodeum slightly bent, area on either side pubescent. Abdomen bare except for usual pubescent patches at base of tergite II, tergite II foliiform. Ventral spine slender, about five times as long as broad in side view, shorter than hind metatarsus. Using width of the head as a base the length of mesonotum ratio is 1.3; antenna 2.6; wing 4.7. Length 1.75–2.15 mm. Average of five specimens 1.99 mm. Differs from *T. coquilletti* Ashmead in having fully developed wings, from amber-colored *T. vacciniifoliae* (Ashmead) in having cheeks not broadened behind the eyes.

Types.—U.S.N.M. No. 60110: Type and paratype. Paratypes also in A.M.N.H. and C.A.S.

Host.—*Quercus chrysolepis.*

Gall (pl. 17, fig. 20).—Tan colored, circular, 6–8 mm. in diameter by 1 mm. high, single or in two's or three's, attached to midrib on upper or lower side of leaf in the fall. Sparingly hairy, thin walled, with an eccentric ellipsoidal cell inside held in place by radiating fibers.

Habitat.—The types are from galls collected at Idyllwild, Calif., November 9, 1948. Both living and dead adults were found in the galls when they were cut open, February 9, 1949. Galls have been seen in the San Bernardino, San Gabriel, and Santa Lucia Mountains, in Giant Forest, Big Basin, on Mount St. Helena, and at Ukiah, Calif. Fresh galls are fully grown by mid-June.

TRICHOTERAS ROTUNDULA, new species

Female.—Particolored, black and brown. Head coriaceous; from above transverse, cheeks not broadened behind eyes; from in front malar space one-half eye, without groove, faintly striate; antennae 12-segmented, first four segments as 10:8:15:13–last 11. Mesoscutum broader than long, not quite smooth, with uniformly distributed pubescence, parapsidal grooves percurrent, a median groove present posteriorly. Scutellum punctate, foveae smooth. Mesopleuron bare and smooth above, pubescent below. Wing pubescent and ciliate, veins slender, brown, first abscissa of radius arcuate, radial cell elongated, areolet small. Claws toothed. Carinae on propodeum diverging below. Abdomen as long as head plus thorax, lengths of tergites on dorsal margin as 65:13:4, tergite II foliiform. Ventral spine slender, as long as hind metatarsus. Using width of head as a base the length of mesonotum ratio is 1.3; antenna 2.4; wing 4.6. Length 2.0–2.05 mm. Described from three specimens. Differs from *T. perfulvum* in having a longer striate malar space and a longer ventral spine.

Types.—U.S.N.M. No. 60111: Type. Paratype in C.A.S.

Host.—*Quercus chrysolepis.*

Gall (pl. 16, fig. 2).—A midrib cluster of a few globular galls, usually on the under side of a leaf in the fall. Covered with short straight hairs when young and green, later bare, smooth, tan, up to 2.7 mm. in diameter with a central cell 1.5 by 1.2 mm. supported by stout radiating fibers.

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Habitat.—The type emerged in November from a gall collected at Camp Baldy, Calif., on November 7, 1939. One paratype was cut out September 5, 1918, from a gall collected at Los Gatos. Another was cut out November 10, 1949, from a gall collected at Idyllwild on November 6, 1948. One (not in the type series and all amber) was cut out dead in 1946 from a gall collected on Mount St. Helena in August 1922.

PARACRASPIS, new genus

Genotype.—*Callirhytis guadaloupensis* Fullaway.

Agamic female.—Head massive, broader than thorax, cheeks broadened behind eyes, malar space without groove, antennae 14-segmented, filiform, third longer than fourth, longer than first two. Thorax normally arched; pronotum narrowed to one-ninth in middle. Mesoscutum broader than long, parapsidal grooves complete or incomplete, median wanting. Scutellum rounded behind, with a transverse groove at base, lateral impressions prominent. Mesonotum covered with uniformly distributed appressed hairs which almost hide the sculpture. Mesopleuron pubescent. Tarsal claws with a tooth. Wings reduced but with evident and nearly normal venation, reaching about to the tip of abdomen. Abdomen longer than head plus thorax, second tergite longest but not reaching half the length of the abdomen, remaining five more or less subequal, sides of III–VI not pubescent. Ventral spine broad, rounded at end, bristly as in *Acraspis* Mayr. Ovipositor almost straight at end, rather short and stout.

Differs from *Acraspis* Mayr in having less reduced wings, a more robust thorax with a normally rounded scutellum. Genus erected to include three agamic species, all from leaf galls not of the "hedgehog" type on *Quercus chrysolepis* in California. Sexual generation unknown.

Included species.—The following species are included in the new genus:

PARACRASPIS GUADALOUPENSIS (Fullaway)

Callirhytis guadaloupensis Fullaway, Ann. Ent. Soc. Amer., vol. 4, p. 363, 1911.

PARACRASPIS INSOLENS (Weld)

Acraspis insolens Weld, Proc. U. S. Nat. Mus., vol. 68, art. 10, p. 59, 1926.

PARACRASPIS PATELLOIDES (Weld)

Acraspis patelloides Weld, Proc. U. S. Nat. Mus., vol. 68, art. 10, p. 60, 1926.

Genus LIODORA Foerster

LIODORA COMATA, new species

Female.—Black; mandibles, palpi, base of antennae and legs yellowish white. Head from above transverse, as broad as thorax, cheeks not broadened behind eyes; from in front wider than high, malar space .3 eye, without groove, antennae 14-segmented, lengths of first five as 9 : 6 : 11 : 10 : 9. Sides of pronotum, mesoscutum, and mesopleuron smooth, bare, polished. Parapsidal grooves narrow, percurrent. A distinct suture between mesoscutum and scutellum. Two smooth, shallow pits at base of scutellum, disk smooth, punctate and pubescent behind and overhanging propodeum. Carinae on propodeum slightly bent. Wing pubescent and ciliate, radial cell five times as long as broad, veins brown, areolet small, first abscissa of radius arcuate. Claws with a strong tooth. Abdomen as high as long, tergites smooth, all visible on dorsal margin. Ventral spine stout, twice as long as broad, not bristly. Ovipositor curved at tip. Length 1.45–2.15 mm. Average of 30 specimens 1.7 mm.

Male.—Head broader than thorax. Antennae 15-segmented, lengths of first five as 9 : 6 : 16 : 11 : 10, third bent and lighter in color. Abdomen with a short pedicel. Length 1.45–1.8 mm. Average of six 1.64 mm.

Types.—U.S.N.M. No. 60112: Type female, allotype, and six paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

Host.—*Quercus alba.*

Gall (pl. 16, fig. 11).—Conical, 3.0 by 1.4 mm., tan, thin walled, covered with crinkly white matted hairs. Produced singly at edge of leaf in early spring when leaves are only an inch or so long.

Habitat.—Type locality East Falls Church, Va. Adults emerged April 26 and May 4–15.

Genus AMPHIBOLIPS Reinhard

AMPHIBOLIPS GLOBUS, new species

SEXUAL GENERATION

Female.—Head, thorax, antennae, legs except fore and middle tibiae and tarsi, black; abdomen red to almost black. Head rugose, from above narrower than thorax, cheeks not broadened behind eyes; from in front broader than high, malar space .4 eye, with radiating ridges, antennae filiform, 13-segmented. Sides of pronotum coarsely reticulate. Mesoscutum coarsely rugose, the percurrent parapsidal and median grooves also rugose. Scutellum more coarsely rugose behind, pits shallow, a median depression on disk hardly apparent. Mesopleuron rugose, more coarsely so anteriorly. Wing pubescent and ciliate, the blotch at base of radial cell covering the areolet also. Tarsal claws toothed. Carinae on propodeum strongly bent, enclosed area rugose with a short median. Abdomen about as long as thorax, lengths of tergites on dorsal margin as 38 : 8, tergite II smooth on hind margin, III punctate. Ventral spine pubescent, as long as hind metatarsus. Using width of head as a base the length of mesonotum ratio is 1.5; antenna 2.1; wing 3.2; ovipositor 2.0. Length 4.15–4.8 mm. Average of 10 specimens 4.58 mm.

Male.—Similar but abdomen black. Antennae 15-segmented, the third stoutest, the flagellum tapering to tip. Abdomen shorter than thorax, all tergites visible on dorsal curvature. Antenna ratio 3.3. Length 3.5–4.0 mm. Average of 11 specimens, 3.74 mm.

Differs from *A. spongifica* (Osten Sacken), whose tergite II is punctate posteriorly.

Types.—U.S.N.M. No. 60113: Type female, allotype, and three paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

Host.—*Quercus palustris.*

Gall (pl. 16, fig. 4, *a*).—A bud gall in June produced from weak lateral buds on previous year's growth of saplings 1 to 3 feet high, on sprouts from stumps and on lower limbs of small trees, occasionally from dormant buds on main trunk of trees. In good light, deep green with white spots at attachment of radiating fibers inside; in deep shade, more or less etiolated. Globular, firm, fleshy, bare, up to 18 mm. in diameter, not deciduous. Wall 1 mm. thick. Central cell relatively large, supported by many coarse, branching, radiating fibers. Larval cell 6 mm. by 3.2 mm. and its wall 1.5 mm. thick with big cells at base of the radiating fibers. Exit hole 2.2 mm. in diameter made while gall is still green. After the emergence of the maker the gall turns brown and becomes wrinkled. Many undersized galls are parasitized. Out of more than 200 galls collected only 20 makers emerged.

Habitat.—The type series of galls was collected at East Falls Church, Va. June 26, 1948. Adults emerged June 28, 30, July 2, 4, 1948. None of these galls was seen at this place in 1949, in 1950, or in 1951. Galls had been seen at Rosslyn and Lucketts, Va., Washington, D. C., and Lanham, Md.

AGAMIC GENERATION ?

In early September 1948 approximately 65 bud galls were collected on the ground under a large pin oak tree only a few feet from where galls of *A. globus* herein described were taken the previous June. Similar galls had not been seen here before—circumstantial evidence that it is the alternating form. It occurs in August and September at the end of the season's growth. It is smooth, bare, green with small purple spots marking the attachment of numerous radiating fibers within, up to 14 mm. in diameter, rounded at distal end, slightly tapering at attached base, the wall relatively thin (.8 mm.) (pl. 16, fig. 4, *b*). Larval cell ellipsoidal, 6 by 4 mm. Galls drop in late August or early September and soon turn brown and become slightly wrinkled. At this time the nutritive layer is all used up and full-grown larvae and pupae are found inside. Some may emerge in the fall but the adults described below were cut out of the galls on October 18 and November 5, 1949. As they are thought to be the alternating agamic generation of *globus* they are not given a different specific name.

Agamic female.—Head and thorax black, abdomen red, tibiae and tarsi brown. Cheeks broadened behind eyes. Antennae 13-segmented. Mesoscutum rugose with parallel longitudinal ridges back of anterior lines and short transverse ridges on either side of them; parapsidal grooves shallow, rugose, percurrent, a median streak percurrent in the sculpture. Scutellum rugose, without distinct median depression or posterior emargination, foveae with oblique ridges in bottom. Large spot on base of radial cell covers areolet also. A short median carina on propodeum. Abdomen as long as thorax, all tergites normally showing on dorsal curvature, hind margin of II smooth, rest punctate, VII pubescent. Ventral spine longer than hind metatarsus. Mesonotum ratio 1.5; antenna 2.0; wing 4.0. Length 3.9–4.55 mm. Average of three 4.3 mm.

Genus ANDRICUS Hartig

ANDRICUS BRUNNEUS Fullaway

Andricus brunneus FULLAWAY, Ann. Ent. Soc. Amer., vol. 4, p. 353, 1911.

This species was described from a "thin-walled subglobular gall, pointed at both ends and about the size of a pea" on the leaves of *Quercus douglasii.* It seems to have been associated with the wrong gall. The type gall in the Stanford collection, agreeing with the above description but with a central cell supported by radiating fibers, seems to be a gall of what was described under the name of *Andricus atrimentus* Kinsey. I have reared adults agreeing with the types from a midrib cluster on this host at Stanford University, the type locality, and also from similar galls on *Quercus lobata*, *Q. dumosa*, and *Q. garryana.* These galls are from 3–5 mm. in diameter, in a cluster of 4 to 6 on the under side of the leaf (pl. 17, fig. 16), tan, slightly mottled, slightly pubescent, thick walled without any radiating fibers or free central cell, dropping in September. From galls collected on *Quercus douglasii* at Stanford University on October 27, 1948, adults emerged October 18 to November 5, 1949.

ANDRICUS ALBICOMUS, new species

Female.—Red, often with some black on occiput, foveae, propodeum, and parts of abdomen. Head coriaceous; from above vertex bare, cheeks slightly broadened behind eyes, occiput not concave; from in front malar space 0.4 eye, without groove, antennae filiform, 13-segmented. Mesoscutum microcoriaceous, shining, longer than broad, with scattered hairs, parapsidal grooves percurrent. Scutellum rugose, pubescent, margined on sides, foveae smooth. Mesopleuron bare, smooth. Wing hyaline, pubescent and ciliate, veins pale and slender, radial cell four times as long as broad, areolet and cubitus almost obsolete. Claws toothed. Abdomen longer than head plus thorax, almost as high as long, lengths of tergites as 45 : 18 : 8 : 4 : 4, slightly gibbous below petiole, the curved tip of ovipositor projecting beyond sheaths. Ventral spine longer than hind metatarsus. With width of head as a base, the length of mesonotum ratio is 1.4; antenna 2.9; wing 4.9; ovipositor 5.8. Range in length 1.5–2.4 mm. Average of 53 specimens 2.0 mm.

Close to *Andricus kingi* Bassett, whose disk is smooth back of septum and antennae are 14-segmented.

Types.—U.S.N.M. No. 60114: Type and 10 paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

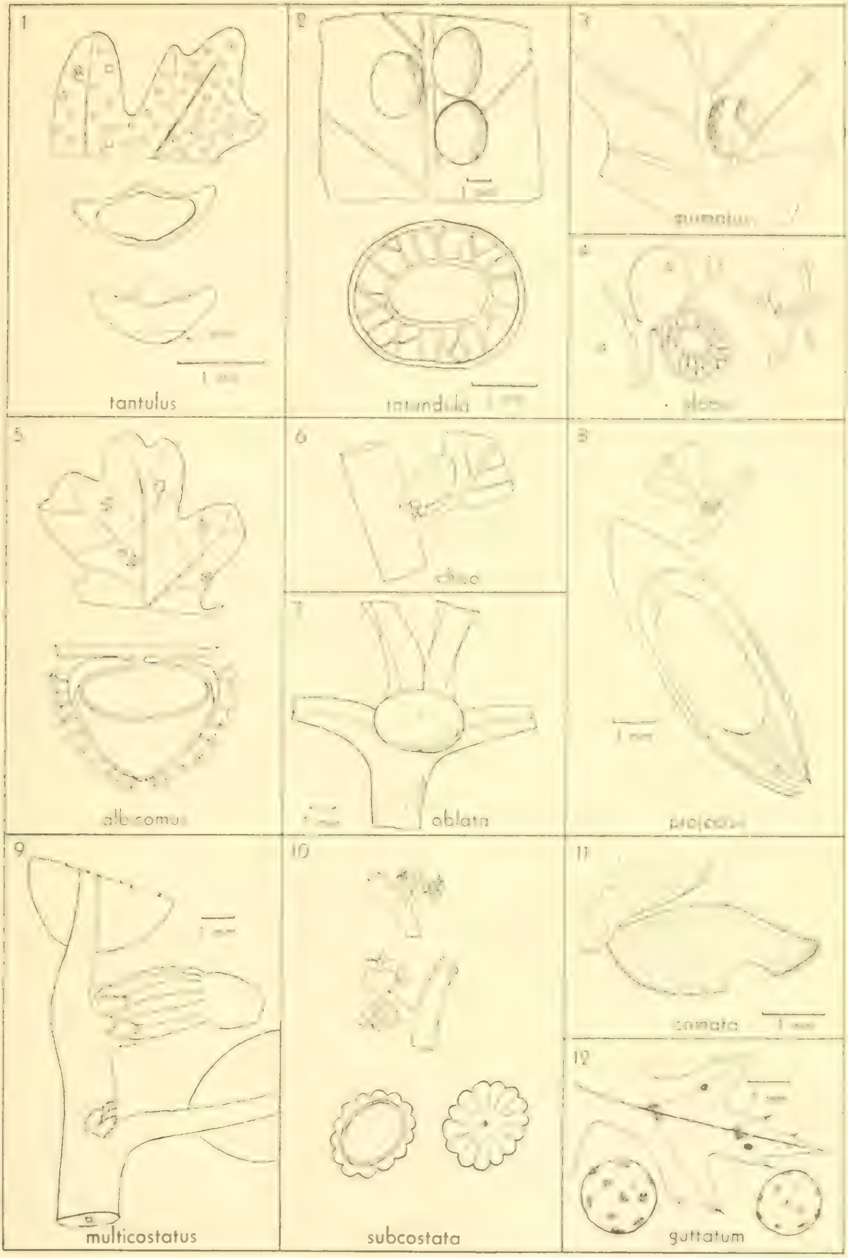
Host.—*Quercus garryana.*

Gall (pl. 16, fig. 5).—A thin-walled conical gall about 5 mm. in diameter on the under side of a leaf in the fall, densely covered with pedicelled, stellate grayish-white hairs. Inside is a transverse basal larval cell with a distal cavity opening at apex.

Habitat.—The types were cut out October 18, 1949, from galls collected at Cave Junction, Oreg., on October 14, 1948. Others emerged in outdoor breeding cage on April 1, 1950. Galls were seen also at Corvallis and at Siskiyou summit, Oregon, on United States Highway 99.

ANDRICUS CHICO, new species

Female.—Light brown; eyes, ocelli and sheaths black. Head coriaceous; from above transverse, cheeks broadened behind eyes, occiput concave; from in front interocular area wider than high, malar space one-third eye, without groove, fan-striae about mouth, antennae filiform, 13-segmented. Mesoscutum coriaceous with short uniformly distributed pubescence from distinct punctures, parapsidal grooves percurrent. Septum between the foveae broad, disk rugose. Mesopleuron smooth under hind wing, striate below, almost bare. Wing pubescent and ciliate, veins beyond second cross-vein pale, areolet distinct. Claws toothed. Carinae on propodeum straight and parallel.



1, *Neuroterus tantulus* on *Quercus alba;* 2, *Trichoteras rotundula* on *Q. chrysolepis;* 3, *Dryocosmus grumatus* on *Q. wislizeni;* 4, *Amphibolips globus* on *Q. palustris;* 5, *Andricus albicomus* on *Q. garryana;* 6, *Andricus chico* on *Q. lobata;* 7, *Callirhytis oblata* on *Q. falcata;* 8, *Andricus projectus* on *Q. chrysolepis;* 9, *Andricus multicostatus* on *Q. subturbinella;* 10, *Callirhytis subcostata* on *Q. stellata;* 11, *Liodora comata* on *Q. alba;* 12, *Zopheroteras guttatum* on *Q. palustris.*

13, *Dryocosmus minusculus* on *Quercus agrifolia;* 14, *Callirhytis hopkinsi* on *Q. imbricaria;* 15, *Andricus prescotti* on *Q. subturbinella;* 16, *Andricus brunneus* on *Q. dumosa;* 17, *Diplolepis terrigena* on *Rosa* sp.; 18, *Andricus crenatus* on *Q. dumosa* and *Q. douglasii;* 19, *Antron pileus* on *Q. subturbinella;* 20, *Trichoteras perfulvum* on *Q. chrysolepis;* 21, *Callirhytis furva* on *Q. palustris;* 22, *Callirhytis cistella* on *Q. emoryi.*

Abdomen as long as head plus thorax, as high as long, all tergites showing on dorsal margin. Ventral spine slender, longer than hind metatarsus. Using width of the head as a base the length of mesonotum ratio is 1.3; antenna 2.3; wing 3.8. Length 2.3–2.6 mm. Average of three specimens 2.48 mm.

Differs from *A. foliatus* (Ashmead) in the shorter and more sparse pubescence on thorax and in having a distinct areolet.

Type.—U.S.N.M. No. 60115: Type. Paratype in C.A.S.

Host.—*Quercus lobata.*

Gall (pl. 16, fig. 6).—A smooth, bare, ovoid bud gall found in fall in the axils of leaves, greenish and mottled with purple, projecting beyond the bud scales, 2–3 mm. in diameter.

Habitat.—The types were cut out November 10, 1949, from galls collected at Chico, Calif., on October 18, 1948. Galls have been seen at Stanford University, Los Gatos, Santa Margarita, Lakeport, Ukiah, and Willits, Calif.

ANDRICUS PROJECTUS, new species

Female.—Body reddish brown, infuscated dorsally; antennae and legs lighter. Head coriaceous; from above transervse, occiput not concave, cheeks broadened behind eyes; from in front broader than high, interocular space broader than high, malar space one-half eye, a few striae from corners of clypeus, antennae filiform, 13-segmented. Mesoscutum pebbled, almost bare, parapsidal grooves percurrent, no median. Disk of scutellum pubescent, rugose except back of septum, foveae smooth, shallow. Mesopleuron and sides of propleura bare, finely striate. Wing hyaline, hairs on surface short, not ciliate, veins almost clear, areolet small, radial cell five times as long as broad. Claws with a strong tooth. Carinae on propodeum straight, parallel. Abdomen longer than head plus thorax, lengths of tergites along dorsal curvature as 44:11:2:2:9; hind margin of II smooth, exposed parts of rest punctate. Ventral spine slender, seven or eight times as long as broad. Using width of head as a base, the length of mesonotum ratio is 1.3; antenna 2.5; wing, 4.5; ovipositor 3.4. Range in length 1.15–3.0 mm. Average of nine specimens 2.12 mm. Differs from *A. niger* Tavares in having tergite III punctate.

Types U.S.N.M. No. 60116: Type and one paratype. Paratypes also in C.A.S. and A.N.S.P.

Host.—*Quercus chrysolepis.*

Gall (pl. 16, fig. 8).—Bursting out far beyond the bud scales in the fall, cylindrical, bare, smooth, greenish with a light tan apex. When detached the base is darker, with a depressed scar at the truncated end, 7.0 mm. long by 2.1 mm. in diameter. Monothalamous. Usually occurs at tip of strong sprouts from stumps.

Habitat.—The type emerged April 16, 1943, from galls collected at Canyonville, Oreg., October 18, 1939. One was cut out February 17, 1941. Two paratypes were cut out October 18, 1949, from galls collected at Canyonville on October 12, 1948. Three emerged April 15, 1941 and April 20, 1942, from galls collected on the Mt. Wilson trail above Sierra Madre, Calif., on November 4, 1939. One is from Colfax, Calif. Galls were seen also at the California-Oregon State line on United States Highway 199 and at San Rafael and Idyllwild, Calif.

ANDRICUS CRENATUS, new species

Female.—Red or amber, slightly infuscated. Head coriaceous; from above transverse, vertex bare, occiput not concave, cheeks broadened behind eyes; from in front as high as wide, malar space one-third eye, without groove, antenna 14-segmented, infuscated distally. Sides of pronotum faintly striate. Mesoscutum microcoriaceous, shining, longer than wide, high arched in profile, with scattered hairs, parapsidal grooves percurrent. Scutellum longer than wide, sides margined, finely rugose, pubescent, the two deep smooth foveae at base often infuscated. Mesopleuron largely bare, smooth. Wing pubescent and ciliate, veins slender, radial cell 4.7 times as long as broad, areolet almost obsolete. Claws toothed. Carinae on propodeum bent, enclosed area smooth, narrowed above. Abdomen longer than head plus thorax, longer than high, all tergites usually showing on dorsal margin, ventral spine slender, longer than hind metatarsus. Using width of the head as a base the length of mesonotum ratio is 1.4; antenna 2.7; wing 5.1. Length 1.5–2.45 mm. Average of 24 specimens 1.9 mm.

Differs from *Andricus pattersonae* Fullaway in its smaller size.

Types.—U.S.N.M. No. 60117: Type and three paratypes. Paratypes also in the C.M.N.H., A.N.S.P., C.A.S., and the M.C.Z.

Hosts.—*Quercus dumosa* and *Q. douglasii.*

Gall (pl. 17, fig. 18).—A spangle about 4 mm. in diameter, usually on the upper side of the leaf, saucer shaped, with a thin crenate margin when young in August and with a prominent hump in center. When mature in fall there is a lens-shaped larval cavity inside, on the floor of which is a thin, white, circular disk from which prominent lines radiate. Galls on *Quercus douglasii* are less crenate.

Habitat.—The type is from a series of dead adults cut out of galls collected on *Quercus dumosa* at Los Gatos, Calif., on December 13, 1935. Others, all from California, are from the San Bernardino Mountains, San Jacinto Mountains, and Banning; other paratypes emerged November 19, 1935, from galls collected at Colfax, on *Quercus douglasii* a few days previously; others are from Stanford University and Angels Camp. Similar galls have been seen on *Quercus engelmanni* at Santa Anita, Calif. Adults not included in the type series have been reared from galls on *Quercus garryana* at Siskiyou summit north of Holbrook, Calif.

ANDRICUS MULTICOSTATUS, new species

Female.—Straw yellow, head and thorax slightly darker, only ventral valves and tips of mandibles infuscated. Head from above transverse, as broad as thorax, cheeks short, not broadened behind eyes, occiput not concave; from in front broader than high with a median ridge above clypeus, malar space striate, half length of eye, antennae 13-segmented, filiform. Mesoscutum coriaceous, with scattered hairs, without evident punctures, parapsidal grooves percurrent, no median. Scutellum rugose with two deep, smooth, shining pits, septum narrow. Carinae on propodeum straight and parallel. Mesopleuron finely striate. Wing hyaline, pubescent and ciliate, first abscissa of radius arcuate, second pale, only distal vein of areolet evident. Tarsal claws toothed. Abdomen longer than head plus thorax, higher than long, only tergites II and III showing on dorsal margin, both smooth; ventral spine slender, almost as long as hind metatarsus. With the width of the head used as a base the length of mesonotum ratio is 1.3; antenna 2.2; wing 4.0. Length 2.2 mm.

Type.—U.S.N.M. No. 60118: Holotype.

Host.—*Quercus subturbinella.*

Gall (pl. 16, fig. 9).—An axillary or terminal bud gall in fall. Cylindrical with 10 to 20 distinct longitudinal ribs, up to 5 mm. long, protruding far beyond the bud scales. Greenish with white spots when fresh, the bulbous distal third smooth and reddish.

Habitat.—The type was cut out alive on October 14, 1944, from a gall collected at Prescott, Ariz., September 13, 1943, by Mrs. N. W. Capron. She collected galls at Cherry and Prescott, Ariz., on October 4, 1935, and September 11, 1947, respectively.

ANDRICUS PRESCOTTI, new species

Female.—Black; antennae, palpi, legs distally and abdomen ventrally brown. Head from above transverse, as broad as thorax, vertex bare, ocellar area punctate, cheeks broadened behind eyes, occiput slightly concave; from in front broader than high, malar space over half eye, without groove, front finely coriaceous. Antennae filiform, 13-segmented. Pronotum pubescent except medially. Mesocutum finely coriaceous with scattered hairs from punctures, parapsidal grooves percurrent, a median notch or short groove behind, lateral and anterior lines depressed. Scutellum finely rugose, pubescent, basal pits smooth, shallow. Carinae on propodeum short, straight, parallel. Wings hyaline, cilia and pubescence short, veins brown, first abscissa of radius angled, areolet reaching one-fourth way to basal. Mesopleuron largely bare, smooth, polished. Claws toothed. Abdomen almost globose, tergite II with usual pubescent patches at base, its hind margin and exposed parts of rest punctate. Ventral spine bare, five times as long as broad in side view, shorter than hind metatarsus. Using width of head as a base the length of mesonotum ratio is 1.4; antenna 1.3; wing 3.7; ovipositor 2.4. Length 2.5–3.15 mm. Average of 30 specimens 2.79 mm.

Types.—U.S.N.M. No. 60119: Type and six paratypes. Paratypes also in the A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

Host.—Quercus subturbinella.

Gall (p. 17, fig. 15).—A bare, smooth, ellipsoidal gall, 5.0 mm. long by 2.9 mm. in diameter with a nipple at the apex, protruding from a shallow depression in the side of the acorn cup and dropping to the ground when mature in late summer, and then showing a girdle of hairs at the base. From one to eight on an acorn. Monothalmous.

Habitat.—The type locality is Prescott, Ariz. From galls collected in October 1935 by Mrs. N. W. Capron, adults were cut out on October 10, 1936, and one emerged April 23, 1937. In July and August 1947 she tied bits of cloth over a lot of affected acorns, so that the galls would not drop to the ground and be lost. Adults were cut out of these galls on March 20, 1948 and January 7, 1949. More were bagged in the summer of 1948, when the galls began to drop by the middle of August, a month earlier than usual, perhaps owing to a dry season. Many of these were blanks. Adults emerged April 15, 23, 26, 30, 1949.

ANDRICUS PILULA Bassett

This species was described from two females cut from galls from southern Utah. The types have the claws toothed, not simple as described. Similar galls were collected by Dr. A. W. Grundmann on *Quercus gambelii* in the mountains near Salt Lake City, Utah, and both females (agreeing with the types) and males were reared June 1–5, 1949. A description of the male is given below.

Male.—Black, flagellum and legs in part yellowish. Antenna nearly three times as long as width of the head, 15-segmented, third longer than fourth and bent, flagellum tapering to tip. Mesoscutum coriaceous, median groove shorter than in female. Disk of scutellum finely rugose, foveae smooth. Mesopleuron bare, smooth except for a few striae in middle. Wing pubescent and ciliate, veins brown, areolet wanting, cubitus traceable from margin nearly to basal. Claws toothed. Carinae on propodeum slightly bent. Abdomen shorter than thorax, lengths of tergites as 15:4. Length 1.7–2.15 mm. Average of 15 specimens 1.83 mm.

Types.—Specimens of the above description of male are in the U.S.N.M., A.N.S.P., C.A.F., and the U.U.M.

ANDRICUS PILULARIS, new species

Female.—Related to *Andricus pilula* Bassett but entirely different in color, being uniform amber. Antennae 13- instead of 14-segmented. Mesoscutum microcoriaceous instead of pebbled, anterior lines scarcely evident, median groove shorter but a dark median line is percurrent, with uniformly distributed, short, appressed pubescence instead of almost bare. Disk of scutellum more finely rugose, foveae smooth instead of with parallel longitudinal ridges. Mesopleuron smooth, without striae in center. Wing with a small but distinct areolet. Hind femur stouter. Carinae on propodeum slightly bent and enclosed area smooth instead of rugose. Abdomen with all the tergites visible on dorsal curvature, only the tip of sheaths projecting. Ventral spine longer. Length 2.05–2.85 mm. Average of 12 specimens 2.45 mm.

Male.—Differs from male of *pilula* in having greatly bulging eyes, the interocular space higher than broad and cheeks narrowed behind eyes. Length 1.9–2.75 mm. Average of 8 specimens 2.28 mm.

Type.—U.S.N.M. No. 60120: Type female, allotype, and two paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

Host.—Quercus subturbinella.

Gall.—Similar to galls of *Andricus utriculus* Ashmead and *A. pilula* Bassett. Globular, about 4 mm. in diameter, projecting more on upper side of leaf.

Habitat.—The types are from galls collected at Wolf Creek, near Prescott, Ariz., by Mrs. N. W. Capron, in June and July 1935. Living adults were cut out of the galls on July 20 and August 15. Others were sent August 1, 1947, and adults cut out August 7. One paratype is from a gall on *Quercus oblongifolia*, from Nogales. Galls have been noted on *Q. toumeyi*, *Q. submollis*, *Q. gambelii*, and *Q. diversicolor.*

Genus ANTRON Kinsey

ANTRON PILEUS, new species

Female.—Amber. Head coriaceous; from above transverse, narrower than thorax, occiput not concave, cheeks not broadened behind eyes: from in front broader than high, malar space .28 eye, without groove, antennae filiform, 15-segmented. Sides of pronotum pubescent. Mesoscutum shining, smooth and almost bare, parapsidal grooves deep, percurrent. Scutellum longer than broad, an arcuate groove and two shallow pits at base, disk finely rugose, pubescent, overhanging propodeum behind. Mesopleuron smooth, shining. Wing pubescent and ciliate, without clouds, veins distinct, brown, abscissa II of radius enlarged at wing margin, areolet reaching one-fifth way to basal. Claws toothed. Carinae on propodeum strongly bent, enclosed area smooth, much broader than long medially. Abdomen as high as long, only 2 or 3 tergites on dorsal margin. Ventral spine stout, bristly, tapering to tip in side and ventral view. Using width of the head as a base the length of mesonotum ratio is 1.3; antenna 2.3; wing 3.8; ovipositor 2.5. Length 1.5–2.35 mm. Average of 24 specimens 2.02 mm.

Male.—Differs from female in having head and abdomen black and 16-segmented antennae. Length 1.5–1.9 mm. Average of 13 specimens 1.58 mm.

Differs from some other species of *Antron* in having the wing clear.

Types.—U.S.N.M. No. 60121, type female, allotype, and six paratypes. Paratypes also in the A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and the M.C.Z.

Host.—Quercus subturbinella.

Gall (pl. 17, fig. 19).—A broadly conical bud gall, usually solitary, at end of new growth in summer. Straw yellow above with a purple margin, 4–7 mm. in diameter, broader than high, strongly concave below like the pileus of the fungus *Coprinus.* Larval cavity at very apex and exit hole just below the short nipple.

Habitat.—The type material was sent by Mrs. N. W. Capron, from Prescott, Ariz., July 12, 1947, and one adult (the type female) emerged en route. More galls were sent August 1, 1947, and dead adults were cut out of the galls. More were sent in early July 1949, and adults emerged July 10–19. In previous years she had sent galls from Camp Creek, Cherry, Pine, and Young, and I had collected them at Ash Fork and Williams, Ariz.

Genus ZOPHEROTERAS Ashmead

ZOPHEROTERAS GUTTATUM, new species

Female.—Living specimens black; head and thorax fading to brown. Head coriaceous; from above transverse, occiput concave, cheeks not broadened behind the eyes; from in front broader than high, interocular area 1.4 times as broad as high, malar space .5 eye, with a groove, antennae 14-segmented, filiform, lengths of first four and last segments as 15 : 5 : 16 : 13 and 10. Mesoscutum coriaceous, bare, longer than broad, not humped in profile, parapsidal grooves distinct, percurrent, widely separated in front, almost meeting behind. Knob on scutellum coriaceous, almost as wide as deep groove at base, in which are two indistinct smooth pits. Carinae on propodeum almost straight, widely diverging below. Mesopleuron striate below, coriaceous above. Hind tibia longer than tarsus. Claws simple. Abdomen as long as head plus thorax, gibbous below petiole, all tergites visible on dorsal margin, ventral spine 6.5 times as long as broad in side view, ovipositor straight at tip. Using width of head as a base the length of mesonotum ratio is .67, antenna 2.7, ovipositor 5.9. Length 1.5–2.65 mm. Average of 42 specimens 2.2 mm.

Differs from *Z. sphaerula* Weld in its smaller size, in having mesoscutum uniformly convex in profile, the mesopleuron striate in part and ovipositor straight at tip.

Types.—U.S.N.M. No. 60122: Type and nine paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and the M.C.Z.

Host.—*Quercus palustris.*

Gall (pl. 16, fig. 12).—Almost spherical, smooth, bare, with purple spots on a cream background, attached singly on under side of leaf on a secondary vein, dropping in early October. From 1.4 to 2.5 mm. in diameter. Pure white inside with the minute larval cavity central.

Habitat.—Type locality East Falls Church, Va. Galls were collected in October in eight different years; adults emerged the second spring in each case on the following dates: March 6, 20, 25, 29, April 1, 3, 7. Buds on pin oak at that time show no signs of swelling. Oviposition not observed. Alternating generation unknown.

Genus EUMAYRIA Ashmead

EUMAYRIA INVISA, new species

Female.—Light brown to amber. Head massive, coriaceous, dull: from above broader than thorax, occiput not concave; from in front broader than high, malar space one-third eye without groove, antennae 14-segmented, first four as 13:8:20:14. Pronotum coriaceous, dull. Mesoscutum lighter in color, somewhat shining, not quite smooth, rather flat, parapsidal grooves percurrent, straight and converging behind but well separated at scutellum. Disk of scutellum margined at sides, narrowed in front, rugose behind. Wing reduced, not reaching tip of abdomen, pubescent and ciliate, venation almost normal, areolet wanting. Mesopleuron with a smooth and polished spot under hind wing. Claws simple, hind femur short and stout. Carinae on propodeum almost straight, slightly converging above. Abdomen longer than head plus thorax, tergite II with usual patches of pubescence at base, rest subequal. Ventral spine longer than hind metatarsus, eight times as long as broad in side view. Using width of head as a base the length of mesonotum ratio is 1.0; antenna 2.3; wing 2.0. Length 2.3–3.2 mm. Average of 12 specimens 2.56 mm. No other species known with reduced wings.

Types.—U.S.N.M. 60123: Type and six paratypes. Paratypes in A.M.N.H. and C.M.N.H.

Host.—*Quercus myrtifolia.*

Gall.—Cells under the bark producing, where numerous, a more or less hypertrophied twig. Similar to gall of *Callirhytis crypta* (Ashmead).

Habitat.—Type locality Carrabelle, Fla. Living adults were cut out of the galls on November 17, 1929. Galls collected 2 weeks previously.

Genus BASSETTIA Ashmead

BASSETTIA FLORIDANA Ashmead

Bassettia floridana ASHMEAD, Trans. Amer. Ent. Soc., vol. 14, p. 147, 1887.
Dryophanta corrugis BASSETT, Trans. Amer. Ent. Soc., vol. 17, p. 71, 1890 (new synonymy).

The types of *Dryophanta corrugis* in the Bassett collection in the Academy of Natural Sciences of Philadelphia agree with Ashmead's *floridana.*

Genus DRYOCOSMUS Giraud

DRYOCOSMUS GRUMATUS, new species

Female.—Red, often with black on occiput, anterior and lateral lines, mesopleura, and dorsal abdomen. Head granulate; from above transverse, cheeks slightly broadened behind eyes, antennae filiform, 14-segmented. Mesoscutum smooth and polished, parapsidal grooves deep, smooth, percurrent, median wanting. Scutellum longer than broad, coriaceous behind the shallow pits, rugose peripherally. Mesopleuron almost bare, faintly striate in center. Wing pubescent and ciliate, veins brown, areolet small, cubitus reaching basal, radial cell four times as long as broad. Tarsal claws simple. Abdomen in side view as high as long, not gibbous below petiole, all tergites showing on dorsal margin. Ventral spine nine times as long as broad, longer than hind metatarsus. Length 2.15–2.75 mm. Average 2.3 mm. Described from eight specimens, all imperfect.

Types.—U.S.N.M. No. 60124: Type and two paratypes. Another paratype is in C.A.S.

Host.—*Quercus wislizeni.*

Gall (pl. 16, fig. 3).—A smooth, bare, ellipsoidal gall about 3 mm. in diameter attached to midrib on under side of the leaf in the fall and bearing a little fleshy knob on its summit exactly like the gall of *rileyi* (Ashmead) in the eastern United States.

Habitat.—Rex Hunt collected a lot of galls in the fall of 1949 at Felton, Calif., and placed them in a wire breeding cage outdoors on the ground for the winter. When examined on March 15, 1950, many adults had emerged and died while other galls still contained larvae. These galls occur also on *Quercus agrifolia* and *Q. kelloggii.*

DRYOCOSMUS MINUSCULUS, new species

Female.—Black; mandibles, antennae and legs mostly brownish. Head coriaceous; from above transverse, cheeks slightly broadened behind eyes, occiput concave; from in front broader than high, malar space .4 eye, without groove, antennae 14-segmented, last 8 with rhinaria. Sides of pronotum striate in part. Mesoscutum bare, polished, parapsidal grooves percurrent. Scutellum with two smooth circular pits at base; disk coriaceous behind septum, rugose behind. Mesopleuron bare, smooth. Wing pubescent, ciliate, veins pale, areolet small, radial cell four times as long as broad. Claws simple. Carinae on propodeum slightly bent, enclosed area broader than high. Abdomen plump, in side view gibbous below petiole, tergites along dorsal curvature as 43 : 10 : 10 : 10 : 13 : 1, III–VI sparsely punctate, VII coriaceous, tip of ovipositor projecting beyond sheath curved. Ventral spine eight times as long as broad, slightly longer than hind metatarsus. Using width of the head as a base the length of mesonotum ratio is 1.3; antenna 2.4; wing 5.0. Length 1.75–2.05 mm. Average of five specimens 1.91 mm.

Differs from *Dryocosmus bicornis* (McCracken and Egbert), which is straw yellow and has the ovipositor straight at the tip. *D. bicornis* forms galls on the same hosts as does *D. minusculus.*

Types.—U.S.N.M. No. 60125: Type and one paratype. Paratypes also in C.A.S., and A.M.N.H.

Host.—*Quercus agrifolia.*

Gall (pl. 17, fig. 13).—Small brown galls up to 2.7 mm. in diameter. shaped like a depressed sphere with a minute pit in the center above. Produced on upper side of leaves of *Quercus agrifolia*, *Q. wislizeni*, and rarely on *Q. kelloggii* in the fall and dropping when mature. Said to be so numerous sometimes as to defoliate the tree. Some years these galls are not common.

Habitat.—The types were reared from galls collected October 22, 1939, on *Quercus agrifolia* on Mount Diablo, Calif. Adults emerged April 17, 1941. Galls have been noted on this host at some 40 localities between Alpine and Ukiah and Red Bluff, Calif. They are also common on *Quercus wislizeni* and have been seen on *Quercus kelloggii* a few times. The guest fly, *Synergus agrifoliae* Ashmead, often reared from it, varies much in color pattern and has been redescribed as *Synergus maculatus* Fullaway (1911) new synonymy, and as *Synergus obscurus* McCracken and Egbert (1922), new synonymy.

Genus CALLIRHYTIS Foerster

CALLIRHYTIS CORRUGIS (Bassett)

When I previously reported (Proc. Ent. Soc. Washington, vol. 33, p. 225, 1931) that this species had been taken in numbers ovipositing in buds of *Quercus maxima*, *Q. velutina*, and *Q. palustris* at various dates in April at East Falls Church, Va., the gall from which they had emerged was not known. It can now be reported that the species has now been reared from "stone" galls in acorns of all the above oaks—galls not distinguishable from those of *Callirhytis fructuosa* Weld. Acorns of red oak were collected in Loudoun County, Va., on September 22, 1940, and from them *fructuosa* emerged April 19, 1942, and *corrugis* May 4, 1943, and April 20, 1947. Acorns of pin oak were collected at East Falls Church, Va., on October 20, 1940. *C. corrugis* (Bassett) emerged April 12, 18, 26, 1942; April 18, 1944; April 14, 1945, and April 6, 1946. Two species thus sometimes make similar galls in acorns of the same host oak. The alternating gall produced by these adults which oviposit in buds has not yet been discovered.

CALLIRHYTIS MODESTA (Osten Sacken)

In the box of Bassett cynipid types in the American Entomological Society the type of *Cynips papula* Bassett, a synonym of *modesta*, is a female of *Ceroptres* sp., a guest fly. A pinned specimen in another case marked "cotype" is the maker of the gall and has now been made the type. This is in spite of the fact that the original description of *papula* was drawn from specimens of two genera and combined the head and thorax of the guest with the abdomen and wing of the maker.

CALLIRHYTIS CISTELLA, new species

Female.—Head and thorax amber, dull; abdomen red, shining; propodeum and tips of antennae infuscated. Head from above transverse, narrower than thorax, cheeks not distinctly broadened behind eyes; from in front broader than high, malar space .4 eye, slightly striate; antennae filiform, 13-segmented. Mesoscutum finely and uniformly rugose, appressed pubescence short, parapsidal grooves obsolete anteriorly, median short. Disk of scutellum slightly coarser posteriorly, not humped back of the narrow septum between two smooth shining pits. Mesopleuron striate on lower half. Wing hyaline, surface dotted, nonciliate, veins brown, not clouded, abscissa I of radius arcuate, areolet wanting. Claws simple. Abdomen as high as long, gibbous below petiole, only two tergites on dorsal margin; ventral spine 7 times as long as broad, longer than hind metatarsus. Using width of the head as a base, the length of mesonotum ratio is 1.4; antenna 2.2; wing 3.7. Length 2.2 mm.

Type.—U.S.N.M. No. 60126: Type.

Host.—*Quercus emoryi.*

Gall (pl. 17, fig. 22).—A stalked, fusiform, pip gall beside young acorns July to October. Spindle shaped, brown, 3 by 5 mm. tapering at both ends, cavity large, wall thin.

Habitat.—The type was reared from a gall collected October 4, 1935, at Cherry, Ariz., by Mrs. N. W. Capron. A paratype emerged April 14, 1951, from a gall she collected at Prescott, Ariz., on September 20, 1950. Galls have been seen at Oracle, Ariz., and in Burro Mountains in New Mexico; seen also on *Quercus hypoleuca* at Patagonia, Bisbee, and in Huachuca and Chiricahua Mountains in Arizona.

CALLIRHYTIS HOPKINSI, new species

Agamic female.—Amber; foveae, propodeum, middle and hind tibiae and tarsi infuscated. Head granulate, dull; from above as broad as thorax, cheeks broadened behind eyes, occiput concave; from in front broader than high, malar space .6 eye with a groove, antennae 14-segmented, first four as 23(9) : 9(7) : 28(6) : 21; last 17(6). Mesoscutum granulate, covered uniformly with very short hairs, parapsidal grooves percurrent, a median evident posteriorly. Sculpture of disk coarser and somewhat transverse, in profile strongly humped back of septum. Mesopleuron dull, granulate, short-pubescent. Wing hyaline, dotted, nonciliate, veins beyond second cross-vein clear, first abscissa of radius angulate, heavy, areolet small. Hind femur broadest back of middle. Claws simple. Carinae on propodeum but slightly bent, enclosed area twice as broad as high. Abdomen length to height to width as 37 : 31 : 31 : lengths of tergites along dorsal curvature as 95 : 26 : 24 : 10 : 12 : 13. Ventral spine 8 times as long as broad, shorter than hind metatarsus. Using width of the head as a base the length of the mesonotum ratio is 1.3; antenna 2.5; wing 3.5; ovipositor 2.4. Length 3.1–4.2 mm. Average of 154 specimens 3.89 mm.

Differs from agamic *Callirhytis operator* (Osten Sacken) in having a shorter ventral spine, 14-segmented antennae and in its lighter color.

Types.—U.S.N.M. No. 60127: Type and 40 paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

Host.—*Quercus imbricaria.*

Gall (pl. 17, fig. 14).—A "pip" gall found in fall on young acorns of current season, green when fresh and secreting honey dew, becoming brown later and dropping to the ground. Short-cylindrical, 4–7 mm. broad by 2–4 mm. high, the larval cell central, the wall thick. Differs in shape and structure from all other known "pip" galls.

Habitat.—The type material was collected at Mineral Wells, W. Va., by Dr. A. D. Hopkins on September 4 and October 8, 1943. By September 12 most of the specimens had fallen to the ground, and he estimated that there were over a bushel of the galls (from 50 to 100 to a square foot) under this one large tree. Adults emerged from an outdoor breeding cage at Falls Church, Va., on March 28 and April 1, 6, 14, 1945, March 29 and April 5, 1946, and April 12, 18, 1947. Galls on this host have been seen at Washington, D. C., and Rosslyn, Va. Alternating generation unknown.

CALLIRHYTIS OBLATA, new species

Female.—Bicolored; red with black on anterior and parallel lines, on foveae, sternum, middle and hind tibiae and all last tarsal segments. Head from above transverse, as broad as thorax, occiput concave; from in front broader than high, cheeks broadened behind eyes, malar space half eye without groove. Antennae 13- or 14-segmented, first six as 16:10:19:18:15:13. Mesoscutum coriaceous with scattered punctures and short appressed pubescence. Parapsidal grooves deep, narrow, smooth, not percurrent, median almost as long as parapsidal. Scutellum rugose, the two pits at base separated by a septum. Mesopleuron largely aciculate and bare. Wing hyaline, pubescence short, nonciliate, veins beyond second cross-vein scarcely evident. Claws simple. Carinae on propodeum straight, parallel, enclosed area broader than high. Abdomen with an interrupted ring of white hairs at base. Lengths of tergites along dorsal curvature as 87:24:14:11:11. Hind margin of tergite II and exposed parts of rest punctate. Ventral spine slender, longer than hind tibia. Using width of the head as a base the length of mesonotum ratio is 1.2; antenna 2.1; wing 4.2; ovipositor 4.8. Range in length 2.85–3.8 mm. Average of 18 specimens 3.29 mm. It seems to be related to those species of the genus that are reared from root galls. Has a much longer ventral spine than *C. fulva* Weld.

Types.—U.S.N.M. No. 60128: Type and four paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

Hosts.—*Quercus coccinea* and *Quercus falcata*, Spanish oak.

Gall (pl. 16, fig. 7).—A green, smooth, bare bud gall at apex of new growth in May, dropping to ground when mature. An oblate sphaeroid, 4–5 mm. in diameter by 2.5 mm. high, red in center above but without a nipple, not at all hidden by bud scales; when detached without a girdle of hairs at base.

Habitat.—The type is selected from a series that emerged March 21, 1946, from galls collected on Spanish oak at Dyke, 3 miles south of Alexandria, Va., on April 19, 1945. Paratypes are from galls on scarlet oak collected near Vienna, Va., and at East Falls Church, Va.

CALLIRHYTIS FURVA, new species

Female.—Reddish brown with clypeus, antennae, occiput, anterior and lateral line areas, propodeum, tibiae, tarsi, and abdomen in part infuscated; foveae and mesopleuron black. Head from above transverse, cheeks broadened behind eyes; from in front broader than high, malar space one-third eye, not striate, antennae filiform, 14-segmented. Mesoscutum coriaceous, with scattered hairs, parapsidal grooves percurrent. Scutellum disk coriaceous anteriorly, rugose behind, the two basal foveae sharply outlined. Mesopleuron bare and smooth under hind wing, striate anteriorly, pubescent below. Wing pubescent and ciliate, veins brown, areolet small. Claws simple. Carinae on propodeum parallel above, bowed out below, enclosed area broader than high. Abdomen compressed, longer than head plus thorax, gibbous below petiole in side view, knifelike back of tergite II, lengths of tergites along dorsal curvature as 73:20:17:15:10:4; tergite II smooth, exposed parts of rest punctate. Ventral spine shorter than hind metatarsus, tip of ovipositor hooked. Using width of the head as a base, the length of mesonotum ratio is 1.3; antennae 2.3; wing 2.9; ovipositor 4.8. Length 2.15–3.65 mm. Average of 46 specimens 2.91 mm.

Differs from *Callirhytis infuscata* (Ashmead) in being particolored, larger, in having setigerous punctures between parapsidal grooves and a longer ovipositor.

Types.—U.S.N.M. No. 60129: Type and seven paratypes. Paratypes also in A.M.N.H., C.M.N.H., A.N.S.P., C.A.S., and M.C.Z.

Host.—*Quercus palustris.*

Gall (pl. 17, fig. 21).—Small, somewhat globular galls, 3–4 mm. in diameter covered with short, straight, stiff brown hairs, scattered along midrib or main veins on upper side of leaf in the fall and dropping off singly when mature. The hairs do not weather away during winter. Similar to galls of *C. infuscata* (Ashmead) on *Quercus laevis* in Florida.

Habitat.—The types were reared from galls collected on ground at East Falls Church, Va., on October 12, 1943. Adults emerged March 20, 24, 1945, and one was cut out alive on January 2, 1946. Others emerged March 20, 29, 1948, from galls collected September 15, 1946. One was cut out December 1, 1919, from a gall collected at Ironton, Mo., on October 15, 1917. Similar galls have been noted on nine other species of red oaks.

CALLIRHYTIS SUBCOSTATA, new species

Female.—Black; sides of pronotum and legs in part amber. Head coriaceous; from above transverse, cheeks broadened behind eyes, occiput concave; from in front broader than high, malar space one-third eye, striate, antennae filiform, 14-segmented. Mesoscutum broader than long, coriaceous, almost bare, parapsidal grooves smooth, percurrent, median short, anterior lines sunken. Scutellum pubescent, coriaceous back of the smooth narrow pits, rugose peripherally. Mesopleuron bare and polished. Wing pubescent and ciliate, veins brown, areolet reaching one-fifth way to basal, second abscissa of radius arcuate, radial cell 4 times as long as broad. Tarsal claws simple. Abdomen in side view as high as long, lengths of tergites as 50 : 15 : 6 : 5 : 4 : 3, tergites smooth. Ventral spine slender, 8 times as long as broad, shorter than hind metatarsus. Using width of the head as a base, the length of mesonotum ratio is 1.3; antenna 2.1; wing 4.0. Length of four specimens 2.45, 2.25, 2.1 and 2.0 mm.

Types.—U.S.N.M. No. 60130: Type and one paratype. Paratype also in A.M.N.H.

Host.—*Quercus stellata*.

Gall (pl. 16, fig. 10).—Produced on the side of the acorn cup when the latter is about 4 mm. in diameter and dropping off when mature in late May. Green, 2.5–3.0 mm. in diameter, ribbed like a melon with about 16 grooves, pinkish in the grooves.

Habitat.—The types emerged April 1, 1950, from galls collected at East Falls Church, Va., on May 29, 1949. The nutritive layer was then about used up and the galls about ready to drop. This isolated tree had been visited almost every spring for many years but these galls had never been seen there before.

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NOTES ON MAMMALS FROM THE NILE DELTA REGION OF EGYPT

By Henry W. Setzer

From July 12, 1946, to April 9, 1947, Ens. P. Quentin Tomich collected mammals from the Nile Delta while serving with Naval Medical Research Unit No. 3. In addition to the large collection made by Ensign Tomich, Lt. S. M. Wheeler, of the United States Typhus Commission, obtained some specimens in the Cairo area. Earlier, in 1924, Miss Annie M. Alexander obtained a small collection from the Cairo area and from the Fayum. The former two collections are on deposit in the United States National Museum while the latter is on deposit at the Museum of Vertebrate Zoology of the University of California (MVZ) and has been made available for study at this time by Dr. Alden H. Miller.

Since impetus is being given study of the role wild mammals play in diseases of man, a brief diagnosis of the external characters plus comments on taxonomic problems as relating to the commoner mammals from Egypt, as based on the above-mentioned material, will be useful to epidemiologists working in the Nile Delta region.

It will be noted that in certain cases names have been validated from Etienne Geoffroy St.-Hilaire, 1803. The "Catalogue des Mammifères du Muséum National d'Histoire Naturelle" meets all requirements for Linnaean names as established by the International Commission on Zoological Nomenclature. In all instances the descriptions are clearly recognizable. It is believed that the statement of Isidore Geoffroy St.-Hilaire, to the effect that his father never intended the above work for a scientific treatise, should not be accepted, inasmuch as the work is clear, concise, and was published and circulated.

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The Tomich collection is perhaps the largest and most complete single collection known from the Nile Delta region. Even so, several species that have occurred and presumably still occur in that region were not taken by the collectors on whose work this paper is based. For the sake of completeness, references to these have been extracted from the literature.

In addition there are four species which have been taken from the Delta region within historic time but have since been extirpated. They are: Wild sheep, *Ammotragus lervia;* dorcas gazelle, *Gazella dorcas;* saberhorned oryx, *Oryx algazel;* and addax, *Addax nasomaculata.*

Capitalized color terms are from Ridgway, "Color Standards and Color Nomenclature" (1912). All measurements are given in millimeters and all weights in grams.

No comments have been made in regard to habitats or habitat preference, since Tomich hopes to publish an account of the natural history of these animals and their role in epidemiology.

Order INSECTIVORA

Family ERINACEIDAE

HEMIECHINUS AEGYPTIUS (E. Geoffroy St.-Hilaire)

Erinaceus aegyptius E. Geoffroy St.-Hilaire, Catalogue des mammifères du Muséum National d'Histoire Naturelle, p. 69, 1803 (Egypt).

Erinaceus libycus Hemprich and Ehrenberg, Symbolae physicae . . ., dec. 2, footnote, folio k, 1832 (near Alexandria, Egypt).

Specimen examined.—One. Giza Province: Abu Rauwash, Cairo area (MVZ).

Description.—Upper parts, except head and shoulders, covered with short (15 to 20 mm.) spines; base of spines (3 to 5 mm.) brownish, then a buffy band, a brown and a terminal white band of about equal width; hairs of entire head, ears, belly, fore and hind legs Warm Buff. Tail short; ears large; eyes small; fore feet broad and short; hind feet relatively long and narrow.

Measurements.—An adult male from Abu Rauwash, Cairo area, measured: Total length 200; length of tail 20; length of hind foot 35; condylobasal length 45.8; length of palate 24.2; width of rostrum at lacrimal canal 10.4; length of nasals 17.0; least interorbital width 11.0; width across zygomatic arches 26.4.

Remarks.—No ear measurements are available for the one specimen examined, but from the appearance of the dry skin the ears appear as though they would, when laid forward in a fresh specimen, reach to the end of the nose.

Family SORICIDAE

CROCIDURA OLIVIERI (Lesson)

Sorex olivieri LESSON, Manuel de mammalogie . . ., p. 121, 1827 (Saqqara Pyramids, Giza Province, Egypt, as a mummy).

Specimen examined.—One. Giza Province: Talbia.

Description.—Entire upper parts Prout's Brown, shading rather rapidly on the lower sides to dark gray, which covers the entire ventral surface with the exception of a small patch of brownish hairs on the throat; tail of uniform color around and finely covered with long whitish hairs; dorsal surfaces of hands and feet grayish, shading to white on the digits; palms and soles naked. Ears large, nearly naked and with a pronounced fold on the ventral surface; tail more than half the length of head and body. Scent gland, lying immediately anterior to flank and between the dark dorsal and light ventral colors, conspicuous and covered with short whitish hairs.

Measurements.—No external measurements were available but the skull of an adult male from Talbia, Giza Province, measured: Greatest length 29.0; occipitonasal length 26.4; greatest width of braincase 12.5; least interorbital width 5.5; length of palate 12.0; width across M^2 9.3; length of tooth row (incisor to M^3) 12.8; width of rostrum 3.6.

CROCIDURA FLOWERI Dollman

This species is known from Giza and Beltim. It is apparently rare and hard to obtain. It differs from *Crocidura olivieri* in smaller size (head and body 57–71 mm. as opposed to 93–110 mm. in *C. olivieri*). No specimens have been examined.

CROCIDURA RELIGIOSA I. Geoffroy St.-Hilaire

This is the smallest *Crocidura* to be found in the Nile Delta. It apparently is fairly common in the Giza Gardens and in the country near Abu Rauwash. The head and body range from 45 to 55 mm. in length, thus separating this species from the other, larger, species of *Crocidura* known to occur in the same general area. No specimens have been examined.

SUNCUS CRASSICAUDUS Lichtenstein

Despite efforts of several collectors to retake this species in Suez and Suakin, Sudan, it has not been found. It is thought that it is probably the same animal as the *Suncus* found along the coastal region of India and that the individuals known from North Africa are merely fortuitous travelers come ashore from some trading vessel. It may be distinguished, if ever retaken, from specimens of the larger species of *Crocidura* by the presence of two more teeth in the jaws (total of 28 in *Crocidura* and 30 in *Suncus*). No specimens have been examined.

Order CHIROPTERA

Family PTEROPIDAE

ROUSETTUS EGYPTIACUS (E. Geoffroy St.-Hilaire)

Pteropus egyptiacus E. GEOFFROY ST.-HILAIRE, Ann. Mus. Nat. Hist. Natur. Paris, vol. 15, p. 96, 1810; spelling of specific name corrected or emended to *aegyptiacus* in Description de l'Égypte. Histoire naturelle, . . . mammifères . . ., vol. 2, p. 134, pl. 3, fig. 2, 1818 (Great Pyramid of Giza).

Specimens examined.—Seven. Giza Province: Gezira Island, Cairo.

Description.—Upper parts between Drab and Hair Brown, shading to between Light Drab and Drab on the underparts; all hairs uniform in color to base; membranes of wings and uropatagium, in dry specimens, blackish; feet, uropatagium and forearm for half its length, sparsely furred; uropatagium reduced to a semicircular membrane, extending but slightly beyond the rump; tail short, barely exceeding the narrow rim of the uropatagium; hind feet large, strongly clawed; thumb long; index finger with small claw; toes of hind feet with short bristlelike hairs; ears large, somewhat pointed; tragus absent.

Measurements.—Averages and extremes of two males and five females from Gezira Island, Cairo, were, respectively: Total length 152 (148–154), 145.4 (134–162); length of tail 14 (13–15), 13.4 (12–14); length of forearm 91.5 (88–95), 87.8 (85–95); length of hind foot 27.5 (26–29), 27.5 (27–28); length of ear from notch 23 (23), 22.2 (22–23); greatest length of skull 42.7 (41.8–43.6), 40.96 (39.2–42.8); basal length 41.1 (40.2–41.9), 39.2 (37.2–41.5); occipitonasal length 41.0 (40.0–42.0), 39.2 (37.3–41.2); greatest zygomatic breadth 25.85 (24.6–27.1), 24.4 (22.8–26.2); breadth of braincase 16.75 (16.5–17.0), 16.7 (16.3–17.1); canine to M^3 16.8 (16.4–17.2), 16.1 (15.4–16.9); weight of two females 125.0 (109–141).

Remarks.—Anderson (1902) regards *Vespertilio aegyptiacus* Linnaeus, in Hasselquist, 1757, as being the first name to be applied to these bats. This is erroneous since the description in 1757 is not tenable but does state that *V. aegyptiacus* has a tragus, that it is of small domestic mouse size and that the tail is the same length as the body. The name, if it were tenable, would have to be used for *Rhinopoma microphyllum.*

Family RHINOPOMATIDAE

RHINOPOMA MICROPHYLLUM (Brunnich)

Vespertilio microphyllus BRUNNICH, Dyrenes historie og dyre-samlingen udi universitetets natur-theater, vol. 1, p. 50, pl. 6, figs. 1–4, 1782 (Arabia and Egypt).

Specimens examined.—Twelve. Giza Province: Cairo area, Saqqara Pyramids, 11; Pyramids of Giza, 1.

Description.—Upper parts Mouse Gray shading to whitish below; membranes of wing brownish; ears light brownish, nearly naked; face but sparsely covered with fine grayish hairs; tragus free of pinna and spatulate. Tail as long as or longer than head and body, three-fourths of which is completely free of the uropatagium; ears joined by a ridge across the forehead; hind legs long.

Measurements.—Averages and extremes of seven males and four females from Saqqara Pyramids, Cairo area, were, respectively: Total length 139 (127–145), 141 (139–143); length of tail, 59.8 (54–67), 60.5 (58–63); length of forearm 68.4 (66–71), 68 (67–69); length of hind foot 16.5 (16–17), 16.2 (16–17); length of ear from notch 20.2 (19–22), 20.2 (19–21); greatest length of skull 20.6 (20.2–21.3), 20.2 (19.8–20.3); condylobasal length 18.6 (17.7–19.5), 18.1 (17.8–18.4); occipitonasal length 17.6 (16.9–18.4), 17.2 (16.7–17.3); greatest zygomatic width 12.1 (11.5–12.6), 11.95 (11.8–12.1); width of braincase 8.5 (8.2–8.8), 8.5 (8.4–8.6); canine to M^3 7.7 (7.3–8.0), 7.5 (7.4–7.6); weight 19 (14–25), 17.5 (17–19).

Remarks.—As may be noted from the measurements, there is a considerable amount of variation in size of these bats. On the basis of size, Thomas described *Rhinopoma cystops* from Luxor, Egypt.

This species may be distinguished from the smaller *R. cystops* by the longer forearm, darker coloration, and larger skull in all measurements taken.

RHINOPOMA CYSTOPS Thomas

Rhinopoma cystops THOMAS, Ann. Mag. Nat. Hist., ser. 7, vol. 11, p. 496, May 1903 (Luxor, Egypt. Type: Adult female, B. M. No. 2.1.17.2).

Specimens examined.—Sixteen. Giza Province: 8 miles southwest of Cairo, at the Pyramids, 12; Pyramids of Giza, 4.

Description.—Upper parts Light Mouse Gray shading to whitish below; membranes of wing brownish; ears light brownish, nearly naked; face but sparsely covered with fine grayish hairs; tragus free of pinna and spatulate. Tail as long as or longer than head and body, three-fourths of which is completely free of the uropatagium; ears joined by a narrow ridge across the forehead; hind legs long.

Measurements.—Averages and extremes of nine males and three females from 8 miles southwest of Cairo, at the Pyramids, were, respectively: Total length 135 (128–143), 131 (125–138); length of tail 68.0 (64.0–73.0), 65.0 (61.0–70.0); length of forearm 57.5 (55.0–60.0), 55.3 (53.0–57.0); length of hind foot 13.3 (13.0–14.0), 13.3 (13.0–14.0); length of ear from notch 19.0 (18.0–20.0), 19.3 (18.0–21.0); greatest length of skull 18.1 (17.9–18.4), 17.6 (17.2–17.9); condylobasal length 16.1 (15.9–16.2), 15.6 (15.5–15.7); occipitonasal length 14.9 (14.7–15.1), 14.4 (14.2–14.6); greatest zygomatic width 10.4 (10.2–10.7), 10.36 (10.3–10.4); width of braincase 7.6 (7.4–7.7), 7.3 (7.3); canine to M^3 6.3 (6.2–6.4), 6.0 (5.9–6.1).

Remarks.—The specimens listed above vary in some detail from the measurements given by Thomas in his description of the species. These measurements of the Cairo specimens are all somewhat larger but are definitely smaller than those given for the larger species *Rhinopoma microphyllum*. Thanks to C. C. Sanborn, curator of mammals, Chicago Natural History Museum, measurements of specimens of *R. cystops* from various localities throughout the Middle East have been made available to me. A topotypical series of 17 specimens of *R. cystops* are only slightly smaller than the measurements given for the Cairo series above. It is apparent that Flower (1932, p. 385) was in actuality comparing specimens of *R. cystops* from the type locality and from the Cairo area. He thus arrived at the conclusion that *R. cystops* was conspecific with *R. microphyllum*. That this conspecificity is not real is shown by a comparison of the measurements listed for the two species in the present paper.

The two species were found together, by Tonich, at the Pyramids of Giza. Among these specimens the larger, darker *R. microphyllum* is easily differentiated.

Family EMBALLONURIDAE

TAPHOZOUS PERFORATUS E. Geoffroy St.-Hilaire

Taphozous perforatus E. Geoffroy St.-Hilaire, Description de l'Égypte. Histoire naturelle, . . . mammifères . . ., vol. 2, p. 126, 1818 (Egypt).

Specimens examined.—Fifteen. Giza Province: north base of Mount Abu Rauwash.

Description.—Upper parts Hair Brown shading to Drab on the belly and throat; all hairs white at base; face and chin but sparsely haired; wing membranes and uropatagium brownish; radio-ulna lightly furred for one-fourth its length with whitish hairs; tail, for about half its length, free of uropatagium and tipped with a few grayish hairs; ears small and haired at base, rest naked; tragus free from pinna, small and papillate in shape; calcar about three-fourths the length of the tibio-fibula.

Measurements.—Averages and extremes of six males and nine females from the north base of Mt. Abu Rauwash were, respectively: Total length 101 (99–102), 102.3 (101–106); length of tail 22.6 (22–23), 23.4 (22–26); length of forearm 64 (63–65), 64 (63–66); length of hind foot 14 (14), 13.6 (13–15); length of ear from notch 17.3 (17–18), 17.5 (17–18); greatest length of skull 20.3 (20.1–20.6), 20.1 (19.8–20.3); basal length 19.4 (19.0–19.6), 19.2 (18.8–19.6); occipitonasal length 17.3 (17.2–17.3), 17.1 (16.9–17.4); greatest zygomatic breadth 11.7 (11.6–11.8), 11.6 (11.4–11.7); breadth of braincase 9.5 (9.3–9.7), 9.35 (9.0–9.5); canine to M^3 8.5 (8.5), 8.5 (8.4–8.6); weight 24.0 (20–27), 24.2 (16–28).

Remarks.—From the other bats available at this time from the Cairo area, this species may be distinguished by its rather long, pointed ears, the peculiar tuft of hair on the rather short, free tail, by the white basal portion of the hairs, and by the long calcar which supports the posterior edge of the uropatagium.

LIPONYCTERIS NUDIVENTRIS (Cretzschmar)

Taphozous nudiventris Cretzschmar, *in* Rüppell, Atlas zu der Reise im nördlichen Afrika, p. 70, pl. 27b, 1828 (Egypt).

Specimens examined.—Five. Giza Province: Abu Rauwash (MVZ).

Description.—Upper parts Hair Brown shading into Cinnamon-Drab on the lower parts; wings, uropatagium, feet and ears, blackish; muzzle, chin, rump, under surfaces of femora, uropatagium, ears and wing membranes, naked, with the exception of a narrow strip of whitish hairs running the entire length of the membrane on the underside of the forearm. Tragus large and truncate; tail about one-fourth of total length, free from uropatagium for about one-half its length, sparsely covered with long whitish hairs.

Measurements.—Averages and extremes of three males from Abu Rauwash were: Total length 124 (121–126); length of tail 30 (28–32); length of hind foot 18 (18); greatest length of skull 28.2 (26.8–29.6); basal length 21.6 (21.4–21.8); occipitonasal length 24.4 (24.0–24.8); greatest zygomatic breadth 16.2 (15.8–16.7); breadth of braincase 11.2 (11.0–11.3); length of tooth row from M^3 to canine 11.3 (11.0–11.5).

Remarks.—This bat may be told from a close relative living in the same area, *Taphozous perforatus*, by the bare rump, the bare underside of the femora and the much larger skull.

It is interesting that in 1924 Miss Alexander obtained only *Liponycteris nudiventris* at Abu Rauwash and in 1946 Tomich obtained only the closely allied *Taphozous perforatus*.

Family RHINOLOPHIDAE

RHINOLOPHUS ACROTIS Heuglin

Rhinolophus acrotis Heuglin, Nov. Act. Acad. Caesareae Leopoldino Carolinae, Halle, vol. 29, pp. 4, 10, December 1861 (Keren, Eritrea, about lat. 15°45′ N., long. 38°30′ E. Type: Adult male, labeled No. 986, Stuttgart Museum).

Specimens examined.—Four. Giza Province: Pyramids of Giza.

Description.—Upper parts Drab, underparts and base of hairs of upper parts Pale Drab-Gray; membranes of wing and uropatagium blackish brown; ears moderately large, rather acutely pointed, naked except at base and basal half of medial margin, tragus but a small rounded projection; noseleaf large, horseshoe shaped, dorsal projection free and rather small; face and muzzle fully haired; wings and uropatagium naked; tail, enclosed in uropatagium for its entire length, about half the length of the head and body.

Measurements.—Average and extremes of three males from the Pyramids of Giza were: Total length 85.0 (84–87); length of tail 28 (24–33); length of forearm 45.6 (45–47); length of hind foot 10.3 (9–11); length of ear from notch 19.3 (19–20); greatest length of skull 19.6 (19.5–19.7); basal length 15.6 (15.4–15.8); occipitonasal length 14.23 (14.2–14.3); zygomatic breadth 9.7 (9.6–9.8); breadth of braincase 8.7 (8.5–8.9); canine to M^3 7.0 (7.0); weight of two individuals 8.0 (8.0).

Remarks.—The two species of *Rhinolophus* supposedly occurring in the Cairo area are represented here by only *Rhinolophus acrotis*. This species is apparently much the same in size and dorsal coloration as *Rhinolophus euryale*. The two species can be distinguished by the light belly and rounded dorsal projection of the basioccipital in *R. acrotis* and the dark belly and pointed basioccipital in *R. euryale*.

Family HIPPOSIDERIDAE

ASELLIA TRIDENS (E. Geoffroy St.-Hilaire)

Rhinolophus tridens E. Geoffroy St. Hilaire, Ann. Mus. Nat. Hist. Natur., Paris, vol. 20, p. 265, 1813 (Egypt).

Specimens examined.—Fifty. Lisht, Upper Egypt, 32 (alcoholic). El Maabdeh Cave, 1 (alcoholic). Oasis of Kharga, 12 (alcoholic). Henneh, 1. Nile, 4 (alcoholic).

Description.—Since only one conventional skin and skull combination is available, and that old and faded, an exact color diagnosis is not possible. Based on the one specimen, the color appears to have been light brown above and paler below; wing membranes and uropatagium dark brown. Nose with prominent "horseshoe" with trilobed leaf on dorsal surface; ears large, connected by narrow band across top of head; no tragus appears on either dry or alcoholic specimens; tail for three-fourths of its length enclosed in uropatagium, other one-fourth free.

Measurements.—No skin measurements were available, but average and extreme skull measurements from five females from Lisht, Upper Egypt, were: Greatest length 18.0 (17.8–18.2); basal length 16.1 (15.6–16.6); occipitonasal length 14.3 (13.6–14.5); zygomatic breadth 10.0 (9.9–10.1); width of braincase 8.35 (8.3–8.5); canine to M^3 6.5 (6.5).

Remarks.—Presumably this bat is not to be found in the lower Nile region, since all records thus far have come from no farther north than Saqqara, Giza Province.

Family VESPERTILIONIDAE

PIPISTRELLUS KUHLII (Natterer)

Vespertilio kuhlii NATTERER, *in* Kuhl, Die Deutschen Fledermäuse. Ann. Wetterau. Gesel. Hanau, vol. 4, p. 199, 1817 (Trieste).

Specimens examined.—Seven. Giza Province: 5 miles west of Simbillawein, 6; Maadi, 1.

Description.—Hairs of upper parts tipped with Buffy Brown, black at bases; underparts lighter than back; wing membranes, in dry specimens, dark brown, uropatagium lighter and strongly veined; posterior margins of wings and uropatagium bordered with white; ears small, brownish and naked; tragus large; base of uropatagium furred; calcar keeled.

Measurements.—Averages and extremes of five females from 5 miles west of Simbillawein and measurements of one male from the same locality are respectively: Total length, 87.2 (84–92), 89; length of tail 35.8 (32–37), 37; length of forearm 35.5 (35–36), 35; length of hind foot 8.5 (8–9), 8; length of ear from notch 12 (12), 12; greatest length of skull, 13.4 (13.2–13.6), 13.4; basal length 12.9 (12.7–13.2), 13.0; occipitonasal length 11.2 (11.1–11.3), 11.2; zygomatic breadth 8.4 (8.3–8.6), 8.5; breadth of braincase 6.6 (6.5–6.7), 6.6; canine to M^3 4.9 (4.9), 4.9; weight 4.25 (4.0–5.0), 5.0.

Remarks.—The series of bats available for study are remarkably uniform in color, in the whitish margins of the wings and uropatagia, as well as in the measurements of the skull. In one character of the skull, however, there is some variation that is rather peculiar. The first premolar on one side of the upper jaw is missing in two specimens. The tooth is extremely reduced in size in any event and even under high magnification no alveolus can be ascertained where the tooth is supposed to be in those specimens where the tooth is missing.

These two specimens present a condition that appears to tend toward the reduced dentition of *Scotozous*.

EPTESICUS INNESI Lataste

To date, there are two specimens of this bat known. They are the pair, on which the original description was based, taken by Dr. Walter Innes from a house in Cairo about 1885. Since that time no additional specimens have been recorded anywhere else in Egypt, although sought after. This bat may be distinguished from *Pipistrellus kuhlii* by the nearly naked face and the lack of white edging on the wings and uropatagium. No specimens have been examined.

PLECOTUS AURITUS Linnaeus

This bat may be distinguished from other species of bats occurring in the Nile Delta region by means of its large ears. The ears are almost as long as the head and body (head and body 45 mm., ear 35 mm.). It has been recorded from Mena House, Second Pyramid, and Minia. No specimens have been examined.

Family MOLOSSIDAE

NYCTINOMUS TENIOTIS (Rafinesque)

Cephalotes teniotis RAFINESQUE, Precis des découvertes . . . somiologiques. . . ., p. 12, 1814 (Sicily).

Specimen examined.—One. Giza Province: near Cairo (alcoholic).

Remarks.—There was available to me only one specimen, preserved in alcohol. Any color diagnosis would, therefore, be worthless. The ears are large and narrowly joined across the forehead. Approximately half the tail is free of the uropatagium. *Nyctinomus teniotis* is considerably larger than *Nyctinomus aegyptiacus*, at least as far as the skull is concerned, from the specimens available. In addition, *N. aegyptiacus* has but two lower incisors on each side of the lower jaw, while *N. teniotis* has three.

It appears that there has been a great deal of doubt as to the names applied and as to what the respective authors were describing. Geoffroy St.-Hilaire (1818, p. 129), in describing *N. aegyptiacus*, says in regard to the teeth. "Les dents deviennent un excellent indicateur de cette organisation; les incisives sont au nombre de deux en haut, et de quatre en bas: celles-la sont fortes, coniques et contigues, quand les secondes sont tres-petites et comme entassees au devant des canines." It thus appears that the plate and the published description are at variance, since he states in the latter that there are four incisors below and the plate appears to show six. Is it possible that the artist interpreted the cingulum of the canine as an incisor? In De Winton's review of *Nyctinomus* he states there are four incisors in *N. aegyptiacus* and six in *N. teniotis*, yet he raises a question as to what *N. aegyptiacus* actually is in the published work of Anderson on the mammals of Egypt.

From specimens of identified *N. aegyptiacus* from Basutoland, *N. teniotis* is at once distinguished by its larger size and the occurrence of three instead of two incisors in each mandible.

Order LAGOMORPHA

Family LEPORIDAE

LEPUS AEGYPTIUS Desmarest

This is the largest of the hares to be found in Egypt. It has long, thin hind legs; the hind feet are long and narrow; the ears are about 1¾ times the length of the head; and the tail is black bordered with brown. It is known to occur in Giza and Fayum Provinces. No specimens have been examined.

LEPUS ROTHSCHILDI De Winton

A medium-sized hare, characterized by short, stout hind legs; broad, short hind feet; ears about 1½ times the length of the head; and the tail black, edged with white. On these characters it can be distinguished from *L. aegyptius*. It also is known to occur in Giza and Fayum Provinces.

Order RODENTIA

Family CRICETIDAE

GERBILLUS GERBILLUS ANDERSONI De Winton

Gerbillus andersoni De Winton, Ann. Mag. Nat. Hist., ser. 7, vol. 9, p. 45–46 [p. 45], January 1902 (Mandara, east of Alexandria, B.M. No. 92.7.1.5).

Specimens examined.—Eight. Behera Province: one-half mile west of Dikheila Airfield, 4; one-half mile east of Muntazah, 4.

Description.—Upper parts between Ochraceous-Buff and Ochraceous Orange; hairs plumbeous at base with a subterminal band of the above color and a terminal band, very minute, of black. Black hairs freely intermixed with banded hairs, thus presenting a somewhat subdued hue. Color purest on sides, flanks, cheeks, rump, and nose. Entire underparts, muzzle, most of the vibrissae, hind and forelegs, dorsal and ventral surfaces of hands and feet, supraorbital and postauricular spots, white. Tail penicillate, ochraceous above shading to yellowish white beneath; tip on dorsal surface with longish brown hairs. Ears blackish, sparsely covered with fine white hairs inside and ochraceous on the outside. Eye bordered by narrow black ring.

Measurements.—Averages and extremes of two males and two females from one-half mile east of Muntazah were, respectively: Total length 222 (219–224), 215 (207–223); length of tail 122 (120–125), 119 (113–125); length of hind foot 30 (30), 28 (27–29); length of ear from notch 15.5 (15–16), 15.5 (15–16); occipitonasal length 29.1 (28.9–29.3), 28.2 (28.2); length of palate 12.95 (12.8–13.1), 12.5 (12.3–12.7); length of palatal foramina 5.5 (5.4–5.6), 5.2 (5.1–5.3); length of auditory bulla 8.85 (8.8–8.9), 8.75 (8.7–8.8); crown length of upper molar series 3.85 (3.8–3.9), 3.85 (3.8–3.9); least interorbital width 5.9 (5.8–6.0), 5.75 (5.7–5.8).

Remarks.—*Gerbillus gerbillus andersoni* may be distinguished from what is here considered the nominate race from 5 miles northwest of the Pyramids of Giza by darker dorsal color and longer more pigmented ear. Cranially it may be distinguished by longer rostrum, larger teeth, more inflated auditory bullae, longer, narrower braincase, longer incisive foramina, and more robust zygomata.

GERBILLUS GERBILLUS GERBILLUS (Olivier)

Dipus gerbillus Olivier, Bull. Sci. Soc. Philom. Paris, vol. 2, p. 121, 1801 (Giza Province, Egypt).

Specimens examined.—Thirty-seven. Giza Province: Abu Rauwash, 1 (MVZ); 5 miles east of Helipolis, 4; 8 miles east of Helipolis, 8; 5 miles northwest of Pyramids of Giza, 10; Saqqara, 2. Suez Canal Zone: 3 miles northwest of Fayid, 12.

Description.—Upper parts Pinkish Cinnamon, hairs plumbeous at base, subterminal band of above color, minute terminal band of some hairs blackish. Color purest on sides, flanks, cheeks, and nose; entire underparts, muzzle, most of the vibrissae, hind and fore legs, dorsal and ventral surfaces of hind and fore feet, supraorbital and postauricular spots, white. Ears flesh-colored, nearly naked. Eye bordered by narrow black ring.

Measurements.—Averages and extremes of four males and six females from five miles northwest of the Pyramids of Giza were: Total length 222 (216–227), 211 (203–217); length of tail 127 (123–131), 120 (113–128); length of hind foot 30 (29–31), 28.5 (28–29); length of ear from notch 12 (12), 12 (12); occipitonasal length 27.3 (27.2–27.4), 26.6 (26.2–26.8); length of palate 12.2 (12.1–12.5), 12.1 (11.7–12.5); length of palatal foramina 4.5 (4.3–4.6), 4.4 (4.3–4.6); length of auditory bulla 8.7 (8.5–8.8), 8.4 (8.3–8.8); crown length of upper molar series 3.45 (3.4–3.5), 3.5 (3.4–3.6); least interorbital width 5.85 (5.8–5.9), 5.7 (5.4–6.0); weight 21 (19–22), 19 (18–21).

Remarks.—This small gerbil, represented by 37 specimens, is remarkably constant in measurement and color. In external measurements it is about the same as *Gerbillus gerbillus andersoni.* The two subspecies can, however, be readily distinguished by their coloration and the longer darker ear and by the noticeably larger skull of *G. g. gerbillus.*

GERBILLUS HENLEYI MARIAE (Bonhote)

Dipodillus mariae BONHOTE, Proc. Zool. Soc. London, 1909, p. 792, April 8, 1910 (Mokkattam Hills, near Cairo, Egypt).

Specimen examined.—One. Giza Province: 5 miles east of Heliopolis.

Description.—Upper parts Pinkish Cinnamon, but little pure color on sides, all pigmented areas strongly suffused with black; hairs of upper parts plumbeous at base; entire underparts, muzzle, fore and hind legs, upper surface of feet, supraorbital and postauricular spots, and narrow ring at base of tail, white; eye and pinnae of ears bordered by narrow black line; ears light brownish, finely covered with whitish hairs; tail long, bicolored (same as back on dorsal surface proximally, grading to blackish distally), penicillate; soles of hands and feet naked.

Measurements.—A male from 5 miles east of Heliopolis measured: Total length 172; length of tail 98; length of hind foot 21; length of ear from notch 9; occipitonasal length 21.3; length of palate 9.0; length of palatal foramina 3.8; length of auditory bulla 7.5; crown length of upper molar series 2.7; least interorbital width 3.8; weight 10.

GERBILLUS NANUS GARAMANTIS Lataste

Gerbillus garamantis LATASTE, Le Naturaliste, 1881, p. 507 (Sidi-Roueld, Ouargla, Algeria. Female, B. M. No. 19.7.7.1596, and its skull, B. M. No. 19.7.7.1597).

Specimens examined.—Three. Giza Province: 1 mile northeast of Kom Aushim.

Description.—Upper parts Clay Color, purest on sides and cheeks; with a strong admixture of black on the back; hairs plumbeous at base in all pigmented hairs; underparts, forelimbs, dorsal surfaces of fore and hind feet, ventral half of tail, supraorbital and postauricular spots and muzzle, white. Ears brownish, nearly naked, bordered by thin blackish line; dorsal surface of nose, blackish; eye bordered by narrow black line; dorsal surface of tail as back color but with more admixture of black, which increases toward the black penicillate tip. Soles of hands and feet naked.

Measurements.—Averages and extremes of three males from 1 mile northeast of Kom Aushim, were: Total length 195.3 (191–202); length of tail 110 (106–115); length of hind foot 23 (22–24); length of ear from notch 12.3 (12–13); occipitonasal length 25.0 (24.2–25.8); length of palate 11.2 (10.6–11.7); length of palatal foramina 4.5 (4.3–4.7); length of auditory bulla 7.9 (7.7–8.2); crown length of upper molar series 3.43 (3.4–3.5); least interorbital width 4.6 (4.5–4.9); weight 19 (16–22).

Remarks.—It seems hardly logical that this gerbil, in view of the apparent plasticity of the genus, could be the same subspecies in the Nile Valley and in Algeria. However, owing to the lack of comparative material, it is felt best to place the above specimens in this subspecies.

GERBILLUS PYRAMIDUM PYRAMIDUM (E. Geoffroy St.-Hilaire)

Dipus pyramidum E. Geoffroy St.-Hilaire, Catalogue des mammifères du Muséum National d'Histoire Naturelle, p. 202, 1803 (near Pyramids of Giza, Giza Province, Egypt).

Specimens examined.—Twenty-three. Fayum Province: 1 mile northeast of Kom Aushim, 4; Sennuris, 3 (MVZ); The Fayum, 2 (MVZ). Giza Province: Abassia Fever Hospital, Cairo, 2; 3 miles northeast of Mount Abu Rauwash, 5; 1 mile northeast of Mount Abu Rauwash, 3. Nubia: Abu Simbel, 1 (MVZ); Amanda, near El Derr, 3 (MVZ).

Description.—Upper parts Pinkish-Cinnamon, purest on sides, flanks, cheeks and muzzle; hairs of the dorsum plumbeous at base, finely tipped with black, remainder of hairs of body white at base; entire underparts, dorsal and ventral surfaces of fore and hind feet, supraorbital and postauricular spots, lower half of cheeks and muzzle, and posterior ventral half of tail, pure white; tail above, same pure color as on sides, shading in the posterior one-fourth to a penicillate black tip; ears finely covered with hair, margins of pinnae blackish; narrow black ring around eye. Tail not quite so long as head and body; hind feet relatively short.

Measurements.—Two males from 1 mile northeast of Abu Rauwash and two females from 3 miles northeast of Mt. Abu Rauwash measured, respectively: Total length 232, 255; 229, 252; length of tail 128, 135; 129, 139; length of hind foot 34, 35; 33, 33; length of ear from notch 15, 15; 15, 15; occipitonasal length 31.5, 33.0; 29.9, 32.1; length of palate 14.5, 15.0; 13.8, 14.5; length of palatal foramina 5.9, 6.0; 5.3, 6.1; length of auditory bulla 9.0, 9.7; 9.1, 10.0; crown length of upper molar series 4.3, 4.3; 4.2, 4.2; least interorbital width 6.6, 7.2; 6.5, 6.8; weight 37, 56; 32, 42.

Remarks.—In the series of specimens available at this time are what appear to be two color phases. However, when these animals are examined critically, these "phases" are seen to be juvenile and adult pelages. The juvenile pelage is darker than that of the adult and appears to be retained longer than in most species of rodents. With respect to pelage these darker animals appear to fit the description of *Gerbillus pyramidum tarabuli*, and it is possible that this subspecies is based on immature specimens of *G. p. pyramidum*. However, until such time as a concerted effort is made to obtain specimens and to study this genus throughout its range, all of the animals cited above are here referred to *Gerbillus pyramidum pyramidum*.

PACHYUROMYS DUPRASI NATRONENSIS De Winton

Pachyuromys dupresi (sic) *natronensis* De Winton, Nov. Zool., vol. 10, p. 285, August 25, 1903 (Bir Victoria, on the way to Wadi Natron from the Nile Valley, Egypt).

Specimens examined.—Two. Giza Province: West of Abu Rauwash, Cairo area, 1 (MVZ). Egypt: Presumably near Cairo, 1.

Description.—Upper parts Pinkish-Cinnamon, individual hairs plumbeous at base and finely tipped with black; color purest on sides, flanks, cheeks and top of muzzle; hairs of cheeks and muzzle, where pigmented, white at base; entire underparts, lower half of cheeks, thighs, dorsal surfaces of hands and feet, tips of ears, and supraorbital spots, white; all unpigmented hairs white to base; tail finely covered with white hairs. Tail short and heavy, becoming expanded more or less club-shaped distally and in dry specimens flattened dorsoventrally; hind feet small; ears rather large.

Measurements.—An adult female, labeled only Egypt but presumably from near Cairo, measured: Total length 165; length of tail 55; length of hind foot 24; occipitonasal length 35.3; length of palate 15.8; length of palatal foramina 6.4; length of bulla 16.5; crown length of upper molar series 4.4; least interorbital width 6.3.

Remarks.—This animal superficially resembles *Meriones libycus* but may be readily distinguished from that species by the short, club-shaped, fatty tail and by a greater extension of the nasals and much larger, more inflated bullae.

The immature animal lacks the bright color of the adult and appears instead much darker, owing to the greater amount of basal plumbeous and black tipping of the hairs. In the immature skull, the general conformation is the same but minor changes occur as adulthood is reached. The space between the mastoid portions of the auditory bullae is greater in the immature, no supraorbital ridge is developed, the nasals appear to encroach more into the frontals, the interparietal becomes slightly smaller and the wings of the supraoccipital become more defined as the animal ages.

MERIONES LIBYCUS LIBYCUS Lichtenstein

Meriones libycus Lichtenstein, Verzeich. Doubl. Zool. Mus. Berlin, 1823, p. 5, No. 9. (Type locality given by Ellerman (1947, p. 485) as near Alexandria, Egypt.)

Specimens examined.—Thirteen. Giza Province: Suez Road, 8 miles east of Heliopolis, 1; Suez Road, 5 miles east of Heliopolis, 10. Suez Canal Zone: 3 miles northwest of Fayid, 2.

Description.—Animals from near Heliopolis have the upper parts Warm Buff with a moderate admixture of black; color purest on sides, flanks and cheeks; entire ventral surface, dorsal and ventral surfaces of hands and feet, muzzle, postorbital and postauricular spots, white; tail above as color of back, shading to a black penicillate tip; purer color on ventral half of tail. All pigmented hairs plumbeous at base. Eye bordered by narrow black ring. Ears light brownish, finely covered with white hairs inside and out. Part of vibrissae white, part black.

Measurements.—Averages and extremes of three males and seven females from five miles east of Heliopolis, were, respectively: Total length 265.3 (256–274), 242 (226–261); length of tail 126.3 (123–132), 120.0 (108–132); length of hind foot 33.3 (33–34), 31.5 (30–33); ear from notch 18 (17–19), 16 (11–18); occipitonasal length 39.2 (38.6–39.7), 35.9 (34.3–37.6); length of palate 16.7 (16.4–17.1), 16.1 (15.5–16.9); length of palatal foramina 6.6 (6.5–6.7), 6.3 (5.6–6.6); length of auditory bulla 14.8 (14.5–15.6), 13.9 (13.1–14.7); crown length of upper molar series 4.7 (4.6–5.1), 4.5 (4.4–4.7); least interorbital width 6.0 (5.5–6.4), 5.9 (5.4–6.3); weight 85.6 (77–100), 59.0 (50–71).

Remarks.—Ellerman, in March 1941 (p. 533), places the species *Meriones shawii* as a pure synonym of *Meriones libycus libycus*, and on the same page (533) places *Meriones crassus* as a subspecies of *M. libycus*. In May 1947 he elevated *M. crassus* to full specific rank and removed *M. shawii* from synonomy, making it a subspecies of *M. libycus*. In raising *M. crassus* to full specific rank, he considered that nine subspecies properly belonged to this former subspecies. The subspecies he placed under *M. crassus* belonged to the species *M. libycus*, *M. schouesboei*, *M. erythrourus*, *M. ismahelis* and *M. arimalius*. In October 1947 Ellerman and Chaworth-Musters listed eight subspecies of *M. libycus*, nine of *M. crassus*, and placed *M. shawii* as a full species with three subspecies. In none of the papers cited above do Ellerman, or his coauthor, Chaworth-Musters, give any reason for suppressing or resurrecting species or subspecies.

In "A Revision of the Genus *Meriones*," Chaworth-Musters and Ellerman (1947) cite as key characters: Hind claws dark, *M. libycus*, and hind claws pale, *M. crassus*. In addition to the claw character he gives the joined or closely aproximated processes around the suprameatal triangle as a character distinguishing *M. libycus*. In *M. crassus* the processes are not supposed to be closed or closely approximating. In specimen U.S.N.M. No. 282509 one hind foot has dark-colored and the other hind foot has pale-colored claws. Several other specimens in the series show a similar condition but not quite so pronounced. The processes around the suprameatal triangle are also variable. In U.S.N.M. Nos. 282509 and 282512, as examples, one side shows the processes closed or nearly approximating, while the other side is open and not closely approximated.

From this and from the indecision in placing species, it thus appears that the degree of variation being dealt with is certainly not on a specific but rather on a subspecific level.

PSAMMOMYS OBESUS NICOLLI Thomas

Psammomys obesus nicolli Thomas, Ann. Mag. Nat. Hist., ser. 8, vol. 2, p. 92, July 1908 (Damietta, northern Egypt).

Specimens examined.—Two. Damietta.

Description.—Upper parts Mikado Brown, strongly suffused with black; color purest on top of head, rump and on the shoulders; dark dorsal color shading over sides into the lighter Clay Color tipped hairs of the underparts; all hairs of the body plumbeous at base; dorsal surfaces of hands and feet yellowish white; narrow dorsal stripe of tail brownish black, expanding distally to form a brush; underside of tail as pure color of the dorsum; vibrissae mixed black and white; cheeks grayish. Tail shorter than head and body; ears short and rounded, sparsely covered with whitish hairs inside and out; forefeet small, four-toed but vestige of thumb remaining as stout claw. Skull resembling that of *Meriones*, except upper incisors are not grooved; supraorbital ridges pronounced.

Measurements.—No external measurements were available; a subadult male skull from Damietta measured: Length of palate 17.3; length of palatal foramina 5.6; crown length of upper molar series 5.5; least interorbital width 6.5; length of nasals 13.7.

Remarks.—In the absence of comparative material and since these specimens are topotypical they are here referred to *Psammomys obesus nicolli.*

PSAMMOMYS OBESUS OBESUS Cretzschmar

This subspecies of sand rat is known from the Alexandria area and may be distinguished from *P. o. nicolli*, from Damietta, solely on the basis of its lighter color. No specimens have been examined.

Family SPALACIDAE

SPALAX AEGYPTIACUS Nehring

The mole rat is apparently only locally distributed in the region around Mariut and Ramleh near Alexandria. Its presence may be ascertained by small mounds of earth thrown out of its burrow system in much the same manner as the pocket gopher of North America.

Even though these animals show no extenal eye, there is supposed to be a minute, completely organized eye present under the skin. No specimens have been examined.

Family MURIDAE

ARVICANTHIS NILOTICUS (Desmarest)

Arvicola niloticus Desmarest, Mammalogie . . ., pt. 2, p. 281, 1822 (Egypt).

Specimens examined.—Two. Behera Province: Alexandria, 1 Fayum Province: Lake Fayum, 1.

Description.—Dorsal hairs tipped with Ochraceous-Tawny, bases and other hairs of the dorsum throughout their length, blackish; strong admixture of blackish hairs on dorsum, becoming fewer on sides and rump; nose, ring around eyes and hairs of rump Buckthorn Brown; tail bicolored, blackish on dorsal surface, but sparsely haired; ears rather large, rounded and but finely covered with hair; hairs of belly, ventral surfaces of fore and hind legs white-tipped, these hairs with blackish bases; immature pelage darker. Tail about equal to head and body in length; hind feet rather long; thumb expressed as a rudimentary claw only.

Measurements.—One adult male from Lake Fayum, Fayum Province, measured: Total length 321; length of tail 141; length of hind foot 38; length of ear from notch 20; length of palate 16.9; length of palatal foramina 8.5; crown length of upper molar series 6.5; length of nasals 14.6; least interorbital width 5.4; weight 56.0.

Remarks.—On superficial examination these animals are surprisingly like the North American Cricetine genus *Sigmodon*, both externally and cranially. From recorded habitat observations they both occupy much the same ecological niche.

RATTUS NORVEGICUS (Berkenhout)

Mus norvegicus Berkenhout, Outlines of the natural history of Great Britain, vol. 1, p. 5, 1769.

Specimens examined.—Twenty-eight. Behera Province: Alexandria, 7. Suez Canal Zone: Port Said, 6; Ismaila, 8; Suez, 7.

Description.—Upper parts near Verona Brown, no pure color, all hairs on back black tipped and plumbeous based, with the intermediate area of the above color; sides, flanks and shoulders somewhat lighter than dorsal color; throat, underside of forelimbs, entire belly and dorsal surfaces of hands and feet, white; hairs of belly and throat, plumbeous based; tail blackish, but sparsely covered with short whitish hairs, annulations distinct. Ears small; tail equal to or somewhat less than head and body; eyes small. Skull: Temporal ridges parallel or nearly so posteriorly; anterior molar with small accessory cusp on anterior edge.

Measurements.—Averages and extremes of five males and two females from Alexandria, Behera Province, were, respectively: Total length 398 (370–428), 415 (415); length of tail 195.4 (182–207), 196.5 (194–199); length of hind foot 42 (40–46), 40 (39–41); length of ear from notch 19.6 (19–20), 19 (19); greatest length of skull 46.4 (44.5-49.5), 27.2 (47.0–47.4); condylobasal length 41.1 (39.3–43.9), 41.8 (41.5–42.1); length of palate 22.3 (21.5–24.2), 22.2 (21.9–22.6); length of palatal foramina 7.9 (7.4–8.4), 7.85 (7.7–8.0); alveolar length of upper molar series 7.5 (7.4–7.6), 7.4 (7.3–7.5); least interorbital width 6.6 (6.4–7.0), 7.0 (6.9–7.1); length of nasals 17.2 (15.8–19.3), 17.75 (17.5–18.0); greatest zygomatic width 22.7 (21.0–25.4), 22.85 (22.8-22.9).

Remarks.—As may be noted from the measurements, these rats show a great amount of age variation. No effort was made to segregate senile from subadult individuals for the purposes of measurement. It is interesting to note that the averages of individuals from the four areas represented are quite close to one another. There are no observable peculiarities in these introduced rats.

RATTUS RATTUS (Linnaeus)

Mus rattus LINNAEUS, Systema naturae, ed. 10, p. 61, 1758 (Sweden).

Specimens examined.—Thirty-four. Behera Province: Alexandria, 11. Daqahlia Province: 5 miles west of Simbillawein, 4. Giza Province: Cairo, 11; Kafr Taharmes, 2; Talbia, 4. Suez Canal Zone: Fayid, 2.

Description.—Three basic color types of this species occur in the Delta region. They are: (1) Blackish brown upper parts, with plumbeous belly and hands and feet; (2) grizzled brown upper parts with buff-tipped plumbeous-based hairs on the belly and brownish hands and feet, the toes of both hands and feet whitish; (3) dorsal color as in (2) but somewhat lighter, with underparts white, washed with yellowish, the hands and feet whitish. Tail longer than head and body, but finely covered with hair; annulations pronounced; ears large and rounded. Temporal ridges of skull more or less in the form of a lyre, never parallel as in *R. norvegicus;* anterior upper molar without accessory cusp.

Measurements.—Averages and extremes of eight males and nine females, all of the third color type, from several localities were, respectively: Total length 412 (378–432), 406 (355–460); length of tail 227.5 (208–249), 224.2 (194–262); length of hind foot 36.5 (34–38), 35.6 (33–37); length of ear from notch 23.5 (21–25), 24.8 (24–26); greatest length of skull 42.3 (40.6–44.3), 42.7 (39.6–46.6); condylobasal length 36.9 (35.0–37.8), 36.7 (33.4–40.7); length of palate 19.6 (18.6–

20.0), 19.6 (18.1–21.4); length of anterior palatal foramina 7.4 (6.8–8.3), 7.6 (7.0–8.3); alveolar length of upper molar series 6.8 (6.3–7.2), 6.9 (6.5–7.8); least interorbital width 6.1 (5.8–6.3), 6.1 (5.6–6.6); length of nasals 14.9 (13.5–15.8), 15.2 (13.3–17.0).

Remarks.—If one were to recognize subspecies of the commensal rat then the three color types mentioned under description would become (1) *Rattus rattus rattus*, (2) *Rattus rattus alexandrinus* (which may be considered topotypical), and (3) *Rattus rattus frugivorous.* However, since the three basic color types do not appear to segregate out in any given series from any given locality as just these three color types, but show in six of thirty-four specimens intermediate conditions between any two of the three, it is felt that here, as in *Acomys*, is an expression of some genetic factor, called by some a single gene character for melanism. Certainly, one of the criteria for subspecies is a free interbreeding between two or more contiguous kinds which would be expected to produce intermediate types. It is extremely hard, though, to visualize three distinct subspecies occupying the same environmental niche. Flower (1932, p. 409) and many others mention the fact that no habitat differences could be ascertained between the so-called three subspecies. It may be that if these animals were to be found ferally, one or the other of the three types would segregate and be completely recognizable. It is worthy of mention, though, that the four wild-caught animals from 5 miles west of Simbillawein show all three color types plus one that is intermediate between types two and three.

It is felt that, since there appears to be no segregation, so far as is known, it is best to ignore the subspecific names for the three abovementioned rats until such time as these names can be shown to be valid.

MUS MUSCULUS Linnaeus

Mus musculus LINNAEUS, Systema naturae, ed. 10, p. 62, 1758 (Upsala, Sweden).

Specimens examined.—Eighteen. Behera Province: Alexandria, 6; ½ mile west of Dikheila Airfield, 1; Heliopolis, 1; Maadi, 1. Daqahlia Province: 5 miles west of Simbillawein, 3. Giza Province: Kafr Taharmes, 1; Kuniessa, 1; Talbia, 1. Suez Canal Zone: Port Said, 1; Suez, 2.

Description.—Three color phases are present in the small series from Egypt. They are: (1) Pallid Neutral Gray rather strongly intermixed with black; (2) Cinnamon-Brown without so much black intermixed; and (3) Mummy Brown, strongly suffused with black. In all color phases the hands and feet are white; the bellies in the first two phases are white; in the first the hairs are white to the bases, in the second the hairs are plumbeous at the base; in the third phase the belly is buffy, with the hairs plumbeous at the base. In all three phases the tail is more or less bicolored and the dark dorsal stripe corresponds to the back color. In the first phase, the ears are pale, resembling the dorsal color; in the second and third phases the ears are dark, as is the dorsal color. The skulls show no one feature that might tend to segregate any of the above color phases as subspecies. They are all regarded as *Mus musculus.*

Measurements.—Averages and extremes of two males and four females from Alexandria, Behera Province, were respectively: Total length 157 (156–158), 166.2 (157–173); length of tail 78 (78), 78.7 (74–82); length of hind foot 17 (17), 17.3 (17–18); length of ear from notch 13 (13), 13.3 (13–14); greatest length of skull 21.7 (21.2–22.2), 21.7 (21.0–22.4); occipitonasal length 21.2 (20.8–21.6), 21.0 (20.5–21.7); length of palate 10.05 (9.8–10.3), 9.9 (9.6–10.4); length of palatal foramina 5.2 (5.2), 4.7 (4.5–5.0); crown length of upper molar series 3.15 (3.1–3.2), 3.2 (3.0–3.4); length of nasals 7.9 (7.8–8.0), 7.8 (7.5–8.3); least interorbital width 3.55 (3.5–3.6), 3.5 (3.5); greatest zygomatic width 11.05 (11.0–11.1), 10.9 (10.6–11.1).

Remarks.—The names applied to the house mice of the Delta region appear to be in as much confusion as are the names applied to *Acomys* and to *Rattus.* It is not thought wise to try to solve the nomenclatural mix-up on so few specimens. The material available is extremely heterogeneous and shows all the types that have been recognized from the Nile Delta and southward.

Mus musculus gentilis, which occurs in a feral condition farther south along the Nile, appears to be the name most applicable to the largest numbers of animals from the Alexandria-Cairo-Suez area. There are, however, individuals that would appear to belong to the north European stock of *Mus musculus musculus* and *Mus musculus domesticus.* In addition, there are specimens of a light color phase from Alexandria that do not correspond to any of the named kinds of *Mus musculus* supposed to be in this area. Cranially, all the specimens examined appear to be of one subspecies.

It is thought best, at this time, merely to refer the house mice of northern Egypt to the species *Mus musculus.*

ACOMYS CAHIRINUS (E. Geoffroy St.-Hilaire)

Mus cahirinus E. Geoffroy St.-Hilaire, Catalogue des mammifères du Muséum National d'Histoire Naturelle, p. 195, 1803 (Cairo, Egypt).

Specimens examined.—Thirty. Behera Province: Alexandria, 8. Daqahlia Province: 5 miles west of Simbillawein, 1. Giza Province: Cairo, Abassia Fever Hospital, 5; Abu Rauwash, 2 (MVZ); Cairo, 4; Kafr Taharmes, 1; Saket Meki, 2. Suez Canal Zone: Suez, 6. Nubia: Abu Simbel, 1 (MVZ).

Description.—Upper parts from between Ochraceous-Orange and Ochraceous-Tawny to deep slate gray; belly yellowish to light slate gray. Color on body nowhere pure; in light phase strongly suffused with black-tipped hairs; in dark phase uniformly slaty. Hands, feet and tail of both color phases as belly color. Tail equal to head and body in length, strongly annulated and with small bristlelike hairs. Pelage coarse but becoming spinose between the ears and spines increasing in size and number over the rump. Ears large, rounded, and but sparsely covered with fine yellowish hairs.

Measurements.—Averages and extremes of two males and six females from Alexandria, Behera Province, Egypt, were, respectively: Total length 209.5 (198–221), 218.6 (208–225); length of tail 113.6 (108–121), 106.6 (97–112); length of hind foot 19 (18–20), 18 (18); length of ear from notch 18.5 (17–20), 18 (17–20); greatest length of skull 28.05 (27.0–29.1), 28.28 (27.9–28.9); condylobasal length 23.85 (22.7–25.0), 24.0 (23.4–24.8); length of palate 14.55 (13.5–15.6), 14.32 (13.7–15.0); alveolar length of upper molar series 4.3 (4.2–4.4), 4.4 (4.4); length of palatal foramina 6.3 (6.2–6.4), 6.2 (5.8–6.6); least interorbital width 4.8 (4.8), 4.7 (4.6–4.8); length of nasals 10.3 (9.9–10.7), 10.6 (10.2–11.1).

Remarks.—These small spiny mice have, at various times, been designated by various specific or subspecific names. Most of these names have, apparently, been based on differences in color. From the specimens now at hand, it appears that the only name strictly applicable is *Acomys cahirinus*. E. Geoffroy St.-Hilaire evidently had before him a specimen of the light-colored phase when he described this animal, and subsequent authors must have had representatives of the other more melanistic types. In all, the two basic types of pelage color are light above and light below and dark above and dark below. From these two phases all possible gradations can be demonstrated by specimens from Abassia Fever Hospital, in Cario, or from Alexandria.

From all appearances this peculiarity of color is nothing more than the expression of melanism. In many ways these small mice recall the variation of pelage found in *Rattus rattus* and considered by many to be subspecies.

Family DIPODIDAE

JACULUS JACULUS JACULUS (Linnaeus)

Mus jaculus LINNAEUS, Systema naturae, ed. 10, p. 63, 1758 (type locality given by Linnaeus as "In Arabia, Calmukia," emended by Allen (1939, p. 423) as Pyramids of Giza).

Specimens examined.—Twenty-two. Giza Province: Abu Rauwash, 5 (MVZ); Suez Road, 5 miles east of Heliopolis, 4; 1 mile northeast of Kom Aushim, 1; Alexandria Road, 5 miles northwest of Pyramids of Giza, 6. Suez Canal Zone: 3 miles northwest of Fayid, 6.

Description.—Upper parts between Vinaceous-Cinnamon and Pinkish-Cinnamon; hairs plumbeous at base, grading into above color and finely tipped with black; sides and flanks with hairs white to base with a slight admixture of the above colors; entire ventral surface, anterior and ventral surface of thighs, forelegs, hip stripe, postauricular and postorbital spots, muzzle, cheeks, tip and ventral half of tail, white. Ears about as dorsal coloration, sparsely covered with fine white hairs. Eye bordered by narrow black ring. Tail above, for proximal two-thirds, as dorsal color; other one-third divided subequally by proximal black ring, incomplete ventrally, and a distal white tip.

Measurements.—Averages and extremes of two males and four females from 5 miles northwest of the Pyramids of Giza were, respectively: Total length 293 (292–294), 294.5 (284–301); length of tail 179 (176–182), 182 (176–188); length of hind foot 62 (60–64), 61.7 (60–65); length of ear from notch 19 (19), 19.2 (19–20); occipitonasal length 30.0 (30.0), 30.2 (29.6–30.7); greatest length of skull 33.1 (33.1), 33.1 (32.6–33.9); length of nasals 10.65 (10.4–10.9), 10.9 (10.4–11.4); least interorbital width 11.9 (11.8–12.0), 12.1 (11.5–12.7); length of palate 15.6 (15.6), 15.6 (15.2–15.9); length of palatal foramina 4.35 (4.3–4.4), 4.25 (4.2–4.3); length of bulla 14.0 (14.0), 13.8 (13.5–14.2); width of skull across bullae 22.6 (22.6), 21.3 (21.1–21.5); width across maxillary arches 22.5 (22.3–22.7), 22.0 (21.3–22.5); crown length of upper molar series 4.5 (4.4–4.6), 4.75 (4.7–4.8); weight 50.0 (48.0–52.0), 53.0 (51.0–56.0).

Remarks.—If the animals from 5 miles northwest of the Pyramids of Giza are considered topotypical, a slight difference is noted in the size of the crania and the length of the hind foot from those animals from 3 miles northwest of Fayid and 5 miles east of Heliopolis. The pelage in the animals from the latter two localities has less reddish and more black admixture, thus presenting a somewhat darker tone.

Order CARNIVORA

Family CANIDAE

CANIS LUPASTER Hemprich and Ehrenberg

Apparently the jackal is not uncommon. The status of the name applied to the jackal of this region is in some doubt. It can be distinguished from the domestic dog by its shorter muzzle, wider face, and brighter coloration. No specimens have been examined.

VULPES VULPES NILOTICA (E. Geoffroy St.-Hilaire)

Canis niloticus E. GEOFFROY ST.-HILAIRE, Catalogue des mammifères du Muséum National d'Histoire Naturelle, p. 134, 1803 (Egypt).

Vulpes vulpes aegyptiaca, ANDERSON and DE WINTON, Zoology of Egypt, Mammalia . . ., p. 227, pl. 32, 1902 (Egypt).

Specimen examined.—One. Daqahlia Province: 5 miles west of Simbillawein.

Description.—Dorsal stripe, beginning between shoulders and continuing onto dorsal one-fourth of tail, Sanford's Brown, strongly intermixed with black hairs; all except black hairs with a subapical band of yellowish white and wide basal band of plumbeous; Sanford's Brown purest on cheeks, around eyes, inside and back of fore limbs and back of hind limbs; throat, chest, and belly to peneal region smoky gray with some admixture of whitish hairs; inside of ears, lower part of cheeks and continuing toward and beyond angle of jaws, lateral and ventral surfaces of base and distal half of tail, white; white hairs of distal half of tail sparsely tipped with black; sides, shoulders, and flanks, grayish; areas on side of neck, behind shoulder and groin, yellowish white; anterior face of foreleg with blackish brown, white and black longitudinal stripes; anterior face of thigh and continuing onto dorsal surface of hind foot with yellowish-white stripe; posterior dorsal one-half of ears black.

Measurements.—An adult male from 5 miles west of Simbillawein measured: Total length 1,052; length of tail 416; length of hind foot 157; length of ear from notch 101; greatest length of skull 149.6; occipitonasal length 130.3; condylobasal length 136.2; length of palate 73.1; width across M^1 40.7; greatest width of braincase 46.3; least interorbital width (behind supraorbital processes) 20.0; length of nasals 40.5; width of rostrum 25.1.

Family MUSTELIDAE

MUSTELA NIVALIS SUBPALMATA Hemprich and Ehrenberg

Mustelae subpalmatae HEMPRICH and EHRENBERG, Symbolae physicae . . ., dec. 2, folio k, p. 2, September 1832 (in houses of Cairo and Alexandria, Egypt).

Specimens examined.—Six. Daqahlia Province: 5 miles west of Simbillawein, 2. Behera Province: Alexandria, 1. Giza Province: Kafr Taharmes, 1; Kuniessa, 1; Saket Meki, 1.

Description.—All dorsal coloration, including hands, feet, ears, and tail all around, between Brussels Brown and Raw Umber; chin, throat, chest, and most of belly, white or a yellowish white; brown of dorsal coloration extending onto belly, sometimes continuous across belly but more frequently merely spotted; tail with faint suggestion of black tip. Ears and eyes small; tail about half as long as head and body.

Measurements.—An adult male from Kuniessa, Giza Province, and an adult female from 5 miles west of Simbillawein measured, respectively: Total length 381, 330; length of tail 120, 92; length of hind foot 47, 39; length of ear from notch —, 17; basilar length 46.7, 42.1; canine to M^3 13.0, 12.0; breadth of rostrum across lacrimals 13.7, 11.2; least interorbital width 8.5, 7.4; mastoid breadth 25.0, 20.9; zygomatic breadth 27.7, 22.7.

Remarks.—Apparently, in Egypt, this animal is more an inhabitant of houses than it is of the countryside. All the specimens studied were caught in buildings during rat-control programs.

POECILICTIS LIBYCA (Hemprich and Ehrenberg)

Mustela libyca HEMPRICH and EHRENBERG, Symbolae physicae . . ., dec. 2, folio k, p. 6, 1832 (Egypt).

Specimen examined.—One. Giza Province: Cairo Area, Abu Rauwash (MVZ).

Description.—Colors of this animal are white and blackish brown. White distributed on the body as small mystacial patches; a narrow white ring occurs between the eyes and ears, then turning ventrad around the point of the jaw and meeting on the bottom of the throat; tip of ears white; base of a more or less lyre-shaped band of white begins in back of the ears and behind the forehead stripe, the band running posteriorly and somewhat lateroventrad to cross the flanks and continue to the base of the tail; inside this large lyre is a smaller lyre-shaped band of white, which becomes closed at the base of the tail; inside the loop of the median lyre is a more or less diamond-shaped patch completely encircled by black and with a small black spot in the center. The outermost lyre-shaped band continues onto the dorsal surface of the tail to the tip and for approximately one-half the ventral surface. The posterior ventral half of the tail has black-tipped white hairs. Entire ventral surface covered with blackish brown hairs. Ears small and rounded; soles of hands and feet, with the exception of the pads, haired; eyes small.

Measurements.—An adult male from Abu Rauwash measured: Total length 388; length of tail 158; length of hind foot 43; condylobasal length 53.6; length of palate 25.1; M^1 to canine 18.1; breadth across P^4 18.5; width of zygomatic arches 33.5; width of rostrum 11.4; width of cranial constriction behind postorbital processes 11.5; width across bullae 31.1.

Remarks.—This small mustelid is remarkably like the North American genus *Spilogale* in its markings.

Family VIVERRIDAE

HERPESTES ICHNEUMON (Linnaeus)

Viverra ichneumon Linnaeus, Systema naturae, ed. 10, p. 43, 1758 (Egypt).

Specimen examined.—One. Daqahlia Province: 5 miles west of Simbillawein.

Description.—Color: Under fur shading from Isabella Color on neck and shoulders to Cinnamon-Rufous on rump, thighs, and base of tail. Guard hairs long (about 65 mm.) and eight-banded, with alternating white and black bands; tips of guard hairs brownish instead of black as rest of bands; face, chin, muzzle, and dorsal surfaces of hands and feet, blackish; palms and soles naked; belly sparsely haired. Entire animal, owing to banded hairs, presents a grizzled appearance. Ears small and rounded; tail not quite so long as head and body, and owing to the banded hairs appears to be ringed; tail more or less tufted at tip.

Measurements.—One male from 5 miles west of Simbillawein measured: Total length 990; length of tail 453; length of hind foot 104; length of ear from notch 37; condylobasal length 104.6; zygomatic width 53.7; postorbital width 17.5; interorbital width 18.5; maxillary width 32.4.

Family FELIDAE

FELIS CHAUS Schreber

This cat is apparently to be found throughout the Delta region, usually in low marshy places. It may be distinguished from the feral *Felis catus* by its shorter tail (less than one-half the head and body length); by its larger, black-tipped ears; and by its reddish feet. It is apparently not uncommon. No specimens have been examined.

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THE SIPUNCULID WORMS OF CALIFORNIA AND BAJA CALIFORNIA

By Walter Kenrick Fisher

Sipunculid is the name informally bestowed on members of a small phylum of marine wormlike animals of world-wide distribution—the Sipunculoidea.[1] These creatures live from the intertidal zone to oceanic depths, in tubular excavations in mud and sand, in clefts of rocks, in masses of coral, in borrowed shells, under rocks, in holdfasts of kelp, or in almost any protected situation that affords access to reasonably clear water and food. They are not found in shifting sand or mud, since in such habitats they are likely to be buried or else deprived of protection. Their food is finely divided detritus selected or trapped by the ciliated tentacles, or bottom material actively swallowed. This latter material is not necessarily finely divided. It is sometimes coarse, including the miscellaneous small fragments of the hard parts of Foraminifera, corals, bryozoans, annelids, mollusks, echinoderms, and crustaceans, often very abundant, especially in calcareous sands.

[1] Adam Sedgwick, in his "Students' Textbook of Zoology" (vol. 1, p. 594, 1898), first accorded this group phyletic rank. It had long occupied in the Annelida the position of a poor relation, as one of the orders of the class Gephyrea, in which Quatrefages also placed the Echiuroidea and Priapuloidea. "Gephyrea" either as a class or a phylum is an unnatural and unsatisfactory association, but one which has been singularly viable. It was used by Shipley (1910) in the "Cambridge Natural History" and by Borradaile and Potts (1932) in "The Invertebrata"—to mention two instances. For a good general account, consult Grace E. Pickford, "Sipunculida," Encyclopedia Brittanica, 1947; J. W. Spengel, Handworterbuch der Naturwissenschaften, vol. 9, pp. 97–106, 1913; Yves Delage and Edgard Hérouard, Traité de Zoologie Concrète, vol. 5, pp. 12–26, 1897; F. Baltzer, "Sipunculida"; Kükenthal and Krumbach's "Handbuch der Zoologie," vol. 2, pt. 9, pp. 15–61, 1931.

The region covered by this report centers in the coastal waters of California and Baja California but includes what little is known of the fauna north to the Alaskan Peninsula.

The material has been accumulating over a considerable period of years and includes specimens dredged by the United States Fisheries steamer *Albatross* in 1904. Unfortunately only about a third of the *Albatross* collection was in a condition suitable for study when it became available in 1946. The Harriman Alaska Expedition (1899), through Dr. Wesley R. Coe and the late Dr. William E. Ritter, made a small but important contribution. By far the largest collections were contributed by Prof. G. E. MacGinitie, Dr. W. F. Thompson, and the late Edward F. Ricketts. I am also indebted to the United States National Museum and the Museum of Comparative Zoology for the loan of material, to Dr. J. H. Gerould for the loan of reprints, and to Dr. Elisabeth Deichmann and Dr. Elise Wesenberg-Lund for extracts from the important works of Leuckart and Diesing.

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As compared with Japan the sipunculid fauna of the west coast of North America is meager. *Phascolosoma agassizii* is the dominant intertidal species from Kodiak, Alaska, to Point Conception, Calif. Its range extends to northern Baja California. *Ph. puntarenae* is its equivalent from Cape San Lucas to Panama. *Dendrostomum pyroides* occurs from Coos Bay, Oreg., to northern Baja California, while *D. dyscritum* has been taken between Point Conception and the northern boundary of California. *D. zostericolum* has been found from Point Conception to Ensenada, Baja California. *D. perimeces*, a consistent inhabitant of sandy mud, probably colonizes estuaries and sloughs from an off-shore, shallow-water population. It has been taken between Bodega Head and Venice, Calif. *D. hexadactylum*, which resembles *pyroides*, has been found only in 10 to 20 fathoms, in Monterey Bay. It was described from Japanese waters. The conspicuously large *Siphonosoma ingens* is a southern California species, extending north to Monterey Bay. *Sipunculus nudus* is an off-shore cosmopolite, which finds its way into estuaries of southern California and into the intertidal zone of Baja California and the Mexican coast. The genus *Golfingia* (formerly *Phascolosoma*) is a negligible element in the shore fauna of California, only three inconspicuous species having been found: *G. margaritacea californiensis*, *G. hespera*, and *G. macginitiei*, all rare or very local in occurrence.

Only two sipunculids are known from Alaska: *Golfingia margaritacea* (Sitka, Kilisnoo, Dutch Harbor, Point Barrow) and *Phascolosoma agassizii* (Cape Fox, Prince William Sound, Kodiak). Undoubtedly *G. vulgaris* occurs in shallow water.

Phascolosoma agassizii has been taken from intertidal stations on Vancouver Island and the Queen Charlotte Islands, British Columbia, and *G. margaritacea* has been taken at Vancouver Island.

Washington has four species, all from Puget Sound and vicinity: *Golfingia vulgaris*, *G. margaritacea*, *G. pugettensis*, and *Phascolosoma agassizii.*

Two species are known from Oregon (Coos Bay): *Dendrostomum pyroides* and *Phascolosoma agassizii.*

With this unimpressive showing, I need hardly emphasize that this paper is not a definitive treatment of the fauna. While it is improbable that many new intertidal forms will come to light, it is equally probable that the list of shallow-water and deep-sea species is very far from complete.

In this paper I have used *Golfingia* Lankester in place of *Phascolosoma* authors and have replaced *Physcosoma* Selenka with *Phascolosoma* Leuckart in order to conform to accepted rules of nomenclature. For the same reason I have employed *Dendrostomum* Grube, the original spelling, instead of *Dendrostoma,* a later emendation by Keferstein.

KEY TO THE GENERA OF SIPUNCULOIDEA

a^1. No horny or calcareous shield or cone at anterior end of trunk, although enlarged horny papillae and tubercles sometimes present in anal region.

b^1. Tentacles surround mouth; tentacles few or many, simple or branched; nuchal organ, when present, dorsal to tentacles.

c^1. Longitudinal muscle layer of wall of trunk divided into separate bundles.

d^1. Skin of usually thick body wall provided with longitudinal coelomic canals or with independent coelomic pouches longitudinally arranged.

e^1. Integumental coelomic spaces are longitudinal canals under cuticle; 4 retractors; intestinal coil with a long, anteriorly anchored loop; introvert with subtriangular scalelike papillae directed posteriorly. **Sipunculus** Linnaeus, 1766 (p. 375)

e^2. Integumental coelomic spaces are in form of independent, usually irregular pockets arranged in longiseries; no accessory anterior loop in intestinal coil.

f^1. Scalelike papillae on introvert; anterior to the 4 retractors are 2 small protractors arising in front of anus; irregular integumental coelomic spaces independent in each quadrilateral division of skin and sometimes with several long papillae; spindle muscle arises on rectum ---------- **Xenosiphon** Fisher, 1947 (p. 377)

*f*². No scalelike papillae on introvert but rings of simple tiny spines; 2 retractors; skin strongly marked in rectangles; spindle muscle arises by 2 roots from body wall behind anus, and a third root is attached to esophagus; nuchal organ prominent; tentacular divisions of oral disk 8, the 2 ventral bifid; no Polian villi.
Siphonomecus Fisher, 1947

*f*³. No scalelike papillae on introvert; skin not divided into rectangles by furrows; hooks or spinelets present or absent on introvert; 4 retractors; spindle muscle arises by 3 roots, a median in front of anus and 2 laterals behind anus; some species with incomplete transverse coelomic dissepiments; contractile vessel usually with Polian villi--------**Siphonosoma**[2] Spengel, 1912 (p. 380)

*d*². Body wall thin without coelomic canals or pockets.

*e*¹. Nephridia with prominent anterior lobe; spindle muscle with one root attached to body wall in front of anus and not anchored posteriorly; no Polian villi; tentacles very small, numerous, filiform; type with tiny complex hooks on introvert.
Siphonides, new genus (p. 386)

*e*². Nephridia not bilobed; contractile vessel with lateral pouches but no villi; no introvert hooks in adults.
Golfingia (subgenus **Phascolopsis** Fisher, 1950) (p. 393)

*c*². Longitudinal muscle layer of body wall forming a continuous layer, without separate bands (except *Phascolopsis* in *Golfingia*).

*d*¹. Anus in anterior part of trunk behind introvert.

*e*¹. Two nephridia; intestine forms a close spiral surrounding spindle muscle; 2 or 4 retractor muscles.

*f*¹. Tentacles relatively small, digitiform to filiform, few to many, in which case they are arranged in longitudinal double series radiating from circumoral disk.
Golfingia[3] Lankester, 1885 (p. 388)

*f*². Tentacles large, bushy, 4 to 8; retractors 2, rarely 4; contractile vessel with accessory tubules, usually conspicuously long, filiform--------------**Dendrostomum**[4] Grube, 1859 (p. 404)

*e*². Only 1 nephridium, fixed by muscular threads; intestine not in close spiral but in loops extending forward and backward and held to body by several strands of muscle fiber; 1 to 3 retractor muscles; body often spirally twisted in adaptation to life in empty gastropod and scaphopod shells; single circle of tentacles.
Phascolion[5] Théel, 1875

*d*². Anus on introvert more or less in neighborhood of mouth; one retractor muscle, attached to posterior end of trunk; 1 nephridium; esophagus forms a few coils and passes into a short somewhat irregular spiral.
Onchnesoma Koren and Danielssen, 1875

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[2] The coelomic pouches have not been verified for several small species and may be rudimentary or absent if body wall is thin, as in *Siphonides*. Small species with head retracted sometimes resemble *Golfingia*.

[3] *Phascolosoma* auct., nec Leuckart, 1828.

[4] *Dendrostoma* Keferstein, 1865.

[5] *Cryptosomum* Quatrefages, 1866.

*b*². Tentacles few to very numerous, arranged in a circle (interrupted dorsally), enclosing nuchal organ and situated dorsal to mouth; longitudinal muscle layer of trunk divided into separate anastomosing bundles; retractors 4, rarely 2; skin covered with papilliform glands which sometimes become tubercular in anal region and at posterior extremity.
Phascolosoma [6] Leuckart, 1828 (p. 422)

*a*². A specialized shield or cone present at anterior end of trunk.

*b*¹. A horny or calcareous shieldlike structure present at both ends of trunk; introvert arises on ventral side of anterior shield; longitudinal muscle layer continuous, or divided into bundles___**Aspidosiphon** Diesing, 1851

*b*². A hard, calcareous, cone-shaped appendage present at anterior end of trunk ventral to which is introvert; no posterior shield.
Lithacrosiphon Shipley, 1902

*b*³. A round caplike structure made up of calcareous plates present at anterior end of trunk, from center of which the introvert is extruded; no posterior shield____________________________________**Cloeosiphon** Grube, 1868

Genus SIPUNCULUS Linnaeus

Sipunculus LINNAEUS, 1766, p. 1,078. (Type, *S. nudus* Linnaeus.)

Diagnosis.—Usually large species with long cylindrical body and short, sharply differentiated introvert covered with squamiform papillae. Trunk generally thick walled, and longitudinal and circular muscle layers divided into regular fascicles. Skin divided into rectangular areas by longitudinal and circular furrows. Posterior end of body rounded or bluntly pointed and sometimes marked off from main trunk by a limiting ring fold of skin. A flat tentacular fold surrounds oral disk and from its margin tentacles of varying complexity develop. No hooks on introvert or papillae on the trunk.

Description.—The longitudinal muscle bundles rarely anastomose. Characteristic of the genus are longitudinal integumentary canals corresponding to the intervals between the muscle bundles and communicating with the coelom by slits between the regular circular fascicles of muscles that are external to the longitudinal. The canals contain coelomic fluid and anything floating in it. Retractor muscles four, separated to head; nephridia two; spindle muscle present or absent; a dorsal and a ventral contractile vessel without appendages; especially characteristic is an accessory intestinal spiral (pl. 18, fig. 1, A) between the end of esophagus and the beginning of the true spire, and coiled in the latter. Esophagus and intestine anchored by very numerous fixing muscles. "A median-dorsal unpaired epithelial tube opens upon the surface of the head immediately behind the tentacular fold, and leads backward to a cerebral sense organ anterior

[6] The genus erroneously called *Physcosoma* Selenka, 1897.

and ventral to the brain. The esophageal connectives do not surround the attachments of the retractor muscles to the head, as in most sipunculids, but lie behind and beneath these attachments" (Gerould, 1913, p. 427). The brain is conspicuous. On its front is a conspicuous cerebral organ or frons, sometimes elaborately lobed (Fisher, 1947, pl. 10, fig. 2; pl. 11, fig. 3). The ventral nerve cord is not attached anteriorly by a mesentery to the wall of the introvert, as in *Siphonosoma*. It is supported on each side by a strong paraneural muscle originating from the first, or first and second, muscle bundles just posterior to beginning of introvert.

Remarks.—Plate 18, figure 1, shows the accessory intestinal spiral *A* dissociated from the regular spiral *B*. This is easily accomplished by clipping the fixing muscles that hold it in place. I have figured (Fisher, 1947, pls. 10, 11) this extra spiral in situ in *Sipunculus polymyotus* and S. *galapagensis*, where the bends *X* and *Y* are indicated. The details of the fixing muscles are so different in these two species as to suggest that they may be of value in classification.

The accessory spiral is not present in *Xenosiphon* or in *Siphonosoma*.

SIPUNCULUS NUDUS Linnaeus

PLATE 18

Sipunculus nudus LINNAEUS, 1766, p. 1,078.

Remarks.—This is perhaps the best known and certainly one of the most widely distributed species of sipunculids—a truly eurythermal type. On the west coast of America it occurs from Monterey Bay, Calif., to Panama. It is found on the coast of Brazil, in the West Indies, and north to Beaufort, N. C. In Europe it inhabits the North Sea, English Channel, and the Mediterranean and Adriatic Seas. It is reported from the Red Sea, Indian Ocean, East Indies, China, Japan, along the western part of the Pacific (Yap, Loyalty Islands), and South Australia.[7]

The specimens recorded below have 30 to 33 muscle bundles. The ventral retractor muscles arise from longitudinal muscles 1–7, 1–6, or 2–5 (Ensenada); the dorsal retractors arise from 9–15, 10–14, 10–15, 11–16. A large specimen from southern California is 190 mm. long, but others are considerably smaller, circa 130 mm. The longest specimen is 290 mm. and was washed ashore at Pacific Grove, Calif., during a heavy surf.

The species has not been found at Monterey Bay in intertidal situations, even at Elkhorn Slough, which has been rather thoroughly explored by Prof. G. E. MacGinitie and others; but it occurs in subtidal situations, since many were washed ashore during a period of spring tides and heavy surf. It seems probable that Newport Bay

[7] A specimen sent me by S. J. Edmonds from Port Willunga, south of Adelaide, South Australia, is superficially like *S. nudus* but belongs to another, probably new, species.

and Anaheim Slough, in southern California, were colonized by an off-shore population, as was the Estero de Punta Banda, south of Ensenada. Professor MacGinitie took it also at a lagoon, Miramar Beach, Guaymas, Mexico, while Ricketts established a record at La Paz.

Specimens examined.—Thirty-five, as follows:

Guaymas, Mexico, lagoon at Miramar Beach, Feb. 9, 1948, G. E. MacGinitie, 1 specimen.

El Mogote, Baja California, near La Paz, March 22, 1940, E. F. Ricketts, 1 specimen.

Estero de Punta Banda, Baja California, 6 miles south of Ensenada, Dec. 19, 1930, sand, G. E. MacGinitie, 5 specimens.

Anaheim Landing, Calif., March 1918, gravel, 2 specimens.

Newport Bay, Calif., January to February 1930, G. E. MacGinitie, 20 specimens.

Pacific Grove, Calif., Jan. 6, 1939, washed ashore by high seas, 6 specimens.

Genus XENOSIPHON Fisher

Xenosiphon Fisher, 1947, p. 360. (Type, *Sipunculus branchiatus* W. Fischer.)

Diagnosis.—Differing from *Sipunculus* sensu stricto in the following particulars: Integumental coelomic spaces in the form of independent sacs of irregular outline; an extra pair of muscles functioning as retractors and protractors arising from posterior border of introvert and inserted in front of brain; rectum unusually long, the anus being in front of nephridiopores; postesophageal intestine without a long forward loop; nephridia long, slender, attached to body wall for nearly their entire length; squamiform papillae of very short introvert increasing in size toward the tentacles, which have very many leaflets arranged in subtriangular pads surrounding the mouth; type species with papilliform dermal outgrowths.

XENOSIPHON BRANCHIATUM (Fischer)

Plate 19

Sipunculus mundanus var. *branchiatus* W. Fischer, 1895, p. 3, pl. 1, figs. 1, 1a, 2.
Sipunculus branchiatus Spengel, 1913, p. 74.
Xenosiphon branchiatum Fisher, 1947, p. 360, pl. 12.

Description.—The following description is based chiefly on three specimens from Panama. Length 310 mm.; introvert and tentacle crown 20–25 mm.; thickness of cylindrical body 8–12 mm., this varying according to constriction of ring muscles. The specimen from La Paz, 420 mm. long, is constricted in the middle of body to 8 mm. diameter. Longitudinal muscle bands 29–34, only rarely anastomosing. When the body is fully inflated the longitudinal and circular muscles divide the surface into flat rectangular areas separated by rather inconspicuous grooves, but when constriction takes place there is apparent a series of more or less convex annuli. The middle third of the body, except for a ventral zone, about six muscle bands in width, is closely covered with slender pointed papilliform outgrowths of the cuticle, 1–1.5 mm. long, which give a furry appearance to skin. These papillae communicate with irregularly zigzag subcutaneous canals, above which the cuticle usually forms slight welts, which have a direction oblique to the longitudinal axis of the dermal rectangles. Each rectangle has its own canal, independent of the others (pl. 19, figs. 4, 5). Beyond the papuliferous area these canals—or more properly spaces, as they are usually branched—can be traced forward half the distance to the head, and also posteriorly, as they are often self-injected with yellowish material from the coelom. On the periphery of the papuliferous area a papilla usually appears, first at the anterior end of the canal, next at the posterior end, then in between, until there are four or five to each rectangle. Brown or yellow, finely divided material, which is sometimes loose in the canals, is also found in the bottom of the papillae. If the top of the canal is stripped off, a pore at either end is seen to lead deeper into the tissue (arrows in pl. 19, fig. 4). If ordinary ink is forced *from the coelomic side* into the pores that exist at intersection of longitudinal and transverse muscle bands, it appears in these pores at the ends of the subcutaneous canals but is usually blocked by material already in the canal. The papillae are highly iridescent in sunlight. The area strongly reminds one of the papularium of a sea star, and the function is probably the same, i. e., respiratory.

The terminal knob of the body is very short, broadly rounded to subtruncate, and the slight margin is capable of disappearing under distension. There is a conspicuous terminal pore, and the skin, either smooth or longitudinally ridged, is closely beset with microscopic pores of at least two sizes.

The short introvert is covered with squamiform papillae, which increase in size toward the front, near which they decrease over a narrow zone to the bare zone behind the tentacles. The largest papillae are 0.75–1 mm. in length and breadth.

The tentacles are composed of very numerous small grooved foliate elements in subtriangular mats or groups, radiating from the mouth, which is ventral to the center. There are seven of these from which ridges of tissue converge to the mouth, two dorsolateral, two lateral, and two ventral, the odd one being the middorsal and much the largest. On the periphery of the crown the space between the major groups is filled in with one to three small groups of tentacles, which probably increase in number as growth proceeds.

The anus is equivalent to about five muscle rings (not clearly differentiated) behind the posterior papillae of the introvert.

Interiorly the longitudinal muscles form flat bands becoming angular in section only when the body is much constricted. The introvert and the four retractors occupy about one-seventh of the body length. The retractors are free from one another and arise at approximately the same level. Both ventrals arise from muscles 1–4, while both dorsals arise obliquely from muscles 7–11. The two protractors arise from muscles 12–15 at the posterior border of the introvert. Before insertion, 4 mm. in front of the brain, they pass over the dorsal retractors. Their form and position, with the introvert out and in, are shown in plate 19, figures 1 and 2. The rectum passes far forward and opens close behind the (dorsal) origin of the protractors. (Muscles 17 and 18 are the two middorsal in figure 1; 18 and 19 are really 17 and 16 of the left side.) The rectum lacks thin, fan-shaped wing muscles. A slender spindle muscle arises from the ventral wall of rectum, 20-24 mm. behind anus; two roots proceed toward anus in the wall of the rectum, while the free muscle proceeds backward following the gut; 10–12 mm. from its origin is a very small coecum to which it is attached. The rectum is fastened dorsally to the body wall by a continuous mesentery, as far back as the two lateral anchors just behind the origin of the spindle muscle. These short lateral strands of tissue fan out slightly and may be rudiments of the rectal wing muscle. At any rate, to them are attached the ends of a delicate filament, forming a loop, which on each side passes obliquely ventralward along the origin of the dorsal retractors Here the thread is thickly beset with delicate racemose structures (poorly preserved). These quickly thin out posterior to the muscles and the rather long posterior loop is very delicate, translucent, and more loosely attached to the coelomic epithelium. Probably the "bandformiges Organ" figured by Selenka (1883, p. 109, pl. 12, fig. 174, y) in *S. mundanus* is a fragment of a similar structure. It resembles a gonad, but may be a more extensive "Zottenbildung."

The alimentary canal is macerated, but it appears to lack the forward loop that complicates the anterior end of the spiral of typical *Sipunuculus*. Although in plate 19, figure 1, the esophagus is drawn to the right, it naturally turns to the left, for its first attachment to the dorsal wall is by separate fixing muscles, along muscle band 9 (or 8) of the *left* side. The mesentery between the esophagus and the left dorsal retractor extends posteriorly only about half as far as the right. This shorter left mesentery allows the ventral vessel to become sinistral, while the dorsal vessel gradually becomes dextral. Both end dorsolaterally at the beginning of the dorsal fixing muscles. From here the alimentary canal passes backward along muscle 9, for an unknown distance, before starting the spiral. The spirals are well established in the posterior half of the body.

Nephridia are long, slender, and except for a short terminal portion are closely attached to muscle 5.

The nerve cord is slender, less than half the width of muscle 1. Anteriorly the rather slender paraneural muscles arise from muscle 1, 4–5 mm. behind nephrostome. The bilobed cerebral ganglion has across the front a prominent frons (cerebral organ) composed of short bushy elements, exactly resembling a very tiny cauliflower.

Color in alcohol faded yellowish; the La Paz specimen is gray varied with straw color.

Type locality.—Esmeraldas, Ecuador.

Distribution.—Ecuador to La Paz, Baja California.

Specimens examined.—Four, as follows:

La Paz, Baja California, Lyman Belding, 1 specimen.
Panama, Hassler Expedition, 3 specimens.

Remarks.—So far as I know there is no record of this species from the region between Panama and La Paz. Its capture at La Paz by Lyman Belding, a pioneer ornithologist of California, illustrates amateur's luck, for E. F. Ricketts, collecting extensively in that locality in 1940, did not find it.

Genus SIPHONOSOMA Spengel

Siphonosoma Spengel, 1912, p. 264 (type, *Sipunculus australis* Keferstein).—Gerould, 1913, p. 432.—Fisher, 1950b, p. 805.

Diagnosis.—Size usually large; body resembling that of *Sipunculus*, while head and introvert suggest *Golfingia;* longitudinal muscle layer always separated into bands, the circular layer into distinct anastomosing fascicles (in most species); larger species provided with integumental coelomic sacs (instead of longitudinal canals of *Sipunculus*); four retractor muscles; a simple intestinal spiral anchored posteriorly by spindle muscle, which has three anterior roots; only the dorsal contractile vessel present, usually with very many Polian villi; two nephridia with large crescentic nephrostomes; paraneural muscles of ventral nerve cord less well developed than in *Sipunculus*, the cord for some distance back of head being fastened to body wall by a mesentery; tentacles filiform, or acute digitiform when contracted, numerous, arranged as in *Golfingia*, and forming a rather dense cephalic cluster; no *conspicuous* scalelike papillae on introvert.

Remarks.—Spengel separated this group from *Sipunculus* mainly on the basis of the integumental coelomic spaces, longitudinally arranged, which are not continuous, long canals as in *Sipunculus* but are small blind sacs showing characteristic forms in different species. He pointed to other differences such as the spindle muscle, the large semilunar nephrostome, attachment of nerve cord in anterior part of introvert, the presence of thick glandular epithelium in the wall of the rectum, structure of the tentacles, and the absence of scalelike papillae on the introvert. Spengel was rather fascinated by the integumental coelomic pouches. While these are fundamental structures, they are of little value in determining species and are perhaps absent in small species having a thin body wall.

The genus contains about 24 nominal species, which fall into 3 fairly natural groups: Subgenus *Siphonosoma*, sensu stricto (p. 381); subgenus *Hesperosiphon* Fisher (p. 386); subgenus *Dasmosiphon* Fisher (p. 386).

Subgenus SIPHONOSOMA, sensu stricto

Diagnosis.—No dissepiments in body cavity; rectum devoid of numerous elongate diverticula. The following species are included:

Spinelets on introvert	Devoid of spinelets on introvert
arcassonense (Cuenot).	*amamiense* (Ikeda).
australe (Keferstein), type.	*boholense* (Semper).
eniwetoki Fisher.[8]	*bonhouri* (Hérubel).
pescadolense Sato.	*dayi* Stephen.
takasukii Sato.	*funafuti* (Shipley).
	ingens (Fisher).
	mourense Sato.
	novae-pommeraniae Fischer.
	rotumanum (Shipley).

KEY TO SPECIES OF SUBGENUS SIPHONOSOMA LACKING SPINES ON INTROVERT

a^1. Retractors arise from body wall at same level; intestinal coecum present. **novae-pommeraniae Fischer**

a^2. Retractors arise at different levels.

- b^1. Nephridia open on same level as anus or slightly in front; no intestinal coecum.
  - c^1. Muscle bundles 20 or more.
    - d^1. Small scalelike papillae on introvert ---------- **dayi Stephen**
    - d^2. No scalelike papillae on introvert.
      - e^1. Circular muscles not divided into fascicles; fixing muscle anchors rectum ---------- **mourense Sato**
      - e^2. Circular muscles divided into anastomosing fascicles; fixing muscle anchors esophagus ---------- **ingens (Fisher) (p. 382)**
  - c^2. Muscle bundles 18 or less.
    - d^1. Dorsal retractors well developed, not very small.
      - e^1. Muscle bundles 14; skin glistening gray with certain blackish papillae scattered over surface becoming closely and regularly arranged on introvert; circular muscles in rings with numerous anastomoses; anus conspicuous; ventral retractors very long, originating from second and third longitudinal muscles; intestine with 30 to 40 coils; no fixing muscle? ---------- **rotumanum (Shipley)**

[8] *Siphonosoma eniwetoki* Fisher, 1950b, p. 805.—Differing from *S. australe* (Keferstein) in having less prominent skin glands in anal region and at end of body; much smaller and blunter introvert hooks; thinner body wall; an esophageal fixing muscle attached to midventral line. Length of contracted specimen 105 mm., plus invaginated introvert, 35 mm.; thickness at middle of body 15 mm.; 16 to 18 rather broad longitudinal muscles, occasionally anastomosing; ventral retractors from muscles 2–3 or 2; the dorsals from 3–4; a fixing muscle to esophagus and one to rectum; intestinal coecum; nephridia small, free; color rosy gray. Type, U. S. N. M. No. 21128, Bogen Island, Eniwetok Lagoon, Marshall Islands, intertidal.

e^2. Muscle bundles 14 or 15, few anastomoses; body tapers posteriorly to a sharp tail; skin silvery white, rather transparent, with scattered papillae on body, but in rings near mouth; intestine with 8 to 12 coils; nephridia small, free; ventral retractors arise from two muscles, dorsals from one; no fixing muscle?. **funafuti** (Shipley)

e^3. Muscle bundles 15 or 16; skin yellowish brown, deepest on introvert; surface rough, especially introvert base and end of body; ventral retractors from muscles 2 and 3 in middle of body, dorsals far more anteriorly from fourth muscle; fixing muscle, with 2 roots, is attached to esophagus; nephridia free, small, deep reddish brown; dorsal lip of nephrostome with 2 or more small processes. **amamiense** (Ikeda)

d^2. Dorsal retractors very weak; ventrals long, arising at commencement of posterior third of body from a single longitudinal muscle; skin very thin with only a few papillae; 18 muscle bundles; intestinal spiral with 16 double loops; spindle muscle strong, with 2 anterior lateral anchors expanded at attachment to body wall; nephridia long, attached by anterior third, nephridiopores slightly behind anus. **bonhouri** (Hérubel)

b^2. Nephridia open posterior to anus (fide Selenka); intestinal coecum present; 30 muscle bundles---------------------**boholense** (Semper)

SIPHONOSOMA INGENS (Fisher)

PLATES 20, 21

Siphonomecus ingens FISHER, 1947, p. 365, pls. 14, 15.

Diagnosis.—Size very large and body slender, either uniform in thickness or posterior portion contracted, with an attenuate extremity; introvert long; skin smooth, with numerous tiny roundish immersed glands, much fewer and smaller on introvert; longitudinal muscle layer of postintrovert region divided into 20–25 muscle bands, rarely anastomosing; circular layer split into anastomosing fascicles; four retractors, the dorsals arising well in front of ventrals, which are separated from nerve cord by two or three muscle bands; postretractor region about half body length; strong spindle muscle of *Siphonosoma* type arising in front of anus and attached at posterior end of body; intestinal spiral very long (60–62 coils); contractile vessel densely papillated posteriorly; nephridia free, opening a short distance in front of anus; small coelomic papillae forming a transverse zone in front of nephridia; tentacular crown capitate; tentacles arranged in 12 double meridional series, upward of 12 to a series; nuchal organ very small, at anterior end of dorsal double series. Length of type, fully relaxed, 500 mm.; diameter 8–10 mm.; introvert about 90 mm.; distance from head to nephridiopores 130 mm.; to anus 140 mm.; to attachment of ventral retractors 215 mm.; to end of intestinal spiral 435 mm. (unusually extended for preserved specimen).

Description.—The skin of the preserved specimens is pale yellow or muddy brown. It is closely beset with small, inconspicuous, roundish glands, on the order of six to eight to each oblong rectangle, into which the skin is divided. These glands are immersed in the skin (which is smooth to touch) and are surrounded by the peripheral portion of the subdermal coelomic pockets. Coelomic fluid enters these irregular spaces by way of the narrow intervals between the circular muscle bands; stain forced into them indicates that the space just under the epidermis is independent for each rectangle. The annular and longitudinal grooves that outline the rectangles vary in depth with the inflation of the skin. The posterior end of specimens is likely to be very attenuate and pointed and the annuli conspicuous. On the introvert the glands are very tiny, fewer, and visible only in strong light.

The introvert is not especially well marked externally except by the absence of the glands, and it is the long portion characterized internally by the sievelike structure of the longitudinal muscle layer. There are no hooks.

The arrangement of tentacles is more easily understood in a small specimen than in the adult, where they are much longer (pl. 20, fig. 1). The crown, while reminiscent of *Golfingia gouldii*, differs in having the tentacles of all the double rows, especially the dorsal, *close together*, with the result that the nuchal organ is almost rudimentary. There are 12 of these double rows separated by 12 grooves: A dorsal double row (not more widely separated than the rest) reaches nearest to the mouth; opposite it is a midventral; on each side, five laterals. Counting clockwise from the dorsal, double rows 2, 4, 6, 8, 10, 12 do not reach quite so near the mouth as the alternates. The middorsal has 7 tentacles in each series in this small specimen, the others, 5 and 6 as a rule. In large specimens the tentacles are relatively about twice as long and 10 to 12 in *each* series. Large specimens would therefore have upward of 240 tentacles altogether. In the small specimen the inner end of the dorsal group of tentacles overlies the brain, which is visible through the skin. The *very small* nuchal organ is at the inner end of this dorsal group, well hidden by the first and second tentacles, and hence is close to the brain.

The inner longitudinal muscle layer is divided into 20 to 25 bundles, which anastomose infrequently. The regular bundles cease 20 to 25 mm. in front of the anus and anastomose every few millimeters, so that this layer from here to the head appears sievelike by reason of very numerous elongate pores. The intervals between the regular longitudinal muscles are crossed by the circular muscle bundles, which anastomose freely. The openings between the circular fascicles give entrance to the transverse lacunae, which in turn feed the subcutaneous spaces that surround the skin glands. In the posterior third of the body the longitudinal muscle bundles change from flat ribbons to ridges, which are narrower than the intervals between. The circular muscle bundles are here seen to best advantage. The transverse slits between them are virtually very numerous pockets directly beneath the thin skin, to which the coelomic fluid and contents have access.

Posterior attachment of the ventral retractors is to muscle bundles 3–4, 4–5, 3–5, from nerve cord; that of dorsals is to muscle 8 or sometimes 7, well in advance of the ventrals. Anteriorly the four retractors are in close contact forming a muscular trough in which lies the esophagus. The lateral mesenteries of esophagus are apparent for only a short distance posteriorly.

The nephridia are slender, free, brown, and open about four muscle bands laterally from the nerve and a short distance (varying with contraction of longitudinal muscles) in front of the anus. In one specimen they are full of eggs. In front of the broad nephrostome, and also sometimes for a short distance back of it, is an area occupied by papilliform outgrowths of the epithelium, the so-called Keferstein bodies. They are either simple or branched (pl. 20, figs. 4, 5).

In the relaxed type specimen the esophagus is very long, slender, and anteriorly marked by the contractile vessel. The lateral mesenteries are inconspicuous and their posterior border has a muscular strand continued upon the sides of the esophagus. The contractile vessel is posteriorly densely papillated and its posterior end is considerably behind the point where the esophagus becomes attached to rectum. Just back of this point the esophagus has a special fixing muscle (F), which is anchored by a fork spanning the nerve cord well in front of the attachment of the ventral retractors. The special fixing muscle, F, sends a few strands to the rectum, which is here closely attached to the esophagus. The intestinal spiral (60 to 62 single coils) is very long and sometimes reaches nearly to the end of the body.

Plate 20, figure 3, and plate 21, figure 3, show the relationship of esophagus, rectum, and spindle muscle in the type and paratype. The spindle muscle arises in front of the anus and after passing backward through the intestinal spiral (which in the type extends to within 65 mm. of the end of body) it sends off numerous branches, which are attached to the longitudinal bands ventrally, laterally, and dorsally, while a small strand continues to the posterior extremity. At the point where the esophagus joins the rectum there are two symmetrical lateral roots (S^1, S^2) attached in front of the dorsal retractors to the first muscle bundle external to that from which the dorsal retractors arise. There is no coecum. The wing muscles are fairly conspicuous.

At the extreme posterior end of the body are four or five slender, terete, fusiform bodies, which open close together (around the end of the spindle muscle), each on a slight pustule of the skin. They somewhat resemble a cluster of nematodes.

The brain measures about 1 mm. in length and is bilobed. It varies somewhat in appearance in different specimens by reason of being partly obscured by muscle fibers.

Young.—The above description applies to the mature specimens. Those under 125 mm. have a thinner body wall, translucent if at all inflated. Both longitudinal and circular muscle layers are thinner, but are subdivided into bundles, although the circular are sometimes difficult to see if the body wall is stretched by inflation. The circular bundles then flatten and close the stomata, which lead to the integumental coeca, and the layer appears to be continuous. In well-relaxed specimens the retractors are very slender, being narrower than the longitudinal bands of body wall. The Keferstein bodies are not present in two specimens measuring 80 and 110 mm., but are present in one 150 mm. long.

Type.—U.S.N.M. No. 20910, January 31 and July 18, 1931, and July 19, 1933, G. E. MacGinitie collector, 8 specimens.

Type locality.—Morro Bay, San Luis Obispo County, Calif.

Specimens examined.—From California:

Newport Bay, Orange County, January to February 1930, and Feb. 14, 1932 (with eggs), among *Zostera*, G. E. MacGinitie, 7 specimens.

Elkhorn Slough, off Monterey Bay, sandy mud, low tide, G. E. MacGinitie, 1 specimen.

Remarks.—*S. ingens* belongs in the subgenus *Siphonosoma*, in the section lacking spinelets on the introvert. It most nearly resembles *S. mourense* Sato (1930, p. 6, pl. 1, figs. 2–4), Mutsu Bay, Japan. It differs in having circular instead of elliptical skin glands; the circular muscle layer is divided into anastomosing fascicles; fixing muscle F anchors the esophagus primarily, and not the rectum; lateral roots S′ S″ of spindle muscle are anchored farther in advance of the dorsal retractors; nephridia open between muscle bands 4 and 5 instead of 3 and 4. Sato states that there are 30 coils in the intestinal spiral; if double coils are meant, the number is about the same as in *ingens*. In *mourense* there are 22 longitudinal muscle bundles; the ventral retractors arise from muscle 3 and 4 and the dorsals from 8, 9, or 10 (8 in the figure). These are possible variations of *S. ingens*.

The genus *Siphonomecus*, in which I originally placed this species, is now restricted to the type, *S. multicinctus* Fisher. It differs from *Siphonosoma* in having only two retractors; a very conspicuous nuchal organ; eight pinnate tentacular groups, of which the two ventral are bifid distally; more complex integumental coelomic pockets; no Polian villi; and a spindle muscle with three roots but of a pattern entirely different from that of *Siphonosoma* (Fisher, 1947, p. 363, pl. 13).

Subgenus HESPEROSIPHON Fisher

Hesperosiphon FISHER, 1950b, p. 805.

Diagnosis.—No dissepiments in body cavity; numerous conspicuous diverticula on rectum. Three species are included:

No spinelets on introvert	Spinelets on introvert
vastum (Selenka and Bülow), type	*crassum* (Spengel) Fischer
	parvum Fischer

Subgenus DASMOSIPHON Fisher

Dasmosiphon FISHER, 1950b, p. 805.

Diagnosis.—Many transverse dissepiments attached to ventral wall of coelom; no diverticula on rectum; no introvert hooks. *Dasmosiphon* includes the following species:

billitonense (Sluiter)	*formosa* Sato
carolinense Spengel	*hataii* Sato
cumanense (Keferstein), type	*koreae* Sato
edule (Sluiter)	

SIPHONIDES, new genus

Diagnosis.—Resembling *Siphonosoma* but with simpler organization, lacking integumental pockets, Polian villi, the lateral roots of spindle muscle and its posterior attachment; nephridia strongly bilobed; no dissepiments; no Keferstein bodies; tentacles numerous, very small, filiform; type with minute, rather complex hooks on introvert.

Type.—*Siphonides rickettsi*, new species.

SIPHONIDES RICKETTSI, new species

PLATE 22

Diagnosis.—A slender, rather *Golfingia*-like species, having an introvert comprising about three-fourths total length; head very small; tentacles very numerous, filiform; 35 rings of minute slender hooks; skin with numerous mammiform glands; nephridia with two lobes; contractile vessel without villi; intestinal spiral free posteriorly; spindle muscle with only one root; 20 to 24 longitudinal muscle bundles; circular muscle layer continuous; no coelomic pouches in body wall, which is probably translucent in life; no dissepiments.

Description.—Length of type 170 mm., of which 135 mm. is in front of anus. The body is slender, 4 to 5 mm. thick, the introvert tapering to 1.25 mm. behind the tentacles, the crown of which, retracted, is 1 mm. high. The tentacles are very numerous, filiform, and appear to be arranged in concentric groups, closely packed. Behind them for a distance of 6 mm. are about 35 circles of minute slender hooks (0.05 mm. long), so closely packed that they touch. There are about 100 to each millimeter. The hook is very characteristic in having at the base, on the incurved side, a comb of curved hooklets that are transparent, but brownish, like the hook. The hook rings are in tiny furrows separated by glandular ridges. The glands are immersed in the skin, 0.08 to 0.09 mm. by 0.04 to 0.05 mm., placed close together (the shorter diameter transverse), and each has a definite pore near the next aboral hook ring, 0.015 mm. in diameter.

The body is covered with spaced, small, mammiform glands surmounted by a more or less evident cylindrical papilla. In the type, probably caused by preservation, these are involved in transverse and longitudinal folds of the skin. These gradually decrease in size forward on introvert, where the skin folds become closely placed rings on which the glands, now tiny conical papillae, are borne.

The longitudinal muscles of the body wall in 20 to 26 rather broad bands, close together, flat when the body wall is inflated, and only occasionally anastomosing. These bands extend in front of the anus for a distance about half that between the anus and the posterior extremity, and forward of this the inner muscle layer is continuous, transversely crinkled like silk. The circular muscle layer is thin and not separated into bundles. Integumentary pockets absent. The retractor muscles are very slender; ventrals arising far forward, at about one-fifth the distance between the anus and end of the body, from muscle bundles 3 and 4; dorsals arising between anus and nephridiopores from muscles 2–3 left, 3 right, or 1–3 both sides (type). Forward of the nephridium, the dorsals and ventrals unite into a single muscle on each side of the slender esophagus. Spindle muscle starts forward of anus and follows usual course, but is not attached posteriorly; the two lateral roots, usually present in *Siphonosoma*, are absent. Fixing muscle F anchors ascending intestine to muscle bundle 1 left.

The nephridia are reddish brown, with a prominent anterior lobe, which may be short or long (up to one-third to one-half length of posterior lobe). The anterior lobe is sometimes turned posteriorly. Nephrostome: the lower part of the lip is attached to the body wall, the free part having slender lobes. The nephridium is attached obliquely for a short distance at base, and opens between muscles 4 and 5, or through a cleft on 4. No Keferstein bodies.

The esophagus is very slender, without fixing muscle. Intestinal spiral with about 20 double coils; a conspicuous coecum on rectum. The contractile vessel is very slender and without diverticula. The nerve cord in the anterior part of the introvert has a mesentery; farther back it is free except for the moorings by the lateral nerves. The gonad is at the origin of the ventral retractors.

Type.—U.S.N.M. No. 21224, from under boulders along with *Phascolosoma antillarum* and *Ph. puntarenae,* March 20, 1940, E. F. Ricketts collector, 2 specimens.

Type locality.—Point Lobos, Espíritu Santo Island, near La Paz, Baja California.

Genus GOLFINGIA Lankester

Phascolosoma authors, not F. S. Leuckart, 1828.

Phascolosomum Diesing, 1851, p. 63, partim; 1859, p. 758, partim.

Phascolosoma Keferstein, 1862, p. 39, partim; 1865b, p. 422, partim.

Homalosoma Keferstein, 1865b, p. 436 (for *Phascolosoma margaritaceum* Sars). (Preoccupied by *Homalosoma* Wagler, 1850, and Agassiz, 1846.)

Petalostoma Keferstein, 1865b, p. 438. (Type, *Phascolosoma minutum* Keferstein.) (Preoccupied by *Petalostoma* von Lidth de Jeude, 1829, Recueil de figures des vers intestinaux . . ., Preface, p. 2.)

Phascolosomum Quatrefages, 1866, p. 616. (Type, *Ph. vulgaris* de Blainville.)

Stephanostoma Danielssen and Koren, 1880, p. 464. (Type, *S. hansenii* Danielssen and Koren.) (Preoccupied by *Stephanostoma* Lenz, 1802, *in* Joerdens, Entomologie und Helminthologie des menschlichen Körpers . . ., vol. 2, p. 29.)

Phascolosoma Selenka and de Man, 1883, p. 15.

Golfingia Lankester, 1885, p. 469, pls. 55, 56. (Type, *G. macintoshii* Lankester = *Phascolosoma vulgare* de Blainville, teste Stephen, 1934, p. 169.)—Fisher, 1950a, p. 548.

Apionsoma Sluiter?, 1902, p. 42. (Type, *A. trichocephalus* Sluiter.)

Diagnosis.—Usually small or moderate sized, rather slender sipunculids having the longitudinal muscle layer continuous except in *G. gouldii.* Distinct finger-shaped, leaf-shaped, or filiform tentacles encircle mouth in one or more rows or in a series of longitudinal double rows, interrupted in median dorsal line by the ciliated nuchal organ; in a few cases tentacles reduced to a circumoral fold. Hooks may or may not be present on introvert. Four or only two (ventral) retractor muscles of introvert. Contractile Polian vessel in most cases simple but in subgenus *Thysanocardia* is covered with Polian villi, and also is sometimes rudimentary in species with few tentacles. Intestine forms a double spiral coil of several, or many, whorls around axial spindle muscle which originates close to rectum and only exceptionally anchors spiral to posterior end of trunk. The pair of nephridia hang free. A pair of photic tubes lead backward from surface of a cerebral sense organ into substance of cerebral ganglion. The bottom (or posterior, blind end) of each of these tubes, when pigmented, forms an "eye spot." (From Gerould, 1913, emended.)

Remarks.—It is unfortunate that the name *Phascalosoma,* long applied to this group, is applicable only to the genus later known as *Physcosoma.* The type of Leuckart's (1828) *Phascolosoma* is *Ph. granulatum* of the Mediterranean, which was transferred by Quatrefages (1866) to his new subgenus *Phymosomum.* This was emended to *Phymosoma* and given generic rank by Selenka (1883), who failed to notice or ignored the discrepancy. He included *Phascolosoma granulatum* Leuckart in the synonymy of "*Phymosoma granulatum.*" *Phymosoma,* being preoccupied, was later changed by Selenka (1897) to *Physcosoma.*

Phascolosomum Diesing (1851) is obviously an emended spelling. In addition to *granulatum* he included species of *Golfingia* (*vulgaris*, *eremita*) and of *Phascolion* (*strombi*). As noted in the synonymy, *Petalostoma* and *Homalosoma* Keferstein (1865b) and *Stephanostoma* Danielssen and Koren (1880) are preoccupied and hence are not available. The only tenable name seems to be Lankester's *Golfingia*, commemorating a holiday with Professor MacIntosh at St. Andrews. The type, *G. macintoshii*, according to Dr. A. C. Stephen, is an example of *G. vulgaris* (de Blainville).

Dr. J. H. Gerould (in litt.) deplores the shift of the name *Phascolosoma* to the genus heretofore known as *Physcosoma*. He believes that Leuckart's brief diagnosis was intended to include smooth-skinned forms that would now be classified as *Golfingia*. This is the view entertained by Keferstein, who did not recognize the value of the fundamental difference in the head region that separates the two genera. It is axiomatic that the identity of a genus is fixed by the type species, and that the type may not be shifted later at the whim of a reviser. This transfer of types is the error that Quatrefages committed. All writers, including Gerould (1913), seem to have ignored the discrepancy that the type of *Phascolosoma* was currently in the younger genus *Physcosoma*.

This genus contains so many species that no apology is offered for the creation of subgenera. The lists of species under *Golfingia*, sensu stricto, and *Phascoloides* are not complete.

KEY TO SPECIES OF GOLFINGIA HEREIN DESCRIBED

a^1. Introvert very slender and more than five times length of trunk; retractors 4, united into a single column for most of their length; minute hooks on introvert; intestinal coil anchored posteriorly; small animals usually in association with *Mesochaetopterus* and *Cerianthus*.
hespera (Chamberlin) (p. 393)

a^2. Introvert not exceedingly long, seldom attaining three times length of trunk; sometimes less than trunk length; retractor muscles separated to head; intestinal coil not anchored posteriorly.

b^1. Four retractors; introvert less than half total body length.

c^1. Spinelets on anterior part of introvert; skin rough, dark brownish.
vulgaris (de Blainville) [9]

c^2. No spinelets or hooks on introvert; skin smooth, pale yellowish, or gray, translucent-- **margaritacea californiensis**, new subspecies (p. 392)

b^2. Two retractor muscles; no Polian villi on contractile vessel; nephridia opening on same level as anus; retractors arising near middle of trunk.

c^1. Introvert about one-third total length armed with nearly straight brown spinelets; no fixing muscles; contractile vessel rudimentary; related to *G. abyssorum*-------------------**laetmophila**, new species (p. 397)

c^2. No spinelets or hooks on introvert.

d^1. Retractors weak; one fixing muscle; contractile vessel rudimentary.
eremita californica, new subspecies (p. 396)

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[9] This species has not been taken in California waters. I have one specimen dredged near Friday Harbor, Wash., 25 to 60 fathoms, by Mrs. Ida Oldroyd, July 1917.

d^2. Retractors strong; seven fixing muscles; a well-developed contractile vessel........................**elachea**, new species (p. 399)

b^3. Two retractor muscles; contractile vessel with numerous branched Polian villi.

c^1. Introvert nearly three-fourths total length.

d^1. Polian villi absent from anterior part of contractile vessel; one fixing muscle...............................**procera** (Möbius) (p. 402)

d^2. Polian villi extend entire length of contractile vessel; two fixing muscles.......................**macginitiei**, new species (p. 402)

c^2. Introvert about half total length; Polian villi not present on anterior portion of contractile vessel; one fixing muscle.
pugettensis, new species (p. 401)

Subgenus Golfingia, sensu stricto

Diagnosis.—Retractors 4; longitudinal muscle layer of body wall not divided into separate bundles; contractile vessel without villi; spindle muscle not attached to posterior end of body.

Type.—*G. vulgaris* (de Blainville).

No hooks on introvert	Hooks on introvert
anderssoni (Théel).	*cluthensis* (Stephen).
anguinea (Sluiter).	*cylindrata* (Keferstein).
appendiculata (Sato).	*elongata* (Keferstein).
capensis (Teuscher).	*muricaudata* (Southern).
charcoti (Hérubel).	*nordenskjöldi* (Théel).
glossipapillosa (Sato).	*ohlini* (Théel).
hudsoniana (Chamberlin).	*ownstoni* (Ikeda).
ikedai Fisher.[10]	*pudica* (Selenka).
margaritacea (Sars).[11]	*sanderi* (Collin).
noto (Sato).	*vulgaris* (de Blainville).[12]
okinoseana (Ikeda).	
signa (Sato).	
soyo (Sato).	
trybomi (Théel).	

[10] *Golfingia ikedai*, new name for *Phascolosoma japonicum* Ikeda, 1904, preoccupied by *Ph. japonicum* Grube, 1877 (*Physcosoma japonicum* authors) Fisher, 1950a, p. 550.

[11] Includes *Golfingia antarctica* (Michaelsen), *G. capsiforme* (Baird), *G. fusca* (Michaelsen), *G. georgiana* (Michaelsen), *G. hanseni* (Danielssen and Koren), *G. socia* (Lanchester). Probably *hudsoniana* is a form of this species.

[12] Includes *Golfingia papillosa* (Thompson), *G. harveii* (Forbes), *G. obscura* (Quatrefages), *G. lutea* (Théel), *G. dubia* (Théel), *G. valida* (Théel), and *G. macintoshii* Lankester.

GOLFINGIA MARGARITACEA (Sars)

PLATE 23, FIGURE 3

Sipunculus margaritaceus SARS, 1851, p. 196.

Phascolosoma margaritaceum KOREN and DANIELSSEN, 1877, Heft 3, p. 135, pl. 15, figs. 43, 44.—SELENKA, 1883, p. 25, pl. 4, fig. 37.—THÉEL, 1905, p. 63, pl. 3, figs. 29–33; pl. 4, figs. 34, 37; pl. 12, fig. 174; pl. 14, figs. 192–196; 1911, p. 26, pl. 2, fig. 20; pl. 5, figs. 67, 68.—GEROULD, 1913, p. 382.—WESENBERG-LUND, 1930, p. 25, pl. 3, figs. 33–36, 44; pl. 5, fig. 51; 1932, p. 5, fig. 3.—STEPHEN, 1941, p. 251, pl. 8, figs. 3, 4.—SATÔ, 1934, p. 5, figs. 5, 6, pl. 1, fig. 3.

Remarks.—This species has a bipolar distribution. In the Arctic it is circumpolar, ranging south in the Atlantic to south of Newport, 705 fathoms, and to Fayal Island, Azores (forma *meridionalis* (Gerould)). Forma *siberica* (Théel) occurs north of Asia and at Bering Strait, whence the species reaches Japanese waters (Sato, 1934, as var. *antarctica* (Michaelson)). On the American side the species was taken by the Harriman Alaska Expedition at Dutch Harbor, Unalaska, at the Shumagin Islands, at Kodiak Island, Kilisnoo, and Sitka. It has been dredged off Point Barrow by Prof. G. E. Mac Ginitie, from 152 to 741 feet. E. F. Ricketts has collected it at Sitka and at Rat Island, British Columbia, and it occurs at Friday Harbor, Wash.

The distribution in the Southern Hemisphere is summarized by Stephen (1941) as follows: Off Patagonia, Falkland Islands, South Georgia, Tierra del Fuego, Graham Region, Cape Andare, Port Charcot, Commonwealth Bay, Ross Sea. Théel (1911) made a critical study of material dredged by the Swedish Antarctic Expedition and was unable to establish any constant distinctions between Arctic and Antarctic specimens.

The synonymy of the species in its widest sense may be followed in Théel (1905, 1911); Wesenberg-Lund (1930); Stephen (1941).

The specimens from Alaska, British Columbia, and Washington seem to constitute a slight race, or form, differing from the typical. But if *Golfingia hanseni* and *G. trybomi* are to be considered as forms of *margaritacea*, it is best to refrain from adding another name to the list. This Alaskan form lacks the reticulated pigment at the end of the body reported by Sato as occurring in Japanese specimens. The papillae are less prominent, and the fixing muscle attached to rectum near anus (shown also by Théel, 1905, fig. 174) does not occur. In the Alaska specimens there are three to five fixing muscles. The typical number is four, which have a fairly constant pattern of attachment, although one may sometimes be missing or an extra one added (see pl. 23, fig. 3, and explanation.)

The small California form, however, cannot be lumped with the Alaska specimens. For typical *margaritacea* see Théel, 1905 and 1911, especially the beautiful figures drawn by G. Liljevall.

GOLFINGIA MARGARITACEA CALIFORNIENSIS, new subspecies

PLATE 23, FIGURES 1, 1, *a*, 2; PLATE 24, FIGURES 6–8

Diagnosis.—Size small, with a single ring of 16 tentacles (or fewer), slender body, no papillae, and the glands most prominent at posterior end of trunk and in a zone at base of introvert; two fixing muscles, F^1 anchoring esophagus to base of left dorsal retractor, and F^4 anchoring intestine (posterior to coecum) to right side between bases of right retractors; bases of dorsal retractors nearer together and coecum relatively much larger than in typical form; eggs much larger than in the Alaskan form. Skin nearly or quite opaque, pale yellowish brown. Length 9 mm. (introvert 3.5 mm.) to 19 mm. (introvert 8 mm.); breadth of trunk up to 2 mm. A living specimen attained 20 mm. in length.

Description.—In typical *Golfingia margaritacea* the number of tentacles increases with the size of the specimen. *G. m. californiensis* is at the stage shown by Théel (1905, fig. 196; typical form). His figure 194 (forma *sibirica*) is somewhat more advanced, but its broader circumoral disk and shorter tentacles are more like those of *californiensis*, which however has four larger and four smaller oral pads. Théel shows the nuchal organ with a single central furrow. *G. m. californiensis* has two furrows dividing the sensory cushion into three parts. *G. m.* forma *finmarckica* (the typical form), 20 mm. long, has 34 tentacles (Théel, 1905, p. 64) while forma *sibirica*, from Bering Strait, 35 mm. long, has only 16 tentacles. *G. m. californiensis* is more like *sibirica*, which likewise has more obtuse tentacles than the typical form. *G. m. sibirica* has "a thin almost transparent body wall, with hardly discernible reticulation." In *californiensis* the body wall is opaque except at anterior end of the introvert, where the skin is translucent and iridescent, and the reticulation is marked at the base of the introvert and the posterior end, where also the glands are prominent (pl. 24, fig. 8). The nephridiopores open at about the level of the anus or slightly in advance and are externally rather conspicuous for such a small animal.

The fixing muscles of *californiensis* are labeled F^1 and F^4, since they are evidently homologous with F^1 and F^4 of the Alaskan specimens. The relatively large coecum may be a characteristic of small specimens. In Alaskan examples 75 mm. long the coecum is rudimentary and the spindle muscle rather weak. In the California form it is rudimentary. The intestinal spire is long, with 30 to 32 single coils.

Although specimens of *californiensis* are small, the eggs are 0.34 to 0.35 mm. in diameter. In a slightly larger Alaskan specimen (Sitka) the eggs measure 0.25 mm. In an example from Dutch Harbor, Unalaska, 75 mm. long, they measure only 0.22 to 0.24 mm. in diameter.

Color in life pale yellowish brown; tentacles whitish; skin slightly translucent, that of introvert being iridescent.

Type.—U.S.N.M. No. 21220.

Type locality.—Pacific Grove, Monterey Bay, Calif.

Specimens examined.—From California:

Pacific Grove, Monterey Bay, Nov. 21 and Dec. 4, 1911 (eggs), W. F. Thompson.
Carmel Bay, low tide, in crevice of granite without sand, N. W. Riser, 1 specimen containing eggs.

Subgenus PHASCOLOPSIS Fisher

Phascolopsis FISHER, 1950a, p. 550. (Type, *Sipunculus gouldii* Pourtalès.)

Diagnosis.—Retractors 4; longitudinal muscle layer divided into separate bundles; spindle muscle not attached to posterior end of body; *Golfingia gouldii* (Pourtalès) only species.

Subgenus MITOSIPHON Fisher

Mitosiphon FISHER, 1950a, p. 550. (Type, *Phascolosoma hespera* Chamberlin.)

Diagnosis.—Retractors four; longitudinal muscle layer not divided into bundles; nephridia bilobed; spindle muscle attached to posterior end of body; introvert hooks with an accessory comb of spinelets at base.

Included species.—*Golfingia hespera* (Chamberlin), *G. misakiana* (Ikeda).

Remarks.—This small group differs from *Golfingia*, sensu stricto, in having nephridia with a prominent anterior lobe, in combination with a very long introvert and posteriorly anchored spindle muscle. The hooks are unlike any found in *Golfingia*, in having at their base a tiny comb of accessory teeth. The four retractors are united for most of their length into a muscular column, which, when the introvert is retracted, fills the body cavity with irregular coils. The tentacles are in a single series surrounding the mouth.

SYNOPSIS OF SPECIES OF SUBGENUS MITOSIPHON

a[1]. Introvert 6 to 8 times length of trunk; coecum present; no fixing muscle; tentacles 12 to 20; end of hook moderately curved; about 7 slender denticles near base------------------------- **hespera** (Chamberlin) (p. 393)

a[2]. Introvert about four times length of trunk; coecum absent; one fixing muscle; tentacles 8; end of hook abruptly curved, 4 or 5 coarser denticles near base-- **misakiana** (Ikeda)

GOLFINGIA HESPERA (Chamberlin)

PLATE 24, FIGURES 1–5

Phascolosoma hespera CHAMBERLIN, 1919, p. 31.

Diagnosis —A small, slender species with long filiform introvert and slender, relatively short, fusiform body; 30 to 50 rings of very small hooks; very small tentacle crown; four retractors free for only a short distance; two large bilobed nephridia; no fixing muscles; *intestinal* *spire anchored posteriorly*; no contractile vessel. Length of a typical fully relaxed specimen 140 mm.; anus (about in middle of trunk proper) to posterior end 13 mm.; diameter of trunk 1.5 mm.; of introvert 0.75 to 1 mm ; introvert 6 to 8 times length of trunk.

Description.—The body wall is thin, usually translucent, a bleached brown or yellow. The trunk is short, slender, and fusiform; the introvert is extremely long and filiform. At maximum retraction it entirely fills the body cavity with irregular coils, displacing the viscera. The introvert cannot be retracted as far as the nephridiopores or the anus, which is at about the middle of the trunk and posterior to nephridiopores. There is no sharp distinction between the trunk and the introvert. The posterior end of the body, which is often pointed, is thickly beset with short ovoid or cylindrical brown papillae, against a paler skin, 0.025 to 0.035 mm. in height and thickness. Overlapping the papilla zone and extending far along the introvert are much larger, transversely elliptical, pale brown glands, producing low conical eminences with a subcentral darker pore. They measure 0.28 by 0.1 mm. on the trunk and become somewhat smaller on the introvert, where they form a few not very regular longiseries. In specimens from Monterey Bay these glands are more conspicuous than in southern examples. When the specimen is well relaxed and fixed, the glands are low conical with pointed apex and darker than the general skin, even on the introvert, where they also are alined as more prominent parts of successive ring welts. The skin, in addition, is marked by numerous fine transverse furrows and at the posterior end of the trunk by longitudinal ones.

Only two Monterey specimens are well enough expanded to show the head region. The tentacular crown is very small, about 0.25 mm. in diameter, in one specimen surrounded by a collar but not in the second. The exact number of short filiform tentacles cannot be determined, but it is between 12 and 20 (pl. 24, fig. 4). A short distance back of the tentacles is a zone of tiny hooks. They form 20 to 50 very regular rings, are close together, and unless the skin is taut they lie in furrows separated by ridges. The hooks average 0.02 mm. in height, are curved, and on the posterior margin near the base there is a comb of slightly curved thorns. This hook zone occupies only 3 mm. of the very long introvert and is therefore visible only in fully extended specimens.

There are four retractor muscles (not two only as Chamberlin states). They are small and originate on about the same level as the anus, the dorsals as far as possible in front of the ventrals. As shown (pl. 24, fig. 2), they soon unite into a solid muscular column, which proceeds to the head. Along the dorsal side of this, and securely fastened to it, runs the esophagus. There is only a short segment between the end of the esophagus and the beginning of the intestinal spiral, which has 30 single coils and is anchored posteriorly by the spindle muscle. The rectum is bent forward and anchored to the dorsal body wall nearly as far as the coecum by a mesentery, along the free edge of which runs the inconspicuous spindle muscle. There are no fixing muscles and the wing muscles are small.

When filled with sex products the two nephridia are very large and each has a long anterior lobe. They open at a conspicuous distance in front of the anus, and the nephrostome has two semicircular lips.

I am unable to find any contractile vessel.

Type.—In the Museum of Comparative Zoology.

Type locality.—Balboa, Newport Bay, Orange County, Calif.

Distribution.—Monterey Bay to Gulf of California.

Specimens examined.—As follows:

Pacific Grove, Monterey Bay, Calif., 1911, W. F. Thompson, 10 specimens.

Newport Bay, Calif., numerous specimens collected at Balboa (mud flats) and Corona del Mar (beach), August 1929, February 1930 and 1933, by G. E. MacGinitie.

Laguna Beach, Calif., September 1917, on "eel grass," 2 paratypes.

San Lucas Cove, south of Santa Rosalia, on gulf coast of Baja California, "commensal in tubes of *Cerianthus*," March 24, 1941, E. F. Ricketts, 19 specimens.

Remarks.—Professor MacGinitie's specimens were found along the outside of the tubes of *Mesochaetopterus* sp.; those collected by Mr. Ricketts were commensal within the tubes of *Cerianthus*. The dissected specimen, with nephridia distended by sperm, was collected in August 1929. *Golfingia misakiana* lives under seaweeds covering a tufaceous sandstone between tide marks, Misaki, Japan (Ikeda, 1904, p. 7, figs. 3, 30–33).

Subgenus PHASCOLOIDES Fisher

Phascoloides Fisher, 1950a, p. 550. (Type, *Sipunculus eremita* Sars.)

Diagnosis.—Retractors two; contractile vessel without villi; longitudinal muscle layer not divided; nephridia without anterior lobe; hooks without accessory spines; spindle muscle not attached to posterior end of body.

No hooks on introvert

abyssorum (Koren and Danielssen)	*laetmophila* Fisher
depressa (Sluiter)	*liljeborgi* (Danielssen and Koren)
elachea Fisher	*macra* (Sluiter)
eremita (Sars)	*mucida* (Sluiter)
filiformis (Sluiter)	*novaezealandiae* (Benham)
fimbriata (Sluiter)	*prioki* (Sluiter)
flagrifera (Selenka)	*rutilofusca* (Fischer)[13]
glacialis (Koren and Danielssen)	*verrilli* (Gerould)
glauca (Lanchester)	

[13] *Aspidosiphon rutilofuscus* Fischer, Zool. Anz., vol. 48, p. 97, 1916 (synonym, *Phascolosoma aspidosiphonoides* Fischer, 1922c, p. 11, pl. 2, fig. 8).

Hooks on introvert

benhami (Stephen)	*improvisa* (Théel)
chuni (Fischer)	*minuta* (Keferstein) [14]
cincta (Gerould)	*papillifera* (Keferstein)
cinerea (Gerould)	*pellucida* (Keferstein)
confusa (Sluiter)	*recondita* (Sluiter)
coriacea (Keferstein)	*sluiteri* (Ten Broeke)
delagei (Hérubel)	*subhamata* (Sluiter)
intermedia (Southern)	

GOLFINGIA EREMITA (Sars)

Sipunculus eremita Sars, 1851, p. 197.

Phascolosomum eremita Diesing, 1859, p. 760.

Phascolosoma eremita Koren and Danielssen, 1877, p. 134, pl. 15, fig. 45.—Selenka, 1883, p. 35, pl. 5, figs. 54, 55.—Théel, 1905, p. 72, figs. 6–8, 173, 187.—Gerould, 1913, p. 385, fig. 1, pl. 58, fig. 5.—Wesenberg-Lund, 1930, p. 28, pl. 5, figs. 53, 54; 1932, p. 6; 1937, p. 11.

Diagnosis.—Size small; body cylindrical, with bluntly rounded posterior end; introvert rather abruptly narrower, about two-thirds length of trunk; tentacular crown small (Théel, fig. 187) with 27 to 40 short, grooved tentacles; skin olive-brown, with fine circular creases and tiny brown papillae, rather more closely placed at end of body and in anal region. Retractors two, rather weak, arising in middle third of body and separated to head; fixing muscles variable, attached to esophagus, to rectum, or to both; spindle muscle not attached posteriorly, esophagus attached to retractors by well-developed mesenteries; a small rectal coecum; intestinal spire long, with numerous coils; contractile vessel present in north Atlantic forms; nephridia short, opening on level with anus.

GOLFINGA EREMITA CALIFORNICA, new subspecies

The California specimens have no functional contractile vessel except possibly for a very short distance back of the head, whereas both Gerould (1913) and Wesenberg-Lund (1930) state that it is present in North Atlantic specimens. Gerould's figure 1 shows a well-developed vessel. In two of my specimens there is a single fixing muscle on the right side in the position shown in Théel's figure 173, but it is attached to the rectum behind the coecum. A third specimen lacks this muscle but has a rather long fixing muscle, arising on the left side, attached to the esophagus by two branches. There is a strong spindle muscle (not present in Gerould's specimens), which is attached close behind the anus and fused with all rectum as far as the small coecum. The long intestinal spiral has about 55 single coils.

The specimens vary in length from 15 to 33 mm., and the introvert varies greatly; in one case, measured from anus, it is as long as the

[14] Includes *Golfingia johnstoni* (Forbes), *G. anceps* (Théel), *G. sabellariae* (Théel), and *G. sarsii* (Théel).

remainder of body. In another specimen a new introvert seems to have been in process of regeneration.

Type (G. e. californica).—U.S.N.M. No. 21218, 291–298 fathoms, gray mud, rocks, April 12, 1904, 10 specimens.

Type locality.—*Albatross* station 4421, off San Nicholas Island, Calif.

Distribution (Golfingia eremita).—Greenland, Spitzbergen, eastward to Nova Zembla and the Kara Sea, south on Scandinavian coast to Bodo, north of Arctic Circle; on eastern coast of North America, in shallow water as far as Massachusetts Bay, and in deeper water as far south as about 40° north latitude (Gerould, 1913). "It occurs usually at depths of less than 100 fathoms, though Théel records a specimen from Umanak, Greenland, from 200 fathoms, and it has been found south of Cape Cod in 480 and 1,098 fathoms." (Gerould, 1913, p. 386.)

Benham (1922, p. 17) has described var. *australis* from Commonwealth Bay, Wilkes Land, in the Antarctic.

It has not heretofore been recorded from the north Pacific.

GOLFINGIA LAETMOPHILA, new species

PLATE 25, FIGURES 4–6

Diagnosis.—Related to *Golfingia abyssorum* (Koren and Danielssen) (Théel, 1905, p. 78). Differs in having papillae at posterior end of body, glandular papillae on introvert, entirely different hooks, better developed and more numerous tentacles, abnormally large wing muscles. Trunk cylindrical, fairly plump; introvert about one-third body length; body wall translucent, a pronounced glandular zone in front of anus, probably also tiny papillae; anterior part of introvert papillose, including dark-brown, blunt spinelets not in definite rings; retractors two, arising in middle of trunk; no fixing muscles; small nephridia having lower lip of nephrostome folded and lobate; contractile vessel largely rudimentary.

Description.—Total length 56 mm., introvert 17 mm.; distance from anus to end of body 36 mm. The introvert does not include the anus but ends a short distance in front, marked by a constriction. The skin of the trunk is smooth except for some tiny papillae at the posterior extremity and a zone between the anus and the base of the introvert, where the skin is somewhat gelatinous and thickly beset with filiform glands perpendicular to surface. It is difficult to ascertain if these extend above the surface as papillae. The proximal half of the introvert has a thick glandular skin, the thickness accentuated by invagination, the first 4 mm. crowded with thick glandular papillae about 0.1 mm. high. About 2 mm. behind tentacles is a zone 1.5 mm. wide of dark-brown spinelets (pl. 25, fig. 6) not in definite rings and closely surrounded by the thicker glandular papillae. These spinelets have a dark-brown granular cortical layer, which rubs off easily, and are 0.14 to 0.17 mm. long. They appear to be soft and flexible. The tentacles are rather short and grooved and are extensions of an oral fold thrown into about 8 angular groups—perhaps 30 to 40 tentacles in all. The contraction of the head and the softness of the tissue make it difficult to be exact.

The two retractors arise about midway between the base of the introvert and the end of the body and are distinct both above and below as far as the head, although the esophagus is attached to them for over four-fifths their length. The inner surface of the body wall has a satiny luster. There are no fixing muscles. The wing muscles are unusually large. The strong spindle muscle is attached immediately behind the anus and is fused to the wall of the rectum but does not extend beyond the intestinal spire. Well-developed mesenteries anchor the esophagus to the retractors.

The nephridia are small and open on nearly the same level as the anus. The nephrostome is characteristic. The dorsal lip is entire, but the ventral is thrown into folds with five or six marginal lobes.

The appearance of the esophagus as it leaves the support of the retractors is shown on plate 25, figure 5. The slight constrictions continue to the head. There is no rectal coecum and the spire contains many coils difficult to count, as the spindle muscle is contracted and has telescoped them.

The contractile vessel is functional for only a short distance behind the head. From here a very slender thread of tissue can be traced along the esophagus to where the vessel normally ends. It can be seen only under brilliant illumination.

Brain large with two eye spots only slightly pigmented.

Type.—U.S.N.M. No. 21219, 1,059 fathoms, green mud, March 22, 1904, one specimen.

Type locality.—*Albatross* station 4387, off San Diego, Calif., 32°32′40″ N., 118°04′20″ W.

Remarks.—It would have been difficult to place this species without the aid of Théel's (1905) work on Arctic sipunculids, to which the following page and figure citations refer.

While *Golfingia laetmophila* appears to belong to Théel's *G. abyssorum* section (p. 57) on account of the translucent skin of the trunk, few papillae, reduction of the contractile vessel, and presence of introvert spines, its tentacle crown is as well developed as that of *G. eremita* (fig. 187) or *G. margaritacea* (fig. 194). The exact number of tentacles is not diagnostic, as it increases with age. The tentacles of *abyssorum* (fig. 206) are much simpler, and while Wesenberg-Lund (1933, p. 9) found fewer and longer tentacles in a specimen from the

English Channel, Théel was dealing with the types. However, *laetmophila* differs from *eremita* in having a translucent body wall, introvert spines, much better developed wing muscles and in lacking fixing muscles (Théel, fig. 173).

Golfingia abyssorum is slenderer than *laetmophila;* it lacks the thick pulpy papillae of spinelet zone; the spinelets are of an entirely different form and lack the opaque brown cortical layer (figs. 71–75). Wesenberg-Lund (1933, p. 10, fig. 3) mentions fixing muscles in her specimen of *abyssorum* and her figure indicates a feebler development of wing muscles. She states also that the contractile vessel is absent.

GOLFINGIA ELACHEA, new species

PLATE 25, FIGURES 1–3

Diagnosis.—A small form belonging to section of subgenus having a very short introvert, no hooks, and nephridia opening behind functional introvert on same level as anus. Skin, including that of introvert, thickly beset with tiny brown pyriform papillae; introvert less than half length of trunk, from which it is separated by a shoulder; retractors stout, originating midway between anus and posterior extremity; *alimentary canal with seven fixing muscles.*

Description.—Length 17.5 mm.; trunk 12 mm. The introvert begins at the horizontal lines on plate 25, figure 1, where the body has a beveled shoulder, and is less than one-half the length of the trunk. Body wall thin but opaque except anterior part of introvert. Skin thickly covered with brown pyriform papillae of nearly uniform size on trunk (0.06 mm. high), becoming a little longer on the "shoulder" in front of the anus, but not differentiated into an anal zone (fig. 3). On the introvert the papillae are abruptly smaller and diminish slightly in size up to a narrow bare zone behind tentacles. On the middle of the introvert, the papillae are 0.035 to 0.04 mm. high (fig. 2). The papillae are invisible to the naked eye but give the skin surface a soft velvety texture. The tentacles are rather numerous, filiform, 0.8 to 0.9 mm. long by 0.07 mm. thick. A cluster of ventral tentacles are conspicuously shorter.

Retractors two, strong, arising midway between the anus and the posterior extremity, the inner margin near the nerve cord (the right closer than the left). Anteriorly they are narrow. The characteristic feature of the species is the large number of fixing muscles—at least 7 (fig. 1), of which F^1, F^3, F^4 arise from the dorsal body wall forward of the middle of the trunk; F^2 and F^5 from the ventral surface to the right of the nerve cord in front of the right retractor; F^6 and F^7 from the right side, about midway between the base of the retractor and the base of the nephridium. F^1 is attached to the esophagus at the terminus of the contractile vessel; F^2, F^3, and F^4 are attached to the uppermost coil of the ascending intestine; F^5, F^6, F^7, anchor the intestinal spiral farther back. The spindle muscle is not attached posteriorly.

The first coil of the alimentary canal, beyond the end of the contractile vessel, has a ringed structure as if it functioned as a gizzard. The spiral is rather snarled but there are about 36 single coils. Well-developed mesenteries anchor the esophagus laterally to the retractors. A small coecum is present.

The nephridia open on the same level as the anus and are not long, reaching only to the origin of the retractors.

The contractile vessel is a simple blind tube without trace of villi. The brain is relatively large with two conspicuous pigment spots.

Color in alcohol a soft brown, lighter on the introvert.

Type.—U.S.N.M. No. 21214, March 20, 1940, E. F. Ricketts, 1 specimen.

Type locality.—Point Lobos, Espíritu Santo Island, near La Paz, Baja California.

Subgenus THYSANOCARDIA Fisher

Thysanocardia FISHER, 1950a, p. 551. (Type *Phascolosoma procerum* Möbius.)

Diagnosis.—Retractors two; contractile vessel with numerous simple or branched villi; no hooks; nephridiopores always in front of anus. Included species are:

catherinae (F. Müller)
hozawai (Sato)
hyugensis (Sato)
macginitiei Fisher
martensi (Collin)
nigra (Ikeda)
onagawa (Sato)
pavlenkoi? (Ostroumov)
procera (Möbius)
pugettensis Fisher
pyriformis (Lanchester)
semperi (Selenka and de Man)
zenibakensis (Ikeda)

Remarks.—The species of this section of *Golfingia* differ from all others in the possession of numerous villi, or blind tubules, either simple or branched, on the contractile vessel. There are two retractor muscles arising in the posterior third of the trunk. The nephridia always open anterior to the anus. Back of the tentacles is a zone of smooth thin skin bounded by a narrow collar. The skin is usually pale sepia and is provided with darker small cylindrical papillae. There are no hooks on the introvert.

G. pavlenkoi (Ostroumov, 1909, p. 323) probably belongs in this subgenus, as it is stated to be related to *G. semperi* and *G. nigra*. The résumé in German does not mention the villi of the contractile vessel. The introvert is one-and-one-third the length of the trunk; the trunk and introvert are uniformly covered with dark yellow papillae, having a short cylindrical or rounded conical form; no hooks;

two strong ventral retractors springing from anterior border of the posterior third of the trunk; one fixing muscle; two wholly free nephridia.

SYNOPSIS OF SPECIES OF SUBGENUS THYSANOCARDIA

*a*¹. Anus and nephridia do not open on introvert; esophagus lies between the two retractors to which it is attached.
 *b*¹. Introvert long, 2 to 4 times length of trunk.
  *c*¹. Anus spaced from posterior extremity about one-fifth total length;[15] tentacles in 6 to 8 groups, relatively few; villi absent from anterior part of contractile vessel.............**procera** (Möbius), 1875 (p. 402)
  *c*². Anus spaced one-fourth to one-third total length from posterior extremity; tentacles numerous, in more than 8 groups.
   *d*¹. Villi simple, rather sparse, present only on posterior part of contractile vessel, one fixing muscle....................**nigra** (Ikeda), 1904
   *d*². Villi thick, bushy, branched, present throughout entire length of contractile vessel; 2 fixing muscles...**macginitiei**, new species (p. 402)
 *b*². Introvert short, less than twice trunk length.
  c¹. Villi of contractile vessel very short and numerous; no coecum.
   *d*¹. Tentacular crown a simple circle of tentacles.**hyugensis** (Sato), 1934
   *d*². Tentacular crown complex, of many tentacles.
    *e*¹. No fixing muscle.....................**hozawai** (Sato), 1937
    *e*². Two fixing muscles.............**catherinae** (F. Müller), 1867
  *c*². Villi of conspicuous length, sometimes bushy and branched.
   *d*¹. No fixing muscle; a diverticulum at end of esophagus; nephridia very long..................................**martensi** (Collin), 1901
   *d*². One fixing muscle; villi absent from anterior part of contractile vessel.
    *e*¹. Skin papillae visible to naked eye.
     semperi (Selenka and de Man), 1883
    *e*². Skin papillae not visible to naked eye; apparently smooth.
     pugettensis, new species[16]
   *d*³. Three fixing muscles; villi present all along contractile vessel.
    *e*¹. Papillae on introvert-base cylindrical, 0.05 mm. high.
     zenibakensis (Ikeda), 1924
    *e*². Papillae club shaped, 0.12 mm. high........**onagawa** (Sato), 1937
*a*². Anus and nephridia open on base of introvert; esophagus free from retractors but anchored by a fixing muscle, attached posterior to origin of retractors.
  pyriformis (Lanchester), 1905

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[15] This is the proportion given by Théel (1905, p. 71) and the same obtains with my specimens. Gerould (1913, p. 384) studied large specimens from off Marthas Vineyard, Mass. The largest measured 180 mm. total length; trunk behind anus, 75 mm. The introvert (105 mm.) is thus 1.4 the length of trunk, not 2.5 as Gerould states. It seems probable that these specimens are not true *procera*.

[16] GOLFINGIA PUGETTENSIS, new species

Diagnosis.—Nearly related to *G. semperi*, but with very inconspicuous dermal papillae which are not visible without a lens; introvert length of trunk or slightly more, but less than twice length; tentacles very numerous, filiform; papillae tiny, the largest 0.07 mm. long and others much smaller; skin light to dark sepia, finely wrinkled; retractors arising in posterior third of trunk; villi crowded, branched, similar to those of *macginitiei*, but confined to free part of esophagus and extending only a very short distance forward between retractors; a strong fixing muscle anchors posterior end of esophagus to dorsal wall (position of F^2 of *macginitiei*); coecum present; intestinal spiral with at least 48 single coils; nephridia rather short, free, opening in front of anus (distance varying with contraction of longitudinal muscles of body wall).

Color, sepia.

Type.—U.S.N.M. No. 21215, Trevor Kincaid, 8 specimens.

Type locality.—Dogfish Bay, Puget Sound, Wash. Also from San Juan Island, Wash., sandy mud, zero tide, D. L. Ray, 8 specimens.

To see the dermal papillae, a ×10 lens is required, whereas Selenka (1883, p. 9) states that in *semperi* the papillae of the entire body can be seen with the naked eye.

GOLFINGIA PROCERA (Möbius)

Phascolosoma procerum Möbius, 1875, p. 157, pl. 3, figs. 1–5.—Théel, 1905, p. 70 pl. 2, figs. 19–26; pl. 3, figs. 27–28; pl. 12, fig. 190.

Diagnosis.—Small, slender, grayish species with very long, slender introvert and crown of 28 to 40 delicate tentacles in six double rows; anus situated not far from posterior end of body, which often ends in a slender projection; two retractors arising near posterior end of body; posterior part of contractile vessel with numerous simple or bifid villi; nephridia opening in front of anus; one fixing muscle anchoring esophagus to body wall in front of anus; length 40 mm.; anus to posterior end of body 7 mm.; diameter of trunk near posterior end 2 mm.

Description.—The small size and condition of material precludes a full description. Reference should be made to Théel's account (1905, p. 70) and Liljevall's accompanying figures. I have had to depend upon Théel for the number of tentacles. There are possibly eight groups in my specimens. The skin is beset with minute papillae (Théel, fig. 24) capping translucent convexities. The villi are definitely confined to the posterior part of the contractile vessel as in the specimens Théel studied. Théel does not mention the fixing muscle, which is attached to the esophagus farther forward than F^1 in *Golfingia macginitiei*, and to the body wall in front of the anus, not posterior to it. I am not able to find a coecum but Wesenberg-Lund (1939, p. 20) verified its presence in Danish specimens.

Type locality.—Bass Rock, Firth of Forth, Scotland.

Distribution.—North Sea to Danish waters and west coast of Sweden, shallow; Irish waters; off Marthas Vinyard, Mass., 100 to 266 fathoms (see footnote 15).

Specimens examined.—As follows:

Albatross station 4548, Monterey Bay, Calif., 46 to 54 fathoms, coarse sand, shells, rocks, 6 specimens.

Remarks.—It is possible, of course, that these specimens represent a distinct form or race of the North Sea *procera*. More material is needed for a conclusion to be reached.

GOLFINGIA MACGINITIEI, new species

Plate 26

Diagnosis.—Introvert nearly 3 times trunk length; tentacles very numerous in 16 double series; body wall opaque; skin smooth but beset with very numerous minute papillae without differentiation in anal region; retractors attached at beginning of posterior third of trunk; 2 fixing muscles anchoring esophagus dorsally; more than 60 coils in intestinal spire; especially characteristic are dichotomously branched Polian villi in great numbers.

Description.—The introvert is partly invaginated; if fully extended, the animal would measure 92 mm. in total length; anus to posterior extremity 23 mm. or one-fourth total length; greatest width near the posterior end 5.5 mm. The body wall is rather thick, opaque; the skin is very glandular, uniformly smooth in appearance, but thickly beset with minute brown subclavate papillae, slightly larger posteriorly (0.06 mm. high). There is no special zone in the anal region, but about 10 mm. in front of the anus, and anterior to the nephridiopores, the papillae become considerably smaller and more crowded (0.1 mm. apart), one or two occupying a quadrilateral or irregular area defined by slight creases of the cuticle. Such areas are also to be seen on the trunk, where the papillae usually have a light circular zone at base, becoming transversely elliptical in front of the anus. In addition to the papillae, numerous skin glands open flush with the surface of the cuticle, the pores being of 2 or 3 sizes. Within a square, the sides of which are 0.5 mm., about 25 of these pores are present, and at each corner is a papilla.

Back of the tentacles is a zone of purple skin, free from papillae, the posterior border plicated. The tentacular crown is more voluminous than in such species as *G. gouldii*, although arranged on the same general plan of double series joined by a fold of tissue at the outer edge of the oral disk. There are 16 of these double series, each comprising about 40 tentacles 0.6 to 0.8 mm. long, with the exception of the middorsal double series. This extends nearly to the mouth, forming a loop to enclose the lanceolate nuchal organ. The extended part of this double series carries about 10 extra shorter nuchal tentacles.

The longitudinal muscle layer is smooth, lustrous, undivided. Retractors two, arising about two-thirds the distance from the anus to the posterior extremity. The base is broad, emarginated, and divided by a deep notch into two parts. The spindle muscle is unattached posteriorly. Fixing muscles F^1 and F^2 anchor the esophagus to the body wall. Nephridia short, opening 4 mm. in front of anus. The rectum has a well-developed coecum. The intestinal spiral is relatively large, comprising 68 single coils.

The contractile vessel accompanies the esophagus to the intestinal spiral and throughout its entire length is provided on each side with Polian villi of characteristic form and arrangement. Just back of the head for a short distance these villi are short, simple, cylindrical, blind tubules. Soon they are bifid at the tip and increase in number until the esophagus leaves the retractor muscles. Then they begin to branch dichotomously twice, then three or four times, and become aggregated in bunches (pl. 26, fig. 5), the branched villi being 0.5 to 0.8 mm. long. These clusters form dense masses along each side of the free esophagus between the retractors and the intestinal spiral.

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The vessel and villi are pale orange and are packed with hemispherical corpuscles, 0.01 mm. in diameter, having one side invaginated.

Type.—U.S.N.M. No. 21223, sandspit, in *Zostera*, January 1930, G. E. MacGinitie.

Type locality.—Newport Bay, Orange County, Calif.

Genus DENDROSTOMUM Grube

Dendrostomum Grube, *in* Grube and Oersted, 1859, p. 118.

Dendrostoma Keferstein, 1865a, p. 207 (emendation of *Dendrostomum*).—Authors since 1865.

Diagnosis.—Distinguishable from other sipunculoids by their four to eight conspicuous, often several times dichotomously branched, grooved tentacles, which carry numerous small tentacules, pinnately or palmately arranged. Oral disk with four primary food grooves, which branch to the tentacles; inner longitudinal muscle layer of body wall continuous, not separated into bands; usually two retractor muscles; a strong spindle muscle attached near anus but not posteriorly; typically three fixing muscles or intestinal anchors; two nephridia not anchored by mesentery; contractile vessel with a few to very many, long or short Polian tubules; hooks or spines on introvert present or absent.

Remarks.—The California Dendrostoma are all large species, and with the exception of *hexadactylum* are found between tide marks. *D. pyroides* lives by preference and attains greatest size in clefts of rocks, especially granite, where it apparently maintains a permanent residence, retreating far from the surface when the tide is out. *D. perimeces*, the longest of all, is an estuarine form dwelling in muddy sand. It also lives off shore in deeper than intertidal water. *D. zostericolum* is found among eelgrass roots and in sandy mud among rocks, in bays, and on the open coast. *D. dyscritum* has been encountered on the open coast in fissures of rock where mud and sand can accumulate and where the deeper parts may be black from sulphur compounds. It also occurs off shore.

It is difficult to describe the shape of these animals since, when alive, they can stretch their bodies to an astonishing degree. Even when killed "extended," with tentacles expanded, there is much variation. However, such species as *zostericolum* and *perimeces* are obviously longer than the others and assume a more cylindrical form when carefully killed, while *pyroides* and *dyscritum* are likely to be swollen posteriorly and hence are more pyriform.

The California species have bushy tentacles, branched dichotomously several times, although the branches of such dichotomy are not necessarily equal. A typical crown, drawn from life, is shown on plate 28, figure 1. In some extralimital species, e. g., *D. blandum*, the tentacles are simpler. Each of the four primary tentacles divides into two elongate branches, along the sides of which the tentacules are arranged pinnately.

Most of the species I have examined have three or four short transverse muscle bands in front of the nephridia.

Under existing rules of nomenclature the correct name of this genus is not *Dendrostoma*, which is an emendation of Grube's earlier *Dendrostomum*.

KEY TO KNOWN SPECIES OF DENDROSTOMUM

a^1. Hooks or spines on introvert, or at its base; two retractor muscles.
  b^1. Polian tubules very long.
    c^1. Tentacles arising from 4 stems, branching dichotomously several times. **pyroides** Chamberlin
    c^2. Tentacles arising from 4 stems, each with 2 branches along which the ultimate tentacules are arranged pinnately; introvert papillae inconspicuous ---------- **blandum** Selenka and de Man
    c^3. Tentacles 4, somewhat palmate, divided into 2 or 3 stems, along which the ultimate tentacules are arranged; 6 tentacles according to Gerould, 1913 ---------- **alutaceum** Grube
    c^4. Tentacles 6 ---------- **hexadactylum** Sato
    c^5. Tentacles 8, divided each into 2 near base; spines at base of introvert only ---------- **spinifer** Sluiter
  b^2. Polian tubules very short.
    c^1. Polian tubules unbranched; tentacles 4; hooks 50± ---------- **minor** Ikeda
    c^2. Polian tubules branched; tentacles 5 or 6; hooks few. **signifer** var., Selenka and de Man
a^2. Hooks on introvert; 4 retractors; 6 tentacles ---------- **pinnifolium** Keferstein
a^3. No hooks on introvert; 2 retractors.
  b^1. Anus and nephridiopores on nearly same level.
    c^1. Polian tubules very long; 6 tentacles.
      d^1. Esophagus with numerous pointed protuberances on its wall arranged in long series; 4 intestinal fixing muscles; small species. **peruvianum** Collin
      d^2. Esophagus without pointed protuberances, fixing muscles 3 or less; large slender species.
        e^1. Intestinal spiral of moderate length, with less than 50 coils (usually 15 or 16 double coils); fixing muscles present; Polian tubules more than 10.
          f^1. Fixing muscle F^2 attached to postesophageal intestine; retractors attached one-fourth to one-third body length from end. **zostericolum** Chamberlin
          f^2. Fixing muscle F^2 attached to intestine; retractors attached one-fifth to one-sixth body length from end. **dyscritum**, new species
        e^2. Intestinal spiral very long with upward of 100 coils; fixing muscles usually absent; Polian tubules 9 or 10 ---------- **perimeces** Fisher
    c^2. Polian tubules very short.
      d^1. Tentacles 4; Polian tubules unbranched.
        e^1. With elliptical glands ---------- **ellipticum** Sato
        e^2. With circular glands ---------- **tropicum** Sato
      d^2. Tentacles 5 or 6; Polian tubules branched. **signifer** Selenka and de Man

b^2. Nephridiopores well spaced behind anus.

c^1. Polian tubules very long; retractors arise posteriorly.

d^1. Size small; gonads on surface of retractors near their origin; F^2 attached to intestine only ---------------------- **lissum**, new species

d^2. Size large; gonad on body wall just back of origin of retractors; F^2 anchors both intestine and postesophageal gut.
schmitti, new species

c^2. Polian tubules short; retractors arise in middle region of body; size large (230 mm. in length) ---------------------- **dehamata** Kesteven

a^4. No hooks on introvert; 4 retractors; tentacles ?; contractile "vessel bears a band of very short contractile villi" ---------------- **stephensoni** Stephen

KEY TO SPECIES OF DENDROSTOMUM DESCRIBED IN THIS PAPER

a^1. Hooks or spinelets on introvert.

b^1. Tentacles arising from 4 roots; hooks smaller; fixing muscle F^2 attached to postesophageal intestine -------------- **pyroides** Chamberlin (p. 406)

b^2. Tentacles arising from 6 roots, hooks larger; fixing muscle F^2 with one branch to postesophagus, the other to intestine, or to intestine only.
hexadactylum Sato (p. 410)

a^2. Hooks absent from introvert.

b^1. Anus and nephridiopores on nearly same level; tentacles 6; upper lip larger than the other three; nuchal organ not longer than wide.

c^1. Intestinal spiral of moderate length with less than 50 coils; fixing muscles of alimentary canal present; skin glands of approximately same size.

d^1. Fixing muscle F^2 attached to postesophagus; retractors attached one-fourth to one-third body length from posterior end; nuchal organ wider than long --------- **zostericolum** Chamberlin (p. 411)

d^2. Fixing muscle F^2 attached to intestine; retractors attached one-fifth to one-sixth body length from end; nuchal organ not obviously wider than long ----------------- **dyscritum**, new species (p. 417)

c^2. Intestinal spiral very long with upward of 100 coils; fixing muscles usually absent; skin glands of two or three sizes.
perimeces Fisher (p. 415)

b^2. Nephridiopores well spaced behind anus; tentacles 4; upper lip not conspicuously larger than others; nuchal organ longer than wide.

c^1. Size small; gonad on surface of retractors near origin; dorsal tentacles not conspicuously smaller than others; fixing muscle F^2 attached to intestine ---------------------------- **lissum**, new species (p. 419)

c^2. Size large; gonad on body wall just back of origin of retractors; F^2 anchors both the postesophagus and intestine with branches to each; dorsal tentacles much smaller than the others.
schmitti, new species (p. 422)

DENDROSTOMUM PYROIDES Chamberlin

PLATE 27, FIGURES 1, 2; PLATE 28, FIGURE 2; PLATE 29

Dendrostoma pyroides CHAMBERLIN, 1919, p. 31.

Dendrostoma petraeum FISHER, 1928, p. 195, pl. 6, figs. 1, 1a, 1b, 2; pl. 7, fig. 2; pl. 8, figs. 1, 1a.

Dendrostoma blandum SATO, 1930, p. 27; 1939, p. 412.

Diagnosis.—Typically a large, elongate-pyriform species with smooth skin and a zone of from few to many small, usually curved, dark-brown thorns occupying middle third of introvert, which is about one-third to one-half body length, depending upon degree of contraction; smooth zone back of tentacles broad, one-fourth to one-third of introvert, reddish brown to purple; no prominent papillae anywhere; tentacular crown strictly dendritic, starting with four major stems, each of which almost immediately divides into two or three branches, and these into others, the crown increasing in complexity with increasing size of animal; dorsal blood vessel with a network of accessory vessels and with numerous, sometimes branched, long blind Polian tubules.

Description.—This is one of the chunky pear-shaped Dendrostoma, apparently larger in central California than south of Point Conception. Ordinarily large specimens attain 120 mm., exclusive of tentacles, but these are small in comparison to an example collected at Bodega Head by Dr. D. M. Wootton. When alive, this giant was 195 mm. long, the introvert alone 50 mm.; thickness of trunk 30 mm.; of introvert 15 mm. The introvert is cylindrical, the anterior fourth to third a reddish brown to purplish glossy zone, marked by fine circular creases; at the posterior border of this collar is a strong sphincter sometimes indicated by a constriction and a narrow purple zone in preserved specimens. Immediately behind this the middle third of the introvert is occupied by dark brown, well spaced, prominent curved spines, directed posteriorly, their bases varying from 0.17 to 0.25 mm. in diameter, and their length from anterior edge of base 0.17 to 0.35 mm. Generally, the smaller the specimen the fewer the hooks. Basal third of the introvert is smooth; the surface of the trunk is superficially smooth, very finely and evenly peppered with minute brown spots of two or three sizes (0.07 to 0.1 mm. diameter) which are sometimes tiny eminences. These extend forward as far as the anterior border of the hook zone, but on the introvert are usually colorless.

Tentacles highly dendritic. Four food grooves lead from the mouth to as many groups of tentacles; each group consists of two main stems, between which a shorter branch sometimes assumes the proportions of a major division. Basically there are four tentacles, which by division close to base give the appearance of eight or nine. The tentacles do not give off secondary dendritic branches near the base as do those of *zostericolum*. Instead, the thin mobile margin of the groove, below the main branches, is produced at intervals into a few slender processes. A specimen 40 mm. long, from Ensenada, has the following number of terminal *branchlets* (bearing the ultimate tentacular elements): dorsal tentacles, 32 and 30; ventral, 26, 14. In big specimens the branchlets are much more numerous.

The two large retractors have their origin in a wide straight attachment at the middle of the posterior third of the body, the inner border of the muscle arising close to the nerve cord; anteriorly they do not join until close to the head. The spindle muscle, inserted in the body wall dorsally just behind the anus, is free for a short distance and then is fused to the gut wall as far as the coecum, beyond which its attachment to the ascending spiral is by short muscular frenula. The descending spiral from the esophagus is attached to the ascending gut. Fixing muscles F^1, F^2, F^3 are rather similar to those of *zostericolum;* F^2 sometimes consists of three strands arising from the same point, or it starts as a single muscle and divides into two or three.

A slight constriction of the gut just posterior to the attachment of F^1 probably marks the end of the esophagus. In a large specimen there are about 30 coils of the intestine (15 or 16 double coils). Along the ascending gut is a conspicuous ciliated groove, terminating at the coecum.

The nephridia are free, very long, and attached to the body wall slightly behind the anus. They may reach to the posterior end of the body.

The contractile vessel gives off dorsolaterally numerous anastomosing branches, which form a network enclosing the esophagus, becoming more complex posteriorly. Usually a *midventral* vessel leaves this complex and runs far forward. For a short distance at the posterior end of this net, numerous long, blind, often spirally coiled tubules are given off from the dorsal vessel and also from some of the laterals. Some of these branch near their base (pl. 29, fig. 3).

Color in life: Ground color pale buffy, suffused with pale or warm sepia, some examples decidedly dark at posterior end, collar pale Hays maroon, madder brown, or liver brown (Ridgway's Color Standards and Nomenclature, pls. 13 and 14); main stem of tentacles the same; branchlets and tips pale yellow, sometimes mottled with madder. In alcohol, paler, the sphincter anterior to the zone of the hooks becoming bluish or purplish. Some of the specimens from Baja California are deeper, ruddy brown with rough skin and reddish brown tentacles. The very large specimen from Bodega Head, Calif., was ochraceous-tawny on the trunk becoming paler on the introvert.

Young.—Up to about 18 mm. in length this species has no hooks or spinelets on the introvert. In a considerable series there is a well-expanded example 18 mm. long with four hooks well forward on the introvert, placed symmetrically, two on each side of middorsal line. A wide zone in front of and including anus is spotted with well-spaced, low, brownish glands of conspicuous size; behind this zone the spots are very much smaller and closer together. In front of the anal zone the glands are paler than the skin and transversely elongated. General color, bleached sepia. Another specimen, about the same length, has the anal zone a warm brown, which is characteristic of most of the young specimens with or without spines. The tentacles, already voluminous, more obviously number four than they do in adults. Each tentacle has two or three branchlets bearing the ultimate tentacules. Another specimen, only slightly longer, has 18 hooks in about 5 spaced groups. A 24-mm. specimen has more than 50 hooks.

In the above lot there are 12 specimens, measuring from 9 to 18 mm., which have no hooks, but have four tentacles and body markings the same as the young with hooks.

Type.—Originally in the Museum of Comparative Zoology but no longer in existence.

Type locality.—Laguna Beach, Orange County, Calif.

Distribution.—From Coos Bay, Oreg., to San Quintín, Baja California.

Specimens examined.—As follows:

Coos Bay (North Bay), Oreg., eelgrass roots, July 26, 1949, D. L. Reish, 2 specimens.

Crescent City, Calif., June 11, 1913, W. F. Thompson, 2 specimens (body cavity full of eggs).

Bodega Head, Calif., in sand under rock, Aug. 4, 1948, D. M. Wootton, 1 specimen.

Tomales Point, Marin County, Calif., 1939, E. F. Ricketts, 5 specimens.

Monterey Bay, Calif. (vicinity of Pacific Grove), intertidal, granitic rocks, numerous specimens.

Santa Rosa Island, Calif., southeast Sandy Point, in rock, January 27, 1949, D. M. Wootton, 1 specimen.

San Clemente Island, Calif., June 20, 1896, H. B. Torrey, 3 specimens.

Ensenada and Boca del Playa, Baja California, E. F. Ricketts, 7 specimens.

San Quintín, Baja California, March 1949, Patrick Wells, 3 small specimens.

Remarks.—In the Monterey Bay region this species spawns during the latter part of February and early March at the same time as *D. dyscritum.*

This is probably the species upon which Sato (1930, p. 27) bases his California record of *D. blandum*, which is a comparatively small animal (upward of 50 mm.). The tentacles (Sato, 1930, fig. 10, p. 24) are much simpler than those of *pyroides*. The four primary trunks divide at once to form eight subequal tentacles. The ultimate tentacules are arranged pinnately along both sides of each of these arms in a single series. Sometimes there is an extra smaller branch between two principal branches. Such tentacles are not dendritic. The fixing muscles have a different arrangement: F^1 is where F^2 is in *pyroides;* F^2 seems to be attached to the intestine or the end of the rectum at about the position of coecum, which is lacking in *blandum.* F^3 is about the same as in *pyroides.*

DENDROSTOMUM HEXADACTYLUM Sato

PLATE 30, FIGURE 2

Dendrostoma hexadactylum SATO, 1930, p. 28, figs. 13–15; pl. 4, figs. 20–24; 1937, p. 162, pl. 4, fig. 17; 1939, p. 412.

Diagnosis.—In general appearance closely resembling *Dendrostomum pyroides;* differing in having six tentacles and larger and more numerous introvert hooks, among which are very numerous and very small upright cylindrical papillae.

Description.—The only available large specimen, at maximum contraction, is 60 mm. long. It was found by E. F. Ricketts on the beach at Monterey, Calif., during a heavy storm (January 7, 8, 1939) and was taken from a fragment of gray shale rock along with boring clams. The hooks are fully twice as numerous as in a *Dendrostomum pyroides* of equal size and are obviously larger. The largest are situated anteriorly, next to the smooth collar, and measure 0.5 to 0.68 mm. in length by 0.3 to 0.4 mm. in diameter at base. The numerous cylindrical papillae, without constricted base, are about 0.1 mm. high and are scattered thickly among the spines. Posterior to the zone of spines they flatten into ellipsoids with convex center, are close together, and often occupy a quadrilateral area defined by five creases in the cuticle. At posterior end of the body certain of them become low papilliform; possibly all are so in life. The major axis of the flattish papillae in Sato's types varied from 0.06 to 0.107 mm.; the minor, from 0.05 to 0.105 mm. In my specimen, which is larger than any of Sato's, the papillae are a little larger.

The tentacles spring from 6 roots, which branch either twice or three times near the base so that the count of tentacular arms is likely to exceed 12. The branching is similar to that of *D. zostericolum.* The internal anatomy resembles that of *D. pyroides*, with the following important exceptions: Fixing muscle 1 is not so far forward (between F^1 and F^2 of *pyroides*); F^2 is nearer the intestinal spiral and usually has 2 terminal branches, one attached to postesophagus, the other to ascending spiral of intestine well back of the coecum; F^3 is attached to intestine posterior to F^2 branch. The contractile blood vessel lacks the elaborate network of the vessels surrounding the esophagus, although there are a few small collateral loops; but the long Polian tubules are more numerous and, instead of branching off toward the distal end of the main vessel as in *pyroides*, arise all along each side from a point in front of the lateral mesenteries of the esophagus. Some of them branch near the base. The origin of the retractors is straighter than in *pyroides* and the gonad is on the muscles rather than on the body wall.

In front of the anterior end of the nephridia are four short, transverse, parallel muscles, resembling low dissepiments, mentioned by Sato. They occur also in *Dendrostomum pyroides.* The posterior merges with the wing muscles.

The nephridia are relatively longer (40 mm.) than in Sato's figure, reaching nearly to base of the retractors. Only 15 mm. of the left nephridium remains in place; the terminal 25 mm. was floating free. The ruptured end of each part was perfectly healed.

Type locality.—Mutsu Bay, northern Honshu, Japan.

Distribution.—Northeastern Honshu; Monterey Bay, Calif.

Specimens examined.—As follows:

Monterey Bay, Calif., 1 large specimen from shallow water, which evidently lived in a cavity excavated by boring mollusks in gray shale, E. F. Ricketts.
Northeast of Monterey, Calif., 15 to 20 fathoms, G. E. MacGinitie, 1 specimen.
Albatross station 4496, 2.1 miles off Santa Cruz, Calif., 10 fathoms, rocky bottom with fine sand, 4 specimens.

Remarks.—Sato (1937, p. 163) reported specimens from Takada, Iwati Province, measuring upward of 180 mm. long and 18 mm. in diameter. In Japan it is found between tide marks.

DENDROSTOMUM ZOSTERICOLUM Chamberlin

FIGURE 87, A; PLATE 30, FIGURE 1; PLATES 31, 32

Dendrostoma zostericola CHAMBERLIN, 1919, p. 30.—PEEBLES and FOX, 1933, p. 201, figs. 1–11.
Dendrostoma mytheca CHAMBERLIN, 1919, p. 30.

Diagnosis.—Tentacles six, branching profusely, either one or both dorsals usually smaller than the others; body long and slender, usually broadest posteriorly, the posterior end rounded to bluntly pointed; some specimens, especially those fixed in formalin and with introvert retracted, may be just the opposite: broadest anteriorly, slender and elongated posteriorly. Introvert relatively short, with scattered tiny clavate papillae, which decrease in size toward broad, smooth zone behind tentacles; no hooks on introvert; skin rather smooth, the postanal region uniformly peppered with very tiny brown glands, which in anal zone gradually lengthen into the papillae of introvert; nephridia very long, opening close behind anus; dorsal contractile vessel with 10 to 12 very long terminal branches. Related to *Dendrostomum peruvianum* Collin.

Description.—This species is one of the long, cylindrical Dendrostoma, in which the length increases over the breadth as the animal grows to large size. The largest preserved specimen (Point Conception) is 245 mm. to base of tentacles; introvert (anus to base of tentacles) 30 mm.; thickness of trunk, 10 mm. The introvert however is contracted and unnaturally short. The more usual proportion of the introvert to total length is about one-fifth, as in examples around 150 mm. in length. The bare zone at anterior end of the introvert occupies one-fourth to one-third total length of latter, again depending upon the condition of the specimen.

The tentacles usually branch into two main stems near the base, and continue to add branches with age, but the tentacles are often asymmetrical in size. Numerous specimens have the two dorsals conspicuously smaller than the others, or one small and one large dorsal. With the above condition, any one or two other tentacles may be smaller than normal size. The figure of oral disk (pl. 30, fig. 1) shows the primitive condition of four food grooves leading from mouth, and how the original two dorsal tentacles were converted to four, producing a dorsoventral asymmetry. Just back of the upper flange of upper lip is a conspicuous nuchal organ, which is broader than long, with shallow longitudinal furrows. At its anterior margin is a crescentic slit, between which and the lip flange is a ridge connecting the bases of the two dorsal tentacles.

The skin papillae of the introvert are rather thick clavate, unequal, the largest (0.135 mm. long) being at the base of the introvert, whence they decrease in size toward the anterior smooth zone. Posterior to the anus they very rapidly decrease in size to the dark brown, only slightly convex, specks rather evenly and closely scattered over the rest of the body. These are 0.04 to 0.07 mm. in diameter and, like the papillae, have a central aperture (pl. 31, fig. 4.).

The essential features of internal anatomy are shown in the figures. The muscles have a satiny luster and the inner thin longitudinal layer is transversely crinkled like silk. Between the circular and longitudinal layers are narrow bands of oblique fibers, which are more conspicuous in small than in fully grown specimens. They do not extend in front of the anus, are irregularly spaced, and not bilaterally symmetrical. In a small specimen 11 could be counted on one side of the body. Peebles and Fox (1933), refer to these as "the so-called veins." The fibers are easily demonstrated. The two long retractors do not join until a short distance behind the head. Rarely one of the retractors is split in two. The distance between the posterior end of the retractors and the end of the body varies; in well relaxed specimens it is one-fourth the body length, or a little more. But in the big specimen from Point Conception the distance is a little over one-third the body length.

Characteristic are fixing muscles F^1, F^2, F^3. F^1 is attached to ventral surface of esophagus, posterior to end of contractile vessel, and passes backward to dorsal body wall. F^2 leaves the postesophageal gut at the top of the spiral, while F^3 anchors the ascending intestine posterior to the coecum. But either F^2 or F^3 is sometimes absent—

FIGURE 87.—Demonstrating attachment of fixing muscles, or intestinal anchors, in three species of *Dendrostomum:* A, *Dendrostomum zostericolum.* B–E, *D .dyscritum:* B, Specimen from Crescent City, Calif.; C, specimen from Crescent City that lacks F^1 and has abnormal attachment F^2 (right nephridium is anchored to spindle muscle); D, specimen from Pillar Point, San Mateo County, Calif. (F^1 is displaced; F^2 has two strands); E, specimen from Monterey Bay (one strand of F^2 sends two branches to postesophagus. F, *D. schmitti*, paratype from Independencia Bay, Peru (F^2 is divided equally between postesophagus and ascending gut.

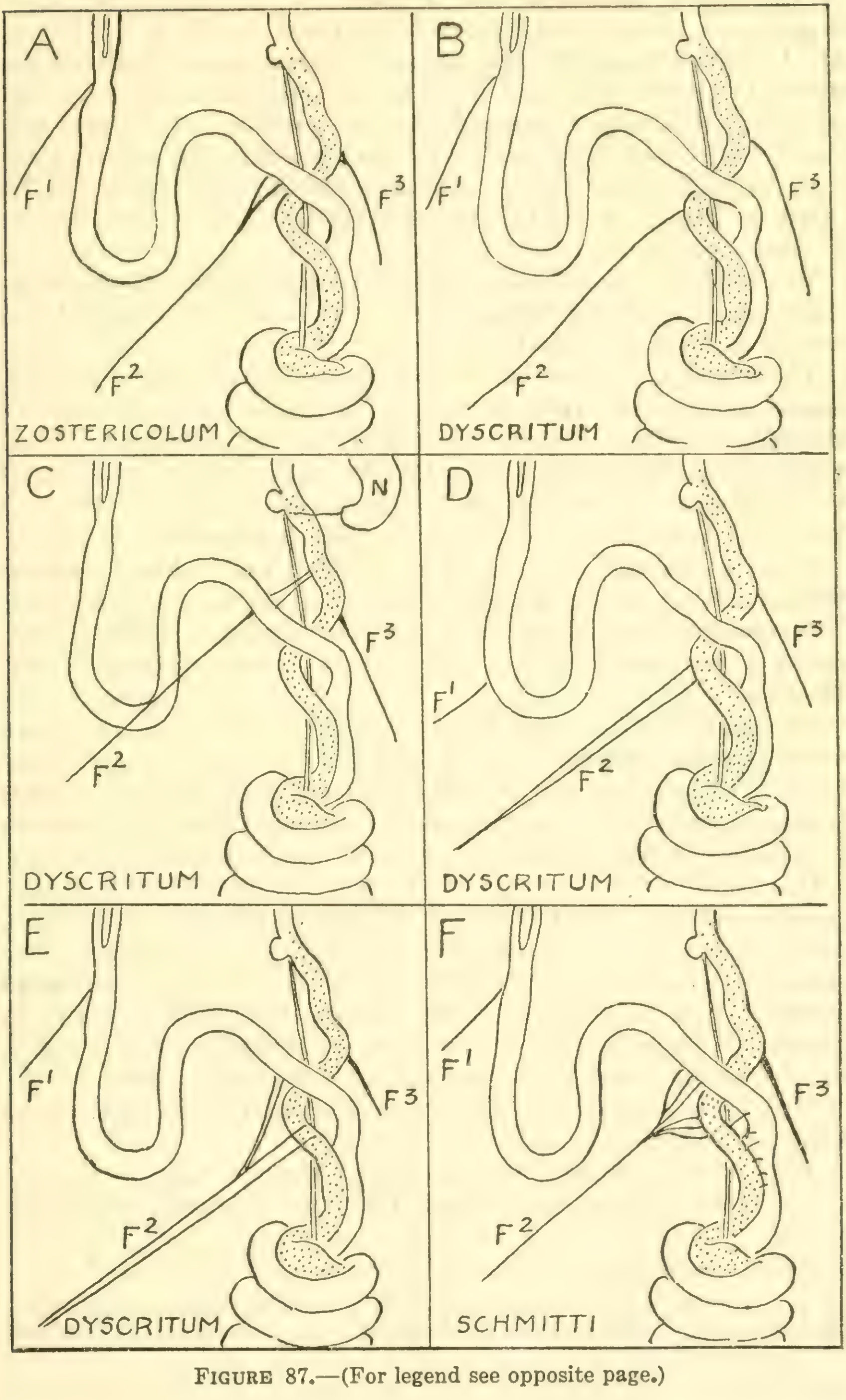

FIGURE 87.—(For legend see opposite page.)

in the largest specimen both F^2 and F^3. Apparently F^2 never anchors the ascending intestine as in *dyscritum* (fig. 87, A, B). There are between 20 and 30 coils in the intestinal spire. Between the point of insertion of F^1 and F^2 on the postesophageal gut very tiny pointed protuberances, resembling conical papillae, may be seen in a small minority of specimens. These are probably rudiments of the more prominent and longiserially arranged structures which Collin (1892, p. 180, pl. 11, fig. 13) cites as being especially characteristic of *D. peruvianum*.

The nephridia are slender, free, and very long in all specimens dissected. In natural position the nephrostome opens forward and toward the dorsal median line.

The contractile vessel (pl. 31, fig. 2) gives off on each side a collateral small vessel, which forms a series of loops along the side of the main vessel and continues posteriorly on the esophagus. These vessels do not ordinarily form a vascular net on the ventral side of the esophagus. Terminally the contractile vessel gives off 10 to 13 very long slender blind tubules, one of which is median.

In all specimens examined, most of which were taken in winter, the gonads are slender transverse bands at the base of retractors. The secondary gonads described by Peebles and Fox (1933, p. 205, figs. 5, 6) have not been observed. Eggs in coelom observed August 10, 1948.

The brain is situated slightly forward of the nuchal organ, therefore under the ridge of tissue connecting the bases of the two dorsal tentacles. The anterior border is deeply notched and a tiny eye spot is present on each side near the anterior margin. When the introvert is retracted the brain is beneath a tough sheath of the united retractors.

Color in life: "The ground color is deep buff marked by dark gray grooves and lines, most of which are due to wrinkles produced in contraction. The collar is smooth and whitish in appearance. The conspicuous arborescent tentacles vary in color from pale yellow to brown, red, or dark purple." (Peebles and Fox, 1933, p. 202.) In alcohol the color is pale brown, dark on contracted area, with a definite brown zone at anus; in formalin it is usually reddish brown.

Type.—Formerly in the Museum of Comparative Zoology but no longer in existence.

Type locality.—Laguna Beach, Orange County, Calif.

Distribution.—Point Conception, Calif., to Ensenada, Baja California.

Specimens examined.—From California:

Near Point Conception, intertidal, July 14, 1916, C. L. Hubbs, 2 specimens.

Santa Rosa Island (Beechers Bay and mouth of Gavanon Canyon), Aug. 10, 1948 (eggs), D. M. Wootton, 2 specimens.

Santa Barbara, tidal sand at Hendys Beach, Patrick H. Wells, 8 specimens.

San Clemente Island, June 20, 1896, H. B. Torrey, 3 specimens.

Newport Bay, in sand under rocks, January–February 1930, G. E. MacGinitie, 9 specimens.

Newport Bay, Corona del Mar, open rocky shore under rocks, Jan. 5, 1936, 1 specimen.

Anaheim Slough, Oct. 12, 1932, G. E. MacGinitie, 4 specimens.

La Jolla (Bird Rock), Earl H. Myers, 4 specimens.

San Diego, E. C. Starks, 2 specimens.

From Baja California:

Ensenada, among eelgrass roots; in gravel and sand under boulders; rocky tide flats, in sandy mud at lowest part of intertidal zone; midwinter, G. E. MacGinitie and E. F. Ricketts, 117 specimens.

Remarks.—The species is probably the North American equivalent of *Dendrostomum peruvianum* Collin (1892, p. 179, pl. 11, figs 7 and 13), Callao, Peru. The two types were only 25 and 30 mm. long; tentacles four, and esophagus posterior to the end of the contractile vessel carries relatively conspicuous slender protuberances arranged in longiseries. The nephridia are short. Fixing muscles F^1, F^2 and F^3 are essentially as in *zostericolum*, but there is an F^4 attached to the gut spiral back of F^3. The dermal glands are similar to those of *D. zostericolum* in being low papilliform on the introvert. Further study of *peruvianum* will possibly change the tentacle count from four to six. In my small *zostericolum* the two smaller dorsals can be considered branches of the adjacent larger tentacles, which would give a count of four primaries. *D. zostericolum* does not possess at any age an F^4 fixing muscle or *prominent* protuberances on the postesophagus. The nephridia in extended young specimens are long, reaching to the origin of the long retractors.

Dendrostoma mytheca was based on a 20-mm. specimen from Laguna Beach that is no longer in existence. The trunk measured 12 mm., introvert 8 mm. The body was widest at the posterior end. The principal characteristic is a "band of abruptly much larger tubercles about the base of the introvert, distad of which region they become again abruptly smaller"; the number of tentacles was not given. This may well have been a young *Dendrostomum zostericolum*, most of which have the enlarged glands, or even an immature *pyroides* (without hooks), which has a zone of larger brown glands at the anus.

DENDROSTOMUM PERIMECES Fisher

PLATE 27, FIGURE 3; PLATE 28, FIGURE 1; PLATE 30, FIGURE 4; PLATE 33

Dendrostoma perimeces FISHER, 1928, p. 196, pl. 6, figs. 3, 3*a*; pl. 7, fig. 1; pl. 8, figs. 2, 2*a*.

Diagnosis.—Very long and slender; tentacles six, bushy; no hooks on introvert. Similar in general habit to *Dendrostomum zostericolum*, but even longer; differing in having more numerous introvert papillae, which do not thin out forward and do not diminish so conspicuously in size; body glands convex, of two or three sizes; collar not obviously reddish or purplish; fewer (6 to 9) Polian tubules at end of contractile vessel; nephridia shorter; alimentary canal much longer, the spire consisting of upward of 100 coils.

Description—This is a larger species, adult specimens from the type locality being 150 to 260 mm. long, while one from Tomales Bay measures 320 mm. and must have been considerably longer when living. The body is very slender, cylindrical, tapering very gradually to the rounded or bluntly pointed posterior end. The greatest width of fully extended living specimens is one-twelfth to one-twenty-fifth the total length—usually nearer one-twentieth. The introvert is cylindrical, its length about one-sixth to one-seventh the total length; the anterior fifth of the introvert is a glossy brown collar or zone, marked by fine creases. This collar is followed by a smooth, not so broad whitish zone. Back of this the skin is pale sepia thickly peppered with tiny dark-brown papillae, which are more numerous than in *Dendrostomum zostericolum*, especially anteriorly (pl. 27, fig. 3, *a*). Posterior to the anus these are replaced by strongly convex brown glands or low protuberances, generally of three sizes, from 0.04 to 0.1 mm. diameter. When the skin is stretched, very small, inconspicuous subquadrate areas can be discerned, with one of these glands to an area. The tentacles are similar to those of *zostericolum*, bushy in large specimens, and one or both of the dorsal tentacles are smaller than the others. In the very large Tomales Bay animal, with well-expanded tentacles, both dorsals are conspicuously smaller than the others. The nuchal organ is broader than long, the surface is furrowed and the anterior margin is hidden by a broad crescentic slit.

The longitudinal muscle layer is satiny smooth and the oblique bands of muscle between it and the circular layer are more conspicuous than in large examples of *D. zostericolum*. The two large retractors are impressively long and have their origin at the beginning of the posterior fifth of the body. The line of attachment is either concave or straight. The spindle muscle is attached as in *zostericolum*, but is longer in accordance with the greatly lengthened intestine. Fixing muscle F^1 seems not to be always present and F^2 and F^3 are absent.

Perhaps the most conspicuous difference between the two species is the much longer intestine of *D. perimeces*. In a specimen that is by no means the largest, there are about 100 single coils in the spiral, while in *D. zostericolum* there are less than half as many.

The contractile vessel terminally has six to nine blind tubules. Branches from the collateral vessels pass along the ventral side of the esophagus and sometimes anastomose, but do not form a network.

The nephridia are similar to those of *D. zostericolum* but allowing for variation are definitely shorter than in that species. The nephrostome opens directly forward.

The brain is similar to that of *zostericolum* but of a slightly different form, the anteroposterior dimension being greater. The eye spots are very tiny.

Color in life, light dull sepia (pale grayish brown), darkest on introvert; anterior collar of introvert brown, sometimes slightly ruddy; tentacles pale olive green or brown, sometimes whitish on sides opposite grooves.

Type.—U.S.N.M. No. 19615.

Type locality.—Elkhorn Slough, a tributary of Monterey Bay, Calif. In sandy mud, among *Zostera.*

Distribution.—Known only from California, intertidal and shallow water, Bodega Head to Venice. Probably south of Monterey Bay the species is found only off shore.

Specimens examined.—From California:

Elkhorn Slough, Monterey Bay, G. E. MacGinitie, 12 specimens.

Tomales Bay, tide flats about 1 mile south of mouth, secured while collector was digging for gaper clam, *Schizothaerus nuttalli*, Aug. 26, 1941, S. F. Light, 1 specimen.

Bodega Head, sand, D. M. Wootton, 1 specimen.

Off Venice, shallow water, sandy mud, M. W. de Laubenfels, 3 specimens.

Young specimen.—Length 49 mm. None of the fixing muscles are present; nephridia 9 mm.; contractile vessel with 6 Polian tubules; intestinal spiral with 60 coils; oblique muscle bands very inconspicuous. In small *zostericolum* the fixing muscles are strongly developed, the nephridia are one-half to three-fourths the length of the fully extended specimen, the contractile vessel has 10 tubules, and the oblique muscle bands are more conspicuous than in adult.

Specimens from off Venice, Calif.—Dr. M. W. de Laubenfels collected 3 specimens that were washed up on the beach during a storm. These had been roughly used by waves and unnaturally lengthened. They measure 480, 620, and 660 mm. long, the posterior part being very attenuate. Even so the nerve cord of the shortest was not broken. The retractors of this specimen are 320 mm. long. From the introvert papillae and the few (9 or 10) Polian tubules at end of the contractile vessel, I have identified these specimens as *perimeces.* In the smallest, least mutilated specimen the tenacular crown is voluminous. The introvert at the collar is 10 mm. thick, which is about twice that of the type, and the same dimension as in the large Tomales Bay specimen. It is safe to estimate this specimen as having a length of about 350 mm. when naturally relaxed.

DENDROSTOMUM DYSCRITUM, new species

FIGURE 87, B–E; PLATE 30, FIGURE 3; PLATE 34

Diagnosis.—Differing from *Dendrostomum zostericolum* in having a shorter, thicker body, about three times length of introvert, fusiform to subpyriform; retractor muscles attached to body wall a little less to a little more than five-sixths total length from mouth; fixing muscle F^2 attached to ascending intestine behind F^3 with sometimes a subsidiary branch to postesophagus; Polian tubules more numerous. Tentacles six, the two dorsals shorter than the others. Length upward of 170 mm.

Description.—It is difficult to state any external characters by which specimens of *dyscritum* may be distinguished easily from *zostericolum*, other than the shorter trunk. The body is peppered with small, rather uniform, circular, convex, light-brown or dark-brown glands, 0.08 to 0.1 mm. in diameter, and situated about 0.5 mm. apart on body and 0.25 mm. on introvert. They are thus larger than in *zostericolum* and the border of each gland is more sharply defined. On the introvert they lengthen to low papilliform and extend to the red collar, which is smooth. In a zone around the anus the glands are usually larger and more widely spaced than on the body, and the roughly rectangular areas of the cuticle are more obvious. The same thing occurs in many specimens of *zostericolum*, especially when they are small.

The distance between the origin of the retractors and the posterior extremity is much shorter than in *D. zostericolum*, being from one-fifth to a little less than one-sixth the total length. In *zostericolum* the distance is one-fourth to one-third the total body length. The spindle muscle is strong, attached dorsal to anus and is fused to the wall of the rectum as far as coecum, beyond which it anchors ascending spiral of intestine, by muscular strands in the generic manner. The attachment of the fixing muscles F^1 and F^3 is normally as in *zostericolum;* F^2 is not attached to the postesophageal gut but to the intestine at the top of the spiral, normally behind F^3 (fig. 87, B). In one variation (Crescent City) F^2 is attached to the postesophageal intestine and from its opposite side continued to the ascending gut (fig. 87, C). Other variations are shown in fig. 87, D and E. F^1 is occasionally absent (fig. 87, C), or it moves backward on the gut (fig. 87, D), while F^2 may be double (fig. 87, D, E). Rarely, F^1 and F^2 are absent (specimen 170 mm. long, Crescent City).

The alimentary canal shows no outstanding peculiarity. The spiral contains 15 or 16 double coils (30 to 32 single). The nephridia are shorter than in *zostericolum*. They vary from the maximum as shown in plate 34, figure 1, to about one-half that length.

The contractile vessel has more numerous Polian tubules than in *zostericolum*, they branch at the base as well as distally, and they are more crowded at the distal end of the contractile vessel than in *zostericolum*. Plate 30, figure 3, shows a typical example.

Color in life: Body dark olive-green, greenish yellow, or sepia, sometimes stained blackish by the mud in which they live; introvert lighter, sometimes yellowish or grayish anteriorly; collar back of tentacles dull reddish purple; tentacles brown, becoming pale and translucent on the hundreds of ultimate tentacules, which at their base are bright pale yellow. Formalin specimens are reddish gray or brown; those preserved in alcohol are bleached sepia or sometimes orange-brown.

Young.—A specimen 26 mm. long, fully extended, from near the type locality, has the form of the adult. It so much resembles the smaller spineless young of *Dendrostomum pyroides* that a dissection was made to determine the differences. F^2 is attached to the ascending gut as in fig. 87, B. The tentacles are less voluminous than in the 18-mm. young *pyroides.* There are basically four tentacles, the extra two of the adult arising from the growth of the inner branch of the two dorsal tentacles. Young *dyscritum* lacks, in front of the spotted anal zone, the area of transversely elongated glands of *pyroides.* The nuchal organ in life was conspicuous light cadmium yellow, and the tentacles light cadmium at base; general tone of skin, pale sepia with a darker zone in anal region.

Type.—U.S.N.M. No. 21221, N. W. Riser, 16 specimens, spawning at end of February and early March 1948.

Type locality.—Monterey Bay, Calif., intertidal, in sand between ledges of granite at Hopkins Marine Station, Pacific Grove.

Distribution.—Point Conception to Crescent City, Calif., intertidal to 10 fathoms.

Specimens examined.—All from California:

Crescent City, intertidal, June 3, 1911, W. F. Thompson, 32 specimens.

Dillon Beach, near Tomales Bay, Marin County, intertidal, in fissure of rocks with *Pholadidea* and *Petricola carditoides*, June 2, 1941, D. F. Hoffmeister, 1 specimen.

Dillon Beach, North Rocks, Dec. 11, 1947, R. J. Waidzonas, 3 specimens.

Pillar Point, Half Moon Bay, intertidal, March 12, 1911, W. F. Thompson, 6 specimens.

Monterey Bay, intertidal, the type series; *Albatross* station 4496, off Santa Cruz, 10 fathoms, fine gray sand and rocks, May 19, 1904, 6 specimens.

Point Conception, intertidal, July 14, 1916, Carl L. Hubbs, 1 specimen.

Remarks.—A specimen collected February 24, 1948, by Dr. N. W. Riser, was observed discharging sperm from one nephridiopore. Later, when I dissected this specimen, I found eggs in the body cavity. Dr. Riser collected a specimen on March 20 that contained sperm in one nephridium and eggs in the other. The gonad was invisible.

DENDROSTOMUM LISSUM, new species

PLATE 35

Diagnosis.—A small, thick-set species, with short body; introvert short, thick, devoid of spines and papillae; glands of skin minute, convex, closely placed; tentacles relatively large, profusely branched, in fours; nephridia opening a conspicuous distance posterior to anus; gut-fixing muscle F^2 attached to ascending intestine; gonad on retractor muscles anterior to their base; Polian tubules branched, numerous. Length of trunk to anus 24 mm.; length to base of tentacles 30 mm.; tentacles 4 mm.; breadth of introvert 3.5 to 4 mm.

Description.—Size small; the body short, the trunk thick set; the thick cylindrical introvert about one-fourth the body length, its anterior third a perfectly smooth, translucent collar, while the rest of the introvert, which is whitish, is crowded with minute convex glands. The body is warm sepia with a darker zone including anus and nephridiopores and one at the posterior extremity. It is very closely covered with low-convex glands, 0.08 to 0.1 mm. in diameter, similar in form to those of introvert, and more or less in transverse serial alinement. They are rather nondescript under high magnification by transmitted light (pl. 35, fig. 3). By reflected light the central canal shows as a dark spot. In the darker anal zone the cuticle is thicker and the glands are deeper, crowded, transverse elliptical (0.02 mm. by 0.07 mm.). In a narrower zone between the anus and nephridiopores there are larger, more superficial, transversely elliptical glands which show as inconspicuous brown spots of about two sizes.

The tentacles branch profusely. One can count four or eight, depending upon the value assigned to each arm. The oral disk has four principal food grooves, each of which divides into two, and each of these goes to an arm. If a sagittal plane and one at right angles is drawn (see arrows, pl. 35, fig. 4), each quadrant contains one of the four primary food grooves, and one tentacle with two arms, or two tentacles, depending upon the point of view. But the two arms in the upper right quadrant branch a little sooner than the others, which gives them more the appearance of primary tentacles than is the case with the two upper left. Hence one might easily reckon the number as five, if reference were not made to the food grooves. The tentacles are light brown. The nuchal organ has a lengthwise V-shaped depression.

The retractors are large and attached at the beginning of the terminal fifth of body. The line of attachment is straight and very broad, and the inner ends nearly meet under the nerve cord, which here gives off numerous nerves to the muscles. The muscles are separated practically to the nuchal organ. The spindle muscle follows the usual course from its attachment above the rectum. The wing muscles are very broad, the left somewhat broader than the right. Fixing muscles F^1, F^2, and F^3 are attached about the same as in *Dendrostomum dyscritum*, F^2 being attached to the uppermost coil of the ascending intestine while F^3 is attached opposite the coecum. The longitudinal, inner muscle layer has a satiny luster and is crinkled transversely. No oblique strands are observable.

Nephridia unequal, the longer about one-third the body length. They differ from all the California species in opening a conspicuous distance behind the anus.

The intestinal spiral has 26 coils. Postesophageal gut rather short. A constriction just posterior to attachment of F^1 marks the end of the esophagus proper.

The vascular system is similar to that of *D. dyscritum.* Even though the specimen is small there are very nearly as many Polian tubules as in a large *dyscritum*, and a majority branch near the base.

Type.—U.S.N.M. No. 21222, March 3, 1940, E. F. Ricketts, 1 specimen.

Type locality.—Point Lobos, Espíritu Santo Island, near La Paz, Baja California.

Distribution.—Known only from intertidal zone, Gulf of California.

Specimens examined.—From Mexico:

San Carlos Bay, on the Gulf side of Baja California, March 30, 1940, E. F. Ricketts, 1 specimen.

Puerto Penasco, Baja California, Dec. 24, 1947, W. H. MacGinitie, 13 retracted specimens from 6 to 16 mm. long. The smallest have a translucent body wall.

Miramar Beach, Guaymas, rocky, shore, Feb. 10, 1948, W. H. MacGinitie, 3 specimens about same size as type.

Remarks.—Whether the representatives of this species are always small it remains for future exploration to ascertain. The nearest relative is a large species, numerous examples of which were collected by Dr. Waldo L. Schmitt at Independencia Bay, Peru. With one exception all the specimens are strongly contracted, but the length of the largest would probably be between 100 and 150 mm.; thickness 15 to 20 mm. The skin is smooth and grayish and there are no elevated papillae or spines on the introvert. The crowded glands of the body are transversely elongated and do not form conical elevations, although on the introvert they do to some extent. The nephridia open well behind the anus as in *lissum.* In the one specimen having partly extended tentacles there are four major stems, each divided into two principal arms near the base, and the two dorsal tentacles are much smaller than the ventrals. All branch profusely.

Fixing muscle F^2 anchors both the postesophageal gut and the uppermost coil of the ascending intestine by sending branches to each (fig. 87, F). F^1 is attached to the esophagus in the usual place, and F^3, a short distance posterior to the coecum. The retractors are powerful and arise considerably farther forward than in *lissum*, as is to be expected in the much larger animals. The gonads are not situated on the muscles, but the stolon lies on the body wall behind the line of origin of the retractors, which is concave to nearly straight. In a large specimen the gut spiral has 27 double coils. The nephridia would be regarded as long, since they extend posterior to the origin of the retractors and sometimes to the end of the body. Allowing for the much greater size of the specimens, the Polian tubules are not quite so well developed as in *lissum.* The brittle condition of the material makes it difficult to work out details, but the plan is very similar to that of *D. dyscritum.* This species appears to be new and may be named:

DENDROSTOMUM SCHMITTI, new species

FIGURE 87, F

Dendrostomum schmitti differs from *D. peruvianum* Collin in lacking introvert papillae, convex trunk papillae, and elevations on esophagus. The nephridia open posterior to the anus, and F^2 anchors both the descending and the ascending gut, not the postesophageal gut alone. The relationship of *schmitti* to *peruvianum* parallels that of *D. lissum* to *D. zostericolum.*

Between *lissum* and *schmitti* the relationship is close; possibly they represent the extremes of geographic variation of one species.

Type.—U.S.N.M. No. 21216.

Type locality.—Independencia Bay, Peru, lee side of Vieja Island.

Genus PHASCOLOSOMA F. S. Leuckart

Phascolosoma F. S. LEUCKART, 1828, p. 22, fig. 5. (Type, *Ph. granulatum* Leuckart.) —FISHER, 1950a, p. 551.

Phascolosomum DIESING, 1851, p. 63, partim; 1859, p. 758, partim.

Phascolosoma KEFERSTEIN, 1862, p. 39, partim; 1865b, p. 422, partim.

Phymosomum QUATREFAGES, 1866, vol. 2, p. 621.

Phymosoma SELENKA and DE MAN, 1883, p. 54 (emendation of *Phymosomum*). Preoccupied by *Phymosoma* Archiac and Haime, 1850, Description des animaux fossiles du groupe nummulatique de l'Inde . . . , p. 54.

Physcosoma SELENKA, 1897, p. 460.—SPENGEL, 1898, p. 50.

Prophymosoma LAMBERT, 1900, p. 54.

Physconosoma BATHER, 1900, Zoological record, Echinoderms, p. 78.

Diagnosis.—Tentacles in a single series, forming a crescent or a circle (open dorsally), which is situated *dorsal to the mouth* and encloses nuchal organ; longitudinal muscle layer of trunk usually split into separate but more or less anastomosing fascicles; usually four retractors, the dorsal and ventral of each side tending to fuse in some species; body covered with papillae fortified by tiny chitinous platelets; introvert hooks, arranged in rings, usually present (not in *Phascolosoma antillarum*); a dorsal contractile vessel, in most species without villi (present in *Ph. antillarum*).

Remarks.—In this genus the arrangement of tentacles is farthest removed from the ancestral type, in which they form a circle surrounding the mouth, with the brain and nuchal organ (if present) outside the circle. In *Phascolosoma* the brain and nuchal organ are situated within the tenacular crown and the mouth is outside and ventral to the circle. The oral disk, including the tentacles, is surrounded by a cephalic collar, while a short distance posterior to this is a thin flange of tissue forming a second, or cervical, collar.

It is unfortunate that the name *Physcosoma* long used for this genus is untenable, since it is preoccupied by *Phascolosoma*. This name dates from F. S. Leuckart, 1828, page 22. The type and only species mentioned by Leuckart is *Phascolosoma granulatum* Leuckart, type locality Cette, France. This is the species called *Physcosoma granulatum*. In Selenka's monograph (1883, p. 79) it appears as *Phymosoma granulatum*, the first citation of the synonymy reading: "*Phascolosoma granulatum* F. S. Leuckardt, Breves animal. descript. Heidelberg, 1828. 4. p. 22, Fig. 5." The confusion started with Quatrefages (1866), who divided *Sipunculus* into five subgenera: *Sipunculus*, *Phascolosomum* Diesing, *Phymosomum*, *Aedematosomum*, *Cryptosomum*. Diesing's (1851) *Phascolosomum*, an emended spelling of Leuckart's name, included species of *Physcosoma*, *Phascolosoma*, and *Phascolion* as used by Selenka and subsequent authors and was thus an expansion of Leuckart's genus. This enlarged *Phascolosoma* was employed by Keferstein, 1862, 1865, 1866, 1867, Baird, 1868, Grube 1859, and others. Obviously Quatrefages's blunder consisted in placing the type (*Phascolosoma granulatum*) in his subgenus *Phymosomum* instead of where it belonged. Quatrefages used *Phascolosomum* for the group which includes *Phascolosoma vulgare*. Apparently no one was satisfied with original spellings; Selenka and de Man (1883) changed *Phymosomum* to *Phymosoma* and adopted Quatrefages' genus, with additional new species. *Phascolosomum* (Diesing) Quatrefages became *Phascolosoma* F. S. Leuckart (Selenka and de Man) with a new type, *Phascolosoma vulgare*, and more new species. *Phymosoma*, being preoccupied, was changed by Selenka (1897) to *Physcosoma* and adopted by authors. *Phymosomum* Quatrefages, *Phymosoma* Selenka and de Man, *Physcosoma* Selenka, *Prophymosoma* Lambert, and *Physconosoma* Bather are synomyms of *Phascolosoma* Leuckart.

KEY TO SPECIES OF PHASCOLOSOMA HEREIN DESCRIBED

*a*¹. Rings of tiny hooks present on anterior part of introvert; tentacles short, digitiform, 24 or less; introvert more than half length of trunk.

*b*¹. Introvert with numerous prominent dorsal, conical, sharp papillae or tubercles, sometimes directed posteriorly.
dentigerum (Selenka and de Man) (p. 432)

*b*². Papillae on dorsum of introvert not conspicuously enlarged.

*c*¹. Clear streak of hooks with conspicuous expansion, and merged below with the triangular clear space; platelets of papillae beyond the crowded central zone, fewer and spaced___**puntarenae** Grube (p. 430)

*c*². Clear streak of hooks with an inconspicuous expanded portion, or none, and not merged with triangular clear space; platelets of papillae more numerous and more crowded in outer zone.
agassizii Keferstein (p. 424)

a^2. No hooks; tentacles long, filiform, very numerous (50 to 200); introvert half length of trunk or less, robust; trunk dark brown from very numerous papillae____________________**antillarum** Grube and Oersted (p. 434)

PHASCOLOSOMA AGASSIZII Keferstein

Plate 36, Figures 3–6; Plate 37, Figures 4–15; Plate 38; Plate 39, Figure 1

Phascolosoma Agassizii Keferstein, 1866, p. 218; 1867, p. 46, pl. 6, figs. 3, 4, 7.
Phascolosoma lordi Baird, 1868, p. 92 (Vancouver Island, B. C.)
Phymosoma Agassizii Selenka, 1883, p. 78.
Physcosoma agassizii Chamberlin, 1919, p. 30; 1920, p. 5d.
Physcosoma japonicum Chamberlin, 1920, p. 5d.

Description.—Size of preserved specimens, with introvert extended, upward of 140 mm. but commonly half that; trunk cylindrical; posterior extremity bluntly pointed. When fully extended the distance from anus to tentacles is three-fourths that from anus to posterior extremity. The body wall varies from slightly translucent to opaque and the skin color from pinkish gray or yellowish gray or pale sepia to reddish brown and dark neutral brown. The lighter colored animals often have a few spots on body (dark purplish brown, neutral brown, reddish brown), which are either obscured or are not present on the darker forms, while the introvert, which is light in shade even when the trunk is dark, is marked by irregular transverse bands and patches of the same variations as the spots, usually along its entire length but sometimes only on the distal part. The skin is rough to the touch from very numerous convex or conical skin papillae of a darker brown than the skin but with a light center. They are smallest midventrally, increasing in size dorsally; and are largest dorsally at posterior extremity and over an area just in front of the anus. Here the papillae are very dark brown, horny, acorn shaped or conical, or in some cases compressed and expanded at base (pl. 38, fig. 31). In front of the preanal area the papillae rapidly decrease in size on the introvert. The relative size of the platelets of the skin-gland papillae is rather constant in specimens of different sizes and from different parts of the geographic range. An example from posterior to anus of a medium-sized example is shown somewhat flattened (pl. 36, fig. 3).

There are 15 to 25 rings of hooks starting a short distance behind the collar, those of the first three to five rows being very small and colorless. Usually there are about 17 rings clearly visible; the last one or two may be incomplete. Twenty-five figures of hooks on plates 20 and 21 give a fair idea of the variation in the proportion of height to base, size of basal piece, the form and position of clear streak, and the triangular spot. All are drawn to the same scale. The expansion in the clear streak may disappear entirely, even in specimens which have it in some of the hooks (pls. 36, 37). The so-called tooth on the concave margin is frequently absent, while there is no uniformity in the degree of curvature or in proportion of height to base.

Plate 36, figure 4, shows the crown of 24 tentacles and nuchal organ, which is relatively large in this species.

Longitudinal muscle bands anastomose rather freely, but there is great irregularity in the extent in different specimens. The number of bands between the origins of the anterior and posterior retractor muscles varies from 20 to 25, but at the level of the nephridiopores is 15 to 17. In a form from Monterey Bay one or two very narrow strands regularly split off from the principal bands (which are therefore narrower than usual) and remain separate for considerable distances, and are as much independent bundles as the principals. In such a specimen the muscle count runs to 35 or even more. A short distance in front of the anus the longitudinal muscles unite to form a continuous sheet. The introvert is ordinarily not invaginated beyond this point, but can be retracted as far as the anus. In fully expanded specimens the retractors are slender. The ventrals arise at the beginning of the posterior third of the trunk from six or seven muscle bands (first or second to sixth or seventh) but details of the relation differ on the two sides and from specimen to specimen. The dorsals arise from usually the fourth to sixth or seventh (or their equivalents if there happens to be much anastomosis). Plate 39, figure 1, shows the joining of the two retractors of each side to form one and the ultimate fusion of these behind the head. There is a single fixing muscle which shows little variation. It arises from two slender roots on midventral line, in front of origins of the dorsal retractors, and is attached by two distal branches to rectum and postesophageal gut (pl. 39, fig. 1). The roots are attached to muscle bands 1–1 to left of nerve cord. The spindle muscle begins just in front of the anus and is attached at the posterior extremity. The contractile vessel is inconspicuous.

The nephridia are moderately long and attached for nearly their length by a delicate mesentery. The small nephrostome is over the interval between muscle bands 2 and 3.

The nerve cord is loosely attached by its numerous nerves. There are two eye spots on the brain.

The gonad is in the usual place at the origin of the ventral retractors. Ripe eggs are found in the coelom in February and March (Monterey Bay). They are spherical and measure 0.12 mm. in diameter with some as small as 0.1 mm. and others reaching 0.14 mm. In much larger Humboldt Bay specimens coelomic eggs (January 1) have the same dimensions.

Type.—In the Museum of Comparative Zoology.

Type locality.—Mendocino, Calif.

Distribution.—From Kodiak Island, Alaska, to San Quintín, Baja California. There are records from temperate and tropical waters of both hemispheres (see under *Remarks*).

Habitat.—This, the dominant sipunculid of the intertidal zone, has adapted itself to a variety of habitats from midtide horizon to 110 fathoms. It is probably most abundant on the lower half of the intertidal zone and just below low tide. Beds of mussels (*Mytilus californianus*) so characteristic of the California coast afford ideal conditions. It is found also under rocks lying on or in fine sandy to muddy bottoms of tide pools, and in some conditions in crevices of rocks, preferred by *Dendrostomum pyroides*. The root masses of surfgrass (*Phyllospadix*) if not clogged with drifting sand, and holdfasts of kelps afford protection for small specimens. Mr. Ricketts found them also in the fenestrated base of a colony of the hydrocoral *Allopora californica*. Professor MacGinitie found them common in the mud of Humboldt Bay, which evidently afforded favorable conditions, as the specimens are all of large size.

At Orcas Island, Wash., Dr. Richard Snyder found a medium-sized specimen in association with the annelid *Aphrodite*. The sipunculid was in the space between the elytra and the dorsal mat of interwoven chaetal threads and must have entered when very tiny.

Specimens examined.—From Baja California:

Boca de la Playa, near Ensenada, Jan. 21, 1932, E. F. Ricketts, 5 specimens.
San Quintín, April 1949, Patrick W. Wells, 5 specimens.

From California:

La Jolla, 1899, F. H. Robinson, 1 specimen.
San Clemente Island, June 26, 1896, H. B. Torrey, 2 specimens.
San Pedro Point, Sept. 1, 1895, 1 specimen.
Point Firmin, U. S. National Museum collection, 1 specimen.
Santa Monica, March 1889, J. J. Rivers, 4 specimens.
Santa Barbara, under wharf, summer of 1948, Patrick H. Wells, 5 specimens.
Santa Rosa Island (Beechers Bay), mussel bed, Aug. 10, 1948, D. M. Wootton, 34 specimens.
Santa Cruz Island (Frys Harbor), mussel beds, Aug. 12, 1948, D. M. Wootton, 10 specimens.
Point Conception, July 14, 1916, C. L. Hubbs, 2 specimens.
Albatross station 4496, 2.1 miles southeast of Santa Cruz, 10 fathoms, fine gray sand, rocks, May 19, 1904, *Albatross*, 33 specimens.
Albatross station 4551, 4.5 miles northwest of Point Pinos, 56–46 fathoms, rocks, coarse sand, June 7, 1904, *Albatross*, 7 specimens.
Monterey Bay, channel off Moss Landing, 110 fathoms, Nov. 28, 1927, 1 specimen.
Monterey Bay, about 50 feet, from colony of *Allopora californica*, Feb. 10, 1927, E. F. Ricketts, 18 specimens.
Monterey Bay, intertidal, from Point Pinos to Carmel Bay, granite shore, many specimens.
Pillar Point, San Mateo County, March 12, 1911, W. F. Thompson, 10 specimens.
Tomales Bay, Nov. 23, 1947, P. J. Menzies, 1 specimen.

Bodega Head, under mussels, Aug. 4, 1948, D. M. Wootton, 15 specimens.
Black Point, Sonoma County, June 21, 1898, H. P. Johnson, 4 specimens.
Mendocino, paratypes, A. Agassiz, 4 specimens.
Humboldt Bay, low tide, mud, Jan. 1, 1931, G. E. MacGinitie, 200 specimens.
Crescent City, intertidal, June 13, 1911, W. F. Thompson, 14 specimens.

From Oregon:

Coos Bay (North Bay), eelgrass roots, July 20, 1949, D. L. Reish.

From Washington:

Puget Sound, 1896, Trevor Kincaid, 2 specimens.
Dogfish Bay, Puget Sound, Trevor Kincaid, 1 specimen.
Off Browns Island, San Juan Islands, July 18, 1936 (dredged), 2 specimens.
Friday Harbor, San Juan Island, 25 to 60 fathoms, Ida S. Oldroyd, 4 specimens.
Waddah Reef, San Juan Islands, eelgrass hold-fasts, July 4, 1936, 3 specimens.
Deer Harbor, Orcas Island, Aug. 14, 1951 (dredged); found in dorsal elytral space of *Aphrodite*, Richard Snyder, 1 specimen.
San Juan Strait, near mouth of Pysht River, under boulders on muddy gravel, July 26, 1930, E. F. Ricketts, 10 specimens.

From British Columbia:

Clayoquot Sound, Vancouver Island, 1946, E. F. Ricketts, 8 specimens.
Ucluelet, Vancouver Island, in the Museum of Comparative Zoology, 1 specimen.
Round Island, Vancouver Island, June 25, 1945, E. F. Ricketts, 1 specimen.
Canoe Pass, Kate Island, June 21, 1932, E. F. Ricketts, 1 specimen.
Fishermans Cove, July 12, 1932, E. F. Ricketts, 3 specimens.
Calvert Island, under rocks, May 11, 1937, T. T. and E. B. McCabe, 3 specimens.
Huston Inlet, Queen Charlotte Sound, July 1, 1913, W. F. Thompson, 7 specimens.
Table Island, Queen Charlotte Islands, June 9, 1937, 3 specimens.

From Alaska:

Sitka, Crab Bay, rocky reef, E. F. Ricketts, 1 specimen.
Thumb Bay, Prince William Sound, Walter J. Eyerdam, 4 specimens.
Orca, Prince William Sound, June 2, 1899, Harriman Alaska Expedition (W. E. Ritter), 3 specimens.
Cape Fox, June 1899, Harriman Alaska Expedition (W. R. Coe), 9 specimens.
Yakutat, June 19, 1899, Harriman Alaska Expedition (W. E. Ritter), 6 specimens.
Kodiak, July 3, 1899, Harriman Alaska Expedition (W. R. Coe), 3 specimens.

Young.—I have numerous small specimens from the region of Point Pinos, Monterey Bay, granite shore. These range in length, introvert extended, from 10 to 30 mm. They vary in skin color from pale translucent to medium brown, sometimes ochraceous, sometimes grayer in tone. There is as much variation as in large specimens in the extent of the preanal area of enlarged papillae and in the size of the terminal and preanal papillae, but in all cases these are conspicuously enlarged. The papillae of the distal part of introvert seem to be a little more conspicuous than in the adult. The transverse bands of yellowish or reddish brown are present on the introvert of nearly all specimens but the spots on the trunk are uncommon. The number of rings of the hooks is as few as 12, more often 15 or 16, less often as many as 25. Out of about 100 examples only one (length 20 mm.) has the large number attributed to juveniles of some species; in this case there are 75, interrupted here and there as if hooks were being shed, but the first 13 rows are intact. There are 11 or 12 tentacles and the nuchal organ is conspicuous.

A specimen with trunk 8 mm. long has 21 anastomosing muscle bundles; the internal anatomy is a miniature of that of large specimens.

Variations.—The principal variations are external and concern the color, the size and shape of the larger tubercles of the anal region and posterior extremity, and the introvert hooks.

The glandular papillae are best seen in light-colored, small or medium sized specimens. They form low conical eminences with a blunt teatlike extremity. The circular brown portion containing the platelets is the upper two-thirds of the papilla, which is delimited by longitudinal and transverse shallow skin grooves forming roughly quadrilateral or roundish areas. The papillae are ordinarily separated by two or three times their own diameter but in fully extended specimens the space becomes greater. The preanal and terminal tubercles are the same shape but three or four times larger than those of the dorsum of the trunk. In very large specimens, particularly in those from Humboldt Bay, the preanal tubercles become very horny, large, and some of them are compressed entirely out of the original conical form. These are more often seen in the darkest brown specimens. The enlarged preanal papillae have the same arrangement of platelets as other papillae.

Irrespective of spotting, the skin color varies from no scattered pigment (pale pinkish gray, translucent) to pale sepia modified by ochraceous or yellowish tints; thence to deeper neutral or reddish brown, to a dark brown (Humboldt Bay). In tide pools of Monterey Bay the palest to the medium brown forms occur, but none of the darkest have been found. The paratypes are medium brown and this general tone predominates in specimens from Washington to Alaska, although some fairly light examples are present (San Juan Islands, Wash.; Clayoquot Sound, British Columbia; Cape Fox, Alaska). The Kodiak specimens are rather darker than "medium brown," and lighter than the deepest brown specimens from Humboldt Bay, Calif.

The 200 specimens from this locality occurred in mud of a quiet bay and are all large (upward of 130 mm. long). They are about half and half medium brown (often reddish) and dark umber-brown, the introvert much lighter and crossed dorsally by reddish-brown stripes. The integument of the trunk is thick and the skin rough, coriaceous. It may be that the darker color is in part due to staining by organisms in the mud. Those examined were all females.

The specimens from Crescent City are medium sized or small, and all are of the pale variety. On the other hand, the Ensenada examples are as dark as the paratypes.

Specimens from a colony of the hydrocoral *Allopora californica* are the pale variety, but those dredged off Point Pinos, Calif., in 46 to 56 fathoms (*Albatross* station 4551) are all well pigmented, medium brown. The same is true of the specimens from 10 fathoms off Santa Cruz.

Finally the darker pigment spots of the trunk are of irregular occurrence and are certainly of no specific importance.

Remarks.—Through similarity of habit, hooks, and internal structure there are six species of *Phascolosoma* more closely related to one another than to others of the genus. These are *granulatum, nigrescens, puntarenae, agassizii, japonicum,* and *scolops.*

Two specimens of *Ph. japonicum* from Aikawa, Rikuzen, Japan, are superficially very similar to pale examples of *agassizii.* Selenka's colored figures (1883, pl. 2, figs. 18, 19) might serve to illustrate some of the variations of *agassizii.* Evidently the hooks are as variable as in *agassizii.* They are the same size and shape, and the clear streak follows about the same course but has no expanded portion (as is sometimes the case in *agassizii*). There is a clear triangular area at the base but this is not indicated in Selenka's figure (1883, fig. 145) or in Sato's (1930, p. 10). The papillae of *japonicum* have obviously *larger* platelets, occupying a wider zone. The Aikawa specimens agree with Sato's figures (1939, p. 384). Internally the only tangible difference is the absence of a coecum. The fixing muscle is almost exactly the same as in *agassizii*; the nephridia are anchored to the same extent, the origin of the retractors varies within the limits of *agassizii*; and the longitudinal muscle bands show no significant difference.

I examined an example of *Phascolosoma japonicum* from Ucluelet, Vancouver Island, upon which Chamberlin (1920, p. 5d) based his record. It is clearly one of the variations of *agassizii*, lacking the essential characters of *japonicum;* that is, the clear streak of hook (pl. 38, fig. 23) has a slight swelling; the platelets of the dermal papillae are as in other examples of *agassizii;* there is an intestinal coecum. I have no means of checking the record of *japonicum* from the Queen Charlotte Islands. The 10 specimens from this locality that I examined are all *agassizii.*

Phascolosoma agassizii (including *puntarenae*) has been recorded from many localities all over the world. Wilhelm Fischer (1922a, p. 7) sums up the distribution. "The species is already known from all tropical and temperate seas." In the Indian Ocean he lists Ceylon, the Laccadive and Maldive Islands, Mauritius, Sumatra, Timor; Sharks Bay and Rottnest Island, western Australia; in the Java Sea, Billiton and Nordwachter Islands; in the Pacific, Sydney (Port Jackson), Eimeo, and Tahiti; in the Atlantic and Mediterranean, Bermuda and Villefranche.

I doubt whether any of these records are valid for *Phascolosoma agassizii* as defined in this paper. Some of them may reasonably refer to *Ph. puntarenae*, a tropical species that has been confused with *agassizii*, a cool- or cold-water form. Fischer (1922a, pl. 1) gives figures of hooks from Sharks Bay (fig. 5), Port Jackson (fig. 6), Panama (fig. 7), and California (fig. 8). Fischer's figures 7 and 8 represent hooks of *puntarenae* and *agassizii* as understood in this paper, although as represented the light streak has too slight a swelling to be quite typical of Panamic specimens while it is over-emphasized in the California example (where it is often absent). These two Fischer regards as *agassizii*, as also the quite different Australian examples, which do not seem to me to represent either *puntarenae* or *agassizii*. Fischer's paper is exceptional in giving figures of details. Without them it is impossible to evaluate records.

To those who hold that *agassizii* and *puntarenae* constitute a single species, it is necessary to point out that the latter name has 7 years priority.

PHASCOLOSOMA PUNTARENAE Grube

PLATE 36, FIGURES 1, 2; PLATE 37, FIGURES 1–3; PLATE 39, FIGURE 3

Phascolosoma puntarenae GRUBE, 1859, p. 13.
Phascolosomum puntarenae DIESING, 1859, p. 761.
Sipunculus (*Phymosomum*) *puntarenae* QUATREFAGES, 1866, p. 624.
Phascolosoma agassizii KEFERSTEIN, partim, 1866, p. 218; 1867, p. 46, pl. 6, fig. 8.
Phymosoma agassizii var. *puntarenae* SELENKA, 1883, p. 79.
Physcosoma agassizii, partim, authors.

Diagnosis—Size small to medium (68 mm.), in general form similar to *Phascolosoma agassizii* but with slightly longer papillae, especially on dorsum of introvert; with transverse bars of brown on introvert; tentacles 24; hooks in upward of 100 rings and half rings, but deciduous and the number not constant. Differing from *agassizii* in structure of hooks, in having generally slightly larger papillae with fewer and less crowded platelets on their periphery, and in having a longer, more conspicuous coecum. Differing from *Ph. nigrescens*, to which it is rather closely related, chiefly in the less sharply bent hooks.

Description.—The largest specimen (Espíritu Santo Island) measures 68 mm. in length, with introvert extended but not fully relaxed. It more nearly resembles *Phascolosoma nigrescens* than it does *Ph. agassizii*. The papillae are enlarged in the same areas as in *agassizii* but the difference is not so marked, as the minor papillae are a little larger and slightly more protuberant and give a somewhat shaggy appearance. The platelets of the papillae are less numerous and, except near the center, are less crowded than in *agassizii*. Two examples from a small Panama specimen are shown on plate 36, figures 1 and 2. In the large specimen some of the papillae have the platelets similar to figure 3 (*agassizii*); but more often they look like figure 3 with the smaller platelets removed, while the larger platelets have an irregular, crenulated periphery. (See Selenka, 1883, pl. 9, fig. 137, *nigrescens*.)

There are about 25 complete rings of hooks; and back of these, about 30 more dorsal half rings, with a few scattered hooks on the ventral side of the introvert. In a Panama specimen (length 33 mm.) there are about 100 rings with a scattering of hooks beyond. In adult *agassizii* the hook rings seldom exceed 25 and are often 17 to 20, but in *nigrescens* the number varies from 30 to 120 (Selenka, 1883, p. 11). The hook of *puntarenae* (Selenka's pl. 1, figs. 1–3) is very different from that of *agassizii* in the position of the clear streak and in having a larger expanded portion of this streak. If the hook were slightly more bent it would closely resemble that of *nigrescens* (see pl. 39, fig. 2, and Selenka, 1883, pl. 9, figs. 130, 135). Even the slight hump (*a*) characteristic of *nigrescens* is indicated in *puntarenae*.

There are 24 tentacles surrounding the large heart-shaped nuchal organ (pl. 39, fig. 3; compare pl. 36, fig. 4). The fold or ridge surrounding the tentacles and mouth is colorless. Below this is the ring collar immediately in front of the hook zone.

The color is pale yellowish brown, the trunk and dorsal side of introvert irregularly peppered with dark brown papillae. The hooks form a brown zone behind the collar; then there is a dorsal half-ring of dark brown, followed by 4 or 5 transverse dorsal bands of much lighter reddish brown. The Guaymas specimen has a reddish brown trunk without spots and about 10 dark-brown dorsal bands on introvert.

In this typical section of the genus the internal anatomy does not vary greatly from species to species. There are 20 to 30 longitudinal muscle bands that anastomose freely, the lesser number being near the front of the trunk. The ventral retractors have a broad base arising from bands 2 to 7 on the right and 2 to 9 on the left. The fixing muscle arises in the same place as in *Ph. agassizii* and its attachment to the esophagus and to the rectum is the same. One point of difference is the coecum, which is papilliform, several times longer than thick, and relatively larger than in *agassizii*. A precisely similar coecum was found in a specimen of *Ph. nigrescens* from the Hawaiian Islands. The reddish brown nephridia are larger than in any *agassizii* examined. The proximal end is inflated. They reach nearly to the end of the body, only the proximal third being anchored. The Hawaiian specimen of *nigrescens* has reddish brown nephridia with conspicuously inflated proximal portion, but the distal part is badly contracted. The contractile vessel has no villi, and there is no sign of them in the Hawaiian specimen of *nigrescens*, although Selenka states that they are present in that species.

Type locality.—Puntarenas, Costa Rica.

Distribution.—Panama to Gulf of California.

Specimens examined.—Five, as follows:

Espíritu Santo Islands, near La Paz, Baja California, March 1940, E. F. Ricketts, 1 specimen.

Guaymas, Mexico, Miramar Beach, rocky, Feb. 10, 1948, W. H. MacGinitie, 1 specimen.

Bay of Panama, F. H. Bradley, 1866, 3 specimens.

Remarks.—This species seems to me to be of tropical derivation and closely related to *Ph. nigrescens* Keferstein, 1865, whereas *agassizii* is primarily a cold-water species, which reaches its best development both in size and number of individuals from Alaska to northern California. South of Monterey Bay large specimens are apparently absent or else are to be found in cooler water off shore.

PHASCOLOSOMA DENTIGERUM (Selenka and de Man)

Plate 39, Figures 4–7

Phymosoma dentigerum Selenka and de Man, 1883, p. 67, pl. 1, fig. 9; pl. 9, figs. 118–123.

Diagnosis.—Medium-sized, slender species with a dorsal preanal area of conspicuously enlarged, dark-brown, sharp conical tubercles, some of which are usually directed backward; a similar area of sharp conical tubercles at posterior extremity; other papillae small; rings of hooks few; hooks sharply bent, with a median, often slightly dilated, clear streak and a separate large triangular clear area.

Description.—The specimens are all slender; one with introvert fully extended measures: trunk 30 mm., introvert 20 mm. A larger example, with introvert retracted, would attain a length of 67 mm. General color of preserved specimens yellowish gray, pale sepia, or pinkish lavender. Longitudinal muscle bands visible through body wall. Papillae of ventral surface very small, gradually increasing in size to middorsal region, where in anterior half of trunk they are still small and of unequal size. Posteriorly, however, they rapidly increase in size to become circular, conical, sharp, dark brown tubercles against the pale ground color. Immediately in front of the anus is a ring zone of the same sharp brown tubercles. These are continued forward on the introvert as a middorsal band for about half to two-thirds its length, usually, but not always, in conjunction with a skin color of burnt-sienna, which makes the area very conspicuous. The largest tubercles are at the base of the introvert and are directed backward in varying degrees, sometimes assuming the stature of short, sharp spines. However, there is much variation. In little specimens and a few adults the enlarged spines remain symmetrically conical. The dorsal light-reddish-brown pigment of the spine area is continued forward, sometimes subdivided into transverse patches of color, becoming darker in the narrow zone of the hooks. The platelets of the smaller papillae are numerous, close to one another, and decrease in size from the central clear pore zone to the periphery, where they are little more than granules. In the outer zone there are no larger platelets among the small ones, as in *Ph. agassizii*. In the larger specialized papillae, or tubercles, of the introvert the platelets are relatively larger, thicker, more crowded and heavily pigmented. Immediately around the pore zone the platelets are usually a little smaller than those over the remainder of the tubercle. On the anterior half of the introvert the papillae are elliptical in outline, become gradually very small (0.07 to 0.1 mm. long diameter) and the platelets are reduced to granules, retreating more and more to the central portion immediately surrounding the pore.

The hooks form 16 to 21 dark-brown rings, the posterior rings being sometimes incomplete from loss of hooks. The hooks are characteristic in having the terminal portion sharply bent, in combination with an unusually large, clear, triangular space, which is separated from the median clear streak (not merged with it as in *puntarenae* and *nigrescens*). Note the dilation of the clear streak. The so-called tooth on the concave border of the hook may be well developed or absent.

In three adults the tentacle counts are 12, 13, 15. Tentacles more or less pigmented with dark olive. The nuchal organ is large and similar to that of *agassizii*. The smooth zone between circumoral collar or ridge and the collar just in front of the hook area is divided into an uncolored anterior half and a brown half.

The internal anatomy differs from that of *agassizii* only in minor details. The longitudinal muscle bands anastomose more freely in some individuals than in others. There are 18 to 20 bands at the origin of ventral retractors. The latter have a broad base arising from the muscle bundles 3–6, varying to 2–5, the dorsal retractors, about the same distance in front as *agassizii*, arise on left from 4–6 or 5–7 and on right from 6–7 or 4–6. The fixing muscle arises on the left of the nerve cord at the same place as in *agassizii* and, forking, is attached to the esophagus and to the intestine a short distance posterior to the coecum. The spindle muscle is strong and is very similar to that of *agassizii*.

There is a well-developed subspherical coecum. The intestinal spiral is of moderate length with about 16 to 18 single whorls.

The nephridia vary in length, sometimes reaching to the origin of the ventral retractors. The proximal third or half is anchored by a mesentery. They open between the third and fourth longitudinal muscles at the same level as the anus. A short distance in front of them the muscle bundles unite to form a single sheet. The contractile vessel is very slender, without villi. The brain has two eye spots. The eggs are elliptical, 0.11 by 0.09 mm. Each end is slightly truncated, with an indentation in the thick shell.

Type locality.—Philippine Islands.

Distribution.—Indo-Pacific, tropical. The paucity of records as compared with *Ph. scolops* is probably due to the habits of *dentigerum* in hiding in crannies of coral rock.

Specimens examined.—As follows:

El Pulmo Reef, Baja California, southeast shore of end of peninsula, in interstices of living coral, *Pocillopora*, March 19, 1940, E. F. Ricketts, 10 specimens.
Puerto Escondido, Gulf of California, Baja California, under boulders, March 25, 1940, E. F. Ricketts, 1 specimen.
San Carlos Bay, Gulf of California, Baja California, among rocks, March 30, 1940, E. F. Ricketts, 17 specimens.
Puerto Refugio, Angel de la Guardia Island, Gulf of California, Baja California, April 2, 1940, E. F. Ricketts, 2 specimens.
Puerto Penasco, Mexico, Dec. 24, 1947, W. H. MacGinitie, 15 specimens.
Panama Bay, Panama, F. H. Bradley, 1866, 3 specimens.

Remarks.—This species varies considerably in ground color, which is usually light brownish or grayish, and in the intensity of brown on the introvert. I have examined specimens from Eniwetok Atoll, Marshall Islands, Hawaiian Islands (Laysan, Kauai, Hawaii) and from the Gulf of Davao, Mindanao. The extent of development of the toothlike tubercles of introvert varies greatly. In the Laysan specimen they are symmetrical, sharp cones, as in some of the Baja California examples. The tubercles of the ventral side of the introvert and the papillae of the trunk are much larger in the Laysan specimen. The specimens described above probably constitute a distinct race inhabiting the Pacific coast within the tropics and subtropics.

Ten Broeke (1925, p. 88) has described from Caracas Bay, Venezuela, *Phascolosoma microdentigerum*, which differs from *dentigerum* in the smaller size of its spines and the presence of little villi on the contractile vessel. Trunk only 10 mm. long. Fischer (1922b, p. 11) records *dentigerum* from Barbados, reef.

PHASCOLOSOMA ANTILLARUM Grube and Oersted

PLATE 39, FIGURES 8, 9

Phascolosoma antillarum GRUBE and OERSTED, 1859, p. 117.—KEFERSTEIN, 1865b, p. 435, pl. 31, fig. 11, pl. 33, fig. 37.
Phymosoma antillarum SELENKA, 1883, p. 57, pl. 7, fig. 93–96.
Physcosoma antillarum GEROULD, 1913, p. 420, pl. 62, figs. 19, 20.—STEINBECK and RICKETTS, 1941, p. 346, pl. 16, fig. 2.

Diagnosis.—Habit robust; trunk brown from numerous low convex papillae, large and crowded at posterior end and in anal region; introvert abruptly cream color, only about one-third trunk length; no hooks; tentacles long, very numerous; superficially resembling *Dendrostomum*. Length, including tentacular crown, 57 mm.; trunk, to anus, 37 mm.; anus to cephalic collar, 16 mm.; width of tenacular crown, 10 mm.

Description.—Selenka gives the number of tentacles 50 to 80; in my specimen there are nearer 200, pale cream color (as is most of introvert) with only an indication of brown spotting near the tips. The expanded tentacular disk, to accommodate the large number of its peripheral tentacles, is thrown into regular folds (pl. 39, fig. 9) as happens in fully expanded sea anemones having a large number of tentacles. The form of the centrally located nuchal organ is shown in this figure. The mouth is overhung by the tentacles. Directly below it the cephalic collar has a slight projection on its otherwise even edge.

The skin of the trunk is divided into subquadrate areas by furrows. In each area is a deep-brown convex subcircular papilla composed of numerous closely placed chitinous platelets, while between these closely spaced papillae the cream-colored skin contains *separated* dark-brown platelets. The ventral papillae are slightly larger than the dorsal; in most species of the genus the reverse is true. At each end of the trunk the papillae are much larger than elsewhere. At the posterior end and on the ventral side of the anal region, the whole of each papilla area becomes filled with densely crowded brown platelets. Dorsally in the anal region the large papillae are slightly separated and often of irregular form. Abruptly, just in front of the anus, the papillae become much smaller, elongate conical, sharp, and decrease in size toward the second collar.

The muscle bundles of the inner layer anastomose. There are about 20 in the anterior part of the trunk and 28 to 30 posteriorly. Dorsal retractors arise only a short distance in front of the ventrals at the beginning of the posterior third of the trunk. The two muscles of each side soon unite. In a strongly contracted specimen there is hardly any separation and the animal appears to have only two retractors arising near the posterior end of the body. The degree of separation is like that of *Phascolosoma asser* (Selenka, 1883, fig. 97). There is one fixing muscle arising on the left of the nerve cord in about the same place as in *agassizii*. It is attached to the rectum in front of the coecum and some of its fibers pass into the spindle muscle. At the point of its attachment to the rectum a part of the muscle continues and is attached to the esophagus as it forms the first coil.

The contractile vessel carries very numerous conspicuous slender villi, which extend from just behind the head to the first coil of the spiral. They are not simple but are dichotomously branched three or four times so that they appear to arise from the vessel in clusters, very much as in *Golfingia macginitiei*.

The nephridia are very long and are attached except for a short terminal portion. They open between the third and fourth muscle bundles. The nerve cord is loosely attached by its nerves. The eye spots are very inconspicuous (not "deutliche" as Selenka describes them). The specimen from Espíritu Santo Island contained many apparently fully formed elliptical eggs 0.1 by 0.12 mm. The shell is thick (0.05 mm.) and by transmitted light appears to be cross striated (pl. 39, fig. 8).

Type locality.—Puerto Cabello, Venezuela.

Distribution.—Florida (Key West, Loggerhead Key); West Indies (Cuba, Porto Rico, St. Thomas, St. Croix, Barbados, Jamaica); Colombia; Venezuela; Dutch Guiana; Brazil. In the Pacific: Gulf of California; Costa Rica; Panama; Chili; Hawaii (Halape); Riukiu Islands (Amami Oshima, Naha, Itoman, Tinensaki).

Specimens examined.—Five specimens:

Point Lobos, Espíritu Santo Island, Baja California, under boulders, March 20, 1940, E. F. Ricketts, 1 specimen.

East of La Paz, interstices of dead coral, E. F. Ricketts, 1 specimen.

Bay of Panama, F. H. Bradley, 1866, 3 specimens.

Remarks.—On account of its more sturdy habit, short introvert, and conspicuous crown of tentacles this species superficially resembles a *Dendrostomum* and is unlike any other *Phascolosoma* from the eastern Pacific.

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EXPLANATION OF PLATES

Plate 18

Sipunculus nudus Linnaeus

1, A portion of the internal structure to demonstrate the extra intestinal spiral *A*, which has been dissociated from the regular spiral *B* and drawn to the left; *X* and *Y* are for identification of the same points in plates 10 and 11, Fisher, 1947; × 2.

2, Frontal view of oral disk and tentacular fold of a small specimen from Newport Bay, Calif. The dotted circle indicates limit of oral disk, external to which is the tentacular fold, subdivided into lobes; × 6.

3, Tentacular fold of a large specimen from Anaheim Landing, Calif., having the dorsal lobes well developed (left side omitted); × 5. Vertical line of dashes indicates sagittal plane.

4, Longitudinal section of a portion of body wall to show integumental coelomic canals (*IC*); × 8. Circular muscle bundles in solid black. Longitudinal muscle (*LM*), seen from side, dotted. Arrows indicate passage to body coelom.

5, Cross section of body wall, cut slightly on bias; × 8. Four integumental canals are shown. The arrows are in the slits, shown in 4, between the circular muscle bundles. On the right the cut is slightly to one side of slits. Longitudinal muscles in solid black.

A, Accessory intestinal spiral; *B*, regular spiral; *C*, coecum, *CV*, dorsal contractile vessel (ventral in solid black); *DT*, dorsal tentacles; *M*, mouth; *N*, nephridium; *RD*, dorsal retractor muscle; *RV*, ventral retractor; *S*, spindle muscle; *W*, wing muscles of rectum (the stippled bodies are the "Zottenbildungen" of Selenka); *X* and *Y*, second and first bends of accessory intestinal spiral.

Plate 19

Xenosiphon branchiatum (Fischer)

1, Anterior sixth of a specimen, with introvert extended, from Panama. It has been opened a little to the left of middorsal line and spread out so that the dorsal retractors are unnaturally spread apart and the rectum is on extreme right instead of being in middorsal line. The esophagus actually bends to left and is attached behind and in a line with the left dorsal retractor; × 2. Figures denote muscle bands to right and left of nerve cord.

2, Sketch of another specimen, from Panama, in which the introvert is partly withdrawn to show altered position of protractors (*P*); × 1.

3, Brain and the bushy frons (cerebral organ); × 10.

4, Six dermal rectangles at margin of papularium of La Paz specimen; × 10. In this specimen the cuticular welts above the canals alone show well, the detail in upper left rectangle being supplied from a Panama specimen. The next rectangle has no papillae but the irregular canal shows through the cuticle. The lower left shows at each end of canal the pores (arrows) which lead eventually to coelom.

5, A single rectangle of skin of Panama specimen about 25 mm. anterior to papularium showing a skin canal gorged with material; × 20. At either end the dark spot marks the canal to coelom.

A, Anus; *C*, intestinal coecum; *CV*, dorsal contractile vessel; CV^1, ventral contractile vessel; *Fr*, cerebral organ or frons; *I*, introvert; *N*, nephridium; *NC*, nerve cord; *O*, esophagus, its mesenteries cross-hatched; *P*, protractors of head; *R*, rectum; *RD*, dorsal retractor; *RV*, ventral rectractor; *S*, spindle muscle; *T*, tentacles, *Z*, filamentous organ described in text.

Plate 20

Siphonosoma ingens (Fisher)

1, Head of small specimen (Elkhorn Slough, Monterey Bay, Calif.) drawn from life; × 8.
2, Anterior end of paratype, × 1, showing the introvert partly invaginated and retractors in contracted state.
3, Portion of 2 enlarged; × 2. The left root (S^1) of spindle muscle has been severed.
4, Nephrostome of a specimen from Newport Bay and associated coelomic papillae; × 10.
5, Coelomic papilla; × 30.
6, Brain of paratype; × 10.

CP, coelomic papillae (Keferstein bodies); *CV*, dorsal contractile vessel; *F*, fixing muscle; *I*, introvert; *N*, nephridium; *NC*, nerve cord; *NO*, position of nuchal organ at anterior end of dorsal double series of tentacular lappets; *O*, esophagus; *RD*, dorsal retractors; *RV*, ventral retractors; *S*, spindle muscle; S', S'', lateral roots of spindle muscle; *W*, wing muscle of rectum.

Plate 21

Siphonosoma ingens (Fisher), types

1, 2, Anterior half of body; × 1.5. The top of figure 2 is a continuation of the bottom of figure 1. This specimen is unusually well relaxed. The coelomic papillae have been omitted and the muscle bands are only slightly indicated in order to avoid confusion of lines.
3, Same specimens; × 3. Point where the esophagus joins and is fastened to the ascending intestine at beginning of rectum, showing relations to spindle muscle (*S*) and its lateral roots, S', S''; the fixing muscle to esophagus is omitted.
4, A segment of the esophagus and four retractors opposite the wing muscles of rectum to show the lateral mesenteries of esophagus; × 5. *M*, right mesentery. Other lettering as for plate 20.

Plate 22

Siphonides rickettsi, new species

1, Map of visceral anatomy, constructed from both type and paratype; × 5. The section shown includes the portion of whole animal between horizontal lines of figure 4. Only the ventral muscle bands of paratype are shown in lower part of figure. The nephridia are from type. Coecum and wing muscles of rectum not lettered and only a few coils of the intestinal spiral are indicated. The simple contractile vessel along esophagus is shown by dotted line.

2, One of the hooks of introvert; × 500.

3, A gland from ridge between consecutive rings of hooks; × 500.

4, Diagram of entire animal; × 1. Between the horizontal lines is portion shown in figure 1; the dot is anus and the two vertical lines are the ventral retractors.

5, Left nephridium of paratype, which has a short anterior lobe, showing attachment to body wall, the large nephrostome, and cleavage of longitudinal muscles. The origin of left dorsal retractor (*RD*) is from muscle bands 2 and 3 with a few fascicles from 1 and 4; × about 10.

6, The mammiform glands of skin, the upper two in profile; × 50. Probably normally all are capped by an elongate papilla as shown on left. It is sometimes brownish.

A, anus; *CF*, nephrostome; *F*, fixing muscle of intestine; *IS*, intestinal spiral; *N*, N^1, the two lobes of nephridium; *RD*, *RV*, dorsal and ventral retractors; *S*, spindle muscle.

Plate 23

1, *Golfingia margaritacea californiensis*, new subspecies. Dissection of paratype; × 7.5. 1, *a*, Two eggs of *californiensis* (larger) and two from Dutch Harbor specimen of *margaritacea;* × 7.5.

2, *G. margaritacea californiensis.* Central portion of visceral complex further enlarged. A section has been removed from the ventral retractors; and the base of the muscles is not shown.

3, *Golfingia margaritacea*, (Sars) Alaskan form, Dutch Harbor, Unalaska, × 4. Central portion of visceral complex to show the fixing muscles, 1 to 4 being normal. In specimen from Kilisnoo, 2 is double and an extra, 2, *a*, is present. In Kate Island, British Columbia, specimen, 4 is completely double. F^1 or F^2 are occasionally absent in Alaskan specimens, and F^3 and F^4 are sometimes attached to intestine close together.

A, anus; *C*, coecum; F^1 to F^4, fixing muscles; *N*, nephridium; *NO*, nuchal organ; *O*, esophagus; RD, dorsal retractor; *RV*, ventral retractor.

Plate 24

1, *Golfingia hespera* (Chamberlin): The animal, natural size; that on left with fully extended introvert, the other with introvert partly invaginated.

2, *G. hespera:* Central portion of visceral complex of figure 3; × 12. The nephridia are shown as hollow vesicles with posterior lobe removed and the nephrostomes (N') as if walls were transparent.

3, *G. hespera:* Dissection of trunk of a specimen from Balboa, Calif., × 6, showing particularly the two nephridia distended by sperm.

4, *G. hespera:* Head with crown of tentacles, not fully expanded, surrounded by collar; × 40. 4, *a*, A line 0.25 mm. long.

5, *G. hespera:* A hook from one of the anterior rings, × 1,000.

6, *Golfingia margaritacea californiensis*, new subspecies: Two animals; × 2.

7, *G. margaritacea californiensis:* Frontal view of the oral disk and tentacles; × 20.

8, *G. margaritacea californiensis:* Glands at end of body seen by transmitted light; × 200.

A, anus; *C*, coecum; *M*, mesentery anchoring rectum; *N*, nephridium; N', nephrostome; *NO*, position of nuchal organ; *R*, united retractor muscles, along dorsal side of which is esophagus; *RD*, dorsal retractor; *RV*, ventral retractor; *S*, spindle muscle.

Plate 25

1, *Golfingia elachea*, new species, × 5: Dissection to show principally the fixing muscles, 1 to 7, indicated in text as F^1 to F^7. A section has been removed from the right retractor and most of the right nephridium is omitted. The horizontal lines indicate posterior limit of introvert. 1, *a*. The holotype, × 1.

2, *G. elachea:* Three papillae from middle of introvert, one seen from top to show pore; × 200.

3, *G. elachea:* Four papillae from posterior part of trunk, × 200.

4, *G. laetmophila*, new species, type; × 2. The introvert is about one-half invaginated. *W*, wing muscles.

5, *G. laetmophila;* × 6. Detail of base of the retractors showing esophagus and one of its mesenteries on left. The faint line in middle of esophagus is the rudiment of the contractile vessel or its mesentery. *O*, esophagus.

6, *G. laetmophila;* × 200. Four introvert spinelets; *a* and *c* with only part of cortical layer adhering; *b*, cortical layer removed; *d*, perfect spine.

Plate 26

Golfingia macginitiei, new species

1, Holotype; × 3. The introvert is invaginated; right nephridium bent forward. The contractile vessel and villi hide esophagus, which is shown at right before entering intestinal spiral, only four coils of which are indicated.
2, Oral end of a double row of tentacles; × 50.
3, Holotype; × 1.
4, A dermal papilla from near end of body; × 200.
5, Part of a cluster of Polian villi, × 50, and, above, the tip of one of the branches, flattened under a cover slip; × 200.
6, Top of intestinal spiral and the rectum to show Polian villi distended with corpuscles. Fixing muscle F^2 is attached to esophagus.

C, coecum; *CV*, contractile vessel; F^1, F^2, fixing muscles; *I*, introvert; *IS*, intestinal spiral; *M*, eight short diagonal bands of muscle; *S*, spindle muscle; *T*, tentacles showing through thin skin; *V*, Polian villi along each side of contractile vessel.

Plate 27

1, *Dendrostomum pyroides* Chamberlin: A robust specimen from life; dorsal side; × 1. 1, *a*, same; skin from introvert showing hooks; × 25. 1, *b*, Same; a hook; × 50.
2, *Dendrostomum pyroides;* lateral view of preserved specimen, showing characteristic curvature of body; × 1.
3, *Dendrostomum perimeces* Fisher; lateral view of preserved specimen; × 0.75. 3, *a*. Skin from introvert just anterior to anus, showing the brown papillae; × 65.

Plate 28

1, *Dendrostomum perimeces* Fisher; Head of a specimen drawn from life, × 5, showing tentacles in natural feeding position, the smooth brown collar, the whitish sphincter zone, and behind this the anterior part of papillae zone.

2, *Dendrostomum pyroides* Chamberlin, × 5; View looking down upon mouth, showing base of the four groups of tentacles, the grooves leading to mouth, and the serrate border of grooves. Between the two dorsal tentacles is the nuchal organ, *N*. Preserved specimen.

Plate 29

Dendrostomum pyroides Chamberlin

1, Dissection viewed from above; × 2. The contractile vessel and Polian tubules are shown in solid black, but not all of the tubules are indicated.

2, Oral disk and bases of four groups of tentacles (1–1V); × 12. Specimen from Boca de la Playa, near Ensenada, Baja California.

3, Side view of esophagus greatly enlarged to show network of vessels arising from the contractile vessel (*CV*) and enveloping esophagus. At lower end of figure the origin of the Polian tubules of left side only is shown.

CV, contractile blood vessel; F^1–F^3 fixing muscles of gut; *G*, gonad; *NO*, nuchal organ; *O*, esophagus; *R*, left retractor.

Plate 30

1, *Dendrostomum zostericolum* Chamberlin. Ensenada, Baja California; oral disk and base of six tentacles (1–VI), × 6, to show pattern of food grooves and large upper lip, behind which is the nuchal organ (*NO*). 1,*a*, one of the small branches at base of tentacles; × 20.

2, *Dendrostomum hexadactylum* Sato, Monterey Bay, Calif. Spines from introvert; × 25.

3, *Dendrostomum dyscritum*, new species, paratype, Monterey Bay, Calif.; × 5. Contractile vessel above esophagus (*O*) showing the pattern of Polian tubules for comparison with *D. zostericolum*, in which the tubules are fewer and do not branch, at least not at the base.

4, *Dendrostomum perimeces* Fisher, × 200. Glands from posterior third of body to show the three sizes; the largest is seen somewhat from side.

Plate 31

Dendrostomum zostericolum Chamberlin

1, Dissection of specimen from Ensenada, Baja California; × 1. The rectum, shown on right, in its natural position would be middorsal above esophagus. Only 6 of the 11 Polian tubules have been completed. The oblique bands of muscle in body wall are indicated as gray lines. 1, *a*, is posterior end of body omitted from 1.

2, Side view of esophagus, × 5, to show contractile vessel and origin of Polian tubules.

3, Rectum and associated structures of figure 1, × 2.

4, A skin papilla from posterior third of body; × 200.

5, Papillae from dorsal side of introvert near anus; × 65.

A, position of anus; *C*, coecum; *CV*, dorsal contractile vessel; F^1–F^3, fixing muscles; *G*, gonad; *I*, intestinal spiral, *IA*, ascending gut of spiral; *ID*, descending gut; *N*, nephridium; N^1, nephrostome; *O*, esophagus; *O′*, postesophageal gut; *PT*, Polian tubules; *S*, spindle muscle; *W*, wing muscles.

Plate 32

Dendrostomum zostericolum Chamberlin

1, Dissection of a specimen from Ensenada, Baja California; × 2. In this example the postesophageal gut (O') is unusually long and does not start to coil around the ascending spiral at +, the usual place. The contractile vessel has 12 Polian tubules. Length of specimen 190 mm.
2, Detail of intestinal coecum and spindle muscle, showing mode of attachment of the latter to intestinal wall posterior to coecum.
3, View of the inside of base of left nephridium with nephridiopore in center and inner opening of nephrostome at upper left; × 10.
4, Nuchal organ; margin of oral disk above and a branch of a dorsal tentacle on right. 4, *a*. Brain × 10. *CO*, circumesophageal commissure; *t*, nerves to tentacles;

C, coecum; *CG*, ciliated groove; *CV*, dorsal contractile vessel; F^1–F^3, fixing muscles; *M*, mesentery of esophagus; *N*, nephridium; N', nephrostome; O', postesophageal intestine; *PT*, Polian tubules; *S*, spindle muscle; *W*, wing muscles of rectum.

Plate 33

Dendrostomum perimeces Fisher

1, Dissection of paratype; × 1. Note the very long intestinal spiral, few Polian tubules, relatively short nephridia; absence of fixing muscles (intestinal anchors). Oblique muscle bands of body wall are indicated.
2, Another specimen showing esophagus, contractile vessel, rectum, and top of intestinal spiral; × 2.
3, Enlargement of posterior end of contractile vessel of figure 1.

A, anus; *CV*, contractile vessel; *N*, nephridium; *O*, esophagus, O', postesophageal intestine; *PT*, Polian tubules; *S*, spindle muscle; *W*, wing muscles.

Plate 34

Dendrostomum dyscritum, new species

1, Dissection of a specimen from Monterey Bay (see pl. 30, fig. 3); details of Polian tubules omitted. F^1–F^3, fixing muscles (see also figure 87); *G*, gonad.
2, Skin gland from posterior third of body; × 200.
3, Contracted specimen from near Point Conception; × 1.
4, One of the paratypes, Monterey Bay; × 1.
5, Detail of end of the intestinal spiral.

Plate 35

Dendrostomum lissum, new species

1, Type; × 4. The Polian tubules have been omitted for simplification and only upper coils of intestinal spiral are indicated.
2, Type; × 3. The dorsal branch of each dorsal tentacle has been removed to show the heart-shaped nuchal organ.
3, Two of the glands from body just anterior to the posterior dark area; × 200.
4, Oral disk and bases of the four or eight tentacles; × 6. The arrows indicate the primary radii.

A, anus; F^1–F^3, fixing muscles; *G*, gonad; *N*, nephridium; N', nephridiopore; *NO*, nuchal organ.

Plate 36

1, 2, *Phascolosoma puntarenae* Grube, Panama. Dorsal papillae from postanal region, 0.105 by 0.14 mm.; × 200.

3, *Phascolosoma agassizii*, Keferstein; Monterey Bay, Calif. A dorsal papilla from postanal region, 0.2 by 0.24 mm., to show typical arrangement of platelets; × 200.

4, *Phascolosoma agassizii*; × 16. Dorsal view of head. The crown of 24 tentacles has been bent rather unnaturally dorsalward; nuchal organ in middle.

5, *Phascolosoma agassizii*; × 2. Large specimen from Humboldt Bay, Calif., to show origin of ventral retractors; nerve cord omitted from midventral line + +.

6, *Phascolosoma agassizii*; × 2. Dissection of a specimen from Bodega Head, Calif., near the type locality. A short section of esophagus has been removed to show attachments of fixing muscle *F* (*F′*, esophageal branch); *N*, nephridium.

Plate 37

Hooks of specimens from Panama to Humboldt Bay, Calif., for comparison. Measurements in millimeters; the first number is total height; the second is extreme width of base. Enlarged × 400.

1, 2, *Phascolosoma puntarenae* Grube, Panama; 0.059 × 0.07 and 0.05 × 0.05; *a*, the thickening of base similar to that of *Ph. nigrescens* (pl. 39, fig. 2).

3, *Phascolosoma puntarenae*, from Espíritu Santo Island, Baja Calif.; 0.0875 × 0.077.

4–15, *Phascolosoma agassizii* Keferstein:

4, San Quintin, Baja Calif.; 0.063 × 0.059.

5, Santa Rosa Island, Calif.; 0.07 × 0.07.

6, 7, Point Pinos, Monterey Bay, tide pool in granite rocks; 0.08 × 0.08 and 0.087 × 0.066.

8, Monterey Bay, from colony of Allopora, 50 feet depth; 0.06 × 0.06.

9, 10, Monterey Bay, common tide pool form from under granitic stones on fine sand or mud. From same specimen, 0.063 × 0.063 and 0.063 × 0.056.

11, Monterey Bay, at Hopkins Marine Station, form with dark purple brown introvert markings; 0.059 × 0.063.

12, Bodega Head; 0.059 × 0.059.

13, 14, Mendocino, from one of Keferstein's paratypes; 0.06 × 0.06 and 0.056 × 0.05.

15, Humboldt Bay, from a light colored specimen; 0.07 × 0.066.

Plate 38

Phascolosoma agassizii Keferstein

Figures of hooks for comparison, continued from plate 37:

16, 17, Humboldt Bay; same specimen as figure 15; 0.063 × 0.052 and 0.066 × 0.05.

18, Humboldt Bay; from one of the darkest brown specimens; 0.063 × 0.05.

19, 20 Crescent City, from same specimen; 0.059 × 0.059 and 0.052 × 0.056.

21, 22 Friday Harbor, Wash.; 0.077 × 0.08 and 0.063 × 0.063, different specimens.

23, Ucluelet, British Columbia; 0.07 × 0.07.

24, Huston Inlet, Queen Charlotte Islands; 0.073 × 0.073.

25, Sitka, Alaska; 0.073 × 0.07.

26, Kodiak, Alaska; 0.042 × 0.049.

27, 28 Cape Fox, Alaska, same specimen; 0.052 × 0.0595 and 0.056 × 0.05.

29, 30 Monterey Bay, vicinity of Point Pinos, from young specimen 20 mm. long, introvert extended, 0.038 × 0.031. Figure 30 is × 400 and 29, another hook, × 800.

31, Humboldt Bay, Calif. Modified papillae from preanal region of a large dark brown female specimen, × 20; at lower right a papilla in profile. The papillae are bent away from introvert.

Plate 39

1, *Phascolosoma agassizii* Keferstein, Humboldt Bay, Calif.; × 2. A specimen in which the fixing muscle has been strongly contracted so that the rectum is lengthened. *C*, coecum; *F*, fixing muscle; *F'*, its esophageal branch; *NC*, nerve cord; *RV*, left ventral retractor; *S*, anterior end of spindle muscle; *W*, wing muscles, *1*, *2*, *3*, et cetera, muscle bands to right and left of nerve cord.

2, *Phascolosoma nigrescens* Keferstein, *Albatross* station 4160, Hawaiian Islands; a hook 0.07 × 0.08 mm., × 400, for comparison with *Ph. puntarenae; a*, the thickening or fold in the basal plate characteristic of *nigrescens.*

3, *Phascolosoma puntarenae* Grube; tentacular crown, × 8; nuchal organ in middle.

4, *Phascolosoma dentigerum* (Selenka and de Man), San Carlos Bay, Baja California; × 30. Tubercles from dorsal surface of a contracted specimen, a short distance in front of anus which is below middle of figure.

5, *Phascolosoma dentigerum;* × 2. Specimen from El Pulmo Reef, Baja California, to show areas of enlarged tubercular papillae. *A*, anus.

6, 7 *Phascolosoma dentigerum.* Two hooks, 0.056 × 0.063 and 0.056 × 0.05 mm.; × 400.

8, *Phascolosoma antillarum,* Grube and Oersted, an egg; × 100.

9, *Phascolosoma antillarum;* × 3. Dorsal aspect of anterior portion of specimen from Espíritu Santo Island, showing tentacular crown, the heart-shaped nuchal organ in center, second collar, introvert, and anal region (darker). An introvert papilla shown enlarged.

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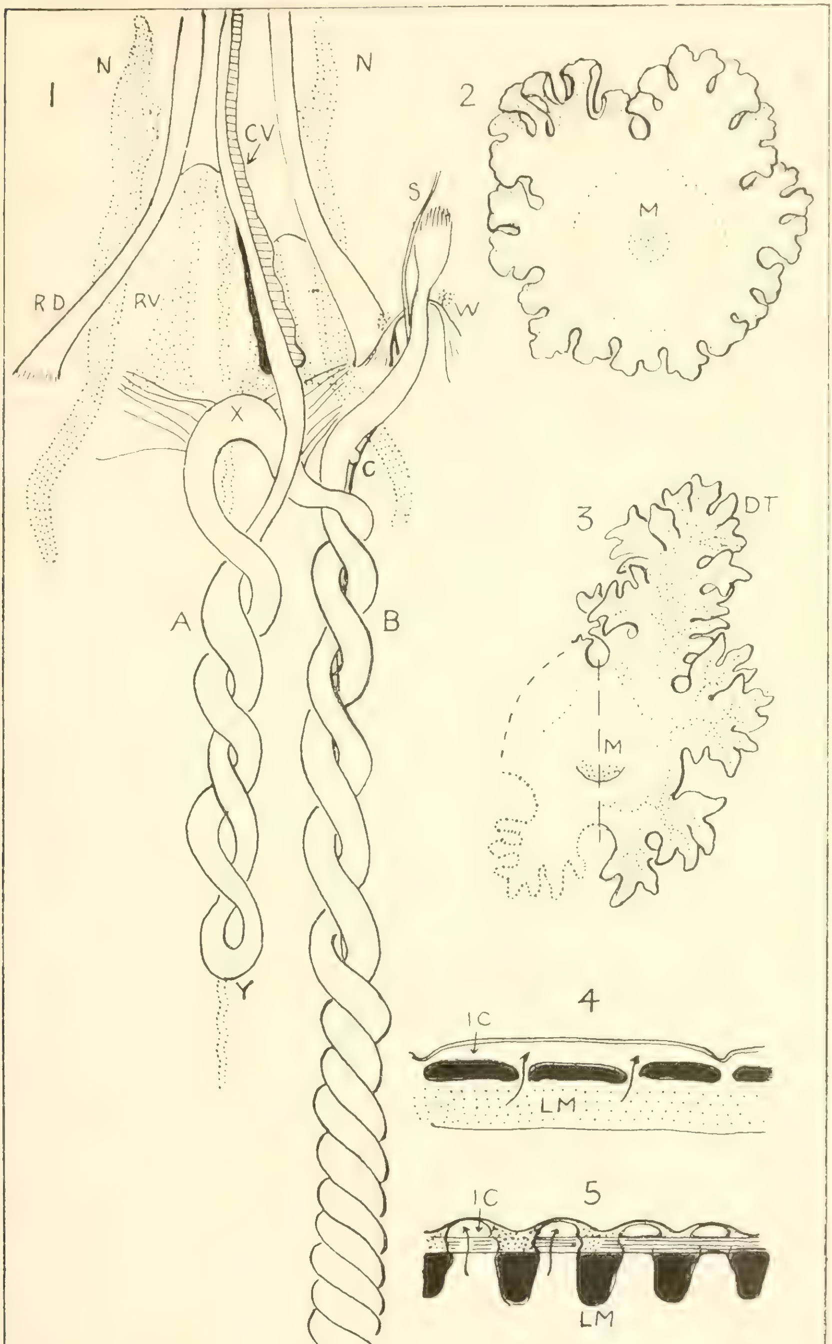
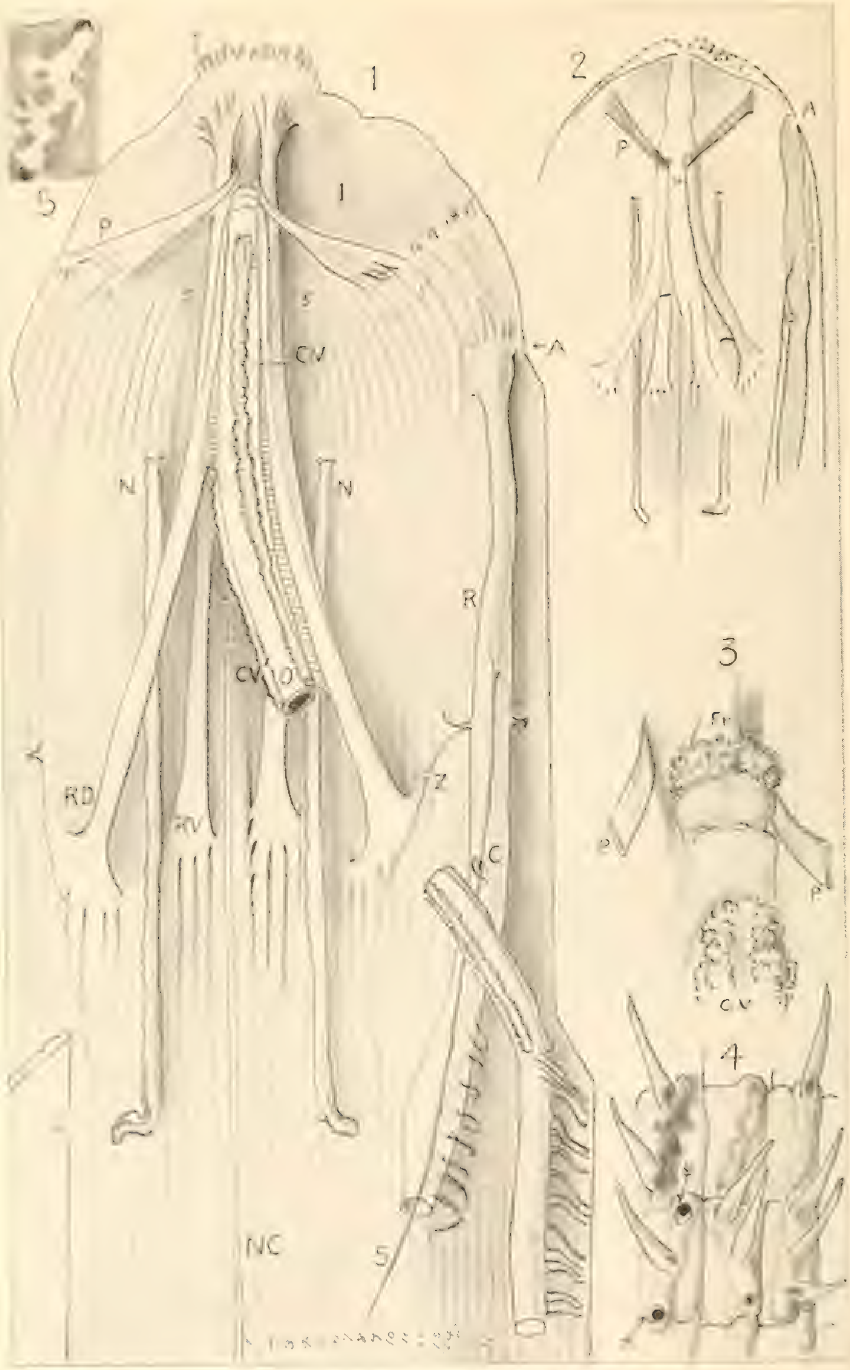


SIPUNCULUS NUDUS LINNAEUS.

SEE PAGE 441 FOR EXPLANATION



XENOSIPHON BRANCHIATUM (FISCHER).

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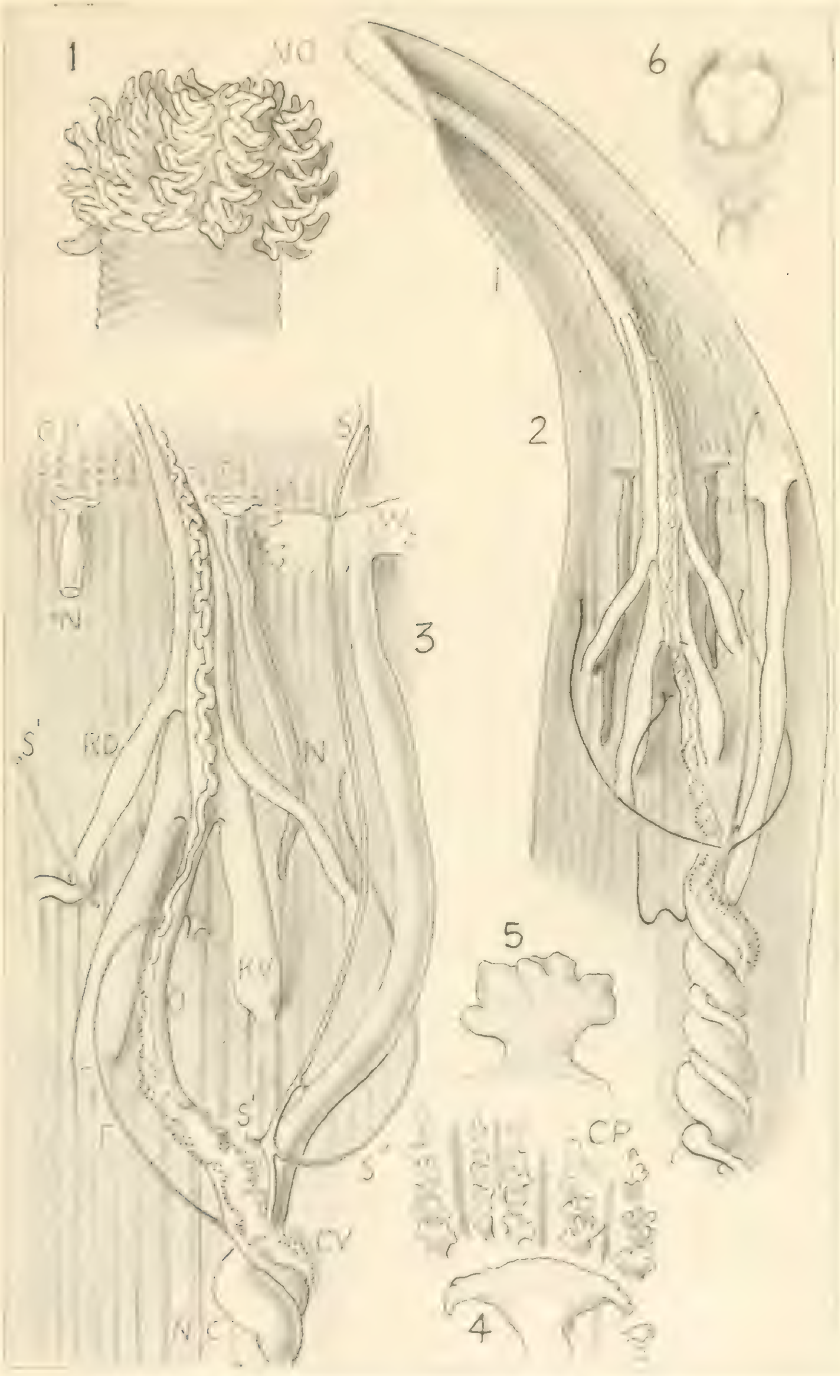
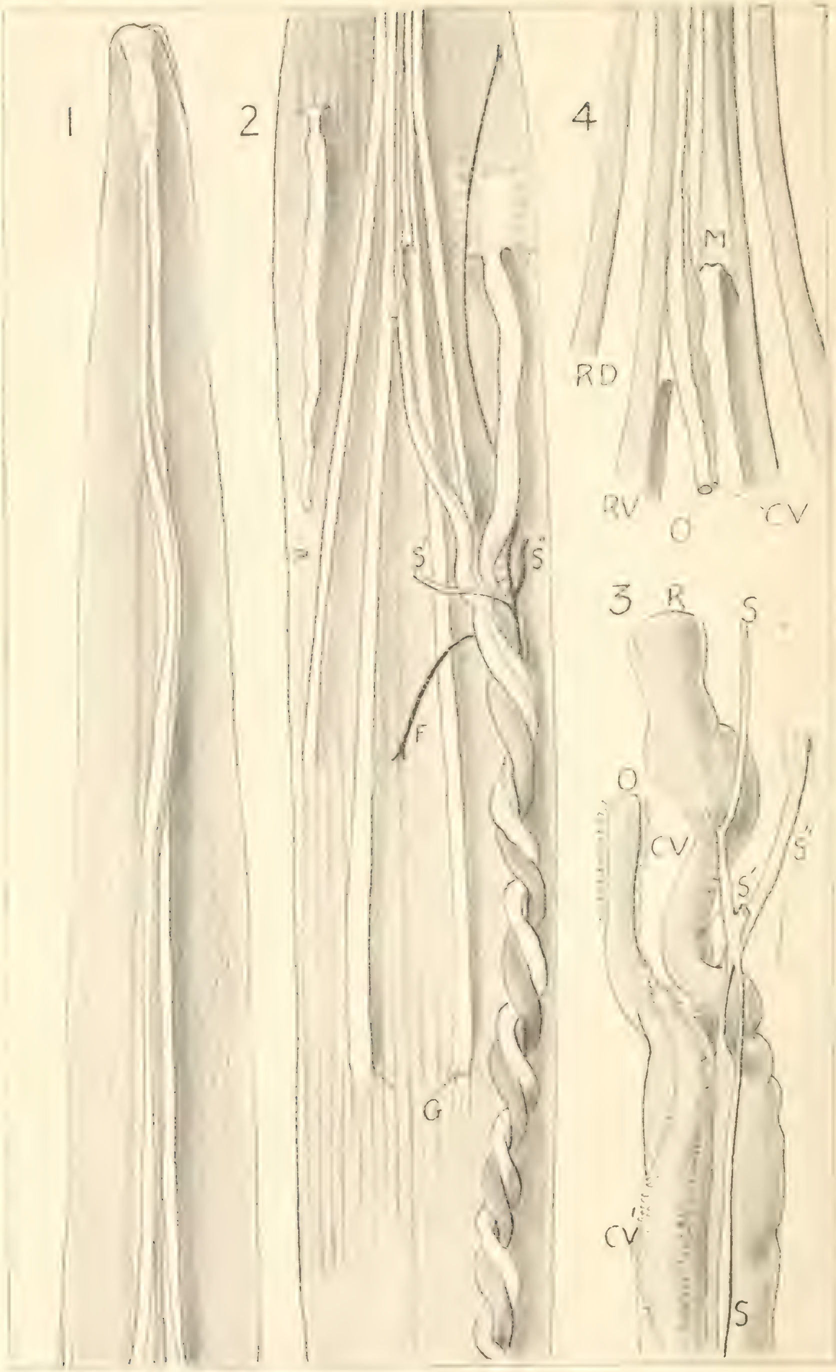


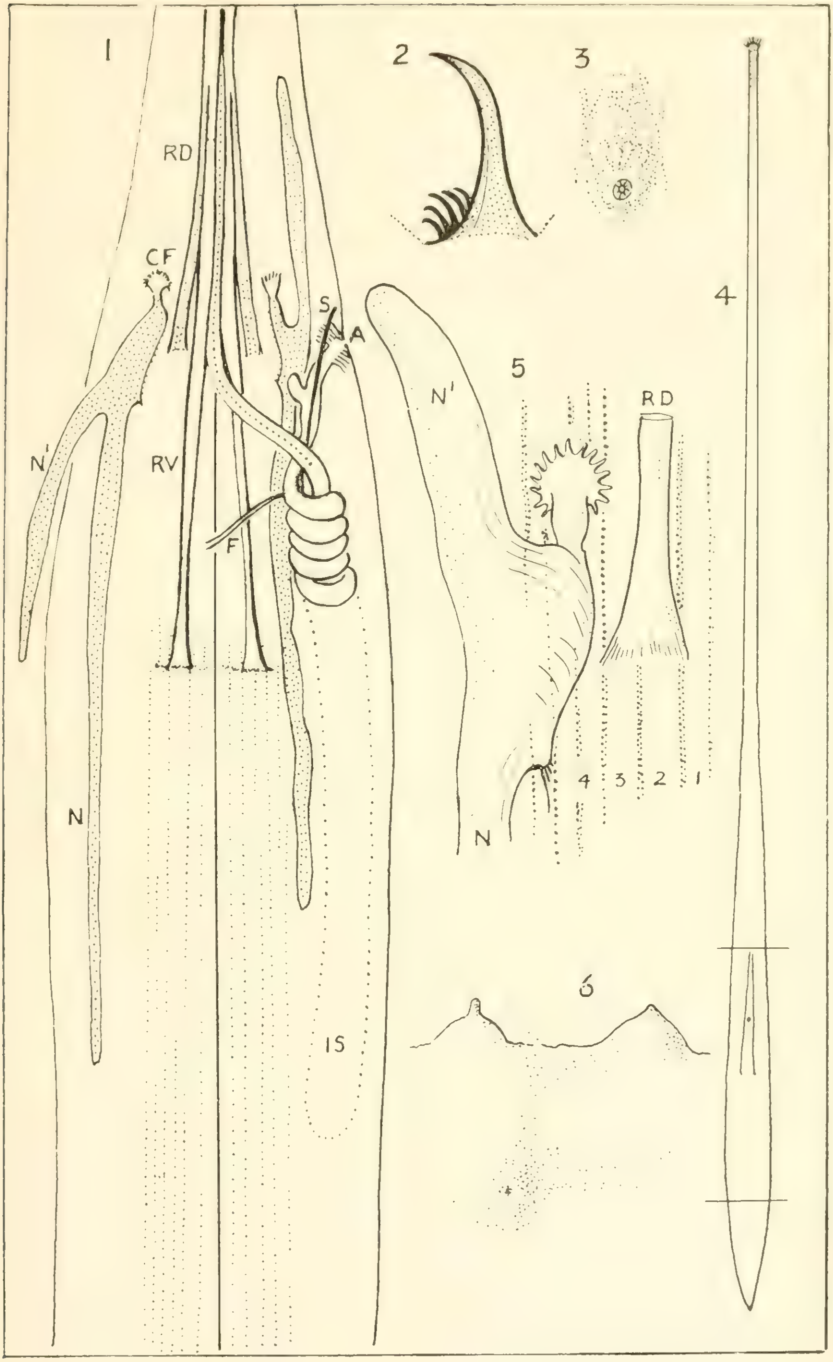
SIPHONOSOMA INGENS (FISHER).

SEE PAGE 442 FOR EXPLANATION.



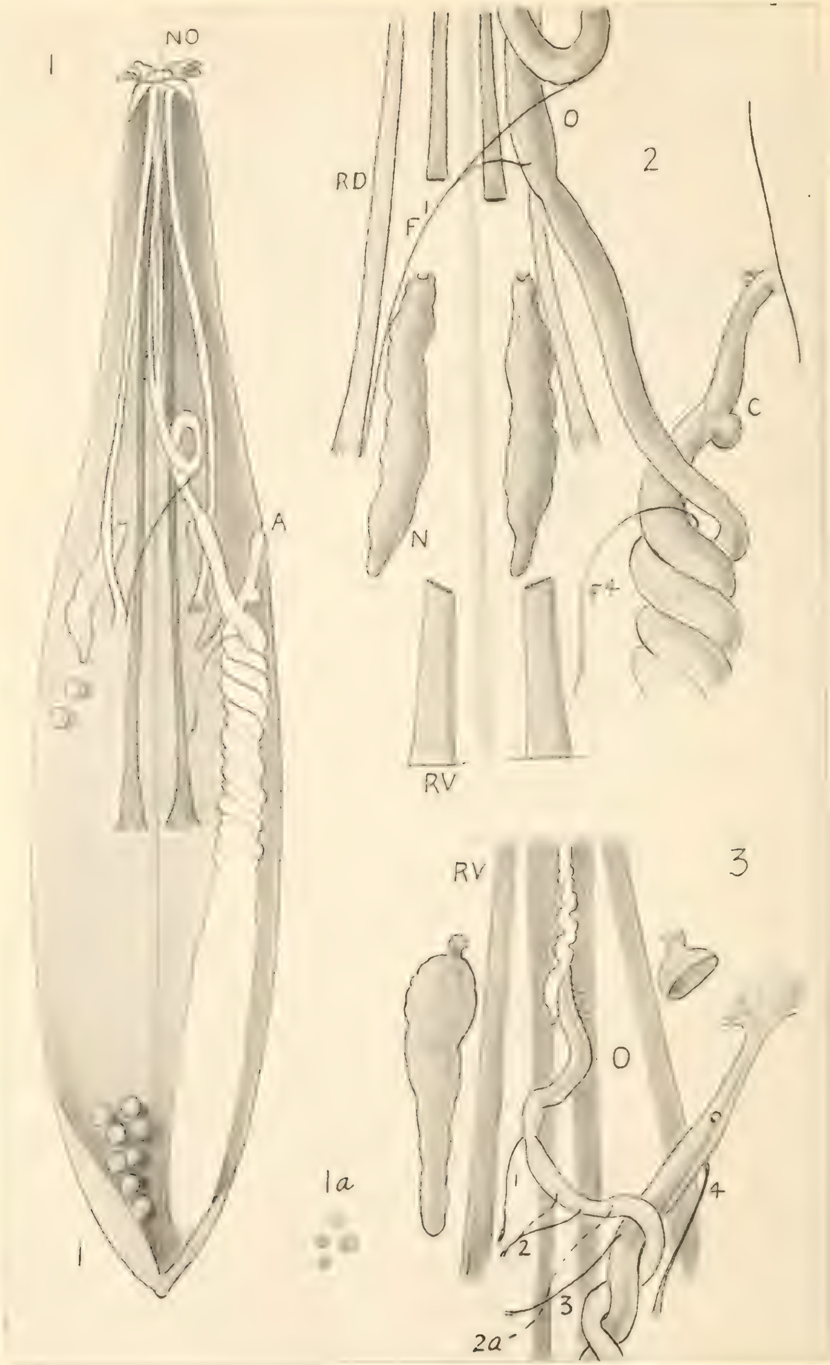
SIPHONOSOMA INGENS (FISHER), TYPES.

SEE PAGE 442 FOR EXPLANATION.



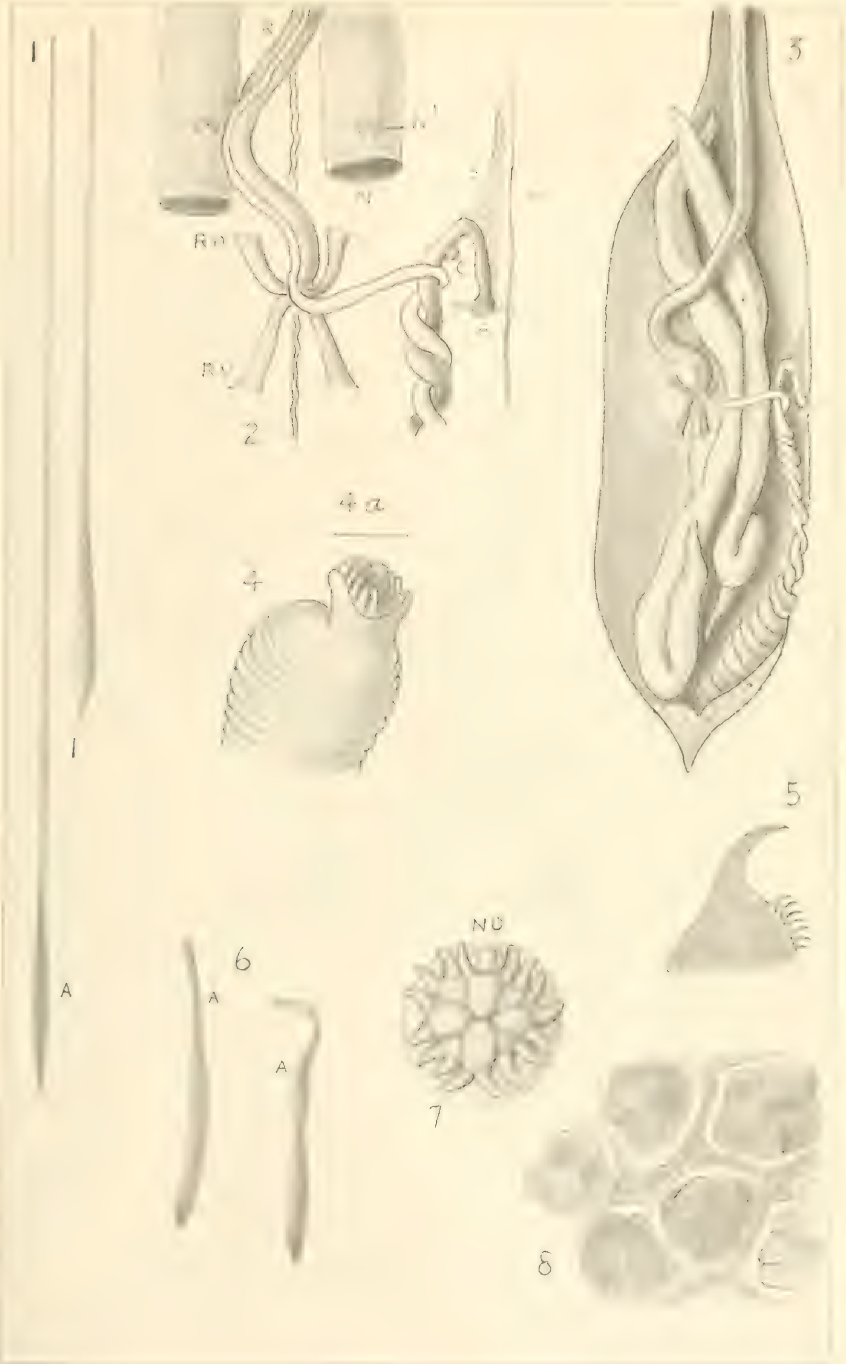
SIPHONIDES RICKETTSI, NEW SPECIES.

SEE PAGE 443 FOR EXPLANATION.



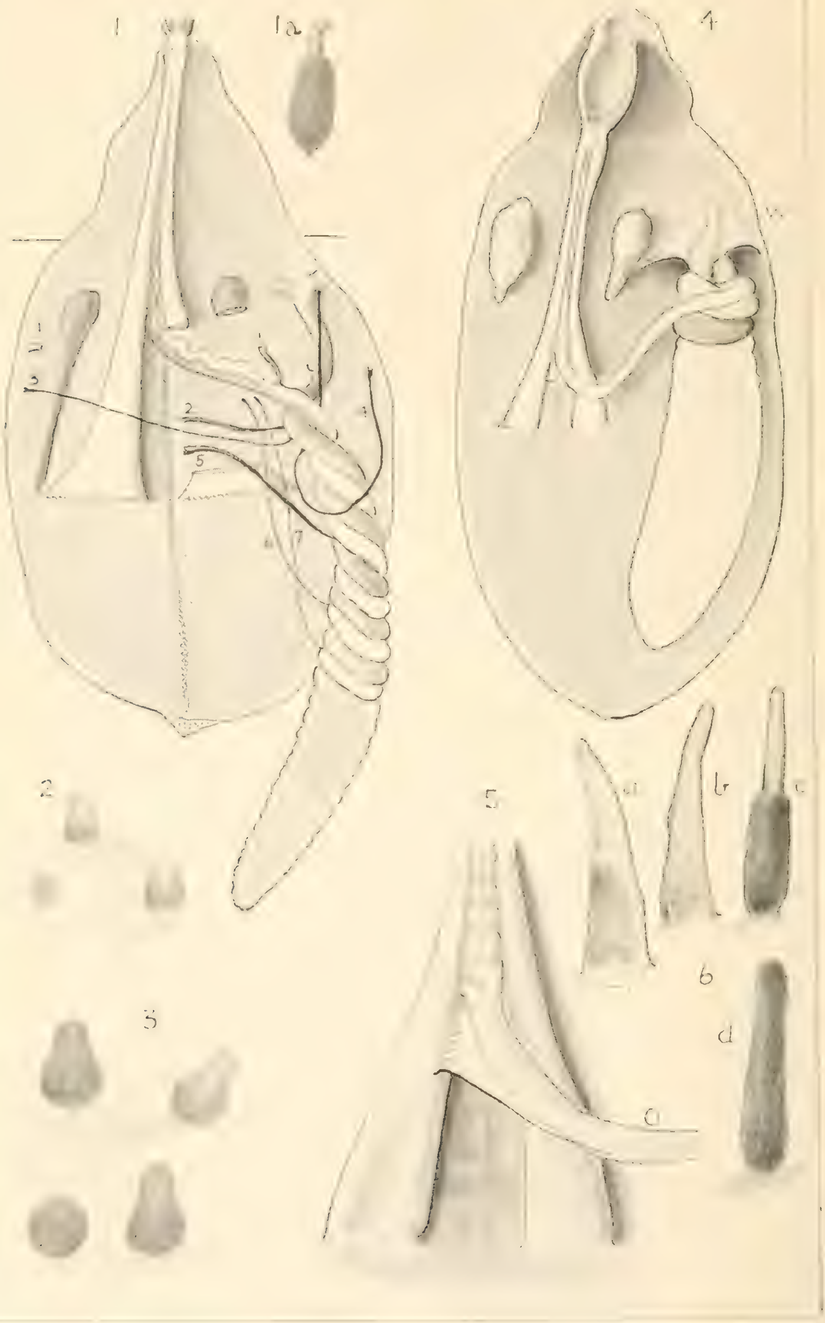
FORMS OF GOLFINGIA MARGARITACEA (SARS).

SEE PAGE 443 FOR EXPLANATION.



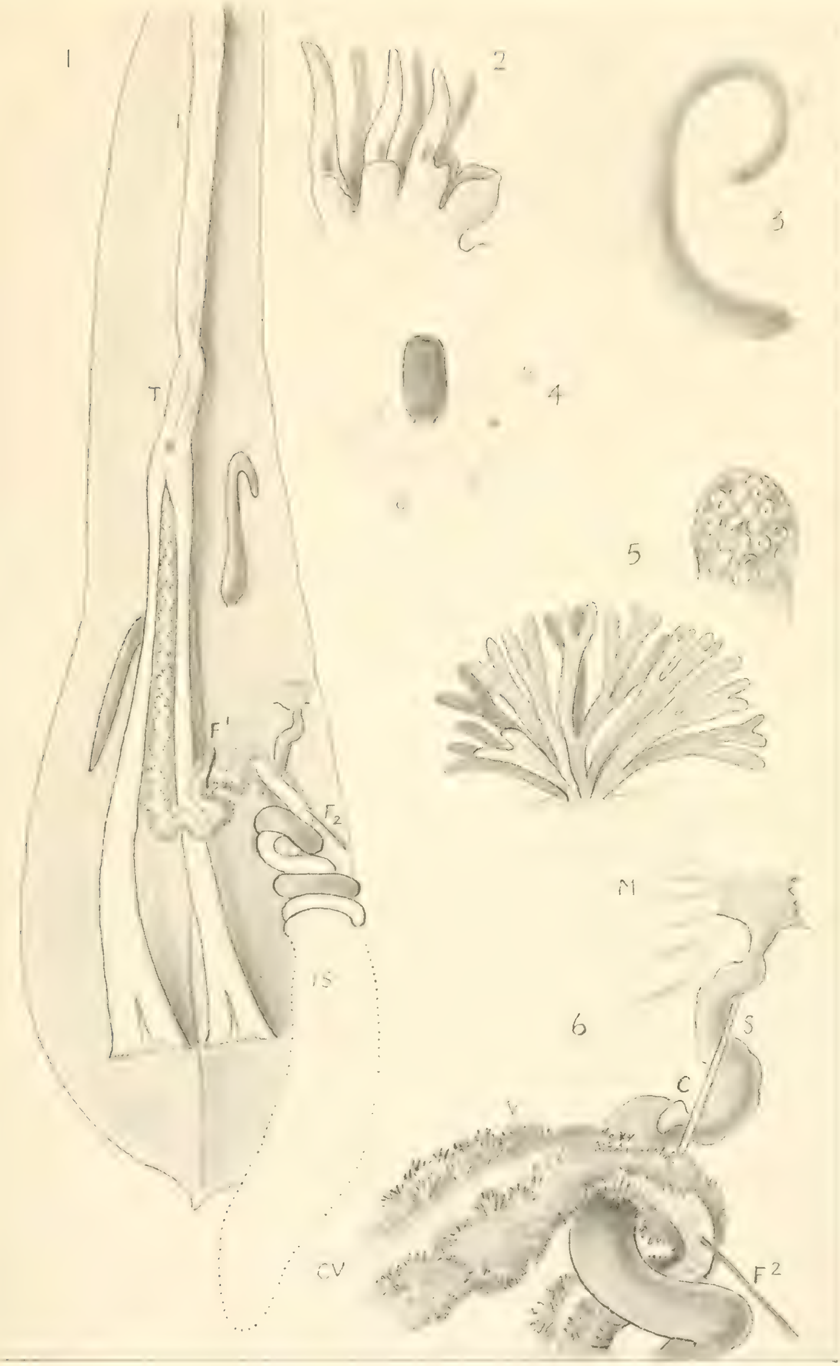
GOLFINGIA HESPERA (CHAMBERLIN) AND G. MARGARITACEA CALIFORNIENSIS, NEW SUBSPECIES.

SEE PAGE 444 FOR EXPLANATION.



GOLFINGIA ELACHEA, NEW SPECIES, AND G. LAETMOPHILA, NEW SPECIES.

SEE PAGE 444 FOR EXPLANATION



GOLFINGIA MACGINITIEI, NEW SPECIES.

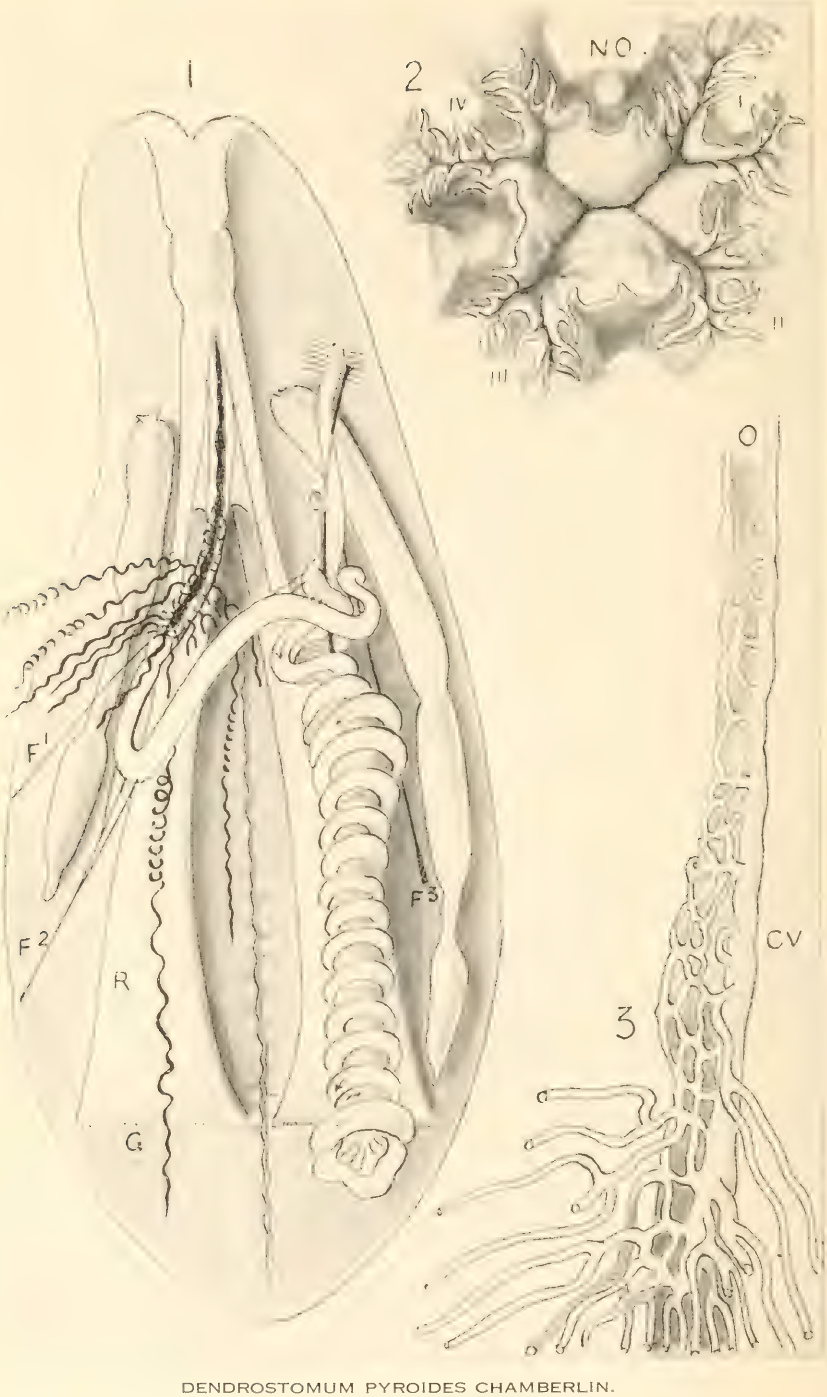
SEE PAGE 445 FOR EXPLANATION.

DENDROSTOMUM PYROIDES CHAMBERLIN AND D. PERIMECES FISHER.

SEE PAGE 445 FOR EXPLANATION.

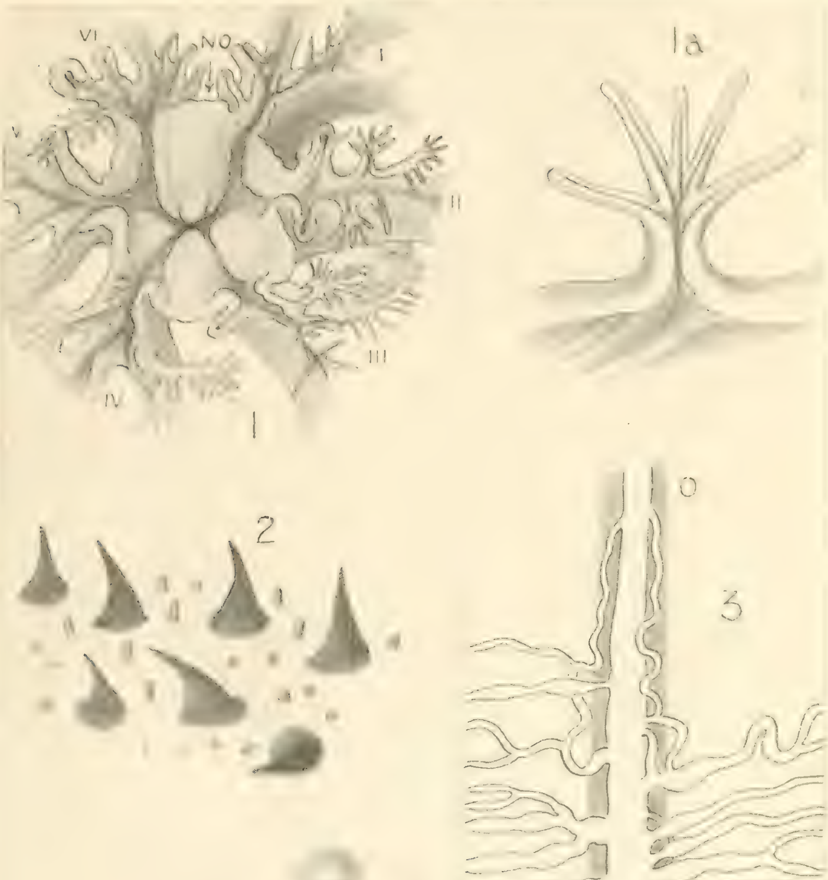
DENDROSTOMUM PERIMECES FISHER AND D. PYROIDES CHAMBERLIN.

SEE PAGE 446 FOR EXPLANATION.



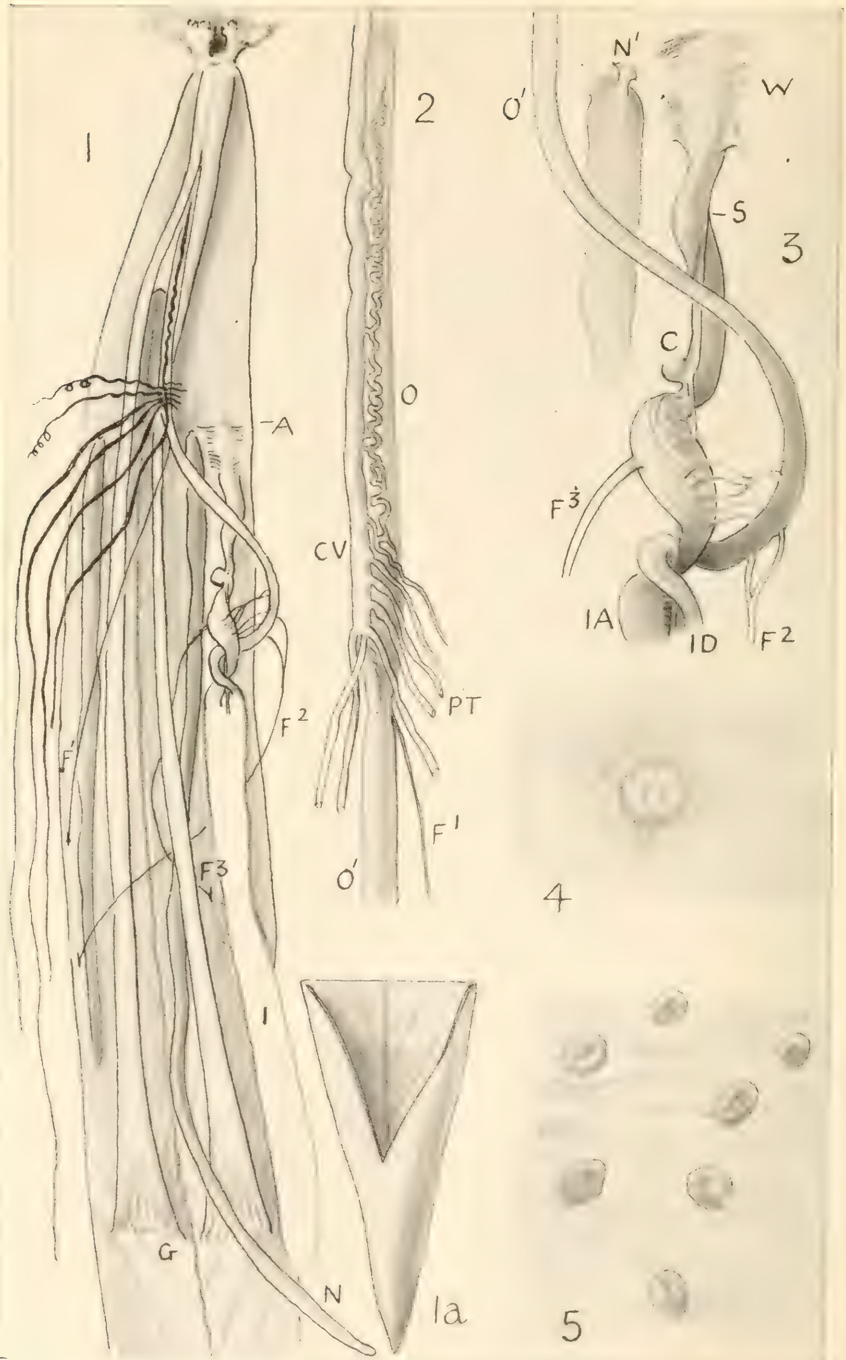
DENDROSTOMUM PYROIDES CHAMBERLIN.

SEE PAGE 446 FOR EXPLANATION.



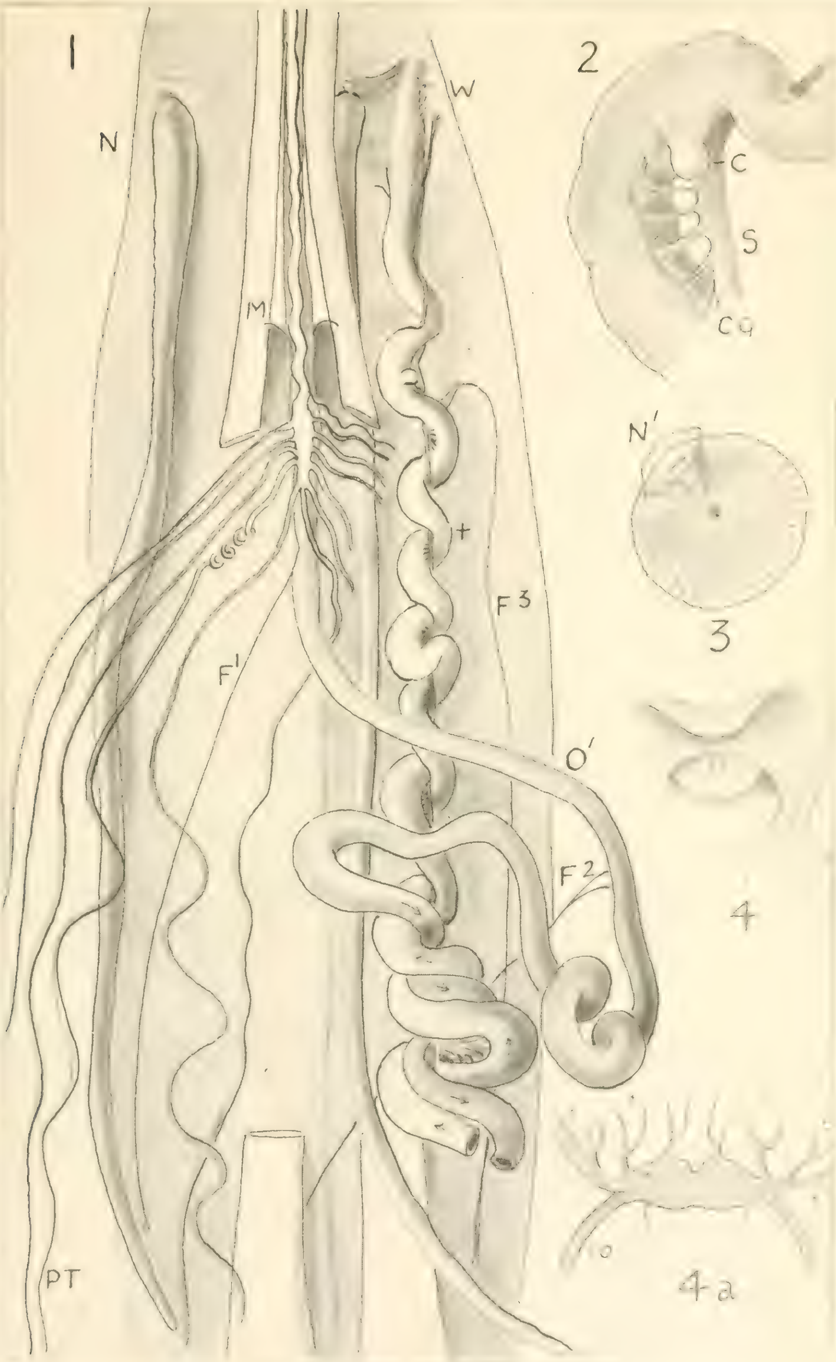
SPECIES OF DENDROSTOMUM.

SEE PAGE 447 FOR EXPLANATION.



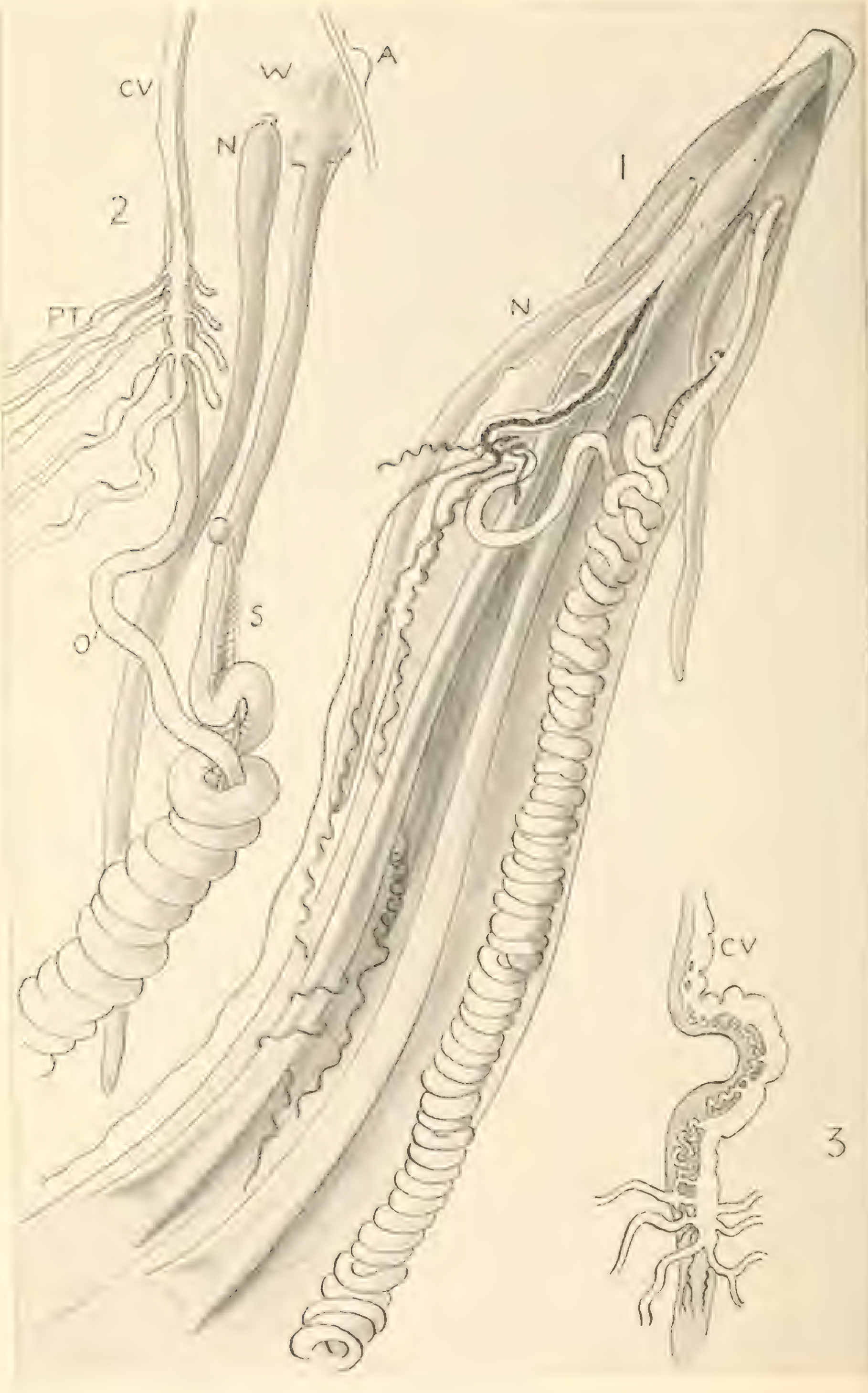
DENDROSTOMUM ZOSTERICOLUM CHAMBERLIN.

SEE PAGE 447 FOR EXPLANATION.



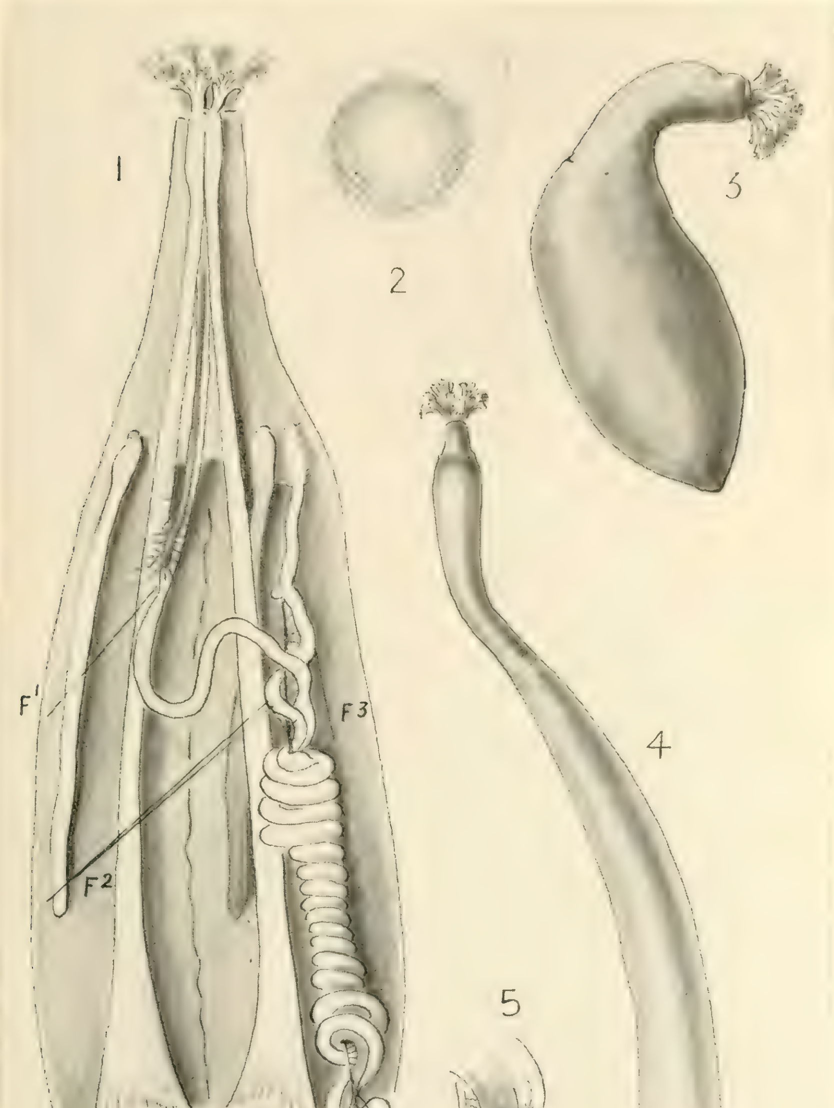
DENDROSTOMUM ZOSTERICOLUM CHAMBERLIN.

SEE PAGE 448 FOR EXPLANATION.



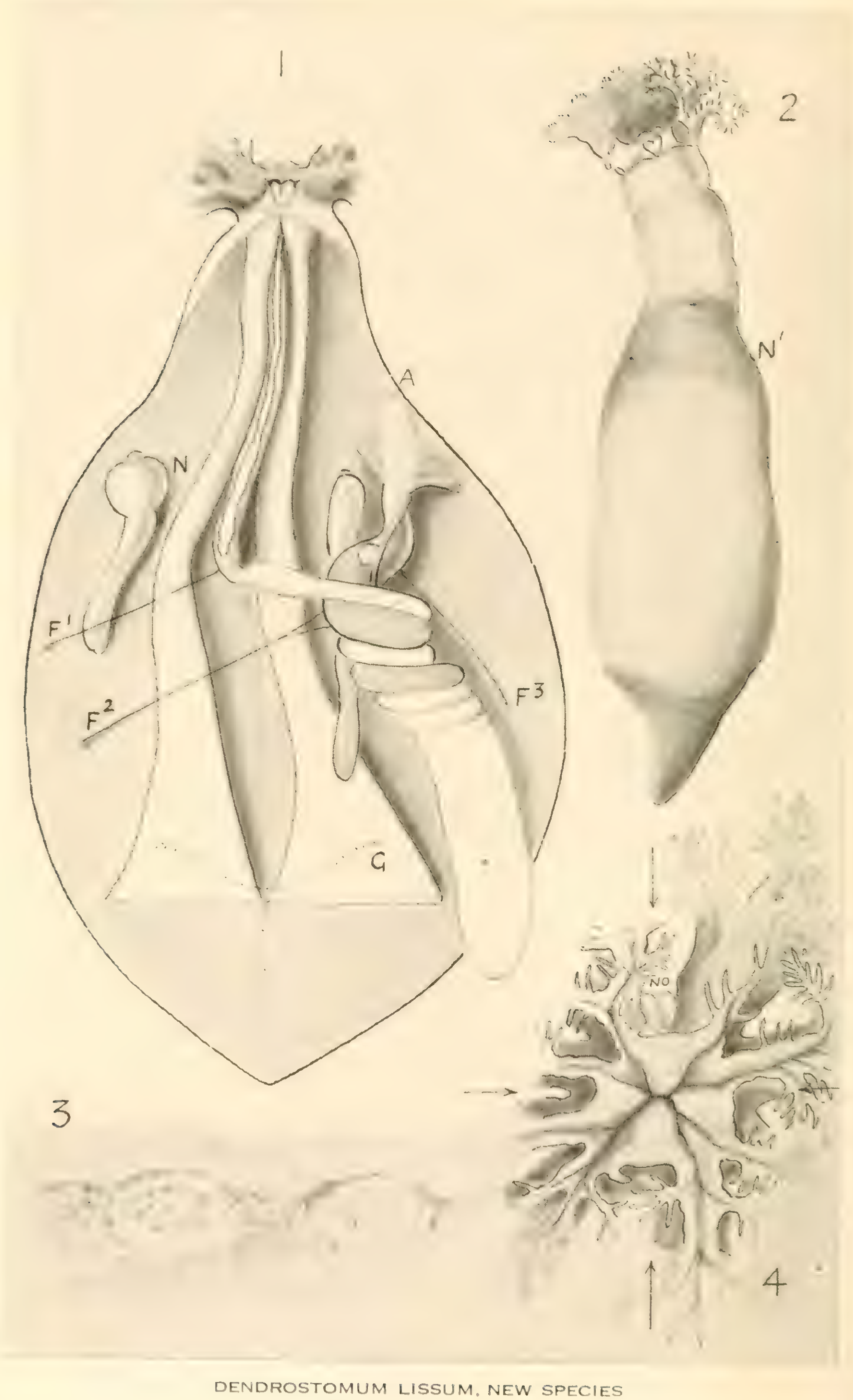
DENDROSTOMUM PERIMECES FISHER.

SEE PAGE 448 FOR EXPLANATION.



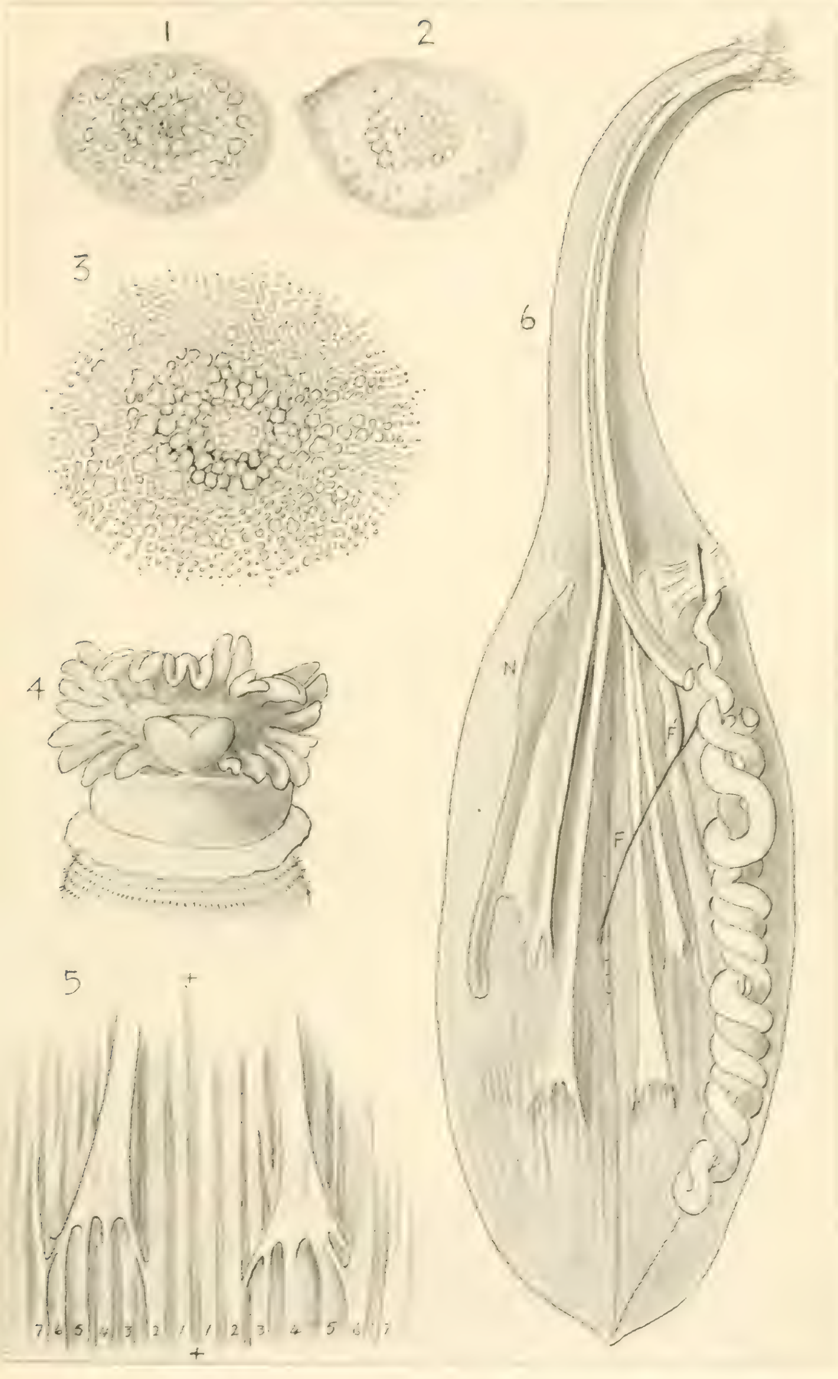
DENDROSTOMUM DYSCRITUM, NEW SPECIES.

SEE PAGE 448 FOR EXPLANATION.



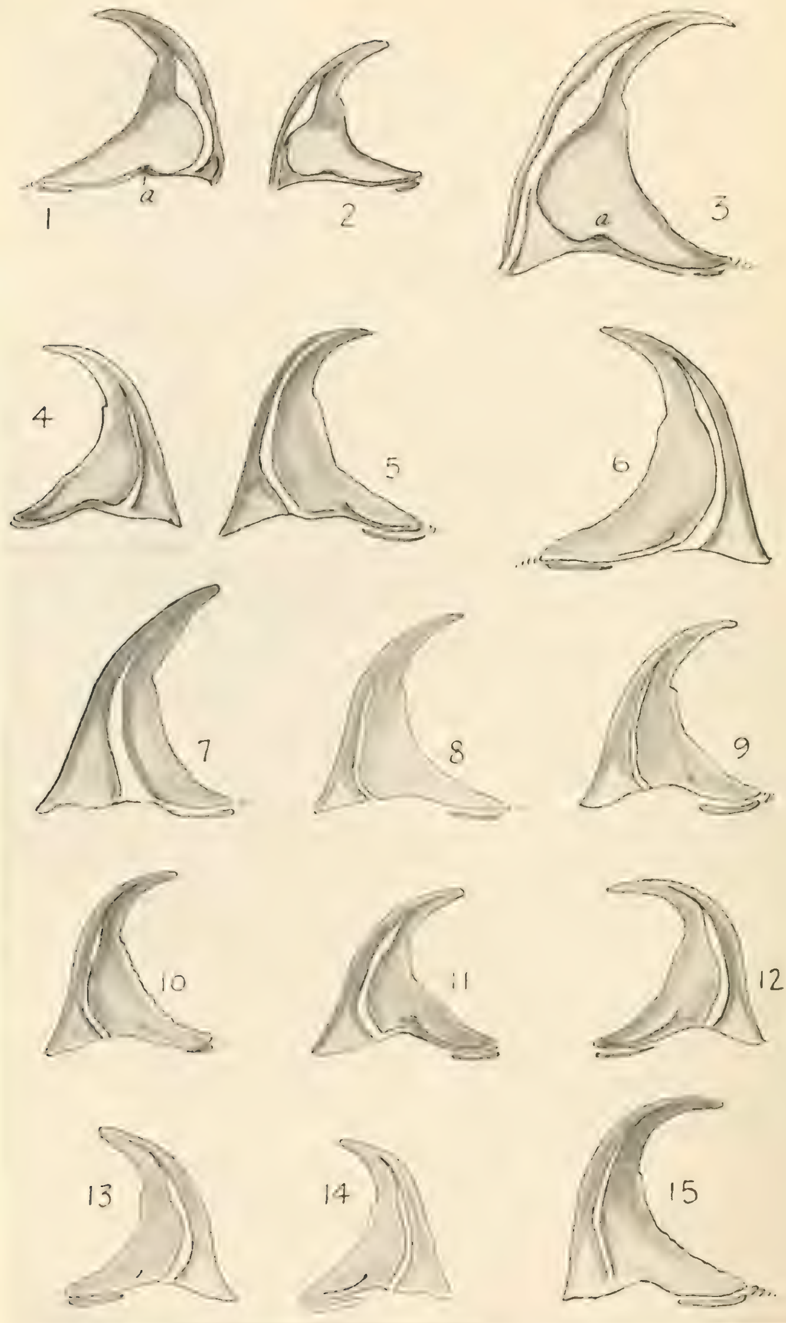
DENDROSTOMUM LISSUM, NEW SPECIES

SEE PAGE 448 FOR EXPLANATION.



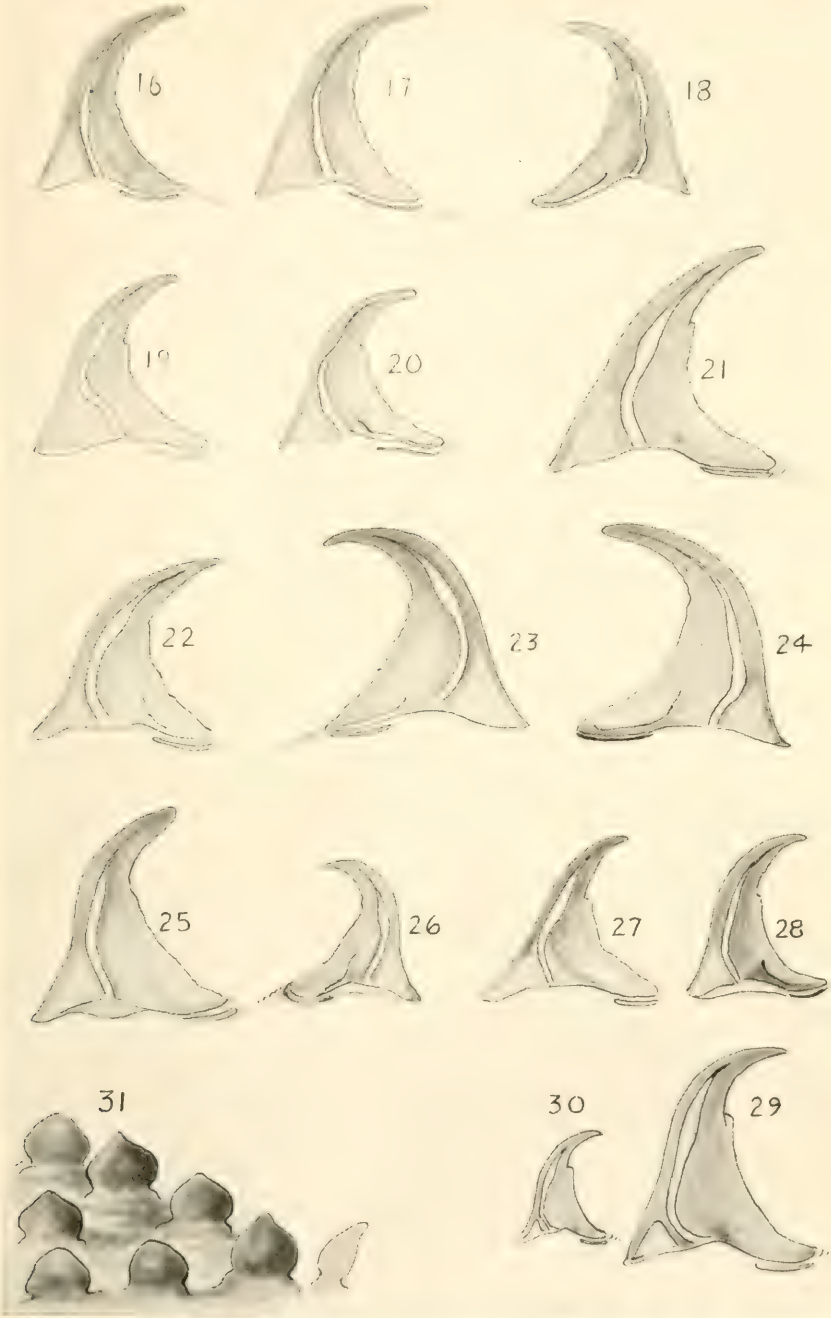
PHASCOLOSOMA PUNTARENAE GRUBE AND PH. AGASSIZII KEFERSTEIN.

SEE PAGE 449 FOR EXPLANATION.



PHASCOLOSOMA PUNTARENAE GRUBE AND PH. AGASSIZII KEFERSTEIN.

SEE PAGE 449 FOR EXPLANATION.



PHASCOLOSOMA AGASSIZII KEFERSTEIN.

SEE PAGE 450 FOR EXPLANATION.

SPECIES OF PHASCOLOSOMA.

SEE PAGE 450 FOR EXPLANATION.

PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM

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Vol. 102 Washington : 1952 No. 3307

SCHIZOSTELLA, A NEW GENUS OF BRITTLE-STAR (GORGONOCEPHALIDAE)

By Austin H. Clark

Thanks to the enthusiastic interest of Count Pourtalès, Alexander Agassiz, Prof. René Koehler, Dr. H. L. Clark, Dr. Th. Mortensen, and others more extensive and intensive work has been done on the echinoderm fauna of the Caribbean area than of any other part of the tropical seas. Yet within the past few years a very considerable number of new and surprising forms have come to light. During recent dredging operations Frederick M. Bayer added another to this growing list of unexpected new types, a new genus of Gorgonocephalidae, which may be known as—

SCHIZOSTELLA, new genus

Diagnosis.—A genus of Gorgonocephalidae, subfamily Astrochelinae, resembling *Asteroporpa* and *Astrocnida* but with seven rays, the arms bifurcate at about the middle, the double rows of hook-bearing granules with the bordering larger granules forming bands as broad as the distance between them, and reproducing by fission.

Genotype.—*Schizostella bifurcata*, new species.

Notes.—The subfamily Astrochelinae of the family Gorgonocephalidae, distinguished from the subfamily Gorgonocephalinae by the absence of interradial accessory plates, includes seven genera of which five, *Astrochele*, *Astrogomphus*, *Asteroporpa*, *Astrothorax*, and *Astrothrombus*, have undivided arms, while in two, *Astrocnida* and *Astroclon*, the arms branch at the tip. The genera *Astrogomphus*, *Asteroporpa*, and *Astrocnida* are represented in the Caribbean region, the two first also in the west Pacific.

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Schizostella seems to be most closely related to *Asteroporpa*, especially to the group of species including *lindneri* of the Caribbean, *australiensis* of Australia, and *hadracantha* of Japan in which the double bands of hook-bearing tubercles on the arms are bordered on each side by a regular row of contiguous enlarged granules, the quadruple bands composed of enlarged and hook-bearing granules are only slightly elevated above the general surface of the arms, and the hooks are small, usually without an accessory tooth. In spite of the forked arms it is less closely related to *Astrocnida*, and much less closely to *Astroclon*.

In several ophiurans in different families the young have six or sometimes seven arms and reproduce by fission, giving rise to adults with usually five arms. But *Schizostella* cannot be the young of any known West Indian species as it differs from all related species in details of its structure and ornamentation.

Although a number of species in several genera of the Trichasteridae are known to reproduce by fission when young, this is the first case to be reported in the Gorgonocephalidae.

SCHIZOSTELLA BIFURCATA, new species

PLATE 40

Description.—The disk is 4 mm. in diameter and is composed of seven triangular segments elevated in the middle and with rounded outer angles which are separated from each other by rather deep grooves, becoming deeper outwardly and ending at a deep notch in the interradial border. The seven segments each contain two radial ribs, but appear as single units, seldom giving any indication of a double structure.

The disk is densely covered with hemispherical granules, the smaller brownish and the larger white, which are irregularly arranged except at the distal ends of the segments, where there are two regular rows of white tubercles separated by two rows of hook-bearing tubercles.

The seven arms are at the base very nearly as broad as the distal width of the disk segments. They are roughly twice as long as the diameter of the disk and bifurcate at about the middle, on or about the thirteenth brachial.

The ornamentation of the arms resembles that of the outer part of the disk segments. There are evenly spaced transverse rows of white hemispherical granules between which are double rows of hook-bearing granules alternating with, at the base of the arms, irregular double rows of larger, lower, polygonal granules which farther out become single irregular rows and disappear almost completely at the arm tips. The hooks are minute, very stout, thick-crescentic, without an accessory tooth, and become very prominent on the slender arm tips.

SCHIZOSTELLA BIFURCATA, NEW GENUS, NEW SPECIES.

The topmost figure (both sides) is the type, U.S.N.M. No. E. 7875; the four lower figures are two cotypes. × 3.

The oral surface is studded with large white granules resembling those on the aboral surface, but widely scattered.

The second tentacle pore has a double arm spine. Farther out there seem to be three arm spines arising from the same base. Distally these become transformed into hooks.

The genital openings, two in each interradius, are very large.

The color is pinkish brown, the under surface and the large tubercles yellowish white.

Type.—U.S.N.M. No. E. 7875, from off Triumph Reef, Elliott Key, Fla.: 20–25 fathoms; collected by Frederick M. Bayer, November 28, 1949.

Notes.—Three additional specimens were collected at the same station. The type and two others were on *Swiftia exserta* (Ellis and Solander) and one was on *Filigorgia*, sp.

The type and the specimen from *Filigorgia* are symmetrical with seven rays each. The two others have two full-sized rays and two much smaller, evidently the result of fission.

For comparison with these specimens there are at hand four examples of the ophiocrenoid stage of one of the species of Gorgonocephalinae. These have five arms which divide once, in some cases with the rudiments of a second forking at the tips of the secondary arms, and the interradial areas of the disk are deeply concave. They were dredged at *Albatross* station 3729, off Omai Zaki Light, Japan, in 34 fathoms and were clinging to *Melitodes*, sp. (?*nodosa*). They resemble in general the specimens described by Matsumoto (Journ. Coll. Sci., Tokyo Imper. Univ., vol. 38, art. 2, pp. 68, 69, fig. 18, p. 69, March 31, 1917) from Sagami Bay in 300 fathoms.

With the four specimens from *Albatross* station 3729 were dredged two specimens of *Astrocladus dofleini* Döderlein (recorded by H. L. Clark, U. S. Nat. Mus. Bull. 75, p. 293, 1911, as *Astrophyton pardalis*) of which they are presumably the young.

Matsumoto said that his ophiocrenoids may be young either of *Astroboa* or *Astrochalcis.* They are from deeper water than the maximum recorded for any of the five species of *Astrocladus*, all of which occur in the sublittoral zone.

While studying the specimens of *Muricea* collected by the *Albatross* in the West Indies Mr. Bayer found a second species of *Schizostella* which may be known as

SCHIZOSTELLA BAYERI, new species

Description.—Resembling *S. bifurcata* and, like it, with seven bifurcate arms; but the white granules on the disk, instead of being scattered, are contiguous and arranged in regular lines to form a conspicuous, white, close reticulation, while those on the arms are contiguous instead of slightly separated, forming regular narrow transverse lines across the arms.

Type.—U.S.N.M. No. E. 7997, from *Albatross* station 2138, southeast of Jamaica (lat. 17°44′05″ N., long. 75°39′00″ W.) ; 23 fathoms; coral and broken shells; February 29, 1884.

Notes.—The type and two additional specimens (E. 7998) were found on *Muricea pendula* Verrill.

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PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM

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Vol. 102 Washington: 1952 No. 3308

MOTHS OF THE GENUS EPEIROMULONA, A NEW GENUS OF LEPIDOPTERA

By William D. Field

The genus treated in this paper (Arctiidae, Lithosiinae) has formerly been represented by a single species originally described as *phelina* by Druce and doubtfully referred by him to the genus *Autoceras* Felder in the text of his description [1] and placed in the genus *Melania* Wallengren on the plate accompanying this text.[2] Subsequently Hampson [3] placed it in *Mulona* Walker and Forbes,[4] recognizing that it did not belong with *Mulona*, transferred it tentatively to the genus *Gaudeator* Dyar. In reality it belongs to quite a distinct and new genus.

A study of the 75 specimens from the collections of the United States National Museum, the British Museum (Natural History), and Cornell University discloses the fact that the genus contains 7 species (one of these with 3 subspecies), all but 1 being new.

EPEIROMULONA, new genus

Type.—Epeiromulona lephina, new species.

Labial palpus upturned, short, barely reaching above lower margin of frons.

Antennae of male and female filiform and gradually more slender to the tip; each subsegment heavily setose underneath. Each subsegment with a pair of bristles arising from middle of ventrolateral

[1] Biologia Centrali-Americana, Insecta, Lepidoptera-Heterocera, vol. 1, p. 139, 1885.

[2] Ibid., vol. 3, pl. 13, fig. 13, 1885.

[3] Catalogue of the Lepidoptera Phalaenae in the British Museum, vol. 2, pp. 386–387, 1900.

[4] Bull. Mus. Comp. Zool., vol. 85, p. 183, 1939.

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margin and with a second pair of bristles arising from just above middle of dorsolateral margin of subsegment and with a single sensory cone arising from near the middle of front margin.

Venation of forewing with vein 2 from outer fourth of cell, nearly straight, not downward curved at base; vein 3 separate from just before lower angle of cell (3 very rarely stalked with 4); 4 from lower angle and 4 and 5 separate; 6 from below upper angle of cell; 9 from stalk of 7 and 8; 10 and 11 free; 10 from cell about halfway between stem of 7, 8, and 9 and base of 11; 11 from outer third of cell and curved distally toward 12.

Venation of hindwing with 2 from outer fourth of cell; 3 stalked with 4 from lower angle of cell; 5 separate and from just below middle of cell; 6 and 7 stalked from upper angle of cell; 8 from about middle or slightly after middle of cell.

Male genitalia (see all figures on pls. 41–43 and figs. 13–17 on pl. 45) with uncus hooklike, broad at base and sharply constricted and curved distally; gnathos absent; anellus present (dorsal plates absent) and represented by a strongly sclerotized, nearly H-shaped juxta; vinculum broadly U-shaped; inner surface of harpe with downward-projecting lobe from near middle (this lobe sometimes fingerlike or hooklike) except in *icterinus;* saccus very small; aedeagus broader posteriorly than anteriorly and bent or at least curved near middle; vesica armed with numerous spinelike cornuti; bulbus ejaculatorius from about anterior fourth or fifth of aedeagus.

Female genitalia (see all figures on pl. 44 and figs. 11 and 12 on pl. 45) with pouch between posterior margin of seventh abdominal segment and anterior margin of eighth abdominal segment; seventh abdominal segment sometimes strongly sclerotized above this pouch, sometimes so much so that the pouch is more like a lip than a pouch; strongly sclerotized species with a pair of lateral lateroventral cuplike shallow pouches on seventh segment, lying on each side of raised central area; eighth segment not at all or only weakly sclerotized ventrally, never forming a solid ventral plate, but with a plate that is broken through the middle; ostium bursae before middle of eighth segment; ductus bursae heavily sclerotized, broad at ostium bursae and somewhat twisted and narrowed at bursa copulatrix; entrance to bursa copulatrix armed with a furcate plate, this plate inwardly covered with short spines; bursa copulatrix with ductus seminalis from right side or slightly dorsal and near ductus bursae; bursa copulatrix subspherical, slightly bent and extended to the left and with a ribbonlike scobinate plate at anterior end.

Comparative remarks.—This genus is somewhat related to *Mulona* Walker and *Gaudeator* Dyar. Vein 2 of forewing is nearly straight, not at all downward curved at base in *Gaudeator* and *Epeiromulona*, whereas in *Mulona* vein 2 is downward curved at base. Vein 5 of hindwing is present in *Gaudeator* and *Epeiromulona*, absent in *Mulona*. Veins 3 and 4 of hindwing are usually connate or separate in *Gaudeator*, stalked in *Mulona* and *Epeiromulona*. *Epeiromulona* is easily distinguished by the male and female genitalia from the other two genera. In males of *Mulona* the juxta is bifurcate and U- or V-shaped. In *Epeiromulona* the juxta is H-shaped and in *Gudeator* a broad, slightly curved plate. The transtilla is absent in *Epeiromulona* and present in *Mulona* and *Gaudeator*. The aedeagus is short and broad in *Mulona*, short and not so broad in *Gaudeator*, and is rather long in *Epeiromulona*. Numerous cornuti are present on the vesica in *Gaudeator* and *Epeiromulona* and absent in *Mulona*. In females of *Mulona* the middle two-thirds or more of bursa copulatrix is heavily serratulate while *Gaudeator* and *Epeiromulona* females are not serratulate but contain instead two areas of armature, one each at anterior and posterior end of bursa copulatrix. The anterior armature in *Epeiromulona* consists of a ribbonlike scobinate plate and in *Gaudeator* this armature consists of a small, nearly round scobinate plate. The posterior armature in *Epeiromulona* consists of a bifurcate plate covered with short spines and in *Gaudeator* this armature consists of a collar covered with long spines, this collar almost half encircling bursa copulatrix near entrance of ductus bursae.

KEY TO THE SPECIES OF EPEIROMULONA

1. Vertex of head orange ---------- icterinus, new species (p. 467)
   Vertex of head white ---------- 2
2. Hindwings, salmon pink ---------- roseata, new species (p. 465)
   Hindwings yellow or orange ---------- 3
3. Legs yellow with black bands ---------- 4
   Legs white with black bands ---------- biloba, new species (p. 460)
4. Fringe of forewing entirely orange or pale orange-yellow; apex of first femur yellow ---------- 5
   Fringe opposite middle of outer margin of forewing black; apex of first femur black ---------- thysanata, new species (p. 466)
5. Males ---------- 6
   Females ---------- 9
6. Upper elements of H-shaped juxta distinctly shorter than bottom elements (pl. 41, fig. 1) ---------- lephina, new species (p. 459)
   Upper elements of H-shaped juxta as long as or slightly longer than bottom elements (pl. 42, fig. 3) ---------- 7
7. Distal end of harpe narrow, much narrower than base ---------- 8
   Distal end of harpe as broad or nearly as broad as base (pl. 45, fig. 17) ---------- hamata colombiensis, new subspecies (p. 464)
8. Harpe with costa not at all or only slightly expanded at apex (pl. 42, fig. 3a; pl. 45, figs. 13, 14).
   hamata hamata, new species and subspecies (p. 462)
   Harpe with costa well expanded at apex (pl. 45, figs. 15, 16).
   hamata venezuelensis, new subspecies (p. 463)

9. Posterior margin of seventh abdominal segment below, with three distinct lobes (pl. 44, figs. 9, 10) ---------------------------------- 11
   Posterior margin of seventh abdominal segment below without these lobes -- 10
10. Shallow cuplike pouches on seventh abdominal segment extending well into ventral surface (pl. 44, fig. 7) ---------- phelina (Druce) (p. 458)
   Shallow cuplike pouches on seventh abdominal segment lateral in position (pl. 44, fig. 8) -------------------- lephina, new species (p. 459)
11. Lobes on each side of mesial lobe of posterior margin of seventh abdominal segment small (pl. 44, fig. 9).
   hamata brasiliensis, new subspecies (p. 465)
   These lobes large, nearly as large as mesial lobe (pl. 44, fig. 10).
   hamata hamata, new species and subspecies (p. 462)

EPEIROMULONA PHELINA (Druce)

PLATE 44, FIGURE 7; PLATE 46, FIGURE 22

Autoceras (?) *phelina* DRUCE, Biologia Centrali-Americana, Insecta, Lepidoptera-Heterocera, vol. 1, p. 139, 1885.

Melania phelina (DRUCE), Biologia Centrali-Americana, Insecta, Lepidoptera-Heterocera, vol. 3, pl. 13, fig. 13, 1885.

Cincia phelina (Druce), KIRBY, A synonymic catalogue of Lepidoptera Heterocera, p. 366, 1892.

Mulona phelina (Druce), HAMPSON, Catalogue of the Lepidoptera Phalaenae in the British Museum, vol. 2, pp. 386, 387 (♀), 1900.—DRAUDT, *in* Seitz, Gross-schmetterlinge der Erde, vol. 6, p. 252, pl. 34, fig. c 9, 1918.—STRAND, *in* Wagner, Lepidopterorum catalogus, pars 26, p. 732, 1922.

Male.—Unknown.

Female.—(pl. 46, fig. 22).—Palpus, head, base of antenna, patagium, tegula, pronotum, and mesonotum pale dirty orange-yellow. Except for palpi this color may be due to a stain and may have originally been white (in the single known specimen of this species). Metanotum and thorax underneath pale orange-yellow. Antenna beyond base black with a long white streak just before apex. There is a black spot in middle of thorax and another on base of tegula. Foreleg pale orange-yellow with most of tibia and last four tarsal subsegments black. First tarsal subsegment nearly white. Hindleg pale orange-yellow (midlegs missing in the single known specimen). Wings white, spotted with 15 black spots and bars, these arranged as in *E. biloba.* Fringe of forewing pale yellowish orange.

Length of forewing 9 mm.

Female genitalia as illustrated (pl. 44, fig. 7) and with characters as given in the key.

Type locality and distribution.—"Volcán de Chiriquí," Panama.

Additional type data.—Described from a single specimen, the holotype female (elevation 2,000 to 3,000 feet; Champion; ♀ genitalia preparation, British Museau No. 1951–22).

Location of type.—In the British Museum (Natural History).

Remarks.—The photographs of the type (pl. 46, fig. 22) and of the genitalia of the type (pl. 44, fig. 7) were furnished through the courtesy of D. S. Fletcher, of the British Museum (Natural History), Department of Entomology.

EPEIROMULONA LEPHINA, new species

PLATE 41, FIGURES 1, 1a, 1b; PLATE 44, FIGURE 8; PLATE 46, FIGURES 18–20

Mulona phelina (Druce), Dyar nec Druce, in part., Proc. U. S. Nat. Mus., vol. 47, p. 167, 1914.

Gaudeator (?) *phelina* (Druce), FORBES nec Druce, in part., Bull. Mus. Comp. Zool., vol. 84, No. 4, p. 163 (on chart), p. 183, August 1939.

Male.—(pl. 46, figs. 18, 20).—Palpus pale orange-yellow. Head, base of antenna, patagium, tegula, pronotum, and mesonotum white. Metanotum and thorax underneath pale orange-yellow. Antenna beyond base black with a long white streak just before apex. A black spot in middle of thorax and on base of tegula (this last spot usually hidden by patagium). Legs pale orange-yellow with foretibia, apex of midtibia and hindtibia and last four tarsal subsegments of all legs black; apex of forefemur yellow. Abdomen orange-yellow, pale yellowish white at base above. Forewings and hindwings above and below very similar to *biloba* with fringe of forewing slightly paler orange-yellow near the margin.

Length of forewing 6.5–7 mm.

Male genitalia as illustrated (pl. 41, figs. 1, 1a, 1b) and with characters as given in the key.

Female (pl. 46, fig. 19).—Habitus like that of the male.

Length of forewing 7–8 mm.

Female genitalia as illustrated (pl. 44, fig. 8) and with characters as given in the key.

Type locality.—Porto Bello, Colón Province, Panama.

Additional type data.—Described from the holotype, male (locality as given above; U.S.N.M. type No. 34839; August Busck; March 1912; ♂ genitalia preparation W. D. F. No. 3191, 1949); allotype, female (same data as holotype; ♀ genitalia preparation W. D. F. No. 3218, 1949); paratypes Nos. 1–5, two males and three females (Río Trinidad, Panama; March, May, June 1911, 1912; August Busck. W. D. F. genitalia preparations as follows: Paratype No. 1, ♂, No. 3190, 1949; paratype No. 2, ♂, No. 3192, 1949; paratype No. 3, ♀, No. 3212, 1949; paratype No. 4, ♀, No. 1666, 1941; paratype No. 5, ♀, No. 3211, 1949); paratype No. 6, ♂ (La Chorrera, Panama; May 1912; August Busck; ♂ genitalia preparation W. D. F. No. 1675, 1941); paratypes Nos. 7–9, males (Cayuga, Guatemala; Schaus and Barnes; March, May, August. W. D. F., ♂ genitalia preparations as follows: Paratype No. 7, No. 3187, 1949; paratype No. 8, No. 1672, 1941; Paratype No. 9, No.

3239, 1949) and paratypes Nos. 10–13, females (Barro Colorado Island, Panama Canal Zone; March, November 1934, 1940, 1941; James Zetek and Marston Bates. W. D. F., ♂ genitalia preparations as follows: Paratype No. 10, No. 3213, 1949; paratype No. 11, No. 3214, 1949; paratype No. 12, No. 3226, 1949; paratype No. 13, No. 3244, 1949).

Locations of types.—Holotype, allotype, and paratypes Nos. 1, 3, 4, 5, 6, 7, 13 in the United States National Museum. Paratypes Nos. 8, 12 in the collection of Cornell University. Paratypes Nos. 9, 11 in the British Museum (Natural History). Paratypes Nos. 2, 10 in the American Museum of Natural History.

Distribution.—PANAMA: *Province of Colón*, Porto Bello (May); Río Trinidad (March, May, and June); *Province of Panama*, La Chorrera (May). CANAL ZONE: Barro Colorado Island (March, April, November). GUATEMALA: *Department of Izabal*, Cayuga (May).

Remarks.—Fifteen specimens (including the genitalia preparations of all these) were examined.

Comparative remarks.—This species differs in habitus from *E. biloba* in having the underside of thorax and the legs colored pale orange-yellow with black bands on the legs, and in having the femur of foreleg pale orange-yellow. In *biloba* the underside of thorax and the legs are white with black bands on the legs and with the apical half of the femur of foreleg black.

EPEIROMULONA BILOBA, new species

PLATE 41, FIGURE 2, 2a, 2b; PLATE 46, FIGURE 21

Mulona phelina (Druce), DYAR nec Druce, in part., Proc. U. S. Nat. Mus., vol. 47, p. 167, 1914.

Male (pl. 46, fig. 21).—Palpus, head, base of antenna, patagium, tegula, and thorax (above and below) white. A black spot in middle of thorax and another at the base of tegula (this spot usually hidden by patagium). Antenna beyond base black with a long white streak just before apex. Forelegs white or very pale yellowish white with black on apical half of femur, basal half of tibia, and the last four subsegments of tarsus. Midlegs and hindlegs white with apex of tibia and last four subsegments of tarsus black. Abdomen orange-yellow except at base above, where it is yellowish white. Forewing above white with 15 small black spots and bars. Five black bars along costal margin, the first near base, the second opposite the beginning of the last one-third of cell, the fourth just beyond end of cell and C-shaped and the fifth subapical and nearly touching the lower element of the C-shaped bar. Four spots lie on lower margin of cell and on vein 2, the first on lower margin of cell just before middle, the second at point of origin of vein 2, the third in the middle of vein 2, and the fourth just beyond this. There is a series of four spots along vein 1, the first near base of vein 1, the second near middle of this vein, the fourth at the margin, and the third between the second and fourth. There are two spots opposite end of cell on vein 4, one in the middle of this vein and the other beyond this near outer margin of wing. Fringe of outer margin of forewing bicolored, orange near margin and pale orange-yellow beyond this. Hindwing above and below, including fringe, pale orange-yellow with an apical black spot on costal margin at apex. Forewing below, including fringe, orange-yellow, usually with a pink tinge on the cell and sometimes also on the surrounding interspaces in middle of wing, and with a black spot on middle of costal margin, a black streak extending from base of wing outward, sometimes to the black spot, a U-shaped black subapical marking on costal margin and a small black spot at end of vein 4 on the margin (this black spot not extending into the fringe opposite).

Length of forewing 6.5–7 mm.

Male genitalia as illustrated (pl. 41, figs. 2, 2a, 2b).

Female.—Unknown.

Type locality.—Río Trinidad (labeled Trinidad River), Colón Province, Panama.

Additional type data.—Described from the holotype, male (locality as given above; June 1912; August Busck; U.S.N.M. type No. 34808; ♂ genitalia preparation W. D. F. No. 3189, 1949); paratypes Nos. 1–3, males (same locality and data as holotype except collected in March and June; ♂ genitalia preparation W. D. F. No. 3188, 1949 for paratype No. 1; ♂ genitalia preparation W. D. F. No. 1665, 1941 for paratype No. 2; ♂ genitalia preparation W. D. F. No. 3186, 1949 for paratype No. 3) and paratypes Nos. 4 and 5, males (Muzo, Colombia; 400–800 meters; Fassl; ♂ genitalia preparation W. D. F. No. 3235, 1949 for paratype No. 4; ♂ genitalia preparation W. D. F. No. 3234, 1949 for paratype No. 5).

Location of types.—Holotype and paratypes Nos. 1 and 2 in the United States National Museum. Paratype No. 3 in the entomological collection of Cornell University. Paratypes Nos. 4 and 5 in the British Museum (Natural History).

Distribution.—PANAMA: *Province of Colón*, Río Trinidad (March, June). COLOMBIA: *Department of Boyacá*, Muzo.

Remarks.—Six specimens (including their genitalia preparations) studied.

EPEIROMULONA HAMATA, new species

Male (pl. 46, figs. 23, 25, 26).—Palpus pale orange-yellow. Head, base of antenna, patagium, tegula, pronotum, and mesonotum white. A black spot in middle of thorax and another on base of tegula (usually covered by patagium). Metanotum and thorax underneath pale orange-yellow (or sometimes whitish yellow). Legs pale orange-yellow (sometimes whitish yellow) and marked with black as in *E. biloba*, except that apex of first femur is yellow, not black. Abdomen pale orange-yellow, slightly whitish at base above. Antenna beyond base black with a long white streak just before apex. Forewings and hindwings above and below very similar to *E. phelina* and hardly separable from *E. biloba*. Apical spot on hindwing variable, sometimes greatly reduced or absent and sometimes enlarged.

Length of forewing 6.5–8 mm.

Male genitalia as illustrated (pl. 42, figs. 3, 3a, 3b; pl. 45, figs. 13–17). This species divides into three subspecies on the basis of apparently constant differences in the harpes (see descriptions, pp. 462–464).

Female (pl. 46, figs. 24, 27).—Habitus like that of the male.

Length of forewing 7.2–8.2 mm.

Female genitalia as illustrated (pl. 44, figs. 9, 10). On the basis of the female genitalia there is a fourth subspecies (see description, p. 465).

Distribution.—Trinidad, northern South America and Brazil.

Comparative remarks.—In addition to the great differences in the genitalia this species differs from *E. biloba* in lacking the black on the femur of foreleg and in having the legs yellow with black bands instead of white with black bands. It is hardly distinguishable from *E. lephina* and *E. phelina* except in the genitalia. However, the black bars in middle and base of costa on forewing above are usually thicker and more round or subquadrate than in *phelina* or *biloba*.

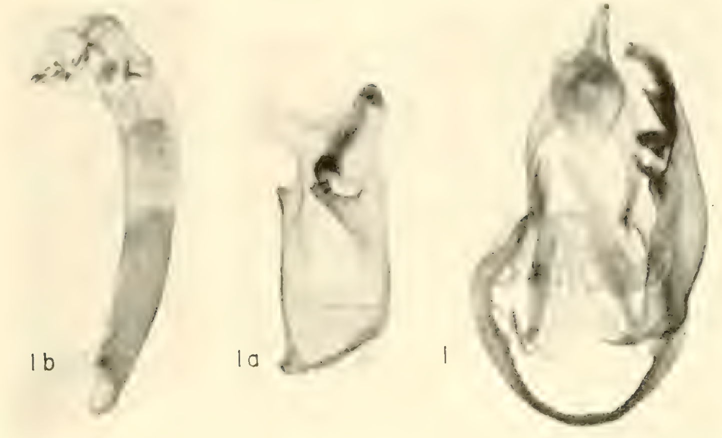
Subspeciation.—As stated above this species divides into four subspecies on the basis of the male and female genitalia. These subspecies appear to be geographically isolated. They do not appear to differ in color and habitus. When more material becomes available for study so that the extent of individual variation can be worked out it is possible that these subspecies will be elevated to specific rank.

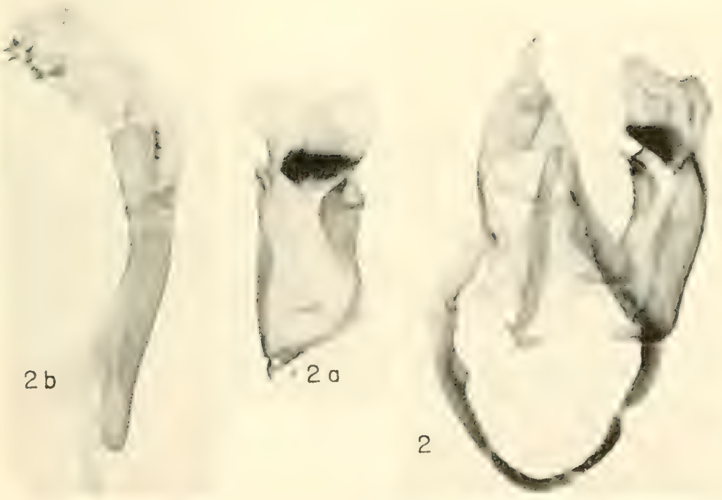
EPEIROMULONA HAMATA HAMATA, new subspecies

PLATE 42, FIGURES 3, 3a, 3b; PLATE 44, FIGURE 10; PLATE 45, FIGURES 13, 14; PLATE 46, FIGURES 23, 24

Male (pl. 46, fig. 23).—Palpus, head, thorax, abdomen, and wings as described above.

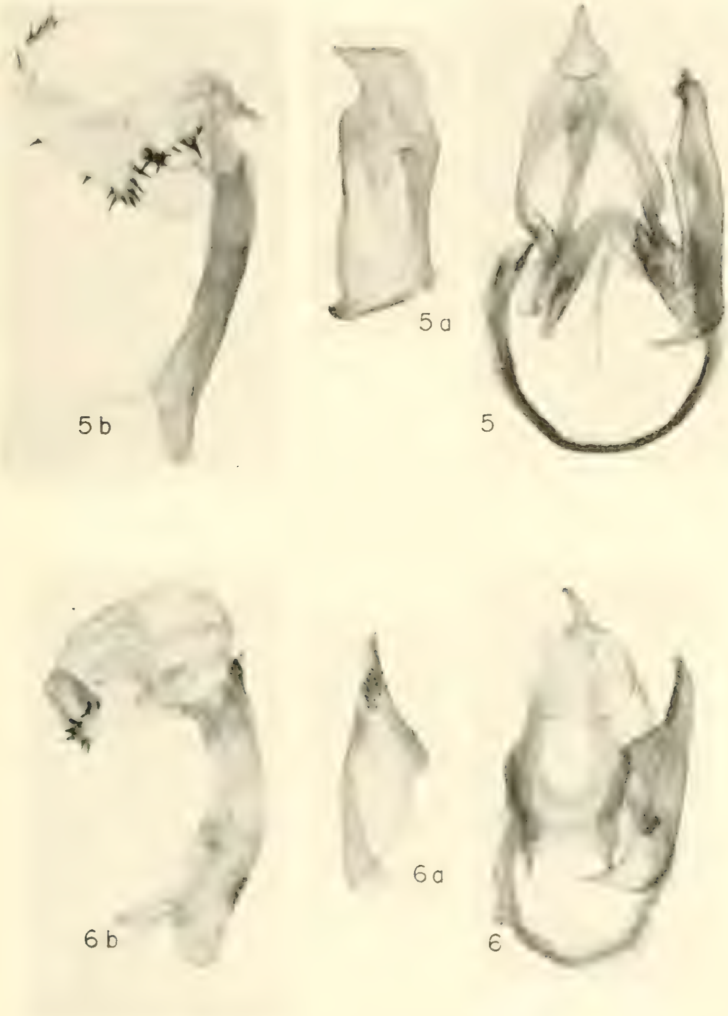
Length of forewing 7.5–8 mm.





1–1b, *Epeiromulona lephina*, new genus and species: 1, Male genitalia; 1a, harpe; 1b, aedeagus; male genitalia preparation No. W.D.F. 3191, 1949; holotype. 2–2b, *E. biloba*, new species: 2, Male genitalia; 2a, harpe; 2b, aedeagus; male genitalia preparation No. W.D.F. 3189, 1949; holotype.

3–3b, *Epeiromulona hamata hamata*, new species and subspecies: 3, Male genitalia; 3a, harpe; 3b, aedeagus; male genitalia preparation No. W.D.F. 1667, 1941; holotype. 4–4b, *E. thysanata*, new species: 4, Male genitalia; 4a, harpe; 4b, aedeagus; male genitalia preparation No. W.D.F. 1670, 1941; holotype.



5–5b, *Epeiromulona roseata*, new species: 5, Male genitalia; 5a, harpe; 5b, aedeagus; male genitalia preparation No. W.D.F. 1674, 1941; holotype. 6–6b, *E. icterinus*, new species: 6, Male genitalia; 6a, harpe; 6b, aedeagus; male genitalia preparation No. W.D.F. 1673, 1941; holotype.

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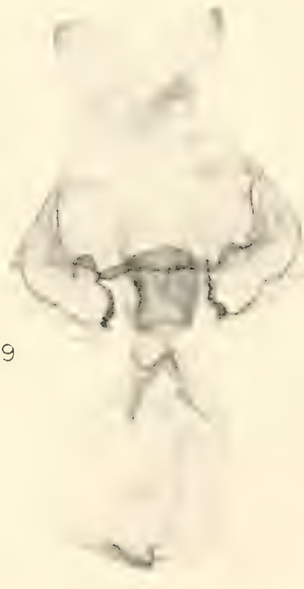

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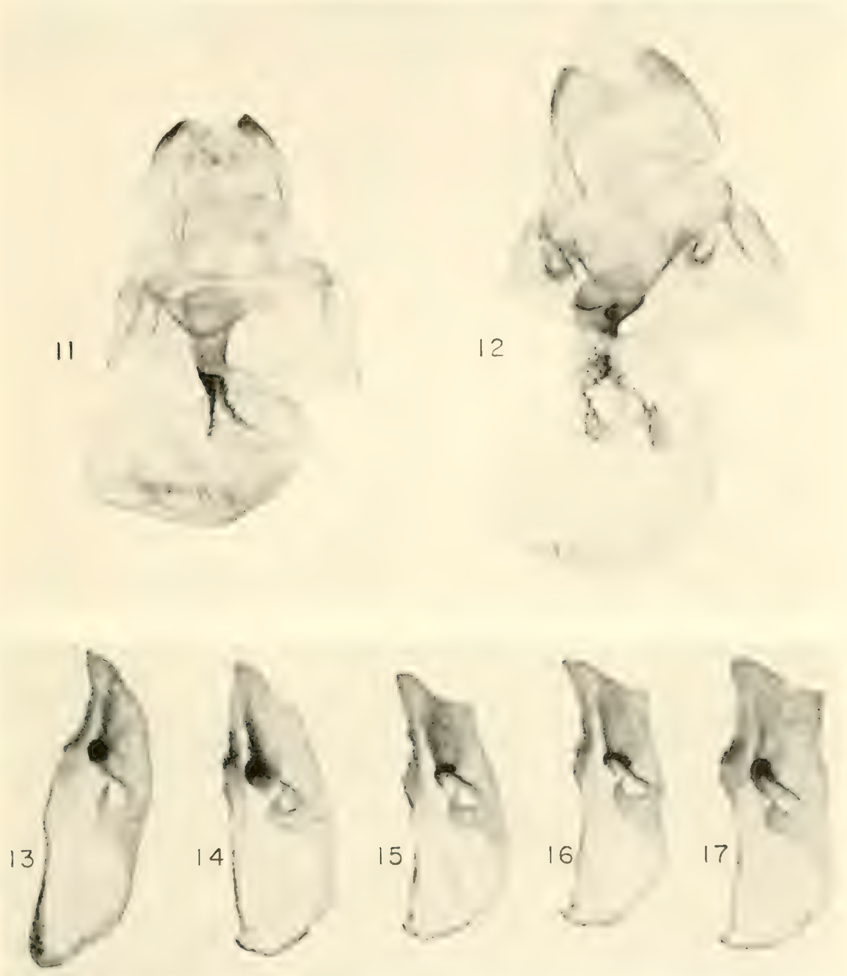
7, *Epeiromulona phelina* (Druce): Female genitalia; British Museum genitalia preparation No. 1951–22; holotype. 8, *E. lephina*, new species: Female genitalia; genitalia preparation No. W.D.F. 3218, 1949; allotype. 9, *E. hamata brasiliensis*, new subspecies: Female genitalia; W.D.F. genitalia preparation No. 3222, 1949; holotype. 10, *E. hamata hamata*, new subspecies: Female genitalia; W.D.F. genitalia preparation No. 1677, 1949; allotype.



11, *Epeiromulona thysanata*, new species: Female genitalia; genitalia preparation No. W.D.F. 1678, 1941; allotype. 12, *E. icterinus*, new species: Female genitalia; genitalia preparation No. W.D.F. 3217, 1949; allotype. 13, *E. hamata hamata*, new subspecies: Left harpe; male genitalia preparation No. W.D.F. 3208, 1949; paratype No. 1. 14, *E. h. hamata*, new subspecies: Left harpe; male genitalia preparation No. W.D.F. 3227, 1949; paratype No. 5. 15, *E. hamata venezuelensis*, new subspecies: Left harpe; male genitalia preparation No. W.D.F. 3231, 1949; holotype. 16, *E. hamata venezuelensis*, new subspecies: Left harpe; male genitalia preparation No. W.D.F. 3233, 1949; paratype No. 2. 17, *E. hamata colombiensis*, new subspecies: Left harpe; male genitalia preparation No. W.D.F. 3236, 1949; holotype.

18, *Epeiromulona lephina*, new species, holotype, male. 19, *E. lephina*, new species, allotype, female. 20, *E. lephina*, new species, underside of paratype No. 7, male. 21. *E. biloba*, new species, holotype, male. 22. *E. phelina* (Druce), holotype, female. 23, *E. hamata hamata*, new species and subspecies, holotype, male. 24, *E. h. hamata*, new species and subspecies, allotype, female. 25, *E. hamata venezuelensis*, new subspecies, holotype, male. 26, *E. hamata colombiensis*, new subspecies, holotype, male. 27, *E. hamata brasiliensis*, new subspecies, holotype, female. 28, *E. roseata*, new species; holotype, male. 29, *E. icterinus*, new species, holotype, male. 30, *E. thysanata*, new species, holotype, male. 31, *E. thysanata*, new species, allotype, female. (All figures twice natural size.)

Male genitalia as illustrated (pl. 42, figs. 3, 3a, 3b; pl. 45, figs. 13, 14). This subspecies differs from the others in having the distal end of harpe narrower and more elongate, with costa not greatly expanded at apex. In this subspecies the downward-projecting, hooklike structure from middle of costa is usually greatly recurved and elongated at tip and the ampullalike spiny knob is located much closer to the ventral margin than in the other subspecies.

Female (pl. 46, fig. 24).—Habitus like that of the male.

Length of forewing 7.2–8 mm.

Female genitalia as illustrated (pl. 44, fig. 10), differing from *E. hamata brasiliensis* in having the apex of ductus bursae slightly broader and with broad lobes along posterior edge of seventh sternum above shallow cuplike depressions that lie on either side of the central raised transverse ridge.

Type locality.—Cayenne, French Guiana.

Additional type data.—Described from the holotype, male (locality as given above; William Schaus; U.S.N.M. type No. 34818; ♂ genitalia preparation W. D. F. No. 1667, 1941); allotype, female (Trinidad, West Indies; August Busck; ♀ genitalia preparation W. D. F. No. 1677, 1941) and from two male and three female paratypes (various localities: Cayenne, French Guiana; Trinidad, West Indies and Caparo, west-central Trinidad, West Indies. Genitalia preparations as follows: Paratype No. 1, ♂, W. D. F. No. 3208, 1949; paratype No. 2, ♀, W. D. F. No. 3215, 1949; paratype No. 3, ♀, W. D. F. No. 3216, 1949; paratype No. 4, ♀, W. D. F. No. 3221, 1949 and paratype No. 5, ♂, W. D. F. No. 3227, 1949).

Location of types.—Holotype, allotype, and paratypes Nos. 1–3 in the United States National Museum. Paratypes Nos. 4 and 5 in the British Museum (Natural History).

Distribution.—French Guiana: Cayenne. Trinidad: Capara in west-central Trinidad; several specimens are labeled simply "Trinidad."

Remarks.—Six specimens (including their genitalia preparations) were studied.

EPEIROMULONA HAMATA VENEZUELENSIS, new subspecies

Plate 45, Figures 15, 16; Plate 46, Figure 25

Male (pl. 46, fig. 25).—Palpus, head, thorax, abdomen, and wings not different from typical *E. hamata.*

Length of forewing 6.5–7.2 mm.

Male genitalia as illustrated (pl. 45, figs. 15, 16). This subspecies differs from typical *hamata* in having the distal end of harpe elongate at ventral margin and with costa expanded at apex. The downward-projecting hooklike structure originates from just before middle of costa and is recurved and elongate at the tip but not as recurved and elongate as in *E. hamata hamata.* The ampullalike spiny knob is located almost midway between the costal and ventral margins.

Female.—Unknown.

Type locality and distribution.—Las Quiguas, Esteban Valley, Venezuela.

Additional type data.—Described from the holotype, male (locality as given above; ♂ genitalia preparation W. D. F. No. 3231, 1949); paratype No. 1, male (same locality; ♂ genitalia preparation W. D. F. No. 3232, 1949) and paratype No. 2, male (same locality; ♂ genitalia preparation W. D. F. No. 3233, 1949).

Location of types.—Holotype and paratype No. 1 in the British Museum (Natural History). Paratype No. 2 in the United States National Museum.

Remarks.—Three specimens (including their genitalia preparations) were studied.

EPEIROMULONA HAMATA COLOMBIENSIS, new subspecies

PLATE 45, FIGURE 17; PLATE 46, FIGURE 26

Male (pl. 46, fig. 26).—Palpus, head, thorax, abdomen, and wings not different from the other subspecies.

Length of forewing 7.5–8 mm.

Male genitalia with harpe as illustrated (pl. 45, fig. 17). *E. h. colombiensis* differs from the other subspecies in having the distal end of harpe very much broader, only slightly elongated at ventral margin. Costa is more greatly expanded at apex than in *E. h. venezuelensis.* The downward-projecting hooklike structure arises from just before middle of costa and is broad and short, only slightly recurved and elongated at tip. The ampullalike spiny knob is located below middle of harpe but is not nearly so close to ventral margin as it is in *E. hamata hamata.* The ventral margin of harpe is greatly expanded just below this ampullalike structure.

Female.—Unknown.

Type locality and distribution.—Upper Río Negro, Colombia.

Additional type data.—Described from the holotype, male (locality as given above; 800 meters; collection Fassl; ♂ genitalia preparation W. D. F. No. 3236, 1949) and paratype No. 1, male (same locality and data; ♂ genitalia preparation W. D. F. No. 3237, 1949) and paratype No. 2, male (same locality and data; ♂ genitalia preparation W. D. F. No. 3238, 1949).

Location of types.—Holotype and paratype No. 1 in the British Museum (Natural History). Paratype No. 2 in the United States National Museum.

Remarks.—Three specimens (including their genitalia preparations) were studied.

EPEIROMULONA HAMATA BRASILIENSIS, new subspecies

PLATE 44, FIGURE 9; PLATE 46, FIGURE 27

Male.—Unknown.

Female (pl. 46, fig. 27).—Palpus, head, thorax, abdomen, and wings not different from typical *hamata.*

Length of forewing 7 mm.

Female genitalia as illustrated (pl. 44, fig. 9) with apex of ductus bursae slightly narrower than in *E. hamata hamata* and with narrow lobes projecting from posterior edge of seventh sternum above shallow cuplike depressions that lie on each side of the central raised transverse ridge.

Type locality and distribution.—Melguina, 10 miles south of Diamantino, Mato Grosso, Brazil.

Additional type data.—Described from a single specimen, the holotype, female (locality as given above; 2,000 feet; C. L. Collenette; ♀ genitalia preparation W. D. F. No. 3222, 1949).

Location of type.—In the British Museum of Natural History.

EPEIROMULONA ROSEATA, new species

PLATE 43, FIGURES 5, 5a, 5b; PLATE 46, FIGURE 28

Male (pl. 46, fig. 28).—Palpus, head, base of antenna, patagium, tegula, pronotum and mesonotum white. A black spot in middle of thorax and another on base of tegula. Metanotum pale yellowish white. Legs pale orange or yellow, sometimes whitish yellow. Foreleg with black on apical half of femur and basal half of tibia and the last four subsegments of tarsus. Midlegs and hindlegs with apex of tibia and last four subsegments of tarsus black. Abdomen yellow with slightly pinkish tinge above and pale whitish yellow below. Forewing above and below very similar to *phelina.* Fringe very pale yellow. Hindwing above and below salmon-pink, usually without apical black spot.

Length of forewing 5.5–7 mm.

Male genitalia as illustrated (pl. 43, fig. 5, 5a, 5b).

Female.—Unknown.

Type locality.—Between La Gloria and Cardel, state of Vera Cruz, Mexico.

Additional type data.—Described from the holotype, male (locality as given above; U.S.N.M. type No. 34836; J. Camelo C.; 1938; ♂ genitalia preparation W. D. F. No. 1674, 1941); paratypes Nos. 1–8, males (Río Temas, Honduras; ♂ genitalia preparations as follows: paratype No. 1, W. D. F. No. 3199, 1949; paratype No. 2, W. D. F. No. 3200, 1949; paratype No. 3, W. D. F. No. 3201, 1949; paratype No. 4, W. D. F. No. 3202, 1949; paratype No. 5, W. D. F. No. 3204, 1949; paratype No. 6, W. D. F. No. 3205, 1949; paratype No. 7, W. D. F. No. 3206; paratype No. 8, W. D. F. No. 3207, 1949); and paratype No. 9, male (Costa Rica; H. Schmidt; ♂ genitalia preparation W. D. F. No. 3229, 1949).

Location of types.—Holotype and paratypes Nos. 1–6 in the United States National Museum. Paratype No. 9 in the British Museum (Natural History). Paratype No. 7 in the American Museum of Natural History. Paratype No. 8 in the collection of Cornell University.

Distribution.—Mexico: *State of Vera Cruz*, between La Gloria and Cardel. Honduras: Río Temas. Costa Rica: *Department of San José*, San José.

Comparative remarks.—Aside from the readily discernible differences in the genitalia this species differs from all the others except *E. icterinus* in having the hindwing salmon-pink instead of yellow or orange-yellow. It is easily distinguished from *icterinus* by having the vertex of the head white instead of yellow or orange-yellow.

A single specimen from San José, Costa Rica, differs from typical *roseata* in having the hindwings above and below white instead of salmon-pink. Whether this specimen is an aberration or a faded specimen cannot be ascertained. It was not included in the type series.

Remarks.—Twelve specimens (including the genitalia preparations of all these) were studied.

EPEIROMULONA THYSANATA, new species

Plate 42, Figures 4, 4a, 4b; Plate 45, Figure 11; Plate 46, Figures 30, 31

Gaudeator (?) *phelina* (Druce), Forbes nec Druce, in part., Bull. Mus. Comp. Zool., vol. 84, No. 4, p. 183, August 1939.

Male (pl. 46, fig. 30).—Palpus and frons pale yellowish white. Vertex of head, base of antenna, patagium, tegula, and nota of thorax white. A black spot in middle of thorax and another on base of tegula. Legs yellow and banded as in *E. lephina*, but with apex of first femur black. Abdomen pale orange-yellow, whitish at the base above. Wings above similar to *lephina* and *E. phelina*, differing in the fringe of outer margin of forewing. In *E. thysanata* this fringe is orange next to the margin with black scales opposite middle of wing, these scales usually covering entire width of fringe. Beyond these black and orange basal scales the fringe is fuscous. The black fringe scales here described represent a change in position of the black spot found in *E. phelina* and other species on the margin of the wing inward from the fringe (i. e., not in the basal scales of the fringe). Hindwing above similar to *phelina* and *lephina*, differing in having fringe of outer margin fuscous along apical third of wing.

Length of forewing 6–6.5 mm.

Male genitalia as illustrated (pl. 42, figs. 4, 4a, 4b).

Female (pl. 46, fig. 31).—Habitus entirely like that of the male. Length of forewing 7 mm.

Female genitalia as illustrated (pl. 45, fig. 11).

Type locality.—Cayenne, French Guiana.

Additional type data.—Described from the holotype, male (locality as given above; U.S.N.M. type No. 34837; ♂ genitalia preparation W. D. F. No. 1670, 1941); allotype, female (Paramaribo, Dutch Guiana; ♀ genitalia preparation W. D. F. No. 1678, 1941); and from six male and two female paratypes (various localities: Cayenne, French Guiana; Godebert-Maroni, French Guiana; Nouveau Chantier, French Guiana; Moengo, Boven, Cottica River, Dutch Guiana; Bartica, British Guiana, and Tumatumari, Potaro River, British Guiana. Genitalia preparations are as follows: paratype No. 1, ♂, W. D. F. No. 1669, 1941; paratype No. 2, ♂, W. D. F. No. 1668, 1941; paratype No. 3, ♂, W. D. F. No. 3228, 1949; paratype No. 4, ♂, W. D. F. No. 1671, 1941; paratype No. 5, ♂, W. D. F. No. 3209, 1949; paratype No. 6, ♂, W. D. F. No. 3243, 1949; paratype No. 7, ♀, W. D. F. No. 3223, 1949; paratype No. 8, ♀, W. D. F. No. 3224, 1949.)

Location of types.—Holotype, allotype, and paratypes Nos. 1, 2, and 4 in the United States National Museum. Paratype No. 3 in the British Museum (Natural History). Paratype No. 5 in the American Museum of Natural History. Paratypes Nos. 6 to 8 in the collection of Cornell University.

Distribution.—FRENCH GUIANA: Cayenne; Godebert-Maroni (October); Nouveux Chantier (January). DUTCH GUIANA: Moengo, Boven, Cottica River (May); Paramaribo. BRITISH GUIANA: Bartica; Tumatumari, Potaro River (June).

Remarks.—Ten specimens (including their genitalia preparations) studied.

Comparative remarks.—The black fringe scales opposite the middle of the outer margin of the forewing distinguish this from all the other species in the genus.

EPEIROMULONA ICTERINUS, new species

PLATE 42, FIGURES 6, 6a, 6b; PLATE 45, FIGURE 12; PLATE 46, FIGURE 29

Mulona phelina (Druce), DYAR nec Druce, in part., Proc. U. S. Nat. Mus., vol. 47, p. 167, 1914.

Gaudeator (?) *phelina* (Druce), FORBES nec Druce, in part., Bull. Mus. Comp. Zool., vol. 84, No. 4, p. 163 (on chart), p. 183, August 1939.

Male.—(pl. 46, fig. 29).—Palpus and frons pale yellowish white. Vertex of head orange. Base of antenna, patagium, tegula, and nota of thorax yellowish white. A black spot in middle of thorax and another on base of tegula. Legs white or pale yellowish white and banded as in *E. phelina* but with apical half of first femur black. Abdomen pale orange-yellow, whitish at the base above and paler below than above. Forewing above and below as in *E. lephina* with black spots on upper side slightly more prominent. Fringe with scales next to outer margin orange or orange-yellow and bordered outwardly with pale yellow or whitish hyaline scales, sometimes with a few black scales along base of fringe opposite middle of outer margin. Hindwings above usually salmon pink, sometimes pale orange yellow. Hindwings below pale orange-yellow.

Length of forewing 7–8 mm.

Male genitalia as illustrated (pl. 43, fig. 6, 6a, 6b).

Female.—Habitus uncertain (only a single badly rubbed specimen is available for study) but probably like that of male. Vertex of head orange as in the male.

Length of forewing 8 mm.

Female genitalia as illustrated (pl. 45, fig. 12).

Type locality.—Cayuga, Guatemala.

Additional type data.—Described from the holotype, male (locality as given above; U. S. N. M. type No. 34838; September; ♂ genitalia preparation W. D. F. No. 1673, 1941) and from 13 male paratypes (various localities: Cayuga, Guatemala; Port Bello, Panama; La Chorrera, Panama; Barro Colorado Island, Canal Zone. Genitalia preparations are as follows: paratype No. 1, W. D. F. No. 3210, 1949; paratype No. 2, W. D. F. No. 3194, 1949; paratype No. 3, W. D. F. No. 3193, 1949; paratype No. 4, W. D. F. No. 3195, 1949; paratype No. 5, W. D. F. No. 1676, 1941; paratype No. 6, W. D. F. No. 3246, 1949; paratype No. 7, W. D. F. No. 3198, 1949; paratype No. 8, W. D. F. No. 3196, 1949; paratype No. 9, W. D. F No 3245, 1949; paratype No 10, W. D. F. No. 3197, 1949; paratype No. 12, W. D. F. No. 3225, 1949.) The single female specimen is from Porto Bello, Panama (genitalia preparation W. D. F. No. 3217, 1949) and because of the badly rubbed wings of this specimen it is excluded from the type series.

Location of types.—Holotype and paratypes Nos. 1–8 in the United States National Museum. Paratype No. 8 in the British Museum of Natural History. Paratype No. 9 in the American Museum of Natural History. Paratypes Nos. 11 to 13 in the collection of Cornell University.

Distribution.—GUATEMALA: *Department of Izabal*, Cayuga (August, September). PANAMA: *Province of Colón*, Porto Bello (March, April, May); *Province of Panama*, La Chorrera (May). CANAL ZONE: Barro Colorado Island (March, October, November).

Remarks.—Fifteen specimens (including the genitalia preparations of 13 of these) studied.

Comparative remarks.—This species is easily distinguishable from all the other species of *Epeiromulona* in having the vertex of the head partially covered with orange or orange-yellow scales.

NOTE ON THE ILLUSTRATIONS

José Oiticica Filho, of the Division of Insects, National Museum of Brazil, made the photographs for all figures except plate 44, figure 7, and plate 46. The photograph of the type of *Epeiromulona phelina*, plate 46, figure 22, and of its genitalia, plate 44, figure 7, was furnished through the courtesy of D. S. Fletcher, of the Department of Entomology, British Museum (Natural History). The remaining figures on plate 46 were done by the photographic laboratory of the United States National Museum. In the photographs of the male genitalia, the aedeagi have been removed from the genitalia and shown in lateral view. The left harpes have also been removed and laid flat to show the structure of their inner faces. The remainder of the male genitalia and all female genitalia were photographed from the ventral view.

No symbols were used on these plates, since the student not already familiar with the structures involved may turn to an earlier paper for explanation (Proc. U. S. Nat. Mus., vol. 100, p. 326, pls. 6, 7, 1950).

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A REVIEW OF THE STINK BUGS OF THE GENUS MECIDEA

By R. I. Sailer

The genus *Mecidea* (Hemiptera: Pentatomidae) comprises a group of stink bugs that occur in the subtropical and adjacent temperate parts of the world. Within these regions the distribution of the genus appears to coincide rather closely with that of xerophytic or semixerophytic environments. Notable exceptions exist that may reflect insufficient knowledge. However, if our present information is even reasonably complete, the distribution of the genus as a whole and of its various species raises a number of interesting questions of zoogeographical significance. This paper is written in the hope that clarification of taxonomic relationships may facilitate the usefulness of the genus as a tool for zoogeographic studies.

Acknowledgments.—I wish to express to the following institutions and individuals my appreciation of the privilege of studying specimens contained in their collections: United States National Museum; University of Kansas Snow Entomological Museum (through R. H. Beamer); Academy of Natural Sciences of Philadelphia (through J. A. G. Rehn); Museo Argentino de Ciencias Naturales (through A. E. Riggi and N. A. Kormilev); British Museum (Natural History) (through R. J. Izzard); Museo de La Plata (through E. J. MacDonagh); Národní Museum v Praze (through L. Hoberlandt); Instituto de Entomología de Fundación Miguel Lillo (through K. J. Hayward); California Academy of Sciences (through E. S. Ross); H. Ruckes, Department of Biology, City College of New York; J. C. Lutz, Philadelphia, Pa.; C. J. Drake, Iowa State College, Ames, Iowa; H. M. Harris, Department of Zoology and Entomology, Iowa State College, Ames, Iowa; R. C. Froeschner, Department of Zoology and Entomology, Iowa State College, Ames, Iowa.

The following abbreviations are used for institutions in which type material has been deposited:

A.N.S.P.	Academy of Natural Sciences of Philadelphia.
B.M.	British Museum (Natural History).
C.A.S.	California Academy of Sciences.
I.E.F.M.L.	Instituto de Entomología de Fundación Miguel Lillo.
I.M.U.L.P.	Instituto del Museo de la Universidad de La Plata.
M.A.C.N.	Museo Argentino de Ciencias Naturales.
U.K.S.M.	University of Kansas Snow Entomological Museum.
U.S.N.M.	United States National Museum.

HISTORICAL ACCOUNT

The generic name *Mecidea* was established by Dallas in 1851 for two species, *indica* (Bengal) and *linearis* (locality unknown). Signoret also described a genus in 1851 that he called *Cerataulax*. This genus was based on the species *quadrivittatus* (Mauritius), which was described in the same paper. In October of 1851 Signoret reported that Dallas' "List of Hemipterous Insects in the British Museum" had been published a few days earlier than his paper "Description de Nouvelles Espèces d'Hémiptères (Ann. Soc. Ent. France, ser. 2, vol. 9, pp. 329–348). As a result he listed several corrections on page cviii of the same volume. One of these corrections states that *Cerataulax vittatus* (sic) Signoret must be changed to *Mecidea linearis* Dallas. While there is no doubt of the generic synonymy, reliable evidence that *quadrivittatus* and *linearis* are the same species is lacking.

Subsequent authors have described 13 additional species in the genus *Mecidea*. The present paper treats 1 of them as a synonym, renames 1 homonym, and adds 3 additional new species. This provides the genus with a total of 18 species.

GENERIC RELATIONSHIPS

Mecidea is included with nine other genera in the tribe Mecideini. These genera form a heterogeneous assemblage within the subfamily Pentatominae. They are set apart from the other tribes of the subfamily by a single common character: Abdomen beneath, antero-laterally, with transversely strigose or rugose stridulatory vittae.

Within the tribe extreme differences of size and structure contrast markedly with the close similarity of species within the various genera as far as they are known to me. This suggests a polyphyletic origin for the tribe. Whatever the result of future studies on the tribe Mecideini, there is no doubt that the closest relatives of *Mecidea* are at present found within this tribe. *Mecidea* is thereby clearly associated with a group of genera that are restricted to the Australasian region. This is the more remarkable since *Mecidea* is not known from that region.

DISTRIBUTION AND ITS SIGNIFICANCE

The distribution of *Mecidea* arouses interest because of its remarkably discontinuous nature. Although the genus belongs to a predominantly Australasian tribe, the Australasian Region is the only one of the six major world zoogeographical regions not included in the distribution of the genus. Within these regions the members of the genus are found in arid or semiarid zones lying roughly between latitude 40° N. and latitude 40° S. (See fig. 88.)

At the present time the center of distribution of the genus appears to be in the Abyssinian and Uganda highlands of Africa. Of the 14 Old World species 5 are found in or adjacent to this area. Of these 5 species 2 are widespread, *Mecidea pallidissima* being found eastward as far as Central India and *pallida* over the Near East and the drier parts of Africa north of latitude 10° N. *Mecidea pallida* is, furthermore, closely allied to and possibly identical with *indica* of India and *lepineyi* of the western Sahara. The distribution of *pallida* assumes greater interest with the discovery that the North American species *major* is so closely related that the two may be no more than subspecifically distinct. Furthermore, *longula*, which is known from at

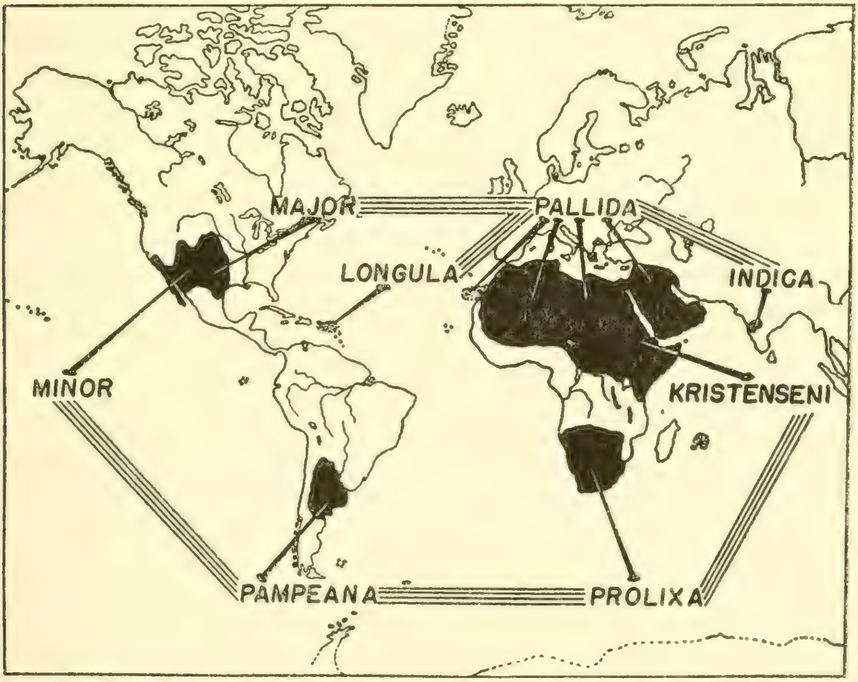

FIGURE 88.—Map showing known distribution of *Mecidea* (in black). Specific names are intended to provide a diagrammatic picture of the distribution of the two principal species groups. Related species are connected by four lines.

least 3 semiarid islands in the West Indies, is clearly derived from *pallida* or from common parent stock.

Of the other three species that are associated with the Abyssinian and Uganda highlands, *Mecidea lutzi* appears to have no close relative and *tellinii* is known only from the original description. However, the third species, *kristenseni*, is clearly allied to the more northern and and eastern *pallidissima* and to the South African *prolixa*. Surprisingly enough the two remaining American species, *minor* (southwestern United States and northern Mexico) and *pampeana* (Argentina), both resemble *prolixa* more than they do *pallida*.

If lines are drawn to connect the areas occupied by related species (see fig. 88) one line must reach from India across North Africa through the West Indies to the southwestern United States. The other line may also start in India, pass south through Ethiopia, and South Africa, across the South Atlantic to Argentina and north to the southwestern United States.

Having described the distribution of the genus and correlated it as far as possible with relationships within the genus, there remains the question of how significant this information may be and what if any conclusions may be derived from it.

The possibility that one or more of the species has been transported from one desert area to another through the agency of man cannot be overlooked. On two occasions living specimens of *Mecidea prolixa* have been intercepted by quarantine inspectors at United States ports, each time in shipments of grass seed from South Africa. The very close relationship of *indica*, *pallida*, and *major* may also be used as an argument for a recent dispersal of what may prove to be one species. Also, if we accept the distribution as resulting from environmental discontinuity following topographic and climatic changes, we must be prepared to accept the probability that *pallida* and its derivatives *indica* and *major* have remained virtually unchanged since early Tertiary time (see Johnston, 1940).

The existence of parallel examples of this particular pattern of distribution probably constitutes the best argument in favor of a historico-geological explanation. Among the plants several genera are common to the arid region of southwestern United States and northwestern Mexico and the deserts of Argentina. These have been treated by Johnston (1940), and Cain (1944) has summarized the information concerning discontinuous distribution of plant genera that are known from the desert regions of North America, South America, and Africa. Cain was able to cite four well-marked xerophytic genera as having representatives on all three continents. *Menodora*, one of the four genera, was shown by Steyermark (1932) to include one North American species that has a variety in South Africa.

Several well-established cases of insect genera that have species distributed among the arid regions of North America, South America, and Africa are known, though in several instances genera so listed in the past do not bear critical scrutiny. It is to be expected that the number of genera exhibiting this distribution will be small, since any relationship shown by these desert floras and faunas must be of very ancient origin, and few genera would be expected to survive the prolonged effects of divergent evolution. This view is amply supported by a large number of tribes and subfamilies that exhibit either this distribution pattern or some variant of it.

Chopard (1938), in a chapter on the habitats of Orthoptera, discussed such relationships and cited 3 subfamilies that contain genera in the desert regions of 2 or more continents. Uvarov (1938) used many of the same genera in an extensive paper on the subject; however, he treated them in tribal rather than subfamily groupings. Uvarov (1937) also mentioned the mecopterous family Bittacidae, which contains 2 allied flightless genera: *Apterobittacus*, which occurs in California; and *Anomalobittacus*, which is known from South Africa. The homopterous genus *Orgerius*, of the family Dictypharidae, has been listed by several authors and most recently by Metcalf (1946) as having about 20 Mediterranean species and at least 4 species in the western United States; however, Ball and Hartzell (1922) expressed the opinion that the Old World species belonged to a different genus and Dr. P. W. Oman, who has examined specimens from both regions, confirms this view. Nevertheless, the tribe Orgeriini remains a good example of the distribution pattern in question.

At the generic level a termite genus, *Amitermes*, appears to provide a distribution picture that is in many respects similar to that of the tribe Mecideini. Like Mecideini it is predominantly Australasian but contains species that are widely distributed in the arid or semiarid parts of southwestern North America, South America, Africa, and Asia. This genus was discussed at some length by Hill (1942). Cockerell (1932) has shown that a genus of bees, *Hesperapis*, occurs in the arid districts of the southwestern United States and under similar conditions in South Africa.

Another genus that has a marked preference for arid or semiarid regions is *Apiocera*, in the dipterous family Apioceridae. Cazier (1941) has provided a generic review of this family and a discussion of the distribution of the family and its 4 genera. Three of the genera have a restricted one-continent distribution; however, the fourth, *Apiocera*, contains 13 known Australasian species, 1 from South Africa, 2 from Chile, and 20 from North America.

Of considerable significance is the thysanuran genus *Machilinus*. While *Machilinus* has not yet been found in South Africa or India its distribution is otherwise remarkably like that of *Mecidea*. Wygodzinsky (1950) calls attention to the minimal possibilities for the active or passive dispersal of machilids and concludes that distribution in this instance is an argument indicating the considerable age of the genus *Machilinus*.

At least two genera are known that provide examples of this distribution pattern, both at the generic and at the specific levels. The first of these is the genus *Leptoconops*, which belongs to the dipterous family Heleidae. This family includes the biting midges and punkies, which are commonly associated with aquatic environments; nevertheless, *Leptoconops* is largely restricted to arid or semiarid regions lying between the parallels of latitude 40° N. and 35° S. Three species are known from Australia, two from South Africa, five from the Mediterranean basin, two from the lower Oriental region, one from South America, and two from North America. In the revision of the genus by Carter (1921), one of the North American species, which has been extremely abundant near Great Salt Lake since that region was first visited by white man, was described as var. *americanus* of the North Africa species *kerteszi* Kieffer. Subsequent workers have reviewed and accepted Carter's opinion.

Finally, there is the leafhopper genus *Circulifer*, which is of interest since it contains the beet leafhopper *C. tenellus* (Baker). The beet leafhopper occurs in the western United States, in xerophytic environments in southern Florida, and in Puerto Rico and the Mediterranean basin. With the exception of *tenellus*, *Ciculifer* appears to be restricted to the arid and semiarid parts of the Mediterranean basin eastward to Central Asia. The fact that *tenellus* belongs to *Circulifer* was shown by Oman (1948), and though he emphasized its Old World distribution and relationships, he did not undertake to explain the species' distribution. Of all the cases discussed here, it seems likely that the strongest argument in favor of a recent introduction can be presented for this leafhopper. Nevertheless, together with *Leptoconops kerteszi*, *Circulifer tenellus* has a distribution pattern closely parallel to that for the combined species *Medicea pallida*, *longula*, and *major*.

It therefore appears that in all categories from the family to the species, examples can be cited that point to an ancient faunistic and floristic relationship between the semidesert and desert regions of the Mediterranean basin, South Africa, southern South America, and southwestern North America. Far from being peculiar, the distribution of *Mecidea* in fact fits a rather well-established pattern. Clearly, the genus should be considered in future speculations concerning animal dispersal and zoogeographical relationships.

Bibliographic references to literature concerned with the distribution of the group discussed in this paper may be found on page 503.

CHARACTERS USED FOR SEPARATION OF SPECIES

In general appearance the species of *Mecidea* are very similar (see fig. 89.) They are unusually uniform in size and color, and such differences as do exist can be expressed only as averages. These differences are often as pronounced within species as between species and so have little value for purposes of identification. The characters seeming to have importance for purposes of specific differentiation are those associated with the internal male genitalia, the shape of the pronotum, and with the antennae of both sexes. These characters are relatively stable but are not easy to use. The antennae show such marked sexual dimorphism that the sexes of each species must be treated individually, while examination and comparison of the internal male genitalia involve rather complicated dissection and preparatory technique.

A step-by-step outline of the technique utilized for study of the internal male genitalia follows:

1. Relax specimen. A solution of one-third 95-percent alcohol, one-third ethyl acetate, and one-third water has proved very effective.

2. Detach genital segment from the abdomen and place the segment in a hot solution of 10 percent KOH.

3. Remove the segment as soon as it turns dark brown and place in water.

4. By using two fine teasing needles, each having their points slightly bent, withdraw the aedeagus either through the genital opening or through the open posterior end of the genital segment.

5. Once the aedeagus is free, osmotic pressure will cause the lateral and median penial vesiculae to expand. The lateral vesiculae and often the median vesicula expand to maximum size without further trouble. If the median vesicula fails to escape from its invaginated position above the penisfilum, manipulation and pressure applied to the cylinder of the aedeagus will usually force it out, whereupon it will expand in a normal manner. *Caution:* Care must be exercised not to puncture either the walls of the lobes or of the cylinder of the aedeagus, as this results in the immediate collapse of the vesiculae.

6. After study of a specimen is finished the genital segment and the aedeagus may be placed in a small (10×4 mm.) vial containing a drop of glycerine. The vial may then be corked and attached to the pin containing the corresponding insect. The vesiculae immediately collapse when the aedaegus is placed in glycerine but will reexpand readily when returned to water.

TERMINOLOGY OF THE PARTS OF THE INTERNAL MALE GENITALIA

The terminology used in this paper is based on that proposed by Alex. D. Baker in "A Study of the Male Genitalia of Canadian Species of Pentatomidae," Can. Journ. Res. vol. 4, pp. 148–220, 1931. Unfortunately the homology of the vesiculae situated at the apex of the aedeagus in *Mecidea* remains obscure. Structures referred to by Baker as titillators are either absent or are represented by the structure treated in the present paper as the median vesicula. This is an unpaired, distensible structure located above the basal attachment of the penisfilum. The structures treated by Baker as the median lobes may be the same as are here termed penial plates. In *Mecidea* these penial plates are paired, sclerotized structures which are connected to each other basally and are attached on their ventral face to the distensible lateral vesiculae. The latter structures are undoubtedly the same as those that Baker called the lateral penis lobes.

The key is unsatisfactory in several respects. The degree of variation shown by the various structures which, of necessity, are used for construction of the key is such that many species must be keyed out in two or more places. In addition, the absence of, or insufficient number of specimens representing several Old World species makes it impossible satisfactorily to key out more than 4 of the 14 species involved.

KEY TO THE SPECIES OF MECIDEA

1. New World 2
   Old World 11
2. (1) With dark markings on midventral line of abdomen. **minor** Ruckes (p. 490)
   Without dark markings on midventral line of abdomen 3
3. (2) Males 4
   Females 8
4. (3) With a tubercule near the posterior ventral margin of the hypopygium (see pl. 48, fig. 53) .... **minor** Ruckes (p. 490)
   Without such a tubercule (see pl. 48, fig. 52) 5
5. (4) Third segment of antenna shorter than second segment. **major**, new species (p. 486)
   Third segment of antenna equal to or exceeding length of second segment 6
6. (5) Black spots just below abdominal setigerous punctures each with greatest diameter equal to one-eighth length of its supporting segment. **major**, new species (p. 486)
   Black spots just below abdominal setigerous punctures each with greatest diameter equal to no more than one-twelfth of its supporting segment 7
7. (6) Pronotum strongly constricted just in front of the humeral angles. **longula** Stål (p. 484)
   Pronotum with lateral margin regularly and shallowly concave from humeral angle to anterior angle .... **pampeana**, new species (p. 495)

8. (3) Third antennal segment cylindrical..............longula Stål (p. 484)
Third antennal segment flattened dorsally at least along basal third.. 9
9. (8) Black spots just below abdominal setigerous punctures each with greatest diameter equal to one-eighth length of its supporting segment.
major, new species (p. 486)
Black spots just below abdominal setigerous punctures each with greatest diameter not exceeding one-twelfth length of its supporting segment 10
10. (9) Width of pronotum just behind calli not exceeding length of second antennal segment..........................minor Ruckes (p. 490)
Width of pronotum just behind calli equal to length of second antennal segment plus at least one-half diameter of eye.
pampeana, new species (p. 495)
11. (1) At least one of the black spots on the abdomen just beneath the setigerous punctures with a diameter three times that of a spiracle.
lutzi, new species (p. 485)
Black spots on abdomen just beneath the setigerous punctures never with diameter more than twice that of a spiracle.................. 12
12. (11) Midventral line of abdomen with a dark mark on at least the sixth visible segment.. 13
Midventral line of abdomen unmarked........................ 14
13. (12) Lateral margins of pronotum noticeably flattened from anterior angle to behind calli, ventral width of margin equal to width of unpunctured area just below................kristenseni Jensen-Haarup (p. 482)
Lateral margins of pronotum carinate from anterior angle to behind calli but not noticeably flattened from dorsal view, ventral width of margin less than width of unpunctured area just below.
proliza Stål and possibly quadrivittata (Signoret) (pp. 497, 498)
14. (12) Males.. 15
Females.. 18
15. (14) Third segment of antenna at least twice as long as second segment.
pallidissima Jensen-Haarup (p. 494)
Third segment of antenna less than twice as long as second segment. 16
16. (15) Third segment of antenna 1.75 times as long as second segment.
vidali, new name (p. 501)
Third segment of antenna subequal to or less than length of second segment.. 17
17. (16) Third segment of antenna subequal to second..linearis Dallas (p. 483)
tellinii Schouteden (p. 501)
Third segment of antenna shorter than second...indica Dallas (p. 481)
pallida Stål (p. 493)
lepineyi Lindberg (p. 483)
sahariana Wagner (p. 500)
18. (14) Dorsal ridge on second antennal segment strongly flattened and explanate along posterior half...pallidissima Jensen-Haarup (p. 494)
Dorsal ridge on second anennal segment more carinate, not noticeably explanate near base........................indica Dallas (p. 481)
pallida Stål (p. 493)
lepineyi Lindberg (p. 483)
sahariana Wagner (p. 500)
rungsi Vidal (p. 499)
straminea Vidal (p. 501)

SYSTEMATIC ARRANGEMENT OF SPECIES[1]

a. Males with penisfilum extending beyond penial plates------**lutzi**, new species
aa. Males with penisfilum not reaching apices of penial plates.
  b. Males with dorsal protuberance of median penial vesicula longer than ventral protuberance.
    c. Males without inner apical angles of lateral vesiculae noticeably produced.
      indica Dallas
      pallida Stål
      major, new species
      longula Stål
    cc. Males with inner apical angles of lateral vesiculae noticeably produced.
      kristenseni Jensen-Haarup
      prolixa Stål
      pallidissima Jensen-Haarup
  bb. Males with ventral protuberance of median penial vesiculae longer than dorsal protuberance------------------------------------**minor** Ruckes
      pampeana, new species

Genus MECIDEA Dallas

Mecidea Dallas, List of the specimens of hemipterous insects in the collection of the British Museum, vol. 1, pp. 131, 139, 1851.—Stål, Hemiptera Africana descripsit Carolus Stål, vol. 1, pp. 79, 132, 1865; Enum. Hemip., vol. 2, p. 17, 1872; Enum. Hemip., vol. 5, p. 34, 1876.—Atkinson, Journ. Asiat. Soc. Bengal, vol. 56, p. 201, 1887.—Distant, Fauna of British India, Rhynchota, vol. 1, p. 140, 1902.—Bergroth, Proc. Zool. Soc. London, 1905, p. 146.—. Kirkaldy, A catalogue of the Hemiptera (Heteroptera) Cimicidae, vol. 1, p 202, 1909. (Genotype: *M. indica* Dallas, designated by Distant, 1902.)

Cerataulax Signoret, Ann. Ent. Soc. France, ser. 2, vol. 9, pp. 335–336 and cviii, 1851. (Genotype: *C. quadrivittatus* Signoret, only included species.)

Body elongate, linear, straw colored, with the punctures sometimes darkened. Color quite uniform throughout genus.

Head somewhat pointed anteriorly; juga longer than tylus, meeting but not fused in front; eyes large, globose, ocelli prominent, nearer eyes than midline of head. Antennae five-segmented and exhibiting sexual dimorphism; second segment three-sided, angles often ridgelike, always longer in the female than in the male; third segment of male proportionately longer than third segment of female, cylindrical and with pubescence similar to fourth segment; third segment of female triangular in cross section at least basally and with pubescence similar to the second segment. Rostrum attaining the middle coxae, first segment not exceeding the bucculae, second segment longer than apical two together.

Pronotum carinate laterally, humeral angles prominent, anterior angles acute, front margin sinuate, not wider than the eyes, hind margin produced posteriorly to the scutellum, truncate across width of scutellum; dorsum coarsely punctured except calli; midline of mesosternum carinate; midline of metasternum broadly and shallowly

[1] Species the relationships of which are uncertain: *lepineyi* Lindberg; *tellinni* Schouteden; *linearis* Dallas; *quadrivittata* (Signoret); *rungsi* Vidal; *sahariana* Wagner; *straminea* Vidal; *vidali*, new name.

sulcate. Osteolar canal extending nearly to the dorsoanterior angle of the pruinose area. Femora unarmed, tibiae sulcate. Hemelytra pale to straw colored, vitreous; corium and clavus more or less regularly punctured, punctures often rufescent, exocorium usually paler than corium and exocorial vein, almost straight, raised and conspicuously pale.

Abdomen with striate area on both sides, starting on the first apparent segment at base of the hind coxa and continuing across segments 2 and 3, evanescent on 4; second segment convex medially. Dorsum of abdomen with a dark vitta on each side just inside the connexivum. Ventrally each segment usually has a black spot located on each side around the innermost setigerous puncture (trichobothria). Genital segment of the male with cup dorsoventrally compressed, deeply concave, opening dorsoposteriorly; inferior ridge forming posterior margin, deeply sinuate in ventral view with a notch at median line; proctiger tubular, membranous except basally; claspers of the single-armed type; superior ridge reduced; superior carinae present as an elongate black tuberculate process opposite apices of claspers. Genital plates of female loosely contiguous at apices, gradually divergent basally along median line. Subgenital plates narrowly rounded apically, extending slightly beyond the tergal plate. Apices of lateral plates bluntly acuminate, barely produced beyond posterior margin of tergal plate. Female genitalia without effective diagnostic value.

MECIDEA INDICA Dallas

Plate 47, Figures 1–3; Plate 48, Figures 31, 32

Mecidea indica Dallas, List of the specimens of hemipterous insects in the collection of the British Museum, vol. 1, p. 139, pl. 3, fig. 3, 1851.—Stål, Öfv. Vet. Akad. Förhandl., vol. 13, pt. 3, p. 57, 1856.—Walker, Catalogue of the specimens of heteropterous Hemiptera (Hemiptera-Heteroptera) in the collection of the British Museum, pt. 1, p. 179, 1867; Enum. Hemip., vol. 5, p. 38, 1876.—Atkinson, Journ. Asiat. Soc. Bengal, vol. 56, pp. 201–202, 1887.—Lethierry and Severin, Catalogue général des Hémiptères, vol. 1, Hétéroptères, Pentatomidae, p. 92, 1893.—Distant, Fauna of British India, Rhynchota, vol. 1, pp. 140–141, 1902.—Kirkaldy, A catalogue of the Hemiptera (Heteroptera), vol. 1, Cimicidae, p. 202, 1909.—Van Duzee, Catalogue of the Hemiptera of North America, p. 29, 1917.—Jensen-Haarup, Ent. Meddel., vol. 14, pt. 1, p. 7, 1922.—China, Ann. Mag. Nat. Hist., ser. 10, vol. 17, p. 97, 1936.

Most clearly related to *Mecidea pallida*, but also near *M. major*. Only three specimens have been available for this study, but it would appear that apart from the penial plates and slightly less carinate lateral margin of the pronotum there is little that will separate *indica* from *major*, and it is even more difficult to distinguish the species from *pallida*. Study of additional specimens of these two species may show that *pallida* and *major* are synonyms of *indica*.

Length: Male, 9.6 mm; width at the humeral angles, 2.5 mm; female, 11.9 mm; width at the humeral angles, 3.2 mm.

Antennae of male: Relative length of segments 30:85:60:80:65. First three segments as shown on plate 48, figure 31.

Antennae of female: Relative length of segments, 40:110:55: lost:lost. First three segments as shown on plate 48, figure 32.

Male genitalia: Penial vesiculae and penial lobes as shown on plate 47, figures 1, 2, and 3.

Variation.—The juga of one female specimen overlap slightly at their apices, while those of the male specimen are divergent.

Type.—In the British Museum.

Distribution.—Recorded by Distant (1902) from Bombay and Poona. One specimen from each of these localities was available, while the third specimen, a male, was collected at Hoshangabad, Central Provinces, India.

Host plants.—None has been recorded.

MECIDEA KRISTENSENI Jensen-Haarup

PLATE 47, FIGURE 19; PLATE 48, FIGURES 50, 51

Mecidea kristenseni JENSEN-HAARUP, Ent. Meddel., vol. 14, pt. 1, pp. 8, 9, fig. 8b, 1922.—LINDBERG, Not. Ent., vol. 18, pt. 3, pp. 85–86, 1938.

Closely related to *Mecidea prolixa* but a little larger and more robust in appearance and with the posterior lobe of the pronotum more convex, clearly distinguished by the shape of the lateral penial vesiculae. The color pattern sets the species apart from all other species of *Mecidea* with the exception of unusually dark specimens of *prolixa.*

The characteristic color was noted by Jensen-Haarup and described as follows: "Body wing covers, three innermost joints of antennae and legs partially more or less densely covered with blackish punctures, which where condensed, form the following dark, longitudinal stripes: two on head, four on pronotum and two on scutellum." The brownish rose-red color that Jensen-Haarup noted as infusing the inner part of the corium is not present in any of the eight specimens available for study. The linear black spots on the midventral line of the abdomen are more pronounced than in either *M. prolixa* or *M. minor* and in several specimens spots are present on each of the last five abdominal segments. The black spots below the setigerous punctures are small, seldom exceeding the diameter of a spiracle. The black vittae on the dorsum of the abdomen are each as broad as the pale intervening area.

Length: Male, 8.7 mm; female, 9.5 mm.

Width at humeral angles: Male, 2.4 mm.; female, 2.8 mm.

Antennae of male: Relative length of segments, 35:60:90:75:65. The last three segments as shown on plate 48, figure 50.

Antennae of female: Relative length of segments, 40:95:70:80:70. The last three segments as shown on plate 48, figure 51.

Male genitalia: Penial plates and lateral penial vesiculae as on plate 47, figure 19. The median penial vesicula is not shown, as it could not be forced out of its invaginated position in any dissection of the three available males.

Variation.—The eight specimens examined were all collected at the same time and place. The most striking variation shown by the series is the degree to which the spots on the median line of the venter of the abdomen are present. In two specimens these spots are present on five segments while on two others only the sixth segment is so marked.

Type.—Presumed to be in the Zoological Museum at Copenhagen.

Distribution.—The species was described from a female specimen collected in Eritrea. The eight specimens that I have studied belong to the British Museum and bear the following data: Abyssinia, plains northwest of Lake Zwai, 5,500 to 6,000 feet, November 1, 1926.

MECIDEA LEPINEYI Lindberg

Mecidea lepineyi LINDBERG, Not. Ent., vol. 18, pt. 3, pp. 85, 87, fig. 1c, 1938.

This species was described from a specimen collected in a region of the west Sahara known as El Djouf. The description does not refer to the sex of the specimen; however, the illustration and description of the antennae are strongly suggestive of a male specimen of *Mecidea pallida*. The fact that the illustration is accompanied by one of a female specimen of *pallida* raises the possibility that Lindberg was not aware of the sexual dimorphism exhibited by the antennae of *Mecidea*. If this is true, it would not be surprising if he failed properly to associate the sexes and decided that his male specimen represented a new species. It seems best, however, not to synonymize the species with *pallida* until the type specimen can be compared with a male of the latter species.

The present location of the type is not apparent from Lindberg's paper.

MECIDEA LINEARIS Dallas

Mecidea linearis DALLAS, List of the specimens of hemipterous insects in the collection of the British Museum, vol. 1, p. 139, 1851.—SIGNORET, Ann. Soc. Ent. France, ser. 2, vol. 9, p. cviii, 1851.—WALKER, Catalogue of the specimens heteropterous Hemiptera (Hemiptera-Heteroptera) in the collection of the British Museum, pt. 3, p. 539, 1868.—STÅL, Enum. Hemip., vol. 5, p. 38, 1876.—LETHIERRY and SEVERIN, Catalogue général des Hémiptères, vol. 1, Hétéroptères, Pentatomidae, p. 92, 1893.—KIRKALDY, A catalogue of the Hemiptera (Heteroptera), vol. 1, Cimicidae, p. 202, 1909.—DISTANT, Ann. South African Mus., vol. 10, pt. 2, p. 39, 1911.—JENSEN-HAARUP Ent. Meddel., vol. 14, pt. 1, p. 7, 1922.—HESSE, Ann. Transvaal Mus., vol. 16, pt. 4, p. 585, 1935.

The specimen described by Dallas as *Mecidea linearis* bore no locality data. When Signoret in 1851 acknowledged that *Mecidea* Dallas should be used for *Ærataulax* Signoret he also made his species *Cerataulax quadrivittatus* a synonym of *M. linearis* Dallas. Walker in in 1868 accepted this synonymy, but subsequent workers have not (see p. 499). In 1911 Distant reported that *linearis* had been collected in South Africa, and in 1922 Jensen-Haarup remarked in a footnote "According to Dr. E. Bergroth in litt. *M. linearis* proved to be an African species." Hesse in 1935 referred to specimens taken in northern Bechuanaland as *linearis* but at the same time he expressed the opinion that a comparison of the types of *linearis* and *prolixa* would show the two species to be the same.

Dallas, in his brief description of *M. linearis*, states "Antennarum articulo secundo, tertio subaequali." This remark was based on a male specimen and is not characteristic of the males of *prolixa* or of the males of any other African species of which material has been available for study.

While this characteristic of the male antennae is common to *Mecidea major, longula,* and *pampeana* these American species lack certain color characteristics described by Dallas. Signoret's description of the color of the female specimen, which he described under the name *Cerataulax quadrivittatus*, suggests that this species and *linearis* may be the same. An examination of male specimens of *quadrivittatus* from Mauritius will be necessary in order to confirm or disprove this possibility.

It is also possible that *linearis* may prove to be an older name for *Mecidea tellinii.* Schouteden's description of the length of the second and third segments of the male antennae of *tellinii* agrees exactly with Dallas' description of this character for *linearis.* On the other hand, Schouteden's specimens are described as being somewhat larger and paler than would be expected if the species were the same.

Type.—In the British Museum.

MECIDEA LONGULA Stål

Plate 47, Figures 7–9; Plate 48, Figures 35, 36, 54, 58

Mecidea longula Stål, Öfv. Vet. Akad. Förhandl., vol. 11, pt. 8, p. 233, 1854; Öfv. Vet. Akad. Förhandl., vol. 13, pt. 3, p. 57, 1856.—Dohrn, Catalogus Hemipterorum, p. 10, 1859.—Stål, Enum. Hemip., vol. 2, p. 17, 1872 [excluding Texas record].—Lethierry and Severin, Catalogue général des Hémiptères, vol. 1, Hétéroptères, Pentatomidae, vol. 1, p. 92, 1893 [excluding Texas record].—Kirkaldy, A catalogue of the Hemiptera (Heteroptera), vol. 1, Cimicidae, p. 202, 1909 [excluding Texas record].—Stoner, Iowa Univ. Stud. Nat. Hist., vol. 10, pt. 1, p. 9, 1922.

Related to *Mecidea major* and *M. pallida* but smaller and slightly more elongate than these species. The antennal characters are distinctive and should serve to distinguish the species. The third antennal segment of the male is equal to or slightly longer than the second, and the third segment of the female is almost entirely cylindrical. In both *major* and *pallida* the third segment of the female antennae is dorsally flattened, at least along the posterior third.

Color almost identical with *major*; dark punctures along lateral line of thorax and abdomen somewhat less numerous. Black spots just below abdominal setigerous punctures, with greatest diameter equal to one-twelfth length of supporting segments. Spiracles pale.

Form narrowly elongate.

Length: Males, 8.6–9.1 mm.; females, 9.3–10.1 mm.

Width at humeral angles: Males, 2.2–2.6; females, 2.6–2.7.

Antennae of male: Relative length of segments, 35:75:80:70:60. First three segments as shown on plate 48, figure 35.

Antennae of female: Relative length of segments, 40:100:55:70:60. First three segments as shown on plate 48, figure 36.

Male genitalia: Hypopygium, clasper, penial plates, and penial vesiculae as shown on plate 48, figures 54, 58, and plate 47, figures 9, 7, and 8.

Variation.—Sixty specimens from Antigua collected at the same place and date show some slight variation in size and some variation in the relative lengths of the second and third antennal segments of the males. In the case of one male the second segment is slightly less than two-thirds as long as the third.

Type.—Not seen. It should be in the Naturhistoriska Riksmuseum, Stockholm.

Distribution.—St. Bartholomew Island (type locality): Antigua, June 21, 1918. Puerto Rico, Ponce, September 2, 1948.

Host plant.—*Chloris radiata* (Linnaeus) Swartz, reported by Stoner (1922), who added the comment, "I believe that I have never found any pentatomid in greater abundance in a limited area."

MECIDEA LUTZI, new species

Plate 47, Figures 26–28; Plate 48, Figures 39, 40

Resembles *Mecidea pallida* and *M. major* in size and color. Differs notably from these species in having the pronotum barely constricted at the middle and in having the lateral margin of the pronotum more noticeably carinate. The male genitalia are characterized by the elongate penisfilum which, relative to the penial plates, is twice as long as in any other species of *Mecidea*.

Color somewhat variable, usually testaceous with the calloused midline of the pronotum and scutellum paler and the hemelytra quite vitreous. Exocorial vein almost white. Inner basal angle of clavus with small fuscus spot. Black spots below abdominal setigerous punctures large, their diameter usually three times that of a spiracle. Midventral line of abdomen unmarked.

Form rather broadly elongate. Pronotum only slightly constricted near middle, the lateral margins carinate and almost serrate along their anterior third. Abdomen with lateral striate areas continuous along first through fourth and evanescent on fifth and sixth visible segments.

Length: Males, 10.0–11.0 mm.; females, 11.3–11.5 mm.

Width at humeral angles: Males, 3.2–3.4 mm.; females, 3.4–3.5 mm.

Antennae of male (holotype specimen): Relative lengths of segments, 40:90:75:80:70. First three segments as shown on plate 48, figure 39.

Antennae of female (allotype specimen): Relative lengths of segments, 45:115:65:85:70. First three segments as shown on plate 48, figure 40.

Male genitalia: Penial plates, penial vesiculae, and penisfilum as shown on plate 47, figures 26, 27, and 28.

Variation.—There is some variation in color and the degree to which the pronotal margin is carinate. The Kenya specimens tend to be darker and the darkest one has four well-marked longitudinal dark bands on the pronotum and a fuscus spot at the inner apical angle of the corium. Most of the punctures on the corium are also fuscous.

Types.—Holotype, male, Djamba, Belgian Congo, altitude 1,700–1,800 feet, August 9, 1929, H. H. Curtiss (J. C. Lutz collection). Allotype, same data (retained for U.S.N.M. collection, No. 609824).

Paratypes: 1 ♀, same data; 2 ♂, 2 ♀, Athi River Crossing, 16 miles N. N. E. of Kibwezi, Kenya, July 25, 1934, J. A. G. Rehn (A.N.S.P.), 1 ♂ and 1 ♀ retained for U.S.N.M. collection; 1 ♀, Makinda, Kenya, April 5 to 7, 1911, S. A. Neave (B. M.).

Distribution.—Since the two Kenya localities are situated within about 10 miles of each other, the species is in effect known from only two widely separated localities in Equatorial Africa. Djamba (also spelled Djumbwi) is located in the District of Stanleyville about 160 miles south of the boundary of French Equatorial Africa. The Kenya localities are situated about halfway between Nairobi and the port city of Mombasa. Rehn described (Proc. Acad. Nat. Sci. Philadelphia, vol. 88, p. 9, 1936) the country near Kibwezi, Kenya as "dense thorn-bush country, with scattered taller boabab, euphorbia, and acacia trees." The northern part of the Belgian Congo including Djamba is largely covered by tall grass savanna.

I take pleasure in naming this species for John C. Lutz. The first examples of this species to be encountered were found in his extensive private collection of Heteroptera.

MECIDEA MAJOR, new species

FIGURE 89; PLATE 47, FIGURES 10–12; PLATE 48, FIGURES 33, 34, 52, 59

Mecidea longula [not Stål] UHLER, List of Hemiptera of region west of the Mississippi River, including those collected during the Hayden Explorations of 1873. Bull. U. S. Geol. Geogr. Surv. Terr., vol. 1, No. 5, pp. 269–361, 1876 (see p. 17 of extract under above title); Check list of the Hemiptera Heteroptera of North America, p. 5, 1886.—VAN DUZEE, Trans. Amer. Ent. Soc., vol. 30, pt. 1, p. 26, 1904 [erroneously reports *longula* as described from Texas material].—BARBER, Sci. Bull. Mus. Brooklyn Inst. Arts Sci., vol. 1, pt. 9, p. 257, 1906 (Texas record).—KIRKALDY, A catalogue of the Hemiptera (Heteroptera), vol. 1, Cimicidae, p. 202, 1909 [Texas record].—BANKS, Catalogue of the Nearctic Hemiptera-Heteroptera, p. 86, 1910.—VAN DUZEE, Check list of the Hemiptera . . . of America, north of Mexico, p. 4, 1916; Catalogue of the Hemiptera of North America, p. 29, 1917.—TORRE-BUENO, Ent. Amer., new ser., vol. 19, pt. 3, p. 201, 1939.—FROESCHNER, Amer. Midl. Nat., vol. 25, pt. 1, pp. 128, 132, 1941.—RUCKES, Bull. Brooklyn Ent. Soc., vol. 41, pt. 3, pp. 86–87, 1946.

Very closely related to *Mecidea pallida*, in fact so closely related that separation of females on the basis of structure may be uncertain, if not impossible. However, the single male example of *pallida* available for study shows characters which, if sufficiently constant, should serve to distinguish the species. These characters are the relative length of the antennal segments and shape of structures pertaining to the internal genitalia. The male specimen of *pallida* has the third segment of the antennae 52 percent as long as the second, while the third antennal segment of male *major* was in no instance found to be less than 62 percent as long as the second. The average for 50 specimens was 75 percent. Among these specimens were four that had the third segment subequal to the second. The male genitalia of both species present a very similar appearance; however, the penial plates of *pallida* are significantly broader and the concave areas on their dorsal surfaces more pronounced. The black spots below the abdominal setigerous punctures are smaller on the three specimens of *pallida* examined than is characteristic for *major*.

Head, pronotum, and scutellum straw yellow. Eyes, punctures on dorsum, and pleurites of pronotum just behind eyes, on anterior lobe of pronotum each side midline, on antenniferous tubercles and side of head before eye, and on apices of jugae, rufescent to black. Sockets of bristlelike hairs on antennae dark. Hemelytra pale vitreous, corium with numerous rufescent punctures, exocorial vein pale, membrane vitreous. Connexivum pale impunctate. Venter pale yellow with reddish tint, impunctate except on lateral line along first five segments, these punctures usually darkened; black spot just below setigerous punctures with greatest diameter equal to one-eighth length of supporting segment. Spiracles often darkened.

Dorsal aspect as shown in figure 89. Rather elongate. Humeral angles obtusely angulate, elevated. Lateral margins of pronotum with edges calloused, almost carinate.

Length: Males, 9.5–10.4; females, 10.0–12.7 mm.

Width at humeral angles: Males, 2.6–3.1; females, 2.8–3.7 mm.

Antennae of male: Relative length of segments (holotype specimen) 40:100:75:80:65. First three segments as shown on plate 48, figure 33.

Antennae of female (allotype specimen), 40:120:55:75:65. First three segments as shown on plate 48, figure 34.

Male genitalia: Hypopygium, clasper, penial plates, and penial vesiculae as shown on plate 48, figures 52, 59, and plate 47, figures 12, 10, and 11.

Variation.—*Mecidea major* shows considerable variation in size and structure. The second antennal segment of both sexes varies considerably and in the case of females often renders this structure of little value in separating *major* from *minor*. The juga show such a degree of variation as to make them of little diagnostic value. In the specimens examined the greater number show the juga to be barely contiguous in front of tylus, with the inner margins divergent toward apices and usually tipped slightly inwardly and downward along apical half; however, many specimens present the almost continuously contiguous, acuminate form characteristic of *minor* as well as the other extreme in which the juga are not contiguous but continue parallel with each other for some distance before the tylus. The genital plates of the female also show considerable variation, making them difficult to use for diagnostic purposes; characteristically all plates tend to be shorter in relation to their length than is typical for *minor*.

Types.—Holotype, male, Bexar County, Tex., October 8, 1937, William F. Turner, U.S.N.M. No. 58421. Allotype, same data.

Paratypes: (43 ♂♂, 57 ♀♀) Texas: Arlington, 1 ♀, September 24, 1907 (U.S.N.M.). Austin, 1 ♂, November 16, 1928, J. O. Martin; 1 ♀, December 7, 1928, J. O. Martin (C.A.S.). Banks, 1 ♀, August 15, 1938; 1 ♀, July 31, 1940, L. S. Jones. Bexar County, 1 ♀, November 8, 1937, William F. Turner; 2 ♂, 1 ♀, November 23, 1938, William F. Turner, on "grass"; 1 ♀, August 24, 1938, William F. Turner; 1 ♂, 2 ♀, September 28, 1939, William F. Turner. Brownsville, Esperanza Ranch, 1 ♂, 1 ♀, July 24, 1904; 1 ♂, 1 ♀, August 17, 1904. Brownsville, 1 ♀, April 1903; 1 ♂, May 29, 1933, P. W. Oman. Clarendon, 1 ♂, 1 ♀, September 19, 1905, C. R. Jones (U.S.N.M.). College Station, 1 ♂, October 14, 1927, H. G. Johnston; 1 ♂, October 17, 1929, H. G. Johnston (H. M. Harris collection). Crystal City, 5 ♀, January 14, 1950, J. B. Duncan, on spinach. Dallas, 1 ♂, 3 ♀, October 16, 1911, H. Pinkus, at light. Dennison, 1 ♂, 2 ♀, October 16, 1938, L. S. Jones. Fort Worth, 1 ♂, September 10; 1 ♀, October 15. Gainesville, 1 ♂, 2 ♀, October 10, 1923, E. E. Russell, on Johnson grass. Houston, 1 ♀, September 23, 1944. BEPQ Special Survey No. 20865 (U.S.N.M.). George West, 1 ♂, June 28, 1938, R. I. Sailer. Hidalgo County, 2 ♀, July 28, 1928, J. G. Shaw; 2 ♂, August 2, 1928, L. D. Beamer; 1 ♂, August 14, 1928, R. H. Beamer. Jim Wells County, 2 ♂, 1 ♀, July 24, 1928, R. H. Beamer. Karnes County, 2 ♂, 1 ♀, July 23, 1928, A. M. James. Kendall County, 5 ♂, 3 ♀, July 22, 1928, L. D. Beamer (U.K.S.M.).

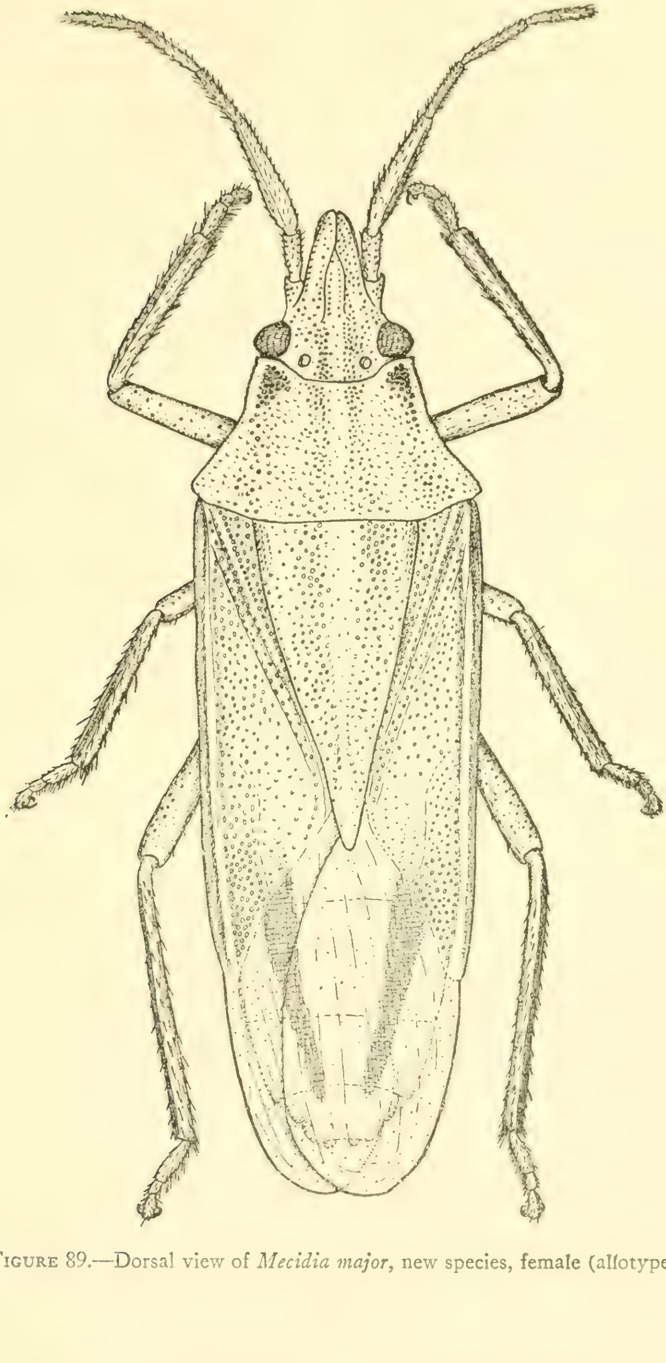

FIGURE 89.—Dorsal view of *Mecidia major*, new species, female (allotype).

Laredo, 1 ♀, June 3, 1933, P. W. Oman (U.S.N.M.). Plainview, 1 ♂, November 9, 1930, S. E. Jones (H. M. Harris collection). Ranger, 3 ♂, November 2, 1940, D. W. Craik (U.K.S.M.). Reinhardt, 1 ♀, September 19, 1907. San Antonio, 1 ♀, Harper and Dean; 4 ♂, 5 ♀, "fall" 1939, H. A. Gunning, on seed heads of *Bouteloua curtipendula* (Michaux) (U.S.N.M.). Sanderson, 3 ♂, 3 ♀, October 22, 1938, S. E. Jones (H. M. Harris collection). Tyler, 1 ♀, October 17, 1938, L. S. Jones. Victoria, 1 ♀, April 19, 1905, W. E. Hinds; 1 ♀, November 9, 1906, J. D. Mitchell. Waco, 3 ♀, October 9, 1939, P. A. Glick, on cotton (U.S.N.M.); 1 ♂, October 1, 1938. Wellborn, 1 ♀, October 4, 1927, H. G. Johnston. Weslaco, 1 ♂, July 17, 1927, M. McPhial (H. M. Harris collection). Wichita Falls, 1 ♂, 2 ♀, November 5, 1904; Texas, with no other data, 2 ♂, 3 ♀ (U.S.N.M.). ARIZONA: Atascosa Mountain, 1 ♀, November 2, 1935, E. D. Ball (U.S.N.M.). ARKANSAS: Howard County, 1 ♂, 1 ♀, December 8, 1938, William F. Turner; Pike County, 1 ♀, October 4, 1939, William F. Turner (U.S.N.M.). OKLAHOMA: Elmer, 1 ♂, July 6, 1937, Standish-Kaiser. Millerton, 1 ♂, August 20, 1934, C. A. Sooter (H. M. Harris collection). Oklahoma City, 2 ♂, August 3, 1917, on cotton (U.S.N.M.). Wichita National Forest, 1 ♀, June 27, 1936, M. B. Jackson (U.K.S.M.). KANSAS: Manhattan, 2 ♂, 7 ♀, June 21, 1937 (H. Ruckes collection). Meade County, 1 ♀, September 13, 1944, R. H. Beamer (U.K.S.M.). MISSOURI: Columbia, 1 ♀, October 5, 1937, R. Froeschner (R. Froeschner collection).

Distribution.—From Sanderson and Brownsville, Tex., north to Manhattan, Kans., and Columbia, Mo. A majority of the records are from south and central Texas.

Dates of collection.—Collected every month except February and March. Three-fourths of all collections were made during the months of July through October. Records from Oklahoma, Kansas, and Missouri range from June 21 through October 5.

Host plants.—*Bouteloua curtipendula* (Micheaux) Torrey, *Sorghum halapense* (Linnaeus) Persoon, "grasses," wheat, spinach, *Senecio*, and cotton. *Mecidea major* is probably associated primarily with members of the grass family. There are no records showing that *major* has caused injury of economic importance to any host plant.

MECIDEA MINOR Ruckes

PLATE 47, FIGURES 13–15; PLATE 48, FIGURES 37, 38, 53, 57

Mecidea minor RUCKES, Bull. Brooklyn Ent. Soc., vol. 41, pt. 3, pp. 87–88, 1946.

Mecidea longula, STÅL, Enum. Hemip., vol. 2, p. 17, 1872 [Texas record].—UHLER List of Hemiptera of region west of the Mississippi River, including those collected during the Hayden Explorations of 1873. Bull. U. S. Geol. Geogr. Sur. Terr., vol. 1, No. 5, pp. 269–361, 1876 (see p. 17 of extract under above title; New Mexico record).—OSBORN, Proc. Iowa Acad. Sci., vol. 5, p. 232, 1898.—HOWARD, The insect book, pl. 29, fig. 18, 1903.—VAN DUZEE, Trans.

Amer. Ent. Soc., vol. 30, pt. 1, p. 26, 1904 [Colorado record].—Snow, Trans. Kansas Acad. Sci., vol. 20, pt. 1, p. 177, 1906.—Van Duzee, Catalogue of the Hemiptera of North America, p. 29, 1917 [in part].—Ruckes, Bull. Brooklyn Ent. Soc., vol. 33, pt. 1, p. 10, 1938.

Related to *Mecidea kristenseni* and *M. pampeana;* however, the males are easily separated since both these species lack the tubercule found near the ventral posterior margin of the genital segment of *M. minor.* The dorsally flattened and usually grooved third antennal segment of *minor* serves to distinguish the females from *kristenseni,* in which the third antennal segment is cylindrical. The presence of black markings on the midventral line of the abdomen is sufficient to distinguish most specimens of either sex from *pampeana.*

Color quite similar to *M. major* except on venter of abdomen. Midventral line of abdomen marked with fuscus or black, varying from a continuous line on fourth, fifth, and sixth visible segments and a lineate spot on the third, through a short lineate spot on each segment to complete obsolescence. Spiracles always pale. Black spots just below abdominal setigerous puncture with their greatest diameter seldom more than one-twelfth length of supporting segment at the same level.

Form more elongate than *M. major* or *M. longula.* Lateral margin of pronotum almost regularly concave; edges carinate anterior to calli but not more than calloused posteriorly. Calloused line along middle of pronotum and scutellum more prominent than in other American species. Pronotum with tendency toward a carina on each side behind calli. Juga usually converging to an acute apex and not deflected along apical half.

Length: Males, 9.1–10 mm.; females, 9.2–11 mm.

Width at humeral angles: Males, 2.1–2.4 mm.; females, 2.2–2.8 mm.

Antennae of male: Relative length of segments, 32:76:87:75:65. First three segments as shown on plate 48, figure 37.

Antennae of female: Relative length of segments, 40:115:65:70:64. First three segments as shown on plate 48, figure 38.

Male genitalia: Hypopygium, clasper, penial plates and penial vesiculae as shown on plate 48, figures 53, 57; plate 47, figures 15, 13, and 14.

Female genitalia: In most instances sufficiently different from *Mecidea major* to be of diagnostic value. Terminal segment not more than twice as wide as long, usually less. Genital plates proportionately narrower than those of *major.* Subgenital plates with a width-length ratio of 18:45.

Variation.—Characteristically more uniform than *Mecidea major.* The second antennal segment of the female varies considerably in length and in the degree to which the dorsal ridge is expanded. The juga show less variation than is characteristic of *major;* however, there is a range from overlapping before the tylus to failure to converge.

Types.—Holotype and allotype in the American Museum of Natural History, New York.

Paratypes: In the H. Rukes collection; 1♂ and 1♀ paratype in U.S.N.M. collection, No. 609825.

Type locality.—Las Cruces, Dona Ana County, N. Mex.

Distribution.—Originally recorded from two localities in New Mexico, one in Colorado (Fort Collins), and one in Arizona (Baboquivari Mountains).

Additional material examined.—MEXICO: Durango: Durango, November 26; Tlahualilo, September 4, 1928. Nuevo Leon: 10 miles south of Linares, December 24, 1940. Sonora: San Bernardino, Río Mayo, July 15 and August 18, 1935. Baja California: Canipole [about 25.5° lat.], October 2, 1941. UNITED STATES: California: Escondido, July 15, 1941; Visalia, June 11, 1909. Arizona: Baboquivari Mountains, March 12, 1932 and October 18, 1935; Badger, Santa Cruz County, July 31, 1924; Cochise County, August 24, 1935; Douglas, San Bernadino Ranch, 3,750 feet elevation; Fort Grant, July 20; Herford, October 20, 1937; Patagonia, on Sonorita Creek, October 14, 1927; Patagonia, August 23, 1937; Springerville, June 6, 1930; Wilcox, August 24, 1937. New Mexico: Dep, August 1938; Las Cruces, August 18, 1937; Organ, July 3, 1940; Virden, August 8, 1929, on *Chen. oblongi.* Texas: Alpine, September 1939; Amarillo, August 10 and September 28, 1930; Bangs, November 16; Bexar County, August 24, 1938; Brownsville, March 31, 1933 and May 31, 1933; Crystal City, January 14, 1950; Dallas, October 16, 1917; El Paso, August 22, 1908; El Paso County, August 24, 1938; Fort Davis, October 22, 1938; Fort Stockton, October 23, 1938; Hidalgo County, July 28, 1928; Laredo, June 31, 1933; Marathon, October 22, 1938; Menard County, July 19, 1928; Presidio County, July 15, 1917; Río Frio, May 10, 1910; San Antonio, July 4, 1936; Sanderson, October 22, 1938; Sutton County, July 20, 1928; Taylor County, July 11, 1928; Terlingua, May 3, 1927; Three Rivers, June 27, 1938; Wades, May 21; Zavalla County, July 3, 1910. Oklahoma: Lawton, August 2, 1918; Wichita National Forest, June 27, 1936. Kansas: Clark County, 1,950 feet elevation, August 23, 1911; Hamilton County; Meade County, September 13, 1944; Morton County, July 27, 1924; Saint John County, July 1885; Scott County, August 23, 1927; Seward County, July 23, 1944; Stevens County, 2,700 feet elevation. Missouri: Kansas City. Colorado: Holly, September 8, 1898. Utah: Salt Lake City, June 25, 1922. South Dakota: Capa, August 15, 1922. Iowa: Sioux City, July 7, 1897 (reported by Osborn, 1898). His specimen has not been examined and his record is placed under *M. minor* only because this species appears to have a more northern range of distribution than *M. major.*

Distribution summarized.—From latitude 24° N. to central California, northern Utah, and central South Dakota; the eastern boundary near the eastern borders of Kansas, Oklahoma, and Texas.

Collection dates summarized.—Collected every month except February and April. More than half the collections were made during July and August and 90 percent between May 1 and November 1. Records north of latitude 33° N., middle of June through September.

Host plants.—*Bouteloua curtipendula* (Michaux) Torrey; also taken on *Chenopodium pratericola* subsp. *desiccatum* (A. Nelson) Aellen and *Spinacia oleracea* Linnaeus (spinach).

MECIDEA PALLIDA Stål

PLATE 47, FIGURES 4–6; PLATE 48, FIGURES 29, 30

Mecidea pallida STÅL, Öfv. Vet. Akad. Förhandl., vol. 11, pt. 8, p. 233, 1854; Öfv. Vet. Akad. Förhandl., vol. 13, pt. 3, pp. 56–57, 1856; Hemiptera Africana descripsit Carolus Stål, vol. 1, p. 132, 1865; Enum. Hemip., vol. 5, p. 38, 1876.—LETHIERRY and PUTON, Ann. Soc. France, ser. 5, vol. 6, p. 15, 1876.—LETHIERRY and SEVERIN, Catalogue général des Hémiptères, vol. 1, Hétéroptères, Pentatomidae, p. 92, 1893.—SCHOUTEDEN, Ann. Soc. Ent. Belgique, vol. 49, p. 7, 1905.—OSHANIN, Berz. Palaerkt. Hemip., vol. 1, p. 85, 1906.—KIRKALDY, A catalogue of the Hemiptera (Heteroptera), vol. 1, Cimicidae, p. 202, 1909.—HORVATH, Ann. Mus. Nat. Hungarici, vol. 7, p. 290, 1909.—BERGEVIN and THÉRY, Bull. Soc. Hist. Nat. l'Afrique Nord, ser. 2, vol. 9, p. 142, 1910.—JENSEN-HAARUP, Ent. Meddel., vol. 14, pt. 1, pp. 7–9, 1922.—CHINA, Ann. Mag. Nat. Hist., ser. 10, vol. 17, pp. 96, 97, fig. b, 1936.—LINDBERG, Comm. Biol. Soc. Sci. Fennica, vol. 6, pt. 7, pp. 7, 20, 1936; Not. Ent., vol. 18, pp. 85, 86, fig. 1, b, 1938.—RUCKES, Bull. Brooklyn Ent. Soc., vol. 41, pt. 3, pp. 86, 87, 1946.—VIDAL, Mem. Soc. Sci. Nat. Maroc, vol. 48, pp. 117–118, 1949.—WAGNER, Eos, vol. 25, pts. 3–4, pp. 190–191, 1949 [fig. of type].

Mecidea pallida var. *virens*, VIDAL, 1949, Mem. Soc. Sci. Nat. Maroc, vol. 48, p. 118, 1949 (new synonymy).

So closely related to *Mecidea major* and *M. indica* that it is doubtful if the females can be distinguished in all instances. Perhaps best characterized by the small degree of secondary sexual dimorphism exhibited by the antennae. Also bears a superficial resemblance to *M. lutzi* but is easily distinguished from that species by the more concave, less carinate lateral margins of the pronotum and the smaller size of the black spots just below the abdominal setigerous puncture.

Habitus does not differ significantly from *M. major;* however, the pronotum is slightly less constricted at middle than in *M. indica.* Black spots just below abdominal setigerous punctures about twice the diameter of a spiracle.

Length: Male, 11.8 mm.; females, 11.8–12.4 mm.

Width at humeral angles: Male, 3.3 mm.; females, 3.0–3.3 mm.

Antennae of male: Relative length of segments, 45:125:70:95: missing. First three segments as shown on plate 48, figure 29.

Antennae of female: Relative length of segments, 45:130:50:missing: missing. First three segments as shown on plate 48, figure 30.

Male genitalia: Penial plates and penial vesiculae as shown on plate 47, figures 6, 4, and 5.

Variation.—Among the five specimens examined the shape of the juga varies from overlapping at their apices to divergent at their apices. Vidal's descriptions of *Mecidia pallida* and of the form of that species that he called *virens* suggest a range of variation very similar to that observed for *major* in North America.

Type.—Not seen; should be in the Naturhistoriska Riksmuseum, Stockholm. The specimen was said to have been collected in "Nubia superior." This would place the type locality somewhere in Anglo-Egyptian Sudan.

Distribution.—Specimens have been examined from the following localities: Gafsa, Tunisia; Minna, northern Nigeria; Al Huseini (near Lahej), Aden Protectorate and Baghdad, Iraq. The literature records *pallida* from the Canary Islands east across North Africa and through the Near East to Iran. It is also recorded from Greece.

Neither the literature nor available specimen data provides any information concerning host plants or dates of collection.

MECIDEA PALLIDISSIMA Jensen-Haarup

PLATE 47, FIGURES 23–25; PLATE 48, FIGURES 41, 42

Mecidea pallidissima JENSEN-HAARUP, Ent. Meddel., vol. 14, pt. 1, pp. 8, 9, fig. 8, a, 1922.—LINDBERG, Not. Ent., vol. 18, pt. 3, pp. 85, 87, 1938.

Mecidea ingramsi CHINA, Ann. Mag. Nat. Hist., ser. 10, vol. 17, pp. 96–97, fig. a, 1936 (new synonymy).

A very pale species which, judging from the characteristics of the male genitalia, is most closely related to *kristenseni.* The sexual dimorphism of the antennae common to all *Mecidea* is more extreme in *pallidissima* than in any of the other known species of the genus.

Punctation of the body not darkened except on juga, pronotum just behind the eyes and inner basal angle of the clavus of some specimens. The setigerous punctures on the first three segments of the antennae usually dark. Without dark markings along median line of abdominal venter and usually without evidence of a dark spot below each of the setigerous punctures.

Pronotum moderately constricted near middle, with lateral margin calloused but without evidence of a carina.

Length: Male, 8.0–9.5 mm.; width across humeral angles: 1.9–2.2 mm. Female, 9.6–11.0 mm.; width across humeral angles, 2.2–2.7 mm.

Antennae of male: Relative length of segments 35:55:135:95:80. First three segments as shown on plate 48, figure 41.

Antennae of female: Relative length of segments, 40:115:80:missing: missing (compared with type specimen) or as taken from China's description of *ingramsi* "11:32:23:25:21." First three segments as shown on plate 48, figure 42.

Male genitalia: Penial plates and penial vesiculae as shown by plate 47, figures 24, 23, and 25.

Variation: Specimens from Kenya, Arabia, and southern India are quite uniform in size and color; however, two male specimens from French Somaliland are noticeably smaller and tend to be darker. China, in his description of *Mecidea ingramsi*, noted that a female specimen from Wadi Maseila, Hadhramaut, was much smaller than the specimen that he made the type of the species. The single specimen from India has the antennal segments generally shorter than the females from Arabia; however, the ratio of their lengths does not vary significantly and the other characteristics of the antennae are quite similar.

Types.—Of *pallidissima*, presumed to be in the Zoological Museum at Copenhagen; of *ingramsi*, in the British Museum.

Distribution.—ERITREA: Recorded by Jensen-Haarup. HADHRAMAUT: Recorded as *M. ingramsi* by China from specimens collected in November and December.

Material examined: KENYA: Kula, July 7, 1935. FRENCH SOMALILAND: Djibouti, August 31, 1926. ARABIA: Jidda, March 14 and 17, 1936; Buriam, May 20, 1936. INDIA: "South India."

From these records it appears that *M. pallidissima* ranges from the mountainous region of northern Kenya, across the Arabian peninsula, and as far east as southern India. With so few records available it is not possible to construct a clear picture of distribution for the species and additional specimens from India are needed in order to confirm the presence of *pallidissima* in that country.

MECIDEA PAMPEANA, new species

PLATE 47, FIGURES 16–18; PLATE 48, FIGURES 43–46, 55, 56

Mecidea longula, BERG, Hemiptera Argentina enumeravit speciesque novas descripsit C. Berg, p. 37, 1879.—PENNINGTON, Lista de la Hemipteros Heteropteros Republica de la Argentina, Primera Parte, Pentatomoideo-Coroidea, p. 7, 1921 (a privately published work).—PIRAN, Acta Zool. Lilloana, vol. 5, p. 12, 1948.

Most closely allied to *Mecidea minor* of North America and *M. kristenseni* of Africa, but readily distinguished from the former by the absence of the tubercle on the median line of the ventroposterior surface of the male genital segment and from the latter by the absence of black markings along the median ventral line of the abdomen of both sexes.

Color variable; in darkest specimens the pronotum shows from obscure longitudinal dark bands. Calloused median line of pronotum and scutellum continuous. Exocorial vein noticeably paler than exocorium. Small black spots below abdominal setigerous punctures with greatest diameter not more than one-twelfth length of supporting segment.

Form narrowly elongate. Jugae loosely contiguous along entire inner margin before tylus, slightly deflected inwardly. Protonum with transverse constriction hardly noticeable; lateral margins slightly concave before the humeral angles, edge almost carinate.

Length: Males, 9–10 mm.; females, 8.6–11.8 mm.

Width of humeral angles: Males, 2.25–2.45 mm.; females, 2.3–2.8 mm.

Antennae of male (holotype specimen): Relative length of segments, 40:85:90:80:63. First three segments as shown on plate 48, figure 43.

Antennae of female (allotype specimen): Relative length of segments, 40:115:55:70:60. First three segments as shown on plate 48, figure 44.

Male genitalia: Hypopygium, clasper, penial vesiculae, and penial plates as shown on plate 48, figures 55, 56, and plate 47, figures 16, 17, and 18.

Variation.—If this species is properly interpreted it exhibits a remarkable degree of variation. This variation involves size, color, and relative lengths of the antennal segments. Among the specimens studied those from Chaco and Córdoba are largest and darkest, and the males generally have the third segment of the antennae longer than the second. A series of 18 specimens from Conhello, La Pampa, are consistently smaller, paler, and several males have the third antennal segment shorter than the second. Variation in relative length of the antennal segments is even more pronounced among female specimens. (See plate 48, figures 43 and 44.) The ratio of lengths of the second to the third segments of the allotype from Agua de Oro, Córdoba, is 115:50, of a female from Mendoza, 110:75, and another from La Rioja is 100:60. The black spots below the abdominal setigerous punctures are reduced in many specimens and often absent.

These differences are as great as those existing between certain species of *Mecidea*; however, the degree of intergradation found among the specimens studied, together with the relative stability of the male genital structures, are accepted as an indication that only one species is involved.

Types.—Holotype, male, Tucumán, Argentina, February 26, 1946, P. A. Berry (U.S.N.M. No. 58422). Allotype, Agua de Oro, Córdoba, Argentina (M.A.C.N.).

Paratypes: ARGENTINA: TUCUMÁN: Tucumán, 1 ♂, February 26, 1946, P. A. Berry (U.S.N.M.); 1 ♀, April 1932; 4 ♂, 2 ♀, November and December 1944, R. Golback; 1 ♂, December 1946, T. Araoz; 1 ♀, October and November 1949, R. Golback. Los Puestos, 1 ♂, April 20, 1948, R. Golback. Parque Aconguija, 1 ♂, April 7, 1947, Sr. Ares. Aconguija, 1 ♀, November 1946; Guardamonte, 1 ♂, April 2, 1948, R. Golback (E.F.M.L.). El Cadillal, 1 ♂, March 14, 1949, N. Kormilev (M.A.C.N.). SANTIAGO DEL ESTERO: Sumampa, 1 ♂, 1 ♀, November 16, 1944. Chilca, 1 ♂, April 7, 1945, R. Maldonado (I.M.U.L.P.). Río Salado, 1 ♂, 1 ♀, M. Gomez (M.A.C.N.); 1 ♀, no other data (C. J. Drake collection). CHACO: Colonia, 1 ♂, May 16, 1936, P. Denier. Colonia Castelli, 1 ♂, May 15, 1936, P. Denier. RESISTENCIA: 1 ♀, November 1935, P. Denier (I.M.U.L.P.). Fontana, 5 ♀, May 12, 1938, A. Meyer (M.A.C.N.). FORMOSA: "Alm. Brown," 1 ♂, 2 ♀, May 19, 1936, P. Denier. Zona 9a, 1 ♂, 1 ♀, June 6, 1939, P. Denier (I.M.U.L.P.). SALTA: Salta Cuidad, March 17, 1949, N. Kormilev (M.A.C.N.). LA RIOJA: La Rioja, 2 ♀ (C. J. Drake collection). MENDOZA: Mendoza, 1 ♂, 1 ♀ (C. J. Drake collection); CÓRDOBA: Córdoba, 1 ♀, identified by Berg as *M. longula.* Bajo Grande, 1 ♀, August 15, 1939, R. Maldonado. Rayo Cortado, 2 ♂, December 15, 1939 (I.M.U.L.P.). Argüello, 2 ♂, 2 ♀, February 1948, De Carlo; El Sauce, 8 ♀, December 1938, M. Viana; Agua de Oro, 8 ♂, 13 ♀, December–January 1949, De Carlo (M.A.C.N.). LA PAMPA: Conhello, 6 ♂, 13 ♀, January 1943, H. Hepper; 1 ♀, January 1939, M. Ibanez (M.A.C.N.). Pico, 1 ♂, 1 ♀, April 1936, P. Denier (I.M.U.L.P.). BUENOS AIRES: Buenos Aires, 1 ♀, determined as *M. longula* by Berg (B. M.). Saavedra, 1 ♀, January 2, 1922 (I.M.U.L.P.). La Colina, 1 ♂, 1 ♀, December 9, 1938, C. J. Drake (C. J. Drake collection).

Distribution.—Argentina, north of the Río Colorado, east of the Andes, and west of the Río Paraná.

MECIDEA PROLIXA Stål

PLATE 47, FIGURES 20–22; PLATE 48, FIGURES 47–49

Mecidea prolixa STÅL, Öfv. Vet. Akad. Förhandl., vol. 14, p. 312, 1858; Hemiptera Africana descripsit Carolus Stål, vol. 1, p. 133, 1865; Enum. Hemip., vol 5, p. 38, 1876.—LETHIERRY and SEVERIN, Catalogue général des Hémiptères, vol. 1, Hétéroptères, Pentatomidae, p. 92, 1893.—SCHOUTEDEN, Ann. Soc. Ent. Belgique, vol. 49, p. 7, 1905.—KIRKALDY, A catalogue of the Hemiptera (Heteroptera), vol. 1, Cimicidae, p. 202, 1909.—JENSEN-HAARUP, Ent. Meddel., vol. 14, pt. 1, p. 9, 1922.—LINDBERG, Not. Ent., vol. 18, pt. 3, p. 86, 1938.

Mecidea linearis, HESSE, Ann. Transvaal Mus., vol. 16, pt. 4, p. 585, 1935.

Most closely related to *Mecidea kristenseni* but easily distinguished by details of the male genitalia, the proportionately broader second antennal segment of both sexes, and the less convex posterior lobe of the pronotum. Judging from material at hand *prolixa* is, on an average, the smallest species of *Mecidea* and with the possible exception of *kristenseni* it is the darkest in color. This dark color is not characteristic of all specimens but there is a decided tendency for all punctures and all points where hair attach to be fuscus.

Calloused median line of pronotum and scutellum prominent and continuous. Exocorial vein and exocorium quite pale and noticeably contrasting with the darker corium. Black spots below abdominal setigerous punctures very small, seldom larger than a spiracle. Mid-ventral line of abdomen with a dark linear spot on sixth visible segment and frequently on fifth, fourth, and third segments.

Length: Males, 7.3–8.2 mm.; females, 9.1–9.8 mm.

Width at humeral angles: Males, 1.8–2.2 mm.; females, 2.2–2.5 mm.

Antennae of male: Relative length of segments; 30:45:90:75:65. First three segments as shown on plate 48, figure 47.

Antennae of female: Relative length of segments, 35:80:70:75:65. First three segments usually as on plate 48, figure 48.

Male genitalia: Penial plates and penial vesiculae as shown on plate 47, figures 21, 20, and 22.

Variation.—The specimens examined show a wide range of variation in several important characters. The most pronounced variation is found in the relative lengths of the second and third antennal segments of the female. Most specimens examined have the third segment shorter than the second (see pl. 48, fig. 48); however, several have the segments subequal and one specimen that is not otherwise different has the third segment noticeably longer, the ratio of length of the segments being 65:80 (see pl. 48, fig. 49). The black spots on the median line of the venter range from barely perceptible on the sixth visible segment to well marked on the third, fourth, fifth, and sixth. The black spots below the setigerous punctures range from entirely absent to a spot having a diameter equal to one-twelfth the length of the supporting segment.

Type.—Not seen. Located in the Naturhistoriska Riksmuseum, Stockholm.

Distribution.—Literature records and locality data on the specimens studied indicate that M. *prolixa* is restricted to the desert or semiarid regions of Africa south of the Zambezi River. The following localities were represented among the 16 specimens studied. SOUTHWEST AFRICA: Okahandja. UNION OF SOUTH AFRICA: Cape Province: Ceres, 1,500 feet; Somerset East; Swellendam. East Cape Province: Katberg, 4,000 feet. Natal: Van Reenen, Drakensberg, 5,500–6,500 feet. Dates of collection range from September through March.

MECIDEA QUADRIVITTATA (Signoret)

Cerataulax quadri-vittatus Signoret, Ann. Soc. Ent. France, ser. 2, vol. 9, p. 336, pl. 10, figs. 9, 9, a, 1851.

Mecidea vittata [lapsus calami] Signoret, Ann. Soc. Ent. France, ser. 2, vol. 9, p. cviii, 1851.

Mecidea linearis, Signoret, Ann. Soc. Ent. France, ser. 2, vol. 9, p. cviii, 1851.—Walker, Catalogue of the specimens of heteropterous Hemiptera (Hemip-

tera-Heteroptera) in the collection of the British Museum, pt. 3, p. 539, 1868.
Mecidea quadrivittata, Stål, Öfv. Vet. Akad. Förhandl., vol. 13, pt. 3, p. 57, 1856; Hemiptera Africana descripsit Carolus Stål, vol. 1, p. 133, 1865; Enum. Hemip., vol. 5, p. 38, 1876.—Lethierry and Severin, Catalogue général des Hémiptères, vol. 1, Hétéroptères, Pentatomidae, p. 92, 1893.—Kirkaldy, A catalogue of the Hemiptera (Heteroptera), vol. 1, Cimicidae, p. 202, 1909.—Jensen-Haarup, Ent. Meddel., vol. 14, pt. 1, pp. 7–9, 1922.

This species is thought to be known only from Signoret's type specimen, which was collected on the Island of Mauritius. Beyond being 11 mm. long and a female specimen with a color pattern suggestive of the darker specimens of *Mecidea prolixa*, Signoret's description reveals little that will serve to identify the species. Jensen-Haarup appears to have reexamined the type specimen, for in his key to the Ethiopian species of *Mecidea* he includes *quadrivittata*, and remarks, "2nd joint of antennae much longer than 3rd." Unfortunately this is not distinctive, since it is true of the female of most species of *Mecidea*.

The possibility that *quadrivittata* may be a synonym of *M. linearis* is examined in the discussion under the latter species.

Type.—Not seen. Believed to be in the Naturhistorische Museum, Wien.

MECIDEA RUNGSI Vidal

Mecidea rungsi Vidal, Mem. Soc. Sci. Nat. Maroc, vol. 48, p. 118, 1949.

Described by Vidal as being near *Mecidea quadrivittatus*. This, together with his description of shape, color, and length of the second and third segments of the antennae would indicate a close resemblance between the two species; however, the body length shown for *rungsi* is nearer that recorded for *M. prolixa*.

The following salient characters are extracted from Vidal's description:

Smaller than *Mecidea pallida* but of the same shape. Punctures on scutellum and hemelytra much more noticeable than in *M. straminea* and *M. lepineyi* (Vidal not Lindberg). Pronotum with sides feebly sinuate, dorsum bearing four longitudinal bands of brown punctures, the two median bands being scarcely visible.

Antennae of the same shape as *pallida*. Comparative lengths of segments 2, 3, 4, and 5 are 95:40:52:45. The first three, covered with spines, the base of each forming a rather large brown puncture.

Scutellum with concolorus punctation and bearing a smooth median longitudinal carina; the pronotum bears traces of this carina. Clavus bordered with a brown line at the base along margin of scutellum. A band of brown punctures on each side underneath body, leaving the head, passing along the thorax and along the line of the abdominal spiracles.

Length: 9.7 mm.

Described from a female specimen collected at Mader Bergat, Morocco, October 1941, by Ch. Rungs.

Type.—In l'Institut Scientifique Cherifien, Rabat, Morocco.

MECIDEA SAHARIANA Wagner

Mecidea sahariana WAGNER, Eos, vol. 25, pts. 3–4, pp. 190–191, 2 figs., 1949.

This species is said by Wagner to be very closely related to *Mecidea pallida*, but it is easily separated from that species by the longer, narrower head, the relatively smaller eyes and shorter second antennal segment. The species is also described as considerably smaller than *pallida*. Wagner's illustration shows the male to have a remarkably wide second antennal segment.

The antennae are described as follows: First segment very short, not attaining apex of head; second segment, male 0.8 or female 0.84 times as long as the head and noticeably flattened; in the male this flattening is most striking and the flattened portion is wider than the segment itself. The third segment of the male is somewhat more than half as long as the second, but in the female it is only 0.3 times as long.

The abdominal segments with a small black spot near the stigmata.

Length: Male, 9.9 mm.; female, 10.0–10.3 mm.

Described from one male and two females from Spanish Sahara (U.–Bomba, March 6, 1943, and Sebka Um Seikira, April 8, 1945, Matéu collector).

Type.—In the Museo de Ciencias Naturales, Barcelona.

As evidenced by his description of *M. sahariana*, Wagner is the first author to note the sexual dimorphism of the antennae that appears to be characteristic of all *Mecidea*. He also speculates on the distribution of *M. sahariana* and *M. pallida* and concludes that since the latter was described from "Nubia Superior" it is unlikely that the two species have the same range of distribution. In consequence he states that it is probable that the records for *pallida* from Algeria, Tunis, and Morocco pertain to *sahariana*.

This conclusion seems highly improbable. Certainly typical *M. pallida* occurs in Tunisia, for I have examined a male specimen collected at Gafsa. Other specimens have been seen from northern Nigeria and from the Aden Protectorate. These facts, combined with the close relation of *pallida* to *M. indica* and to *M. longula* and *M. major*, suggest a wide range of distribution for *pallida*. Furthermore, the wide range of variation exhibited by the New World species makes it seem likely that several of the species now listed from the North African region will prove to be only variants of *pallida*.

MECIDEA STRAMINEA Vidal

Mecidea straminea VIDAL, Mem. Soc. Sci. Nat. Maroc, vol. 48, pp. 118–119, 1949.

Described by Vidal as being near *Mecidea lepineyi* (Vidal not Lindberg) but darker in color and with different comparative lengths of the second and third antennal segments.

According to Vidal the comparative lengths of antennal segments 2, 3, 4 and 5 are as 77 : 39 : 50 : 45.

Length: 10 mm.

Described from a female specimen collected at Fort Trinquet, Mauritania, French West Africa, November 1942, by Ch. Rungs.

Type.—In l'Institut Scientifique Cherifien, Rabat, Morocco.

MECIDEA TELLINII Schouteden

Mecidea tellinii SCHOUTEDEN, Ann. Soc. Ent. Belgique, vol. 49, p. 7, 1905.—BERGROTH, Mem. Soc. Ent. Belgique, vol. 15, p. 152, 1908.

This species was described from two male specimens collected in Eritrea. Schouteden characterized the species as more robust than *Mecidea pallida* and *M. prolixa.* This comparison is unfortunate since *prolixa* is the smallest and least robust of the genus, while of the species known to me *pallida* is the largest and most robust. The antennae (male) are described as having the second and third segments subequal in length. This agrees with Dallas' description of *linearis* and suggests that *M. tellinii* might be a synonym of that species. Characters of size and color, however, seem to indicate that the species are different. Schouteden states that his specimens were 10.25 mm. long and 3.75 mm. wide across the pronotum. This would make *tellini* the least elongate species in the genus.

Types.—The type specimens are believed to be in Schouteden's private collection.

MECIDEA VIDALI, new name

Mecidea lepineyi VIDAL, Mem. Soc. Sci. Nat. Maroc, vol. 48, p. 119, 1949 (preoccupied by *M. lepineyi* Lindberg, Not. Ent., vol. 18, ser. 3, pp. 85, 87, fig. 1c, 1938).

Described by Vidal as paler but of the same shape as *rungsi*, the punctation of the head, scutellum, and hemelytra as concolorous and hardly visible, and the antennae as bearing brown punctures.

The comparative lengths of antennal segments 2, 3, 4, and 5 were described as 40 : 70 : 56 : 49.

Length: 9 mm.

Described from a male collected August 30, 1941, by Lepiney, Sauvage, and Rungs.

Type.—In l'Institut Scientifique, Cherifien, Rabat, Morocco.

Comments.—In his last descriptive sentence concerning *Mecidea lepineyi* (Vidal not Lindberg) Vidal states that the comparative lengths of the second and third antennal segments are sufficient to identify this species. Unfortunately, this is not true since the males of *M. kristenseni* Jensen-Haarup have almost the same comparative lengths for the second and third antennal segments. This fact suggests that *vidali* may prove to be only a very pale form of *kristenseni*.

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PLATE 47

Illustrations of characters on the aedeagus of species of *Mecidea:*

1–3, *Mecidea indica* Dallas, from Hoshangabad, Central Provinces, India: 1, Lateral vesiculae, dorsal view; 2, penial plates, showing penisfilum; 3, median vesicula, lateral view.

4–6, *M. pallida* Stål, from Gafsa, Tunisia: 4, Median vesicula, lateral view; 5, lateral vesiculae, dorsal view; 6, penial plates.

7–9, *M. longula* Stål, from Antigua, British West Indies: 7, Lateral vesiculae, dorsal view; 8, median vesicula, lateral view; 9, penial plates.

10–12, *M. major*, new species, from Bexar County, Tex.: 10, Lateral vesiculae, dorsal view; 11, median vesicula, lateral view; 12, penial plates.

13–15, *M. minor* Ruckes, from Zavallo County, Tex.: 13, Lateral vesiculae, dorsal view; 14, median vesicula, lateral view; 15, penial plates.

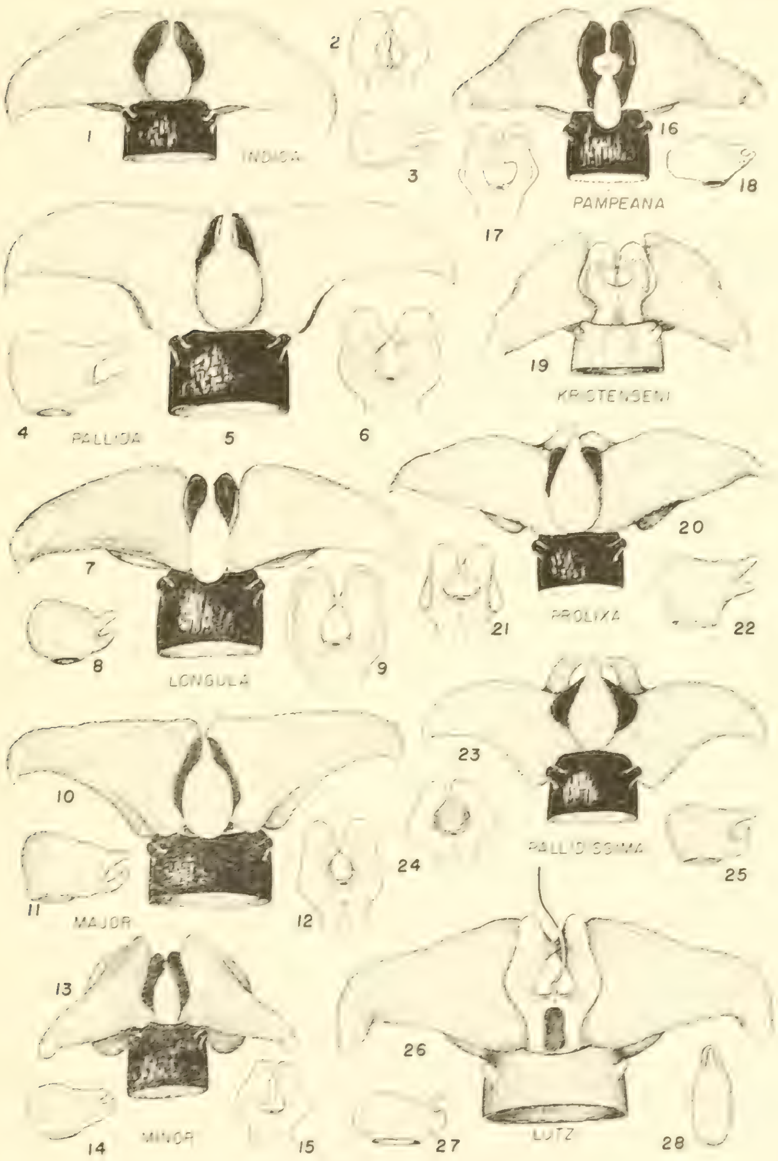
16–18, *M. pampeana*, new species, from Tucumán, Argentina: 16, Lateral vesiculae, dorsal view; 17, penial plates; 18, median vesicula, lateral view.

19, *M. kristenseni* Jensen-Haarup, from plains northwest of Lake Zwai, Abyssinia: Dorsal view, showing lateral vesiculae, penial plates, and penisfilum. Median vesicula not evaginated.

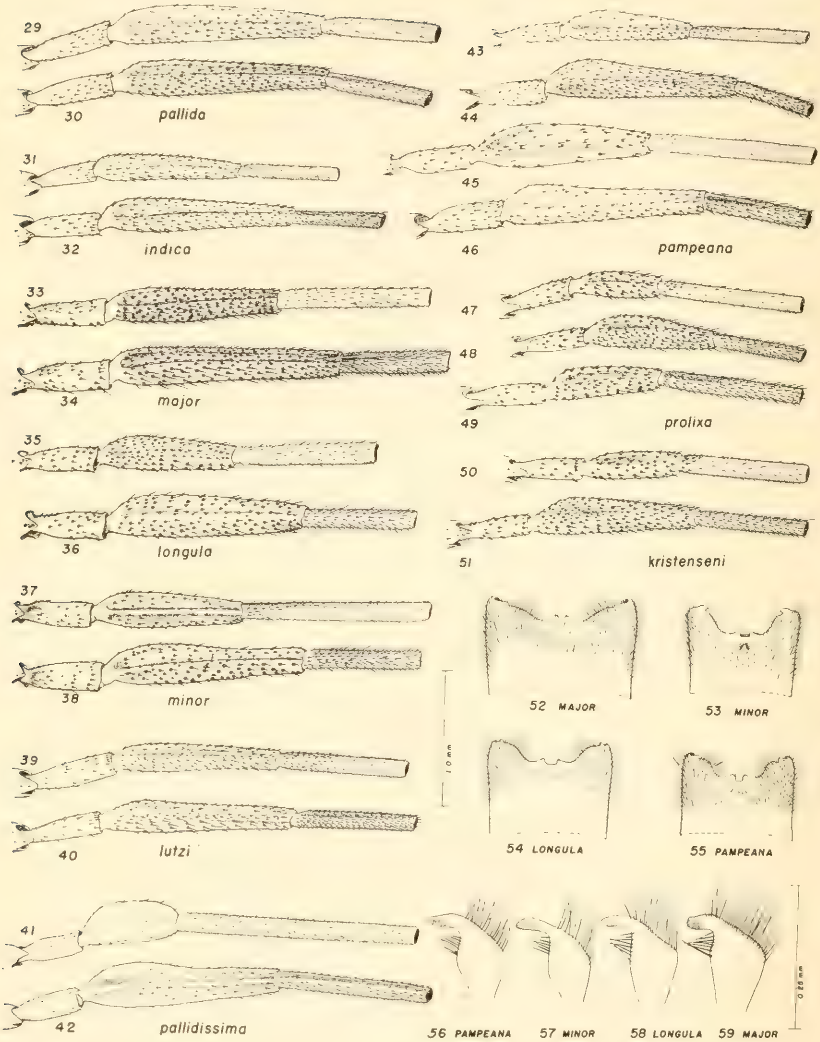
20–22, *M. prolixa* Stål, from Cape Province, South Africa: 20, Lateral vesiculae, dorsal view; 21, penial plates; 22, median vesicula, lateral view.

23–25, *M. pallidissima* Jensen-Haarup, from Djibouti, French Somaliland: 23, Lateral vesiculae, dorsal view; 24, penial plates; 25, median vesicula, lateral view.

26–28, *M. lutzi*, new species, from Djamba, Belgian Congo: 26, Dorsal view of lateral vesiculae and penial plates, showing penisfilum; 27, median vesicula, lateral view; 28, median vesicula, dorsal view.



(For explanation see page 504.)



(For explanation see page 505.)

Plate 48

Illustrations showing the first three segments of the antennae of both sexes of species of *Mecidia*. For each species an illustration of the male is shown first, followed by another of the female. To some extent it is intended that these illustrations show the limitations, as well as the usefulness, of the antennal characters, for purposes of identification:

Mecidea pallida Stål:
- 29, Male, from Gafsa, Tunisia.
- 30, Female, from Minna, northern Nigeria.

M. indica Dallas:
- 31, Male, from Hoshangabad, Central Provinces, India.
- 32, Female, from Poona, Bombay, India; compared with type.

M. major, new species:
- 33, Male, from Bexar County, Tex.
- 34, Female, from Bexar County, Tex.

M. longula Stål:
- 35, Male, from Antigua, British West Indies.
- 36, Female, from Antigua, British West Indies.

M. minor Ruckes:
- 37, Male, from Zavalla County, Tex.
- 38, Female, from Dallas, Tex.

M. lutzi, new species:
- 39, Male, from Djamba, Belgian Congo.
- 40, Female, from Djamba, Belgian Congo.

M. pallidissima Jensen-Haarup:
- 41, Male, from Jidda, Arabia.
- 42, Female, from Buraim, Arabia.

M. pampeana, new species (examples from two localities are intended to show extremes of variation encountered in this species):
- 43, Male, from Conhello, La Pampa, Argentina.
- 44, Female, from Conhello, La Pampa, Argentina.
- 45, Male, from Agua de Oro, Córdoba, Argentina.
- 46, Female, from Agua de Oro, Córdoba, Argentina.

M. prolixa Stål:
- 47, Male, from Cape Province, South Africa.
- 48, 49, Female, from Cape Province, South Africa.

M. kristenseni Jensen-Haarup:
- 50, Male, from plains northwest of Lake Zwai, Abyssinia.
- 51, Female, from plains northwest of Lake Zwai, Abyssinia.

Figures showing a ventral view of the hypopygium, of species of *Mecidea:*
- 52, *M. major*, new species, from Bexar County, Tex.
- 53, *M. minor* Ruckes, from Dallas County, Tex.
- 54, *M. longula* Stål, from Antigua, British West Indies.
- 55, *M. pampeana*, new species, from Tucumán, Argentina.

Figures showing an outside lateral view of the left clasper, of species of *Mecidea.*
- 56, *M. pampeana*, new species, from Tucumán, Argentina.
- 57, *M. minor* Ruckes, from Dallas, Tex.
- 58, *M. longula* Stål, from Antigua, British West Indies.
- 59, *M. major*, new species, from Bexar County, Tex.

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REVIEW OF THE FISHES OF THE BLENNIOID GENUS ECSENIUS, WITH DESCRIPTIONS OF FIVE NEW SPECIES

By WILBERT M. CHAPMAN [1] and LEONARD P. SCHULTZ

McCulloch described the fish genus *Ecsenius* on the basis of a new species, *E. mandibularis*, from Australian waters. Norman further defined the genus and indicated that several other species of blennies, formerly referred to *Salarias* Cuvier, should properly be included in *Ecsenius*. The present study is a review of the genus and the species included in it.

Ecsenius is a closely knit genus of 11 known marine species occurring only in the tropical Indo-Pacific faunal area. Within that area species have been found from the Red Sea on the west through the Marshall and the New Hebrides Islands to the Hawaiian Islands on the east and from Formosa on the north to Queensland, Australia, on the south. While this genus occurs in the coral area, in relation to coral heads, it typically occurs not on the shallow reefs but apparently in moderate depths, and this perhaps accounts for the relative scarcity of specimens in ichthyological collections.

The dentition clearly sets off *Ecsenius* from all other genera of blennies. In the upper jaw are more than 100 tiny, independently movable teeth, a condition typical of the genera *Istiblennius* Norman and *Salarias*, whereas in the lower jaw, the labial teeth are fewer than 50 in number, they are much stouter than those above (usually with the one or two teeth on each side farthest from the symphysis somewhat

[1] The senior author was aided in these studies by grants in aid from the John Simon Guggenheim, Jr., Memorial Foundation and by the California Academy of Sciences.

enlarged or stronger than the others), and they are only slightly flexible. This condition suggests *Rhabdoblennius*, and is distinctly in contrast with that of *Salarias* and *Istiblennius*. The canine far back on the lower jaw, typical of salariin blennies, is tiny but stout, and may be one or two in the same species. Furthermore, as Norman has reported, traces of more teeth in this same dentary series can be detected. Indeed, in the genotype *E. mandibularis* there are six or seven plainly apparent teeth on each dentary in this series, quite distinct from the series of labial teeth on the anterior part of the dentaries, a situation quite unknown in other salariin blennies. Norman has suggested, on this account, that *E. mandibularis* might be properly placed in a separate subgenus. A study of the other species of the genus has, however, inclined us to reject this suggestion. In all other particulars, *E. mandibularis* agrees closely with the other species of the genus. The types of that species are considerably larger than specimens available in the other species. It is possible that these latter are mostly juvenile and that the greater number of dentary teeth in *E. mandibularis* is simply a factor of age, representing an adult condition detectable as traces of teeth noted by Norman in other species.

While the condition of the dentition might indicate a relationship somewhere between *Istiblennius*, *Salarias*, and *Rhabdoblennius*, there is little else that does, and no lineal phyletic connection is apparent between *Ecsenius* and those three genera. The lack of orbital or nuchal cirri, the low number of dorsal spines, the unbranched caudal rays, the full membranous connection of the last anal ray to the caudal peduncle, the slender genital tube of the male, the elongation of one or more caudal rays well beyond the fin membrane, which is normal in most species, the lack of crenulation on the lips, the pelvics I,3, the short lateral line with its double, rather than single, line of pores, are characters that are mostly confined to *Ecsenius* among the salariin blennies, and, when put together, set the genus off sharply from its relatives. There are other more subtle but just as definite characteristics—the slender fin rays, which give an air of diaphanous fragility to the vertical fins, and the anterior profile, which is either vertical or even slopes backward from the forehead to the margin of the upper lip.

The distribution of the known specimens and species of the genus is suggestive of the division of the vast tropical Indo-Pacific fish fauna into subareas, illustrated by the other genera of Salariinae and other families of fishes studied by the authors. Two species have been found only in the Red Sea and at Djibouti; two have been found only in the Solomon Islands; one each in the Marshall Islands, northeast Australia, the Philippines, Formosa, the Hawaiian Islands, the western Indian Ocean, and the Persian Gulf. Only one species has been determined to have a broad range, occurring in Ceylon, Bengal, Christmas Island, Timor, and the New Hebrides Islands. In discussions under each species some notes have been made of the possible relationships of the several species, but clarification of these relationships must await further collections throughout the range of the genus.

Genus ECSENIUS McCulloch

Ecsenius McCulloch, Rec. Australian Mus., vol. 14, p. 121, 1923. (Genotype, *E. mandibularis* McCulloch.)—Norman, Ann. Mag. Nat. Hist., ser. 11, vol. 10, p. 810, 1943.

Description.—Dorsal rays XII, 12–20; anal II, 13–21; pectoral 13–15; pelvic I,3.

No crest on head in either sex (except low ridge on large male of *mandibularis*); nasal cirrus either simple, bifid, or trifid; no supraorbital or nuchal cirrus; both lips smooth; one or more tiny, hidden canines posteriorly on each dentary; 45 to 50 firmly placed teeth in lower jaw (typical of *Blennius*); more than 100 independently movable, slender teeth in upper jaw (typical of *Istiblennius* and *Salarias*); no teeth on vomer; depth 3.6 to 6.0, head 3.3 to 4.8, both in standard length; lateral line a double series of pores anteriorly, ending under tenth or eleventh dorsal spine, not turning downward on side, continued on as a faint line with no visible pores to end of dorsal; dorsal notched or not, reaching to or over first small rays of caudal; last ray bound to caudal peduncle by membrane; caudal usually with 12, occasionally 13, unbranched principal rays, with 6 or 7 small rays above and below, mostly hidden under skin; upper and lower principal caudal rays typically exserted beyond margin of fin, by as much as length of shortest caudal rays in large individuals of certain species; 2 spines in anal, always plainly visible in male and usually so in female, but very minute in latter; no crenulated pads on first anal rays of male, instead these rays on adult males are normally a little swollen or bulbous at distal tip; no anal ray extends beyond margin of fin in males; last anal ray fully bound to caudal peduncle by membrane; males with a slender, tubular genital pore midway between anus and insertion of anal spine; pelvics always with I, 3 rays, the third soft ray normally bound to second and not visible without dissection; pelvic spine always present but not visible without dissection.

TABLE 1.—*Counts on certain species of* Ecsenius

Species	Number of fin rays																					Number of basal tentacles on each nostril		
	Dorsal								Anal									Pectoral						
	XII	12	13	14	15	16	17	18	II	13	14	15	16	17	18	19	20	12	13	14	15	1+0	1+1	1+2
bicolor	11					4	6	1	11							8	3		20	2			18	4
hawaiiensis	13					3	9	1	13						1	10	2	1	24	1			25	1
opsifrontalis	2		2						2			2							6			6		
stigmatura	3					1	2		3						1	2			1	3	2	6		
lividanalis	10	1	8	1					9	2	7								9			6		
pro-oculis	1			1					1			1							2			2		

KEY TO THE SPECIES OF ECSENIUS

1*a*. (See also 1*b* and 1*c*.) Pectoral with 15 rays and no dark spot around anus (Red Sea and Djibouti).

2*a*. Color of head, body, and vertical fins a rich, uniform brown, with no markings; dorsal XII,19; anal II,20 (Red Sea).
Ecsenius frontalis (Cuvier and Valenciennes)

2*b*. Color of head and body light tan with no markings other than a few scattered black specks on upper part of caudal peduncle; a jet black band as wide as eye diameter running along base of both spinous and soft dorsal, outer part of fin hyaline; top and bottom of caudal fin jet black to end of long rays, rest of fin hyaline; anal fin colorless; dorsal XII, 18; anal II,20 (Djibouti)____________________Ecsenius gravieri (Pellegrin)

1*b*. Pectoral rays 13 to 15, usually 14; anal rays II, 18 or 19; a distinct dark spot around anus; a large dark brown spot on base of caudal fin; dark brown streak from lower edge of eye backward across gill cover; dorsal rays XII, 16 or 17 (Philippines)___Ecsenius stigmatura Fowler, new species

1*c*. Pectoral with 13 or 14 rays, rarely 12; if area around anus is black anal rays are II,13 or 14 (tropical Indo-Pacific oceans).

3*a*. Nasal cirrus simple and single.

4*a*. Dorsal with 19 or 20 soft rays; anal with 21 or 22; a dark band along base of dorsal (western Indian Ocean and Persian Gulf).
Ecsenius pulcher (Murray)

5*a*. Body evenly brown, without markings___(Ecsenius pulcher, female)

5*b*. Head, throat, and body to level of sixth dorsal ray rich, light brown (paler below), without markings; rest of body to caudal abruptly pale, crossed by 5 or 6 equally spaced narrow, sharply defined vertical bars, reaching from dorsal to ventral edge of body.
(Ecsenius pulcher, male)

4*b*. Dorsal with 12 to 14 soft rays; anal with 13 to 17 soft rays; no dark streak along base of spinous dorsal and never sharply defined if present on soft dorsal.

6*a*. Spinous and soft dorsal separated by shallow notch in young but no notch at all in adults; sharply defined black spot, half the area of eye, around anus, set off from rich brown body by light peripheral band; no other markings on head, body, or fins; dorsal with 12 or 13 soft rays; anal with 13 or 14 soft rays (Solomon Islands).
Ecsenius lividanalis, new species

6*b*. Spinous and soft dorsal separated by a deep notch reaching nearly to base of fin; last dorsal spine minute, nearly hidden in basal fin membrane; no dark spot around anus; well-defined dark streaks, bars or spots on body; dorsal with 13 to 16 soft rays; anal with 15 to 18 soft rays.

7*a*. A row of 6 or 7 small teeth laterally on ridge of dentary; anal with 16 to 18 soft rays; double row of small, dark, roundish spots along side of body, but no bars or bands (Queensland, Australia)__________________Ecsenius mandibularis McCulloch

7*b*. One or 2 tiny teeth posterolaterally on the dentary, but never more; anal with 15 soft rays; no dark spots on body, but dark bars or bands present on sides; 2 pale horizontal bands, each as wide as pupil, running full length of body, one from upper corner of opercle, the other from under pectoral.

8*a*. Dorsal with 14 soft rays; a dark band as wide as pupil extending back from eye to opercular edge; no vertical dark bars on body; nasal cirrus about a third the diameter of eye in length; membrane from last dorsal ray covering first 3 or 4 small caudal shorter than postorbital length of head by about one-third the diameter of eye (Solomon Islands).
Ecsenius pro-oculis, new species

8*b*. Dorsal with 13 soft rays; dark band from eye extending beyond opercular edge onto body to a vertical from middle of spinous dorsal; 8 or 9 narrow, dark, vertical bars on body extending to base of dorsal, where 2 or 3 may be divided; nasal cirrus about half the diameter of eye in length; membrane of last dorsal ray not covering first few caudal rays; pectoral shorter than head by less than half the diameter of eye; pelvics longer than postorbital length of head by nearly half the diameter of eye (Marshall Islands).
Ecsenius opsifrontalis, new species

3*b*. Nasal cirrus always double, ventral one may be bifid or double; dorsal with 16 to 20 soft rays; anal with 19 to 21 soft rays.

9*a*. Head and anterior part of body evenly dark with no markings; posterior part of body and adjacent vertical fins often abruptly pale (bright golden in life) with no markings.

10*a*. Dorsal with 16 of 17 soft rays; anal with 18 to 20 soft rays (eastern Indian Ocean; Christmas Island; Timor; New Herbrides Islands).
Ecsenius bicolor (Day)

10*b*. Dorsal wth 20 soft rays; anal with 21 soft rays (Formosa).
Ecsenius namiyei (Jordan and Evermann)

9*b*. Middle of side of body with 5 to 7 short but distinct white bars evenly spaced; a dark spot behind eye; middle caudal fin rays dusky to blackish; body plain olive to light greenish brown, undersides pale olive............................Ecsenius hawaiiensis, new species

ECSENIUS FRONTALIS (Cuvier and Valenciennes)

Salarias frontalis Cuvier and Valenciennes, Histoire naturelle des poissons, vol. 11, p. 328, 1836 (type locality, Massuah, Red Sea).—Günther, Catalogue of the fishes in the British Museum, vol. 3, p. 245, 1861 (in synonymy of ?*S. fuscus*).—Bamber, Journ. Linn. Soc., vol. 31, p. 484, pl. 46, fig. 1, 1915 (Suakim, Red Sea).

Specimens.—Three specimens, 37 to 49 mm. long, from Baie de Djibouti, Gravier (in a jar with specimen of *Enchelyurus*), labeled as *Salarias fuscus*), P. M. 04.318; 1 specimen, 52 mm. long, collected by Crossland in Red Sea, B. M. 1915.10.25.9.

Description.—Dorsal rays XII,19; anal II,20; pectoral 15; pelvic I,3.

Nasal cirrus single and simple, on level with upper level of pupil, lanceolate, nearly as long as eye diameter; snout vertical or somewhat projecting; one or two tiny canines below on either side; depth 4.8 to 5.4, head 3.6 to 4.4, both in standard length; dorsal spines and rays of same height, with no trace of notch, the fin ascending gradually to greatest height in middle of soft dorsal; last ray with its tip free from membrane binding it to caudal peduncle, the membrane not covering first small caudal rays; caudal truncate, upper and lower two rays extended out from level of fin; anal with tip of last ray free from membrane; pectoral extending back to anal insertion; pelvics are equal to two-thirds the postorbital length of head.

Coloration.—MALE: Color of head, body and vertical fins a rich uniform brown with no markings and the abdomen only a little more pale than the rest of body; peritoneum black; anterior top edge of spinous dorsal white; caudal somewhat dusky in the two larger males; pectorals pale and clear. FEMALE: As male, except caudal clear.

Remarks.—The four specimens listed are without doubt the *Salarias frontalis* of Cuvier and Valenciennes. Except for the lack of markings, the higher pectoral count, and the single nasal cirrus this species resembles *E. bicolor*, and it should be considered the Red Sea cognate of that species.

ECSENIUS GRAVIERI (Pellegrin)

Salarias gravieri PELLEGRIN, Bull. Mus. Hist. Nat. Paris, vol. 12, p. 93, 1906 (type locality, Djibouti).

Specimen.—One male, 53 mm. long, collected by Gravier in Baie de Djibouti, the type of the species. P. M. 04–319.

Description.—Dorsal rays XII,18; anal II,20; pectoral 15; pelvic I,3.

Nasal cirrus single and simple, no longer than diameter of pupil; snout vertical or forehead somewhat projecting; one or two tiny canines on either side below; depth 4.8, head 3.5, both in standard length; all dorsal spines except first excised, the first few to a third their depth; shallow notch between the spinous and soft dorsal, the last spine short and hidden in basal membranes; only tips of soft dorsal free; all caudal rays excised at tips, but upper and lower two principal rays extended by a length equal to two-thirds the length of the middle rays; dorsal and anal attached to caudal peduncle, the membranes reaching to, but not over, first small rays of caudal.

Coloration.—MALE: Except for a few scattered black specks on the upper part of the caudal peduncle the body and head are pale tan with no markings; peritoneum black; a jet black band running along base of both dorsals, as wide as eye diameter; outer part of fin perfectly clear and unmarked; a few scattered black specks on base of caudal; top and bottom of caudal jet black to end of long rays; rest of fin hyaline; anal and paired fins colorless. FEMALE: None available.

Remarks.—This species is closely related to *E. frontalis* (from the same locality), but the character of the dorsal and the striking color pattern seem to set it off clearly. This can scarcely be an older male of *E. frontalis*, for specimens of the latter, examined in the Paris and British Museums, were of practically the same size as those of *E. gravieri.*

ECSENIUS STIGMATURA, Fowler, new species

FIGURE 90

Holotype.—U.S.N.M. No. 99379, Philippine Islands, Dammi Island between Jolo and Tawi Tawi Straits, lat. 5°52′12″ N., long. 120°31′00″ E., depth 244 fathoms, September 21, 1909, *Albatross*, standard length 46.5 mm., female.

Paratypes.—U.S.N.M. No. 111878, taken with the holotype and bearing same data, standard length 37 mm., female; U.S.N.M. No. 122444, Philippine Islands, Cataingan Bay, east of Masbate Island, April 18, 1908, *Albatross*, standard length 36.2 mm., female.

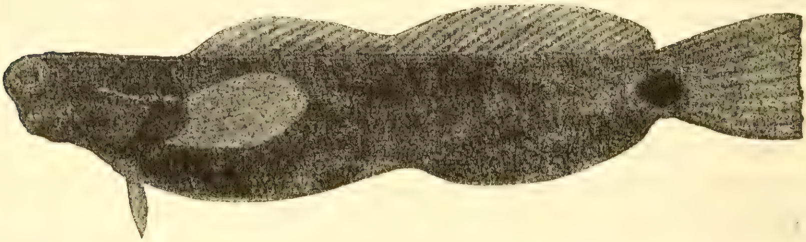

FIGURE 90.—*Ecsenius stigmatura* Fowler, new species. (From photograph of color drawing from the Philippine *Albatross* collection.)

Description.—The following counts were made on the holotype and paratypes, respectively: Dorsal rays XII,17; XII,17; XII,16; anal II,19; II,19; II,18; pectoral 13–14; 14–14; 15–15; pelvic I,3; I,3; I,3; no branched caudal rays; nasal cirri 1–1; 1–1; 1–1.

Certain measurements were made on the types and these data are recorded in thousandths of the standard length in table 2.

Head (tip of upper lip to end of gill cover) 3.6 to 4.0; greatest depth 3.8 to 4.7, longest pectoral ray 5.2 to 5.8, snout tip (upper lip) to anus 1.8 to 1.9, anal fin base 2.5 to 2.7, all in the standard length. Eye 2.7 to 3.3, snout 3.5 to 3.7, postorbital length of head 1.5, greatest depth of body 1.1, least depth of body 2.2 to 2.3, longest pectoral ray 1.4 to 1.5, longest dorsal spine 1.8 to 1.9, all in the length of head from tip of upper lip (snout) to rear of gill cover. Fleshy interorbital space 2.5 to 3.0 in eye.

No orbital cirrus; no nuchal cirrus; a single, simple, nasal cirrus arising on upper edge of nasal opening; snout profile with a notable backward slant of 25 to 30 degrees from the vertical; edges of both lips smooth; lateral line running a dorsal course over pectoral fin and ending about opposite tip of pectoral fin and base of eighth or ninth dorsal spine, not descending to middle of side; vertical line through dorsal origin passes through rear edge of opercle, base of pectoral fin, and notably far behind base of pelvics; last dorsal ray attached by membrane to dorsal edge of caudal peduncle but not to base of caudal fin; anal origin opposite base of last dorsal spine; last anal ray attached by membrane to lower edge of caudal peduncle; pectoral fins reaching about two-thirds the way to the anus; anal spines small, first embedded; posterior canine of lower jaw short but strong; teeth in upper jaw about 110, movable, those in lower jaw larger movable, about 40 to 45 in number, the teeth on each side farthest from the symphysis notably enlarged; no vomerine teeth; posterior margin of caudal fin probably truncate; no cephalic crest; a vertical line through front edge of upper lip passes through front edge of eye; forehead a little in front of tip of upper lip.

Coloration.—In alcohol: Background coloration plain reddish brown; a large area in front of anus blackish brown; on base of caudal fin and on caudal peduncle a dark brown spot, somewhat angular posteriorly; pectoral, pelvics, dorsal, and caudal fins hyaline or pale; anal fin dusky brown; a narrow dark brown streak extends from lower edge of eye backward to rear angle of opercle, below this dark streak on opercle is a narrow pale streak that continues on body behind head only, just dorsal to base of pectoral fin.

Alive (based on color sketch made on *Albatross*): Background coloration reddish brown; anal spot purplish black; caudal spot black; anal reddish brown; dorsal spines orange; an orange streak along base of dorsal fin; iris orange; dark streak behind eye is dark blue, and pale streak below it is orange; upper lip slightly yellowish brown.

Ecology.—This species probably came from deep water, as the *Albatross* dredge record indicates 244 fathoms.

Remarks.—*E. stigmatura* is one of two known species with a black area (purplish black when alive) in front of the anus; *E. lividanalis*, new species, lacks the caudal spot and streaks behind the eye. Additional characters that distinguish *E. stigmatura* from the other species referred to the genus may be found in the accompanying key.

ECSENIUS PULCHER (Murray)

Salarias pulcher Murray, Journ. Bombay Nat. Hist. Soc., vol. 2, p. 47, 1887 (type locality, Kurrachee Manora Rocks, India); Indian Ann. Mag. Nat. Sci., vol. 1, p. 23, 1887 (Kurrachee, India).

Salarias phantasticus Boulenger, Ann. Mag. Nat. Hist., ser. 6, vol. 20, p. 422, 1897 (type locality, Mekran Coast, Persia).

Salarias anomalus Regan, Journ. Bombay Nat. Hist. Soc., vol. 16, pp. 327, 331, pl. B, fig. 4, 1905 (type locality, Persian Gulf; Mekran Coast, Karachi); Journ. Zool. Soc. London, p. 406, 1909 (on type material).

Specimens.—Two males, each 45 mm. long, collected by Murray at Kurrachee (the types of *Salarias pulcher*), B. M. 87.9.22.59—60; 2

males, 56 and 58 mm. long, collected by Townsend on Mekran Coast, Persia (types of *Salarias phantasticus*), B. M. 97.9.22.20–21 (these are like *pulcher* types except that the posterior dorsal spines and caudal rays are even longer and more extended; black vertical lines, respectively, 7 and 8; two tiny black dots on posterodorsal quarter of orbit); 16 female, 32 to 58 mm. long, collected by Townsend in Persian Gulf (the type series of *Salarias anomalus*), B. M. 1900.5.9.47–56; 1 female, 41 mm. long, collected by Stephens at Henjam Islands, Persian Gulf, B. M. 1932.2.18.43; 1 female, 58 mm. long, collected by Townsend at Hinderabi Islands, Persian Gulf, B. M. 98.6.29.163; 2 females, 29 and 34 mm. long, collected by Townsend at Jask, Mekran Coast, Persia (these specimens have a short horizontal white bar on the cheek under posterior part of eye—caudal and spinous dorsal only barely lengthened); female, 51 mm. long, collected by Knox at Muscat, B. M. 1912.11.26.1.

Description.—Dorsal rays XII,19–20; anal II,20–21; pectoral 14; pelvic I,3.

Nasal cirrus slender, single, simple, pointed, about equal to eye in length; forehead projecting, a concavity between it and upper lip; eye high and large, reaching into anterior profile and almost into dorsal profile; a single tiny canine on either side below, hidden in fold of membrane at corner of jaw; depth 5.2 to 5.7; head 4.3 to 4.5, both in standard length; dorsal deeply notched, the last spine about one-third length of the next preceding; posterior dorsal spines elevated, their tips free from the fin membrane, the fourth from the last as long as head, its distal one-fourth free from membrane; membrane from last ray reaching to, but not over, first small ray of caudal; caudal with 12 principal rays, none branched, the second and eleventh rays longest, the fin forked, almost filamentous, longer than head in specimens as much as 45 mm. long; anal spines of male both small and hidden at base of first ray; no pads or swellings at tips of anal rays; last ray bound fully to caudal peduncle but not reaching first caudal rays; longest pectoral ray equal to postorbital length of head; longest pelvic ray less than two-thirds postorbital length of head.

Coloration.—Male: Head, throat, and body rich, light brown (paler below) and with no markings back to level of sixth dorsal ray; on this pale posterior part of body five or six equally spaced, narrow, sharply defined dark vertical bars reaching from dorsal to ventral edge of body; the anterior line a little wider than pupil, the posterior one a little narrower; in some specimens there may be a shorter fine line between some of the main lines; basal half of spinous dorsal and all of soft dorsal evenly dusky; this area, while pigmented, transparent and with no markings; distal half of spinous dorsal pale, but bearing markings—an oval dark spot the size of pupil between spines 1 and 2, another between 2 and 3, another between 5 and 6, another near end of 7, and another near ends of spines 8 and 9, last two spots thickened and involving the spines (on one specimen only the third and fifth of these dorsal spots are present): anal clear, narrowly edged with black; caudal dusky distally but with no actual markings and transparent; paired fins clear. FEMALE: Like male except that the body is plain brown without the markings so typical of the male.

Remarks.—As in most other species of the genus, the males and females of this species cannot normally be differentiated by the external sex organs. Examination of the gonads of the types of both *pulcher* and *anomalus* demonstrates that the former is the male, the latter is the female of the species. It is quite possible that this is the cognate in the western Indian Ocean of *opsifrontalis* from the Marshall Islands and *pro-oculis* from the Solomon Islands.

ECSENIUS LIVIDANALIS, new species

FIGURE 91

Holotype.—U.S.N.M. No. 144723, male, 34 mm. in standard length, collected by Chapman and Cheyne at Munda, New Georgia, Solomon Islands, June 15, 1944.

Paratypes.—U.S.N.M. No. 144291, 3 specimens, 24 to 33 mm., collected with holotype and bearing same data; U.S.N.M. No. 144292, 6 specimens, 24 to 30 mm., collected by Chapman and Cheyne in Munda Lagoon, New Georgia, Solomon Islands.

Description.—Dorsal rays XII,12–13; anal II,13–14; pectoral 13; pelvic I,3.

Nasal cirrus simple, slender, pointed, equal to about half diameter of pupil in length; forehead projecting slightly, but profile rounded; a single, tiny canine on each side below, rather far forward and no more than one-third the size of labial teeth; lateral tooth occasionally set off a little from the labial teeth; depth 3.6 to 4.3, head 3.3 to 3.5, both in standard length; spinous dorsal slightly rounded anteriorly, a little lower than soft dorsal; younger specimens show slight notch between spines and rays but older specimens have no notch, only a difference in level between spines and rays; last spine does not come up to edge of fin membrane and is only two-thirds height of next spine; membrane attaching last dorsal ray to caudal peduncle reaching over first two or three small caudal rays; last ray of anal similarly attached to caudal peduncle; genital papilla of female similar to that of *Salarias* and hides first tiny anal spine; second anal spine half length of first ray; anal highest in middle where it is two-thirds height of soft dorsal; male genital tube slender, nearly as long as first anal spine and situated midway between it and anus; caudal evenly rounded, shorter than head by length of snout and one-third the diameter of eye; none of rays forked or exserted; longest pectoral ray shorter than head by snout and half the eye; longest pelvic ray equals two-thirds postorbital length of head, spine completely hidden, slender third ray scarcely visible without dissection.

Coloration.—MALE: Over-all color a rich, reddish brown, only a little lighter on throat than elsewhere; brown extends onto dorsals

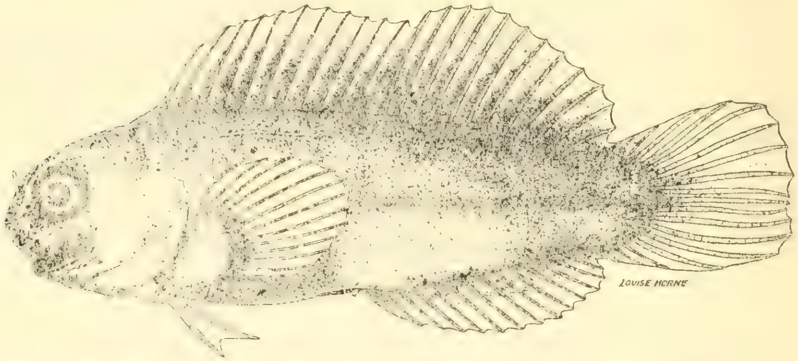

FIGURE 91.—*Ecsenius lividanalis*, new species. Holotype. (Drawn by Louise Horne.)

but fades distally so that outer half of fin more or less transparent; anal rather evenly dusky with edge lighter; caudal with only a little pigment along rays and on membrane basally; pectorals clear; eye black; a sharply defined black spot (brilliantly blue in life) half the area of eye surrounding anus, and set off from brown of body by a light peripheral band; no other markings on head, body, or fins. FEMALE: Same as male.

ECSENIUS MANDIBULARIS McCulloch

Ecsenius mandibularis MCCULLOCH, Rec. Australian Mus., vol. 14, No. 2, p. 122, pl. 15, figs. 1 and 2, 1923 (type locality, Masthead Island, off Port Curtis, Queensland, Australia).

Specimens.—None examined. Description after McCulloch.

Description.—Dorsal rays XII,13–16; anal II,16–18; pectoral 13; pelvic I,3.

Nasal cirrus single, simple, borne on posterior nasal pore and about half diameter of eye in length; forehead slightly projecting but evenly rounded; six or seven small conical teeth on each side on ridge of dentary and behind labial teeth (in position occupied by the one or two tiny canines found in other species of the genus); depth 4.7, head 4.1, both in standard length; spinous dorsal rounded posteriorly, the last spine tiny, buried in membranes at bottom of deep notch between spinous and soft dorsals; longest dorsal spine a trifle shorter than longest ray; last dorsal ray bound to caudal peduncle by membrane extending to first small rays of caudal; first anal spine buried in genital pad of female, but visible in male; anal lower than soft dorsal with a small fleshy pad at tip of each ray in male; caudal with 12 or 13 principal rays, those above and below irregularly exserted beyond fin margin in males; pectoral as long as postorbital length of head and half diameter of eye; longest pelvic ray about two-thirds postorbital length of head.

Coloration.—Male: Head and body uniformly light brown with a bluish tinge on sides; two rows of well-defined, evenly spaced, dark spots each smaller than pupil along the sides, the upper, of about nine spots, above level of lateral line, the lower, along middle of side, beginning behind pectoral, and containing about seven spots; no other markings on head or body; fins without markings except pads on tips of anal rays distinctly lighter than rest of fin. Female: Like male.

Remarks.—Set off from other species in the genus chiefly by the number of teeth in the canine series on the dentary.

Figure 92.—*Ecsenius pro-oculis*, new species. Holotype. (Drawn by Louise Horne.)

ECSENIUS PRO-OCULIS, new species

Figure 92

Holotype.—U.S.N.M. No. 144722, a male, 40 mm. in standard length, collected by Chapman and Cheyne, May 20, 1944, at a little island in Munda Lagoon near Sessavelle, New Georgia, Solomon Islands, among coral heads in about 10 feet of water.

Description.—Dorsal rays XII,14; anal II,15; pectoral 13; pelvic I,3.

Nasal cirrus single and simple, rather bluntly pointed, as broad as nasal pore on whose upper edge is it borne, about one-third diameter of eye in length; forehead strongly projecting so that anterior edge of orbit is a little beyond a vertical from margin of upper lip, giving the eyes the effect of protruding; a single canine on either side below, rather far forward and no larger than corner labial teeth of lower jaw; the two corner teeth on each side of the lower jaw somewhat detached from rest of series and caninelike; depth 4.3, head 4.2, both in standard length; third spine of dorsal highest, with fin shortening rapidly posteriorly, next-to-last spine only half length of third spine or first ray, last spine a tiny nubbin almost buried in basal membrane of fin; third ray of soft dorsal longest; this part of fin also shortening rapidly posteriorly; membrane binding last ray to caudal peduncle covering first three or four small rays of caudal; soft dorsal a little higher than spinous dorsal, with deep notch between two parts of fin; anal lower than spinous dorsal; both anal spines plainly visible, the second being two-thirds the length of first ray, the first two-thirds the length of second; all rays except last with a small fleshy pad at the tip; last fully bound to caudal peduncle by membrane; genital papilla or tube of male a little longer than wide; caudal with 13 principal rays and 7 small rays both above and below; middle caudal rays equal head in length; third and fourth dorsal principal rays greatly elongated, extending beyond level of fin by two-thirds the length of middle rays; third principal ray from ventral edge of fin only slightly extended; none of caudal rays forked; longest pectoral and pelvic rays approximately equal in length and shorter than postorbital length of head by one-third the diameter of eye; third ray of pelvic, while entirely bound to, and much more slender than, second, plainly visible; pelvic spine not visible without dissection.

Coloration.—MALE: Peritoneum black; throat noticeably paler than sides of head and without markings; rest of head and the body a very dark reddish brown; a darker band as wide as pupil extending back from eye to edge of opercle; two horizontal light bands, each as wide as pupil, run full length of body, one from upper corner of opercle to upper part of caudal base, the other from under the pectoral to lower part of caudal base; no spots or other markings on head or body; spinous dorsal clear and transparent; soft dorsal with a clear band at base, then a narrow dusky band which shades off above to leave most of fin clear and transparent; middle third of caudal dusky, upper and lower thirds mostly clear; anal uniformly dusky with pads at tips of rays a little paler; pectorals clear; pelvics uniformly dusky. **FEMALE**: None available.

Remarks.—This species, and *E. opsifrontalis* from the Marshall Islands, are distinguished from the species by the marked projection forward of the orbits and the resultant backward slope from the forehead to the upper lip.

ECSENIUS OPSIFRONTALIS, new species

Figure 93

Holotype.—U.S.N.M. No. 142065, Rongelap Atoll, Rongelap Island, Marshall Group, collected by Brock, Herald and Kohler, July 25, 1946, in lagoon at depth of 18 feet, standard length 31 mm.

Paratype.—U.S.N.M. No. 142066, Bikini Atoll, collected by Brock and Schultz in lagoon at depth 20 to 25 feet, March 26, 1946, 1 specimen, 26.3 mm.

Description.—Dorsal rays XII,13; anal II,15; pectoral 13; pelvic I,3.

Certain measurements were made on the types, and these data are recorded in thousandths of the standard length in table 2.

Nasal cirrus single and simple, slender, rising on dorsal side of nasal pore, about half diameter of eye in length; forehead projecting so that anterior slopes from level of eye back to margin of upper lip at an angle of 30 to 45 degrees from the vertical; a single, small canine close behind other teeth on dentary, hidden by fold of membrane at

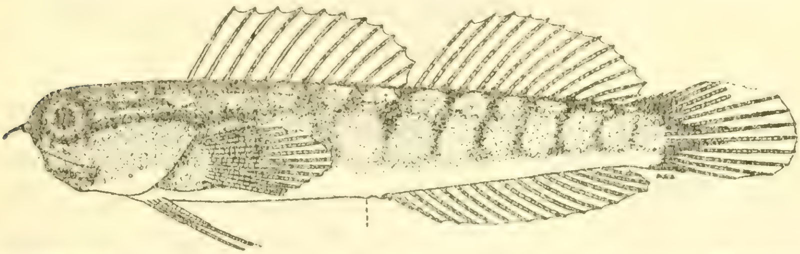

Figure 93.—*Ecsenius opsifrontalis*, new species. Holotype. (Drawn by Dorothea B. Schultz.)

corner of mouth; depth 4.8 to 5.1, head 3.8 to 3.9, both in standard length, dorsal spines all about same length, except that last is no more than two-thirds length of next-to-last; membrane definitely notched behind spinous dorsal; soft dorsal highest in middle, the longest ray a little longer than longest spine; last ray bound to caudal peduncle by a membrane which does not reach first small caudal rays; both anal spines visible in both sexes; females with a rounded, rather large genital pad with a tiny nubbin on posterior edge; males with a slender tube, half length of first spine, between anus and first anal spine; tips of first anal rays not swollen; longest anal rays shorter than longest dorsal spine or ray; caudal approximately truncate, the upper and lower rays not exserted in specimens of the sizes available; 13 principal rays, with about 6 or 7 small rays above and below; none of rays branched; pectoral shorter than head by less than half the diameter of eye; pelvic fin longer than postorbital length of head by more than half the diameter of eye, spine completely hidden, third ray slender, shorter than second and so closely bound to it as to be clearly visible only by dissection.

Coloration.—MALE: Background of head and body light brown; a dark band as wide as eye extending straight back from posterior edge of eye to a vertical from about middle of spinous dorsal; two faint light bands about as wide as pupil running horizontally on body to base of caudal, one from upper edge of opercle, the other from below pectoral; eight narrow, dark, transverse bars spaced on body, running from base of dorsal down to, but not across, lower pale longitudinal band; two or three of these bars may be split dorsally; the last, on caudal peduncle, is C-shaped with the opening posterior; no spots or other markings on head or body; both lips dusky; anal fin with a dusky submarginal band, tips of rays white; other fins with no markings. FEMALE: essentially the same coloration as male.

Remarks.—This species is probably the Marshall Island cognate of *E. pro-oculis*, with which it shares many characters, but from which it differs as indicated in the key. The color is generally less dark than in *E. pro-oculis* and the markings are therefore less sharply defined.

ECSENIUS BICOLOR (Day)

FIGURE 94

Salarias bicolor DAY, Supplement to the fishes of India, p. 798 (on Tickell ms.) 1888 (type locality, Saddle Island, Kyoukphyoo Aracan); The fauna of British India . . ., vol. 2, Fishes, p. 323, 1889 (on type material).—WEBER, Die Fische der *Siboga*-Expedition, vol. 57, p. 533, 1913 (eastern tip of Timor).

Salarais furcatus (non De Vis 1884) JOHNSTONE, Report of Ceylon Pearl Oyster Fisheries, vol. 2, No. 15, p. 213, pl. 1, fig. 4, 1904 (type locality, Chilam Paar, Ceylon, at 15 to 20 meters depth).—WHITLEY, Rec. Australian Mus., vol. 17, No. 3, p. 136, 1929 (notes that this species is not the same as that of De Vis).

Salarias burmanicus HORA and MUKERJI, Rec. Indian Mus. Calcutta, vol. 38, p. 34, 1936 (type locality, Maung. Magan, Tavoy District, lower Burma).

Specimens.—11 specimens, 31 to 49 mm. long, collected by Chapman and Cheyne at Espiritu Santos, New Hebrides Island, U.S.N.M. Nos. 144716, 144293 and 144294; 6 specimens, 30 to 49 mm. long, collected by Andrews at Christmas Island (the type series of *Salarias melanosoma* Regan), B. M. 1909.3.4.52–57; 1 specimen, 44 mm. long, from Godeffroy Museum, from Ponape, B.M. 81.10.20.139; 2 specimens, 42 and 49 mm. long, from Godeffroy Museum, from Ponape, B.M. 81.10.-20.137; 1 specimen, 38 mm. long, collected by Weber at *Siboga* station 282, Oosthoek of Timor.

Description.—Dorsal rays XII,16–17; anal II,18–20; pectoral 13–14; pelvic, I,3.

Nasal cirrus double; cirrus on dorsal side of nasal pore simple, slender, pointed, and equal to or a little greater than diameter of eye in length; cirrus on ventral edge of pore usually simple, but may be forked or even nearly double, half the length of the dorsal cirrus and of same shape; anterior profile either vertical or with forehead slightly projecting; a single small canine close behind labial teeth, hidden by fold of membrane in corner of mouth on each side of lower jaw in males; not found in females; depth 5.0 to 5.2, head 4.5 to 4.8, both in standard length; dorsal spines all approximately same height except last, which are half height of first ray and two-thirds height of next-to-last spine; soft dorsal highest in its middle, and longest spine a little shorter than longest ray; spines not extending beyond fin membrane; in small specimens fin membrane comes down to height of last spine, making a distinct, if shallow, notch; in larger specimens of both sexes the membrane extends straight back with no notch between fins, only difference in level; membrane binding last ray of dorsal and anal to caudal peduncle reaching to, but

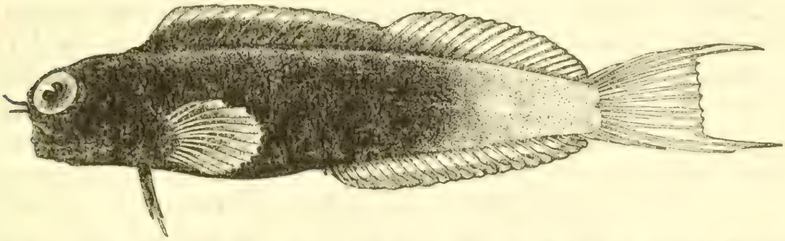

FIGURE 94.—*Ecsenius bicolor* (Day). Specimen from New Hebrides Islands. (Drawn by M. Nickerson).

not over, first small ray of caudal; caudal with 13 principal rays and 6 smaller ones both above and below; second and third principal rays extending beyond edge of middle rays, third to a distance equaling half length of middle rays; third principal ray from bottom extending even farther; in females of the same size the elongated caudal rays project by no more than one-fourth the length of the middle rays, and in smaller specimens of both sexes they scarcely extend beyond normal edge of fin; both anal spines plainly visible in both sexes, the second three-fourths the length of the first ray, the first one-half the length of the first ray; in male, but not female, each anal ray bears a small bulbous enlargement on anterior side of its tip; in male a slender genital tube half the length of first spine between anus and first spine; in females a rounded, rather large genital pad with a tiny nubbin on its posterior edge; longest pectoral ray shorter than head by length of snout and two-thirds eye; longest pelvic ray equal to about two-thirds postorbital length of head; pelvic spine and third ray completely hidden and visible only by dissection.

Coloration.—MALE: Head and anterior two-thirds of body almost uniformly dark brown (bluish in life); blackness of peritoneum makes abdomen darker than above; in posterior third of body this dark area shades off into a very pale area, which extends over the caudal; this pale area bright golden in life; pale area extends anteriorly farther along base of anal, and a little way along base of dorsal; on smaller specimens the dark pigment extends farther posteriorly until there may even be a little on the base of the middle caudal rays, but always the fish is lighter posteriorly than anteriorly; no spots or markings on the head or body, except for an indistinct light band from the eye down across the upper lip and an indistinct dark streak directly behind the orbit; a continuous dusky band along basal portion of dorsal back to where light area of body begins, covering basal two-thirds of spinous dorsal, where it contains, over the first three spines, a horizontal, elongate, black streak; anteriorly the distal part of spinous dorsal clear except for margin; posteriorly this dark margin becomes wider until it melts into lower dusky band; soft dorsal with a dusky marginal band, but remainder of fin clear except for basal pigment anteriorly and a little pigment along each ray; in smaller specimens the dusky basal band extends to end of soft dorsal; anal fin with a fine clear band mesially, on anterior rays, which broadens posteriorly to cover base and more than half of fin; rest of fin, including whole distal edge, dusky except for fleshy pads on tips of rays, which are lighter; caudal entirely pale; pectoral rays dark, especially lower ones, but membranes clear and light; pelvics dusky, but lighter than body next to them; eyes almost black, as are the nasal cirri. Female: Same as male except light posterior part of body continued to part of caudal peduncle, more of anal dusky, and there is some pigment on the distal two-thirds of middle of caudal.

Remarks.—While the description of *bicolor* by Day is brief and the fin counts contain either none of the spines, or not all of them, there is no question but that he was dealing with this well-marked species, as is true of the specimens described by Johnstone as *S. furcatus* and Hora and Mukerji as *S. burmanicus*.

The series of specimens described as *S. melanosoma* from Christmas Island might be considered as being subspecifically distinct from the above, for all these specimens have 18 soft rays in the anal (all the New Hebrides specimens have 19 or 20 soft anal rays), the upper and lower caudal rays either do not project, or project less than one-fourth the length of middle caudal rays, and the color is a uniform rich brown, scarcely lighter below than above. However, of the three specimens from Ponape one had 18 soft anal rays and the other two had 19, and there is no clearly distinguished color break posteriorly. One has the caudal rays extended by the length of the middle caudal rays, the other two by less than one-third the length of the middle caudal rays. There is no dependable evidence in this group of subspeciation.

The specimen from Timor is identical with the New Hebrides specimens except that it has only 18 soft anal rays. Coloration well marked.

Ecsenius namiyei is doubtless the Formosan cognate of this species, marked particularly by the greater number of dorsal and anal rays, and the uniform coloration of the body.

Escenius frontalis is very likely the Red Sea cognate of this species, well marked, however, by the single nasal cirrus and the 15 pectoral rays.

ECSENIUS NAMIYEI (Jordan and Evermann)

FIGURE 95

Salarias namiyei JORDAN and EVERMANN, Proc, U. S. Nat. Mus., vol. 25, p. 362, fig. 25, 1902 (type locality, Pescadores Islands).

Specimens.—None seen; description from Jordan and Evermann.

Description.—Dorsal rays XII,20(?); anal II,21; pectoral 13; pelvic I,3 (?).

A pair of tentacles on nasal pore, the longest no longer than diameter of pupil; forehead vertical, the orbits reaching the dorsal but not

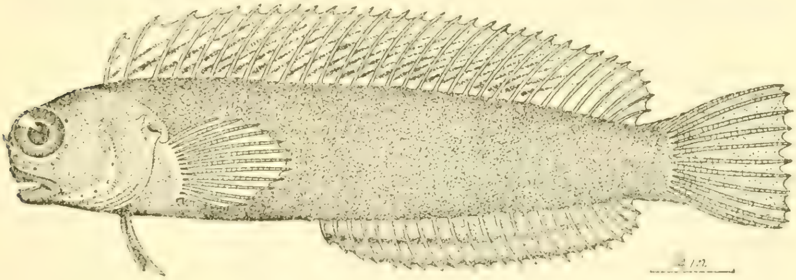

FIGURE 95.—*Ecsenius namiyei* (Jordan and Evermann). Holotype. (Drawn by A. H. Baldwin.)

anterior profile of head; depth 4.5, head 4.5, both in standard length; dorsal rays all about the same height except for last three rays, no trace of notch; membrane from last dorsal and anal rays free from first caudal rays; caudal with 12 principal rays, none branched, truncate behind; pectoral shorter than head by snout and half the eye diameter; pelvics two-thirds postorbital length of head.

Coloration.—Body purplish red, paler posteriorly; dorsal fin with narrow oblique darker markings; anal darker along margin, with a similar median band.

Remarks.—This is undoubtedly the Formosan cognate of *E. bicolor*. The three more rays in dorsal, one more in anal, and the oblique markings of the dorsal prevent synonymizing it with *bicolor* in the absence of a series of specimens for comparison.

ECSENIUS HAWAIIENSIS, new species

FIGURE 96

Holotype.—U.S.N.M. No. 112293, Oahu Island, Pearl Harbor, from a drydock, "hauled from Guam about a year ago and left standing," April 1950, collected by Spencer Tinker, standard length 66 mm.

Paratypes.—U.S.N.M. No. 112294, taken with holotype and bearing same data, 12 specimens, 48 to 70 mm.

Description.—In addition to the counts recorded in table 1, the pelvics were always I,3; none of the caudal fin rays is branched.

Certain measurements were made on the holotype and two paratypes and these data are recorded in table 2.

TABLE 2.—*Measurements on certain species of* Ecsenius, *recorded in thousandths of the standard length*

Characters	*opsifrontalis*		*stigmatura*			*hawaiiensis*		
	Holotype	Paratype	Holotype	Paratypes		Holotype	Paratypes	
Standard length in mm	31.0	26.3	46.5	37	36.2	66	66.7	48
Head, tip of snout to front of upper lip	255	266	249	251	263	227	220	227
Total length of head	281	278	262	273	279	242	234	240
Greatest depth	197	209	215	224	248	207	202	217
Least depth of body	97	95	105	116	111	112	111	104
Postorbital length of head	181	182	178	184	180	165	157	161
Eye	77	80	69	81	83	59	68	71
Snout	74	76	67	73	72	77	73	67
Interorbital space (fleshy)	31	34	32	30	33	38	30	38
Length of posterior nasal cirrus	39	38	49	65	83	52	60	69
Longest fin ray:								
Dorsal spine	158	141	114	135	146	121	135	150
Dorsal soft ray	177	145	142	119	163	189	165	133
Anal	126	126	118	122	105	118	112	125
Pectoral	242	236	183	184	191	151	145	133
Pelvic	226	198	110	132	122	103	84	110
Caudal	232	240	221	249	265	313	331	202
Snout tip to anus	558	559	542	552	530	508	487	516
Snout tip to dorsal origin	258	285	236	257	248	212	210	219
Length of anal fin base	355	327	380	386	378	434	408	406

Head 4.0 to 4.2; greatest depth 4.5 to 4.8; longest pectoral ray 6.1 to 6.3; snout tip (upper lip) to anus 2.1; anal fin base 2.3 to 2.4; all in the standard length. Eye 3.5 to 4.0; snout 3.1 to 3.4; postorbital length of head 1.4 to 1.5; greatest depth of body 1.2 to 1.3; least depth of body 2.2 to 2.5; longest pectoral ray 1.5 to 1.6; longest dorsal spine 1.7 to 1.8; all in the length of head from tip of upper lip to rear of gill cover. Fleshy interorbital space 1.8 to 2.0 in eye.

No orbital cirrus; no nuchal cirrus; a single, simple nasal cirrus arises on upper edge of anterior nasal opening, and a shorter cirrus, sometimes bifid to base, arises on lower edge of nasal opening; snout profile with a notable backward slant from the vertical of about 15 degrees; edges of both lips smooth, lateral line running a dorsal course and ending opposite bases of last or next-to-last dorsal spines, about an eye diameter behind tip of pectoral fin; lateral line does not descend to middle of side; vertical line through dorsal origin passes a trifle in front of upper edge of gill opening; base of pectoral fin notably behind base of pelvics; last dorsal ray attached by membrane to dorsal edge of caudal peduncle, but not to base of caudal fin; anal origin opposite base of last dorsal spine; last anal ray attached by membrane to lower edge of caudal peduncle; pectoral fins reaching about two-thirds the way to anus; anal spines small, first embedded on females; posterior canine of lower jaw short but strong; teeth in upper jaw about 110, movable; those in lower jaw movable but firmer, in one specimen 38, the tooth farthest from the symphysis on each side enlarged; no vomerine teeth; posterior margin of caudal fin truncate on smallest

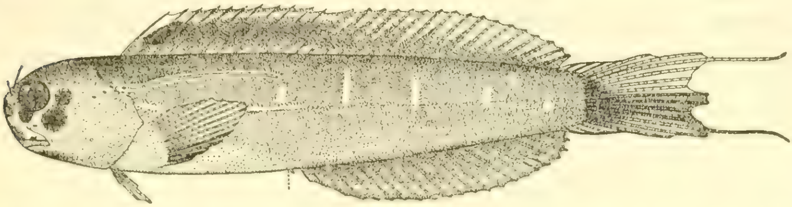

FIGURE 96.—*Ecsenius hawaiiensis*, new species. Holotype. (Drawn by Aime M. Awl.)

specimen, with an outer ray in each lobe slightly elongate, whereas in largest specimens the inner sixth or seventh caudal rays are shortest and of nearly equal length, the fourth and fifth from center of fin in upper caudal lobe are greatly elongate, and the third and fourth from center in lower lobe are greatly elongate, sometimes twice the length of shortest caudal fin ray; no cephalic crest; a vertical line through front edge of upper lip passes through front edge of eye; the forehead is a little in front of front edge of upper lip.

Coloration.—In alcohol, olive-brown to light greenish brown; darker dorsally, paler ventrally; the posterior part of body not notably paler than anterior part of body as is *E. bicolor;* middle of sides with five to seven short narrow vertical white bars not wider than pupil and about two to four times longer than wide, the lower edge of these bars a little below midlengthwise axis of body, then they continue dorsally, fading out gradually before reaching base of dorsal fin; pectoral, dorsal, and anal fins dusky; pelvics slightly dusky; caudal fin with outer rays white or nearly so, the middle rays dusky; behind eye is an obliquely oblong blackish blotch, margined with pale; a pale streak extends posteriorly from behind middle of eye a short distance; corner of mouth white or pale.

Remarks.—This new species belongs to the group of species centering around *E. bicolor* but differs from that species chiefly in coloration; *hawaiiensis* has short white bars on the midsides, whereas *bicolor* is plain brown without markings.

Doubt might be cast on the source of this material, "a dry dock hauled from Guam about a year ago," if with this new species (which did not occur in the extensive collections made in the Marshall and Marianas Islands by a group of collectors during and after the war) other species had not been taken as follows: *Scorpaenopsis cacopsis* (known only from the Hawaiian Islands), *Cirrhitichthys aprinus*, a specimen of *Apogon*, several specimens of gobies not yet identified, 2 specimens of an unidentified species of *Acanthurus* in the settling stage of late metamorphosis, specimens of *Pseudochromis tapeinosoma* and *Tripterygion hemimelas* (common to the Marshall, Marianas, and Hawaiian Islands) having about one more scale on the average than those from the Marshall and Marianas Islands, and *Gymnothorax undulatus* (common to all three named localities). We conclude that the fishes in this collection are endemic to the Hawaiian Islands and were not transported in the drydock brought from Guam.

U. S. GOVERNMENT PRINTING OFFICE: 1952

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(New genera, species, etc., are printed in *italics*)

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