PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY

OF

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FOR THE PROMOTION OF ZOOLOGY AND OTHER BRANCHES OF NATURAL HISTORY.

VOL. XVIII.

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PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXXXIX.

I.—Presidential Address, 1909.

(Read 25th October 1909. Received 31st December 1909.)

I. Remarks upon Certain Points connected with Evolutionary Theory.

It is inevitable that a Presidential Address to any Biological Society at this time must allude to the great anniversaries which this year marks—the one-hundredth anniversary of the birth of Charles Darwin, and the fiftieth of the publication of the *Origin of Species.*

The occasion has been marked by celebrations all over the civilised world, and the greatest of these celebrations, that at Cambridge, was one which will never be forgotten by anyone who was privileged to take part in it. Probably never in the history of human knowledge has there been gathered together such an assemblage to do honour to the memory of any one purely intellectual worker.

It is not my intention to devote this address to an estimate or an appreciation of the effect which Darwin's work has had upon the development of the Biological sciences; this has been done already by heads and hands more skilled than mine—notably in the volume published recently at Cambridge.[1] But there are one or two points in connection with Darwin's field of work to which it seems necessary to devote a few words.

At the present time as at any time since the publication of the *Origin*, the great task before the philosophical zoologist is the further working out of the Evolution problem. For continued successful attack on this problem it is above all things necessary to bring to bear upon it the different weapons afforded by research in the various departments of Zoology. In mapping out the path of evolutionary change, Palæontology, Embryology, and Comparative Anatomy must each play its part, and with Comparative Anatomy

[1] *Darwin and Modern Science.* Edited by A. C. Seward. Cambridge, 1909.

I include those parts of the subject which are the special domain of the systematist,[1] and regarding which all deference must be paid to his special knowledge. The opinion of the systematist is of the greatest possible weight in regard to the relatively minute and often obscure differences which go, some of them, to constitute generic and specific differences, others to form individual variations.

It will probably be generally admitted that instability—whether it finds its expression in the ceaseless processes of change which are grouped together under the term Metabolism, or in the processes which make every living individual differ to some extent from every other living organism—is an inherent characteristic of living substance; is, indeed, one of those qualities which go together to make up what we call Life. If this be admitted, it is clear that this instability must form the basis of evolutionary change, and that the actual causes of Evolution are to be sought for amongst factors which will favour the departures from the "normal" occurring in certain definite directions, and will thus bring about the relative concentration of variations in these particular directions, so that by their aggregation a process of evolutionary change will be brought about.

Variability Essential to Survival.

It should be accentuated that mere variability—*i.e.*, the tendency to vary indiscriminately in different directions—is of the first importance to the survival of strains of organisms. Nothing probably is more certainly fatal to a species than the loss of its variability. A species proceeding along the evolutionary path is as certainly doomed by the loss of its variability as is a moving bicycle with its front wheel clamped so that it can not deviate either to the right or to the left. If we could study the environment of a strain of organisms through a prolonged period of evolutionary time, we should find that the environmental conditions show constant slight fluctuations, some of them consisting of climatic or other physical changes, others of changes in organic environment. To each of these the ever mobile species adapts itself, and upon the faculty of so doing its continued existence depends.

[1] I use the word in its ordinary sense. Strictly speaking the systematist is a morphologist, and the morphologist is a systematist. Both have as one of their main objects the working out of a perfect genetic classification of the animal kingdom. The different methods of investigation necessitated by the more deeply-seated features characteristic of the main groups on the one hand, and by the more superficial and often minute features characteristic of the subsidiary groups such as genera and species on the other, has not unnaturally resulted in practice into the division of workers along these lines into two separate groups.

Heredity, it must be admitted, acts on the whole as an anti-evolutionary factor; it tends on the whole to keep the organism like its immediately preceding ancestors. The factors that guide the progress of Evolution must then lie outside the organism.[1]

While the mapping out of the path along which evolutionary progress has taken place is the special work of the morphologist, the investigation of these various factors which bring about progress along that path lies rather with the physiologist, by which term I mean the investigator of living things in relation with environmental conditions. The environmental conditions afford an all-important part of the field of inquiry. To endeavour to investigate Evolution scientifically without at every step taking these conditions into account, is a task of the same order as would be an investigation of gravitation in which account was taken of the masses of the attracting bodies while the distances between them were ignored. The mere laboratory, or garden, or museum worker, may give valuable aid to the study of Evolution by adding to our detailed knowledge of the phenomena of variation, but he cannot get near the main question, that of the factors which are at work stimulating and guiding evolutionary change. This problem lies before the physiologist in the broad sense of the term. It is observers of this type which are above all things wanted at the present time—highly skilled and highly trained field naturalists who will devote their lives to the study of organisms in their natural environment.

We have at present before us one and only one purely scientific theory of the rôle of environment in relation to evolutionary change. By "purely scientific," I mean a theory which is merely an expression of known fact, a theory which does not involve the assumption of any factor the existence of which has not been demonstrated. The theory in question is of course the

[1] There is from the philosophical point of view nothing objectionable in the assumption of an inherent tendency in living substance to evolve along definite lines. The philosopher, in speculating upon the evolution of the Universe as a whole (including in the expression Universe the sum of all existence), is indeed driven to an assumption of this kind, as it is clear that the Universe must have contained within itself from the beginning the potentialities of all the developments which have subsequently become apparent. What is a logical necessity when indulging in speculations upon the evolution of the Universe as a whole ceases to be so when we deal with only a part of it, such as, *e.g.*, the world of living beings. There is now—in addition to the existences whose evolution we are studying—an *environment*, and as scientific investigators we are bound to restrict ourselves to the scientific method, and inquire whether the explanation of evolutionary progress can not be found in the inter-relationships of organisms and environment without having recourse to the transcendental which lies outside the limits of Science. Such a principle as that of "Orthogenesis" (in Nägeli's sense) is inadmissible not because it is necessarily wrong, but because it lies outside the boundaries of Science.

theory of Natural Selection. This theory is the expression of the following facts:—

(1) The fact of the variability of organisms;
(2) The fact that organisms by their multiplication tend to increase beyond the numbers which the conditioning factors allow to exist;
(3) The fact that the numbers are kept within the necessary limits by death rate;
(4) The fact that death rate is necessarily selective—the more fit tending to live longer and leave more descendants;
(5) The fact that such a selective death rate *must* necessarily involve, when acting for prolonged periods, evolutionary progress of the race in the direction of greater fitness—or better adaptation to environment.

These are fundamental facts which have to be admitted whatever be one's view as to the potency of Natural Selection.

The only aspect of Natural Selection open to question has to do with the *rate* at which it produces evolutionary change: whether it is rapid enough in its action to account for any considerable part of the evolutionary change which has taken place in the organic world. In our present state of ignorance, both as regards the rate of change which may be produced by Natural Selection,[1] and as regards geological time,[2] it is clear that we are not in a position to discuss this question with profit.

In Natural Selection, then, we have a factor which is necessarily producing evolutionary change. Few will doubt any more than Darwin himself doubted that there are other factors at work. That Natural Selection is a very potent factor is indicated by the wide-spread phenomena of adaptation. A good deal is already known about such phenomena, but I think many, particularly such as have spent some time observing Nature in wild parts of the Tropics,

[1] It is clear that in a large proportion of the animals in which the sexes are separate, the loss of a female individual is of much greater importance to the species than the loss of a male. It follows of necessity that Natural Selection will produce evolutionary change more rapidly in secondary sexual characters of the female than in those of the male: or in a given period of time Natural Selection will produce a greater extent of evolutionary change in such characters of the female than in those of the male. Consequently where such characters are adaptive they will, on the whole, be more perfectly adaptive in the female than in the male. This principle is well brought out in cases of mimicry in Butterflies, where indeed "the female is often alone mimetic" (Poulton). The same principle apparently also holds in regard to the greater variability of the female in certain groups of Butterflies (Poulton)—mere variability being, as already indicated, a character of the utmost importance for the persistence of the species.

[2] The recent discovery of Radium has afforded a good example of the kind of disturbing factors of which there may exist any number still unknown, which must necessarily render absolutely unreliable all calculations regarding geological time.

will agree with me that we are as yet merely on the fringe of the subject, and that the phenomena of adaptation pervades living nature to an extent undreamt of by the majority of naturalists.

In any case, I think that it is quite clear that what we need at present is not expressions of academic opinion in regard to Natural Selection, Adaptation, and so on, but, rather, prolonged study by skilled observers of animals living under natural environment, with the special object of critical investigation of—(1) the phenomena of adaptation and selection; and (2) other factors which may co-operate with Natural Selection in bringing about evolutionary change.

A Darwin Institute.

We have had during the past year many celebrations of the memory of Darwin, but I have seen no suggestion anywhere of the kind of memorial which I should like to see associated with his name. What would, I think, be the memorial most worthy of him would be the foundation of a great research organisation, which would have for its object the pushing forward of investigations into the struggle for existence and the phenomena associated with it in wild Nature. It would be out of place to express anything other than admiration for the patient researches into certain aspects of evolutionary phenomena which are being so actively carried on at the present time. But from the Darwinian point of view many of them are beside the point, and many of the conclusions based upon them are quite unwarranted. Take the case of suddenly arising variations of considerable magnitude for example. It seems absurd to refuse to admit that such "mutations" occur at least occasionally in Nature. But there are doubtless many who, like myself, believe that every race of organisms is, as regards the whole of its complex organisation and functions, in a state of the most delicately poised equilibrium with its highly complex environment, and that it is absolutely dependent for its continued existence on the maintenance of this equilibrium. This being so, we believe that as a general rule any wide variation from the normal would involve a disturbance of the condition of equilibrium, and this would in turn bring about the extermination of the strain of individuals showing such a variation. While therefore readily admitting the possibility of the ever frequent occurrence of such "mutations" in Nature, we should feel inclined to be sceptical as to their playing as a rule any important part in Evolution.

What then we want is an investigation of living things under strictly natural conditions—a highly organised and thoroughly scientific field Natural History. It is obvious that, as in all investigation of Natural Phenomena, our first aim should be to investigate the phenomena under the most favourable conditions. It is further obvious that, as the primary object of investigation is the struggle for existence with its correlated phenomena, the natural conditions to which attention should be directed are those under which life is most luxuriant. This suggests that our field of operations should be the Tropics. It should, further, deal with terrestrial rather than marine life, for the obvious reason that we are so greatly handicapped in our means of observation of marine organisms under their natural conditions.

What is needed then is an organisation which will make it possible for able young Biological observers with a sound preliminary training to devote a number of years to the accumulation not indeed of facts *for* Darwin, but of facts bearing upon Darwinian theories. It would be necessary for each observer to remain a number of years in the field. Any organisation which simply enabled promising young University graduates to spend a year in the Tropics would do harm rather than good to the object in view, for as is well known to anyone who has worked in the Tropics at least a year is consumed in the necessary preliminary work of getting a general idea of the local fauna and local conditions, and in learning to observe under the new and unfamiliar circumstances. Most workers who have had occasion to spend two or three years in Biological work in the Tropics will probably have realised how imperfect and indeed erroneous their observations are apt to be during a more or less prolonged probationary period, owing partly to their untrained powers of observing under new and unfamiliar conditions, and perhaps still more to their tendency to interpret the observations according to academic teaching. The first year or more then of such workers should be devoted simply to training themselves how to observe; the really valuable results would come later on. It is perhaps too much to hope that some beneficent millionaire will build such a monument to Darwin's memory as an institute upon these lines, but should he do so there can be no question as to the magnificent results that will accrue to Evolutionary Science.

Mendelism.

The Natural Selectionist has received during the past few years a welcome reinforcement through the rediscovery of the experimental results obtained by Mendel. It looks as if Mendelian segregation were probably a general character of inheritance. It seems improbable that the principle should hold for certain characters and not for all. Apparent exceptions, such as the case of Mulattos, will probably find a Mendelian explanation later. While admitting the fact of Mendelian inheritance, I do not find so far any reason to depart from the view which I have consistently held since the republication of Mendel's paper, viz., that the main importance of his discoveries lie—(1)

in their helping to do away with the intercrossing bogey in regard to Natural Selection; and (2) in their remarkable support which they appear to give to the idea of localisation of hereditary characters within the gametic chromatin as suggested long ago by Weismann.

Superficiality of Biological Knowledge.

I should like to accentuate the necessity of constantly bearing in mind how extraordinarily superficial our knowledge is of many of the characters of animals that we study. If we compare say a mammal from which a particular organ has been removed by operation early in life, with another of the same species in which there is congenital absence of the same organ, our first impression is that the two individuals are alike, and we are struck with surprise that the absence of the organ is inherited in the one case and not in the other. As a matter of fact there is a profound difference between the individuals. The congenital absence or presence of an organ is a superficial symptom of a profound difference in the constitution of the animal. When we remove the organ by operation, we remove only that superficial character without touching the extreme complexities of constitution of which its presence is the expression. Can we wonder then that the deep-seated characters are inherited and the superficial not? It appears to me that the failure so far to substantiate the inheritance of acquired characters may be due simply to the superficiality of the characters which have been specially investigated. If this be so, then what we have to do is to cause characters to be acquired in response to some induced change in constitution, and we may well expect such to be inherited.

Classification of Variations.

Variations are obviously to a certain extent reactions to environmental conditions—such are "acquired" characters, *e.g.*, the variations which are brought about by causing zygotes of the same ancestry to develop under different sets of environmental conditions. It seems, by the way, remarkable how comparatively little attention has been paid to this field of investigation. Surely one of the first essentials in a scientific investigation of variation is to endeavour to get our notions clearer as to the relative importance of such characters in building up the complex of features characteristic of the individual. Behind this problem of the effect of external conditions upon the zygote or individual, lies the still more important problem of the effects of such conditions upon the gametes—or better gonad—during the period before the occurrence of the karyogamous formation of the zygote.

I cannot help feeling that if we were able to get at them, we should find that the characters which exist in an invisible form in the gamete are—like those of the adult organism—a mixture of characters due to heredity with others due to environment. In other words, the gamete would be to a certain extent plastic, just as is the individual later on.

Taking this standpoint, the characters of animals would fall into the following categories:—

A. Inherited—

(1) Ancestral; gametic; præ-conjugational.

(2) Amphimixis; conjugational.

B. Environmental—

(3) Præ-conjugational (*i.e.*, produced by the action of environmental conditions upon the gametes).

(4) Conjugational.

(5) Post-conjugational (*i.e.*, produced by the action of environmental conditions upon the zygote).

Apparently new characters—*i.e.*, variations—might obviously belong to any of these categories, except the first. As is well known, Weismann has suggested that those included under (2) are of great importance in Evolution, while he has done the great service of demonstrating how insufficient is the evidence that those included under (5)—"acquired characters" in the ordinary sense—play any part at all in Evolution. As a matter of fact, we cannot be said to have any proof that such characters as would be included in (2) and (4) actually exist in Nature. As regards class (3) our knowledge is still in its infancy, but recent and contemporary work indicates with no uncertain accent that it is there where the causes of the variations which form the basis for evolutionary change are to be sought:[1] it is in fact during the periods before conjugation that the elements of the gonad have impressed upon them these constitutional changes which find their expression in the zygote, and in the individual which develops from it, as variations which tend to be inherited by future generations. No doubt the chief environmental impulses acting upon the cells of the gonad, are those which come to them from changes in the metabolism of the parental tissue in which they are developing; these changes in metabolism being in turn due, some of them, to internal processes in the organism, others to direct influences received from the outer world.

[1] See, *e.g.*, Tower's beautiful paper, "An Investigation of Evolution in Chrysomelid Beetles of the genus *Leptinotarsa*." Carnegie Institute, Washington, 1906.

Agar also finds, in the case of *Simocephalus*, that the gonad may be influenced by certain external conditions in such a way as to produce eggs which develop into abnormal individuals. The production of such abnormal individuals continues for some time after the removal of the exciting cause.

In such a classification of characters, there is nothing to correspond with de Vries' division of variations into mutations—those fortuitous variations which alone, according to de Vries, play a part in Evolution—and fluctuations, or ordinary variations, which do not play any part in Evolution, for it does not appear to me that the existence of any such fundamental distinction has been demonstrated, or even rendered probable.

De Vries adduces evidence to show that artificial selection is unable to accumulate certain variations (fluctuations) beyond a certain limit, and argues that Natural Selection would be equally impotent. He also points out that when the artificial selection is stopped, the organisms soon show regression to their previous state—no permanent change having been brought about by the artificial selection.

To this it must be remarked,[1] that in reasoning from the data afforded by artificial selection, it has to be borne in mind that artificial selection selects definite isolated characters—the result being a thoroughly abnormal race of individuals—in which, by the exaggeration of the selected features, the normal physiological balance of parts in the organism has been disturbed. When Nature selects, on the other hand, she has the whole organisation of the creature firmly in her grip the whole time. The individuals are of necessity physiological, not pathological,[2] and there is no obvious reason why under those conditions there should be any limit to her power of producing change.

When artificial selection ceases there is a regression towards the original condition—in other words, a return towards the physiological from the pathological, which is surely not surprising when one considers the immense weight of hereditary tendency on its side. Unlike artificial selection, Natural Selection does not cease; organisms are kept in Nature's merciless clutch the whole time, and there is therefore no regression.

The Conception of Units in Biology.

I confess that my suspicions are at once aroused by all investigations which deal with isolated "individual" characters apart from the general organisation of the animal. There is an insatiable desire in the human mind to resolve a complex into the simple units of which it is built up, and it is of course to the carrying out of this that we owe the triumphs of the analytical method in the most varied departments of Science. In regard to living substance, it seems a very natural idea that it is built up of ultimate units.

[1] Poulton expresses the same criticism in his *Darwin and the Origin*, p. 279.

[2] No weight can be attached to the experimental failure to increase the quantity of sugar in the cells of the sugar beet beyond a certain limit. Even sugar is a poison if in sufficient quantity.

Just as with the molecules or atoms of non-living substances, so we may say of living substance that it is theoretically possible to go on subdividing it into smaller and smaller pieces, each of which shall still be living, but that eventually a limit must be reached below which the distinctive features of living substance disappear. There thus naturally arises the idea of an ultimate unit of living substance such as has been employed by Nägeli, Darwin, Weismann, and others. It seems to me extremely doubtful whether the actual existence of such units is at all a necessary assumption. I see no special difficulty in believing that living substance is *not* built up of units. But whether or not this idea of ultimate living units is a sound one, I think it must be confessed that similar conceptions have done considerable harm. Such harmful influence has become apparent in recent years as regards the cell theory. It is also, I think, apparent in the tendency shown by many writers still to regard the organism as an aggregate of organs, rather than as an organism in which organs are more or less distinctly differentiated. The fallacious reasoning which this involves is often seen to intrude itself into discussions on Natural Selection. *E.g.*, if a special species of animal is characterised by marked elongation of some particular organ, it is asked : " How can this have arisen by Natural Selection ? It is surely impossible to believe that stray variations of very minute magnitude can have really been of any marked advantage in the struggle for existence." What really leads to survival is not however the possession of a favourable variation in some one particular organ, but "general fitness" of the organism as a whole, which is a far more complicated thing.

In, *e.g.*, a complex Metazoan, such as a bird or a mammal, variability affects probably every bit of every tissue in the body. No bit of any tissue is absolutely normal. Everything varies slightly. And the comparatively fit individual, the individual which is selected in the evolutionary progress towards more and more perfect adaptation, is the individual in which the sum of the variations in all its varying parts is comparatively favourable. Very small variations in individual organs, trivial enough in themselves, yet go to build up the general fitness which plays a part in Evolution.

While acknowledging the vast debt which Zoology owes to the method which breaks up the organism into its constituent parts for the purpose of investigation, and while recognising the immense stimulus to research afforded by such fascinating working hypotheses as the Cell doctrine, the Neuron doctrine, the doctrine of Pangens, we must ever bear in mind that such doctrines are working hypotheses and nothing more, which, so long as they are recognised as such, may be of great service to Science before they are finally relegated to the scrap heap, but which may on the other hand form formidable barriers in the way of progress when they become elevated in the worker's mind to the level of scientific theory.

II. The Development of the Peripheral Nerves of Vertebrates.

The problem of the mode of development of the peripheral nerves of the Vertebrate is one of great interest and importance, not merely to the embryologist, but also to the morphologist, the physiologist, and the pathologist. It has for long been the subject of controversy, and quite recently it has attracted much attention owing to the appearance of a number of important publications upon the subject, amongst which I need only mention those of Harrison[1] and Held.[2]

In making the endeavour to arrive at a true solution of this or any similar problem of histogenesis, an all important preliminary is to select the most favourable available material for investigation. To choose unsuitable material is to run the risks of becoming lost amidst the details of observations, of being led astray, and of failing completely to reach the goal. I think that most morphologists will admit that there are two chief criteria to be employed in deciding upon suitable material.

(1) The animals should belong to the lower or more primitive groups of the gnathostomes, for upon the whole an animal which retains primitive characters in the adult state is more likely to retain relatively primitive characters in the earlier stages of development. In other words, the mode of development of its various organs is, on the whole, less likely to be obscured by secondary modifications.

(2) The animal selected should be one with a histological texture as coarse as possible; the cell elements composing its tissues should be of large size.

The groups of the Gnathostomata which are generally regarded as the most primitive are the Elasmobranchs, the Crossopterygians, and the Lung-fishes, and amongst these there is one, and so far as is known only one, form—*Lepidosiren*—which is characterised by the remarkable coarseness of its histological texture, and by the great size of its cell elements. On this account it must be admitted that *Lepidosiren* is an extraordinary favourable object upon which to tackle any such problem as that under consideration. I therefore feel justified in accentuating the points made by the study of its development.[3]

[1] Harrison, "Embryonic Transplantation and Development of the Nervous System," *Anat. Record,* ii., Dec. 1908.

[2] Held, *Die Entwicklung des Nervengewebes bei den Wirbeltieren*, Leipzig, 1908.

[3] *C.f.* Graham Kerr, *Trans. Roy. Soc. Edin.*, xli., 1904, p. 119; and *Proc. Roy. Physical Soc. Edin.*, xvi., 1906, p. 206.

(1) The motor nerve trunk is already present as a protoplasmic bridge placing spinal cord and myotome in organic continuity at a period so early that these two structures are still in immediate contact. It is clear that this fact, and similar observations have been made by Stewart Paton[1] on Elasmobranchs, places completely out of court, for these particular cases, the view taught by His of the free outgrowth of nerve fibres. Here a protoplasmic nerve trunk is present long before nerve fibres have made

Fig. 1.

Part of transverse section through *Lepidosiren* larva of stage 24, showing motor nerve trunk (*n.*) in the form of a thin protoplasmic bridge connecting spinal cord (*s.c.*) and myotome (*m.*).

their appearance. Of course there is no proof that the protoplasmic bridge has not itself been formed by outgrowth, but on the other hand there is no justification for assuming that it has been. Observation merely testifies that the connection is there from the very early period mentioned.

(2) The protoplasmic nerve trunk, at first merely granular, gradually assumes a fibrillated structure.

[1] *Mitt. Zool. Sta.* Naples, vol. xi., 1907.

FIG. 2.—Similar section to that shown in Fig. 1, but stage 25.
The nerve trunk has increased much in size, and fibrillation is beginning to appear.

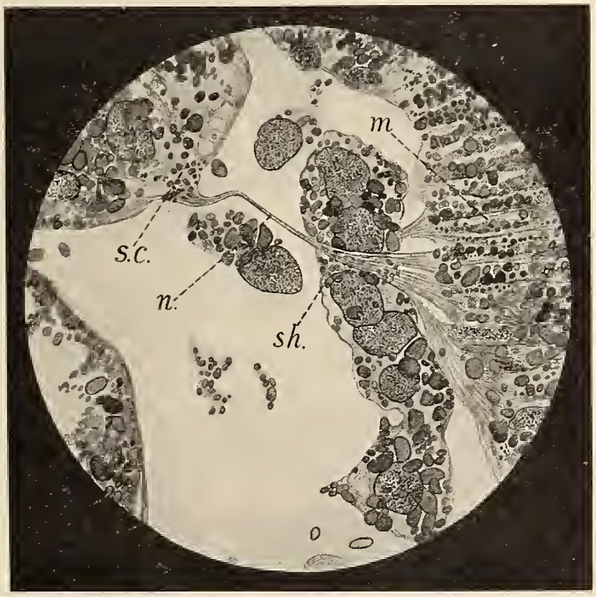

FIG. 3.—Similar section ; stage 27.

The nerve trunk is now elongated : it is naked towards its central end ; non-nucleated ; distally it is for some distance surrounded by heavily yolked sheath-mesenchyme ; its peripheral end is now broken up into a fanlike arrangement which in places can be seen to be continuous with the protoplasm of the myoblasts.

m., Myotome : *n.*, Nerve ; *s.c.*, Spinal cord : *sh.*, Sheath.

(3) The at-first naked and non-nucleated nerve trunk acquires a sheath, the heavily yolked nature of whose protoplasm demonstrates it to be of mesenchymatous origin. This sheath also first appears round the nerve trunk peripherally, so that a central origin by emigration from the spinal cord is absolutely excluded.

Fig. 4.

Similar section ; stage 29 + .

The heavily yolked protoplasm has now spread itself out along the course of the nerve trunk so as to form a definite though still very thick sheath. In later stages of development the yolk is gradually used up and the sheath protoplasm is reduced to a thin layer.

n., Nerve trunk ; *sh.*, Sheath.

The observations summarised may, I think, be taken as definitely established, the phenomena described being relatively plain and distinct in *Lepidosiren*. Here, for example, there is no room for doubt regarding the mesenchymatous origin of the protoplasmic sheath, whereas in such forms as Elasmobranchs, where it possesses no conspicuous histological characters, the appearances seen in sections may be interpreted, according to the standpoint of the observer, in totally different fashions.

If these observations are correct, it must be admitted to be probable either that (1) they illustrate the fundamental features of nerve development of the Vertebrata ; or that (2) *Lepidosiren* developes its motor nerve trunks and their sheaths in a manner of its own. No zoologist needs to be told that all the probability lies on the side of such a process as the development of the main nerve trunks taking place in a manner fundamentally the same throughout the Vertebrata. We should naturally expect there to be *apparent* differences, some of them due simply to the greater difficulties of observation upon small-celled types, others real, due to superficial modification of the general type.

I am therefore inclined to believe that the phenomena of nerve development which I have described in *Lepidosiren* represents the type of nerve development which is fundamentally characteristic of Vertebrates. As regards the ultimate conducting or neuro-fibrils, I see no reason to depart from the view expressed in previous papers, that it is most profitable to regard these structures from the physiological standpoint, to look upon them as tracts of living substance highly specialised for the carrying out of the special function of nerve, viz., the conduction of impulses, and that their specialisation in structure is correlated with the repeated passages of impulses along them. It is probably one of the most characteristic features of all individualised living substance that there is a ceaseless flitting backwards and forwards of impulses within it. It is these which play a great part in giving the organism its individuality. As the organisation of the organism proceeds, and as the control of the general living processes becomes concentrated in different centres, these impulses, at first vague in their directions become accentuated along definite pathways or nerves. And finally, each particular impulse, as it is repeated over and over again between its central cell and its end cell, sensory or motor, beats out as it were its own special pathway, which we term a neuro-fibril. Continuing on the rough analogy of a pathway, we should expect the pathway to become first of all distinct in the neighbourhood of the centre from or to which impulses are passing most frequently—just as a pathway made by men or by leaf-cutting ants may be observed to fade away and become less distinct when traced some distance from the site of the central community. On this view, associating all the characters of the neuro-fibril with its functional activity, we should include these otherwise unknown characters which find their expression in specific staining reactions. And we should therefore expect that in studying the development of nerves by special neuro-fibril staining methods, we should constantly find fibrils with apparently free ends, for it would only be that part of the fibril which had assumed its definitive characters which would take the stain, and so be rendered visible. It is, of course, known to all that such appearances are frequent. They are well shown in the plates of Held's beautiful monograph. A feature to be specially noticed is the frequency with which such "freely ending" fibrils have an expanded (*cône d'accroissement*) or almost "frayed-out" appearance at the end, recalling exactly the appearance of a pathway as it fades away in the region where traffic becomes no longer definitely localised in it. The point which I wish to make is that the occurrence of such apparently freely ending neuro-fibrils must by no means be taken, as they are commonly taken, as demonstrating that a neuro-fibril extends outwards by its own growth activity; they are at least equally well explained by the hypothesis that the fibril gradually takes form—commencing at the ends from which impulses start, or towards which they go—in the substance of an originally protoplasmic matrix.

Some of the most fascinating recent work upon the development of the nerves of Vertebrates has been upon the experimental lines used first by Born, and elaborated by Spemann and others. Amongst such work there is deservedly none which has attracted more attention than that of Harrison.

During the last few months he has published an account of some beautiful experiments which call for special notice, as they have been taken as demonstrating once for all the truth of the His or outgrowth theory of nerve development. Their author himself says of his observations that they "show beyond question that the nerve fibre begins as an outflow of hyaline protoplasm from cells situated within the central nervous system. This protoplasm is very actively amœboid, and as a result of this activity it extends farther and farther from its cell of origin. Retaining its pseudopodia at its distal end the protoplasm is drawn out into a thread, which becomes the axis cylinder of a nerve fibre." "We have in the foregoing a positive proof of the hypothesis first put forward by Ramon y Cajal and von Lenhossék." "The experiments now place the outgrowth theory of His upon the firmest possible basis—that of direct observation. The attractive idea of Hensen must be abandoned as untenable. The embryological basis of the neurone concept thus becomes more firmly established than ever." The reviewer of Harrison's paper, in *Nature*,[1] says: "Such observations show beyond question that the nerve fibre develops by the overflowing of protoplasm from the central cells," and that the author "has demonstrated the correctness of the views of His."

It is clearly then necessary to cast a cold and critical glance upon these experiments of Harrison's, and to inquire whether they really have the finality which is claimed for them.

Harrison removed small pieces of tissue from a living frog embryo, and

[1] 13th May 1909.

found that with proper precautions he could keep these fragments living in clotted frog's lymph, on a hollow slide under a coverslip, for a period of weeks on end. Now when fragments of embryonic spinal cord were observed in this way, it was found that after a day or two of cultivation a considerable number of nerve rudiments were seen extending out from the piece of spinal cord into the clotted lymph in which it was embedded. The free end of the nerve rudiment projected into irregular tags of protoplasm, which showed active amœboid movements. Measurements of individual rudiments at short intervals showed marked increase in length—as much as 20 μ in twenty-five minutes. These are the essential observations upon which Harrison's conclusions are based.

Now the question at once suggests itself: Has Harrison excluded the possibility that his excised fragments of embryonic spinal cord included the short nerve trunk rudiments, like those figured in my Figs. 1 and 2? He naturally has not. Such rudiments have only been observed in sections of particularly favourable material, fixed and stained with great care, and their detection amongst a mass of heavily yolked living cells would be a practical impossibility. Granting that such nerve rudiments were present in the excised fragments, as in all probability they were, what do the experiments prove? Simply that the young nerve grows in length—which is, of course, a self-evident fact, quite independent of any particular theory. For the demonstration of the truth of His' theory, what is needed is not a proof of this well-known fact, but a demonstration that the young nerve shows a *differential* rate of growth greater than that of the tissues amongst which it is normally situated, so that its free end moves through or between these tissues until it reaches its definite end organ.

These short remarks are sufficient to indicate that, in my opinion, Harrison's experiments, beautiful and interesting as they are, do not by any means necessarily have the finality that has been attributed to them.[1]

Myoepithelial Cells in Vertebrates.

There is one other point in connection with the developing motor nerve trunks of *Lepidosiren* which I wish to accentuate, viz., that it is occasionally possible to demonstrate the fact that there is absolute continuity of substance between the nerve trunk and the myoblast or young muscle cell. The young muscle cell is, in fact, a myoepithelial cell with a protoplasmic nerve tail as

[1] Hensen (*Physiol. Verein Kiel.*, 18th Nov. 1907) somewhat caustically points out that Harrison must be thanked for such a striking demonstration that after all embryonic nerves can grow along a wrong path!

typical as any that we could find in a Cœlenterate or a Nematode. Such observations are of interest from two points of view.

(1) They accentuate the probability that it is wrong to think of the motor apparatus of the Vertebrate as built up of independent sets of units—nervous (neurons) and muscular. If the conception of units is made use of at all as a working hypothesis, the unit should be the complex consisting of central nerve cell, nerve fibre, and muscle cell, which we may appropriately term a *myoneuron*, such as is diagrammatically shown in Fig. 5. The

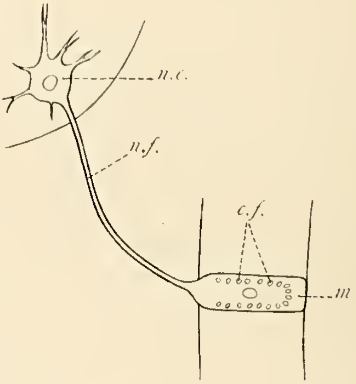

Fig. 5.

Primitive Myoneuron of a Vertebrate.
c.f. Contractile fibrils ;
m. Myoblast lying in myotome ;
n.c. Motor nerve cell in spinal cord ;
n.f. Motor nerve fibre.

motor end-plate of the fully-formed muscle fibre is of course the remnant of the protoplasmic body of the muscle cell—the part of that cell which has not become replaced by contractile elements.

(2) They fit in with the reference back of the nervous and muscular systems of the Vertebrate to an epithelial condition in a far back ancestral form. The data of Vertebrate embryology, when due weight is attached to the developmental phenomena of the lower groups, seem to me to indicate with as near certainty as we can hope for in such things, that the myotome of the typical Vertebrate have been developed from enterocœlic pouches of the type still persisting in the ontogeny of *Amphioxus*. The main muscles of the Vertebrate have then upon this view become evolved out of the epithelial walls of pouch-like outgrowths of the archenteric or cœlenteric wall.

Similarly in regard to the nervous system, all the probabilities seem to point to its having become evolved out of a subepithelial nerve plexus of the type which still persists in Cœlenterates, Echinoderms, etc. We may take it that this nerve plexus was not absolutely restricted to the ectoderm, it probably showed more or less extension under that part of the bounding epithelium which became invaginated to form the endoderm.

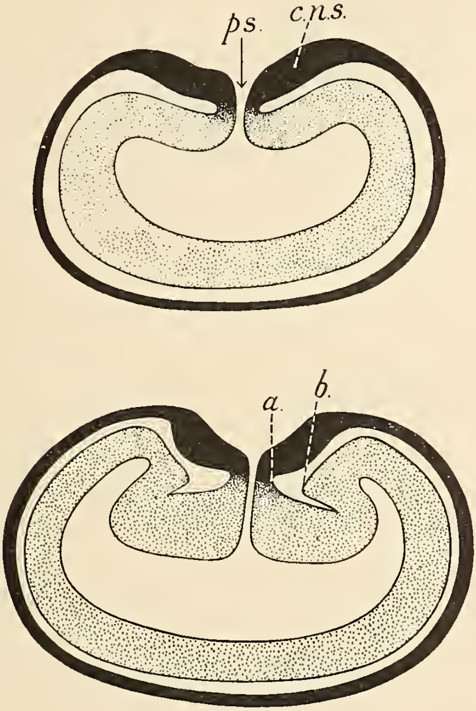

Fig. 6.

Diagrammatic transverse sections through primitive Metazoan organisms possessing a protostoma or primitive mouth (*p.s.*).

In each a concentration of nervous system (*c.n.s.*) is shown on each side of the protostoma.

In the lower figure, which represents a more advanced stage in Evolution, cœlenteric pouches are becoming marked off by the down growth of a chink or involution of the endoderm between the points *a* and *b*.

Now it is well known that in the ontogeny of various Vertebrates there exists in early stages of development continuity between the cell layers along the mid-dorsal line—a very puzzling phenomenon—the only plausible explanation of which so far suggested is, that this line of continuity is a vestige of a once present dorsally situated slit-like mouth or protostoma.

In Fig. 6, I show a diagrammatic transverse section through the body of such a hypothetical ancestral vertebrate with cœlenteric pouches and protostoma, and the point which I wish to bring out is that in such forms the part of the endoderm, which later forms the tip of the cœlenteric pouch, would be at first joined up to the central nervous system by a continuous and comparatively short extent of epithelium with its underlying nerve plexus. The motor nerve trunks of existing Vertebrates would represent localised thickenings of this plexus passing from central nervous system to each cœlenteric pouch. Here I am perhaps wandering into the realms of very "high morphology." I have ventured to do so because it has been urged to me by various friends, that there *must* have been originally a free growth outwards of nerve trunks from the primitive central nervous system to the myotomes which they supply.

(*Issued separately, 17th February* 1910.)

II.—Echinoidea and Asteroidea from the Mergui Archipelago and Moskos Islands, Lower Burma. By R. N. Rudmose Brown, D.Sc.

(Received 12th October 1909. Read 22nd November 1909.)

THE material which forms the subject of the present paper was collected by Mr James J. Simpson and myself, during our investigation of the pearl-oyster fisheries of the Mergui Archipelago on behalf of the Indian Government in 1907.

Previous to this, the only published record of Echinoids and Asteroids from the Mergui Archipelago was to be found in papers[1] by Prof. P. Martin Duncan and Mr W. P. Sladen, founded on material obtained by Dr John Anderson in 1882. From the Moskos Islands several species of Echinoderms are recorded by Dr A. R. S. Anderson in the Surgeon Naturalists Report for the season 1898-1899 (Report of the Marine Survey of India, 1899). The present collections would have been larger if time and opportunity had permitted, for the fauna of the Archipelago is clearly a rich one, but both Mr Simpson and myself had to concentrate all our attention on the pearl oysters and questions immediately relating to that subject: there was, in consequence, all too little time for general collecting. Some of the largest specimens, notably those of *Pentaceros superbus, P. lincki*, and *P. gracilis*, we could never hope to have obtained in perfect condition with a dredge; these we owe to our divers, whom we instructed to bring up anything they could find in addition to pearl and mother-of-pearl oysters. This is probably one of the first expeditions in which a diver has been employed to make zoological collections, and the success of the method, even more in other groups than in Echinoderms, should commend it to others.

My acknowledgments are due to Prof. F. Jeffrey Bell for his valuable opinion on certain species; to Prof. J. Arthur Thomson, who kindly gave me accommodation in his laboratory at Marischal College, Aberdeen; and to Dr W. S. Bruce, who was of great assistance to me in obtaining literature.

ECHINOIDEA.

The present collection contains fifteen species, none of which are new. Dr Anderson, in 1882, collected six species, two of which, *Temnopleurus toreumaticus* (Klein), Agass., and *Arachnoides placenta* (Linn.), Agass., are not represented in this collection. The total number of species of Echinoids known from the Mergui Archipelago is, therefore, seventeen.

[1] "Echinoidea of the Mergui Archipelago," by P. M. Duncan and W. P. Sladen, *Jour. Linn. Soc. London Zool.*, xxi. (1889), pp. 316-319. "Asteroidea," by W. P. Sladen, *loc. cit.*, pp. 319-331.

The fifteen Echinoids in the present collection are as follows:—

1. *Phyllacanthus baculosus* (Lam.), A. Ag.
2. *Diadema saxatile*, Linn.
3. *Echinothrix turcarum*, Ret.
4. *Astropyga radiata*, Gray.
5. *Asthenosoma Grubei*, A. Ag.
6. *Echinometra lucunter*, de Blainv.
7. *Salmacis bicolor*, Agass.
8. *Salmacis Dussumieri*, Agass.
9. *Salmacis sulcata*, Agass.
10. *Salmacis globator* (Bell).
11. *Mespilia globulus*, Agass.
12. *Laganum depressum*, Less.
13. *Laganum decagonale*, de Blainv.
14. *Laganum* sp.
15. *Lovenia subcarinata*, Gray.

The most noteworthy species in this collection are *Asthenosoma Grubei* and *Salmacis globator.*

A. Grubei, of interest in itself as a specimen of a little known species, has an additional claim to notice since its occurrence in the Mergui Archipelago extends to the Indian Ocean the range of a species that was previously known only from the Philippines and Dutch East Indies.

Salmacis globator has been recorded previously from Singapore and the Pacific, but never from the Indian Ocean.

1. **Phyllacanthus baculosus** (Lam.), A. Ag.

A. Ag., Rev. Ech., p. 388.[1]

Locality.—XXIX.,[2] High Peaked Island, coral reef.

A large specimen, 60 mm. in height and 75 mm. in diameter. Most of the spines are of a very light-green colour banded with faint purple.

Distributed from the Red Sea, Zanzibar, Mozambique, and Mauritius, to Timor and the Philippines.

2. **Diadema saxatile**, Linn.

A. Ag., Rev. Ech., p. 274.

Localities.—III., Iron Island, shore pools; XIV. and XXIX., Bushby Island and High Peaked Island, coral reefs.

[1] References are given only to Agassiz's *Revision*, except in the case of species described since the date of that work.

[2] These numbers refer to the Stations.

It is noticeable that at Iron Island this species flourishes in rock pools, away from any coral reefs, contrary to its usual habit.

Known from the Atlantic, Indian, and Pacific Oceans.

3. **Echinothrix turcarum**, Ret.

A. Ag., Rev. Ech., p. 416.

Locality.—VIII., Port Maria, Elphinstone Island, 3 fathoms, fine sand.

The spines of this species are but slightly hollow as a rule: in this specimen, however, they are hollow throughout and very nearly approach the spines of *E. calamaris.* The ambulacral areas are markedly gibbous near the abactinal area.

Height, 27 mm.; diameter, 55 mm.; longest spine, 56 mm.

Distributed in the Indian Ocean and Pacific to Japan and Fiji.

4. **Astropyga radiata**, Gray.

A. Ag., Rev. Ech., p. 420.

Locality.—XXXII., Bentinck Island, 29 fathoms, soft mud.

A single small specimen, almost bare of spines.

Known from Zanzibar and Mozambique to the Philippines.

5. **Asthenosoma Grubei**, A. Ag.

A. Ag., Proc. Amer. Acad., xiv. p. 200 (1879).

Locality.—XIV., Bushby Island, 15 fathoms, rock and sand.

A single dry specimen in perfect condition, agreeing with the "Challenger" specimen as described and figured by Sladen ("*Challenger*" *Reports,* iii. p. 82, and pls. xv., xvi., xvii., etc.). It may be identical with *Asthenosoma varium* from the China and Java Seas, but Grube's description of that species is too vague and general to be of much value to systematists.

Not previously known from the Indian Ocean, and apparently only recorded from the Philippines and Dutch East Indies.

6. **Echinometra lucunter**, de Blainv.

A. Ag., Rev. Ech., p. 431.

Locality.—VIII., Port Maria, Elphinstone Island, 3 fathoms, fine sand.

Two small specimens in perfect condition. The spines are light-green and olive-green respectively (in alcohol), and are tipped with straw colour; a few narrow abruptly towards their extremities.

Distributed in the Indian and Pacific Oceans.

7. **Salmacis bicolor**, Agass.

A. Ag., Rev. Ech., p. 471.

Localities.—XXXIII., Christmas Island, 23 fathoms, sand and mud; IX., Bentinck Island to Courts Island, 12 to 26 fathoms, coral and sand; XXV., Gregory Group, 4 to 14 fathoms, sand and shell; II., Iron Island, 10 to 25 fathoms, stones and mud.

In general appearance these specimens bear a strong resemblance to those which I have referred to *S. globator*, Bell, but on closer examination they prove to be distinct. The sutural furrows are marked, and the sutural pores conspicuous; the tubercles are prominent even above the ambitus; the spines are numerous all over the test, the ambital ones attaining a length of 15 mm.

Height,	30 mm.	27 mm.	24 mm.
Diameter,	43 mm.	41 mm.	34 mm.
Actinostome,	13 mm.	12 mm.	10 mm.

Recorded from the Western Indian Ocean, Ceylon, and the Philippines; and from King Island, Mergui Archipelago, by Dr Anderson.

8. **Salmacis Dussumieri**, Agass.

A. Ag., Rev. Ech., p. 473.

Localities.—XXXIII., Christmas Island, 23 fathoms, sand and mud; IX., Courts to Bentinck Islands, 12 to 26 fathoms, coral and sand; XVI., Alligator Rock, 8 to 18 fathoms, rock and sand; XXX., Fly Island (High Peaked Island), 8 fathoms, sand; XXV., Gregory Group, 4 to 14 fathoms, sand and shell.

A good series of this species, all with the spines complete. Spines spathiform and up to 17 mm. in length at the ambitus; much shorter, 5 mm., sharper and relatively stouter on the abactinal surface; on the actinal surface mostly spathiform, especially around the actinostome, and from 5 to 7 mm. in length. Only ambital and actinal spines banded with purple.

Height,	19 mm.	19 mm.	19 mm.	11 mm.
Diameter,	42 mm.	41 mm.	42 mm.	29 mm.

Recorded from the China Seas, the Philippines, and "East India Islands"; and from King Island, Mergui Archipelago, by Dr Anderson; also Mozambique.

9. **Salmacis sulcata**, Agass.

A. Ag., Rev. Ech., p. 476.

Localities.—IX., Bentinck to Courts Islands, 12 to 26 fathoms, coral and sand; XVIII., Off Paway Island, 10 to 21 fathoms, sand and shell; XVII., Sir

John Malcolm to Charlotte Islands, 18 fathoms, coarse sand; XXV., Gregory Group, 4 to 14 fathoms, sand and shell; XXIV., Cat and Kitten, 12 fathoms, rock and sand.

All small specimens, the largest being 38 mm. in diameter. In the largest the spines are tipped with violet; the smaller ones have them entirely white.

Height, 18 and 20 mm. Diameter, 37 and 38 mm.

Recorded from the Red Sea, Mozambique, and Ceylon, to the Philippines and Australia; and from King Island, Mergui Archipelago, by Dr Anderson.

10. **Salmacis globator**, Bell.

Bell, P.Z.S. (1880), p. 431, pl. xli. figs. 2, 3, and 8.

Localities.—XVI., Alligator Rock, 8 to 18 fathoms, rock and sand; XXII. Hastings Harbour, St Luke's Island, 15 to 20 fathoms, sand and shell.

These two specimens agree in all respects with F. Jeffrey Bell's description and figure of *S. globator β*. There can be no doubt as to the identity of the Mergui specimens, and the only difficulty that confronts one is the synonymy of the species (see F. P. Bedford, *P.Z.S.* (1900), p. 282, pl. xxii.). The primary spines are greenish-white and encircled with narrow bright red bands at irregular intervals; on the actinal surface they are more numerous and longer, attaining a length of 10 mm. around the actinostome; they are flattened at the tips.

Height,	41 mm.	36 mm.
Diameter,	59 mm.	57 mm.
Actinostome,	15 mm.	16 mm.

Professor Bell's *Salmacis alexandri* (*S. globator α*) (*loc. cit.*) is not represented in this collection.

Distributed from Singapore to the east coast of Australia, and possibly in the Korean Straits.

11. **Mespilia globulus**, Agass.

A. Ag., Rev. Ech., p. 477.

Localities.—VIII., Port Maria, Elphinstone Island, 4 fathoms, sand; XX., High Island, 5 fathoms, sand and rock; XXV., Gregory Group, 4 to 14 fathoms, sand and shell.

The median tracts of the ambulacral areas are scarcely bare except in the largest specimens.

Not previously recorded from the Indian Ocean, but known from the Philippines, Japan, and the Sandwich Islands.

12. **Laganum depressum**, Less.

A. Ag., Rev. Ech., p. 518.

Localities.—VIII., Port Maria, Elphinstone Island, 3 fathoms, fine sand; XXXII., Bentinck Island, 29 fathoms, soft mud.

The edges of the larger specimens have decided re-entrant angles, especially posteriorly. A young specimen (22·5 mm. long) has the angular outline of the adult, but the edges are straight.

Known from Zanzibar and Mozambique to the Philippines and Australia; and collected by Dr Anderson at King Island, Mergui Archipelago.

13. **Laganum decagonale**, de Blainv.

Peronella decagonalis, A. Ag., Rev. Ech., p. 520.

Localities.—XXXII., Bentinck Island, 29 fathoms, soft mud; XIII., Maria Island, shore pools; XVIII., Off Paway Island, 10 to 21 fathoms, sand and shell; XXV., Gregory Group, 4 to 14 fathoms, sand and shell; XXII., Hastings Harbour, St Luke's Island, 15 to 20 fathoms, sand and shell; and XLI., Moskos Islands, 12 to 15 fathoms, sand and rock.

The largest specimen has a longitudinal diameter of 108 mm.

The youngest specimens have an almost circular outline with a bare suggestion of the angles. A young denuded test (31 mm. diameter) from Hastings Harbour recalls *Clypeaster humilis*, but, I think, is referable to this species.

Distributed in the Bay of Bengal and the Western Pacific. Also recorded from Mozambique.

14. **Laganum** sp.

Locality.—XVIII., Off Paway Island, 10 to 21 fathoms, sand and shell.

Five small dead and denuded tests were found in the dredge; the largest has a longitudinal diameter of 17 mm. The test is orbicular and somewhat swollen; there are four genital pores.

These specimens seem to be identical with those described and figured by F. P. Bedford as *Laganum* sp., from Singapore and Malacca (*P.Z.S.* (1900), p. 285, pl. xxiii. fig. 7, *a* and *b*). They may or may not be the young of *L. depressum*.

15. **Lovenia subcarinata**, Gray.

A. Ag., Rev. Ech., p. 577.

Locality.—I., Tavoy Island, 10 fathoms, sand and shell.

Three individuals were obtained, of which the largest is 32 mm. long and 24 mm. broad.

Its occurrence in the Mergui Archipelago extends the range of the species, which was previously known only from the Philippines to China, Japan, and the Sandwich Islands, and Dutch East Indies. Later it has, however, been recorded from the Mozambique coast.

ASTEROIDEA.

Nineteen species of Asteroids were collected, including no new species but many new records for the Mergui Archipelago, and, in some cases, for the Indian Ocean. These collections have therefore not borne out Dr Anderson's belief of "a reasonable expectation that a number of new species may ultimately be found in the Mergui Archipelago." Dr Anderson[1] collected nine species, of which three were new. Of these nine species only four occur in the present collection, or, at the most, five, if we can include *Astropecten Hemprichii*, should it prove to be the same as *A. mauritianus*. None of Anderson's new species are included in our collection. The total number of Asteroids known from the Mergui Archipelago is therefore 24, or possibly 23. In addition, a species of *Culcita* was frequently seen on the coral reefs, but no specimen reached this country.

The Asteroids in the present collection are as follows :—

1. *Archaster typicus*, M. & T.
2. *Craspidaster hesperus* (M. & T.), Sladen
3. *Astropecten mauritianus*, Gray.
4. *Astropecten zebra*, Sladen.
5. *Astropecten polyacanthus*, M. & T.
6. *Luidia forcifer*, Sladen.
7. *Luidia maculata*, M. & T.
8. *Goniodiscus articulatus* (Linn.), Lütken.
9 *Stellaster incei*, Gray.
10. *Anthenea flavescens* (Gray), Perr.
11. *Anthenea pentagonula* (Lam.), Perr.
12. *Pentaceros granulosus*, Gray.
13. *Pentaceros lincki* (de Blainv.).
14. *Pentaceros superbus*, Möbius.
15. *Pentaceros gracilis*, Lütken.
16. *Palmipes rosaceus* (Lam.), Duj. & Hupé.

[1] *Jour. Linn. Soc. Lond. Zool.*, xxi. (1889), pp. 319-331.

17. *Fromia milleporella*, Gray.
18. *Retaster cribrosus* (von Mart.).
19. *Echinaster purpureus* (Gray), Bell.

The absence of any species of *Linckia* is noticeable, for this genus is widely diffused and common in many parts of the Indian Ocean. Three species constitute new records for the Indian Ocean, namely, *Craspidaster hesperus*, a Pacific species, and *Anthenea flavescens* and *Pentaceros granulosus*, both Australian forms. *Pentaceros gracilis* is extremely abundant on the pearl banks of the Mergui Archipelago, and has since been noted in numbers on the pearl banks of the Mozambique coast of Africa; yet, as far as I can ascertain, it was previous to these discoveries looked upon as an Australian form; a fact which forcibly illustrates the poverty of our knowledge of the marine fauna of many parts of the Indian Ocean.

1. **Archaster typicus**, M. & T.

Perrier, Révision de Stellérides,[1] Arch. de Zool. expér. et gén., v. (1875), p. 265.

Locality.—XVI., Alligator Rock, 8 to 18 fathoms, rock and sand.

Two specimens in which $R = 44$ and 46 and $r = 10$ and 9 respectively.[2] In the smaller specimen a single spine appears on one supero-marginal; otherwise the supero-marginals have no trace of spines. A similar occurrence in this species is noted by Lütken (*Vidensk. Medd.* (1864), p. 136), and by Sladen ("*Challenger*" *Reports*, xxx., p. 124).

This species is also recorded from the Mergui Archipelago by Dr Anderson in 1882. Widely distributed in Eastern Indian Ocean and Western Pacific.

2. **Craspidaster hesperus** (M. & T.), Sladen.

Sladen, "Challenger" Reports, xxx. p. 177, pl. xvii. figs. 5-7; and pl. xviii. figs. 1-4.

Locality.—XXXII., Off Bentinck Island, 29 fathoms, soft mud and sand.

Two specimens agree with the young phase described by Sladen. The adpressed spinelets on the infero-marginal plates tend to fall off very readily, but their presence is quite evident in both specimens.

$$R = 22 \qquad r = 6{\cdot}5.$$

Apparently not previously recorded from the Indian Ocean. Known from Japan to Singapore.

[1] In the case of species included in Perrier's *Révision*, I give no other reference than to his paper as a rule: the synonymy is therein discussed.

[2] All measurements are in millimetres.

3. **Astropecten mauritianus**, Gray.

Perrier, *loc. cit.*, v. p. 279.

Localities.—Frequent on pearl banks throughout the Archipelago, in 5 to 25 fathoms, sand and rock.

$R=111$ $r=21{\cdot}5$ $R=81$ $r=19$.

Undoubtedly this species is very closely allied to *A. Hemprichii*, M. & T., despite de Loriol's belief that the two species cannot be confused (*Mém. Soc. Phy. Hist. Nat. Gen.*, t. xxix., No. 4, p. 74, and pl. xxi.). He lays stress on the absence of supero-marginal spines in the angles of *A. Hemprichii* and their presence in *A. mauritianus*, but this, as Jeffrey Bell has pointed out, is not a reliable character in *Astropecten*. It will not be surprising if the two species prove to be one and the same. I have named the Mergui specimens after careful comparison with specimens in the British Museum.

A new record for the Eastern Indian Ocean, but Dr Anderson collected *A. Hemprichii* in the Mergui Archipelago.

4. **Astropecten zebra**, Sladen.

Sladen, "Challenger" Reports, xxx. p. 212, and pl. xxxvi. figs. 3 and 4; pl. xxxix., figs. 7 to 9.

Localities.—IX., Courts Island to Bentinck Island, 12 to 26 fathoms, coral and sand; XXV., Gregory Group, 4 to 14 fathoms, sand and broken shell.

Four specimens, the two larger of which are each in process of regrowing an arm.

$R=26$ $r=7{\cdot}5$ $R=30$ $r=8$ $R=25$ $r=7$ $R=16{\cdot}5$ $r=5{\cdot}5$.

A slight prominence in the centre of the upper surface of the disc appears as a conical beak in the smaller specimens; it is most prominent in the smallest. Of the supero-marginal plates, as many as the eight innermost on either side of each arm may bear spines, but of these the last two are very rudimentary. In the smallest specimen, one or two of the supero-marginals on each side of the median interradial line bear spines. Even in the larger specimens, however, the number of spines is variable, bearing out Jeffrey Bell's contention as to the absence of value of these in classification (Hornell and Herdman, *Ceylon Pearl Oyster Fisheries Report*, ii. p. 149). Bell thinks (*loc. cit.*) that *A. zebra* and *A. Hemprichii* are identical. They certainly approach one another very closely in their characters, but those which Bell figures (from photographs) as *A. Hemprichii* seem to be *A. zebra* and apparently were thus named by Sladen.

Known previously from Torres Strait and Ceylon.

5. **Astropecten polyacanthus**, M. & T.

Perrier, *loc. cit.*, v. p. 275.

Locality.—I., Tavoy Island, 8 fathoms, shelly sand and mud.

$R = 15{\cdot}5$ $r = 4$.   Breadth of arm at base $= 4{\cdot}5$.

A single specimen, apparently a young form, in which the spines of the ventral surface are scarcely developed. One supero-marginal on either side of the median interradial line bears a distinct tooth-like spine inclined slightly inwards.

The specimen seems to be referable to this species.

Recorded previously from the Red Sea, Zanzibar, and Mozambique, the Seychelles and Ceylon to Hong Kong, the Fiji Islands, and Port Jackson.

6. **Luidia forcifer**, Sladen.

Sladen, "Challenger" Reports, xxx. p. 258, pl. xliv. fig. 5, and pl. xlv. figs. 5 and 6.

Locality.—IX., Between Courts Island and Bentinck Island, 12 to 26 fathoms, coral and sand.

A single specimen, not of full growth, but which can be referred to this species. $R = 30$ $r = 5$.

Collected by Dr Anderson at King Island and at Sir William James Island in the Archipelago, and also known from Torres Strait and the Arafura Sea.

7. **Luidia maculata**, M. & T.

Perrier, *loc. cit.*, v. p. 258.

Localities.—XVIII., Off Paway Island, 10 to 21 fathoms, sand and shell; XXV., Gregory Group, 4 to 14 fathoms, sand and shell.

Several young specimens, in the largest of which $R = 62$ and $r = 11$.

Found by Dr Anderson at King Island. Also known from Mozambique to Madras, Manilla, and Japan.

8. **Goniodiscus articulatus** (Linn.), Lütken.

Lütken, Vidensk. Medd. (1864), p. 147.

Locality.—XLI., Moskos Islands, 12 to 25 fathoms, rock and sand.

A single dried specimen in which $R = 70$, $r = 35$. Number of marginals, 14 to 15.

This specimen agrees with that collected by Dr Anderson at King Island in 1882 in having the interbrachial arc more rounded than in de Loriol's figure, and consequently the rays appear more well-defined (de Loriol, *Rec. Zool. Suisse.*, t. i. p. 638, pl. xxxv., 1884).

Also known from Singapore, the Sunda Straits, and Western Australia.

There is quite evidently some confusion prevalent with regard to this species. Perrier ("Pédicellaires," *Ann. Sci. Nat.*, xii. (1869), p. 279) describes his *Goniodiscus articulatus*, Ed. P., which is certainly not *Goniodiscus articulatus*, Lütken, nor *Asterias articulata*, Linn. In his *Révision des Stéllerides* (v. p. 91), Perrier reduces *his Goniodiscus articulatus* to *Anthenea pentagonula* (Lam.), and these are the same species, but *Goniodiscus articulatus* (Linn.), Lütken, is quite distinct.

9. Stellaster incei, Gray.

Perrier, *loc. cit.*, v. p. 43.

Localities.—II., East of Iron Island, 10 to 25 fathoms, stone and mud; XXXIII., Christmas Island, 23 fathoms, sand and mud; IX., Between Courts and Bentinck Islands, 12 to 26 fathoms, coral and sand; XVIII., Off Paway Island, 10 to 21 fathoms, sand and shell; XXV., Gregory Group, 4 to 14 fathoms, sand and shell; XXII., Hastings Harbour, St Luke's Island, 15 to 20 fathoms, sand and shell.

The commonest asteroid in the Mergui Archipelago, and represented in this collection by an extensive series of specimens. Among these are certain ones which might be referred to *S. belcheri*, Gray, but the distinctive characters, never very marked, break down entirely in intermediate forms. It is therefore unjustifiable to separate the two species, and I have followed F. P. Bedford (*P.Z.S.* (1900), p. 294) in combining them under the first name.

The measurements of the largest and smallest are

$R=51 \quad r=21 \qquad R=30 \quad r=12.$

Recorded from Sumatra and Singapore to Australia, and Korea, and Ceylon, but apparently rare in the Indian Ocean. A single one has been recorded from the Mozambique coast.

10. Anthenea flavescens (Gray), Perr.

Perrier, *loc. cit.*, v. p. 92.

Localities.—II., East of Iron Island, 10 to 25 fathoms, stones and mud; XXV., Gregory Group, 4 to 14 fathoms, sand and shell.

In the largest specimen $R=50$ and $r=21$.

The smallest specimen ($R=20$) from the Gregory Group shows a strong resemblance to a young form of *Anthenea* dredged by the "Challenger" in Torres Strait and referred provisionally by Sladen to *Anthenea tuberculosa*, Gray, *juv.* ("*Challenger*" *Reports*, xxx. p. 340, and pl. lvi. figs. 5 to 8). It seems likely that both these young specimens from Torres Strait and the Mergui Archipelago belong to *A. flavescens*.

Previously recorded from Port Jackson and Freemantle.

11. Anthenea pentagonula (Lam.), Perr.

Perrier, *loc. cit.*, v. p. 90. *Goniodiscus articulatus*, Ed. P. (non Lütken) Pédicellaires, p. 279.

Locality.—XLI., Moskos Islands, 12 to 25 fathoms, rock and sand.

A single dried specimen in which $R = 120$, $r = 62$. Number of marginal plates, 19. The arms are more acute than in the smaller specimens in the British Museum.

Known from Hong Kong, Madras, and N.W. Australia.

12. Pentaceros granulosus, Gray.

Perrier, *loc. cit.*, v. p. 52.

Locality.—IX., Between Courts and Bentinck Islands, 12 to 26 fathoms, coral and sand.

Several dried specimens. $R = 34$, $r = 14$; $R = 20$, $r = 7$.

This species, which has the habit of a *Goniodiscus* rather than of a *Pentaceros* has been referred, from Singapore specimens, to *Goniodiscus articulatus* (Linn.), Lütken, by F. P. Bedford ("Malayan Echinoderms," *P.Z.S.* (1900), p. 294). The specimens in the present collection agree in all respects with certain ones from Singapore in the British Museum (*P. granulosus*), and in the meantime it may be advisable to keep the two species separate.

Apparently only recorded previously from Swan River and Freemantle, Western Australia.

13. Pentaceros lincki (de Blainv.).

P. muricatus, Perrier, *loc. cit.*, v. p. 55.

Localities.—XIV., Bushby Island, 15 to 23 fathoms, sand, shell, and rock; XVII., Sir John Malcolm Island, 14 fathoms, sand and rock; XXV. Gregory Group, 4 to 14 fathoms, sand and shell.

Very frequent on the pearl banks, where it is reputed by the divers to work havoc among the mother-of-pearl oysters. The collection includes a series of nine dried specimens of this variable species.

In some specimens the development of spines is very luxuriant, and in these cases the distal supero-marginals bear conspicuous spines: in other cases, however, all the spines are more poorly developed, and those of the supero-marginals are not prominent. Two specimens have no central apical spine. The number of pedicellariæ which develop varies considerably. In some cases they are numerous on the reticulating bars of the dorsal ossicles up to the base of the lophial spines; in other cases they are rare even on the supero-marginals.

There is great variation in the colour of this species when alive. Most individuals are bright red or carmine except for the poriferous areas which are brown or grey, but many examples were noticed of a bright yellow or even orange colour.

Distributed from Mozambique and Zanzibar to Ceylon.

14. Pentaceros superbus, Möbius.

Möbius, Abh. Geb. Naturw. Hamburg, Bd. iv., Abth., ii. p. 5.

Locality.—XIV., Bushby Island, 15 to 23 fathoms, sand and rock.

Two large dried specimens from Bushby Island pearl bank. These remarkably fine specimens are superior to any which I have seen in this country.

$R = 220$ $r = 63$. Width of arm at base $= 70$.

Previously known from Tuticorin and Sumatra.

15. Pentaceros gracilis (Lütken).

Lütken, Vidensk. Medd. (1871), p. 260. Perrier, *loc. cit.*, v. p. 62.

Localities.—Abundant throughout the Archipelago and Moskos Islands on all pearl banks in 10 to 30 fathoms.

All the marginals are tuberculated. On the largest specimens the tubercles in the arc between the arms tend to split into two or three or more, especially on the infero-marginals. The lophial tubercles tend to be larger than others in many specimens. Tubercles occur at the corners of all the poriferous areas, especially in larger individuals: in smaller ones they do not all develop. Apical tubercles are specially prominent in smaller specimens: in larger ones other tubercles approximate to them in size. There are generally spines on the apical region, but sometimes only two or three around the anus.

There are many small valvular pedicellariæ on the marginals of both series and on the ventral surface.

In the two largest specimens $R = 200$ $r = 66$. $R = 146$ $r = 60$.

In life the colour of this animal is orange-red with the tubercles of a brighter orange colour and the poriferous areas greyer.

Recorded from Mozambique and East Australia; and Port Molle and Port Denison, Queensland.

15a. **Pentaceros gracilis** (Lütken), young.

Locality.—XIV., Bushby Island, 15 fathoms, rock and sand.

Apparently a young specimen. $R = 65$.

Disc not very high. Five large apical tubercles and three small ones around the anus.

The lophial line of tubercles distinct: tubercles few and small on a line on either side of the lophial line.

Supero-marginals with a single distinct tubercle generally absent on the most proximal but one; placed higher on the most proximal plate.

Infero-marginals with a similar tubercle, occasionally absent near the distal end.

Actinal surface with plates distinct, granulated, with a tendency to tubercles on the innermost ones.

Small valvular pedicellariæ on proximal plates of the row adjacent to the ambulacral grove, one on each plate.

Ambulacral armature: inside row of five or six spines, among which one or two seem decidedly larger: then two, large, stout, blunt: and finally an inconspicuous row of two or three small ones.

The specimen bears some resemblance to *P. chinensis*, Gray, but is probably a young form of *P. gracilis.*

16. **Palmipes rosaceus** (Lam.), Duj. & Hupé.

Perrier, *loc. cit.*, v. p. 210.

Localities.—XVII., Between Sir John Malcolm and Charlotte Islands, in 18 fathoms, coarse sand; XXV., Gregory Group, 4 to 14 fathoms, sand and shell.

Two damaged specimens, in the largest of which $R = 105$ and $r = 80$.

Recorded from the Bay of Bengal and Japan.

17. **Fromia milleporella**, Gray.

Perrier, *loc. cit.*, iv. p. 437.

Locality.—XXII., Hastings Harbour, St Luke's Island, 15 to 20 fathoms, sand and shell; and XXX., Fly Island, 8 to 15 fathoms, rock and sand.

Two specimens in which the five arms are of unequal lengths.

$R = 50$ (longest arm) or 38 (shortest arm) $r = 10$

$R = 60$ $r = 11$

In its somewhat irregularly arranged plates and unequal arms these recall the specimens from the Red Sea mentioned by Perrier.

Recorded from the Red Sea, Ceylon, Madagascar, and Mauritius to the Loo Choo Islands, the Moluccas, New Caledonia, Samoa, and the Fiji Islands.

18. **Retaster cribrosus** (von Mart.).

Sladen, "Challenger" Reports, xxx. p. 482, pl. lxxvi. figs. 3 and 4 ; and lxxvii. figs. 11, 12.

Localities.—II., Iron Island, 10 to 25 fathoms, stones and mud ; XXIII., Five Islands, 12 fathoms, rock and sand; XXII., Hastings Harbour, St Luke's Island, 15 to 20 fathoms, sand and shell.

Several specimens, including a young one, in which $R=18$ and $r=7$.

Known from Zanzibar and Mozambique to Ceylon, Singapore, the Philippines, and Samoa.

19. **Echinaster purpureus** (Gray), Bell.

Echinaster fallax, M. & T., Perrier, *loc. cit.*, iv. p. 370.

Localities.—IX., Courts to Bentinck Islands, 12 to 26 fathoms, coral and sand; XVI., Alligator Rock, 8 to 18 fathoms, rock and sand; XVII., Malcolm to Charlotte Islands, 18 fathoms, coarse sand; XVIII., Off Paway Island, 10 to 21 fathoms, sand and shell; and XXII., Hastings Harbour, St Luke's Island, 15 to 20 fathoms, sand and shell.

Nine specimens, varying in size from a very young one in which $R=13$ to a large one in which $R=82$ and $r=6$.

Throughout the Indian Ocean and South-Western Pacific.

(*Issued separately, 17th February* 1910.)

III.—Echinoidea from the Kerimba Archipelago, Portuguese East Africa (Mozambique). By R. N. Rudmose Brown, D.Sc.

(Received 12th October 1909. Read 22nd November 1909.)

The collection of Echinoids described in the present paper was made by Mr J. J. Simpson, M.A., B.Sc., on the coast of Portuguese East Africa between latitudes 10° 42′ S. and 12° 58′ S. from September 1907 to May 1908. All were gathered on a coral bottom in depths under 20 fathoms. The collection comprises 21 species, and is chiefly interesting from a distributional point of view, our previous knowledge of the Echinoderm fauna of that particular part of the East African coast being very meagre indeed.

The 21 species of the present collection are all forms known from the tropical waters of the Indian and Pacific Oceans, with the exception perhaps of *Goniocidaris canaliculata*, which is characteristic of the colder southern circumpolar waters but has also been found at Zanzibar. Several species show an extension of range. *Lovenia subcarinata* until recently had only been recorded from Pacific waters. Mr Simpson and I found it at the Mergui Archipelago in 1907, and now it is recorded from the western shores of the Indian Ocean. Curiously enough the allied *L. elongata* does not occur among these specimens nor was it found in the Mergui Archipelago, although more than once it has been recorded from the Indian Ocean.

Chaetodiadema granulatum is one of the "Siboga" species described from Dutch East Indian waters. *Brissopsis luzonica* is another Pacific species which previously had not been recorded from the Indian Ocean. - Otherwise the facies of this collection is very similar to that of the Echinoid fauna of the Indian Ocean generally. The complete list of the species is as follows :—

1. *Phyllacanthus baculosus* (Lam.), A. Ag.
2. *Phyllacanthus verticulata*, A. Ag.
3. *Goniocidaris canaliculata*, A. Ag.
4. *Echinothrix turcarum*, Ret.
5. *Astropyga radiata*, Gray.
6. *Chaetodiadema granulatum* Mortensen.
7. *Echinometra lucunter*, de Blainv.
8. *Echinostrephus molare*, A. Ag.
9. *Microcyphus maculatus*, Agass.
10. *Salmacis bicolor*, Agass.
11. *Salmacis Dussumieri*, Agass.
12. *Toxopneustes pileolus*, Agass.

13. *Clypeaster scutiformis*, Lam.
14. *Clypeaster humilis*, Agass.
15. *Laganum depressum*, Less.
16. *Laganum decagonale*, de Blainv.
17. *Echinodiscus auritus*, Leske.
18. *Maretia planulata*, Gray.
19. *Lovenia subcarinata*, Gray.
20. *Brissopsis luzonica*, A. Ag.
21. *Schizaster gibberulus*, Agass.

In addition, *Diadema saxatile*, Linn. was noted as being very common all along the coast but no specimen was collected.

I must take this opportunity of expressing my indebtedness to Professor J. Arthur Thomson, for the use of a laboratory in the University of Aberdeen; to Professor F. Jeffrey Bell, for facilities in comparing specimens with those in the British Museum; and to Mr James Ritchie, B.Sc., for assisting me in getting access to literature bearing on the subject.

1. Phyllacanthus baculosus, A. Ag.

A. Ag., Rev. Ech., p. 388.[1]

Locality.—III., Mtundo Bay, sand, shell, and coral, 6 fathoms.

One young specimen, 14 mm. in diameter. A few spines, smooth and without serration: all banded with violet and of the characteristic coloration at the base.

Two larger ones, 23 mm. in diameter, with spines up to 37 mm.

Distribution.—Mauritius, Mozambique, Zanzibar, and the Red Sea to Mergui, Timor, and the Philippines.

2. Phyllacanthus verticulata, A. Ag.

A. Ag., Rev. Ech., p. 392.

A small specimen from no precise station: very fine spines.

Distribution.—Indian Ocean.

3. Goniocidaris canaliculata, A. Ag..

A. Ag., Rev. Ech., p. 395.

Localities.—IX., Ibo Bay, Matemo Island; I., Tunghi Bay, sand, mud, and shell, 5 to 18 fathoms; III., Mtundo Bay, sand, shell, and coral, 6 fathoms; XI., Manangoroshi Point to Lurio Point, coral reefs.

[1] References are to Agassiz's *Revision* only for all species included in that work.

Ten specimens in all. The spines vary considerably: they are all fluted, but the conspicuous serrations on some tend to disguise this character: they are all blunt and banded with violet brown: the larger ones tend to be swollen in the middle.

Height,	15 mm.	11 mm.
Diameter,	26 mm.	17 mm.
Spine,	20 mm.	12 mm.

Distribution.—Fuegia, Cape Horn, Falkland Islands, Heard Island, Kerguelen, Australia, Natal, and Zanzibar. On the whole apparently a cold-water species.

4. Echinothrix turcarum, Ret.

A. Ag., Rev. Ech., p. 416.

Locality.—X., Montepes Bay, sand and mud, 5 to 22 fathoms.

A small specimen whose height and diameter are 7 and 15 mm. respectively; the longest spine is 22 mm. In so young a specimen as this there might well be room for doubt whether it belonged to *E. turcarum* or to *E. calamaris.* The spines are long, hollow throughout, and delicate, quite characteristic of *E. calamaris.* On the other hand, the tuberculation and the character of the apical system are in favour of *E. turcarum*, Moreover, in specimens of this species from the Mergui Archipelago, the spines are delicate and hollow throughout like those of *E. calamaris* rather than those generally found in *E. turcarum.*

Distribution.—Indian Ocean and the Pacific to Japan and Fiji.

5. Astropyga radiata, Gray.

A. Ag., Rev. Ech., p. 420.

Localities.—III, Mtundo Bay, sand, shell, and coral, 6 fathoms; X., Montepes Bay, sand and mud, 5 to 22 fathoms.

Five small specimens which, although young, show no departures from the well-defined characters of the adult. The outline from above is pentagonal. In the living animal the spines are brown with white bands.

Height,	11·5 mm.	10·5 mm.	?
Diameter,	27·0 mm.	31·0 mm.	33 mm.

The younger specimens are naturally, considering the flexible nature of the test, more rigid and consequently are relatively higher than the older ones.

Distribution.—Throughout the Indian Ocean, in the Dutch East Indies, and in the Philippines.

6. **Chaetodiadema granulatum**, Mortensen.

Mortensen, Vidensk. Medd. (1903).
De Meijere, Die Echinoidea der Siboga-Expedition, Mon. xliii., Résultats des Explorations du Siboga, 1904, p. 54 and plates.

Locality.—XIII., Pemba Bay, mud, 10 to 20 fathoms.

Three specimens are referable to this little known species, although I have had to rely on Mortensen's and de Meijere's descriptions in default of actual specimens for comparison. De Meijere's coloured plate (*loc. cit* xi. 101) does not agree accurately with his own description of the species in tuberculation and spinulation. The specimens before me have been in spirit for about a year and consequently show practically no coloration.

Diameter.	Height.	Spines.	Dia. Act. sys.	Dia. Abact. sys.	Dia. Anal sys.
55 mm.	11·5 mm.	12 mm.	8·5 mm.	17 mm.	6·0 mm.
45 mm.	10·5 mm.	24 mm.	8·5 mm.	14 mm.	5·5 mm.
43 mm.	10·0 mm.	21 mm.	9·0 mm.	15 mm.	4·5 mm.

The "Siboga" specimens were collected in the Sunda and Banda Seas and vicinity.

7. **Echinometra lucunter**, de Blainv.

A. Ag., Rev. Ech., p. 431.

Localities—IX., Ibo Bay, around Matemo Island, and between Matemo Island and mainland.

Several specimens, including a very young one. This species varies considerably in colour when alive. A deep purple is commonest, but individuals are often found of a dark olive-green and "black ones are seen not rarely." It was found in the usual habitat, burrowing in coral and coral rock.

Distribution.—Indian and Pacific Oceans.

8. **Echinostrephus molare**, A. Ag.

A. Ag., Rev. Ech., p. 457.

Three small specimens from no precise locality.

Distribution.—Indian and Western Pacific Oceans.

9. **Microcyphus maculatus**, Agass.

A. Ag., Rev. Ech., p. 466.

Locality.—II., Maiyapa Bay, sand, mud, and coral, 10 fathoms.

Three specimens, two of which are complete. The test is markedly pentagonal, but the interradius can scarcely be said to be re-entrant as Agassiz describes it in a specimen of 29 mm. (*loc. cit.*), although, when not denuded of spines, the animal gives such an appearance owing to the bare interambulacral areas. The bare interambulacral spaces extend to the poriferous areas and to the actinostome.

Heights, 21 and 25 mm.; Diameters, 33 and 36 mm.

Distribution.—Zanzibar and Mayotte, Moluccas, Australia, Navigator Islands, and Japan.

10. **Salmacis bicolor**, Agass.

A. Ag., Rev. Ech., p. 471.

Locality.—VII., Pekawi Bay, exposed coral reef.

A single fine individual belongs to this species. The spines below the ambitus are short and stout; they are flattened at their distal ends, increasingly so towards the actinostome where they are spathiform. In colour they are light purple banded with yellowish green. On the abactinal surface the spines are shorter and sharp, passing from light red at their bases to bright purple, generally with one or more yellowish green bands.

Height, 41 mm. Diameter, 35 mm. Spine 14 mm.

Distribution.—Indian Ocean and to the Philippines.

11. **Salmacis Dussumieri**, Agass.

A. Ag., Rev. Ech., p. 473.

Localities.—III., Mtundu Bay, sand, shell, and coral, 6 fathoms; VI., Kero-Nyuni Bay, sand, 5 to 10 fathoms.

Several fine specimens of various sizes, of which the largest has a diameter of 66 mm., a height of 33 mm., and ambital spines of 16 mm. The spines of the abactinal surface are relatively short, sharp, and evenly tapering to a point; those of the actinal surface are a little longer, blunt, and flattened; while the ambital spines in three or four horizontal rows are long, stout, and uniform in diameter throughout and fashioned like a gouge at the ends. These differences among primary spines are less marked in smaller specimens, but do exist. The shorter spines are green, faintly banded with purple; but the ambital spines tend to be very light purple, banded faintly with green.

Distribution.—China Seas to the Philippines, Dutch East Indies, and the Mergui Archipelago. These specimens seem to extend the range.

12. **Toxopneustes pileolus**, Agass.

A. Ag., Rev. Ech., p. 497.

Localities.—I., Tunghi Bay, sand, mud, and shell, 5 to 18 fathoms; III., Mtundo Bay, sand, shell, and coral, 6 fathoms; VI., Kero-Nyuni Bay, sand, 5 to 10 fathoms; IX., Ibo Bay, Matemo Island.

A large series of specimens which shows considerable variety in shape; some specimens are more globular, others are more compressed. But the globular shape is not a development of age for it occurs in some small and obviously young individuals. In outline the test from above is often decidedly pentagonal, less often almost circular. The ambulacral areas are slightly gibbous around the apical system. The actinal surface is only very slightly concave. The spirally arranged bands of colour mentioned by A. Agassiz (*loc. cit.*) are not obvious in these specimens.

Height (mm.)	28	26	22	20	20	17	15	11
Diameter (mm.)	39	35	29	29	26	26	21	15

Distribution.—Indian and Pacific Oceans.

13. **Clypeaster scutiformis**, Lam.

A. Ag., Rev. Ech., p. 512.

Localities.—X., Montepes Bay, sand and mud, 5 to 22 fathoms; XIII., Pemba Bay, mud, 10 to 20 fathoms.

A large and a small specimen. The outline of the former is decidedly pentagonal with rounded edges. The abactinal surface, from the swollen border, is convex but slightly flattened again at the apex. The extremities of the poriferous zones of the petals are a little concave.

Height, 11 mm.	Long. dia., 51 mm.	Trans. dia., 42 mm.
„ 7 mm.	„ „ 31 mm.	„ „ 21 mm.

Distribution.—Japan, Formosa, Malay Archipelago generally, and Indian Ocean including Rea Sea, Ceylon, Mauritius, and Ibo.

14. **Clypeaster humilis**, Agass.

A. Ag., Rev. Ech., p. 510.

Locality.—II., Maiyapa Bay, sand, mud, and coral, 10 fathoms.

Several young individuals having the characteristic form of the adult. Their slightly pentagonal outline gives them a strong resemblance to certain species of *Laganum*.

Distribution.—Western Pacific and Indian Oceans.

15. **Laganum depressum**, Less.

A. Ag., Rev. Ech., p. 518.

Localities.—II., Maiyapa Bay, sand, mud, and coral, 10 fathoms; III., Mtundo Bay, sand, shell, and coral, 6 fathoms; VI., Kero-Nyuni Bay, sand, 5 to 10 fathoms.

Many specimens of various ages. In shape these specimens show many of the variations in outline habitual in this species: the truncated angles give a sub-decagonal or sometimes almost orbicular outline. The greatest transverse diameter is just anterior to the anterior pair of ambulacra in the largest specimen; in the smaller ones, it tends to run posterior to them or across the apex: this is not in accordance with what A. Agassiz describes (*loc. cit.*). In the larger specimens, the petals are relatively shorter than in the young, and in the largest specimen of all the margin of the test is distinctly swollen. In this specimen the posterior sides tend to show re-entrant angles, and on one side the test has evidently been damaged and partial regeneration, at least to the extent of the upper and lower surfaces fusing, has taken place.

The largest specimen has these dimensions:—

Long. dia., 68 mm.	Length, ant. pair ambulacra, 17 mm.
Trans. dia., 65 mm.	Length, odd ambulacrum, 18 mm.

Distribution. — Zanzibar, Mergui, Australia, the Philippines, and Fiji Islands.

16. **Laganum decagonale**, de Blainv.

A. Ag., Rev. Ech., p. 520.

Locality.—III., Mtundo Bay, sand, shell, and coral, 6 fathoms.

A single dead specimen rather more oval than decagonal in outline.

Distribution.—Western Pacific and Bay of Bengal.

17. **Echinodiscus auritus**, Leske.

A. Ag., Rev. Ech., p. 531.

Localities.—Kifuki Island and Foomo Island.

Only one specimen was collected but it is a very perfect one. The outline, especially posteriorly, is somewhat irregular. The edge on one side anterior to the lunule is very ragged and gives the impression that it has suffered injury and has undergone a certain degree of regeneration. The length of the lunule is 40 mm., the total distance from the edge of the test to the apex is 92; this is a longer lunule than generally is found. The anus, however, is as usual in a line with the inner ends of the lunules.

The measurements of this fine specimen are worth recording.

Height, 13 mm.	Long. dia., 158 mm.	Trans. dia., 147 mm.
Post. petals, 29 mm.	Odd petal, 34 mm.	Width, porif. zone, 5 mm.
Width, inter. porif. zone, 5·5 mm.		Anus from edge of test, 37 mm.
	Mouth from anterior edge, 76 mm.	

Distribution.—Indian Ocean, especially the west, Amboina, Philippines, and Straits of Macassar.

18. **Maretia planulata**, Gray.

A. Ag., Rev. Ech., p. 570.

Localities.—III., Mtundo Bay, sand, shell, and coral, 6 fathoms; VI., Kero-Nyuni Bay, sand, 5 to 10 fathoms; X., Montepes Bay, sand and mud, 5 to 22 fathoms.

A series of seven specimens of various ages. All the specimens seem to be a little flatter than is usual in this species. The slight anterior ambital grove, never at all prominent, is practically indistinguishable in the largest specimens. The variations in colour (in spirit specimens) common in this species are not noticeable. A uniform straw colour prevails, except in one specimen, in which the lateral petals on one side show a certain amount of violet brown coloration, and the same colour appears on the primary tubercles. The primary spines in this case are banded with faint violet brown.

Height, 16 mm.	Long. dia., 68 mm.	Trans. dia., 54 mm.
„ 12 mm.	„ „ 46 mm.	„ „ 37 mm.

Distribution.—Western Pacific through the Indian Ocean to Zanzibar.

19. **Lovenia subcarinata**, Gray.

A. Ag., Rev. Ech., p. 577.

Localities.—VI., Kero-Nyuni Bay, sand, 5 to 10 fathoms; XIII., Pemba Bay, mud, 10 to 20 fathoms.

Several fine specimens.

The specific characters which distinguish this species from *L. elongata* in young specimens—the sub-triangular actinostome, the outward slope from the anal system to the abactinal surface, and the triangular actinal plastron—are maintained in the older ones. More mature specimens show no departure from the small number of primary tubercles on the abactinal surface in the anterior half of the posterio-lateral interambulacra.

Height,	19 mm.	Length,	46 mm.	Diameter,	35 mm.
„	19 mm.	„	47 mm.	„	34 mm.
„	14 mm.	„	36 mm.	„	26 mm.
„	11 mm.	„	29 mm.	„	22 mm.

Distribution.—Only known from the Western Pacific—Japan to the Sandwich Islands—and the Mergui Archipelago.

20. Brissopsis luzonica, A. Ag.

A. Ag., Rev. Ech., p. 593.

Locality.—V., Namegus Bay, mud and rocks.

A solitary injured specimen belongs to this species. The anal plastron is missing. The bare areas on the actinal surface with undiminished width run from the mouth to the sub-anal plastron.

Height, 23 mm. Long dia., 45 mm. (approx.). Trans. dia., 38 mm.

Distribution.—Western Pacific, from New Zealand to Japan. This record gives a great extension of range.

21. Schizaster gibberulus, Agass.

A. Ag., Rev. Ech., p. 612.

Locality.—VI., Kero-Nyuni Bay, sand, 5 to 10 fathoms.

A single specimen. This species strongly resembles S. *canaliferus.* The points of difference between the two species enumerated by Agassiz (*loc. cit.*) are not of great value, for all are very slight. If anything, the test of *S. gibberulus* is narrower and more arched, the apical system is slightly more anterior, and the bare abactinal surfaces are larger than in *S. canaliferus.* The tubercles of the actinal plastron cannot be said to be "coarser" and "more distinct," but the spines on the anterior half of the plastron are conspicuously spathulate. The species is certainly very closely allied to the Mediterranean *S. canaliferus.*

Height, 18 mm.	Length, ant. petals, 16 mm.
Long. dia., 42 mm.	Length, post. petals, 7 mm.
Trans. dia., 35 mm.	Length, odd petal, 22 mm.

Distribution.—Red Sea and Ceylon.

(*Issued separately, 17th February* 1910.)

IV.—Asteroidea of Portuguese East Africa, collected by Jas. J. Simpson, M.A., B.Sc. (1907-1908). By Jas. J. Simpson, M.A., B.Sc., and R. N. Rudmose Brown, D.Sc.

(Received 12th October 1909. Read 22nd November 1909.)

THE present collections were made on the Mozambique Coast of Portuguese East Africa, between September 1907 and May 1908. The portion of the coast on which faunistic work was done extends from near Cape Delgado in 10° 42′ S., to Pemba Bay (Maunhane Point), 12° 58′ S.

Very little work of this nature has been done on the western shores of the Indian Ocean, so that, although the collections made by the R.I.M.S. "Investigator" have done much to elucidate the fauna of the eastern side, our knowledge of the fauna of the east coast of Africa is very scanty.

The present collections therefore may help in some measure to fill in many gaps in our knowledge, both of the Indian Ocean fauna in general and in the distribution of many tropical forms in particular.

The collection of Asteroids consists of fourteen named species, but in addition to these we have described four species which we have at present refrained from naming. The latter include two species of *Pentaceros* and one of *Anthenea;* they are probably all young forms, so that although it has been impossible to refer them to any known species we do not feel justified in describing them as new. A study of different stages of growth, in other species of Asteroids, has convinced us that it is almost impossible to be certain of any species from a young specimen, and we strongly agree with Professor F. Jeffrey Bell that the application of new names to what may be young and immature stages is a course to be thoroughly condemned. A very good example of this is the species *Linckia marmorata*, which we have here described in some detail, as from the original description, based on a young specimen, it is almost impossible to identify mature individuals.

We have, however, given short descriptions of the essential diagnostic features of these young forms, as they may, by comparison with others, help to form a series of developmental stages in definite species.

We have attempted to show the geographical range of those species which occur on this coast. *Archaster angulatus* is here recorded for the first time from the western side of the Indian Ocean; and *Luidia aspera* appears to be new for the East coast of Africa.

The bathymetrical range in distribution and the nature of the associated bottom has also been recorded when possible, and a comparison made with other records.

Numerous observations on colour schemes have been given, and these, though often ignored by the cabinet zoologist, are of great significance to the field biologist, and show the futility of basing specific characteristics on colour. Very good examples of this are seen in species of *Pentaceros* and *Culcita*

We would like here to draw attention to a peculiar association or commensalism which, although it has been observed in Holothurians, has so far escaped notice in Asteroids, viz., that between a species of *Fierasfer* (as yet unidentified) and *Pentaceros lincki.*

While dissecting specimens of this species of starfish for drying, we were surprised to find occasionally a small *Fierasfer* ALIVE; careful dissection showed that these fish, occasionally in pairs, inhabited the stomach of the starfish, but were quite healthy and normal; in fact, we were able to keep them alive for some time in tanks. On placing some of these large starfish in the same tanks, it was possible to watch the *Fierasfers* passing out and in at the "mouth" of the *Pentaceros.* This disappearance and reappearance continued daily, so that we feel quite in a position to say that it is another example of commensalism, similar to that between fish and Holothurians, added to our knowledge of "associations."

Several very interesting specimens of *Linckia diplax* showing different stages in the regeneration of lost arms occur in the collection. Especially noteworthy are the comet-forms.

We are glad to have this opportunity of expressing our indebtedness to Professor J. Arthur Thomson, for kindly granting us laboratory accommodation in his department in the University of Aberdeen, as well as for other facilities; and we wish also to thank Professor F. Jeffrey Bell, for allowing us to compare our specimens with those in the British Museum, and for the interest he has taken in the collection.

For general utility we have adopted the classification given by Sladen in his report on the "Challenger" asteroids ("*Challenger*" *Reports, Zoology,* vol. xxx.), although a better classification has since been published in Bronn's *Thierreich.*

In accordance with the former, the following table shows the general relationships of the various genera and species reported upon:—

Class **ASTEROIDEA.**

Sub-Class **Euasteroidea**, Sladen.

Order I. **PHANEROZONIA**, Sladen.

Family ARCHASTERIDÆ.

Sub-Family ARCHASTERINÆ.

Archaster angulatus, M. and T.

Family ASTROPECTENIDÆ.

Sub-Family ASTROPECTENINÆ.

Astropecten Hemprichii, M. and T.
„ *polyacanthus*, M. and T.

Sub-Family LUIDIINÆ.

Luidia maculata, M. and T.
„ *aspera*, Sladen.

Family PENTAGONASTERIDÆ, Perrier.

Sub-Family GONIODISCINÆ.

Stellaster incei, Gray.

Family ANTHENEIDÆ.

Anthenea sp.

Family PENTACEROTIDÆ.

Pentaceros lincki, (de Blainv.).
„ *superbus*, Möbius.
„ *gracilis*, Lütken.
„ sp.
„ sp.
Culcita schmideliana (Retz.).
„ sp.

Order II. **CRYPTOZONIA**, Sladen.

Family LINCKIIDÆ.

Sub-Family LINCKIINÆ.

Ophidiaster cylindricus (Lam.), M. and T.
Linckia diplax, M. and T.
„ *marmorata* (Michelin).
Nardoa variolata, Gray.

Family PTERASTERIDÆ.

Sub-Family PTERASTERINÆ.

Retaster cribrosus (von Mart.).

Archaster angulatus, M. and T.

This typically shallow-water species is represented in the collection by four specimens of different size, all captured in the same haul of the dredge, in Mtundo Bay, between the islands of Wamizi and Kifuki.

Their measurements[1] are as follows:—

$R = 58 \qquad r = 10$

$R = 55 \qquad r = 9{\cdot}5$

$R = 36 \qquad r = 7$

$R = 27 \text{ to } 29 \qquad r = 6$

R therefore varies from $4{\cdot}8r$ to $5{\cdot}8r$.

In the first and largest specimen one arm has evidently been regenerated.

This is the first record, as far as we can discover, from the extreme western side of the Indian Ocean.

Locality.—Station III., Mtundo Bay (Wamizi Island to Kifuki Island).

Previously recorded from—West Australia; Freemantle; Port Darwin; Torres Strait; New Guinea; Philippines; Fiji Is.; Mauritius.

Astropecten Hemprichii, M. and T.

Several specimens of various ages and slightly different in superficial appearance represent this species. They were obtained in three separate localities, viz., Tunghi Bay, Mtundo Bay, and Montepes Bay. They agree exactly with those of the same species in the British Museum, collected by H.M.S. "Alert" on the Mozambique Coast. One specimen has been regenerating three arms from the disc.

Localities.—Station I., Tunghi Bay; Station III., Mtundo Bay (Wamizi Is. to Kifuki Is.); Station X., Montepes Bay.

Previously recorded from—Mozambique Coast; Red Sea; Mauritius; Ceylon; Tuticorin; Mergui Archipelago.

Astropecten polyacanthus, M. and T.

In the specimens, which we have identified with this species, the first supero-marginal plate is strongly armed with a vertical spine. The second supero-marginal on each side of the median interradial line is devoid of a spine, while the remainder have the same structure as the first.

Sladen draws attention to a specimen in which this characteristic absence is not pronounced.

This species is fairly abundant on the coast, and its distribution is

[1] All measurements are in millimetres.

interesting. It is a typically shallow-water species, as the following bathymetrical notes will show :—

China, ...	Beach.
Japan, ...	5 to 25 fathoms.
Admiralty Islands, . .	16 to 25 fathoms.
Port Jackson, . . .	2 to 11 fathoms, and 6 to 15 fathoms.
Mergui Archipelago, .	8 fathoms.
East Africa, . . .	6 to 12 fathoms.

Locality.—Station VI., Kero-Nyuni Bay, near Ras Pekawi.

Previously recorded from—Japan; China; Fiji Is.; Admiralty Is.; Port Jackson; Banda Sea; Arafura Sea; Macclesfield Bank; N. W. Australia; New Zealand; Andaman Is.; Mergui Archipelago; Ceylon; Seychelles; Amirante Is.; Mauritius; Zanzibar; and the Red Sea.

Luidia maculata, M. and T.

This species is represented by two specimens: the first, from Mtundo Bay, has seven arms; and the second, which is immature, has five complete arms, and three being regenerated from the disc.

The diagnostic characters in this species seem to be fairly constant, and our specimens agree very well with those previously described.

Locality.—Station III., Mtundo Bay (Wamizi Is. to Kifuki Is.); Station VI., Kero-Nyuni Bay.

Previously recorded from—S. Japan; Philippines; Singapore; Malacca; Macclesfield Bank; Mergui Archipelago: Tuticorin; and Mozambique.

Luidia aspera, Sladen.

This is a very distinct species, and we have no hesitation in referring our specimens to it. It is characterised by the form of the paxillæ and by the armature of the infero-marginal plates. The species is represented by one specimen from Tunghi Bay, and several detached arms which were obtained in a different haul of the dredge near the same place.

The following are the measurements of the complete individual:—

$$R = 145 \qquad r = 16 \qquad R = 9r.$$

Sladen, in describing this species, gives $R = 7{\cdot}5\,r$ and $R = 8{\cdot}5\,r$. He also remarks that the number of arms varies from 8 to 10, but in the above specimen the number was 7, so that this feature cannot be regarded as specific.

The bathymetrical distribution of this species shows a considerable range. The specimens from the Admiralty Islands were obtained in from 10 to 150 fathoms, whereas those on the East Coast of Africa were dredged in 9 to 15 fathoms.

Locality.—Station I., Tunghi Bay.

Previously recorded from—Philippines; Admiralty Is.; Macclesfield Bank.

Stellaster incei, Gray.

This species is represented by a single specimen, in which $R = 285$ and $r = 10$. The nature of the bottom on which a certain species exists is always interesting, inasmuch as it has often a distinct bearing on the individual specimens; but *S. incei* does not seem to be associated with any particular kind of bottom. At Mergui we found it occurring on—(1) mud and stones; (2) sand and mud; (3) coral and sand; and (4) sand and shell.

Its bathymetrical distribution is, however, restricted. The following records are noteworthy:—East Africa, 3 to 15 fathoms; Torres Strait, 6 to 8 fathoms; Arafura Sea, 28 fathoms; Philippines, 18 fathoms; Port Molle, 5 to 11 fathoms; Port Denison, 6 fathoms; Ceylon, up to 40 fathoms.

Locality.—Station VI., Kero-Nyuni Bay.

Previously recorded from—Korea; Singapore; North-West Australia; Port Curtis and Albany Island; and Mergui Archipelago (in addition to the above).

Anthenea sp.?

There occur in the collection seven small specimens which we have referred to the genus *Anthenea*. They are all immature, and as we were unable to identify them with any known species, we have refrained from establishing a new species to include them. The following notes, however, may be of interest:—

$R = 42$	$r = 18$	$R = 2{\cdot}3\ r$
$R = 41$	$r = 18$	$R = 2{\cdot}3\ r$
$R = 41$	$r = 17$	$R = 2{\cdot}4\ r$
$R = 39$	$r = 17$	$R = 2{\cdot}3\ r$
$R = 33$	$r = 15$	$R = 2{\cdot}2\ r$
$R = 29$	$r = 13$	$R = 2{\cdot}2\ r$
$R = 28$	$r = 12$	$R = 2{\cdot}3\ r$

There are nine marginal plates, excluding the unpaired terminal one; these are rectangular in shape and bear no pedicellariæ.

The supero-marginal plates are tuberculated; all, except those in the arcs, bear two tubercles, while three or four are not infrequent; the tubercles are arranged transversely. The infero-marginal plates bear spines only towards the extremities of the arms; three spines sometimes occur, either clustered or disposed longitudinally, never transversely.

The lophial line is composed of about 17 to 19 rounded plates; the proximal 5 of these bear tubercles, while the innermost of each line has a very large tubercle; a distinct pentagonal area is thus enclosed. The arrangement of the plates within this area is irregular; a few sometimes bear minute tubercles.

The madrepore is lozenge-shaped, and lies between the two adjacent plates which form one of the angles of the pentagon.

Valvular pedicellariæ occur in a discontinuous row on each side of the lophial line, while a few are also scattered on the interlophial plates and in the pentagonal area.

On the ventral surface the granulation is not prominent, and the plates are distinct. A definite line of valvular pedicellariæ extends on either side of the ambulacral grove; these lie usually longitudinally, but occasionally oblique. Larger forms also occur, scattered on other plates.

The ambulacral armature appears to consist of a single series, but near the apex of the arms a trace of a second series of spines is discernible. Each plate bears four almost equal spines; these are obtuse, flattened at the tips, and arranged in a palisade.

Locality.—Station X., Montepes Bay.

Pentaceros lincki,[1] de Blainville.

Locality.—Stations I. to X., Bottom—sand, or sand and rock.

Previously recorded from—Mergui; Tuticorin; Ceylon; Mozambique; and Zanzibar.

Pentaceros superbus,[1] Möbius.

Locality.—Stations I. to X., Bottom—sand, or sand and rock.

Previously recorded from—Tuticorin; Mergui; Sumatra.

Pentaceros gracilis,[1] Lütken.

Locality.—Stations I. to X., Bottom—sand, or sand and rock.

Previously recorded from—Mergui; East Australia; Port Molle and Port Denison, Queensland.

[1] These three well-known species are extremely abundant over almost the whole coast, and are a distinct menace to pearl-oyster beds. During the period over which my work extended on the coast, more than five thousand of these were brought up in the dredge, while on the shallow reefs thousands may be seen daily at low tide. The colour patterns on all these species, but especially on *P. lincki*, are worthy of attention. The general tone is in most cases blue, but the following variations in the colour of the spines were observed—(1) central spines orange, the others creamy-white; (2) all the spines vermilion-red; (3) all the spines creamy-white. Another type had bright yellow as a groundwork, while the spines were orange-coloured.

These few observations demonstrate the futility of basing any specific character on coloration in brightly-coloured asteroids. J. J. S.

Pentaceros sp.

In the collection there are three small specimens which are undoubtedly immature, but which belong to the genus *Pentaceros.* After a careful comparison of the type specimens of the various species of this genus in the British Museum, we have come to the conclusion that they approach nearest to *P. nodulosus*, Perrier, but in view of the fact that they are young and immature we would refrain from definitely referring them to this species.

The following notes may, however, be useful in illustrating the chief points of similarity and contrast.

The present specimens differ from the British Museum specimens on which Perrier founded the species *P. nodulosus* (*Archiv. de Zool. Expér.*, v., 1876, p. 53) in the following respects:—

$R=67$	$r=24$	$R=2{\cdot}8\,r$
$R=59$	$r=21$	$R=2{\cdot}8\,r$
$R=56$	$r=21$	$R=2{\cdot}3\,r$

Perrier gives $R=2\frac{1}{3}\,r$.

Marginal plates:—	Type specimen, .	36 to 38.
	Present specimens, .	15 to 17.
Tubercles on the lophial line:—	Type specimen, .	Ellipsoidal.
	Present specimens, .	Dome-like.

In addition to this we may note that in our specimens there are tubercles, conical or dome-like, on the lateral and supero-marginal plates. On the lateral plates they become larger towards the disc, while, in contrast to this, on the supero-marginal plates they are more prominent towards the tip of the arm.

In larger specimens of *P. nodulosus* these lateral lines are not to be seen, and it is possible that those of the specimens before us would disappear with the growth of the individual. In want of evidence regarding the possibility of this, we think it more advisable not to identify our specimens with this species at present. In the living animal the tubercles are light yellow, and the rest of the dorsal surface is dark brown.

The position of the madreporite is the same as in the type specimen, but whereas in *P. nodulosus* it is lozenge-shaped, in the present forms it is triangular to heart-shaped.

The spines of the ambulacral grove also show some variation:—

In *P. nodulosus*—	(1) inner series, .	7 to 9 spines on each plate.
	(2) outer series, .	3 larger spines.
In the present specimens—	(1) inner series, .	5 spines on each plate.
	(2) outer series, .	2 larger spines.

If our view of the species be correct, the great differences which may obtain between immature and mature specimens are most noticeable.

Locality.—Station IX., Matemo Island, Ibo Bay.

Pentaceros sp.

Another small specimen from Tunghi Bay is too young for specific determination. $R=32$; $r=13{\cdot}5$. The disc is distinctly elevated in the manner of *P. lincki.* On each lophial line are three or four prominent conical tubercles, culminating in size in the topmost one on the central disc, which is 3 to 4 millimetres in height. The tubercles are closely granulated, and through the granulated surface projects the small sub-acute apex. On the last two or three distal infero- and supero-marginal plates there are small spinous tubercles.

This may be a young form of *P. gracilis,* a species in which we know the development of spines is very variable. On the other hand, however, it may be an immature stage of *P. lincki,* but any categorical statement would be ill-advised.

Locality.—Station I., Tunghi Bay.

Culcita schmideliana (Retz.).

This very variable species is represented in the collection by a single large dried specimen which has become slightly damaged by damp. Only the dorsal skeleton and fragments of the ventral surface remain; however, the ventral tesselated plates show well.

In life the aboral surface was dark brown with much lighter brown poriferous areas; the oral surface was purple, becoming paler towards the mouth; the sides of the ambulacral grove were yellow, and around the actinostome there were distinct dark blue areas.

Referring to this species from Ceylon, Professor Herdman (*Rep. on Ceylon Pearl Oys. Fish.*, vol. ii. p. 144) remarks that "this cushion-like starfish . . . shows on the aboral surface a bright orange-coloured pentagon closely papillated, and with the ambulacral groves running as narrow red lines out to the angles. On the aboral surface there are short red spines on the well-marked lobed areas, while the surface between has a fine fluffy or velvet-like appearance."

Locality.—Station IX., Matemo Island.

Previously recorded from—Red Sea; Dar-es-Salaam; Zanzibar; Mozambique; Madagascar; Mauritius; Ceylon; Andaman Is.; and Amboina.

Culcita sp.?

This large starfish, popularly known as the "leather bun," is almost universally distributed along the coast, though not in such abundance as *Pentaceros.* The following notes may show the protean nature of the colour schemes in this wonderful genus. It is difficult to say if one or more species are here represented, but the former is more probable. These varieties are, at any rate, discernible:—

A. With black tubercles and scattered soft poriferous areas.

Ground, yellow, . . .	Areas, grey.
„ blue, . . .	„ brown.
„ bright yellow, . .	„ greenish-brown.
„ salmon-pink, . .	„ yellow.
„ light grey, . .	„ dark grey.
„ bright yellow, . .	„ yellowish-brown.
„ grey, . . .	„ dark brown.

B. With tubercles but no different coloured poriferous areas.

Tubercles black, with the general tone yellow, orange-yellow, brown, or pink.

C. With coloured poriferous areas but no tubercles.

Ground, yellow, . . .	Areas, brown.
„ blue, . . .	„ grey.
„ salmon-pink, . .	„ brown.

One specimen was entirely red.

These notes show the extraordinary variability in colour of the highly coloured Asteroids, a fact very often overlooked by the cabinet zoologist, but well known to every field naturalist. This is evidence how little, if any, reliance can be placed on colour as a specific character.

Ophidiaster cylindricus (Lam.), M. and T.

This is a typical coral-reef species, and is represented in the collection by several specimens of different ages from Montepes Bay. The following notes may prove interesting in a study of development:—

$R = 146$	$r = 14$
$R = 104$	$r = 11$
$R = 92$	$r = 9$
$R = 69$	$r = 8{\cdot}5.$

In life the colour schemes of this species are extremely striking, and are by far the most brilliant in the associated fauna. Many specimens are dark red all over; others are of a bright yellow, with dark red to vermilion blotches on the arms. They are somewhat slimy to the touch when alive. There is never more than one madrepore plate.

Locality.—Station X., Montepes Bay, between Kilalia Island and Sinkori Island.

Previously recorded from—Muscat (Brit. Mus.); Mauritius; Ceylon; Kondavi, Fiji Islands; Moluccas.

Linckia diplax (M. and T.).

This is apparently one of the commonest Asteroids on the coast. There are numerous specimens from three separate localities, viz, Tunghi Bay, Kero-Nyuni Bay, and from the reefs separating Das Rolas Is. from Matemo Is.

$$R = 175 \qquad r = 11 \qquad R = 16\,r.$$

The number of arms varies from four to six, and two madrepore plates occur on every individual except in one with six rays, which has three.

There are three comet individuals, in one of which $R = 112$, $r = 9$; in another $R = 60$, $r = 8$; while in the third $R = 89$, and $r = 39$.

In the largest specimens the small rays are thick in proportion to their length, and comparatively blunt. In the others they are almost normal in proportion.

In several individuals one or more arms have been truncated, and regeneration is in progress.

The two predominant general colours are brown and blue, with black dots. Many, however, are greenish blue on the aboral surface, and bear minute black dots, which give the whole the appearance of a branching coral. The oral surface is purplish-red.

Localities.—Station I., Tunghi Bay; Station IX., Matemo Is.; Station VI., Kero-Nyuni Bay.

Previously recorded from—Mozambique; Madagascar; Bourbon; Mauritius; Ceylon; Christmas Is.; New Caledonia; Fiji; and Friendly Islands.

Linckia marmorata (Michelin). (Figs. 1-4.)

The specimens which we have referred to this species were at first a little perplexing—in fact, from the original description and figures of *L. marmorata* it is well-nigh impossible to distinguish the species.

The type specimen was described by Michelin in 1844 in the *Revue Zoologique* as *Ophidiaster marmoratus*, thus:—

> "O. minima; radiis quinis, cylindraceis, violaceis et luteolis; parte superiori longitudinaliter quinque costatis, transverse rugosis, subtilissime granulatis, ad interstitiis varie tribus poris ornatâ; parte inferiori granulosâ; canalibus clausis; marginibus papillosis, duabus lineis parvulis tuberculis ornatis, tuberculo madreporiformi parvulo, rotundo, sulcato, violaceo."

In 1845 Michelin again referred to it in the *Magazin de Zoologie*, p. 21, and also figured it (plate 10)—("Essai d'une faune de l'île Maurice").

In 1869, von Martens placed the species in the genus *Linckia* (*Claus von der Decken's Reise; Seesterne und Seeigel*, p. 130); while in 1875 Perrier (*Archiv. de Zool. Expér.*) revised the species but gave little new specific character to it. He notes, however, that the type specimen had the following measurements:—$R = 10$ mm., $r = 4$ mm. The species was therefore established on a very immature specimen.

In 1884, Bell resuscitated the species and made a valuable contribution to the specific diagnosis (*Zool. Coll. of H.M.S. "Alert,"* p. 125). On this description, and taking as a basis some specimens in the British Museum which Bell has referred to this species, we have identified these puzzling forms in the present collection.

The following notes are given as a contribution towards the study of this species, and should be taken in conjunction with Bell's valuable variation references.

The arms are five in number; they are subconical, being slightly flattened on the ventral surface.

The measurements of the different specimens in the present collection are:—

$$R = 48 \qquad r = 9$$
$$R = 38 \qquad r = 7$$
$$R = 37 \qquad r = 7$$
$$R = 37 \qquad r = 7$$
$$R = 36 \qquad r = 7$$
$$R = 34 \qquad r = 6$$

i.e., $R = 5\frac{1}{7}$ to $5\frac{2}{3}\, r$.

The following is a description of the largest specimen (Figs. 1-4). The plates are all arranged in definite rows; they are markedly convex, and the axis is transverse. The following series may be distinguished:—One mid-dorsal series; two sub-lateral series; one very broad sub-ventral series. Several of the plates appear as if composed of segregations of smaller dome-like plates.

The median row, or mid-dorsal series, terminates in a larger plate at the junction of the arm and disc. Between these five plates, which are arranged pentagonally, five others are disposed symmetrically, while in the centre of the disc there occurs a single plate of a size similar to the others. The arrangement of the tubercles on the surface of the disc is markedly symmetrical.

The sub-lateral rows on opposite sides of adjacent arms are continuous through the angle; this series does not extend to the tip of the arm, but is terminated abruptly by the union of two sub-parallel poriferous areas.

The plates of the sub-ventral series are more or less rectangular in shape; they are densely covered with coarse regular granulations which are interrupted by a furrow, running medianly to half-way from the ventral edge of the plate.

The poriferous areas lie in six longitudinal rows, three on each side of the arms; the average number of pores in each group is about fifteen; the areas are distinctly larger than the corresponding plates. On each side of an arm the upper sub-lateral series of plates does not extend to the tip; consequently the poriferous areas which are otherwise separated by these plates are confluent in this region. Occasionally these larger poriferous areas are united transversely by small and almost inconspicuous lines, bearing pores.

The madrepore is simple and distinct, and recalls the structure of the coral *Fungia*. It is larger than the plates of the dorsal surface, and lies in the angle formed by the dorsal row of plates and the upper sub-lateral row.

The ambulacral armature is bi-serial; the inner row consists of large and small alternate spines, four or six on each plate (five may occur); they are blunt, sub-triangular in shape, and interlock. The spines of the outer series are larger, more distant, vertical, conical, and occur in pairs or threes on each plate.

In both series there is a tendency towards an alternation in these numbers—*e.g.* (1) inner series, four and six on alternate plates;
(2) outer series, two and three on alternate plates;
but from about halfway from the mouth to the tip of the arm the number tends to diminish and the rows lose their regularity. Occasionally a single

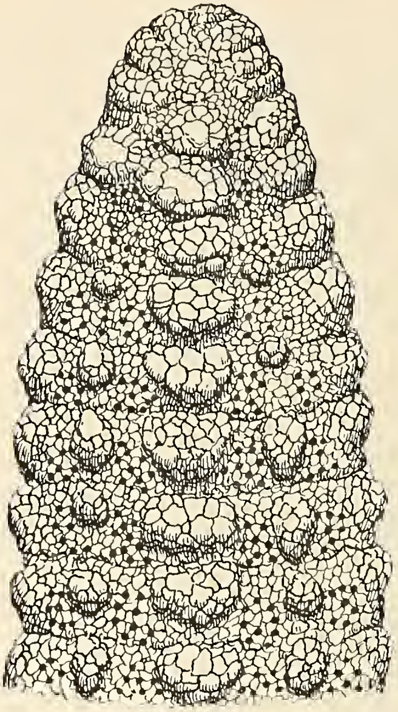

Fig. 1.

Tip of arm, dorsal view, showing the disposition of the various series of plates and poriferous areas.

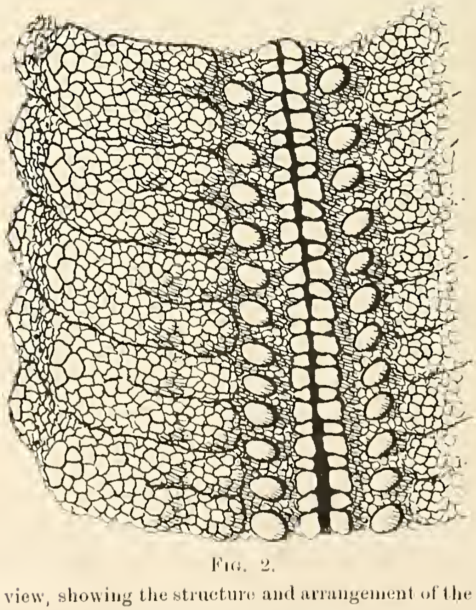

Fig. 2.

Portion of arm, ventral view, showing the structure and arrangement of the adambulacral armature.

Linckia marmorata.

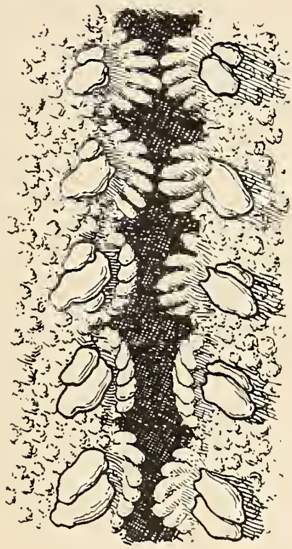

Fig. 3.
Portion of arm, ventral surface, showing the adambulacral armature.

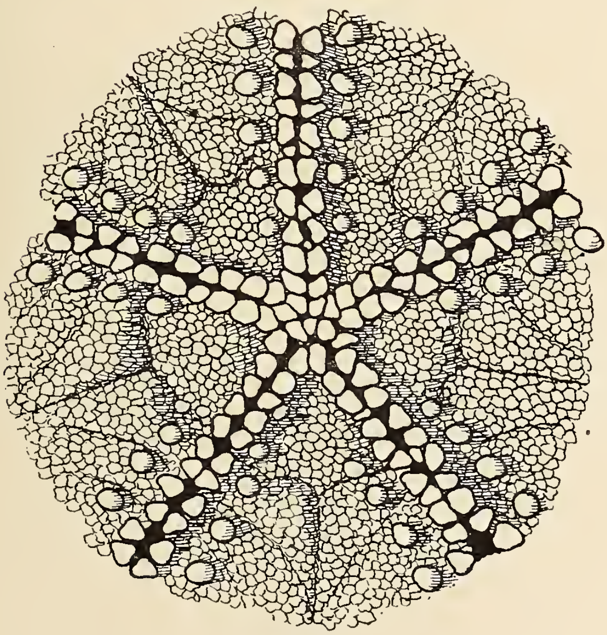

Fig. 4.
Oral Region.

Linckia marmorata.

additional spine may occur near the middle of a plate; this is more marked towards the distal end.

The colour fundamentally is brownish-grey, but the centre of the disc is usually purple. There are usually three or four transverse purple bands on each arm; these extend in some cases to the ambulacral grove.

Locality.—Type specimen: Station II., Wamizi Island. Five other specimens: Station I., Tunghi Bay.

Nardoa variolata, Gray.

Two specimens from the reefs around Matemo Island represent this species. In the largest $R=65$, $r=11$. Neither specimen is fully mature, and the number of plates on the side of each arm does not exceed 30 or 31, whereas in full-grown individuals 45 is not infrequent.

Locality.—Station IX., Matemo Island.

Previously recorded from—Red Sea; Zanzibar; Bourbon; Mauritius; Mozambique; Rodriguez; Ceylon; and Australia.

Retaster cribrosus (von Mart.).

This species is very abundant on the coast, and specimens from four different localities are represented in the collection.

$$R=38,\ r=\ 9;\ R=4{\cdot}2\,r.$$

$$R=37,\ r=13;\ R=3\,r.$$

Most of the specimens are fully grown, and in some of them the arms taper more than is usual in this species. In some individuals the paxillæ spinelets on the dorsal surface are not well developed, but even in young specimens they are never entirely absent.

The colour of the specimens is rather unusual. Most of them are black, with ashy-white ridges on the dorsal surface; sometimes these ridges are ruddy or even orange-coloured.

One specimen has only four arms, and these are arranged symmetrically.

Localities.—Station II., Maiyapa Bay (near Magi-mazizi); Station III., Mtundo Bay (between Wamizi Is. and Kifuki Is.); Station VI., Kero-Nyuni Bay; Station IX., Matemo Island.

Previously recorded from—Samoa and Philippines to Mergui; Amboina; Port Molle and Thursday Island, 4 fathoms (coral); Singapore; Ceylon; Mozambique; Dar-es-Salaam; and Zanzibar.

(*Issued separately, 18th February* 1910.)

V.—Note on a Hydrocoralline from Rockall.

By Professor **J. Arthur Thomson**, M.A.

(Read 20th December 1909. Received 20th December 1909.)

I received this summer, from a trawler, three pieces of an interesting Hydrocoralline brought up near Rockall,—that lonely granite rock in the North Atlantic (57° 36′ N. lat.; 13° 41′ W. long.),—184 miles west of St Kilda, 260 from the North of Ireland, 290 from the nearest part of the mainland of Scotland. As northern records of Hydrocorallinæ are few and far between, it is of interest to register this one.

The specimens are white flabellate colonies which agree with the description and figures of *Stylaster gemmascens* (Esper) given by Professor P. Martin Duncan (*Trans. Zool. Soc.*, viii., 1874, p. 332, pl. ix. 12 figs.). The diagnosis, quoted by Duncan from Milne-Edwards and Haime, reads :—"The corallum is subflabelliform. The branches often coalesce, and the younger are crowded with small granulations, which are irregularly placed between the calyces. The old branches are almost smooth. The calyces are alternate on young branches, and sparingly developed on the old; they are circular, oval, or deformed, and have projecting margins. There are from twelve to sixteen septa, which are often irregular."

The surface of the colony shows the "cups" that are characteristic of Stylasterids. They occur all round the smaller branches, but are chiefly lateral on the larger. Each "cup" consists, as is well known, of the cavity of a nutritive polyp or gastrozooid, surrounded by a circle of twelve or so smaller cavities lodging the tactile dactylozooids. Each cup bears a deceptive resemblance to the calyx of a Madrepore, a resemblance heightened in some cases, notably in *Aulopora*, by septa-like ridges extending inwards from the dactylozooids. It is historically interesting to notice that in Martin Duncan's memoir of 1874, where this form is beautifully figured, it is still misinterpreted as a Madreporarian, with which it has, of course, nothing whatever to do. To get a general picture of the nature of a Hydrocoralline colony, we have to imagine a much-branched hydrorhiza in which lime is secreted from the tubes instead of a perisarc, so that numerous fine canals are enclosed in a coherent calcareous framework. To this we have to add that the polyps are dimorphic or trimorphic,—gastrozooids, dactylozooids, and sometimes medusoid reproductive buds.

The type of *Stylaster gemmascens* came from the Indian Ocean The North Atlantic forms identified with the type were dredged by the "Lightning" and the "Porcupine" (530 fathoms). Another record is given by Sars (*Forh. Selskabs Christiania*, 1872, p. 115), from a great depth in the Foldenfjord, Norway.

(*Issued separately*, 18*th February* 1910.)

VI.—On a new Pseudaxonid Genus—*Dendrogorgia*. By Jas. J. Simpson, M.A., B.Sc., Carnegie Research Fellow, University of Aberdeen.

(Read 20th December 1909. Received 20th December 1909.)

In 1900 Professor Hickson (*Marine Investigations in South Africa—The Alcyonaria and Hydrocorallinæ*, p. 85) described two specimens under the name of *Juncella elongata* (Pallas), with the following observations:—

"Owing to the very imperfect state of our knowledge of the *Juncella* group of Alcyonarians, I have considerable hesitation in naming the two specimens of the genus sent to me from the Cape. . . . One of the most characteristic features of the specimen is the great preponderance of triple-star spicules 0·07 mm. in length, but there are also many spicules of the shapes known as double-stars, warted spindles, etc. There are very few spicules of the club-shape which are so characteristic of the species *J. juncea* and *J. gemmacea*."

The specimens were dredged at Rij Bank, off Algoa Bay, long. 25° 51′ 30″ E., lat. 33° 58″ S. Depth—25 fathoms. Bottom—dark sand.

In 1904 (*Alcyonaria of the Cape of Good Hope*, part ii., p. 233), while admitting that the triple-stars might be regarded as a character sufficient to distinguish these specimens as a distinct species, Professor Hickson refrained from doing so, but renamed them *Juncella elongata* (Pall.) var. *capensis*.

Professor Hickson very kindly sent me a small portion of one of his specimens along with various Juncellids, and later, Professor Thomson placed a magnificent specimen, identical with the type, at my disposal. The latter specimen was also found at the Cape.

Owing to the inadequate descriptions of *Juncella elongata* very diverse forms have been, from time to time, ascribed to it, but an investigation of the spicules hitherto undescribed, has shown that the specimens under consideration—Professor Hickson's and ours—cannot be referred to the genus *Juncella*. In fact the specimens do not belong to the Juncellids at all.

Before entering into a discussion of the systematic position of our specimen, we shall give a short description supplementary to that which Professor Hickson gave of those specimens which he referred to *Juncella elongata* (Pallas) var. *capensis*, n.

Dendrogorgia capensis, n. gen. et sp.

A beautiful specimen of a deep-red colour (Fig. 1), massive in appearance, and branched openly in one plane in what is evidently a false dictotomy.

The base is wanting. The total height of the colony is 20 cm. and the maximum breadth is 3·5 cm. The diameter of the main stem at the base is 9 mm. Near the base it gives rise to two primary branches with diameters of 8 mm. and 7 mm. respectively. The former divides after a distance of 10·5 cm., giving rise to a branch 6 mm. in diameter at its point of origin. The latter branches after a distance of 5 cm.; the diameter of this secondary branch is 6 mm. Slightly beyond this point the main branch has been contorted and curves towards the secondary branch.

All the branches taper very slightly; one, however, maintains its original diameter throughout and terminates bluntly in a dome.

The axis is 5·5 mm. in diameter at the base and tapers to a fine point in the branches; it is comparatively soft and is easily cut with a knife. The horny part is spongy and the calcareous portion is composed of long smooth or slightly warty irregular spicules, quite unlike those of the cœnenchyma. These are longitudinally disposed. The axis is composed of concentric layers, which, however, are not very distinct; the outermost of these may be detached in flakes, and the actual arrangement of the spicules is there visible. When boiling down the cœnenchyma in strong caustic potash many of the spicules become detached from the axis, and prolonged boiling of the axis disintegrates the greater part of it. The axis is separated from the cœnenchyma-proper by a thin horny layer in which spicules identical with those of the axis are embedded; this detaches with the cœnenchyma, but it is undoubtedly a young layer of the axis.

The cœnenchyma is almost uniformly thick throughout, being, however, slightly thinner towards the base. The proportion of cœnenchyma to axis is markedly different at the various levels (Fig. 3), but in this connection it is noteworthy that increase in thickness towards the base is due not so much to growth in the cœnenchyma as to growth in the axis. The cœnenchyma is comparatively soft, but at the same time densely spiculose.

Canal system (Fig. 2).—Around the periphery of the axis there is a series of minute longitudinal canals all of the same size. Towards the outside of the cœnenchyma, between the polyps, not internal to them, there are also a number of longitudinal canals, and several are also scattered in the cœnenchyma between these two series. The whole of the cœnenchyma external to the inner series is penetrated by a net-work of transverse canals uniting the various longitudinals.

The polyps are distributed over the whole of the cœnenchyma (Fig. 3), the actual number at one level being dependent upon the position in the colony. There are no very distinct verrucæ, due no doubt to the great thickness of the cœnenchyma; the anthocodiæ are withdrawn into the

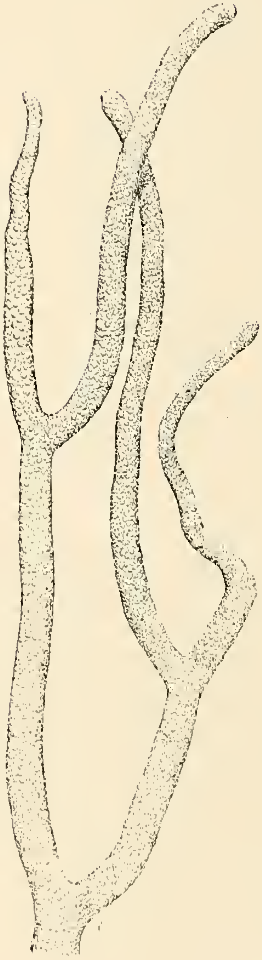

Fig. 1.

Colony, to show general habit.

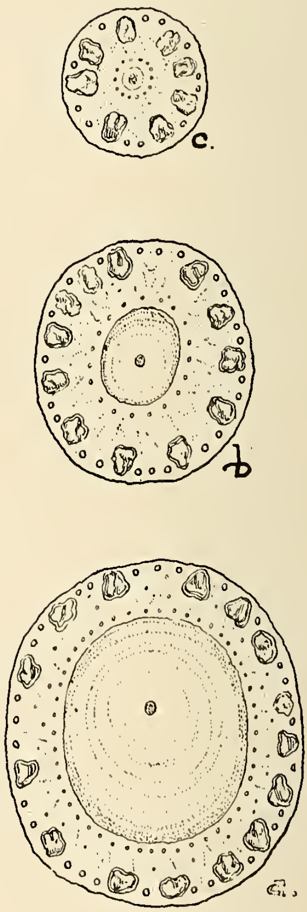

Fig. 2.

Transverse sections at three levels, to show the internal structure.

Fig. 3.

Small portion enlarged, to show the nature and distribution of the verrucæ.

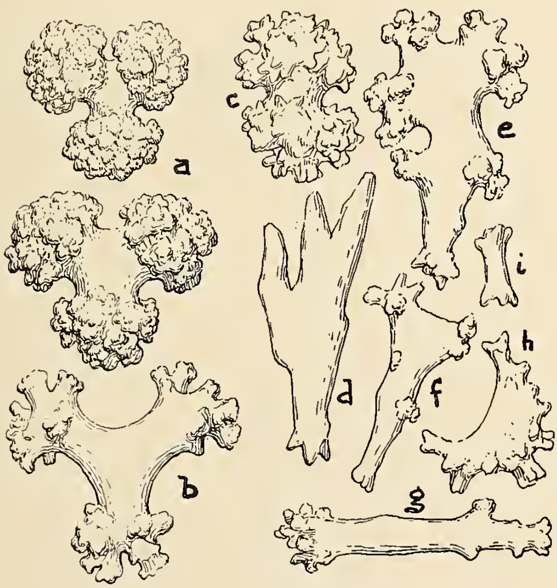

Fig. 4.

Spicules.

cœnenchyma, and their position is marked by a slightly elevated wart-like projection with a central pore, around which may be discerned an eight-rayed figure.

The spicules of the cœnenchyma (Fig. 4, *a*, *b*, and *c*) consist almost entirely of triple-stars. Of these there are two distinct types—(*a*) triple-stars with very densely-warted and closely-set heads, and with very short handles; (*b*) triple-stars with much longer handles and with the heads covered with openly-set long warts; (*c*) a few double clubs also occur. Most of these spicules are red in colour. The spicules of the axis are colourless; they are very irregular in shape. Some are almost smooth, while others are warty. A few of the characteristic variations in these spicules are shown in Fig. 4 (*d–i*).

The following are some of the measurements [1] in millimetres:—

1. Cœnenchyma (Fig. 4, *a–c*).

   (*a*) Triple-stars with short shafts and densely-warted star portions.

   0·076; 0·068; 0·065; 0·038; 0·03.

   (*b*) Triple-stars with long shafts and with few simple warts in the star portion.

   0·087; 0·068; 0·065; 0·053.

   (*c*) Double-stars—a few of these occur, but they are usually small and may be undifferentiated triple-stars.

   0·072 × 0·03; 0·057 × 0·042; 0·038 × 0·019.

2. Axis (Fig. 4, *d–i*).

   0·152 × 0·076; 0·114 × 0·065; 0·106 × 0·06; 0·106 × 0·075.

There can be no doubt that our specimens belong (1) to the Order Pseudaxonia, and (2) to the Family Sclerogorgidæ, which is thus defined by Bourne (Lankester's *Treatise of Zoology*, part ii., "The Anthozoa," p. 25): "The medullary mass forms a distinct axis consisting of closely packed elongate spicules with dense horny sheets. The axis does not contain solenia but is surrounded by longitudinal canals, *i.e.*, by large solenia which are connected with the zooid cavities by smaller ramifying solenia."

The position of the Gorgonellidæ, in general classification, is a matter of some difficulty, but in a memoir on that family about to be published, we have suggested that forms such as the one under consideration may be annectent between types like *Suberogorgia* and types like *Juncella*, but our present knowledge does not warrant the inclusion of this form in the

[1] The measurement of the triple-stars taken is the maximum, *i.e.*, from the extreme end of one "star" to the extreme end of an adjacent "star."

Gorgonellidæ. The axis is markedly "sclerogorgic" in that it consists of individual spicules, different from those in the cœnenchyma, embedded in a horny matrix. The horny substance, in which the spicules lie longitudinally, is deposited in the form of concentric laminæ, but the same applies to the genus *Suberogorgia,* as was pointed out by Gray in his original description of this genus, where he says:—"Axis, pale brown, formed of rather loosely concentric fibrous laminæ, containing a large quantity of calcareous matter."

The proportion of the horny material to the calcareous is, however, very much greater in the present case than in *Suberogorgia;* the nature of the colony is quite different; there is no trace of two main longitudinal canals larger than the others in the present specimen, and the spicules are very distinctive, both those of the axis and those of the cœnenchyma.

For these reasons it seems necessary to establish a new genus, which we propose to call *Dendrogorgia,* in the Family Sclerogorgidæ, Order Pseudaxonia.

The following generic diagnosis, based however on a single species, may be given:—

Colony very robust, slightly branched approximately in one plane; the branching is a false dichotomy. The axis is "sclerogorgic," and is moderately soft; it does not contain solenia, and is composed of concentric laminæ, consisting of a horny matrix in which spicules are embedded longitudinally.

The spicules of the axis are smooth or warty, and very irregular in shape. The cœnenchyma is very thick, and is almost of a uniform thickness throughout. It is densely packed with small spicules which are predominately triple-star-shaped; double-stars also occur. The triple-stars are of two kinds—(1) those with short "shafts" and large, closely tuberculated "heads," and (2) those with long "shafts" and openly-warted "heads." The canal system is very definite; it consists of (1) an inner longitudinal series separating the axis from the cœnenchyma, and (2) an outer longitudinal series which is situated near the periphery. Uniting these there is a dense network of small transverse solenia. The polyps are disposed over the whole cœnenchyma; there is no distinct separation into verrucæ and anthocodiæ; they are capable of being completely retracted into the cœnenchyma when a small pore surrounded by an octoradiate structure is to be seen.

Locality.—Bird Island, E. by N. ¼ N., 5 miles (Cape Colony); depth, 40 fathoms; bottom—mud.

(*Issued separately, 19th February* 1910.)

VII.—On the Distribution of the Thorny Lobster (*Palinurus vulgaris*) in British Waters. By James Ritchie, M.A., B.Sc., Natural History Department, The Royal Scottish Museum.

(Read 22nd November 1909. Received 10th January 1910.)

This note is an effort to dispel, in one instance, the haziness of knowledge which shrouds the limits of distribution of even common British marine invertebrates.

The Thorny Lobster—*Palinurus vulgaris*, Latreille (*P. elephas* (Herbst))—otherwise known on the coasts of Britain as the Spiny Lobster, Rock Lobster, Red Crab, Craw-fish, even as the Long Oyster, and in Europe as the Langouste, is a southern form, very common, according to d'Orbigny, on the rocky parts of the southern and western coasts of France, occurring also on the shores of Algeria, especially in the roadsteads of Algiers and Oran. Its distribution from this southern centre is not a wide one, for, as we pass northwards, it gradually drops out of existence; so that in fixing its British distribution we practically fix at the same time the limits of its dispersal to the north.

General accounts of British Crustacea agree in allotting to the Thorny Lobster a vague area on our southern and western coasts, none being more definite than that of Bell: "This fine species is an inhabitant of our western coasts, where it occurs in great numbers, and from whence it is brought in considerable quantities to the London market. It is much esteemed as an article of food, although certainly of inferior flavour to the lobster. It is but sparingly found in the north, whether of England or Ireland, but is equally common on the southern coasts of both."[1]

Of its abundance on the south coast of England there are many records. It is "taken in large quantity all round the coast [of Cornwall] and at Scilly, and ranks in importance with the Lobster and the Edible Crab. Though often found inshore it is most plentiful, of largest size, and of finest condition in deep waters, where its most congenial haunts are on rocky and on 'scuddy' ground, in shady lanes among rocks, and indeed where sand and rock come together."[2] Eastward from Cornwall it appears to be scarcely so abundant, for although it is common in the neighbourhood of Plymouth,[3]

[1] T. Bell, *A History of the British Stalk-eyed Crustacea*, London, 1853, p. 215.

[2] J. Clarke, *Zoologist*, Aug. 1909, p. 303.

[3] Marine Biological Association, "Plymouth Marine Invertebrate Fauna," 1904, p. 252, *Jour. Mar. Biol. Ass.* (n s.), vii. 2.

and Stebbing vouches for its presence at Salcombe and Torquay, in Devonshire,[1] at the Isle of Wight it "appears to be a rare species in the Island. Specimens are very occasionally taken by fishermen in Sandown Bay (G. T. Woods)."[2]

Rounding the South Foreland, *Palinurus vulgaris* makes its appearance in the North Sea, for Dr H. C. Sorby, in MS. notes relating to the Crustacea of Essex, says of it that he has "never obtained any in trawling or dredging, but it is caught in traps off Walton-on-Naze."[3] The most northerly authentic record I have noted for the east coast is that of a fine specimen taken in a trawl off Flamborough Head and presented to the Grimsby Museum.[4] The species is unknown off the coast of Durham and Northumberland, and Canon Norman and Mr Brady, in their recent catalogue of the Crustacea of those counties, include it in a list of the species which, "well known in the south of our islands are wholly absent from the north-east coast of England."[5]

On the west coast of Britain the distribution is more general than on the east. Abundant in the neighbourhood of Lundy Island, *Palinurus vulgaris* occurs at various localities in Wales and on both sides of the Irish Sea. Northwards, however, records become more scarce. In the Firth of Clyde it is occasionally found. Henderson says: "Off Campbeltown (Martin). Mr Brook obtained a single specimen in Loch Fyne. It is occasionally seen in fishmongers' shops in Glasgow."[6] Specimens from this area also exist in the collections of the Royal Scottish Museum, in the Millport Marine Station (Mr R. Elmhirst), and in the Bute Museum, Rothesay. Mr Archibald Burn Murdoch informs me that the Thorny Lobster occurs, but not commonly, in the Sound of Mull, off Drimnin, in trammel nets set for common Lobsters, and a specimen from "near Tobermory" is in the M'Lean Museum, Greenock. Here also is to be found an example "from near the Island of Skye," in all probability a specimen which Dr Thomas Scott of Aberdeen presented several years ago.[7] From

[1] T. R. R. Stebbing, in *Victoria Histories of the Counties of England: Devonshire*, i., 1906, p. 262.

[2] F. Morey, *A Guide to the Natural History of the Isle of Wight*, Newport and London, 1909, p. 286.

[3] T. R. R. Stebbing, in *Vict. Hist.*, *Essex*, i., 1903, p. 208.

[4] A. Smith, quoted by Stebbing, in *Vict. Hist.*, *Yorkshire*, i., 1907, p. 300.

[5] A. M. Norman and G. S. Brady, *Trans. Nat. Hist. Soc. Northumberland, Durham, and Newcastle-on-Tyne* (n.s.), iii., 2, 1909, p. 10.

[6] J. R. Henderson, *Trans. Nat. Hist. Soc. Glasgow* (n.s.), i., 1883-1886 [1887], p. 325.

[7] For the data regarding the Greenock specimens, I am indebted to Mr Charles Brunton, Greenock.

this latter neighbourhood comes one of the Royal Scottish Museum examples, a large female, which in October 1909 Mr A. Johnston presented, with the information that it had been caught on his line while he was fishing off Mallaig in Inverness-shire. In the same collection are a small male specimen from North Uist, presented in 1888 by the Rev. J. Agnew, Dunbar; and a small female found in May 1907, in a crab-pot off the Point of Stoer, in Sutherlandshire, and presented by the light-keeper, Mr John Mathieson, who described it as previously unknown in the locality.

The distribution of *Palinurus vulgaris* comprises, therefore, practically all the west coast, although that it is a rare animal in the northern portions is vouched for by the scarcity of records, better still by the experience of observers so skilled as Professor W. C. M'Intosh and Dr Thomas Scott, neither of whom found any trace of the Thorny Lobster during his stay on the Outer Hebrides.

I am aware of only two occurrences of the species on the North of Scotland. To Dr W. T. Calman I owe the information that a specimen exists in the British Museum labelled "Papa Westra, Orkney, presented by J. Cowan, Esq., 90.6.16.1"; while in May 1909, I received for identification from Mr W. Wood, Stromness, a life-sized and very characteristic sketch of *Palinurus vulgaris,* with a descriptive note stating that the animal portrayed had been found near Stromness in a lobster-creel, and was unknown to the fishermen thereabouts. It is of interest to find that Canon Norman, at the British Association Meeting in 1868, included this species in a list of those "especially characteristic of the Fauna of the Southern portion of the British Isles, which are wholly absent from the Shetland seas."[1]

This rapid survey of the British distribution may be completed by a glance at the records of *Palinurus vulgaris* from Irish seas. For the references and for the still unrecorded observations made by Mr Rankin and by the Fisheries Branch of the Irish Department of Agriculture and Technical Instruction, I am indebted to the courtesy and kindness of Mr Stanley W. Kemp of the above-mentioned department. I have already quoted Bell's statement that the Thorny Lobster, while common on the south coast of Ireland is sparingly known in the north. On the east are records from Antrim (Larne Lough, Rankin), and from Dublin (Dalkey Sound, rare, Kinahan;[2] and Kingston and Killeney Bays, Kinahan);[3] on the south from Cork (Youghal, R. Ball;[1] and Cove, Humphreys);[2] on the west from Kerry

[1] A. M. Norman, *Rep. Brit. Assoc.*, Norwich Meeting, 1868 [1869], p. 262.

[2] J. R. Kinahan, Nat. Hist. Review (*Proc. Dublin Nat. Hist. Soc.*), iv., 1857, p. 158.

[3] J. R. Kinahan, *Brit. Ass. Rep.* (Oxford Meeting), 1860 [1861], p. 31.

(Derrynane, where it is not uncommon, Fisheries Branch; and Valentia, Kinahan);[3] and from Galway (Galway Bay, rare, Melville;[4] Oranmore, Galway Bay, rare, Fisheries Branch; Ballynakill Harbour, uncommon, Fisheries Branch); on the north Kinahan records a specimen in the Ordnance Survey Collection from Magilligan, in Londonderry.[3]

These records indicate that *Palinurus vulgaris* occurs all round the Irish coasts, but, according to Mr Kemp, "it is never found commonly, and in my experience it is always scarcer than the lobster."

Note.—I have to thank Dr Calman for drawing my attention to the fact that the most northerly record in Europe is that of a single specimen from near Bergen, of which Professor Appellöf says, that if, indeed, it has not been thrown overboard from a ship, it is, at least, a zoogeographical abnormality. The occurrence of the Thorny Lobster at places all along the west and also on the north of Scotland renders the Norwegian record—in almost the same latitude as the Orkney localities—less abnormal than would at first sight appear, for it is well known that southern species found on our west, but not on our east coast, frequently reappear on the shores of Norway.

Summary.

Palinurus vulgaris has been recorded from various localities along all the coasts of the British Isles, except from that portion of the east coast which lies to the north of Flamborough Head. It is most abundant in the south-west, becoming scarcer northwards, although the apparent scarcity may, in part, be due to its long and unyielding antennæ which, Couch states,[5] frequently hinder it from entering crab pots. This extended British distribution makes more intelligible an isolated Norwegian record from almost the same latitude.

[1] R. Ball, in J. R. Kinahan.[3]

[2] Harvey, Humphreys, and Power, *Contributions to the Fauna and Flora of Co. Cork*, 1845.

[3] J. R. Kinahan, Nat. Hist. Review *(Dublin Nat. Hist. Soc. Proc.)*, iv., 1857, p. 68.

[4] A. G. Melville, Nat. Hist. Review *(Proc. Dublin Nat. Hist. Soc.)*, iv., 1857, p. 153.

[5] J. Couch, *Cornish Fauna*, 1838, p. 77.

(*Issued separately*, 19*th February* 1910.)

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OF THE

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PROMOTION OF ZOOLOGY AND OTHER BRANCHES OF NATURAL HISTORY.

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VIII.—"On some Habits and Hosts of Bird *Ceratophylli* taken in Scotland in 1909; with description of a new species (*C. rothschildi*), and records of various Siphonaptera." By James Waterston, B.D., B.Sc.

(Read 24th January 1910. Received 31st January 1910.)

The immediate occasion of the present paper was the discovery of a new *Ceratophyllus* sparingly represented in a long series of *C. farreni*, Rothsch., received in October 1909. This abundant material (*farreni*), then and subsequently examined, also afforded an opportunity of making some observations on life-history, etc., which, with others of slower accumulation, have now been put into a more connected form. The captures made last year include all the known British bird fleas of the genus *Ceratophyllus*. This result must be ascribed to the hearty co-operation of several workers who searched for nests and sometimes forwarded linings. Whenever practicable, however, a personal visit to the various localities indicated was paid to ensure identification of the host, if necessary, and to gather proper material. All the assistance rendered has, I hope, been acknowledged, but special mention must be made of the services of the following—Messrs A. Bennett, jun., Arniston, Midlothian; J. Brown, Lochgelly, Fifeshire; J. F. Cormack, jun., Lockerbie; J. Gloag, Loudoun, Ayrshire; Rev. J. R. Fraser and A. M'Innes, Kinneff, Kincardineshire. To these gentlemen, and to all who have helped, my warmest thanks are due. I have also been indebted in very many ways to the unfailing kindness of the Hon. N. Charles Rothschild, M.A., who has made the study of the Siphonaptera peculiarly his own.

So much remains to be done among the bird *Ceratophylli* of Scotland not simply in working out their local distribution and the various œcological problems connected with them, but almost certainly in the discovery of new species, that it might seem idle to attempt to indicate where investigation may most profitably be directed. A good rule is never to pass a nest, while every examination made should be as exhaustive as possible. But special attention might now be given to for rarer breeders, and to all sea birds and Raptores. A detailed record, say, of the fleas taken in the nest of a Golden Eagle (*Aquila chrysaëtus*) during a breeding season would add materially to our knowledge of these insects.

No one is more aware than the writer how fragmentary are many of the following notes, and how tentatively any conclusions as to habits, etc., should be offered. These remarks, however, will perhaps serve as a basis for further work in a group which has hitherto received far too little attention in Scotland. It should be added that in what follows the references have been reduced to a minimum, but a full Bibliography of papers, lists, and records dealing with Scottish Siphonaptera will form part of a "Census" now in preparation.

I have arranged the observations made in the order of the chief stages of the life-history.

A.—Ovum and Oviposition.

The act of egg-laying has not yet been observed by myself, but once or twice eggs have been detected in dust or débris in the bottom of nests. This powdery matter, composed largely of dried, rubbed-down fæces of the birds mingled with scales from their young, forms a most suitable food for the larvæ of *Ceratophylli.* It is much frequented by gravid females. Bird flea eggs are relatively large, oblong, rounded at both ends, and opaquely white. They are in my experience usually laid singly, and, unlike Mallophagous eggs or Pediculine "nits," do not adhere to the surface on which they are placed. Occasionally one or two eggs are found cohering, and once a female (*C. walkeri*) in alcohol was accompanied by a regular chain of eggs. These, however, may have been forced out of the abdomen by contraction of the muscles in spirit.

Ceratophylli may also lay their eggs *on the hosts themselves.* From a Meadow-Pipit (*Anthus pratensis*) I have taken a single egg, probably of *C. garei*, as a female of this species occurred on the same host, and no other parasite or indication of a parasite (*e.g.*, eggs or empty skin) was present. On an equally clean Redwing (*Turdus iliacus*), from Colinton, December 1909, there was a single crushed egg attached to a feather by the expressed yolk. This, too, apparently belonged to a *Ceratophyllus.*

B.—From Ovum to Imago.

From 1905–1908 I had on several occasions bred *Ceratophylli* by the simple expedient of keeping nest linings in bags. The only care taken was to avoid drying up of the larvæ or pupæ. In 1909 more accurate notes of the time occupied in the various life stages were made, and in particular a very interesting opportunity occurred of studying the whole life-history under natural conditions.

During the second week of March 1909, Mr Alex. Bennett, jun., Shank Garden, Arniston, made a cavity in the decaying limb of an ash tree there, in the hope of inducing Owls, observed to be haunting the spot, to nest. The hole, some 2 feet in depth, was situated about 15 feet from the ground.

Within 10 days a pair of Tawny Owls (*Syrnium aluco*) had taken possession and laid two eggs.

From the entirely artificial nature of the nesting site, it was clear that any parasites found later would be derived either from the Owls or from their prey. Accordingly, from time to time throughout the summer, bagfuls of nesting material were carefully examined and the results noted. This material consisted mainly of woody detritus mixed with feathers, fur, and castings.

On 8th April there were numerous castings in the nest, while feathers of the Sparrow (*Passer domesticus*) were plentiful. Very minute Siphonapterous larvæ were present in swarms. These being kept damp in a warm corner grew rapidly and had spun up in a few days. On 28th April imagines began to emerge. These included two species of *Ceratophyllus*, viz., *gallinæ*—in crowds, and *sciurorum*—a few.

By 5th May there were two young birds in the nest, one showing incipient quill feathers, the other being in down. The prey was more varied than a month before, for, in addition to mouse and vole casts, there were undoubted remains of Pied Wagtail (*Motacilla lugubris*); Wren (*Troglodytes pauvulus*); Greenfinch (*Ligurinus chloris*); and Thrush (*Turdus musicus*). Other feathers pointed almost certainly to Garden Warbler (*Sylvia hortensis*) and Chaffinch (*Fringilla cœlebs*).

Siphonapterous larvæ were less numerous now, but an additional species, *C. fringillæ*, was sparingly bred from material collected on this visit. Larvæ of a Dipteron, *Blepharoptera serrata*, occurring in swarms, yielded imagines by 31st May.

Several visits were paid to the nest in the first ten days of June. On the second a striking sight was to be seen—*Ceratophylli* leaving the nest in a regular[1] army. They jumped towards one when approached within 2 to 3 inches and bit viciously at the exposed hands. *Sciurorum* only was detected in the act on this occasion, but *gallinæ* was far the commoner species.

Owing to the accumulation of fæces, largely composed of lumps of pink chalky urates, the nesting hole had a strong alkaline smell. Under these conditions the dipterous maggots throve well, but latterly not a single flea larva could be detected. The environment was possibly too acrid.

In June the bill of fare included Blackbird (*T. merula*), and Starling (*S. vulgaris*), in addition to others already mentioned. Latterly heavy toll was exacted from young Passerines—especially Thrushes.

[1] Very large swarms of fleas have been noted on five occasions. In three cases the species was *gallinæ*, in the other two, *farreni*.

As regards the *Ceratophylli* observed—*sciurorum* was most probably introduced during the chance visit of an inquisitive Squirrel, though an avian source is not impossible. Or the Squirrel even may have fallen a victim to the Owl. *Gallinæ* and *fringillæ* may have come from almost any of the birds noticed. The really surprising feature of the list is its omissions. No mammalian fleas occurred, and the ubiquitous *gallinulæ* failed to put in an appearance. For this reason no effort has been made to identify the castings accurately. Many of the more doubtful feathers have been determined by Mr Eagle Clarke.

Some additional notes may be given on,

C.—The Pupal State.

This may last from a fortnight to several months according to temperature, etc. At the time of writing (31st December 1909), I have by me living cocoons of *farreni* which were spun not later than the middle of September. Possibly if left alone these would continue unchanged till the return of the Martins in April. Unlike many of our insects which hibernate in cocoons, bird *Ceratophylli* reach maturity shortly after spinning up. This fact has been noted in many instances (several species) and its occurrence is probably general. If a cocoon be opened, the perfect insect is found already divested of its pupal envelopes. Cocoons may generally be found in deserted nests, among feathers, inside straws, etc., and sometimes form dense felted masses when numerous. They are particularly sensitive to mechanical disturbances. If a small bunch of nest débris containing cocoons be teased out and the mass put in a bag, in a short time all the imagines will emerge. Emergence normally takes place by a forward movement of the insect. It is quickly achieved and jumping may begin at once. Owing to the number of backwardly-directed bristles or spines on these creatures, it is impossible to pull them from the cocoon *à posteriori* without mutilation. Yet if instead of attempting a forceful eviction one simply stimulates a cocoon behind, the enclosed flea will in the majority of cases come out at once.

D.—The Imago.

Adult habits.—At all times *Ceratophylli* shun light, and in a bag seek the dark corners. When shaken on to a sheet at a window they invariably move towards an observer, which frequently facilitates handling the creatures. Their usual progress is a scrambling run on rough, woolly, or fibrous surfaces, alternating every now and then with apparently aimless leaping. But on smooth surfaces *Ceratophylli* move almost entirely by leaping. Often when examining material from nests, one finds fleas feigning death with the legs tightly tucked up to the body, in which condition they resemble little shining seeds.

Thrice when a swarm was encountered, I found that no attention was paid to my hand till it had approached within, say, a couple of inches of the vanguard. Then an excited jumping ensued so straight up and down, that, at the time, the conviction was irresistible that the fleas were aware of the proximity of food. Later the point became more doubtful when examples of *farreni* could not be induced to leap towards a warm object held above them. It is more than likely that, in a life so precarious as a flea's, speculative jumping plays a very large part. It is only fair to add, however, that smell may guide *Ceratophylli* to their hosts. I have not tried to ascertain if this is so, indeed it does not seem easy to devise a decisive experiment.

Presumably all these bird fleas will attack man on occasion, and I am personally satisfied that *gallinæ* and *farreni* (and *sciurorum*) do so. But it is by no means certain that they will always bite even when they have the chance. Newly emerged imagines have much fat in their tissues—especially round the alimentary canal—which must form a reserve of food for some time. I have not been attacked by bird fleas in this condition. Probably their attention is otherwise engaged.

Breeding.—Possibly my experience may be unusual in this respect, but until December 1909 few cases of ♂ and ♀ in *coitû* had come under observation. In examining then a Martin's nest (*Chelidon urbica*) I put the fleas (*C. farreni*) into a glass-topped box as they were taken. As nothing happened the box was laid aside, but shortly afterwards a ♂ and a ♀ were seen to have copulated. In this state they remained about half an hour, which subsequent observation showed to be fairly normal, though sometimes (with a low temperature) an hour to an hour-and-a-half elapsed before separation. Of twenty fleas put into a test tube on the same day three pairs shortly mated, but, at the time, no details were made out owing to the creatures confused and rapid movements.

Next morning about a dozen *farreni*, newly emerged from pupæ, were segregated in a test tube and the mouth plugged with cotton wool. In half an hour no unions had occurred. This was so contrary to expectation as to cause a comparison of the conditions of the two experiments. The only difference seemed to be this, that on the previous day the weather had been appreciably warmer, besides which both box and tube had been held sometime in hand, while this morning the temperature was hardly above freezing point. Accordingly I placed the test tube in the palm of my hand, At once the fleas began to quicken their sluggish scramblings, jumping up and down and tumbling over one another. Two ♂ ♂ were selected for closer observation. Soon one was seen to jerk his posterior segments upwards repeatedly. Watching him with an aplanatic lens (× 20) I could see that the 8th tergites[1] were plainly diverging while the "fingers" of the clasper were in motion up and down.[2] Suddenly he ran to a ♀, shoved his head below her till his frons rested beneath and slightly behind her posterior coxæ. At the same time his forelegs seemed to catch momentarily the hind ones of the ♀, pinning her down and forcing her to elevate the posterior segments, which were at once gripped by the upturned, outspread 8th tergites of the ♂. Thus in *coitû* the last sternites of the ♂ are opposed to the last tergites of the ♀ and *vice versa*. The coupled pair usually remain at rest but they may crawl about freely, all twelve legs (which, owing to the position adopted, fall in the same plane) being used for locomotion. Copulation often took place in the neck of the bag in which the nests were kept, but, once paired, the insects showed a tendency to hide themselves in the débris at the bottom.

The position of the sternites and tergites concerned is, in *farreni*, briefly as follows:—

The 8th tergite ♂ covers a large portion of the end of the ♀ abdomen. It reaches back as far as the apex of the 7th sternite (which it fully covers) lying well over the sinus. It even touches, and may possibly sometimes cover, the posterior ventral angle of the 7th tergite. Below it also lie the ♀ sternites 8-10, and part of tergite 8, viz., the distal ventral region which is bristly on both sides. The 8th sternite ♂ rests so that the long terminal bristles lie on the pygidium of the ♀. A slight general movement outwards of the 9th tergite ♂ has taken place so that the "finger" is above the sinus of the 7th sternite ♀. Proximally and ventrally the 9th sternite ♂ is pressed up against the 10th sternite ♀. At the point of contact their respective bristles and spines interlock, while the "stylets" are held in the V-shaped collar formed by the almost terminal lateral flaps of the 8th tergite ♂. The distal hairy portion of the 9th sternite ♂ is pushed well forward, its apex appearing below the 7th tergite ♀, in which position it seems not only to hold the ♀ but also to act as a support for the extended chitinised portion of the penis. The *receptaculum seminis* is backwardly displaced and its sinuous duct partially straightened in copulation. The thin, free, distal portion of the penis, which ordinarily lies coiled like a watch-spring between two chitinous, triangular, basally-

[1] Strictly speaking the halves or lateral lobes of the 8th tergite.

[2] Probably to unlock the hairs, etc., of their inner surfaces.

hinged lobes, enters the duct a distance of ·3 m.—·4 m. (*farreni*). Its entrance is facilitated probably by the displacement of a small chitinous structure lying at the mouth of the duct. The terminal triangular lobes, referred to above, from lying in a straight line with the internal penis, move downwards through a right angle. Their effect in tightening the membrane (9th tergite ♀?) on which they press, can plainly be discerned. Their points also compress the rectum of the ♀ behind the 10th sternite.

Speaking generally one would say that this complex arrangement of parts is a lock and key to prevent crossing with another species. It is not so easy, however, to explain details. Clearly the great reduction of the 8th sternite ♀ is correlated with the *position* assumed in copulation. If the ♀ 8th sternite were like that of the ♂ it would be impossible for him to bend under her as he does. By impinging on the pygidium of the ♀ the bristles of the 8th sternite ♂ may supply some necessary stimulus. It is noteworthy that three parts of the ♂ appendages converge on or near the 10th ♀ segment. This may be either to hold the ♀ securely or to close the anus. Both interpretations may be correct, and certainly the second is suggested by the presence of the hairy flaps (rising at the basal ventral angle of the 9th sternite ♂) behind the ♀ anus.

Several trials showed that copulation is the first business of the imaginal state. It proved much easier to induce this condition than to fix the insects in position. Dropped into alcohol (70 %) they struggled apart long before death. A mixture of absolute alcohol, chloroform, and glacial acetic acid, in equal proportions, was hardly more effective. Suddenly treated with chloroform or ether, the relaxation of the insects was so great that they fell apart. By gradual narcotising and subsequent plunging into a quick fixative one or two pairs were secured without much alteration. Boiling water also in one case proved a satisfactory killing agent, and decapitation with a sharp razor was sometimes successfully tried.

Summary.—Bird fleas breed in the nests of their hosts either by the carrying there of pregnant ♀ ♀, or by the rarer introduction of eggs shaken from the birds' plumage. After a life-history (*i.e.*, from hatching of the ova to emergence from the pupæ) of about a month new imagines are born and copulate at once. Successive broods will be produced so long as the conditions of food, temperature, etc., are favourable. If the numbers born are large, an exodus may occur. Of the last brood many probably wait the return of spring before hatching out, but there is evidence to show that any casual visitor to a deserted nest in winter may carry away fleas.

The whole subject of this life-history, however, bristles with difficulties and before leaving it I may mention three problems that have been before me for some time. Does the food of these *Ceratophylli* consist only of mammalian and avian blood? Is there no probability of their attacking invertebrates,[1] *e.g.*, the lepidopterous and other larvæ so frequently found in the same nests. How again do they reach the nests of their hosts? Is the passage from one nest to another always effected on the bird's body? Or is it not possible that *Ceratophylli* seek the hosts' nests of their own accord? If not, are we to say that all fleas found among leaves, herbage, stones, etc., have been dropped by passing hosts? It is highly probable that, where several species of birds resort to nesting sites such as open moors, cliffs, caves, and ruins which provide easy access from one point to another, *Ceratophylli* will spread without any direct transference *via* the host's body. What finally becomes of the hordes of fleas that are occasionally to be met with leaving nests? Do they scatter only to die? Amongst more special points may be mentioned the method of rupture of the cocoon. I have seen this happen repeatedly, but cannot yet tell how it is effected. Possibly the frontal tubercle is employed in the operation.

Ceratophyllus rothschildi, spec. nov.

A pale, very distinct species.

HEAD—Rather bare. Broadened in the ♂ towards the occiput, in the ♀ relatively wider anteriorly. (See Fig. 1.)

Frons—With a marked tubercle in both sexes. Before and below the eye two rows of bristles (3, 2 or 3). The lowest bristle of the posterior row long, reaching well towards the end of the 3rd palpal joint.

Occiput—Basal row of stout hairs, about 12. Row of fine short hairs immediately on the upper edge of the antennal groove. Parallel to this is a row of bristles (3), two anterior, above the 1st antennal joint and one at the lower angle of the occiput.[2]

Palpi—Equal to the rostrum (♂) or slightly shorter (♀). The rostrum reaching to the tip of the fore coxæ.

THORAX—

Pronotum—With a comb of 32-34 teeth. Before this a row of moderately strong bristles between which and the comb itself are some minute hairs.

[1] The *Zoological Record* has the following reference:—1882, Pulex feeding on larvæ of Tineina, *Boden. Ent.*, xv., p. 70; but I have not seen the article.

[2] Three other bristles, one at the lower angle of the pronotum and two on the mesothoracic epimeron, continue this row backwards.

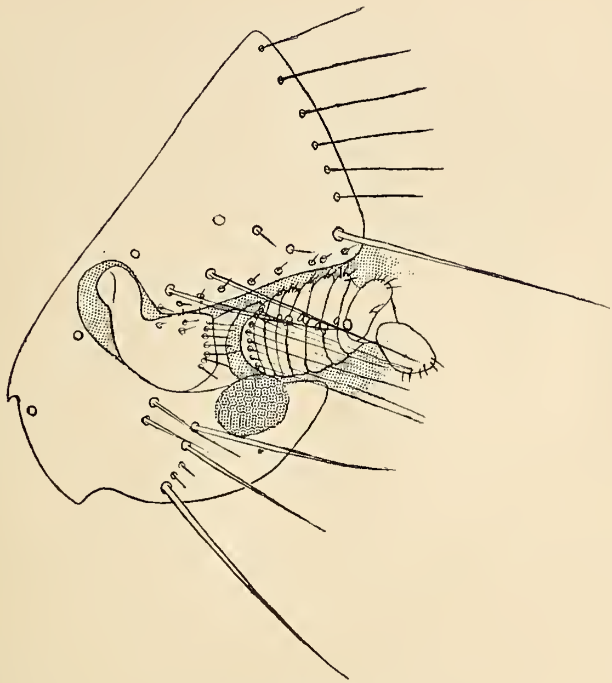


Fig. 1. Head of ♂.

The antenna of *Ceratophyllus* consists of three joints, the first and second being simple, while the third has nine divisions. In Fig. 1, the second joint appears to be compound, but the shaded area is really the first division of the third joint which is deeply inset in the second. To the second also belongs the pencil of long hairs.

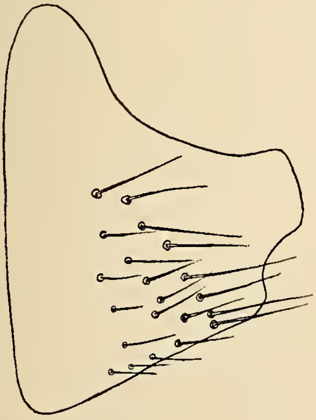


Fig. 2. 7th sternite ♀.

Fig. 3. 8th tergite ♂.

Mesonotum—2 rows:

(*a*) Irregular antemedian of fine hairs;

(*b*) Post median of long bristles;

and also (*c*) A row of slender spines posteriorly.

Metanotum—Post median irregular row of hairs followed by a row of long bristles above the internal incrassation. The metanotum bears also 6 broad, blunt teeth, while tergites 1-3 may have from 4-7 such teeth. Tergite 4 usually bears 4 but may have less.

Epimeron—4 or 5 bristles (1, 2, 1 or 2, 2, 1).

Abdomen—

Tergites—1st tergite in both sexes with 3 rows, with (in one ♀ only) additional bristles in front.

Tergites 2-7 (♂ and ♀), an anterior row of short hairs or fine bristles and a posterior of stouter bristles. In the ♀, tergite 7 bears an extra row of short bristles before the normal two, while tergites 5 and 6 show indications of this increase also. In both sexes tergite 7 bears on each side one long ("antepygidial") bristle accompanied by one fine hair (♂) or bristle (♀).

Sternites—

♂—From the second to the sixth inclusive the sternites bear 1-3 bristles on each side, while the seventh has constantly 1.

♀—Sternites two to six have on each side the following bristles—2, 5, 6, 6, 8. One of the ♀♀ shows on one side of the 5th sternite two minute extra bristles.

The 7th sternite is produced into a short, broad lobe, abruptly truncated above but with the lower angle more rounded (see Fig. 2). It bears many bristles, there being over 20 on each half. These bristles form two fairly well-defined rows of about 7 each (a median and a postmedian row), while anteriorly the others are more irregularly placed.

In general the ♀ is more densely clothed with bristles or hairs than is the ♂.

Modified Segments—

♂—The 8th tergite bears on its upper edge, which is level, 10 straight bristles. There are also on its external surface about a dozen more, distributed fairly evenly over the dorsal and ventral areas respectively (Fig. 3). The corresponding sternite articulates by a narrow apophysis. Distally it bears six (3, 3) long curved bristles. On pressure it is seen to be joined to the parts above by

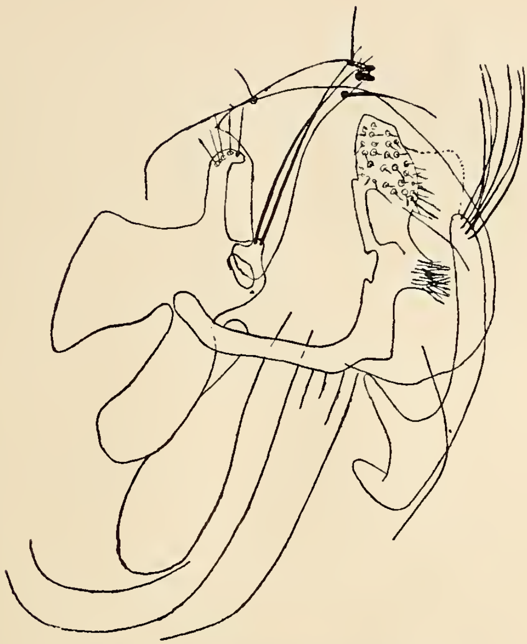


FIG. 4. Modified segments of ♂.

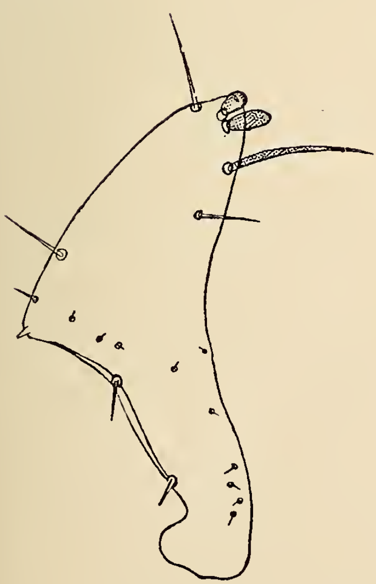


FIG. 5.

FIG. 7.

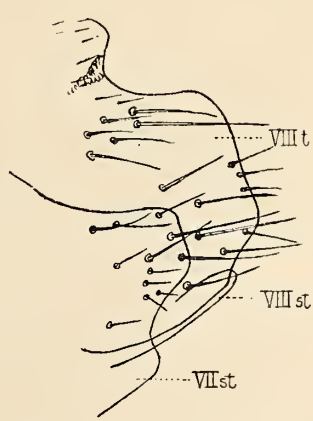


FIG. 6. Modified segments of ♀.

two external and terminal membranous processes whose proximal edges are chitinised.

The shape of the 9th tergite is seen in Fig. 4. The apex of the "process" is somewhat hooked. The "finger" is roughly triangular in shape, with the dorsal edge convex and the sides concave. The posterior (distal) angle has on the inside two conspicuous short, black peg-like spines with below, after a brief interval, a stout curved bristle. One or two other bristles or short hairs are placed as indicated in the larger sketch (Fig. 5). On the 9th sternite ventrally there is a dense tuft of short hairs and spines.

The inner chitinised portion of the penis shows a characteristic spatulate outline.

♀—The 8th tergite has about six short hairs above the spiracle. There are two strong bristles below the pygidium with a few weaker ones in front. The lower distal third bears numerous bristles (long and short) externally (about 20). There are fewer bristles on the corresponding inner surface (see Fig. 6).

The 8th sternite is narrow and inconspicuous.

The 10th sternite bears, besides the usual long almost terminal bristles, 4 broad short spines which probably lock in copulation with the bunch of spines and bristles on the ventral surface of the 9th st. ♂.

The narrow region and the bulb of the *receptaculum seminis* are of almost equal length.

Legs.—The hind femur bears outside 4-6 bristles in a row and inside 8-10.

Length.—♂, 2–2·7 mm. ♀, 2·5–2·7 mm.

In drawing up this description (as regards the ♂) I have had communicated to me some critical remarks by Dr K. Jordan, for which my best thanks are due.

A small series, 7 ♂♂ and 2 ♀♀, from nests[1] of *C. urbica*, taken from the cliffs at Todhead, near Kinneff, Kincardineshire, by Mr A. M'Innes, in the middle of September 1909. The types (♂ and ♀) have been

[1] Three nests were sent by Mr M'Innes (on 5th Oct.), who had taken them down some six weeks previously. As all three seemed to be swarming with the same flea (*farreni*), one was burned after a cursory examination. Shortly afterwards, with a view to determining the proportions of the sexes, I began a thorough examination of the remaining nests and, after going through some 300 fleas, came on the first ♂ of *rothschildi*. It may be of some interest to give in detail the results of the completed census (see p. 85).

presented to Mr Rothschild, in whose honour this fine species is named.

C. rothschildi has apparently affinities in two directions. On the one hand, it is related to the *gallinæ* group, *e.g.*, with *dalei* in the shape of the 8th sternite ♂. The 8th tergite ♂ is also of the type usual in this group. On the other hand, there are even more obvious links between the present species and the recently named *C. frontalis*, Rothsch., "which is unlike any other described *Ceratophyllus*."[1] With *frontalis*, *rothschildi* agrees in the strongly tuberculate frons of both sexes (though *frontalis* seems to have this feature more pronounced); in the number of spines in the pronotal comb; but specially in the movable finger of the clasper (♂) which has the same general shape in both species, the most noticeable difference between the two being that while in *frontalis* there is one peg-like spine at the distal angle, there are in *rothschildi* two. *C. frontalis* was described from specimens taken in a nest of the Alpine Chough (*Pyrrhocorax alpinus*). Possibly, as has been suggested to me, *C. rothschildi* may be the flea of the Common Chough (*P. graculus*) which has transferred its attention to a new host when the old became extinct in this locality. An exchange of the kind might easily occur in the case of birds which, like the Chough and the House-Martin, nest in cliffs. There seems, however, to be no evidence that the Chough has at any time *bred* in Kincardineshire. The St Abb's station, according to Howard Saunders,[2] has long since been deserted.

Census of Fleas, etc, from Martins' Nests, Kinneff.

	C. farreni.	*C. dalei.*	*C. rothschildi.*
♂ ♂	1672	*none*	7
♀ ♀	2368	40	2

There were besides about a dozen puparia of *Stenopteryx hirundinis*, Leach, in the débris of the nests. Few acarids occurred, but some lepidopterous larvæ were present and one or two Beetles.

Thus out of over 4000 examples of *farreni* 41·38 % were ♂ ♂, which agrees fairly closely with a previous[3] estimate of the proportions of the sexes in the species, based on a much smaller number of specimens. Apart from the larger series counted, the present percentage ought to be more accurate since the bulk of these imagines had just emerged from the pupa. The occurrence of one sex only of *dalei* is noteworthy and

[1] *Novitates Zoologicæ.*, vol. xvi., May 1909, p. 58.

[2] *Manual of British Birds*, second edition, 1899, p. 230.

[3] *Ann. Scot. Nat. Hist.*, Oct. 1909, p. 228.

somewhat inexplicable since practically all these examples seem to be newly emerged. The sexes of this species have not yet been taken together in Britain.

List of Species taken in 1909.

During the past year the *Ceratophylli* of birds have been principally investigated, but one or two other *Siphonaptera* were secured, and these are mentioned here. With regard to the actual records—the number and sex of fleas taken have been carefully noted. Where the note "abundant" occurs, the numbers were to be reckoned in hundreds. "Swarming" has been sparingly used, and denotes an estimate of 1000 and upwards. The numbers in one case where the term is used are given above. County names appear (in brackets) with the first mention of a locality, but not afterwards. The generic names of hosts are at first given in full, later as initials only. All specific names are italicised, and where no genus is indicated *Ceratophyllus* should be understood.

Pulex irritans, L.

♀. Kincraig (Invernesshire), "by sweeping," P H. Grimshaw, 5–20 : vii : 09.
♀. Domestic Cat, Kinneff (Kincardineshire), J. R. Fraser, 4 : x : 09.
♂. Ollaberry, Shetland, 10 : ii : 10.

Ctenocephalus erinacei, Bouché.

2 ♂♂ and ♀, on Hedgehogs (*Erinaceus europæus*), Colinton (Midlothian), J. M. Bruce, 5–16 : vii : 09. Two of these animals were chloroformed, thoroughly examined, and released apparently none the worse—which suggests a reasonable way of procuring parasites from our useful or harmless mammals.

Spilopsyllus cuniculi, Dale.

Both sexes numerous on snared rabbits (*Lepus cuniculus*), Coventree, nr. Auchinblae (Kincardineshire), 13 : iv : 09.
4 ♂♂ and 6 ♀♀. Cat, Kinneff, J. R. Fraser, April–August.
♂. Hallhill, Kinneff, on *Lepus europæus*, 20 : iv : 09.
Both sexes on *Lepus timidus*, Black Hill, Pentlands (Midlothian), A. Menzies; also *ib.* on *L. cuniculus*, 11 : ix : 09.
Both sexes on domestic Cat, and *L. cuniculus*, Dunskeig Farm, Claehan, Kintyre, J. M'Dougall, 1st week Jan. 1910.
S. cuniculi, Dale, has now occurred in Scotland on all three of the British species of *Lepus*.

Ceratophyllus fasciatus, Bosc.

Abundant on Ferret (*Mustela putorius domesticus*), and in nest, Lochhead, (Fifeshire), J. Brown, 25 : v : 09.
2 ♀♀. Howletburn, Galston (Ayrshire), on *Mus decumanus*, 25 : vi : 09. In some numbers again in August; but a series of rats sent were clean.—J. Gloag.
♀. 300 yds. from foot of 30 fm. shaft, Croft Head Pit, No. 5, Fauldhouse (W. Lothian), on *M. decumanus*, 31 : viii : 09.

♂. *M. decumanus*, Lochgelly (Fifeshire), J. Brown, 21 : x : 09.

2 ♂♂. *M. decumanus*, Dunskeig Farm, Clachan (Kintyre), Peter M'Intyre, per D. M'Rae, 25 : xi : 09.

Ceratophyllus sciurorum, Bouché.

A few from nest of the Tawny Owl (*S. aluco*), Arniston (Midlothian), April–June, A. Bennett, jun.

Ceratophyllus gallinæ, Schrk.

From this point onwards, unless when otherwise stated, all the examples recorded are from birds' nests. An asterisk denotes the rare cases where the fleas occurred on birds themselves. "Nest of" should be understood elsewhere.

♀, *Cinclus aquaticus*, and ♂, *Erithacus rubecula*, Auchinblae, L. Duffus, 17 : iv : 09.

From Arniston, chiefly through Mr Bennett, from April–June, in the following nests—*S. vulgaris*, numerous ; *S. aluco*, latterly in swarms ; *Parus major*, swarming ; *F. cœlebs*, 2 ♀♀ ; *Parus cœrulens*, 11 ♂♂, 24 ♀♀.

♀. *T. merula*, St Margaret's, N. Queensferry (Fifeshire), W. H. Elder, 9 : vi : 09.

♀. Nest of Ferret, Lochhead, J. Brown, 25 : v : 09.

♂ and 13 ♀♀, *S. vulgaris ;* and ♀, *Columba œnas*, Colinton, 19 : v : 09.

♀, *Emberiza citrinella ;* and 2 ♀♀, *T. merula* and *T. musicus* (joint nest), Nethercraigs (Renfrewshire), 4 : v : 09.

2 ♂♂, 6 ♀♀, *Gallus domesticus ;* 2 ♂♂, 7 ♀♀, *Hirundo rustica*, both from Dirleton (E. Lothian), J. Gardiner, 2 : ix : 09.

4 ♂♂, 10 ♀♀, *G. domesticus*, Biggar (Lanarkshire), 10 : ix : 09.

♂ and ♀. *T. merula*,* Colinton, 26 : vii : 09.

Ceratophyllus fringillæ, Rothsch.

♂ and 5 ♀♀, *S. aluco*, bred May and June ; 14 ♂♂, 8 ♀♀, *M. lugubris*, 8 : vi : 09 ; ♂ and 9 ♀♀, *Muscicapa grisola*, 3 : viii : 09 ; Arniston (A. B.).

3 ♀♀. *P domesticus*, Auchinblae, J. Campbell, 27 : v : 09.

Both sexes, Cat, Kinneff, J. R. Fraser, August–October.

3 ♀♀. *F. cœlebs*, Loudoun, J. Gloag, summer : 09.

Both sexes, *P. domesticus*, Dunlaverock, nr. St Abbs ; and *C. urbica*, *ib. ;* also from nests of same host, Coldingham (Berwickshire), Aug. and Sept., J. F. Cormack, jun

Ceratophyllus garei, Rothsch.

♀. *Phasianus colchicus*, Arniston, 28 : v : 09.

♂ and 2 ♀♀, *Totanus calidris ;* 2 ♂♂, 6 ♀♀, *P. colchicus ;* abundant *Gallinago cœlestis ;* 4 ♂♂, 5 ♀♀, *Anas boscas ;* 4 ♂♂, 6 ♀♀, *Vanellus vulgaris ;* 8 ♂♂, 12 ♀♀, *Spatula clypeata*. All near Lochhead, J. Brown, 25 : v : 09. Also *ib.*, ♀, *A. pratensis*,* J. B., 21 : x : 09. /

♀, "supposed Linnet's (?) nest" ; ♀, *Ægialtis hiaticola ;* ♂ and ♀, *P. colchicus ;* 5 ♂♂ and 3 ♀♀, *V. vulgaris*, Aberlady (E. Lothian). J. F. Cormack, jun., 22 : v : 09.

2 ♂♂. *V. vulgaris*, Tentsmuir (Fifeshire), J. F. C , 12 : vi : 09.

♀. *Perdix cinerea*, Banks of Bervie, Arbuthnot (Kincardineshire), 14 : vi : 09.

♂. *Larus argentatus*, Cliffs, Todhead, Kinneff, 15 : vi : 09.

♀. *Emberiza miliaria*,* Todhead, Kinneff, 16 : vi : 09.

Ceratophyllus dalei, Rothsch.

8 ♂♂. *C. urbica*, "Elderbank," Coldingham, J. F. Cormack, jun., 23 : viii : 09. An interesting capture—the second occurrence of this species in Scotland. Mr F. J. Cox took 2 ♂♂ in July 1908, at Carie, Rannoch, from the same host (N.C.R. in MSS.).
40 ♀♀. *C. urbica*, Cliff nests, Todhead, Kinneff, A. M'Innes, mid. Sept. 1909. The first ♀♀ taken in Britain.

Ceratophyllus farreni, Rothsch.

Mr Cormack has again forwarded this species from the Coldingham district—three localities, Aug. and Sept. All from the same host, *C. urbica*. One ♀ occurred in a cliff nest on the "Heugh," 24 : viii : 09.
10 ♂♂, 10 ♀♀. *C. urbica*, Dirleton, J. Gardiner, 2 : ix : 09.
Swarming (upwards of 4000 examined) in two nests of *C. urbica* from cliffs, Todhead, nr. Kinneff, A. M'Innes, Sept. 1909.

Ceratophyllus hirundinis, Rothsch.

2 ♂♂. *C. urbica* (cliff nest), The "Heugh," St Abb's, J. F. Cormack, jun., 24 : viii : 09.
56 ♂♂, 123 ♀♀. *C. urbica*, Coldingham, J. F. C., 23 : viii : 09.
2 ♂♂, 12 ♀♀. *C. urbica*, Dirleton, J. Gardiner, 2 : ix : 09.

Ceratophyllus columbæ, Walck.

♂. *Columba livia* (wild birds), cave in cliff, nr. Todhead, Kinneff, A M'Innes, 15 : vi : 09.
11 ♂♂, 15 ♀♀. *C. livia* (impure), in cave and on rocks, near Fast Castle (Berwickshire), J. F. C., 6 : ix : 09.

Ceratophyllus styx, Rothsch.

Swarming (pupæ), *Cotile riparia*, nr. Perth, F. Smith, per A. M. Rodger, 4 : x : 09.
Swarming (pupæ chiefly), *C. riparia*, side of quarry in Culalo Hill, nr. Aberdour (Fifeshire), M. Scott, 31 : ix : 09.

Ceratophyllus gallinulæ, Dale.

♂, *P. colchicus ;* ♀, *L. chloris ;* several *Ruticilla phœnicurus ;* 4 ♂♂ and 3 ♀♀, *S. vulgaris*. 28 : v : 09.
♂, *P. major ;* ♂ and ♀, *Phylloscopus trochilus ;* 4 ♂♂, 3 ♀♀, *T. merula ;* ♂, *M. lugubris ;* 2 ♀♀, *F. cœlebs*. 2–8 : vi : 09.
♂ and ♀, *S. hortensis*, 25 : vi : 09 ; ♂, *Motacilla melanope ;* 4 ♂♂, 4 ♀♀, *Accentor modularis ;* ♂ and 4 ♀♀, *Gallinula chloropus*. 29 : vi : 09.
46 ♂♂, 50 ♀♀, *Phylloscopus sibilatrix*, vi : 09, bred later.
The above from Arniston. A. Bennett, jun.
♂ and ♀. *E. rubecula*, Auchinblae, L. Duffus, 17 : iv : 09.
♂ and 3 ♀♀. *T. merula* and *T. musicus* (joint nest), Nethercraigs, 4 : v : 09.
♀. *V. vulgaris*, Lochgelly, J. Brown, 25 : v : 09.
2 ♂♂ and ♀. *T. merula*, St Margaret's, N. Queensferry, W. H. Elder, 9 : vi : 09.
Swarming. *C. aquaticus*, Torduff Reservoir, nr. Colinton, J. Miller, 12 : v : 09.
♀. *A. modularis*,* Colinton, 31 : v : 09.
2 ♂♂. *T. musicus*,* killed by Cat, Kinneff, 14 : vi : 09.
2 ♀♀. *M. grisola*, Kinneff (Fawsyde), 15 : vi : 09.
2 ♂♂, 9 ♀♀. *F. cœlebs ;* "Stonechat's nest" from which 24 ♂♂ and 17 ♀♀ were bred. J. Gloag, Loudoun (Ayrshire), June.
Dr Rettie took several pupæ of this species from a deserted nest of *T. merula*, nr. Burntisland (8 : xi : 09). I have a ♀ from one of these.

CERATOPHYLLUS INSULARIS, Rothsch.

♀. *L. argentatus*, cliff, nr. Todhead, Kinneff, 19 : iv : 09.

CERATOPHYLLUS BOREALIS, Rothsch.

♀. *L. argentatus*, cliff, Todhead, A. M'Innes, 15 : vi : 09.

CTENOPHTHALMUS AGYRTES, Heller.

♀, *Talpa europœa*, 16 : vi : 09 ; ♂, domestic Cat, August ; ♂, *M. decumanus*, 6 : x : 09. All from Kinneff, J. R. Fraser.
♂ and 3 ♀♀. *M. decumanus*, Mill of Allardyce, Arbuthnot, J. R. F., 14 : vi : 09.
♀. *Erinaceus europæus*, Colinton, J. M. Bruce, 16 : vii : 09.
♀. *M. decumanus*, Kirkcaldy (Fifeshire), W. Mitchell, 21 : x : 09.
2 ♀♀. *M. decumanus*, Lochgelly, J. Brown, 21 : x : 09.
3 ♀♀. *M. decumanus*, Dunskeig Farm, Clachan, P. M'Intyre, per D. M'Rae, 25 : xi : 09.

Relation of bird Ceratophylli to their hosts.—The common, and in some ways not unreasonable, impression that particular fleas are attached to particular hosts whose range[1] determines that of the parasite, is only slightly supported by the available evidence. The rule evidently holds for species like *styx*, *columbæ*, and *hirundinis* which are normally attached to one host. It is likely that within this group *dalci* and *farreni* fall (with *C. urbica* as their true host), though both species (one wonders if it were by coincidence only) were originally made known from nests of the Wood-Pigeon (*C. palumbus*).

At the other extreme are forms like *gallinæ*, *gallinulæ*, *garei*, and *fringillæ* which feed on so many hosts as to make classification seem, at first sight, hopeless. *Gallinulæ*, indeed, seems to have no special preferences. It has been very widely taken in Scotland, the only noticeable gap hitherto being among the Ducks. *Fringillæ*, a well-named species, haunts the nests of Sparrows and smaller Passerines generally. *Gallinæ* has a range, hardly if at all inferior to that of *gallinulæ*. Waders, moor and shore birds, and Ducks seem the usual host of *garei*, but the presence of this species is determined rather, I think, by the locality than by the hosts. One always expects to

[1] A flea may have a range exceeding or falling short of that of its usual host. In Orkney, *Hystrichopsylla talpæ* has recently been found by Mr Ellison, though the Mole (*Talpa europœa*) is absent. Again, *Xenopsylla cheopis* has occurred in Britain only as a casual importation, though suitable hosts abound here. It is plentiful on *Mus* spp. in India. On the other hand *C. fasciatus*, a common rat flea in Britain, is relatively rare in India, forming only a small proportion of the fleas taken by the Plague Commission.

As the environmental conditions of fleas must be fairly equable when on the host, other factors must limit their distribution in lands where the same hosts occur. Possibly these factors are climatic. They may not affect the imagines directly, yet their influence may be potent on ova and larvæ.

find it by the sides of streams and ponds, on moor and waste land, and on links by the sea. The results of one test examination are perhaps worth giving. A small, low-lying field beside a well-preserved loch was searched, and linings taken from the following nests:—Pheasant (1); Tufted Duck (2); Shoveller (2); Mallard (2); Snipe (1); Redshank (1); Lapwing (2). In the case of every species but one (Tufted Duck, whose nests contained no fleas), *garei* was found. In the same field *garei* later occurred on a specimen of the Meadow-Pipit.

Borealis, insularis, and *rothschildi* have not yet been taken in sufficient numbers to justify remark.

One might then, with reservations, propose the following categories to exhibit the relation between these bird fleas and their hosts.

A. Strictly monoxenous, *e.g.*, *styx*.

B. Polyxenous:
- Indiscriminately, *e.g.*, *gallinulæ*.
- Attached usually to an order of birds, *e.g.*, *fringillæ*.
- Infesting nests in certain localities, *e.g.*, *garei*.

The possibility of casual occurrences, *e.g.*, *fringillæ* in Martins' nests, has constantly to be borne in mind. Such cases are not always easily recognised.

A classification like the above, of course, only groups the facts conveniently. The cause of the attachment of a *Ceratophyllus* to its host must be deeper. Many explanations are possible, the simplest conceivable being that the blood of a particular bird proves agreeable to some flea. It may be looked for again in modifications of mouth parts, claws, or the like to suit a certain type of skin, or (as I am inclined to think is the case with *styx*) the parasite's habits may be nicely adjusted to those of the host. Temperature, etc., may also play some part in regulating distribution.

Ceratophylli are not met with on birds themselves with the frequency one would expect from their almost universal occurrence in nests.[1] This is not to be explained away by the fact that fleas leave their host after death whenever the body begins to cool. During last year I have examined a number of newly-shot birds, which had been forwarded in bags so securely sealed that not even tiny acarids escaped. Nearly all these specimens were more or less infested by *Mallophaga*, a considerable proportion carried acarids, *but less than* 10 *per cent. harboured Ceratophylli*, and then seldom more than one or two examples. Of nests, probably 75 per cent. held some kind of fleas. It is a matter of regret that I cannot quote exact figures, as no record of the blanks has been preserved. But that the discrepancy referred to

[1] The Grouse Commission in examining thousands of birds encountered very few fleas. See "Ectoparasites of the Red Grouse (*Lagopus scoticus*)," by A. E. Shipley, *Proc. Zool. Soc. Lond.*, pp. 325, 326. Aug. 1909.

exists (and it is a great one) can hardly be doubted. It is the more striking since the birds, examined feather by feather, have been common species. Of course, the absence of fleas from certain birds must be due to a great extent to the preening habit. For exactly the same reason, it will be found that species of *Docophorus* (Mallophaga) live on some Passerines only on the crown of the head and on the upper feathers of the throat.

The number of *Ceratophylli* affecting a species of bird varies. Often in the same nest two or more kinds occur. *Gallinæ* and *Gallinulæ* is perhaps the commonest combination

The case of *C. urbica* is noteworthy, for this little bird is victimised by no less than six *Ceratophylli*, if one includes *gallinæ* which has occurred with the others. Between fleas, acarids, *Stenopteryx hirundinis*, and the Swallow Bug, [1] Martins' nests must be rather lively nurseries. Leaving out of account the casuals, *gallinæ* and *fringillæ*, one might try to explain the large number of *Ceratophylli* by supposing that the bird, a migrant which roosts and breeds naturally on cliffs, etc., has in its passage through various lands acquired new parasites from time to time. This can hardly be the true reason, for *C. riparia* has only one species of flea attached to it, while *H. rustica* does not seem to have even one, in Scotland at least. *Gallinæ* has occurred in its nest, but surely by accident.

It must be confessed that we know little as yet of the species of *Ceratophylli* found on birds,—still less of the factors physiological, biological, and possibly climatic that govern the relations between parasite and host.

[1] I have not met with this parasite in Scotland.

(*Issued separately*, 6*th April* 1910.)

IX.—Note on *Piona carnea* C. L. Koch and *Eurycypris pubera* (O. F. M.) By Wm. Williamson.

(Received 15th February 1910. Read 28th February 1910.)

It is generally recognised that watermites prey on Entomostraca; an instance which recently came under my observation tends to show that the eggs of watermites may be subjected to the same treatment from some of the Entomostraca.

In July 1909, while tow-netting on Kilconquhar Loch, I took a number of specimens of the Hydracarid,[1] *Piona carnea* C. L. Koch, and of the Ostracod, *Eurycypris pubera* (O. F. M.). Very often after capture, watermites deposit eggs in patches on the sides of the tubes containing them, and on this occasion *Piona carnea* deposited several clusters of eggs. A day or two after, I noticed among these eggs, others of a smaller size and deeper colour. These latter I found to be the eggs of *Eurycypris pubera* and to have been deposited in the following manner. The female Eurycypris commenced by hacking away, chiefly with the second pair of antennæ, but also sometimes by nibbling, at the gelatinous matrix in which hydracarid eggs are often embedded. When a sufficiently large aperture had been made and the cell containing the hydracarid egg had been penetrated, the Eurycypris then inserted the tips of the second pair of antennæ. These lying close together formed a track along which the ostracod egg was rolled into the place selected for its deposition. Some little effort appeared to be necessary to

[1] I have here employed the term hydracarid in preference to hydrachnid for the following reasons. The term Hydracarina is now used to cover all the genera hitherto included in the Hydrachnidæ—more correctly Hydrarachnidæ—while the latter is greatly restricted in its application, including at the present time only the genera Hydrarachna and Bargena, and, according to Koenike, one other genus. It seems to me, therefore, that to use the word hydrachnid (or hydrarachnid) in anything but the restricted sense would not be proper, and that for use in the wider sense the word hydracarid is preferable. There will thus be available two words from the same stem to denote aquatic acarina, viz., hydracarid, for the fresh-water forms, and halacarid for the marine forms.

With regard to the etymological correction indicated above, though Hermann pointed this out in 1804, almost no support was given to the change until Koenike recently substituted Hydrarachna for Hydrachna (*Süsswasserfauna Deutschlands, Heft* 12). Hermann's views are expressed as follows:—"J'ai observerai à cette occasion que le nom *d'hydrachna*, employé par Muller, n'est point étomologiquement juste. Des contractions de cette espèce ne répondent point au génie de la langue: on ne dit point hippotame au lieu d' hippopotame. Le nom d'hydrachna ne peut être approuvé, d'autant moins qu'il exprime toute autre chose qu'une araignée aquatique, le mot ἄχνη signifiant *suie, paillette, écume*, et par conséquent *hydrachna* signifieroit *paillette d'eau*" (*Mém. Aptérol*).

get the eggs on to this track; in a few cases the eggs rolled off and fell within the shell of the ostracod. These eggs hatched out in six to seven days, but I could not see that the larvæ caused any damage to the eggs or developing larvae of the Hydracarid, which did not emerge until two or three days later—the total period in their case being twelve to fourteen days. While some of the patches of eggs hatched out, others did not get a chance. I found that though several of the Eurycypris were occupied in depositing their eggs, others of the species were as busily occupied in devouring the gelatinous matrix and with it the hydracarid eggs embedded therein. The assiduity with which this was done, particularly where the eggs were concerned, suggested to me that this must have been palatable food for the Ostracods. Nor were the ostracod eggs exempted from the destruction, since only a thin film remained on the glass to mark the place where the mass had been. It is thus evident that the gelatinous matrix which covers the hydracarid eggs and attaches them to some object during the period of incubation does not afford them a complete protection.

Though some of the egg clusters were completely destroyed, others were only partially so, and I was thus enabled to isolate a number of the developing larvæ of *Piona carnea* in the deutovum stage. A number of these had attached to them, in some cases anteriorly and in others posteriorly, half of the first covering or egg shell, and I was thus enabled to see how the deutovum was freed from this. When describing the species examined by him, Claparède figured the shell in one case as rupturing longitudinally and in another case obliquely. Kramer also describes the rupture as oblique. In the case of *Piona carnea,* I found the hyaline shell had ruptured transversely and from its subsequent behaviour I judge it to be somewhat elastic. So long as the Embryo retains its globose form, the two hemispheres of the original egg shell will remain attached. As the creature develops it assumes a flatter form, thus relieving the pressure which keeps each hemisphere distended and allowing each to slip off from the deutovum. Each half of the shell then collapses into the form of a semicircle having a double membrane stretched within its curvature. The curved margin straightens itself out in a short space of time, and as it does so the membrane stretches and rolls its free edges back until the whole assumes a lanceolate shape. These lanceolate figures are to be seen in the gelatinous matrix during the development of the egg, and at first sight are suggestive of diatoms lying among the eggs. The larvæ were all too far developed to permit observation of their earlier stages, but I had opportunity to observe their behaviour from the time when the power of movement was first manifested. At first a faint twitching of one pair of limbs only was apparent. After an interval the movement was repeated and then with gradual shortening of the interval and increase of the activity, a stage marked by vigorous and rapid movement of the limbs was arrived at, without, however, appearing to cause any stretching of the deutovum membrane. Up to this time the rostrum, which was folded under the body, remained passive, but it now gradually extended itself at right angles to the body and in doing so stretched the membrane considerably. The next stage was to get the rostrum extended anteriorly in line with the body, thereby stretching the membrane still more, and when this was accomplished the palpi began to move vigorously. Before long the strong claws with which they are equipped caused several rents in the membrane, and with the rupture of this the creature made its escape to begin the first free stage of its existence. In all the cases observed by me the membrane was colourless and was ruptured at its anterior end, but the time from the first evidence of motion to the escape of the larva, varied considerably in each case.

With regard to the occurrence of *Piona carnea* referred to above, I found it was not restricted to any one part of the loch, but was distributed all over it. This I connected with the immense number of Entomostraca to be found in every part of the loch. Indeed the number was so great as to become a nuisance, necessitating the net being cleared of a handful of Entomostraca every few minutes.

I am obliged to Dr Thos. Scott, F.L.S., for naming the Eurycypris for me.

(*Issued separately, 28th April* 1910.)

X.—Note on a Peculiar Clutch of Blackbird's Eggs and some other Abnormalities. By Professor J. Arthur Thomson, M.A.

(Read 28th February 1910. Received 28th February 1910.)

THAT the eggs of birds show considerable variability—in size, shape, and colouring—is, of course, very well known, but I thought it might be of use to record an interesting case of variation—especially in size—in a clutch of Blackbird's eggs. I owe the clutch and the data as to the order in which the eggs were laid to my friend Mr R. Hay Fenton, who not long ago very generously presented to the Natural History Museum of Aberdeen University his remarkably fine and almost complete collection of the eggs of British birds.

There are four eggs in this Blackbird's clutch, which have the following dimensions—

(i.) 38×24 mm.
(ii.) 33×23 mm.
(iii.) $28 \times 22{\cdot}5$ mm.
(iv.) 27×21 mm.

The largest egg (i.) was laid first, but it did not develop; the next largest (ii.) followed and was fertile; the third (iii.) was near the normal size; the smallest egg (iv.) was laid last. The third and fourth were quite fresh when the clutch was taken.

In his great work on the eggs of the birds of Europe, Dresser notes that the eggs of the Blackbird vary from $28 \times 21{\cdot}33$ mm. to $32 \times 22{\cdot}35$ mm., and quotes as an average of 48 eggs, 28×21 mm.; so that the interest of the clutch exhibited is that the first egg is far above the average, and that the abnormality goes on decreasing egg after egg. There is a progressive variation in a minus direction.

I do not wish to make too much of a little thing, but it is of interest to compare a case like this with others where we see at work the mysterious regulative tendency which is characteristic of living creatures. Thus Raymond Pearl recently described a case (*Journ. Exper. Zool.*, vi., 1909, pp. 339-351, 1 pl.) in which the first egg laid by a pullet was very abnormal in shape—elongated ovate pyriform. In the subsequent eggs laid there was a quite gradual change of shape, which was regulative in character, until finally the eggs were quite normal.

Numerous abnormalities in the eggs of the common fowl have been recorded, and the collection now shown illustrates not a few. It is an object-lesson in variability. The most remarkable form which I have to show consists of a small oval giving origin to a twisted tube like the horn of a shorthorn sheep. Such occurrences have been in some measure cleared up by a recent daring experiment made by Pearl and Surface (*Science*, xxix., 1909, pp. 428-9). In order to determine the nature of the stimulus which induces the making of a shell, they performed an operation on a hen as a result of which the contents of the intestine were made to pass through the shell-secreting part of the oviduct. The interesting result was, that they got curious enshelled masses of various shapes, and they were led to the conclusion that the stimulus which excites the shell-making glands is mechanical rather than chemical in nature, and that the formation of the shell is brought about by a strictly local reflex, and is not immediately dependent upon the activity of other portions of the reproductive system.

It may be said that this was to a certain extent known before from a study of what are popularly known as "wind-eggs." These are not true ova, they contain no vitellus. They consist of a mass of albumen the stimulus of which has induced the making of an enveloping shell. It has also been shown that foreign bodies may ascend from the cloaca into the oviduct and become surrounded by a shell. Thus a species of *Distomum*, which frequently occurs in the *bursa Fabricii* opening into the cloaca, may pass up the oviduct and be included intact in the albumen of an egg.

In an interesting paper on abnormal eggs in fowls, J. Kunstler points out (*Mém. Soc. Sci. Bordeaux*, iii., 1903, pp. 65-72, 7 figs.) that a frequent cause is a lack of tone in the oviduct, the normal peristaltic movements being disturbed in consequence. Thus an egg may return on its path and become surrounded by a second shell, thus resulting in one form of the not unfamiliar *ovum in ovo*.

In a paper on "Ovum in Ovo," by F. H. Herrick (*American Naturalist*, xxxiii., 1899, pp. 409-414, 3 figs.), it is suggested that an abortive egg or egg-fragment may be enshelled and then included within the shell of another egg of larger size. In other cases, what is included has nothing of the nature of an egg about it, though it has been enshelled. Entirely different again are eggs with double or triple yolks, where we have to deal with a fusion of the albumen in two or more ova, which are treated in the oviduct as one egg and surrounded by a single shell. This process may be sometimes complicated by the inclusion of a third egg of normal size and already covered by a hard shell. So when we speak of an egg within an egg, we may mean one of three or four different things.

The problem of the factors which determine the shapes of the eggs of birds has been discussed in a very interesting paper by Prof. D'Arcy W.

Thompson (*Nature*, 4th June 1908, pp. 111-113). The egg, consisting of a slightly extensible membrane filled with an incompressible fluid is subject to external pressure from the radially contractile oviduct, and an equation for the shell can be worked out. It is pointed out that from the nature and direction of the usual peristaltic wave in the oviduct the pressure will be greatest somewhere behind the middle of the egg; in other words, the tube is converted for the time being into a more conical form, and the simple result follows that the anterior end of the egg becomes the broader and the posterior the narrower. One may recall how the peristaltic movements of the intestine in many animals, such as the rabbit, divide the fæcal matter into spherical or oval masses.

The object of the present note is to record a case of variation with subsequent regulation, to show in a collection of hen's eggs how large the crop of variations is, and to note the suggestions that have been offered in interpretations of certain not uncommon freaks, such as a trumpet-shaped egg or an egg within an egg.

(*Issued separately, 11th May* 1910.)

XI.—Note on *Eunephthya glomerata*, Verrill, from the Færoe Channel. By Professor J. Arthur Thomson, M.A.

(Read 28th March 1910. Received 28th March 1910.)

I HAVE previously recorded in the *Proceedings* of this Society the occurrence of two interesting Anthozoa from the Færoe Channel, *Primnoa reseda*, Linn., and *Antipathes larix*, Esper, and as it seems worth while continuing the list as specimens turn up, I wish now to add *Eunephthya glomerata*, Verrill. I obtained a single specimen from the collections of the "Goldseeker," and I am indebted to Prof. D'Arcy W. Thompson, C.B., for permission to make it the subject of this note.

The small colony rises to a height of about 22 mm. with a maximum breadth of 15 mm. A short trunk bears about three dozen polyps in ill-defined groups. There are so many spicules that the whole colony is stiff, and the surface has a glistening, frosted appearance—more or less white in colour. Most of the polyps are 3 to 4 mm. in height, and the upper part shows eight strongly-marked longitudinal ridges and intervening grooves. The ridges taper, bend inwards round the mouth, and are continued into the inturned tentacles. These are curved like a crozier, and their aboral surface is heavily armoured with spicules which cease near the tip. The spicules are clubs and spindles, some compact irregular bodies and a few cruciate forms. The clubs vary greatly in size and appearance, but most of them have enlarged heads, extremely rough, with stout blunt processes usually directed towards the apex. The following measurements were taken of length and breadth—the latter measured across the club, $0{\cdot}15 \times 0{\cdot}06$; $0{\cdot}2 \times 0{\cdot}04$; $0{\cdot}3 \times 0{\cdot}1$ mm. The spindles have usually sparse, blunt tubercles. Two common sizes are—$0{\cdot}4 \times 0{\cdot}04$; $0{\cdot}8 \times 0{\cdot}02$ mm.

The large and somewhat difficult genus *Eunephthya*, as re-defined by Kükenthal, includes more or less branched Nephthyid colonies, with thin canal walls not thickly filled with spicules, with polyps without Stützbündel, in groups or singly, retractile or non-retractile, but not divided into distinct calycine and retractile portions. The nearest genus is *Gersemia*, in which a portion of the polyp is retractile within a distinct calyx.

The genus *Eunephthya* is divided into two main divisions—(1) *Alcyoniform*, with thickened contractile terminal branches, with completely retractile, elongated cylindrical polyps disposed singly; and (2) *Nephthyiform*, with unthickened, non-retractile terminal branches, with polyps grouped in bundles, club-shaped, and non-retractile.

It is evident that our specimen belongs to the Nephthyiform division or sub-genus of *Eunephthya*, and to the group which Kükenthal calls Divaricatæ glomeratæ, including *E. glomerata*, Verrill, *E. hyalina* (Danielssen), *E. racemosa*, Studer, and some doubtful species.

I have recorded this specimen for faunistic reasons—it is a characteristically boreal animal previously recorded from deep water of 500 to 600 fathoms in Northern Seas, *e.g.*, off Franz-Joseph Land, Spitzbergen, Jan Meyen, and Greenland. It was dredged in the Færoe Channel, Station 18A, 18th June 1906, from a depth of 355 metres. But the specimen has also some systematic interest.

My specimen agrees with *Eunephthya glomerata* in all respects except that it shows more numerous *delicate* spindles, more irregularly headed clubs, and among its irregular spicules none that I should call double stars. By making several distinct preparations from different parts of the colony, I have convinced myself that the slight divergence in the spiculation is quite unimportant, and not greater than that separating some other recorded varieties of the species. I strongly suspect that many of the spicules described and figured as double stars are the broken off heads of very much knobbed clubs. In appearance, and in some of its spicules, my specimen very closely resembles *Eunephthya racemosa*, Studer, from Newfoundland, and may, I think, be taken as showing that the latter should be included in *E. glomerata*, Verrill.

Kükenthal has already united with *Eunephthya glomerata* quite a number of species—*Ammothea luetkeni*, Marenzeller, *Nephthya polaris*, *Nephthya flavescens*, *Nephthya rosea*, *Drifa islandica*, and *Gersemiopsis arctica* (all due to Danielssen's exaggerated emphasis on minute differences). I think *E. racemosa*, Studer, should be added to the list. Moreover, in the detailed description and numerous figures that Danielssen has given of *Drifa hyalina* (which, as Kükenthal shows, is certainly a species of *Eunephthya*), I find no satisfactory reason for keeping even it apart.

Danielssen noted that *Nephthya flavescens*, *N. polaris*, and *N. rosca*, which are now identified with *Eunephthya glomerata*, are viviparous, and he gave a careful account of the embryos found free in the gullet. It is interesting to notice that the specimen under consideration, collected in the month of June, has numerous large free embryos in some of its polyps. Perhaps, as in some other cases, the viviparous habit is an adaptation to life in deep water.

(*Issued separately*, 11*th May* 1910.)

XII.—Note on "*Leptus phalangii*" and "*Leptus autumnalis,*" and their parent Earth-mites. By William Evans, F.R.S.E.

(Read 28th February 1910. Received 3rd March 1910.)

The minute hexapods known as harvest-bugs, to which the generic name of *Leptus* has long been applied, are generally, and no doubt rightly, recognised as the first or larval stage of mites belonging to the *Trombidium* group. Regarding the particular adult form to which each belongs, much uncertainty, however, exists. As a slight contribution to the subject, the following results of some observations made by me in this district during the summers of 1908 and 1909 may, therefore, be worth recording.

Rhyncholophus (*Ritteria*) *nemorum*, Koch :—To this species Dr C. F. George refers a brown Rhyncholophid mite which I have found rather commonly among moss and fallen leaves, and also under stones, in widely scattered localities around Edinburgh. There appears to be some doubt as to the identity of Koch's *Rh. nemorum;* and Dr Sig Thor, in his paper on Norwegian Rhyncholophidæ (1900), places it with a ? under *Ritteria vertex*, Kramer.[1]

On 31st July 1908 I got, at Crosswood Reservoir in the south-west of Midlothian, two Phalangids or "Harvest-men" (*Phalangium opilio*) with six and eight, respectively, of the little red larval ticks known as *Leptus phalangii* adhering to their legs. Without disturbing the *Lepti,* the Phalangids were put into a glass-topped box containing a layer of fresh earth. Next day three of the parasites left their hosts, and within a week all had dropped off, and entering the earth went to rest just beneath the surface. There they underwent a developmental change, and in the beginning of September (3rd and following few days) nine emerged as Rhyncholophid mites which, though immature, were to all appearance of the same species as my *Ritteria nemorum* specimens; this Dr George has no hesitation in saying they are. Unfortunately none of these "nymphs" reached maturity although some of them remained alive for several weeks.

Trombidium holosericeum (L.) Fab. :—On 24th April 1909 several examples of this beautiful scarlet mite, which is also common and widely distributed in this district, were taken on Largo Links, Fife. Two females were placed in a glass tube along with some sprays of moss. There, in the end of May (27th, etc.), they deposited about 300 red eggs in clusters of 20-40. Hatching started on 8th July, and in the course of the next four

[1] I have since submitted specimens (including one of the nymphs reared from *L. phalangii*) to Dr Sig Thor. He agrees in designating them for the present *Rhyncholophus* (*Ritteria*) *nemorum*, Koch, but indicates that this may be a "Collektiv-name" for more than one species. I hope to hear from him again when he has had time to prepare dissections of the specimens, and study the whole subject more closely (22 iv. 10).

or five days over 200 tiny scarlet larvæ were running about in the tube. These larvæ were unlike figures of the "*Lcptus autumnalis*" or harvest-bug—the reputed larval form of *Trombidium holoscriceum*—which I had seen, and agreed perfectly with the figures of *T. holosericeum* larvæ recently hatched and figured by Dr George (see *The Naturalist*, Dec. 1908, p. 452). To test them for harvest-bugs, I first placed a few on my arm and watched them through a magnifying glass for a considerable time without seeing them make any attempt to penetrate the skin. I next put a number inside one of my stockings and tied it below the knee; but, although the stocking was worn continuously for four days, no "bites" were experienced. It can hardly be that I am a bad subject for the experiment, for I never visit certain parts of East Lothian at the proper season without suffering more or less from the attacks of the "berry-bug" as the pest is there called. Most of the larvæ left in the tube survived for five or six weeks and then suddenly died. A small Phalangid put beside them did not seem to stimulate their parasitic instinct. In this district *Trombidium holosericeum* is, according to my experience, much more widely distributed than the annoying harvest-bug.

Likely enough the larval or hexapod stages of several closely allied mites are included under the name *Leptus autumnalis;* but, for the reasons mentioned above, I have formed the opinion that the larva of *T. holosericeum* is not one of them. Further research, however, is needed to settle the point.

I may add that a female *Ottonia conifera*—a Trombidiid recently described, along with several others, by Dr George in *The Naturalist* from specimens taken by me in the Forth Area—captured at Bavelaw Moss on 5th May 1909, laid 70-80 eggs on 29th May, which hatched on and about 1st July. While bearing a general resemblance to those of *T. holosericeum*, and like them very active, these larvæ were distinctly different both in shape and colour, being in the latter respect pale yellow in place of red. A young Phalangid (*Oligolophus agrcstis*) offered as a "host" did not appear to have any attractions for them.

Postscript.—Prof. J. Arthur Thomson, who presided at the meeting at which the above was read, has called my attention to a short paper by L. Bruyant (*Comptes Rendus Soc. Biol.*, Paris, tom. lxvii., No. 26, 23 July 1909, pp. 207-9), in which he reports that eggs of *Tr. holosericeum* produced larvæ which were identified as the *Allotrombidium striaticeps*, Oudemans. A further paper by M. Bruyant (*Zool. Anzeiger*, Bd. xxxv., No. 11, 18th January 1910, pp. 347-352) on Trombidiid larvæ, has been brought to my notice by Dr J. H. Ashworth; and in *The Naturalist* of 1st March, Dr George gives figures of one of my *Ottonia conifera* larvæ.

(*Issued separately, 23rd May* 1910.)

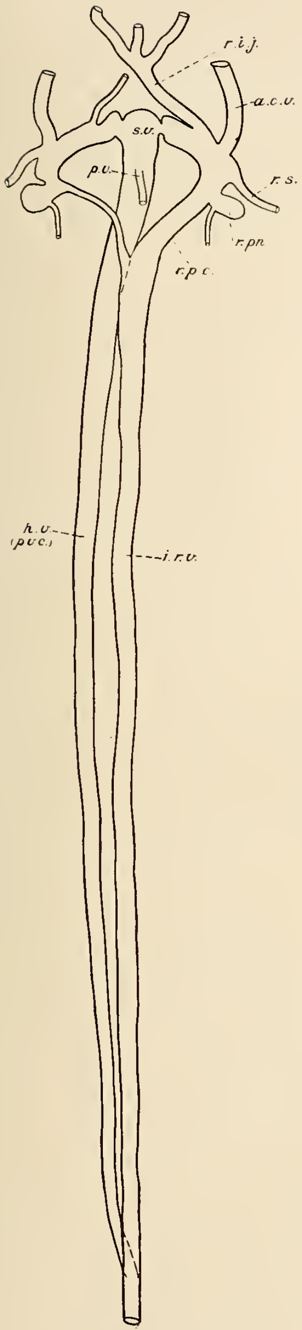
XIII.—Note on the Posterior Vena Cava in *Polypterus*. By J. Graham Kerr.

(Read 28th March 1910. Received 7th April 1910.)

One of the interesting phylogenetic puzzles connected with the morphology of the higher vertebrates is that associated with the evolution of the inferior or posterior vena cava—the great vein which, in the higher vertebrate, serves to drain the blood from the hinder region of the body to the heart. The special element of puzzle about the inferior vena cava is afforded by its developmental history, for, as is well known, the vessel in question has a double origin. Its hinder portion is simply a persisting portion of the posterior cardinal or interrenal vein, while its front portion develops quite independently in relation with the veins of the liver, and only secondarily becomes joined up to the posterior cardinals, forming a direct channel by which their blood passes straight to the heart, and the establishment of which speedily brings about the reduction of the anterior parts of these vessels.

How has this short circuiting of the renal blood stream come about in phylogeny? A probably satisfactory answer to this question is afforded by the conditions in the lung-fishes. We see how, in these forms, the kidneys extend relatively far forward, while the liver extends relatively far back along the right side of the splanchnocoele. As a result of this arrangement we see, in *Lepidosiren* and *Protopterus*, that the tip of the liver is in contact, and fused, with the tip of the right kidney.

A natural result of the contact between the liver, with its perfect blood drainage towards the heart *via* the hepatic vein, on the one hand, and the highly vascular kidney on the other, has been the establishment of a venous anastomosis between the two organs leading to the passage of renal blood to the heart through the substance of the liver. With the establishment of this anastomosis the hepatic vein has become a large direct channel leading from the tip of the right kidney straight through the liver, receiving numerous branches from the liver substance as it does so, to the heart. It is this main trunk of the hepatic vein which forms the anterior section of the posterior vena cava. In other words, the condition in the two lung-fishes in question supports the view that what we call the anterior section of the posterior vena cava is really the primitive hepatic vein, and that what we commonly call hepatic veins in the higher vertebrates are lateral branches of this primitive hepatic vein.



Arrangement of main veins in a young Polypterus of 30 mm. in length.

a.c.v. Anterior cardinal ;
h.v. Hepatic (Posterior vena cava) ;
i.r.v. Interrenal ;
p.v. Pulmonary ;
r.i.j. Right inferior jugular ;
r.p.c. Right posterior cardinal ;
r.pn. Right pronephros ;
r.s. Right subclavian ;
s.v. *Sinus venosus.*

As is well known the presence of a posterior vena cava is frequently associated with an asymmetrical condition of the anterior portions of the posterior cardinal veins. In *Polypterus* such an asymmetry exists, and this suggested the desirability of ascertaining whether a posterior vena cava is not present in that animal. As a matter of fact, *Polypterus* does possess a posterior vena cava. In Budgett's paper on the anatomy of *Polypterus* there occurs the sentence, "The [air-bladder] vein on the right side is of great size, corresponding to the size of the right air-bladder, and posteriorly unites with the caudal vein."

Examination of the vein in question shows that it is not the right pulmonary vein, but the hepatic vein. This vein is of great size, and the main trunk of it traverses the liver right to its posterior end, and then runs free for a considerable distance (about 2 inches in an adult of 14 inches total length) through the splanchnocoele along the right side of the right lung till it joins the interrenal vein (fused posterior cardinals). It is clear that the vein which I have described is a true primitive posterior vena cava of the same type as that in lung-fishes, and peculiar only in the fact that its communication with the interrenal (posterior cardinal) vein is further back than usual.

(*Issued separately, 23rd May* 1910.)

XIV.—Notes on Prof. E. A. Minchin's Preparations of the Early Stages in the Development of *Sepia.* By J. H. Koeppern (Glasgow University). [Plates I. to X.]

(Read 20th December 1909. Received 14th February 1910.)

THROUGH the kindness of Prof. J. Graham Kerr, I was enabled to study the slides which Prof. E. A. Minchin prepared at Naples in 1892, of the early stages in the development of *Sepia.* Prof. Minchin's drawings of the preparations are so admirable that it would be regrettable to refrain from publishing them, and expedient to add such notes on the preparations as might be of use in elucidating the problem of Cephalopod development. I have to record my thanks to Prof. Kerr for suggesting this work and for his help and advice. My thanks are also due to Dr W. E. Agar for his kind interest.

The ova of *Argonauta* and *Loligo* are known to form three polar bodies (Ussov); in *Sepia,* however, only two polar bodies have been observed. Although Vialleton describes the first polar body as being frequently binucleated, he mentions that he never saw a third polar body. It was, consequently, not surprising that three distinct polar bodies were evident in some of the preparations under observation (*e.g.* Fig. 1).

There seems to be no determinate relation between their situation and the direction of the first cleavage furrow, nevertheless, the latter always occurs in very close proximity to the polar bodies. As no preparations of the germ calotte at a stage before the formation of the first cleavage spindle were available, it was not possible to corroborate Vialleton's statements regarding a causal connection between the course of the uniting pronuclei and the first cleavage plane.

The process of cleavage and the nuclear figures correspond with Vialleton's drawings.

After the germ calotte has been divided up into a considerable number of blastomeres, the elongated ones radiating at the periphery, the "blastocones," gradually assume club shape. The handles of the clubs become thinner, until they form delicate rays fading away into the membrane of protoplasm surrounding the yolk. Simultaneously, the basal parts of the "blastocones" divide into polygonal cells. These become detached from the germ calotte and are much modified in their outline. The protoplasm surrounding the nuclei wanes, until a stage is reached where the nuclei may be observed to be situated on the "files radiales" surrounded by a halo of protoplasm. At first the nuclei are arranged concentrically round the germ calotte and karyokinetic figures are in evidence,[1] the axes of the spindles being directed

[1] Owing to the dense arrangement of the chromosomes and the lack of suitable sections the number of the chromosomes could not be satisfactorily ascertained. Twelve rod-shaped chromosomes were observed in several telophases.

radially. In later stages, however, the nuclei assume an irregular shape and are scattered over the surface of the yolk.

While these "autoplasts" (Lankester) are yet in the act of forming the yolk epithelium, a thickening of the periphery of the blastoderm takes place. Transverse sections at this stage show a single layer of cells (Fig. 28); at the periphery of this layer cells are dividing, the spindle axes being directed obliquely. After this peripheral proliferation of cells forming a ring on the lower surface of the blastoderm, a layer of cells gradually grows from it towards the centre of the blastoderm, like the closing of a diaphragm. The spindle axes are parallel to the surface of the blastoderm, therefore the formation of the inner layer can hardly be termed a delamination (Metchnikoff, Ussov), or an inbending of the outer layer (Bobretzky). In-growth is a more suitable descriptive term.

It is not quite precise, however, to describe the inner layer as having the shape of a ring. Bruce already observed, but erroneously interpreted this stage ("mesoderm-bands"), of which Vialleton gave the following description:—"La zone obscure[1] ne présente pas partout la même teinte, mais elle paraît formée de deux moitiés plus sombres séparées l'une de l'autre sur la ligne médiane par le cercle central et par des espaces clairs situés au-dessus et au-dessous de ce dernier." I can endorse this, as well as Teichmann's account, though the latter only observed *one* "espace clair" the indication of the stomodœum. The other part of the blastoderm where the lower layer of cells hesitates to grow for a time, but which disappear again, I should like to interpret as a reminiscence of the proctodœum.

In our preparations we have, finally, a stage when the epithelium (or syncytium) arising from the "autoplasts" has inserted itself under the blastoderm, thus entirely enveloping the yolk, and the outer layer of the blastoderm has grown peripherally to form a second sheath round the yolk. The inner layer of the blastoderm, situated between the outer layer and the yolk epithelium, is restricted to the area of the germ calotte.

Sepia is a striking example of bilaterality persisting from the ovum (Lankester, Vialleton, Watase) through the entire development of the embryo to the adult.

The desideratum in Cephalopod development, a correct interpretation of the origin and fate of the germ layers, is not very easy to supply. In previous memoirs on the subject we encounter a number of conflicting opinions and an unsatisfactory terminology.

Vialleton was the first to furnish conclusive evidence as to the formation of the yolk epithelium (membrane périvitelline) from the peripheral segments

[1] *Area opaca*, Ussov.

of the germ calotte, and more recent researches (*e.g.*, Faussek) have corroborated his account in main outline and only added a few details. The difficulty arises when we come to view the yolk epithelium and the other products of segmentation in the light of the germ-layer theory. Ussov, Bobretzky, Bruce, and Vialleton are unanimous in terming the yolk epithelium the endoderm. Subsequent investigations have made this purely topographical criterion of nomenclature untenable, especially after it had been proved without doubt (Faussek, Distaso) that the yolk epithelium does not only not participate in the formation of the mid-gut, but also has nothing whatever to do with the actual construction of the animal, beyond aiding it in its early metabolism. Although it is justifiable to draw a comparison between the blastocones and the macromeres in other telolecithal ova (cf., *Teleosteans*), I do not consider it expedient to term a structure the endoderm when its cells do not possess any histogenetic properties whatsoever, nor its chromatin the hereditary qualities for any part of the adult. In some records (Faussek) a compromise has been made by calling the yolk epithelium the primitive endoderm, and the layer between it and the ectoderm (ectoderm is the only name which has been applied unambiguously by all) the mesendoderm. The latter word, again, has been used by Korschelt to denote the *Anlage*, situated at the under side of the periphery of the ectoderm, of both the yolk epithelium ("endoderm") and of the layer hitherto universally—with the exception of Teichmann—accepted as "mesoderm" or "mesendoderm." This medley of creeds may be obviated most effectively by dropping "mesendoderm" here altogether, and either refraining from committing oneself to any name for the layer from which *inter alia* the mid-gut originates or substituting endoderm for the sometime "mesoderm" or "mesendoderm."

Further research on the development of *Sepia* and its allies is urgently required to ratify what is already known and elicit more details, and in order to pave the way for a homogeneous embryology of the Cephalopoda.

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Explanation of the Figures.

[Figures 1-23 were drawn by E. A. M. with the camera lucida and Zeiss oc. 2, obj. B.; the enlarged drawings of the polar bodies with Z. oc. 4, obj. D. Figures 24-30 were drawn by J. H. K.—fgg. 24-26 with Z. oc. 2, obj. B.; fgg. 27-29 with Z. oc. 4, obj. A.; fgg. 30-31 with Z. oc. 2, obj. D.]

Fig. 1. 2 blastomeres. Nuclei resting. (3 polar bodies).
Fig. 2. 2 blastomeres. Nuclei dividing.
Fig. 3. Ditto.
Fig. 4. 4 nuclei. Indication of second cleavage furrow.
Fig. 5. Ditto. Slightly advanced.
Fig. 6. Second cleavage furrow formed.
Fig. 7. 4 blastomeres. Nuclei resting.
Fig. 8. 4 blastomeres. 2 nuclei resting, 2 dividing.
Fig. 9. 4 blastomeres. 4 nuclei, dividing.
Fig. 10. Formation of 8 blastomeres.
Fig. 11. 8 blastomeres. 8 nuclei, resting.
Fig. 12. Formation of 16 blastomeres. 12 nuclei resting, 2 dividing.
Fig. 13. Formation of 16 blastomeres, advanced.
Fig. 14. Ditto.
Fig. 15. 16 blastomeres. 16 nuclei, resting.
Fig. 16. 16 blastomeres. 8 nuclei resting, 8 dividing.
Fig. 17. „ „ 4 „ „ 12 „
Fig. 18. „ „ 2 „ „ 14 „
Fig. 19. „ „ 16 „ dividing.
Fig. 20. Formation of 32 blastomeres.
Fig. 21. Ditto, advanced.
Fig. 22. Ditto.
Fig. 23. Blastoderm.
Fig. 24. Ditto.
Fig. 25. Formation of "autoplasts."
Fig. 26. Ditto.
Fig. 27. Transverse section through blastoderm.
Fig. 28. Ditto.
Fig. 29. Ditto.
Fig. 30. Ditto.

(*Issued separately, June* 2, 1910.)

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

Plate II.

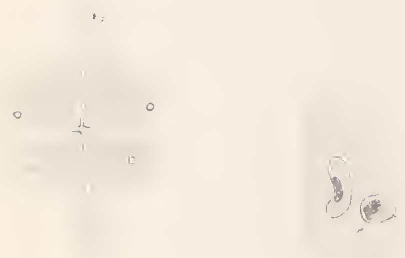

Fig. 5.

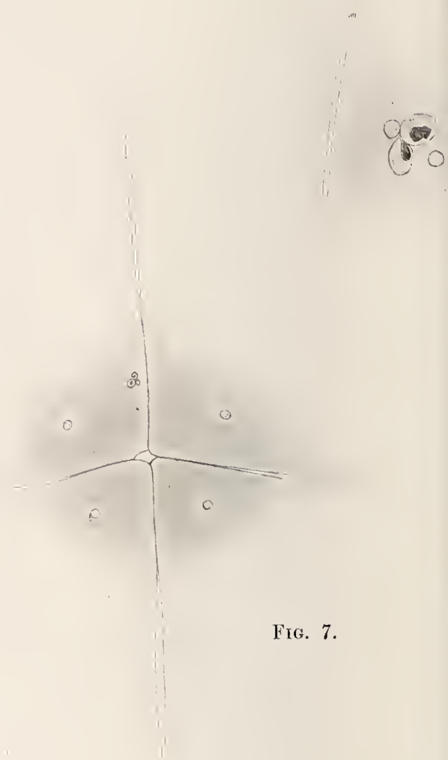

Fig. 7.

Fig. 6.

Fig. 8.

FIG. 10.

FIG. 9.

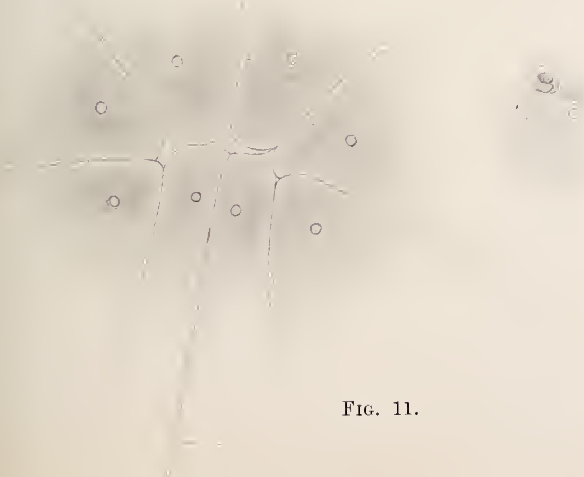

FIG. 11.

FIG. 12.

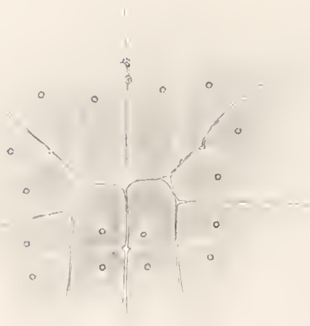

FIG. 13.

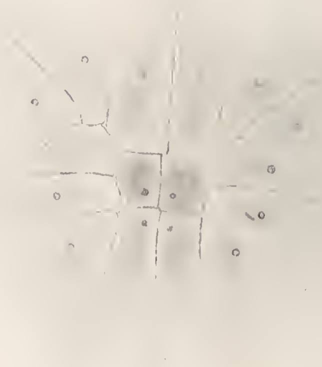

FIG. 14.

Fig. 15.

Fig. 16.

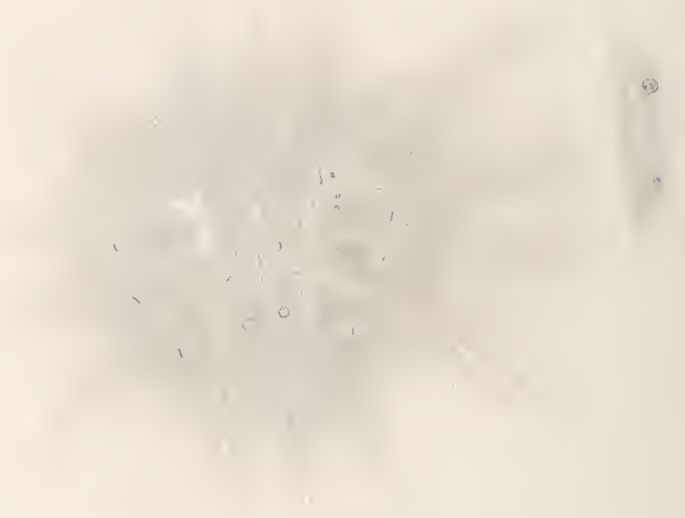

FIG. 17.

FIG. 18.

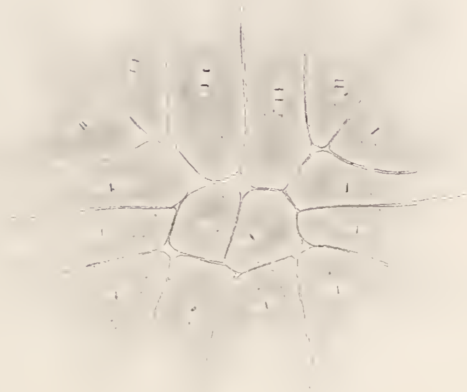

FIG. 19.

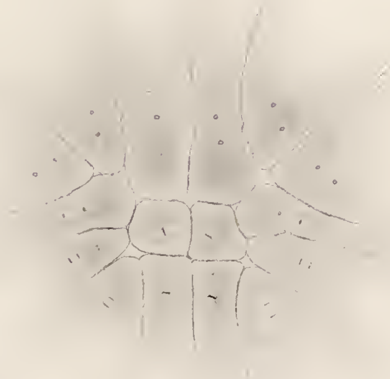

FIG. 20.

FIG. 21.

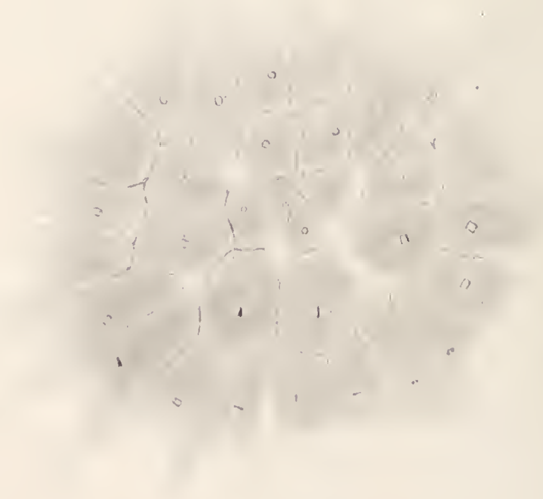

FIG. 22.

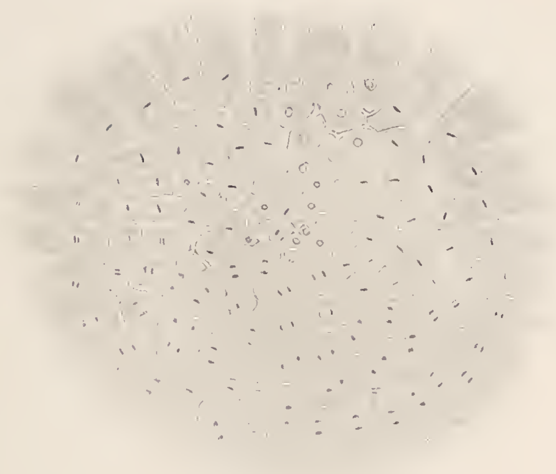

FIG. 23.

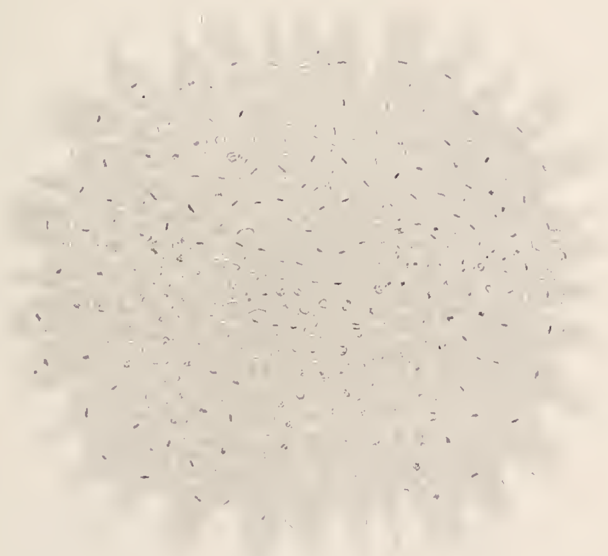

FIG. 24.

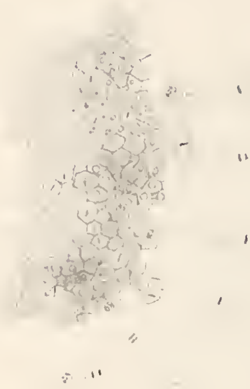

FIG. 25.

FIG 26.

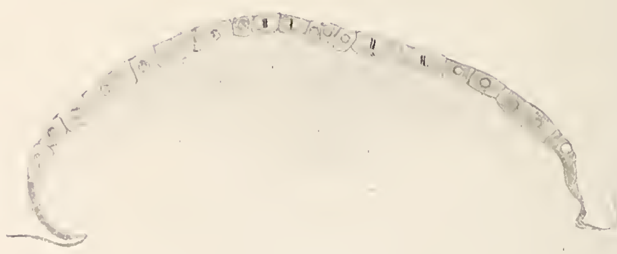

FIG. 27.

FIG. 28.

FIG. 29.

FIG. 30.

XV. The Oligochæta (Earthworms and their Allies) of the Forth Area. By William Evans, F.R.S.E.

(Read 28th March 1910. Received 13th April 1910.)

The investigation of the Oligochæte Fauna of Scotland has still to be undertaken. Only a few scattered records, apart from the short list presently to be mentioned, exist for any of the areas. In the Handbook of the Fauna and Flora of "Clyde," published in 1901, the Oligochæta are not represented; and, as I have shown in my recent review[1] of our knowledge of the Fauna of the "Forth" area, no list has hitherto been published for this district either. The records contained in the present contribution are the result of a certain amount of intermittent attention I have given to the group in Forth during the past five or six years. Except in the case of the Lumbricidæ—the typical Earthworms—the catalogue must, I am well aware, be very incomplete; but I hope to add to it from time to time, and in any case it may serve as a basis for a fuller one.

When I first became interested in the Oligochætes Mr F. E. Beddard, whose tables in the second volume of the "Cambridge Natural History" (pp. 390, 391) I was working with, kindly examined some for me, as did also the Rev. Hilderic Friend, to whom a number of collections of Lumbricids from various parts of the district have since been submitted. Mr Friend is well-known as an expert on the British Earthworms. Here progress might have ceased had not Mr R. Southern, of the Dublin Museum, taken up the study of the Enchytræidæ of the British Isles, and, being desirous to know what species occurred in Scotland, willingly examined such material as I was able to send him in the living state.[2] The results are embodied in his valuable "Contributions towards a Monograph of the British and Irish Oligochæta,"[3] published last year. Of other records there are exceedingly few—practically only one or two of aquatic forms in Sir John Dalyell's works. These are mentioned under the species to which they refer.

The number of forms recorded in the present catalogue is 47 inclusive of two varieties or sub-species, but excluding an exotic species living in hothouses.[4] Ten belong to the aquatic families, 17 are Enchytræids (small, mostly

[1] *Proc. Roy. Phys. Soc.*, vol. xvii. pp. 29-31.

[2] Mr Southern considers it very unsafe to name preserved Micro-Oligochæta, of which I have a considerable number, and probably he is right.

[3] *Proc Roy. Irish Acad.*, vol. xxvii., sect. B, No. 8 (pp. 119-182, pls. vii.-xi.), April 1909.

[4] Search for exotic species in the Botanic and other gardens has not been made, as however interesting in themselves they form no part of our fauna.

whitish worms), and 20 are Lumbricids. Southern, in his paper mentioned above, gives a list of the Oligochæta then known to occur in the British Isles, showing in parallel columns which of them had been recorded from England, Scotland, Wales, Isle of Man, and Ireland. Of the 135 species and varieties comprised in the list, 88 were recorded from England, Wales and Isle of Man combined, 48 from Scotland, and 96 from Ireland. Adding to the above 88 those in the Scottish list not recorded from south of the Border, we get 103 from Great Britain against the 96 from Ireland. The lesson conveyed by these figures is, of course, not that Ireland has a richer Oligochæte fauna than the other regions, but that certain sections of the group, the Enchytræids in particular, have been more thoroughly investigated there. The Scottish part of the table was made up mainly from my Forth records, the preliminary list submitted to this Society in March 1909 having been placed at Mr Southern's disposal for the purpose. Subsequent additions bring the Scottish list only up to 55, so that if a zoologist trained in the methods necessary for the investigation of the internal characters by which so many of the Micro-Oligochæta are separated would take the matter up, a large accession to the list would speedily be made.

Regarding the Lumbricidæ—the only section which has been at all adequately worked—there are, as has been mentioned, 20 forms now known from Forth, being only 6 or 7, if we neglect a few unimportant varieties, less than the total for the whole of the British Isles. Most of them are common and widely-distributed both in these Islands and on the Continent. Three, however—namely *Helodrilus* (*Eopila*) *oculatus* (assuming there is no mistake in the determination), *Eisenia alpina*, and *Eiseniella tetraedra* var. *hercynia*—are not otherwise known from this country, while the striking *Octolasium cyaneum* is recorded for the first time from Scotland. There is one species, *Dendrobæna octaedra*, which, contrary to expectation, I have not yet detected here. Friend has recorded it from England and Paisley, Southern finds it commonly in the north of Ireland, and abroad its range extends from Portugal to Norway, Iceland, etc., so it should surely occur in some part of our area.[1]

In the choice of habitat Oligochætes, in common with other creatures, have their likes and dislikes. "I have seen," writes Darwin in his book on "Vegetable Mould and Earthworms" (1881 ed., p. 10), "worms in black peat in a boggy field; but they are extremely rare, or quite absent in the drier, brown, fibrous peat, which is so much valued by gardeners." The all but total absence of Earthworms from our peat moors has often come

[1] I have since (29th April) found it near Peebles in the adjoining "Tweed" area.

under my notice,[1] and the same remark applies to the coast sandhills. With these exceptions their distribution is very general, extending from sea-level, just above high-water mark, to the tops of the highest hills. Mr Friend tells me he has a record of a Lumbricid from the summit of Ben Lomond (3192 ft.) on the Forth and Clyde water-shed, and I have found *Allolobophora chlorotica* close to the top of Stuc-a-Chroin (3189 ft.). On a steep hillside at Balquhidder, early in April, I found the following species at from 1000 to 1500 ft.:—*Eiseniella tetraedra*, *Eisenia rosea*, *Allolobophora caliginosa*, *A. chlorotica*, and *Lumbricus rubellus*. They occurred chiefly under stones on the margin of a rill where *Saxifraga aizoides* and other sub-alpine plants were growing on mica-slate debris. In the "Tay" area I have found (August 1905) *A. chlorotica*, *Dendrobæna mammalis*? (immature), and *L. castaneus*, on wet mossy ledges, at 2500 to 2700 ft., and *L. castaneus*? (imm.), at 3250 ft., on the Tarmachans; while in July 1906 I had *D. mammalis* from about the roots of *Draba rupestris* at the summit of Ben Lawers, close on 4000 ft. *L. terrestris* and some others appear to restrict themselves very much to the cultivated districts. Gardens, fields, old pastures, and the heaps of scrapings to be seen on most roadsides all provide the worm-hunter with rich collecting-grounds, as do also the margins of streams and lakes where several species, such as the amphibious *Eiseniella tetraedra*, are fond of lurking under stones or in the mud. Others, again, belonging to the sub-genera *Dendrobæna* and *Bimastus*, are usually found under the bark of decaying trees and old stumps or among dead leaves. I have never seen a Lumbricid within the salt-water zone. Several of the Enchytræidæ, however, are littoral species living under stones and rotting seaweed at and below high-water mark. One species, *Enchytræus albidus*, occurs both in this littoral habitat and in manure in inland localities. *Marionina sphagnetorum* is usually found in peaty soil on elevated moors, but I have obtained it near sea-level in Fife. Three Tubificids dwell in the mud of the Estuary between tide-marks, while a fourth makes its home in the mud in the shallows of fresh-water lochs and slow streams. The members of the other aquatic families seem to prefer the weedy ponds of the lowlands, but I have found *Lumbriculus variegatus* plentiful among sphagnum in peat-pools on an upland moor. The deep-water *Stylodrilus gabreteæ* (Vejd.) may be expected to occur in the large lochs at the head of the valley, seeing it is common in Loch Tay and Loch Lomond (C. H. Martin[2]), but I have had no opportunity of looking for it.

[1] The abundance of humus acids may have to do with their absence.

[2] "Notes on some Oligochæts found on the Scottish Lake Survey," *Proc. Roy. Soc. Edin.*, vol. xxviii. p. 21, 1907.

Most of my records, it will be seen, are for the months February to April. This is accounted for chiefly by the fact that the majority of worms are mature and in good condition for identification during the spring, and also by the circumstance that at that season ploughing and gardening operations facilitate their collection. Mature examples may, however, be found at other times of the year, winter included. Earthworms, so far as I can make out, do not hibernate; during frost they merely retire deeper into the ground, but come up again as soon as the frost disappears. What is the extent of a worm's life-time I am unable to say, and I do not remember having seen any statement on the point.

With regard to nomenclature, a matter in which the Oligochæta have had their full share of confusion, I have adhered to that employed by Southern in his recent "Contributions," which, with one or two exceptions, is the same as in Dr Michaelsen's volume on the "Oligochaeta" in *Das Tierreich* (Lief. 10, 1900). The few synonyms added here and there are mostly connected with references to the species as members of the British fauna. For considerations explained in a paper on the Collembola of the district,[1] I have given my records in some detail even in the case of common species.

Before proceeding to the systematic portion of the paper, I desire to express my thanks to those specialists whose kind help I have already referred to; it is their stamp upon so many of the records that gives them their value. I wish some resident zoologist accustomed to modern methods of research would take up the study of the Micro-Oligochæta in Scotland. In adding to the list, describing new species, and demolishing spurious ones—of which I expect not a few will be detected when examples from a wider range of localities and in more stages of development have been examined—he will find much to reward his labour.

Order OLIGOCHÆTA.

Fam. ÆOLOSOMATIDÆ.

Æolosoma quaternarium, Ehrbg.

When looking for rotifers in some wet moss which I sent him from a ditch in Hopetoun woods in Dec. 1905, Mr James Murray detected an *Æolosoma* which I refer to this species. He described it as "orange-spotted like *hemprichi*, but head not expanded, and with setæ two or three times diameter of body." *Æolosomæ* are for the most part minute creatures from 1 to 2 mm. in length.

[1] *Proc. Roy. Phys. Soc.*, vol. xiv. p. 222, 1899.

Æolosoma hemprichi, Ehrbg.

Æolosoma ehrenbergii, Örst.

This species, in which the prostomium is broader than the next segment, and the oil globules are orange-coloured, seems to be common in stagnant weedy pools. Murray detected it among duck-weed (*Lemna minor*) from the Upper Elf Loch, Braid Hills, Nov. 1905, as recorded by me in *Ann. Scot. Nat. Hist.* for 1906 (p. 57); and in Dec. 1905 I found several among the same plant from a pond at Duntarvie near Winchburgh. In Feb. 1906 I again noted what was doubtless the same species among water ranunculus from a pond at South Queensferry.

Mr Murray reported an *Æolosoma* "with colourless spots" in material from a pool on Largo Links, Sept. 1906, but this character alone is insufficient for its identification.

Fam. **NAIDIDÆ.**

Chætogaster diaphanus (Gruith.)?

Beddard in his "Monograph of the Oligochaeta" 1895 (p. 306) refers Dalyell's *Nais lacustris*[1] (renamed *N. scotica* by Johnston[2]), which was doubtless from the Edinburgh district, to this species.

When examining water-weeds and other material from ponds in our area, I have once or twice observed a small aquatic worm apparently belonging to this genus.

Chætogaster limnæi, K. Baer.

Dr J. H. Ashworth has shown me six specimens of this interesting Oligochæte, mounted as microscopic slides, which he took from the shell of a water-snail (*Limnæa peregra*) got in the marl pit at Davidson's Mains, near Edinburgh, in June 1904. About a dozen of the worms were protruding from the mouth of the shell, which contained a living mollusc. Allusion to this occurrence was made by me in a former paper in the Society's *Proceedings* (vol. xvii., p. 31, footnote).

[**Nais elinguis**, Müll.

From a pool at Callander in Sept. 1906, I obtained a Naid which I made out to be of this species, but confirmation of my identification is desirable before placing it unreservedly on our list.]

Stylaria lacustris (L.).

Nais proboscidea, Dalyell in "Powers of the Creator," vol. ii. (1853) p. 131.

Common in ponds and pools among the potamogetons and other water plants.

[1] "Powers of the Creator," vol. ii., 1853, p. 130, pl. 17, f. 1-5.

[2] "Catalogue of Non-parasitic Worms," 1865, pp. 71, 336.

Localities in which I have found it are the following:—

Upper Elf Loch, Braid Hills, common, May 1905, etc. (*Ann. S. N. H.*, 1905, p. 215); pond in Botanic Garden, Edinburgh, Oct. 1905; Humbie Reservoir, near Winchburgh, June 1906; Loch Leven, July 1906; marl pit, Davidson's Mains, Aug. 1907.

Fam. TUBIFICIDÆ.

Clitellio arenarius (Müll.).

Plentiful in mud between tide-marks in Dalgetty Bay, west of Aberdour, Fife, and at Bo'ness, Linlithgowshire, March 1910. I have compared Forth examples with Plymouth ones received alive from Dr E. J. Allen, and have no doubt of their identity.[1]

Dr Michaelsen ("Oligochaeta," p. 55) suggests that Dalyell's *Lumbricus littoralis* may belong to the genus *Clitellio*. Johnston (*t.c.* p. 67) gives *C. arenarius* from Berwick Bay, and Professor M'Intosh[2] has recorded it from the shore at St Andrews.

Tubifex tubifex (Müll.).

Tubifex rivulorum, Lam. and others.

Abundant in the mud of slow-running streams, ponds, and lake-margins apparently throughout the area. I have submitted specimens to Mr Southern, and he confirms my identification. Dr S. Macadam[3] and Dr T. Scott[4] have recorded *Tubifex rivulorum* from Water of Leith and Loch Leven (June 1900) respectively.

The localities in which I have found this worm are:—

Lochend, Edinburgh, abundant in foul black mud, Oct. 1907; Bavelaw Burn at head of Threipmuir Reservoir, May 1905; pond at Bush, near Roslin, June 1906; slow stream at head of Loch Fitty, Fife, June 1905; Cocklemill Burn, near Elie, April 1906; Orr Water, Thornton, March 1910; stagnant pool at Blackness, Linlithgowshire, and ditch near Falkirk, Stirlingshire, March 1910; ditch at Balquhidder, south-west Perthshire, 2nd April.

Tubifex benedeni (Udek.).

Hemitubifex ater, Beddard in *Proc. Zool. Soc.*, 1888, p. 486, fig. A.
H. benedii, Beddard's "Monograph of the Oligochaeta," 1895, p. 261.
Psammoryctes benedeni, Michaelsen's "Oligochaeta," 1900, p. 51.

I have found this species in considerable abundance in the mud of the Estuary of the Forth, west of Aberdour, and at Bo'ness, during the present

[1] Living examples of this and *T. benedeni* from Aberdour have since (May 1910) been submitted to Mr Southern who confirms the identification.

[2] "Marine Invertebrates and Fishes of St Andrews," 1875, p. 114.

[3] *Proc. Roy. Phys. Soc.*, vol. iii. p. 234 (1865).

[4] 9th Rep. Fish. Bd. Scot., pt iii., p. 273.

month (March 1910); and no doubt it occurs in similar situations all along the coasts. Identification confirmed by Mr Friend. It is a very papillated worm, as shown in Beddard's figure (*l.c.*) from a Plymouth specimen.

Tubifex costatus (Clap.).

Psammoryctes costatus, Michaelsen's "Oligochaeta," p. 52.

In June 1909 a few examples of this species were found under a stone in a muddy bay about a mile east of Dunbar, Haddingtonshire. For their determination I am indebted to Mr Southern. Both this and the previous species appear to be additions to the Scottish list.

Fam. **LUMBRICULIDÆ.**

Lumbriculus variegatus (Müll.).

Lumbricus teres, Dalyell, "Powers of the Creator," vol. ii., 1853, p. 140.

This interesting aquatic worm is common in pools, ponds, ditches, and slow streams in most, if not all, parts of the area. It is very quick in its movements, and requires care in preservation to prevent it breaking itself into pieces.

My localities for it are:—

Bavelaw Moss, abundant in submerged sphagnum, May and Nov. 1904; Upper Elf Loch, Braid Hills, Oct. 1904, etc. (*Ann. S. N. H.*, 1905, p. 215); pond near Kirknewton, common among submerged leaves, March 1905; Logan Water, Pentlands, Dec. 1906; pond in Botanic Garden, Edinburgh, May 1909; ditch at Hallyards, near Kirkliston, March 1910; Camilla Loch, Fife, Aug. 1906; ditch in wood near Thornton, March 1910; Lake of Menteith, June.

Fam. **ENCHYTRÆIDÆ.**

Henlea ventriculosa (Udek.).

Doubtless common. Mr Southern has determined specimens for me from the under-noted localities:—

Margin of Clubbiedean Pond, Pentland Hills, a good many under log, 15th Nov. 1907; Loch Gelly, Fife, under rejectamenta, 26th Dec. 1907; at roots of plants in garden, Morningside, 19th January 1908.

Marionina sphagnetorum (Vejd.).

Probably common on elevated moors, but easily overlooked owing to its small size. Specimens from a tuft of sphagnum and hepatics on Dunbar Common, Lammermuir Hills, at about 1000 ft. above sea-level, 10th Oct. 1908, and from near Thornton, Fife, March 1910, were determined by Southern. I have also observed it at Bavelaw Moss on the north side of the Pentlands, and on Ben Ledi at about 2500 ft., Sept. 1906.

Marionina semifusca (Clap.).

In small colonies under stones on the south shore of the Firth of Forth, at Dalmeny, Linlithgowshire, 30th Aug. 1907; also under rotting fuci west of Granton, March 1910. Claparède's specimens were found in Skye.[1] In Ireland Southern finds it commonly round Dublin Bay.

Lumbricillus verrucosus (Clap.).

Pachydrilus verrucosus, Beddard in *Proc. Roy. Phys. Soc.*, vol. x. p. 101 (1889).

Specimens of this seemingly common British littoral form have been identified from the following places on the shores of the Firth of Forth, as mentioned in my paper in the previous volume of the Society's *Proceedings*, (xvii. p. 31):—

Dalmeny, under stones on mud between tide-marks, Aug. 1907; Aberdour, Fife, among stones and sand under rotting seaweed at high-water mark, Aug. 1907, and between tide-marks, May 1910.

Lumbricillus evansi, Southern.

This recently described species[2] is no doubt common on the shores of the Firth of Forth. When drawing up his description, Mr Southern had before him specimens found by me on 22nd Aug. 1907, among stones and gravel beneath rotting seaweed (fuci, etc.) at high-water mark, on the Fife coast west of Aberdour, where it was again plentiful on 5th March 1910. On the Haddingtonshire coast, I found it in abundance under stones in a muddy bay east of Dunbar, on 8th May 1909 (specimens determined by Southern). Has been taken also at Dublin Bay and Isle of Man.

Lumbricillus fossarum (Tauber).

This is another form which was detected among the Enchytræids got under decomposing wrack at Aberdour in Aug. 1907.

Mesenchytræus celticus, Southern.

In leaf mould on roadside south of Aberdour, Fife, 15th Feb. 1908, several mature specimens. These along with others taken near Montpelier, Co. Dublin, in Dec. 1907, supplied the material for the description of the species.[3]

Enchytræus albidus, Henle.

Abundant under rotting seaweed on both sides of the Firth of Forth;[4] also

[1] Mém. Soc. Genève, xvi. p. 76, 1861.

[2] Southern, *tom. cit.*, p. 151.

[3] Southern, *tom. cit.*, p. 155.

[4] W. Evans, *Proc. Roy. Phys. Soc.*, xvii. p. 31.

in manure-heaps about farms, etc. Mature examples from Aberdour beach, March 1905, were determined for me by Dr Michaelsen; and from the same locality and also from Dalmeny beach, Aug. 1907, by Southern. Other records are :—

West of Granton, March 1910; Gosford Bay, March 1909; Aberlady Bay, Sept. 1909, immature; Thornton, common in farm manure, March 1910.

Enchytræus bucholzii, Vejd.

At Cullalo, near Aberdour, several examples were found in a decayed log, February 1908.

Enchytræus turicensis, Bret.

E. turicensis, Bret. + *E. minimus*, Bret.

In the damp outer layer of a mole's nest on Dirleton Links, 14th March 1908.

Fridericia striata (Levins.).

Among old leaves on roadside near Aberdour, Feb. 1908; and under bark of dead beech, Ravelrig, Midlothian, common, March 1908.

Fridericia magna, Friend.

Several specimens of this form were found under stones beside the Water of Leith four miles above Balerno on 26th March 1909. (*Cf.* Southern, *tom. cit.*, p. 165, footnote.)

Fridericia glandulosa, Southern.

Detected by Southern among some Enchytræids received from me from the Edinburgh District in December 1907.

Fridericia lobifera (Vejd.).

The specimens of this interesting addition to the British list, recorded by Southern, were found by me in a mole's nest near Dirleton on 14th March 1908.

Fridericia ratzeli (Eisen) var. **beddardi**, Bret.

In leaf mould near Aberdour, Feb. 1908.

Fridericia bretscheri, Southern.

Among old leaves on roadside near Aberdour, Feb. 1908.

Fridericia michaelseni, Bret.

Common under stones and rejectamenta on the margins of lakes and streams.

The following are the localities from which I have had it identified:—

Clubbie-dean pond, Pentlands, common, under a log at the water's edge, Nov. 1907; Loch Gelly, Fife, abundant under rejectamenta, April 1905, and Dec. 1907; near Aberdour, in moist earth, Feb. 1908; under stones beside the Water of Leith above Balerno, March 1909.

[Fam **MEGASCOLECIDÆ.**

Pheretima (= Perichæta) indica (Horst).

I have found this exotic species on several occasions in hot-houses in Edinburgh, where, if allowed, it seems readily to establish itself. Presumably it is not able to live out-of-doors in our climate. I once, however, found one crawling at the side of the footpath in Morningside Park; probably it had dropped from a flower-pot during removal from a hot-house in the neighbourhood. As Mr R. Service, who, in 1890, recorded[1] the establishment of this Earth-worm in hot-houses in Kirkcudbrightshire, remarks, "it is a hard, wiry, agile creature." I have seen one spring a distance of six or seven inches.]

Fam. **LUMBRICIDÆ.**

The *Lumbricidæ* or typical Earth-worms have usually been recorded by British naturalists under the three generic names *Allurus*, *Allolobophora*, and *Lumbricus*. Following Dr Michaelsen,[2] Mr Southern, in his recent paper to which reference has already been made, substitutes *Eiseniella* for *Allurus*, and splits *Allolobophora* into three genera, *Eisenia*, *Helodrilus*, and *Octolasium*; *Helodrilus* being again divided into four subgenera, namely, *Allolobophora*, *Dendrobæna*, *Helodrilus* (*Eophila*), and *Bimastus*. Representatives of all these genera and subgenera occur in our area.

Eiseniella tetraedra (Sav.).

Allurus tetraedrus, Beddard in *Proc. Roy. Phys. Soc. Edin.*, vol. x. p. 208.

As pointed out by Mr Beddard (*l.c.*) this is an amphibious species. In the Forth district it is common in mud and under stones about the margins of streams and ponds, often quite under the water. I have also found it under the bark of an old log in a damp wood. The following list of occurrences shows that it is widely distributed.

Midlothian:—In stream at Nether Habbie's Howe, Pentland Hills, April 1902; Kirknewton, under bark of rotten log in damp spot in wood, April 1903; Gladhouse Reservoir, under stones at the water's edge, common, Nov. 1904; Cobbinshaw Reservoir, under flood refuse, common, April 1905; margin of river Almond, at Cramond Bridge, Dec. 1904; Lochend Loch, Oct. 1909; ditch

[1] *Proc. Roy. Phys. Soc.*, vol. x. p. 396.

[2] "Das Tierreich," Lief. 10, Oligochaeta, 1900.

near Colinton, March 1910. East Lothian:—Pressmennan Lake, in sandy mud at water's edge, abundant, Sept. 1904; Luffness Marsh, one under water-vole's nest, Feb. 1905; side of Tyne above East Linton, April. Fife and Kinross:—Loch Gelly, May 1895 and Oct. 1905; Loch Leven, south shore, April 1905. Stirlingshire:—In ditch south of Falkirk, March 1910. So. Perthshire:—ditch at Balquhidder, and also by rill on hillside, at over 1000 ft., April; Lake of Menteith, June.

Eiseniella tetraedra hercynia (Michlsn.).

An example of this subspecies (perhaps it is only a variety) has been detected by Mr Friend among some worms I collected in the neighbourhood of Thornton, Fife, on 19th inst. (March 1910). It is, Mr Friend writes me, "in splendid form and unmistakable." In *E. t. hercynia* the male pore is on the 15th segment, and not on the 13th as in *E. t. typica.* It does not appear to have been previously noticed in the British Isles.

Eisenia fœtida (Sav.).

Allolobophora foetida, Beddard's table in "Cambridge Nat. Hist.," vol. ii. p. 391.

The Brandling or Bramble-worm, as this very distinct species is called, is common about gardens, in dunghills, leaf-mould, etc.; and occasionally occurs away from houses—in a rotten tree, for instance.

I have noted it in the following localities:—

Penicuik; garden at Bruntsfield, Edinburgh, common, May 1902; garden at Morningside, Sept. 1904; banks of the Almond at Cramond Bridge, Dec. 1904; Polton woods, under bark of rotten tree-stump, several, March 1905; Tyninghame, East Lothian, May 1910; Dunipace, Stirlingshire, in garden, March 1910 (from J. M'Naughton).

Eisenia alpina (Rosa).

Mr Friend reports a solitary example of this species among a number of worms I collected at Balquhidder, south-west Perthshire, on 2nd April 1910. It is an addition to the British list.

Eisenia rosea (Sav.).

Allolobophora rosea, Rosa, and others.
A. mucosa, Eisen; Friend.

Widely, but somewhat sparsely distributed, preferring, according to my experience, decidedly wet soil. It well deserves the name of *rosea.* Has been identified from the undernoted localities:—

Ditch near Balerno, one, March 1905; in road-scrapings, near Dunblane, a well-marked specimen, April 1905; under stone by side of Water of Leith above Ravelrig, March 1909; side of Tyne above East Linton, April 1910; Carriden, near Bo'ness, March 1910; old quarry near Falkirk, common, March 1910; near Thornton, Fife, several, March 1910; Balquhidder, both low down, and at 1000-1500 feet on hillside, April.

Genus **Helodrilus**, Hoffmstr., em. Mchlsn.

The following three species are placed by Michaelsen in the subgenus **Allolobophora**, Eisen :—

Helodrilus (A.) caliginosus (Sav.).

Abundant in fields, gardens, old pastures, etc., throughout the area. So far the var. *trapezoides* has not been detected here.

Specimens have been examined from the following localities :—

Midlothian :—Fairmilehead and Temple, many turned up by the plough, Feb. 1904, and Feb. 1905 ; under stones by side of the Almond at Cramond Bridge, Dec. 1904 ; Pentland Hills above Hillend, and in road-scrapings at Polton, March 1905 ; banks of Water of Leith above Ravelrig, March 1909 ; field near Granton, March 1910. East Lothian :—Roadside near Gifford, April 1905 ; Aberlady, in garden, April 1907 ; side of Tyne above Hailes, April. West Lothian :- Carriden, near Bo'ness, March 1910. Stirling :—near Falkirk, common, March 1910. Fife and Kinross :—Loch Gelly, under flood refuse, and in adjoining pastures, common under stones and cow-dung, April 1905 ; south side of Loch Leven, April 1905 ; Thornton, March 1910. Perth So. and Clackmannan :—Dunblane, April ; Aberfoyle, June ; Dollar, July 1905 ; Balquhidder, April 1910.

Helodrilus (A.) longus (Ude).

Allolobophora terrestris, Beddard's table (*l.c.*).

Common in fields, about roadsides, etc., and widely distributed.

Localities are :—Field at Fairmilehead, Feb.; Polton, in road-scrapings, March ; Pentlands above Hillend, March 1905 ; Bolton, near Haddington, April 1905 ; Athelstaneford, April 1910 ; Carriden, near Bo'ness, and old quarry near Falkirk, March 1910 ; Thornton, Fife, March 1910 ; Isle of May, one, June 1909.

Helodrilus (A.) chloroticus (Sav.).

The Green-worm, as it may well be called, is common and generally distributed in the district, ranging from sea-level almost to the tops of the highest hills. Under a stone on the margin of a stream is a favourite habitat. When disturbed it curls itself into a circle, as Beddard (*l.c.*) and others have remarked. Some examples are much greener than others, and I have seen several of a distinctly reddish colour.

Localities :—Ditch near Balerno, and road-scrapings at Polton, March 1905 ; Water of Leith above Currie, common under stones, April 1908 ; Boltonmoor, near Gifford, April 1905 ; side of rill on the Lammermuirs above Castle Moffat, Oct. 1908 ; side of Tyne, near East Linton, April 1910 ; Carriden and Blackness, March 1910 ; near Falkirk, common at roots of hedge, March 1910 ; Dunblane and Bridge of Allan, April and Dec. 1905 ; Callander, and near summit of Stuc-a-Chroin (3000 ft.), Sept. 1906 ; Balquhidder, from bottom of valley up to 1500 ft. (see p. 111), April 1910 ; Charlestown, Fife, turned up by plough, Feb.; and Loch Gelly, common under flood refuse, April 1905 ; Isle of May, one under stone, Sept. 1909.

The next three species come under the subgenus **Dendrobæna**, Eisen.

Helodrilus (D.) rubidus (Sav.).

Allolobophora (*Dendrobæna*) *arborea*, Eisen (in part ?); Friend, in Journ. Linn. Soc., Zool., xxiv., p. 301, 1892.

A. putris, Beddard's table, *l.c.*, p. 390. Presumably the *A. rubida* (?+*A. profuga*) of the table = *Octolasium lacteum* (Örley).

Not very common in either of its forms according to my experience. Usually, but not always, in decaying trees and rotten stumps; among dead leaves is also a habitat for it. Typical specimens from the following localities have been determined for me either by Mr Friend or Mr Southern :—

Side of Almond above Cramond Bridge, two, Dec. 1904; Ravelrig, near Balerno, several under bark of dead beech, March 1908; and under bark of dead elm, March 1909; Hallyards, near Kirkliston, half a dozen in rotten stump, and similarly, near Falkirk, March 1910; Balquhidder, several among old leaves in ditch, April.

H. r. var. **subrubicunda** (Eisen), Michaelsen (*l.c.*).

Allol. (*Dend.*) *subrubicunda*, Friend (*l.c.*).

I have had this form, which Friend calls the "gilt-tail"—and which, though delighting to live among dead leaves and dead branches, he says is by no means confined to woodlands—determined by him from the following localities :—

Polton, in rotten tree, several, March 1905; Morningside, in garden, Dec. 1904; Isle of May, one under board, Sept. 1909; Balquhidder, one "not quite typical," under stone at foot of larch, April 1910. I have also a specimen got under a stone at about 2500 ft. on Stuc-a-Chroin, in Sept. 1906.

Helodrilus (D.) mammalis (Sav.).

Allolobophora (*Dendrobæna*) *celtica*, Rosa; Friend, in *tom. cit.*, p. 297.

This active little Earthworm, which was found by Mr Friend at Langholm, Dumfriesshire, in 1890, and received by him from Paisley in 1892 (*l.c.*), is common in fields, gardens, etc., throughout the district. Specimens have been identified from the following localities :—

Morningside, in garden; Colinton Dell; and banks of the Almond, near Cramond, Feb. 1905; Balerno, March 1905; Aberlady, April 1907; Carriden, near Bo'ness, March 1910; old quarry near Falkirk, common, "some with spermatophores" (Friend), March 1910; Kilconquhar, Fife, April 1906; Aberdour, in road-scrapings, Feb. 1908; Thornton, March 1910; roadside near Dunblane, April 1905.

Subgenus **Helodrilus**, Hoffmstr. (= **Eophila**, Rosa, in part).

Helodrilus (H.) oculatus, Hoffmstr.

Helodrilus oculatus, Evans, in *Proc. Roy. Phys. Soc.*, vol. xvii., pt. 1. (1909), p. 31, footnote.

In 1905 I found near Edinburgh a worm which Dr Michaelsen of Hamburg identified for me as *Helodrilus oculatus*, Hoffmeister, a species not otherwise recorded from the British Isles. It occurred in considerable numbers in mud under water on the margins of small streams in three localities, in two of which I have found it again during the present month. The submerged habitat is evidently quite natural to it, and when taken from the mud it is seen to be more or less enveloped by a thin film composed of mucus and fine particles of sediment. Colour rose-red, the dorsal blood-vessel being clearly visible through the transparent cuticle; length two to three inches; and, for a Lumbricid, of distinctly slender build.

Although I have no mature examples to produce, and am uncertain whether there were any among the specimens sent to Dr Michaelsen, I have nevertheless every confidence in his identification.

Localities:—Ditch at Seafield, near Roslin, Jan. 1905; ditch near Craiglockhart, Feb. 1905, and March 1910; stream above Torduff Reservoir, Pentland Hills, March 1905 and 1910.

Our two remaining **Helodrili** belong, according to Michaelsen, to the subgenus **Bimastus**, H. F. Moore.

Helodrilus (B.) eiseni (Levins.).

Allolobophora eiseni, Beddard's table, *l.c.*, p. 391.

I have obtained this species on but two occasions, which would seem to indicate that it is not common in the area. The fact that its prostomium completely cleaves or is dove-tailed into the first segment gives it the distinction of being the exception to the rule that otherwise serves to separate the genus *Lumbricus* from the rest of the family.

My two records are as follows:—

Boltonmoor, near Haddington, two, under bark of fir stump, April 1905; and Ravelrig, near Balerno, two, under bark of dead beech, March 1908 (determined by Mr Southern).

Helodrilus (B.) constrictus (Rosa).

Under the names *Allolobophora putris* and *A. arborea* the present species and *H. rubidus* (p. 121) have been much confused.

This small reddish Lumbricid is fairly common, occurring wherever there are dead trees and decayed stumps, beneath the bark of which it finds shelter and an abundant food supply.

Examples from nearly all of the following localities have been submitted either to Mr Friend or Mr Southern:—

Bavelaw Wood, near Balerno, under bark of rotten fallen pine, April 1903; Comiston, under bark four feet from ground on partially dead beech, Oct. 1904; Boltonmoor Wood, common in fir, etc., stumps, April 1905 and 1906; Clackmannan Forest, Sept. 1904; Doune, under bark of old willow, April 1905; Cullalo, Fife, in decayed tree, Feb. 1908; wood near Thornton, March 1910.

Octolasium cyaneum (Sav.).

Allolobophora studiosa, Mchlsn, 1890.

This fine species is apparently very local with us, but evidently common enough where it does occur. On the 19th of the present month (March 1910) I entered a field near Thornton, Fife, where two ploughs were at work. Many Earthworms were to be seen in the furrows, one of the commonest being *O. cyaneum* in fine mature condition. I have sent specimens to Mr Friend and Mr Southern, both of whom confirm my identification. This discovery brought to my recollection a worm I got in a similar manner in a field at Yorkston, near Temple, Midlothian, in February 1905; and on looking out the specimen I find it belongs to the same species. Further, on 26th of the present month, I found an undoubted, though immature, example under a stone in an old quarry near Falkirk, Stirlingshire.

O. cyaneum does not appear to have been previously recorded from Scotland. Some of my Thornton examples, when fully extended, were over six inches in length. Colour pale bluish lavender, with the first dozen segments pinkish, the clitellum brownish-yellow (ochre), and a spot at the posterior extremity pale yellow. It does not flatten its tail as *Lumbricus rubellus*, for instance, does.

Octolasium lacteum (Örley) var. **gracile**, Örl.

Allolobophora profuga, Rosa = *O. lacteum* (Örl.).

In a collection of Earthworms made by me in the neighbourhood of Balquhidder, South-west Perthshire, on 2nd April 1910, Mr Friend reports a specimen of a small form of *O. gracile*, Örley. Seeing that Michaelsen includes *O. gracile*, Örl., in the synonymy of *O lacteum* (Örl.), I here treat it as a variety of that species. *O. lacteum* is recorded from Paisley (Friend) in Southern's "Contributions," p. 174.[1]

Of the genus **Lumbricus**, L., em. Eisen, I have found four species, three of them abundantly, in the Forth area. For the characteristics of these Lumbrici, a paper by H. Friend on "The Annedid Fauna of Worcestershire" (*The Naturalist* for December 1909, p. 425) may be consulted.

Lumbricus rubellus, Hoffmstr.

Very common and generally distributed, occurring both in cultivated and uncultivated land, and ranging from sea-level to far up the hills.

Specimens (mature) from the following localities have been definitely noted:—

Morningside, in garden; and Craiglockhart, in field, Feb. 1905; Polton, in

[1] I have since, April 1910, found it near Peebles.

road-scrapings; Pentlands above Hillend, and Wester Howgate, under stones on hill-pasture, March 1905; near summit of East Cairnhill, Pentlands, one under stone, Sept. 1905; banks of Water of Leith above Balerno, March 1909; Aberlady, in garden, April 1907; Athelstaneford, April 1910; near Bo'ness, and in old quarry at Falkirk, common, March 1910; Otterston, Fife, under stones, March, and Lochgelly, common under cow-dung in old pasture, April 1905; Thornton, in field, March 1910; Aberfoyle, May 1902; Balquhidder, under stone at fully 1500 ft. on hillside, April.

Lumbricus castaneus (Sav.).

Lumbricus purpureus, Eisen, and others.
L. minor, Johnston ?

Common in old pastures, etc. This is a distinctly smaller species than the last, though closely related to it.

Localities from which it has been identified are:—

Banks of the Almond (Midlothian side) at Cramond, Feb. 1905; banks of Water of Leith above Currie, April 1908; Gullane Links, East Lothian, under stone, Jan.; Athelstaneford, April; and near Gifford, in road-scrapings, April, 1905; Carriden, near Bo'ness, under stones on edge of wood, and near Falkirk, in old quarry, March 1910; Dunblane, in roadside earth, April 1905; Lochgelly and Thornton, under stones and cow-dung in old pastures, April 1905; field between Thornton and Wemyss, March 1910; Isle of May, several under stones, etc., Sept. 1905 and 1909.

Lumbricus terrestris, L., Müll.

Lumbricus herculeus (Savigny).

Although not more common, if indeed it be not less so, than *L. rubellus* and some others, this is the species which is associated in our minds with the term "common Earthworm." In the Forth area it is undoubtedly common and widespread, affecting chiefly cultivated lands. It attains a length of six inches or even more.

Mature examples have been examined from the undernoted localities:—

Garden at Morningside, fields at Fairmilehead, Craiglockhart, and Temple, Feb.; Pentlands above Hillend, under stones, March; near Gifford, April, 1905; Dunbar, March; Aberlady, April, 1907; Athelstaneford, one with spermatophores, April 1910; near Bo'ness, March; near Falkirk, one with spermatophores, March, 1910; field near Limekilns, Fife, Feb.; old pasture, Lochgelly, and south side of Loch Leven, April, 1905; field near Thornton, March 1910; Isle of May, June 1909.

Lumbricus festivus (Sav.).

Lumbricus rubescens, Friend, in *Jour. Linn. Soc.*, Zool., xxiv., p. 305, 1892.

One found under a stone on the Isle of May, 16th September 1909, is the only example of this form I have so far met with. It was identified for me by Mr Friend. The species has already been recorded from Scotland (Paisley) by Friend (*l.c.*, p. 309); and there is a somewhat doubtful Berwick record by Johnston ("Catalogue of Non-parasitic Worms," 1865, p. 59).

(*Issued separately, 8th July* 1910)

XVI.—Variation in *Aurelia aurita*. By D. C. M'Intosh, M.A., B.Sc., F.R.S.E. (From the Zoological Department, University of Edinburgh.)

(Read 22nd March 1909. Received 5th May 1910.)

The main purpose of this research, suggested by Mr E. T. Browne, is to ascertain whether forms of *Aurelia aurita* (Linn.) from the Clyde exhibit as many deviations from the normal type as have been found in this, or in closely allied, species from other areas. It has long been known that this is one of the most variable species of Scyphomedusæ. The obviously symmetrical appearance of a normal specimen, the definite number of certain important organs, the readiness with which, as a rule, any increase or decrease in these numbers can be detected, as well as the ease with which large numbers of this jelly-fish may often be collected, doubtless, to some extent at least, explain the fact that it has formed the subject of several important researches on variation. It is neither necessary nor desirable to review here in detail the results of these observations, for very satisfactory reviews of previous researches treating of variation in Medusæ, and especially in *Aurelia aurita*, and also references to literature, are given by Ballowitz[1] up till 1898, and by Mayer[2] up till 1901. Since then, important contributions to this subject have been made by Browne[3] and by Hargitt.[4]

Material.

The original intention of the writer was to collect in the spring of the year over a thousand specimens of *Aurelia aurita* in the Ephyra stage, and to return to the same neighbourhood in the summer and collect an equal number of adults, presumably of the same race. Thus it was proposed to ascertain not only how Clyde forms varied as compared with forms from other areas, but also to find to what extent, if at all, abnornal ephyræ are handicapped in the struggle for existence. Circumstances, however, made it impossible for me to get to the West of Scotland Marine Biological Station till the middle of April, and it was on 20th April that

[1] Ballowitz, E., 1898, "Ueber Hypomerie und Hypermerie bei *Aurelia aurita*," *Archiv. für Entwick. der Organismen*, Bd. viii., pp. 239-252.

[2] Mayer, A. G., 1901 (April), "The Variations of a Newly-arisen Species of Medusa": The Museum of the Brooklyn Institute of Arts and Sciences, *Science Bulletin*, vol. i., No. 1, pp. 1-27 (two plates, 67 figs.).

[3] Browne, E. T., 1901 (October), "Variation in *Aurelia aurita*," *Biometrika*, vol. i. pp. 90-108 (three text-figs.).

[4] Hargitt, C. W., 1905. "Variations among Scyphomedusæ," *The Journal of Experimental Zoology, Baltimore*, vol. ii. pp. 547-582 (one plate and 17 text-figs.).

the material which forms the basis of this paper was collected. By that date, unfortunately, *Aurelia aurita* had just passed through the ephyra stage, and though there were a few larval forms in the collection, these were so few that they were disregarded. The material in the hauls consisted almost entirely of very small, immature adults, whose diameter varied from 7 to 27 mm. The hauls were taken in Loch Ridden, near Ormidale Pier, at a depth of from 3 to 5 fathoms, and I am greatly indebted to Mr Gray, who was then Curator of the Marine Station, for help readily given. We were fortunate in getting all we required in two successive trials, though at the time the sea was extremely rough in this usually quiet loch. A cheese-cloth net, worked from the S.Y. "Mermaid," was the collecting instrument employed. Except for a few *sagittae*, the contents of the net were almost entirely of one species of immature jelly-fish. As has been said, the intention was to return to the same area about July and to collect adults. But so few jelly-fish were seen in the Clyde during the summer and autumn of that year, 1903, that it was absolutely impossible to gather anything like the necessary number. Thus it came about that as the ephyræ had not been found, and as the adults could not be found, the examination of the immature adults was delayed. The material collected was, however, carefully preserved, according to the directions given by Browne,[1] and so successful has this preservation been that the specimens are still in wonderfully good condition. The somewhat laborious work of examination of these tiny organisms takes considerable time, and as it has been done at odd moments, often separated by prolonged intervals, the observations have only now for the first time been tabulated.

I have to thank Mr James Ritchie of the Royal Scottish Museum for his kindness in making for me the sketches which illustrate this paper. My thanks are also due to Professor J. Cossar Ewart and to Dr Ashworth, who kindly let me have the use of the Edinburgh University Zoological Laboratory, as well as to Professor J. Arthur Thomson for permission to work at the Aberdeen University Table at Millport Biological Station. Part of the expenses incurred in connection with this research has been met by a grant kindly given me by the Carnegie Trustees.

Original Research.

The number of the principal organs in *Aurelia* seems to be definitely fixed not later than during the ephyra stage, and a typical ephyra of

[1] Browne, E. T., *l.c.*, p. 108.

A. aurita shows eight marginal lobes, eight unbranched canals, eight tentaculocysts or marginal sense-organs, four sets of gastric filaments, and four mouth lappets, while a normal mature adult shows eight branched canals (four perradial and four interradial), eight unbranched canals (the adradials),

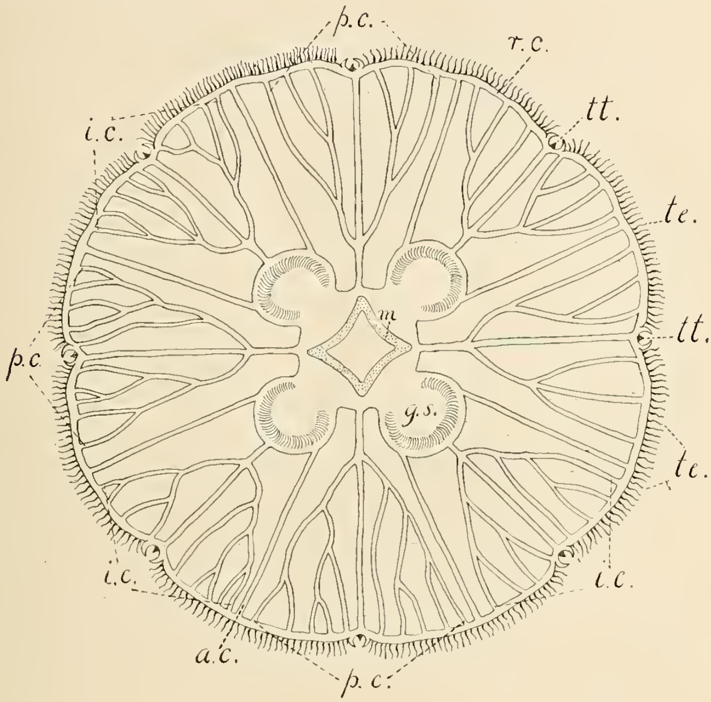

Fig. 1.

Normal *Aurelia aurita*.

p.c. Perradial canal system.
i.c. Interradial canal system.
a.c. Adradial canal system.
tt. Tentaculocyst.
te. Tentacle.
r.c. Ring canal.
g.s. Genital sac with gonad.
m. Manubrium (the four oral lobes not shown in diagram).

eight tentaculocysts (at the margin of the bell and at the end of the branched canals), four genital sacs (with gonads), a four-lipped manubrium (with the angles situated perradially), a ring canal, and a fringe of tentacles round the outer edge of the umbrella (Fig. 1). In normal examples of even very immature adults, these tentaculocysts, genital sacs, oral lips and radial canals may be distinctly seen on examining each individual with a lens. The variations noted consist (*a*) in the amount of increase or decrease in the number of (1) Tentaculocysts, (2) Genital sacs and gonads, (3) Oral lobes, (4) Branched radial canals: (*b*) in the occurrence of forms showing change in the number of certain parts, the organism being sometimes radially symmetrical, sometimes bilaterally symmetrical, and sometimes asymmetrical. Comparative tables are also given showing to what extent the observations made on specimens from the sheltered waters of the Clyde correspond with facts already recorded for individuals of the same, or a closely allied, species from such different localities as the Tamar, near Plymouth,[1] the coast of Northumberland,[2] and from near Wood's Hole, Mass.[3] The following is the record of my observations on 1000 individuals:—

1. *Variations in the Number of Tentaculocysts.*

Table I. shows the variation in the number of tentaculocysts in the specimens I examined. Browne collected 2000 small adults, varying from 10 to 40 mm., from the Tamar, near Plymouth, between 23rd and 27th April 1898. His specimens give an average umbrella diameter of about 18·8 mm., whereas the ones I gathered on 20th April 1903, from the Clyde, are considerably smaller, being on an average only about 12·3 mm. in diameter. Growth is probably at that stage very rapid. Although Browne does not specifically say so, it is possible from the tables he gives to show, that in about five weeks, a race of *Aurelia aurita* grew from immature adults (average diameter 18·8 mm.), just past the ephyra stage to a series with an average diameter of almost 56 mm., and "most of the larger ones carried planulæ in the pouches on the oral arms, showing that they had reached full maturity" (*l.c.*, p. 93).

But the main purpose of Table I. is to exhibit the variation found in the number of tentaculocysts. This is seen to range from 4 to 16, and to give a total variation of exactly 16 per cent., 2·2 per cent. having fewer than and 13·8 per cent. having more than, the normal 8 tentaculocysts. From the last column of Table I., it is seen that Browne finds (in 2000 immature adults) the number of tentaculocysts ranges from 4 to 15, and a total variation of 20·2 per cent. (4·5 per cent. showing a deficiency and 15·7 per cent. an excess). This is a greater variation than I found in the Clyde

[1] Browne, E. T., *op. cit.*
[2] Bateson, W., *Materials for the Study of Variation*, pp. 423-429, London, 1894.
[3] Hargitt, C. W., *op. cit.*

examples. It is possible that the frequency of variation in the number of tentaculocysts varies for groups of *Aurelias* from different localities. Browne has already expressed the opinion, after an examination of 3000 specimens of all sizes from the Tamar, where the variability in the number of tentaculocysts is 21 per cent., that "the Tamar *Aurelia* may be safely regarded as a local race" (*l.c.*, p. 91). Further, it may very well be that this theory of the existence of "local races" receives, indirectly, support from Hargitt

TABLE I.

The Numerical Variation of the Tentaculocysts of 1000 *Immature Adults.*

Diameter of the Umbrella in Millimetres.					Total.	Percentage for 1000 Clyde Specimens.	Percentage for 2000 Plymouth Specimens.
Number of Tentaculocysts.	10	15	20	25			
4	1	...	...	...	1	0·1	0·05
5	1	...	...	...	1	0·1	0·1
6	1	...	...	...	1	0·1	0·6
7	15	3	1	...	19	1·9	3·75
8	548	219	67	6	840	84·0	79·8
9	16	6	3	1	26	2·6	5·75
10	24	13	3	2	42	4·2	4·55
11	10	6	2	...	18	1·8	3·6
12	18	12	2	...	32	3·2	1·25
13	1	4	1	...	6	0·6	0·35
14	7	3	...	...	10	1·0	0·1
15	...	1	...	...	1	0·1	0·1
16	1	2	...	...	3	0·3	...
TOTALS,	643	269	79	9	1000	100 p.c.	100 p.c.

(*op. cit.*, p. 581), who finds that, after an examination of 2500 specimens of *Aurelia flavidula*—very closely allied to *A. aurita*—25 per cent. of those from Wood's Hole show an abnormal number of tentaculocysts (the deficiency being 2 per cent. and the excess 23 per cent.).

A specially noteworthy feature of Table I. is seen in a comparison of the percentage columns. Of specimens showing an excess (9, 10, etc.) in the number of tentaculocysts, Browne's percentages read 5·75, 4·55, 3·6, 1·25, 0·35, 0·1, 0·1—a consistently decreasing series, in fact, just such a decreasing series as one might expect as one departs further and further from the normal type. On the other hand, the corresponding percentages of abnormality for Clyde specimens are 2·6, 4·2, 1·8, 3·2, 0·6, 1·0, 0·1, 0·3—giving *two series*, one regularly decreasing series (2·6, 1·8, 0·6, 0·1) for specimens with 9, 11, 13, 15 tentaculocysts, and another regularly decreasing series (4·2, 3·2, 1·0, 0·3) for specimens with 10, 12, 14, 16 tentaculocysts. (It is obvious that there is an insufficient number of individuals with a *decrease* in the number of tentaculocysts for us to expect a double series to be seen here also.) In this connection, Browne (*l.c.*, p. 100) has the very interesting remark that "if a very slow and gradual change is taking place in the number of tentaculocysts, then the tendency is towards the establishment of a race with ten tentaculocysts," and "if no check occurs and the variation still continues . . . the ultimate result will probably be a race with twelve tentaculocysts." Yet it is not very obvious how his figures led him to this conclusion. Hargitt (*l.c.*, p. 582) considers that Browne's suggestion "seems hardly warranted by the facts as known."

The measurement of the diameter of the disc was taken in order that the continuity of the series as a whole might be ascertained. When these diameter-breadths, which are summarised in Table I., were arranged in order, there was no indication of a break in the series for individuals whose disc measures from 7 to 27 mm., and therefore we are entitled to assume that we are dealing with individuals of a single race. This, for a single group of immature adults, whose tentaculocysts vary in number, is in accordance with what Browne found for *Aurelias* at ephyra, immature and adult stages. There is much evidence, as Hargitt points out (*l.c.*, p. 561), in support of the general proposition that "varietal features found in the ephyra persist in the adult, and furthermore, there is no evidence of any selective process involved during these several changes in ontogeny."

The twenty-two examples I found with a decreased number of sense-organs had altogether 148 instead of the normal 176 tentaculocysts, while 138 individuals with more than the normal number had altogether 1517 sense-organs instead of 1104. What may be called the "coefficient of productivity" for tentaculocysts thus becomes in the one case 0·83 and in the other case 1·37. Looking at this in another way, we find a total of 8385 tentaculocysts possessed by 1000 individuals, whereas had there been no variation in this respect there should have been but 8000. Thus, on the average, each of the thousand specimens had 8·385 tentaculocysts, while the abnormal ones, considered by themselves, had an average of 10·4 tentaculocysts. This shows how marked the variability is towards an *increase* in the number of tentaculocysts. Table II. gives some comparative statistics on this point. (It has to be noted that Hargitt's results are based on an examination of *A. flavidula*.)

TABLE II.

Table showing Percentages with an Abnormal number of Tentaculocysts.

Authority	M'Intosh.	Browne.	Hargitt.
Total examined	1000	2000	2500
P.c. with less than the normal number of Tentaculocysts	2·2	4·5	1·96
P.c. with more than the normal number of Tentaculocysts	13·8	15·7	22·97
Total Percentage of Variation	16	20·2	24·93

2. *Variations in the Number of Reproductive Organs.*

In an adult *Aurelia*, the most conspicuous organs are undoubtedly those connected with the reproductive system. This probably explains the fact that, though variation in them is comparatively small, earlier observers have paid more attention to these than to the other organic systems. Ballowitz (*op. cit.*) gives a very admirable synopsis, with many illustrations, of the then (1898) known facts.

TABLE III.

Showing details of Specimens with an Abnormal number of Gonads.

No. of Specimens.		No. of Gonads.	No. of Oral Lobes.	No. of Tentaculocysts.	Arrangement of Branched Canal System.
Decrease	1	2	2	4	Per. . 1 1 Inter. . 1 1
	1	3	3	5	Per. . 1 0 1 Inter. . 1 1 1
Increase	1 } 9	5	5	9	Per. . 1 1 1 1 1 Inter. . 1 1 0 1 1
	7 } 9	5	5	10	Per. . 1 1 1 1 1 Inter. . 1 1 1 1 1
	1 } 9	5	5	11	Per. . 2 1 1 1 1 Inter. . 1 1 1 1 1
	1 } 7	6	6	7	Per. . 1 1 1 0 Inter. . 1 1 1 1
	1 } 7	6	6	10	Per. . 1 1 1 1 1 1 Inter. . 1 1 0 0 1 1
	4 } 7	6	6	12	Per. . 1 1 1 1 1 1 Inter. . 1 1 1 1 1 1
	1 } 7	6	6	14	Per. . 1 1 2 2 1 1 Inter. . 1 1 1 1 1 1
TOTAL,	18	2–6	2–6	4–14	Per. . 2–8 } Range of Inter. . 2–6 } Variation.

The results of my observations are summarised in Table III. A normal specimen has four genital sacs and four gonads, symmetrically placed round the mouth with its four oral lobes (Fig. 1). In the thousand examples I examined, 98·2 per cent. had the normal number of gonads. These, however, were not always in perfect symmetry as to size or position or degree of separation from each other. But variations in such respects are so difficult to estimate that details are here given of numerical variation only. It may well be that an accident at or before the time of capture, or even attempts to place a specimen in the best position for observation, might, without seriously damaging an individual, upset the original symmetry of its parts. Of the eighteen abnormal examples in my collection, two show a decrease and sixteen an increase in the number of gonads. One result is that provided the functioning of each gonad remains constant, there is an increased productiveness owing to this variation; for instead of 4000 gonads there were in my collection 4020, and thus, what may be called the "coefficient of fertility" is

$$\frac{4020}{4000} = 1{\cdot}05.$$

The two examples with fewer than the normal number of gonads have only five gonads between them: hence the coefficient of fertility for specimens with a decreased number of gonads is 0·625. The sixteen individuals with an increased number of gonads have a total of 87 instead of the normal 64, and thus the coefficient of fertility for them is 1·36. In place of the normal four gonads, there are on the average 5·1 gonads for each of the eighteen abnormal forms. Thus such variation as is found in the number of gonads is markedly towards an increase beyond the normal.

It is also seen from Table II. that no perfect correlation exists between the number of gonads and the number of tentaculocysts and radial canals. Of the eighteen forms with an abnormal number of gonads

1 specimen	with	2 gonads	had	4 tentaculocysts.
1 „	„	3 „	„	5 „
9 specimens	„	5 „	„	9-11 „
7 „	„	6 „	„	7-14 „

The Table, however, supports Browne (*op. cit.*, p. 107), who pointed out that a decrease in the number of genital sacs is usually accompanied by a decrease, and an increase by an increase, in the number of tentaculocysts and radial canals. Browne found a single specimen (in 3000) with a decrease in the number of genital sacs and an *increase* in the number of tentaculocysts, while I found a single specimen (out of 1000) with an *increased* number of genital sacs and a *decreased* number of tentaculocysts. Although my observations are that an abnormal number of gonads is in every case accompanied by an abnormal number of tentaculocysts and unbranched radial canals (the converse is not true), Browne (*op. cit.*, p. 107) detected four examples (in 3000) with eight tentaculocysts and an abnormal number (3, 3, 5, 8) of genital sacs. It has further to be noted, from Table III., that the range of gonads is from 2 to 6, the number of tentaculocysts from 4 to 14, and that as regards the branched canal system, the perradials range from 2 to 8 and the interradials from 2 to 6.

Table IV.

Comparative Table of Adults with an Abnormal number of Gonads.

Authority . . .	M'Intosh.	Browne.	Bateson.	Hargitt.
Locality	Clyde.	Plymouth.	Northumberland.	Wood's Hole.
Number of Specimens examined . .	1000	3000	1763	2500
Range of number of Gonads . . .	2–6	2–10	2–6	2–6
P.c. with decrease in number of Gonads .	0·2	0·6	0·62	0·56
P.c. with increase in number of Gonads .	1·6	1·8	0·85	2·20
Total p.c. Abnormal	1·8	2·4	1·47	2·76

In Table IV. there are given comparative lists showing the number of specimens with an abnormal number of genital sacs. These lists are remarkably consistent in showing that for *A. aurita* (for Hargitt thinks *A. flavidula* is identical with *A. aurita*)—(1) there is but a small variation in the number of gonads (on an average about 2 per cent.); and (2) such variation as does occur is towards an increase in the number of gonads.

3. *Variations in the Number of Oral Lobes.*

Columns 2 and 3 of Table III. show the interesting fact that in every one of my specimens where there is an abnormal number of gonads, there is the same abnormal number of oral lobes. This corroborates Browne, who says (*op. cit.*, p. 107)—"There is a perfect correlation between the number of genital sacs and the number of oral arms, and I have not found any exceptions; a specimen with six genital sacs has always six oral arms." On the other hand, I find that Hargitt records a few ephyræ of *A. flavidula* where these organs are not in perfect correlation, and he mentions, without comment, in his tables (*loc. cit.*, pp. 566, 567) two adults of that species which are abnormal in this respect. The abnormality, however, is not very marked, for one specimen has four gastric lobes (the normal number) and two oral lobes, and the other has three gastric lobes and four oral lobes (the normal number). This at least is perfectly clear—(1) there is a very intimate relationship between the number of genital sacs or gonads and the number of oral lobes; and (2) such variation as is found in the number of oral lobes is small, and is almost identical with the variation found in the number of genital sacs (only about 2 per cent.).

4. *Variations in the Number of Branched Radial Canals.*

It is in the number and arrangement of the branched canal system that I found the greatest variation. In a typical *Aurelia* at ephyra stage there are eight simple, that is, unbranched canals. These eight primitive canals undoubtedly become the eight branched canals of the adult. They stretch from the stomach, of which they are really prolongations, to the margin of the umbrella, and as they normally are placed at regular intervals they help in making more obvious the animal's radiate symmetry. It may be taken as proved that "larval variations are carried over into the adult through the several phases of metamorphosis" (Hargitt, *l.c.*, p. 555). For convenience, it is customary to name the four branched canals situated opposite to the genital sacs as Interradial Canals, and the other four, situated between the gonads and opposite to the mouth angles, as Perradial Canals (Fig. 1). While the branching is essentially of one type, it may be doubted whether two specimens occur with identical branching. There is as great variation as in the venation of the leaves of a tree. Thus it is that when we speak of symmetry in an adult, we must consider it as applying (so far as the canal system is concerned), not to the branches of the canals but to the canals themselves. There is developed, even in immature adults, a single unbranched canal, named the Adradial, between each of the eight canals already mentioned. There are thus sixteen main canals, symmetrically placed to each other, and to the central systems of the organism.

There is a very definite correlation between the number of branched radial canals and the number of tentaculocysts. Normally a single tentaculocyst is found at the outer margin of each of the eight branched canals. The relative position of these radial canals to each other, to the unbranched canals, and to the genital and nutritive systems, is so clear that there is no difficulty in locating the eight tentaculocysts (Fig. 1). The protective hood at the margin of the canal, as well as the peculiarly persistent character of the tentaculocyst itself, is an additional guide in identification. I did not find a single case in which a branched canal occurred without a tentaculocyst (cases of twinning will be referred to later on), nor did I ever find a tentaculocyst except at the margin of a branched canal. It follows that since there is such a close relationship between the two systems, much of what has been said about variation as regards tentaculocysts is applicable to the branched canal system, for there is the same meristic variation in the one as in the other.

The variation in the branched canals is shown in Tables III. and V., where it is seen that altogether 16 per cent. or 160 individuals are abnormal in this

TABLE V.

Table showing the arrangement of the Branched Canal System in 142 *Specimens with an abnormal number of Tentaculocysts.*

No. of Specimens.	No. of Tentaculocysts	Arrangement of Radial Canals.				
1	6	Per.	1	1	1	0
		Inter.	1	0	1	1
13 } 18	7	Per.	1	1	1	0
		Inter.	1	1	1	1
5 }	7	Per.	1	1	1	1
		Inter.	1	1	1	0
24 } 25	9	Per.	2	1	1	1
		Inter.	1	1	1	1
1 }	9	Per.	2	1	2	1
		Inter.	1	1	0	1
19 } 34	10	Per.	2	1	2	1
		Inter.	1	1	1	1
10 }	10	Per.	1	2	2	1
		Inter.	1	1	1	1
1 }	10	Per.	2	1	1	1
		Inter.	2	1	1	1
1 }	10	Per.	2	1	1	1
		Inter.	1	1	1	2
1 }	10	Per.	3	1	1	1
		Inter.	1	1	1	1
2 }	10	Per.	1	1	1	1
		Inter.	1	2	2	1
13 } 17	11	Per.	2	2	2	1
		Inter.	1	1	1	1
2 }	11	Per.	3	1	2	1
		Inter.	1	1	1	1
2 }	11	Per.	3	1	1	2
		Inter.	1	1	1	1

No. of Specimens	No of Tentaculocysts.	Arrangement of Radial Canals.				
20 } 28	12	Per.	2	2	2	2
		Inter.	1	1	1	1
2 }	12	Per.	1	2	2	1
		Inter.	1	2	2	1
1 }	12	Per.	1	3	3	1
		Inter.	1	1	1	1
1 }	12	Per.	3	1	2	2
		Inter.	1	1	1	1
1 }	12	Per.	3	2	1	2
		Inter.	1	1	1	1
1 }	12	Per.	2	1	1	1
		Inter.	1	2	2	2
1 }	12	Per.	2	2	1	2
		Inter.	2	1	1	1
1 }	12	Per.	1	1	1	1
		Inter.	2	2	2	2
2 } 6	13	Per.	2	2	2	2
		Inter.	2	1	1	1
4 }	13	Per.	3	2	2	2
		Inter.	1	1	1	1
4 } 9	14	Per.	3	3	2	2
		Inter	1	1	1	1
4 }	14	Per.	3	2	3	2
		Inter.	1	1	1	1
1 }	14	Per.	2	2	2	1
		Inter.	2	2	2	1
1	15	Per.	3	3	3	2
		Inter.	1	1	1	1
3	16	Per.	3	3	3	3
		Inter.	1	1	1	1
Total 142	Range 6–16	Per. 3–12 } Range of Variation.				
		Inter. 3– 7 }				

respect, 22 individuals having fewer than, and 138 individuals having more than, the normal number. The tables further show that this variation is most marked in the perradial canal system. (It is worthy of remark that the perradial canals are first in order of development in the larval stage.) Here, as in the case of the tentaculocysts, the great tendency is towards an increase in the number. Thus, these 160 abnormal specimens have altogether a total of 994 perradials instead of the normal 640. This is an increase of over 55 per cent. On the other hand, the interradials give a total of 671 canals, or less than 5 per cent. increase. The perradials range for a single individual from 2 to 12, and the interradials from 2 to 7, while the thousand specimens give an average of 8·385 perradial and interradial canals instead of the normal 8. The following are the numbers:—

1	individual	had	4	branched radial	canals.
1	”	”	5	”	”
1	”	”	6	”	”
19	”	”	7	”	”
840	”	”	8 (normal)	”	”
26	”	”	9	”	”
42	”	”	10	”	”
18	”	”	11	”	”
32	”	”	12	”	”
6	”	”	13	”	”
10	”	”	14	”	”
1	”	”	15	”	”
3	”	”	16	”	”

On calculating the curve[1] of the canals we find that the following are the main factors, and that the curve is asymmetric and of limited range in both directions (Pearson's Type I).

The Mean (M.),	=	8·385
The Standard Deviation (σ),	=	1·148
The Coefficient of Variability (C.V.),	=	0·137
The Probable Error of Mean (P.E.M),	=	± 0·245
The Probable Error of Standard Deviation,	=	± 0 0173

5. *Note on Twinning.*

It has been said that there was found perfect correlation between the number of branched radial canals and the number of marginal sense-organs. But this requires some qualification, for in ten individuals *two* adjacent tentaculocysts occurred at the outer end of a single radial canal (Fig. 2).

[1] Karl Pearson, "Contributions to the Mathematical Theory of Evolution," *Phil. Trans. Roy. Soc. London*, 1894, *et seq.*

C. B. Davenport, "Statistical Methods with special reference to Biological Variation." London and New York, 1899.

Browne, in noting this, calls it a case of twinning of the tentaculocysts, and adds "this is very rare and only occurred five times in 1000 adult specimens" (*l.c.*, p. 90). Hargitt also refers to these double sense-organs as "twin rhopalia, several cases of which were found" (*l.c.*, p. 555). These variations, amounting to exactly 1 per cent., have not been included in the tables already given, because in each case there is but one radial canal and but

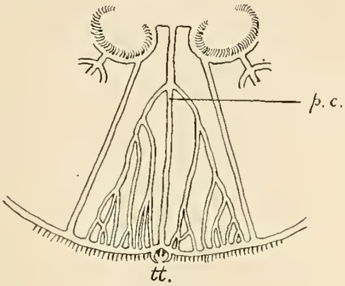

FIG. 2.

Example with twin-tentaculocyst (*tt.*) on perradial canal (*p.c.*).

one protective hood for the two sense-organs. The adjacent positions of the tentaculocysts are such that it is impossible to decide which is the additional one. They are well named twin-tentaculocysts. Their exclusion from the tables given does not alter the number of abnormal forms, but only the extent of the variation, since no case of twinning was found except in individuals where there was independently an excess of the normal number of tentaculocysts. The following Table (VI.) gives some details of those examples with twin sense-organs.

TABLE VI.

The Canal System of 10 *Individuals with Twin-Tentaculocysts.*

Arrangement of Branched Canal System.	Number of Branched Canals.	Number of Tentaculocysts.	Number of Examples.	Position of Twins.
Perradial . 2 2 2 1* Interradial . 1 1 1 1	11	12	6	Perradial
Perradial . 2 2 1* 2 Interradial . 2 1 1 1	12	13	1	Do.
Perradial . 1 2 2 1* Interradial . 1 2 2 1	12	13	1	Do.
Perradial . 2 1* 1* 1 Interradial . 1 1 1 1	9	11	1	Do.
Perradial . 2 1 2 1 Interradial . 1 1* 1 1	10	11	1	Interradial

* Indicates position of twins.

It is very easy, even in immature adults, to detect cases of twinning, for there is an enlarged notch on the margin of the umbrella and an enlarged hood protects the tentaculocysts, each of which is removed slightly to the side at the end of a branched canal. It is seen that in nine of the ten specimens the twin is situated perradially, and that in one example there is a double case of twinning, giving this particular individual nine branched canals and eleven tentaculocysts. Four of the five twinned examples which Browne noticed had the twin tentaculocysts perradially placed, and these had respectively 9, 9, 9, 10, 11 tentaculocysts. It is not easy to agree with Browne when he says that "it is possible for two tentaculocysts to become widely separated by the growth of the umbrella, and each to have its own canal system" (*l.c.*, p. 90). It seems rather to be a case of once a twin always a twin.

With this case of a double sense-organ in *Aurelia aurita* may be compared that in another cœlenterate, *Clavatella prolifera,* which has normally a single eye at the base of each arm. "Clapadère figures a case of duplicity of an eye, and says that specimens occur in which each eye is doubled, so that there are two eyes at the base of each arm instead of one" (Bateson, *l.c.*, p. 425).

6. *The Question of Symmetry.*

In Nature, regularity of form generally shows itself in symmetry, which is all but a universal feature of organisms. While radial symmetry is the characteristic type of symmetry found in the Cœlenterata, bilateral symmetry is the type usually exhibited by more highly organised forms.

From what has already been said as to the number and arrangement of the more important organs in *Aurelia aurita,* it is clear that a normal living example shows radial symmetry. Some cases where this symmetry is departed from are sufficiently obvious from the tables given. There are all degrees of departure from radial symmetry to forms that are purely asymmetrical. Examples are found where the separate organs considered by themselves show radial symmetry (Bateson's *Minor Symmetry*), but the correlation of the various organs has been so altered that there is not complete radial symmetry among the different kinds of organs (Bateson's *Major Symmetry*). It has been noted as a curious fact that if one kind of symmetry is lost, there is a tendency in the animal world to replace it by another kind of symmetry. Several examples, among the thousand here considered, show that radial symmetry has been disturbed in such a way that bilateral symmetry takes its place.

It has already been remarked that the branching of the canal system while essentially of one type, showed considerable variety (Fig. 1). Sometimes the lateral branches do not always start from the same point on the main canal (Fig. 3). There is not always the same degree of separation

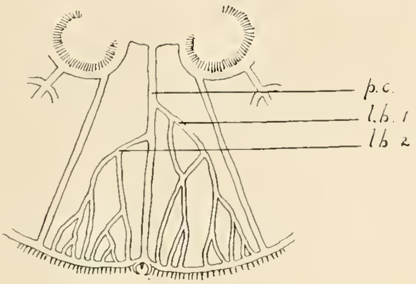

Fig. 3.

Perradial canal (*p.c.*) with non-adjacent lateral branches (*l.b.* 1 and *l.b.* 2).

between the genital sacs or the gonads, nor are they always of equal size. Sometimes a gonad in its genital sac seems to have pushed its way outwards towards the margin of the umbrella to such an extent that the base of the interradial canal is entirely cut off, and the starting-point of the branching canal system is obliterated (Fig. 4). The result of this is that what was undoubtedly originally a branched interradial canal becomes an unbranched

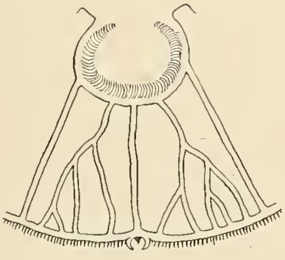

Fig. 4.

Example in which genital sac (with gonad) has advanced so far toward the margin of the umbrella that the original main lateral adjacent branching of the interradial canal system is obliterated.

canal, still of course retaining its interradial position and having its tentaculocyst. As the tentacles, which fringe the margin of the umbrella, are apt to become detached, their number was not systematically counted, but sufficient note was taken to make it certain that the number between two sets of adjacent tentaculocysts is not constant for a single individual, much less for individuals of the same size. As far as possible no account was taken of any individual with a "variation" which was suspected to be the result of an accident. Only a few had to be rejected on this account.

For the reasons which have just been stated, it follows that there is often a real difficulty in determining whether a given individual, no matter how normal it may appear to be, does or does not show radial symmetry. Besides, it is practically impossible to measure the extent of departure from radial symmetry in some of these tiny organisms. For in the process of capturing, preserving, and examining a collection of over a thousand specimens, it may very well be that parts are damaged and symmetries upset. But wherever it was found that any numerical variation occurred in any of the organs considered, the question of symmetry was easily settled. It was noted that most forms which had lost their radial symmetry had a bilateral symmetry so far as the number and position of the main organs were concerned. It is obvious that if there is any numerical variation in two sets of organs in the same individual there can't be, as a rule, even bilateral symmetry, unless there is perfect correlation among these organs.

Let it be definitely stated that no attempt is being made to bring all those examples showing numerical variations under one or even two types of symmetry. What is clear is, that in a general way, a normal *Aurelia aurita* shows radial symmetry; that even where numerical variation is found in a set of organs, there may still exist a bilateral type of symmetry; that there may be bilateral symmetry even when meristic variation is found in more than one set of organs (provided they are perfectly correlated); and that there are many cases where, keeping strictly to meristic variation, the organism is unsymmetrical.

In discussing this question of symmetry, Hargitt (*op. cit.*, p. 565) says of Romanes[1]—"In both the illustrations and the analysis of the facts, there is an apparent effort of the author to reduce the variations to as few symmetrical types as possible." Bateson found twenty-eight abnormal specimens out of 1763 adults which he examined for the number of gonads and oral lobes. "There were therefore 1735 normals, 19 symmetrical varieties and 9 irregulars. It will be noted not only that the symmetrical varieties are comparatively frequent, but also that the several forms of irregularity were seen for the most part in single specimens only" (Bateson, *l.c.*, p. 429). It is not very clear from this how Hargitt (*l.c.*, p. 564) can criticise Bateson for "attempting to reduce

[1] Romanes, George J., "An Account of some new Species, Varieties, and Monstrous Forms of Medusæ," *The Journal of the Linnean Society (Zoology)*, vol. 12, pp. 524-531; vol. 13, pp. 190-194 (2 plates).

the variations to 'symmetrical varieties,'" and for "regarding 'irregular varieties' as exceptional." All that Bateson seems to me to imply is that even where radial symmetry has been lost, a large proportion of the abnormal specimens still show another kind of symmetry, and that an abnormal form is not necessarily therefore an asymmetric form. This, at least, is precisely what I found.

In this connection Mayer (*op. cit.*, p. 4) remarks: "The abnormal forms of *Aurelia* are peculiar in that they generally preserve the radial symmetry of the disc, even though the usual number of segments be changed. Thus, instead of being composed of quadrants, the disc may be made up of halves, the animal possessing two genital organs and two oral lobes, 180° apart; eight radial canals and two marginal sense-organs. The symmetrical varieties appear to be about twice as numerous as the irregular abnormalities. It is evident that symmetrical 'sports,' or discontinuous variations of *Aurelia*, are continually being produced, and yet the form of the species as a whole remains unchanged." And again (p. 5), "It appears from an inspection of Hargitt's figures that when radial canals are non-radially symmetrical in arrangement, they show a decided tendency to be bilateral in arrangement."

Hargitt figures some interesting examples of *Aurelia flavidula* with tentaculocysts adradial in position. It may be at once conceded that whether a particular canal is adradial or not, is largely a question of the relative position of branched canals to each other and to other organs. So far as my examples are concerned, I did not once find an undoubted adradial canal which showed branching, nor did I find a tentaculocyst (which is merely a modified tentacle) that could not be associated with either a perradial or an interradial canal. Just because adradial canals do not normally have tentaculocysts, no detailed account is given of them. Occasionally an individual was found with one or more adradials absent. In such a case, as also in that where there is no perradial canal, the intervening space is filled up by excessive branching on the part of the adjacent branched canals.

It is especially difficult to decide the question of symmetry of gonads and genital sacs in small adults. The shape, position and size of the gonads, their position in the genital sac as regards other gonads and as regards the mouth (which is the centre of symmetry of the individual), have all to be considered though they cannot conveniently be "measured." Specimens of equal size did not have the gonads equally developed, and in a few cases one or more gonads were poorly developed, or showed signs of degeneration, compared with the remaining gonads in the same individual. Ehrenberg records a single example with the gonads round the mouth so fused that these appeared to be one circular gonad; and Hargitt (*l.c.*, p. 565) alludes to "the not infrequent occurrence of signs of atrophy" of gonads. He gives a figure of a specimen of which he says, "It will be observed that associated with the small size of the pouch and gonad is the entire absence of the inter-radial canal and its marginal organ" (*l.c.*, p. 565).

Summary.

1. There may be "local races" of *Aurelia aurita.*
2. The rate of growth is very rapid.
3. About 16 per cent. have a variable number of tentaculocysts.
4. The range of variation is from 4 to 16 tentaculocysts for one individual.
5. The variation is distinctly towards an increased number of tentaculocysts.
6. The marginal system is connected with the central system by means of radial canals, but there is a lack of correlation between the sensory system and the reproductive system.
7. About 2 per cent. have an abnormal number of genital organs.
8. The range of variation for gonads is from 2 to 6 for a single individual.
9. The variation is distinctly towards an increased number of gonads.
10. There is a very close relation between the number of oral lobes and the number of genital organs.
11. There is a very definite correlation between the number of branched radial canals and the number of tentaculocysts.
12. The perradial canal system (the first in order of development) is much the more variable of the two branched canal systems.
13. Examples of *Aurelia aurita* from the Clyde with 10, 12, 14, or 16 tentaculocysts (or branched radial canals) are more numerous than those with 9, 11, 13 or 15 tentaculocysts (or branched radial canals).
14. About one per cent. have twin-tentaculocysts.
15. The twin-tentaculocysts are usually situated at the bases of perradial canals.
16. The characteristic radial symmetry of a normal *Aurelia aurita* may be changed, owing to the absence of correlation amongst certain sets of organs, to bilateral symmetry.
17. Asymmetrical forms are comparatively few.

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(*Issued separately, 13th July* 1910.)

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XVII.—Observations on the Number of Genital Apertures and on the Disproportion of Sexes in the Norway Lobster (*Nephrops norvegicus*). By D. C. M'Intosh, M.A., B.Sc., F.R.S.E. (From the Zoological Department of Edinburgh University.)

(Read 24th October 1910. Received 25th October 1910.)

During each session there are brought to the Zoological Department of Edinburgh University, for use in the Laboratory, several boxes of Norway lobsters. For some years it has been my privilege to examine each boxful as delivered. All are procured from the fish-market at Newhaven, whither they are brought by Granton trawlers. It is well known that there occur individuals with additional spermatic apertures, and the main purpose of my examination has been to ascertain the percentage showing this abnormality. Incidentally some other observations were made, and in particular the proportion of the sexes was noted.

While Bateson [1] in his "Materials" makes no mention of variation in the number of genital apertures of *Nephrops norvegicus*, he gives interesting records relating to *Astacus fluviatilis*. Marshall,[2] in a communication in 1902, says: "The only published record, so far as I know, of additional genital openings in *Nephrops*, is a recent paper by Mr Cole, who states that 'abnormalities in oviducal and spermatic apertures are by no means uncommon.'" Marshall's communication deals with his record of observations made on 1068 Norway lobsters, in the Zoological Laboratory of Edinburgh University, in 1901. In the autumn of 1906, I examined 630 specimens preserved for dissection purposes in the Zoological Laboratory. During session 1906-7, three additional boxfuls, each containing on the average 243 specimens, were also examined. An account of my observations on these 1359 examples, as well as on 3689 procured for other purposes, but also captured in the North Sea, has been published.[3] In the interval, between the summers of 1907 and 1910, there have been brought to Edinburgh University Zoological Laboratory 2064 Norway lobsters, and it is now proposed to consider the further record of abnormalities observed during these consecutive years.

[1] Bateson, W., *Materials for the Study of Variation.* London, 1894.

[2] Marshall, F. H. A., "On Variation in the Number and Arrangement of the Male Genital Apertures in the Norway Lobster," *P.Z.S.*, pp. 2-12. London, 1902.

[3] M'Intosh, D. C., "Variation in the Norway Lobster," *Proceedings of the Royal Physical Society of Edinburgh*, vol. xvii. pp. 129-142. 1908.

GENITAL APERTURES.

A normal male *Nephrops norvegicus* has two genital apertures, one on each of the fifth pair of walking legs, while in the female the openings are on the third pair. Of the 2064 individuals here dealt with, 1775 males and 76 females showed the typical arrangement of spermatic and oviducal openings. In the remaining examples, the following abnormalities in the genital pores were noted among the males:

(1)	1 individual had	1 genital opening.			
(2)	154 individuals had	3	„	openings.	
(3)	45	„	„ 4	„	„
(4)	10	„	„ 5	„	„
(5)	3	„	„ 6	„	„

1. Example with One Genital Opening.

In a previous communication on this subject, I remarked[1] that "the abnormality consists in the occurrence of *additional* genital apertures, for in no case were the normal ones awanting" (*l.c.* p. 140). This statement must now be modified. So far as I have been able to ascertain, this is the first recorded case of a male with a single genital aperture, and that such an individual is of rare occurrence, is shown by the fact that only one was found among over 8000 individuals which have been specifically examined. The single opening occurred on the fifth right leg; the fifth left leg, while being otherwise normal, had no genital aperture. This individual is well-grown, and is now preserved in Edinburgh University Zoological Laboratory.[2] In the case of *Astacus fluviatilis*, while there is no record, so far as I can find, of examples with any additional spermatic apertures, Bateson[3] says: "Of 714 males examined, only one was abnormal, having no trace of a genital opening on the right side, the *vas deferens* ending blindly and hanging free in the thoracic cavity." Dr J. H. Ashworth of the Zoological Department of Edinburgh University has kindly shown me an example in his possession, with an identical external abnormality.[4] Bateson also gives the results of the examination of 586 female *A. fluviatilis*: "Of these, 563 were normal, in respect to the number of oviducal openings, and 23 were abnormal" (*l.c.*, p. 153). Of the 23 abnormal specimens, 19 showed an excess of oviducal openings, and of the remaining 4 individuals, "3 had a single oviducal opening on the left side only, and one had a single oviducal opening on the right side" (*l.c.*, p. 153).

[1] M'Intosh, D. C., *l.c.*, p. 140.

[2] This specimen was exhibited at the meeting.

[3] Bateson, *op. cit.*, p. 154.

[4] This specimen was also exhibited.

2. Examples with Three Genital Openings.

154 individuals show the abnormality of a single spermatic opening in addition to the normal two. This is the most common form of variation as regards the genital pores. The additional aperture is found on the right or left leg of the third or fourth pair of walking legs. This gives a series of four different arrangements, which may be represented more clearly in the following manner:—

Walking Legs.	R.[1]	L.	R.	L.	R.	L.	R.	L.	
Third Pair . . .						•	•		
Fourth Pair . . .		•	•						
Fifth Pair . . .	•	•	•	•	•	•	•	•	
Total Num. of Examples	77		72		3		2		=154

It will be noted that variation occurs here without any regard to symmetry. In five of these examples there are no openings on the fourth pair of legs, while these occur on the third and fifth pairs. There is thus a gap in the series of openings in the segments, a good example of what Bateson calls homœotic variation as distinguished from purely meristic variation.

3. Examples with Four Genital Openings.

This form of variation is found in 45 examples. As in the previous case, the additional apertures are found on the third and fourth pairs of walking legs. The different arrangements observed are the following four:—

Walking Legs.	R.[1]	L.	R.	L.	R.	L.	R.	L.	
Third Pair . . .				•	•		•	•	
Fourth Pair . . .	•	•		•		•			
Fifth Pair . . .	•	•	•	•	•	•	•	•	
Total Num. of Examples	40		2		2		1		=45

[1] R. and L. stand for Right and Left sides.

Bilateral symmetry, which is such a characteristic feature of the Crustacea, is seen in the arrangement of the additional genital openings in 41 of these 45 abnormal examples. The presence of the characteristic modifi-

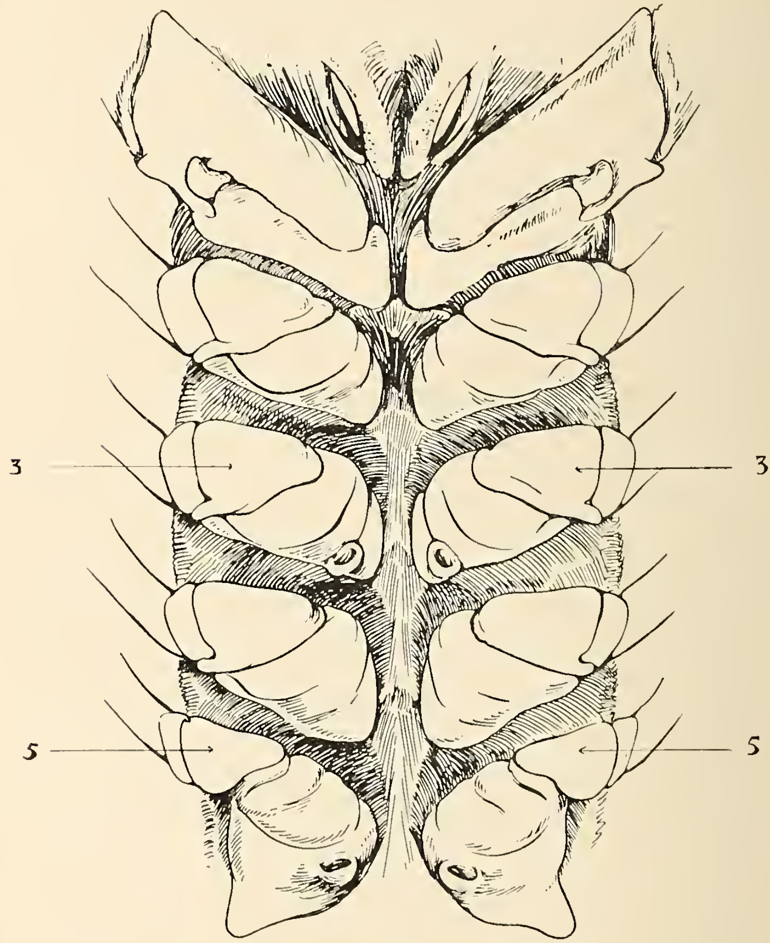

FIG. 1. Genital Apertures of *Nephrops norvegicus*.

Male of *Nephrops norvegicus* with abnormal genital apertures on the third pair of walking legs.

cation of the anterior abdominal appendages, as in the male *Nephrops*, establishes the sex of the solitary example with apertures on the third and fifth pairs of walking legs (Text-fig. 1). The abnormality here shown is a very interesting one, and I have not been able to find another record of a similar example.

4. Examples with Five Genital Openings.

In this collection there are ten examples, each with five genital apertures. These show the following three arrangements:—

Walking Legs.	R.[1]	L.	R.	L.	R.	L.	
Third Pair	•			•	•	•	
Fourth Pair	•	•	•	•	•		
Fifth Pair	•	•	•	•	•	•	
Total Num. of Examples	5		3		2		=10

Here, as in those specimens with three openings, there must necessarily be an entire absence of bilateral symmetry. The modified anterior abdominal appendages prove the two examples with openings on the third and fifth pairs of legs to be males.

5. Examples with Six Genital Openings.

This variation occurs in only three specimens, all of which show the same arrangement of apertures—one on each of the right and left legs of the third, fourth and fifth pairs. This is an example of perfect bilateral symmetry.

6. Summary.

Though I did not observe an example with seven genital openings, Dr Marshall (*l.c.*, p. 3) found such a specimen in the Zoological Laboratory material in 1901. His example with seven openings had a single opening on each of the legs of the third, fourth and fifth pairs, and also on the left second walking leg. Examples with so many apertures are certainly not numerous. I have previously recorded (*l.c.*, p. 141) an individual with an arrangement of six apertures which was not noticed in this collection. It is referred to here because it exhibits the only arrangement of openings which I had already noted, which has not been again observed amongst those

[1] R. and L. stand for Right and Left sides.

individuals now under consideration, and because, like Dr Marshall's example with seven apertures, it had an opening on one of the second pair of legs. This specimen had a single aperture on the second right leg, one on the third left leg, and one on each of the right and left legs of the fourth and fifth pairs of legs. The example with a single aperture on the fifth right leg (already referred to), and the other example with an opening on each leg of the third and fifth pairs of legs (also already referred to), show two arrangements of genital openings which, so far as I can ascertain, have not been previously recorded. It is worthy of remark that in every case where supernumerary spermatic openings occurred, the normal openings were also present.

In the present instance, 213 abnormal males have been noted out of 1988 males examined. This shows an abnormality of 10·7 per cent. in the number of spermatic openings. It will be observed that these examples exhibited thirteen different arrangements of the genital apertures. Including the arrangement of seven apertures which Dr Marshall gives, the arrangement of six apertures which I have previously recorded, and the normal type, we have thus a record of sixteen different arrangements of these openings in *Nephrops norvegicus*. The total range of variation, which has come under my observation, is from 1 to 6 genital openings.

Of the forms showing variation

0·5	per cent.	had	1	genital	opening.
72·3	„	„	3	genital	openings.
21·1	„	„	4	„	„
4·7	„	„	5	„	„
1·4	„	„	6	„	„

This series shows how great is the tendency towards an increase in the number of genital apertures, and also how markedly the number of abnormal forms decreases as the extent of the abnormality increases.

From the following comparative Table it is seen that 4491 of the Norway lobsters sent to Edinburgh University Zoological Laboratory have been examined with the view of ascertaining the extent of variation in the number and arrangement of genital openings. Lot A consists of those examples which Dr Marshall (*op. cit.*) examined in 1901; Lot B, those which I examined (*op. cit.*) in 1906 and 1907; and Lot C (the present collection), those which I examined between the summers of 1907 and 1910. We have thus a record of all the specimens *sent* to the Laboratory during the past six years, all obtained (as well as Dr Marshall's lot) under exactly the same conditions (so far as these are known), and all examined without selection.

Comparative Table.

Lots.	Number of Individuals.	Total Males.	Normal Males.	Abnormal Males.	Percentage of Abnormal Males.	Total Females.
A	1068	1000	878	122	12·2	68
B	1359	1249	1167	82	6·3	110
C	2064	1988	1775	213	10·7	76
Totals	4491	4237	3820	417	9·8	254

A study of this Table shows how accurately Dr Marshall summed up the facts when he remarked (*op. cit.*, p. 8): "That Norway lobsters with additional genital apertures have been common in Scottish waters for a considerable number of years, appears from information supplied me by Professor Ewart, Dr Beard, Dr Masterman and others. Before I began my investigation on the degree of frequency of such abnormal lobsters, Dr Masterman expressed the opinion that quite 10 per cent. of the specimens he had observed since he had been in Scotland had additional genital openings." From the Table given, it is seen that 9·8 per cent. of the 4237 male specimens had other than the normal two spermatic openings. As indicating the fallacy resulting from examining occasional boxfuls, the following are some of the percentages of abnormal males found—10·5 per cent. of 238 specimens, 14·5 per cent. of 268 specimens, and 4·1 per cent. of 169 specimens.

DISPROPORTION OF SEXES.

A remarkable feature of the Table given is the small percentage of females. In Lot A Dr Marshall found 6·4 per cent., and in seeking for an explanation of the relative scarcity of females, he suggested that probably "the majority of them had migrated to a greater distance from land" (*op. cit.*, p. 6). In Lot B there were 8·1 per cent. females, and in commenting on this (*op. cit.*, pp. 136-138) I sought for an explanation in the fact that females, being distinctly smaller than males, may escape through the meshes of a trawl net in greater numbers. I gave statistics of actual measurements showing the relative size of the sexes, and I also showed how much greater is the proportion of females captured when a small mesh net is used (*op. cit.*). In view of all this, I am not surprised to find only a small percentage of females among the 2604 specimens in Lot C. It is, however, noteworthy that out of 2064 individuals only 76 or 3·7 per cent. are females. In connection with the explanation I have offered as to the preponderance of males found, I transcribe the following from my rough notes made after examining a boxful of specimens sent to the Zoological Laboratory on 26th February 1908: "Specimens small, box only three-fourths full. Of 309 examples, 41 are females. These 41 are so small that it would be very difficult to pick other 41 specimens equally small from the remaining 268 individuals." In another box there was only one female among 239 individuals, and in still another box there were only three among 226. Of the combined total of 4491 Norway lobsters which have now been examined in the Zoological Laboratory less than 5·7 per cent. were females.

None of the females showed any variation in the number of oviducal openings. My observations therefore do not confirm Cole's[1] statement that in *Nephrops* "abnormalities in oviducal . . . apertures are by no means uncommon." In each of the 186 females found in Lots B and C, as well as in 703 additional females captured in the North Sea, no abnormality was noted either in the number or in the position of the genital openings. It is remarkable that while few variations occur in the oviducal, and many in the spermatic, apertures of *Nephrops*, there are many variations in the oviducal, and few in the spermatic, apertures of *Astacus*.

Among those individuals examined on 10th May of this year there was found a medium-sized "berried" female, the only example of a "ripe" female among the 76. As it does not seem to be definitely known which is the particular season of the year when the female *Nephrops* liberates the "eggs," which she has carried for some time glued to her swimmerets, it may be worth recording that I have found "berried" females in the months of October (several examples), February (a few specimens), and one in each of the months of April and May.

Norway lobsters are known to frequent areas where the sea floor is muddy, and many of the examples had the carapace, legs and abdominal segments partly covered with polyzoa (*e.g. Flustra*), barnacles, worm tubes (*e.g. Serpula* and *Spirorbis*), hydroids (*e.g. Sertularia* and *Eudendrium*), and other creatures, such as small bivalves and tunicates.

[1] Cole, "Some Variation in the Spinal Nerves of the Frog," *Trans. Liverpool Biol. Soc.*, vol. xv. p. 114 (1901).

Traces of the incessant struggle for existence were seen in several individuals which had lost one or more legs (or part). In a few cases the right forceps was enormously large compared to the left, and occasionally the left chela was greater than the right—doubtless examples of regeneration of parts. In two cases the outermost joint of the forceps was longer than the second joint. No recently moulted specimen was found.

I desire to acknowledge heartily my indebtedness to Professor J. Cossar Ewart and to Dr J. H. Ashworth for their kindness in allowing me to examine the stock of Norway lobsters in the Zoological Laboratory of Edinburgh University.

While these observations were in proof copy, there came to my notice a paper,[1] *Die Homoeosis bei Arthropoden*, by Dr H. Przibram, in which in a note on "*Überzählige Geschlechtsöffnungen an Decapodenbeinen*," he mentions and illustrates by diagrams and photographic reproductions three of the types of abnormality in male *Nephrops*, which are mentioned in the present communication. It is interesting to note that the specimens referred to are Scottish examples sent by Dr J. H. Ashworth from Edinburgh University.

[1] *Archiv. f. Entwicklungsmech*, Bd. xxix., 1910, pp. 599-601, text-fig. 6 A-C, pl. xxi.

(*Issued separately, 6th January* 1911.)

XVIII.—The Marine Fauna of the Mergui Archipelago, Lower Burma, collected by James J. Simpson, M.A., B.Sc., and R. N. Rudmose Brown, D.Sc., University of Aberdeen, February till May 1907. The Ophiuroidea. By Donald C. M'Intosh, M.A., B.Sc., F.R.S.E., Research Student, University of Edinburgh.

(Read 27th February 1911. Received 27th February 1911.)

I.—INTRODUCTION.

THE material which forms the subject of the present communication was collected by Mr Jas. J. Simpson and Dr Rudmose Brown in 1907, while they were investigating, on behalf of the Indian Government, the pearl-oyster fisheries of the Mergui Archipelago.

Our knowledge of the Ophiuroidea of the Indian Seas has been greatly extended within recent years by accounts which various workers have published, and in particular by Professor Koehler's (1898) report on the collections made by the "Investigator" in 1896. The only published record, however, of Ophiuroidea exclusively from the Mergui Archipelago, is Professor P. Martin Duncan's description, in the Journal of the Linnean Society for 1886, of the collections by Dr J. Anderson in that locality in 1882. Of the thirteen species, in addition to some young unidentified forms of *Ophioglypha*, in Professor Duncan's list, all were new, except the following four species, *Ophiolepis cincta* Müller et Troschel, *Ophiocnemis marmorata* (Lamarck), *Ophiocoma scolopendrina* (Lamarck), and *Ophiothrix martensi* Lyman, which are well known, and have been repeatedly recorded from the Indian Ocean and the neighbourhood of the Western Pacific Islands. It is not a little remarkable that while the present collection contains three of these four species, it contains only one of Duncan's new species, viz., *Ophiocampis pellucida*, for *Ophiothrix variabilis* Duncan, is now regarded as synonymous with *O. hirsuta* Müller et Troschel. Yet four of Duncan's species, first described from Dr Anderson's collection, have since been found elsewhere in Eastern seas, one species, *Ophiocampis pellucida*, by the "Investigator," and three species, *Ophiolepis nodosa*, *Ophiocnida sexradiata* and *Ophiothrix andersoni* by the "Siboga" expedition (Koehler, 1905).

In the present collection there are seventeen species, amongst which the Zygophiuræ are represented by fifteen species (five families), and the Cladophiuræ by two species. Ten of the species, including such forms as *Pectinura gorgonia*, *Ophiocoma scolopendrina*, *Ophiothrix foveolata* and *Ophiothrix stelligera*, are well-known inhabitants of the Indian and Eastern seas, and are found either in the "Investigator" or in the "Siboga" lists; in most cases, indeed, they appear in both lists. With one exception, the others are also previously known forms, but their presence in the Mergui Archipelago extends, in some cases considerably, their geographical distribution. For example, *Ophiomastix venosa,* while common in the western part of the Indian Ocean, has not hitherto been found east of the Maldive and the Laccadive Islands; and *Lutkenia cataphracta,* originally described by Brock (1888) from a single example captured off Cape York, North Australia, has now for the first time been found in the Indian Seas. Further additions to the fauna of the Mergui Archipelago are *Ophiactis savigyni, Ophiocoma valenciae, Ophiothrix exigua* and *Astrophyton clavatum.*

The most interesting Ophiuroid, however, in the collection is undoubtedly a new species of *Ophiopteron.* One hesitates in establishing a new species from a solitary example, even for a form with such distinct characters as are exhibited by an *Ophiopteron,* since the study of the Ophiuroidea has passed into the hands of experts, who alone are entitled to say whether a certain specimen is or is not a new species. Accordingly, before publishing this paper, I sent the example to Professor Koehler, who kindly examined it for me. It was with great pleasure that I read Professor Koehler's confirmation of my diagnosis of the specimen as a new species of *Ophiopteron,* and I most cordially thank him for his courtesy in connection with this and other matters bearing on this communication. I have figured the new species, *Ophiopteron gymnatum,* and have described it in detail.

All the examples in the collection are essentially types characteristic of the shallow-water Ophiuroidea of the Indo-Pacific Ocean, and while some of the species are better known from the western side of the Indian Ocean, most of them are rather representative of the seas round the Western Pacific Islands. If one can come to any conclusion as regards the distribution of Ophiuroidea in the Mergui Archipelago from the frequency with which the same species occurs at different stations, then the most widely distributed species in this limited area are *Pectinura gorgonia, Ophioglypha sinensis, Ophiothrix stelligera* and *Ophiothrix hirsuta.* It would also appear that Hastings Harbour, Station XXII., where the bottom is rocky and sandy, and the depth varies from the shore to 20 fathoms, is, of the local areas, most prolific in Ophiuroidea, for eight species were collected there. But this abundance may be accounted for by the fact, that, in addition to shore collecting and the employment of a dredge, a diver was employed in the investigation of the deeper waters. In this connection Dr Rudmose Brown (1910) says:—"We instructed our divers to bring up anything they could find in addition to pearl and mother-of-pearl oysters. This is probably one of the first expeditions in which a diver has been employed to make zoological collections, and the success of the method, even more in other groups than in Echinoderms, should commend it to others" (p. 21).

Unfortunately, in some cases a species is represented by a single individual. With the exception, however, of some specimens of the genus *Trichaster*, every example in the collection has been identified. In this connection, special reference ought to be made to Professor Koehler's paper on "Ophiures nouvelles ou peu connues," in the *Mémoires de la Société Zoologique de France* for 1904, which has been most useful in the identification of individuals belonging to the difficult group of the Ophiothricidæ, which are here represented by nine species.

It is remarkable that there are no Ophiuroidea in the collection from the neighbourhood of the Moskos Islands, though examples of both Echinoidea and Asteroidea were found in that locality (Brown, 1910).

I desire to express my heartiest thanks to Mr Simpson and to Dr Rudmose Brown for entrusting this collection to me for examination. I also desire to thank Professor Koehler for his kindly interest in the work, and for his very generous assistance in identification; and Dr J. H. Ashworth, of Edinburgh University, for much guidance in connection with literature bearing on the subject. My especial thanks are due to Professor J. Cossar Ewart for his courtesy in affording me facilities for the examination of this collection in the Zoological Laboratory of the University of Edinburgh. Some literature required for reference, not available in Edinburgh libraries, I was enabled to purchase by means of a grant kindly given me by the Carnegie Trustees.

II.—LIST OF SPECIES.

OPHIUROIDEA.

1. ZYGOPHIURÆ.

Family OPHIOTHRICIDÆ.

(7) *Ophiothrix foveolata* Marktanner-Turneretscher, p. 161.
(8) „ *martensi* Lyman, p. 162.
(9) „ *stelligera* Lyman, p. 163.
(10) „ *exigua* Lyman, p. 164.
(11) „ *hirsuta* Müller et Troschel, p. 164.
(12) *Ophiocampis pellucida* Duncan, p. 165.
(13) *Ophiocnemis marmorata* (Lamarck), p. 166.
(14) *Ophiopteron gymnatum*, nov. sp., p. 167.
(15) *Lutkenia cataphracta* Brock, p. 170.

2. CLADOPHIURÆ.

Family EURYALIDÆ.

(1) *Euryale studeri* Loriol, p. 171.
(2) *Astrophyton clavatum* Lyman, p. 171.

III.—REMARKS ON THE SPECIES.

1. ZYGOPHIURÆ.

(1) Pectinura gorgonia Lütken.

The following notes are based on an examination of fifty-five examples of this species from four stations.

The disc is distinctly pentagonal, with a notch for the insertion of each of the arms, which, on the dorsal side, are ridged rather than "cylindrical," as is stated by Lyman (1882). While the oval radial shields are very distinct, the other scattered and smaller non-granulated disc-plates do not stand out so clearly as is indicated in Koehler's diagram (1900). A "specific" character is the presence of a couple of pores between the first and second ventral arm-plates. But in three of my specimens, which are the largest in the collection, having a disc-diameter of about 19 mm. and an arm-length of over 85 mm., there is also found a pair of smaller pores between the second and third ventral arm-plates. The arms carry on each side seven smooth flattened spines, which are less than the length of a lateral arm-plate, and the base of the lowest arm-spine is overlapped by the upper of two tentacle-scales. There is an elongated genital opening which stretches to the margin of the disc from the inner corner of the supplementary plate just outside the mouth-shield. My examples are creamy-white below, and of a greenish-grey colour on the upper surface, while every alternate four or five joints on the upper side of the arms are ringed with a darker green.

Localities.—St. IX., Between Bentinck Island and Courts Island, 12 to 26 fathoms, sand and coral (five examples). St. XVII., West of Sir John

Malcolm Island, 13 to 18 fathoms, coarse sand and broken shells (three examples). St. XVIII., West and south-west of Paway Island, 10 to 21 fathoms, sand, shells and rock (six examples). St. XXV., Gregory Group and Crichton Island, 4 to 14 fathoms, stones and broken shells and rock (41 examples).

P. gorgonia is a littoral form, and is very widely distributed up to a depth of over 40 fathoms. It has been taken from the coasts of Natal, Mozambique, Zanzibar, Madagascar, Ceylon, Andaman Islands, Fiji Islands, Samoa, Thursday Islands, etc.

(2) **Ophioglypha sinensis** Lyman, 1871.

This species is represented by eleven specimens from five stations. In all my examples there is found only one pit or depression between the ventral margins of the lateral arm-plates, and this occurs at the very base of the arm, *i.e.*, on the proximal side of the first ventral arm-plate. In this respect Lyman's figure, plate i., fig. 1 (1871), is misleading in that he indicates depressions even beyond the disc, a possible error to which Koehler (1898) draws attention, stating that, of seven specimens examined by him, only two showed a couple of depressions, while the others have only one. Koehler suggests that the smaller size of his examples may account for the difference between his and Lyman's examples, those of the former being considerably smaller. This explanation, however, can scarcely be admitted, for my specimens, the largest of which has a disc-diameter of over 8 mm., are very similar in size to the one selected by Lyman as characteristic of his examples. It may be added that the single depression is very distinct, and reminds one of the ventral pits in *Ophiura ciliaris* (Linn.).

The innermost ventral arm-plate, immediately outside the depression to which reference has been made, is somewhat triangular in shape. From the figure which Lyman gives, it appears as if the margins of the ventral arm-plates are gently rounded, except on the proximal side, and the distal edge arc-shaped, whereas, in my examples, these plates have the lateral edges straight, the distal edge almost straight, and the proximal edge also straight except for a slight projection at the line of junction of the lateral arm-plates along the middle of the ventral surface of the arm. The ventral arm-plates are thus almost rectangular. They are twice as broad as they are long, and they are small and widely separated. So widely separated and so nearly linear are these transverse plates, that in spite of their presence the sutures formed by the junction of the ventral margins of the lateral arm-plates give one the impression of forming almost a continuous straight line along the centre of the arm.

The dorsal arm-plates are distinctly arched. The innermost plate at the base of the radial shields is triangular, the second is roughly square, the third is rectangular and slightly broader than long. From the fourth outwards to the tip of the arm, the plates are longer than broad, and are four-sided with a narrow proximal edge, two straight outward sloping lateral edges, and a wide curved distal edge.

A very marked feature of the arms of my specimens is their variegation, brownish coloured rings occurring at about every fourth articulation.

Outside the area of the disc there is but one tentacle-scale.

Measurement gives ratio of arm-length to disc-diameter to be fully 3 : 1, and my specimens vary from over 5 to just under 9 mm. in diameter.

Localities.—Four specimens from St. I., east of Tavoy Island and Port Owen, 4 to 12 fathoms, sand and broken shells and mud. St. XIII., Shore of Maria Island, 8 to 10 fathoms, rock and sand (one specimen). St. XIV., Bushby Island pearling ground, shore to 21 fathoms, sand and mud (one specimen). St. XXII., Hastings Harbour, St. Luke's Island, shore to 20 fathoms, rock and sand (one specimen). St. XXV., Gregory Group and Crichton Island, 4 to 14 fathoms, stones and broken shells and rock (four examples).

O. sinensis has been recorded by Lyman from the neighbourhood of Yokohama, and by Koehler from the Malabar coast, from the south of Ceylon and round the Bay of Bengal. It has also been found (Koehler) near the Andaman Islands, and in the Mergui Archipelago (King's Island). It appears to be a littoral form, having been taken in these places at a depth of from 4 to 36 fathoms.

(3) **Ophiactis savignyi** Müller et Troschel.

A single small and somewhat damaged example is the only representative of this species.

Much has been written by Lyman, Grube, Ludwig, De Loriol, Koehler and others, on the synonymy of *Ophiactis savignyi*, *O. sexradia*, *O. reinhardti*, *O. incisa*, *O. virescens* and *O. krebsii*. All that need be added is that if one species, *O. savignyi*, is to include all these forms, there are undoubtedly great variations amongst the individuals of that species.

My solitary example has a disc-diameter of 4 mm. and an arm-length of 15 mm. It is the form with five arms, each arm carrying six short and stout arm-spines, one tentacle-scale, ventral arm-plates longer than they are broad, the disc without spines, and the radial shields non-diverging, and the length of each about two-thirds the radius of the disc.

Locality.—St. XX., Hastings Harbour, St. Luke's Island, 3 to 20 fathoms and shore, rock and sand (one example).

While the species has not hitherto been recorded from the Mergui Archipelago, it has been found at the Andaman Islands, and its distribution is as wide as its forms are various.

(4) **Ophiocoma scolopendrina** (Lamarck).

The species is represented by a solitary example from each of two adjacent stations.

So many variations of this species have already been described, that it must seem superfluous to add to the perplexities of the systematist by further detailed redescription. Both my specimens have a disc-diameter of 19 mm. and an arm-length of over 110 mm. They show that: (1) the variation in the distribution of the surface granules has not the geographical significance which a reading of Koehler's (1898) description (*loc. cit.*, pp. 78, 79) would suggest, for while one of my specimens agrees with his description of examples from the Laccadive Islands, in that the granulation is confined to the dorsal surface, the other agrees with the variation usually described by authors in which the ventral interbrachial spaces also bear granules; (2) the alternation of three and four spines is not carried out with perfect regularity, and near the base of the arm a series of five spines occurs occasionally; (3) the tentacle-scales may be continued in pairs, even to the tip of the arms, and even where a series of single scales is the rule the continuity is occasionally broken by the occurrence of a pair.

Localities.—St. XIII., Shore of Maria Island, 8 to 10 fathoms, rock and sand (one example). St. XIV., Bushby Island pearling ground, shore to 21 fathoms, sand and mud (one example).

The species is widely distributed over the Indian Ocean and the Pacific Ocean, from Mozambique to the Fiji Islands.

(5) **Ophiocoma valenciae** Müller et Troschel, 1842.

There are thirteen well-preserved examples of this species from three nearly adjacent stations.

The disc-diameter of a fair-sized specimen is 18 mm., and the arm-length is over 100 mm. The disc is closely covered with small granules, and is yellowish-brown, while the arms are straw-coloured, often ringed with brown on the dorsal surface at intervals of four or five plates. There are generally six arm-spines near the disc, further out five, and for two-thirds of the arm-length there are only four. The third and fourth arm-spines are the longest. Most of the specimens have two tentacle-scales on the first two vertebræ, and thereafter for the whole length of the arm only one, large, flat and oval shaped.

Localities.—St. XXX., Fly Island, Observation Island, and south-west of Domel Island, 8 to 15 fathoms, rock and sand, diver and small dredge (two examples). St. XXXII., South-west of Domel Island, 26 to 29 fathoms, sand and mud, large dredge (nine examples). St. XXXIII., Christmas Island Group, 8 to 23 fathoms, rock and sand and mud, diver and dredge (two examples).

The species was not found either by the "Investigator" or by the "Siboga" expeditions, and it has not hitherto been recorded from the Mergui Archipelago. It has, however, been taken from the Maldive and Laccadive Archipelagoes, and it is known to have a wide geographical distribution, for examples have been also taken from the Red Sea, Zanzibar, Mozambique, Port Natal, Samoa and the Fiji Islands.

(6) **Ophiomastix venosa** Peters, 1852.

There are in the collection two examples of this species from one station.

There is no mistaking this splendid example of the Ophiuroidea, for the skin-covered disc with its few stout blunt spines and its peculiar markings, and the very large club-shaped upper arm-spines (generally every fourth one is clubbed), are very distinctive. While Lyman (1882) says that there are "usually one, rarely two tentacle-scales" (p. 175), both my examples have two tentacle-scales for nearly two-thirds the length of the arm, and thereafter towards the arm tip only a single scale.

Locality.—St. XXXII., South-west of Domel Island, 26 to 29 fathoms, sand and mud, large dredge (two examples).

The species is well known as an inhabitant of the western parts of the Indian Ocean, having been taken from Mozambique and from Zanzibar, and also from the Maldive and Laccadive Archipelagoes, where Bell (1903) found it "common in the Maldives." But as it was not found either by the "Investigator" (1898), or by the "Siboga" (1905), and it has not hitherto been recorded farther east than the Maldives, its appearance in the Mergui Archipelago adds considerably to its range of geographical distribution.

(7) **Ophiothrix foveolata** Marktanner-Turneretscher.

The species is represented by two examples from different stations. Each has a disc-diameter of 5·5 mm. and an arm-length of about 27 mm.

It is some satisfaction to find that *O. picteti* Loriol, is now regarded as synonymous with Brock's *O. foveolata*, and that Koehler, after an examination of the original example of *O. foveolata*, is satisfied that his new species *O. insidiosa* (1898) is not sufficiently distinct to justify its retention. Of my examples, the colour of one exactly fits Koehler's statement in the original description (1898) of *O. insidiosa*, "La couleur générale est gris-bleuâtre" (p. 92); while of the other it may be said with equal truth, as Koehler says of *O. foveolata* in the "Siboga" expedition reports (1905), "La coloration générale est jaunâtre ou légèrement rosée" (p. 77). The spines on the interradial and central plates of the dorsal disc-surface are fewer and shorter in one of my examples than in the other. But as there is undoubtedly considerable variation in what is now regarded as *O. foveolata*, it is sufficient for me to add that my identification of *O. insidiosa* is admitted by Koehler, and that he adds, "*O. insidiosa* Koehler est synonyme de *O. foveolata* Marktanner-Turneretscher ainsi que je l'ai reconnu."

Localities.—St. XXII, Hastings Harbour, St Luke's Island, 3 to 20 fathoms and shore, rock and sand (one example). St. XXX., Fly Island, Observation Island and south-west of Domel Island, 8 to 15 fathoms, rock and sand (one example).

An example of this species was taken by the "Siboga" expedition at a depth of 141 metres. This seems an exceptional case. Previous records for the Indian Ocean are from the Andaman Islands and from the south of Ceylon.

(8) **Ophiothrix martensi** Lyman, 1874.

This species is represented by a single example, with arms broken at about 25 mm. from the disc, and with a disc-diameter of 8 mm. Lyman (1874), after describing his type, which had a disc-diameter of 14 mm. and an arm-length of 63 mm., gives (p. 235) some points of difference observed in "a smaller specimen with a disc of 6·5 mm." My example, as the size might indicate, approaches more closely to Lyman's description of his smaller specimen than to that of his type. In the type "the disc is covered by thick skin which obscures the outline of the radial shields and nearly hides the scaling" (p. 235). The smaller specimen "had a thinner skin so that the various parts were better defined" (p. 235). If there is any skin covering the disc in my specimen it must be exceedingly thin, for the scaling is very distinct. The radial shields, which are smooth, are triangular in shape, with a notch in the base, and each is separated from its fellow by a single row of about four elongated scales, coloured blue along the centre, and with the margins white. This blue line stretches along the arm, on the middle line of the dorsal arm-plates. In the centre of the disc there is a large circular plate surrounded by several circles of much smaller scales. Between the radial shields, in the interradial space, there are four rows of oval scales radiating from the margin of the disc to the smaller scales surrounding the central plate. There are several short spines on the margin of the disc, and a few are scattered over the outer part of the ventral inter-brachial space. The mouth-shields are three-sided, the outer margin semicircular, and the inner two edges almost straight and meeting at a point within. The side mouth-shields are stout and taper from without inwards, where they just meet.

The under arm-plates are squarish with slightly rounded corners, and have a broad central white line and blue coloured lateral margins.

Of the seven arm spines the lowest is the smallest and the most characteristic. The tip is bent into a hook, and on this spine, on the same side of it and in the same plane, there are two or three other smaller hooks decreasing in size from above downwards. The other spines have a smooth shaft and thorny club-shaped heads.

Locality.—St. XXIV., Cat and Kitten Islands, 8 to 22 fathoms, rock, sand and broken shells (one specimen).

O. martensi has been noted from the Philippines, by Semper; and from Owen Island, Mergui Archipelago, by Duncan (1882), whose reference to "well-marked radial shields" (p. 97), would seem to indicate that the disc was not covered by skin.

(9) Ophiothrix stelligera Lyman, 1874.

Eighteen examples of this species were collected from seven stations. They have a disc-diameter of from 4 to 6·5 mm. and an arm-length up to 30 mm. While some of the specimens show only stumpy, star-headed spines on the disc, others have in addition a number of elongated spines distributed irregularly.

In an example from Station XXIV., which, like all the others, has the ventral arm-plates with the characteristic "clean curve, without" (Lyman, 1874, p. 237), there appear along the ventral median line of the arms one or two small dark specks (or they may be pits) between each plate. In other respects this specimen is similar to the rest, which agree with the original brief description by Lyman as supplemented by Koehler (1905) in the "Siboga" reports.

Localities.—St. I., East of Tavoy Island and Port Owen, 4 to 12 fathoms, sand and broken shells and mud (four examples). St. VI., between Grant's Island, Ross Island and Elphinstone Island, 3 to 7 fathoms, rock and sand or rock and mud (one example). St. XIII., Shore of Maria Island, 8 to 10 fathoms, rock and sand (five examples). St. XXII., Hastings Harbour, St Luke's Island, 3 to 20 fathoms and shore, rock and sand (two examples). St. XXIV., Cat and Kitten Islands, 8 to 22 fathoms, rock and sand and broken shells (four examples). St. XXV., Gregory Group and Crichton Island, 4 to 14 fathoms, rock and stones and broken shells (one example). St. XXVIII., Riou Island and Hobson Island and adjacent islands, 2 to 8 fathoms, rock and sand (one example).

The species has been taken from the Andaman Islands, Amboina, Borneo, Japan, the Philippines, etc.

(10) Ophiothrix exigua Lyman, 1874.

This species is represented by two well-preserved specimens from different stations.

Koehler (1904 and 1905), who has compared some examples captured during the "Siboga" expedition with an example named by Lyman from the Jardin des Plantes, has made some desirable corrections and important additions to Lyman's original description. Koehler asserts that though no further examples of *O. exigua* had been found till the "Siboga" expedition, the explanation is that they were designated by another name, doubtless owing to Lyman's imperfect description. Koehler further asserts that certain specimens in the museum in Vienna (from the Red Sea), named *O. comata*, by Marktanner-Turneretscher, are in reality *O. exigua*, and that two examples from Amboina, which De Loriol (1893) named *O. comata* on the assumption that the Vienna specimens were correctly identified, are also examples of *O. exigua*. Koehler has discussed this matter at length both in his "Ophiures nouvelles ou peu connues," and in the "Siboga" reports.

My specimens agree essentially with the amended description: the only comment I venture to make is that the notch on the distal margin of the ventral arm-plates is somewhat more marked than is shown in Koehler's figure (1904).

Both examples have a disc-diameter of 5 mm. and an arm-length of 18 mm.

Localities.—St. I., East of Tavoy Island and Port Owen, 4 to 12 fathoms, sand and broken shells and mud (one example). St. XX., High Island, shore and 3½ to 9 fathoms, sand and shells or rock and sand (one example).

The present is a new record for the Mergui Archipelago. But, owing to the confusion that has undoubtedly existed between *O. comata* and *O. exigua*, it is difficult to say definitely what is the exact geographical distribution of either of these species.

(11) Ophiothrix hirsuta Müller et Troschel.

There are eight examples of this species from five stations. Owing to the length of the arms it is not easy to preserve specimens entire, but the individual whose arms are least damaged has an arm-length of 165 mm., and a disc-diameter of 17 mm. I observe that the disc of these specimens shrinks considerably on being dried.

My examples agree in every detail, except that of colour, with Lyman's (1865) description of *O. cheyeni*, which is synonymous with *O. hirsuta*. Instead of a dark prussian blue, which Lyman notes as the colour of the dorsal disc-surface in alcohol, a dark brown would rather indicate the prevailing colour of my specimens.

Localities.—St. I., East of Tavoy Island and Port Owen, 4 to 12 fathoms, sand and broken shells and mud (one example). St. XXII., Hastings Harbour, St Luke's Island, 3 to 20 fathoms and shore, rock and sand (two examples). St. XXIII., Five Islands, 8 to 12 fathoms, rock and sand and mud (one example). St. XXIV., Cat and Kitten Islands, 8 to 22 fathoms, rock and sand and broken shells (one example). St. XXV., Gregory Group and Crichton Island, 4 to 14 fathoms, stones and broken shells and rock (three examples).

This species is known from Zanzibar, the Red Sea, Nicobar, Singapore, the Philippines, Fiji Islands, etc.

(12) **Ophiocampis pellucida** Duncan, 1886.

There is but a solitary example of this interesting form.

Duncan (1886), who first described the species from material collected from near King's Island, Mergui Archipelago, from which locality this individual was also taken, found it possessed such unique characters that he established a new genus for it. The arm bones are very peculiar. There are no upper arm-plates, and the broad arched upper surface of the arm is covered with a minutely squamous skin. The ventral arm-plates towards the disc are almost rectangular, but farther along the arm they are distinctly narrowed proximally and distally, and project at the middle. The side arm-plates are large. Especially remarkable is the arrangement of the opposed surfaces of the arm bones, which have a large umbo and no median articulating "peg." The arms are thus not only capable of movement in a lateral direction, but they may also, to a great degree, be curled downwards.

In my specimen the parts of the upper disc-surface seem to be contracted or drawn together, and the radial shields, as now seen, are distinctly oval in shape, and are not triangular, as in Duncan's figure. The disc-diameter is 5 mm. and the arm-length is about 60 mm. While the arms are buff in colour, the disc is pale yellow.

Locality.—St. IV., North-west of King's Island, 8 to 25 fathoms, rock and sand, dredge (one example).

Some examples of this species, which is apparently not widely distributed, were found by the "Investigator," near the coast of Orissa, at a depth of 11 fathoms, and also 30 miles south of Coconda, at a depth of 4 to 5 fathoms.

(13) Ophiocnemis marmorata (Lamarck).

Duncan's remarks (1889, pp. 103, 104) on Lyman's (1882) amended definition of this species of Ophiocnemis, which Müller and Troschel insufficiently diagnosed, are very full. The four examples of this species in my collection are from one station, and have a disc-diameter of 10, 15, 15, and 16 mm. respectively. Duncan's specimen, also from the Mergui Archipelago, had a disc-diameter of 13 mm. and an arm-length of 70 mm.

While my specimens conform to Duncan's description, I note the following points:—The disc is notched at the insertion of the arms. Four rows of very short nodular stumps extend inwards interradially from the margin of the disc, and two rows of similar stumps extend inwards radially, separating the large radial shields from each other. These rows all meet near the centre of the disc. Thus the whole dorsal disc-surface is covered by the ten large radial shields and by these short stumps. The slate-coloured radial shields have numerous irregular dark spots, and are smooth except that the nodular stumps stretch round the edge of the disc, even invading the outer margin of the radial shields. The interbrachial ventral surface is naked, except for a few short scattered stumps towards the outer margin. There is an obvious genital process on the outer side of the mouth-shield. Lyman's figure does not show that the mouth-shield is much broader than long, and that the side mouth-shields are pointed. The innermost ventral arm-plate has a conical projection directed towards the centre of the mouth. Close to the disc, on the first and second arm-joints, there are at least six spines, but beyond this there are only four or five. The second and third are much longer than the uppermost, and the lowest one is very small and pointed.

Locality.—St. XXX., Fly Island, Observation Island and S.W. of Domel Island, 8 to 15 fathoms, rock and sand (four specimens).

This species has also been taken from Zanzibar, Ceylon, Madras, Singapore, Sonda Islands, N.W. Australia, etc., up to a depth of 34 fathoms.

(14) **Ophiopteron gymnatum**, nov. sp. (Figs. 1 and 2.)

The disc-diameter is 5 mm. and the length of the arms is 25 mm.

The disc is round, and is covered with plates without any spines on the dorsal surface. There is a large centro-dorsal shield surrounded by two circles of smaller irregularly-shaped scales. The radial shields are large, triangular, twice as long as they are broad, almost touching without where there is a small notch for the insertion of the arms, and slightly diverging inwards where they are very pointed. They are separated from each other, except at the margin of the disc, by two or three elongated over-lapping scales, which increase in breadth inwards. The interradial space is covered by about three irregular rows of somewhat elongated imbricated scales, the centre row being larger than the side ones which bound the radial shields. A distinct purple line, which stretches along the upper side of each arm, extends inward to the centre of the disc along the scales separating the radial shields.

On the interbrachial space, on the ventral side of the disc, no plates are visible, but the space is filled, with the exception of a narrow border along the genital openings, with some twenty to thirty short cylinders, quite separate from each other. These cylinders with their smooth shaft, terminated in a crown of. three diverging short prongs, recall the disc-spines of *Ophiopteron sibogae* Koehler. There is a very distinct genital plate bounding the large genital openings.

The oral shields are fairly large, broader than long, roughly three-sided, the outer margin gently rounded with a large genital process, and the two inner sides slightly curved and meeting at a not very sharp point within. The adoral plates are narrow and meet internally. The jaw plates have a small triangular notch between them, and bear two regular lateral rows of teeth and an irregular middle row.

The dorsal arm-plates are large, broader than long, angular and six-sided, with the distal margin only slightly broader than the proximal one. Of the other sides, the two adjacent to the proximal side are longer than the two adjacent to the distal side, and hence a dorsal arm-plate is broadest about one-third of the length from its distal margin.

The ventral arm-plates are also large. The innermost one is nearly square, but along the arm they become rectangular, with the length greater than the breadth. There is a linear division between the plates, and there is no notch in either distal or proximal border. Two purple lines, one on each lateral margin of the ventral arm-plates, extend along the whole length of the arms.

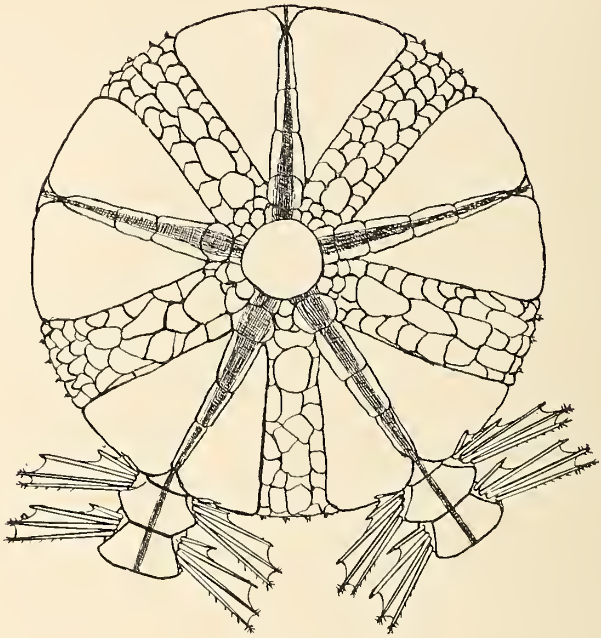

Fig. 1.

Dorsal surface of disc of *Ophiopteron gymnatum.*

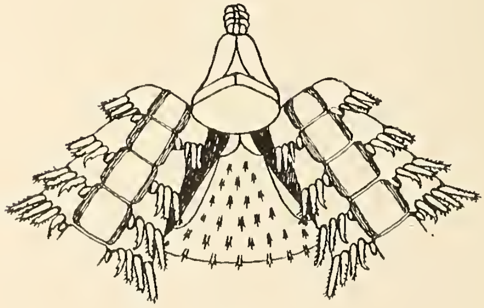

Fig. 2.

Ventral surface of disc of *Ophiopteron gymnatum.*

The lateral arm-plates project slightly and bear arm-spines which vary in number, from eight or nine next the disc to four towards the tip of the arm. On the first arm-joint the lowest spine is needle-shaped, but along the arm it becomes hook-shaped, and bears at first two, and then three or even four, hooks all turned downwards. Close to the disc, the next three arm-spines (farther along the next two or one) are broadened at the tip and serrated, and each is slightly longer than the one below it. The next spine, which is still a little longer, has a length of two arm-joints and is the longest of all. The other spines number from four to one according to the distance along the arm from the disc, and where there are two or more they gradually decrease in length so that the shortest of these upper spines is the most dorsal. The spines on the upper side of the longest are smooth and pointed, except the one next to the longest, which for one-third of the length of the arm from the disc is serrated at the tip.

On the arm-joint next the disc, the upper five spines are united by a thin translucent membrane. A similar membrane joins into a web the most dorsal four spines on the second, third and fourth joints of each arm. For about the next half-dozen joints there are only three spines so united, and thereafter the spines are free.

Both the dorsal and the ventral arm-plates bear fine scattered granulations. There is a single flattened and pointed tentacle-scale.

The genus *Ophiopteron* was founded on two specimens which Brock brought from Amboina, and which Ludwig first described and figured in 1888, under the appropriate designation of *Ophiopteron elegans.* In 1894 Bell found seven more examples amongst the Echinodermata collected from the Macclesfield Bank. Four years later, Koehler reported a single example of this remarkable Ophiuroid taken by the "Investigator" from the Andaman Islands. Again, in 1903, Bell reported that *O. elegans* had been "dredged five times in three atolls, 22 to 35 fathoms, in every case near passages, hard bottom, perhaps rubble and weed," near the Maldive and Laccadive Islands. It will thus be seen how wide is the distribution of this extraordinary form.

In the reports of the "Siboga" expedition, Koehler in 1905 described two other littoral species of *Ophiopteron*—*O. sibogae*, from Lesser Sunda Island (one example); and *O. puncto-coeruleum*, from the Bay of Badjo (six examples), from the Aru Islands (one example), and from the Island of Rotti (one example).

A fourth species has now been discovered among the Echinodermata collected in the Mergui Archipelago. It is, unfortunately, represented by a single example, which, however, is fairly well preserved. It is extremely interesting in that it is of a somewhat simpler type than even *O. puncto-coerulcum*, which had already helped considerably to bridge the gulf between the genus *Ophiothrix* and the genus *Ophiopteron*, as exemplified in the complex structure of *O. elegans*.

The new species essentially agrees with the other species of *Ophiopteron* in having some of the arm-spines on several of the arm-joints united by a membrane, thus entitling it to be considered a true *Ophiopteron*. But while *O. elegans* and *O. sibogae* have the disc covered with short spines, and while *O. puncto-coerulcum* has the radial shields naked and the remainder of the dorsal side of the disc covered with spines, this new species has *no spines on any part of the upper surface of the disc*. *O. gymnatum* has large radial shields and a very distinct centro-dorsal plate, and these, as well as the smaller disc-scales, are naked and slightly roughened with very fine granulations. The disc appearance undoubtedly closely resembles that of an *Ophiothrix*, and is, indeed, very similar to that of *O. martensi* Lyman.

Professor Koehler, to whom I submitted this unique specimen, most kindly sent me the following note regarding it:—

"It is indeed a new species of *Ophiopteron*, neighbouring to *O. puncto-coerulcum*, which it recalls by the expansions which are found only on the spines near the base of the arm, but it differs therefrom, in respect of the coloration, the presence of more arm-spines, the absence of spines on the disc, etc."

Locality.—St. XXII., Hastings Harbour, St Luke's Island, 3 to 20 fathoms and shore, rock and sand (one example).

(15) Lutkenia cataphracta Brock, 1888.

This species is represented by a single example. To the description given by Brock, who first established the genus, which is very closely allied to the genus *Ophiomaza*, and to the couple of wholly admirable figures given by Koehler (1904, figs. 92, 93), who first illustrated this species, there is little to be added. The main point is that on the interbrachial ventral surface the scales are more numerous than represented in Koehler's diagram, and Koehler's own comment on confirming my identification of this individual is that "the chief difference consists in the ventral plates of the disc being a little smaller than in the type."

My example has a disc-diameter of 6 mm., and while the length of the longest arm is 19 mm., the shortest complete one is only 8 mm. There are five short stout conical arm-spines, and towards the tip of the arm the lowest one is hooked or has a hooked projection. There is a narrow indigo coloured line in the interradial space around the margin of the disc, and this is continued along the arm at the base of the uppermost spine, on both sides of the arm. A broader line of the same colour, about one-third the breadth of a ventral arm-plate, also stretches along the median line of the ventral surface of each arm. The centro-dorsal disc-plate is also indigo coloured.

Locality.—St. XXII., Hastings Harbour, St Luke's Island, 3 to 20 fathoms and shore, rock and sand (one example).

This appears to be the first time this species has been found in the Mergui Archipelago.

2. CLADOPHIURÆ.

(1) Euryale studeri Loriol, 1900.

This species is represented by seven examples from three stations. My examples agree with the description and figures of Loriol (1900), who first distinguished this species from *E. aspera* Lamarck.

Localities.—St. II., East of Thamihla or Iron Island, 10 to 15 fathoms, mud or sand and mud (four examples). St. XVII., West of Sir John Malcolm Island, 13 to 18½ fathoms, coarse sand and broken shells (two examples). St. XXV., Gregory Group and Crichton Island, 4 to 14 fathoms, rock and stones and broken shells (one example).

Koehler (1907, p. 350) now considers the individuals taken by the "Investigator" in the Straits of Malacca and Gaspar, and which he identified as *E. aspera* Lamarck, to be in reality *E. studeri.* The species was also found by the "Siboga" expedition in the Sulu Archipelago, north-west of Borneo.

(2) Astrophyton clavatum Lyman, 1865.

There is but a single example of this species.

It is a very large specimen, having a disc-diameter of over 50 mm., while some of the arm-branches extend to about 400 mm. The arms show an extraordinary amount of branching, and the radial ribs are very prominent. The only point in which this splendid specimen of *A. clavatum* seems to differ from the type is in having not only the radial ribs but also the inter-brachial spaces on the dorsal surface of the disc closely and uniformly covered with microscopic grains or thorny stumps. Professor Koehler, however, who kindly examined this specimen, reports that he has seen other examples of the species with similar uniform granulations.

Locality.—St. XXV., Gregory Group and Crichton Island, rock and stones and broken shells, 4 to 14 fathoms, dredge and diver (one example).

While examples of the species have been found from Madagascar, Mauritius, Zanzibar, the Persian Gulf, the Maldive and Laccadive Archipelagoes, and Ceylon, this is the first record from a locality as far east as the Mergui Archipelago.

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(*Issued separately, 9th June* 1911.)

XIX.—Notes on the Adult Anatomy of *Solaster endeca* (Forbes): (1) Madreporite, etc.; (2) Anus; (3) Egg ducts; (4) and (5) Aboral and Oral Perihæmal sinuses. By James F. Gemmill, M.A., M.D., D.Sc.

(Read 28th November 1910. Received 10th March 1911.)

1. Relation of Pore Canals of Madreporite to Stone Canal and Axial Sinus (Figs. 1-5).

As is well known, in the larval condition and at metamorphosis, the pore canal is single and leads into the axial sinus. During this period the stone canal, which was formed in the sinistral[1] wall of the axial sinus, communicates with the axial sinus by a single aperture situated near the internal end of the pore canal, and looking dextrally[1] into the cavity of the sinus in question.

Two points arise in connection with the later growth of starfish—(1) What are the final relations of the usually numerous pore canals of the madreporite to the stone canal and to the axial sinus; and (2) How have these relations arisen, and, in particular, how do the pore canals come to be so numerous. The first of these points only will be taken up in this paper.

Many of the older observers had noted that injected fluids passed readily from the stone canal into the axial sinus, within or underneath the madreporite. This method is, however, open to the objection that by its employment delicate septa may be ruptured, and more recently the question has been studied by means of sections (Ludwig, Perrier, Hamann, Cuénot, Durham and Goto).

Ludwig's account (1) now stands practically alone in affirming that all the pores of the madreporite open into the stone canal, and that the latter is entirely separated from the axial sinus.

Cuénot (3) states that many of the madreporic pores lead into the axial sinus, and that this sinus and the stone canal are placed in communication by means of anastomosing channels in the madreporite. Hamann (2), though his earlier work was in agreement with Ludwig, gives a later description similar to that of Cuénot.

Durham (4) states that in a full-grown specimen of *Cribrella oculata* (*a*) one

[1] Throughout this paper *dextral* and *sinistral* indicate respectively the sides towards which, or away from which, the hands of a watch would seem to move on the starfish disc as viewed aborally.

of the lateral lobes of the ampulla of the stone canal had an opening into the axial sinus; (*b*) most of the madreporic pores passed into collecting canals, which opened into the madreporite, but some few led into the upper extremity of the axial sinus. Durham mentioned incidentally in this connection that his observations in *Asterias rubens* agreed with the view of Ludwig given above, and he considered the condition he found in *Cribrella* to be probably abnormal. Perrier (5), in very young *Asterias spirabilis*, found an aperture connecting the upper end of the stone canal with the axial sinus. Macbride (6) states that the axial sinus has an opening into the stone canal, and also communicates by pore canals with the exterior.

Goto (7) would distinguish, as separate from the anastomosis described by Cuénot, a special opening underneath the madreporite on the dextral side of the commencement of the stone canal. The latter opening he finds in *Asterias pallida*, *Asterias tenera*, *Asterina gibbosa*, *Solaster endeca* and *Cribrella sanguinolenta*, and he considers that it represents the primitive connection between axial sinus and stone canal existing since larval life. I find a similar opening in young specimens of *Asterias rubens*, L., *Solaster papposa*, L., and *Porania pulvillus* (O.F.M.), but, as will be indicated below, I believe that the channels of Cuénot and Goto's opening belong to the same system, the latter, at any rate in the fully-grown *S. endeca*, being broken up into a large number of apertures, all of which are embedded within the madreporite. This view is in general agreement with Cuénot's comparison of the relation of these parts in other starfish and Echinoderms.

I had available for study a very good horizontal series through the madreporic interradius of a specimen of *Solaster endeca* measuring 7 inches across disc and arms.

The pore canals are very numerous, amounting to over four hundred. Those near the middle of the madreporic surface pass vertically downwards, but the marginal ones slope slightly towards the centre of the madreporite. At their external orifices, and for a short distance inwards, the lining of all of them is made up of strongly ciliated columnar cells, while farther in, it consists of cubical weakly ciliated epithelium, not much stronger than that forming the general lining of the axial sinus.

As they pass inwards, the pore canals unite in small groups on a common stalk. Deeper down, adjacent stalks also unite to form larger collecting branches, between which a fairly free anastomosis may be found.

The collecting branches which are in relation with the pore canals occupying the middle area of the madreporite, open directly into a small horseshoe-shaped central chamber lying within the substance of the madreporite, and to be afterwards described. On the other hand, the collecting

Figs. 1 to 4. Horizontal sections (drawn with camera lucida, × 20) of madreporite, and underlying parts in a large adult *S. endeca*. The sections are looked at from the aboral side, and the centre of the starfish disc is towards the lower side of the page.

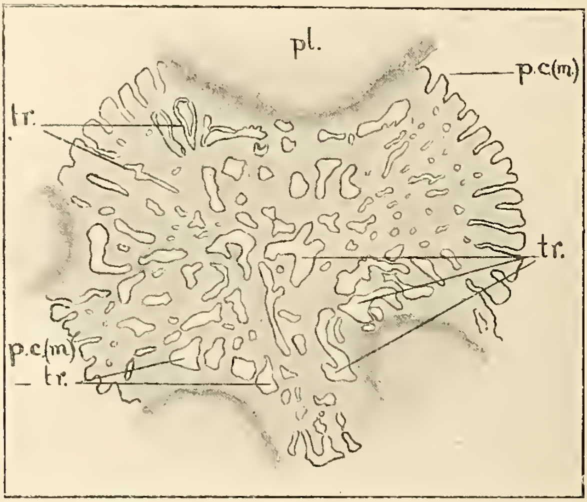

Fig. 1. See above. Section near the beginning of the series. As the external surface of the madreporite is convex, pore canal openings appear at the margin, while towards the centre we have chiefly larger or smaller collecting trunks.

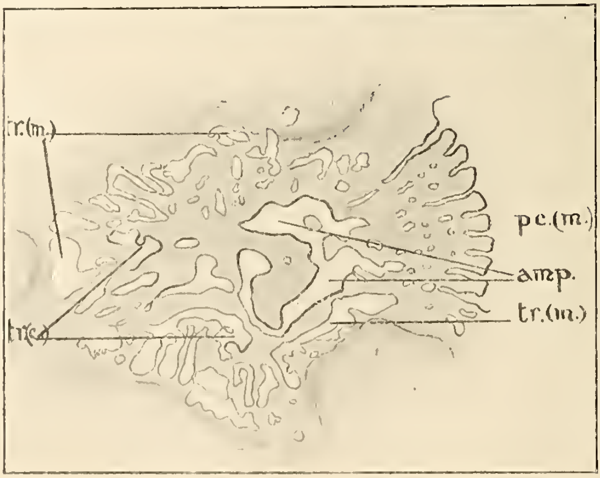

Fig. 2. See above. Section a little deeper, showing commencement of central chamber as well as the openings of two large collecting trunks which enter it near the middle of its convex side.

Fig. 3. See above. Stone canal now with characteristic form. Marginal spaces running together to form aboral end of axial sinus. Dorsal sac with upper end of axial organ and diverticulum from axial sinus invaginated into its lumen.

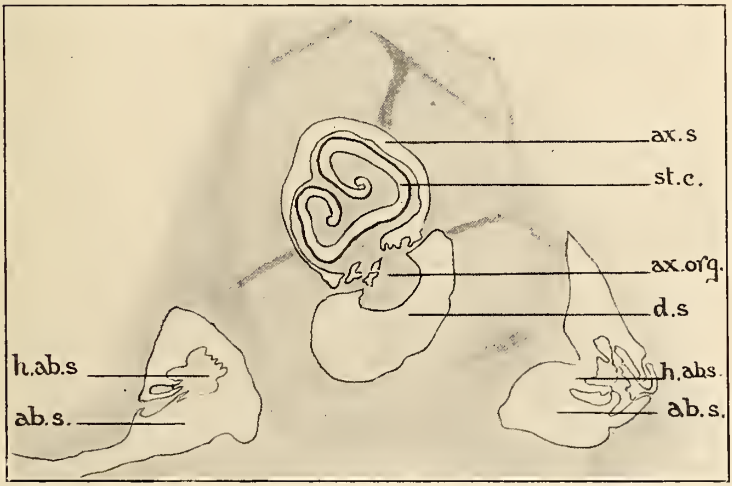

Fig. 4. See above. Section still deeper, showing stone canal, etc., as well as the two limbs of the aboral perihæmal sinus.

Lettering in Figs. 1 to 4.

ab. s . aboral perihæmal sinus.
amp. . central chamber of madreporite (ampullary part of axial sinus).
ax. org. axial organ. *ax. s.* . axial sinus. *d. s.* . dorsal sac.
d. v. . diverticulum from central chamber of madreporite.
h. ab. s. hæmal tissue within aboral perihæmal sinus.
p. c. (*c*) and *p. c.* (*m*) pore canals perforating the central and marginal areas of the madreporite.
tr. (*c*) and *tr.* (*m*) collecting spaces belonging to the central and marginal pore canals.
st. c. . stone canal.

branches which are in relation with the marginally placed pores, while communicating with the first set of branches and also with the central chamber at points all round the convex side of the horse-shoe, are continued more directly in a downward direction, and gradually flowing together form the upper or aboral end of the axial sinus. The lining epithelium of these cavities, except at the parts to be afterwards noted, consists of low cubical epithelium, and the marginal collecting trunks nearly all contain a considerable number of corpuscles of leucocytic nature.

The central chamber mentioned above is horse-shoe shaped, with the concavity of the horse-shoe looking to the sinistral side, as well as slightly outwards, *i.e.*, towards the margin of the disc. The horse-shoe itself lies practically in the horizontal plane of the starfish, though, if anything, the sinistral limb is a little higher (*i.e.*, more aboral) than the dextral limb. The roof of the chamber receives the openings of the collecting branches from the central set of pore canals, while the sides of the chamber, except within the bend of the horse-shoe, have free communication by nine or ten apertures with those collecting branches which are in connection with the marginal pore canals on the one hand, and with the axial sinus on the other. These apertures are all of the same general character, but two, slightly larger than the rest, are found a little to the dextral side of the middle of the horse-shoe. The floor of the chamber is deficient. The blank left is the commencement of the stone canal, and the horse-shoe cavity of the chamber passes by gradual transition into the simply folded lumen which, in this species, is characteristic of the stone canal. As it goes deeper, the canal rotates clockwise through about half a right angle, so that its concave or folded side now looks outwards towards the margin of the disc, as well as slightly to the sinistral side.

On those parts of its inner surface the curvature of which is concave towards the lumen, the stone canal is lined by greatly elongated cells carrying long and powerful cilia. This lining passes upwards for a short distance on the sides of the central chamber. It may also be continued into some of the main branches of the chamber in the form of broader or narrower tracts, which are usually to be found along the floor of the branches in question. It merges, by gradual transition, into the cubical epithelium mentioned above as lining the intramadreporic spaces generally.

Careful examination of the whole series leads me to the conclusion (1) that there are no channels connecting the external surface with the axial sinus which do not communicate within the madreporite directly or indirectly with the central chamber; and (2) that one cannot speak of any single large communication between the stone canal and the axial sinus, unless one means that blank in the floor of the central chamber which was referred to above as forming the commencement of the stone canal.

This communication in a young *Solaster endeca*, according to Goto (7), was through a lateral opening on the dextral side of the commencement of the canal. Evidently its lower lip has grown up, so that the margin of the opening is now horizontal instead of vertical, and at the same time the aboral end of the axial sinus has become divided into a branching set of spaces, all communicating directly or indirectly with the central chamber described above. The central chamber itself represents that part of the axial sinus which, in

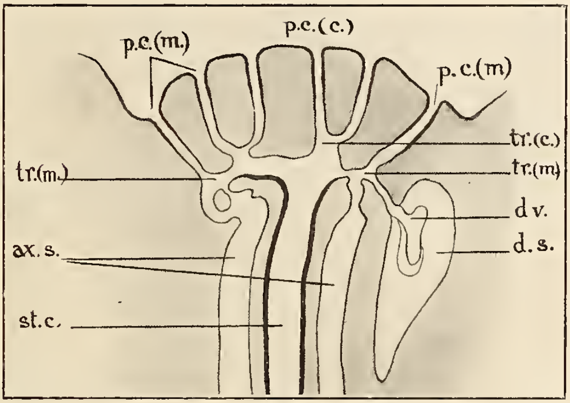

Fig. 5.

Diagram to illustrate in vertical section the relation of pore canals, stone canal axial sinus, etc., in a large adult *Solaster endeca*. The branching of the pore canals has been greatly simplified. (Lettering as in Figs. 1 to 4.)

early stages, lay adjacent to the laterally placed opening of the stone canal. What has been described by various authors as the ampulla of the stone canal seems to correspond with this chamber in the adult condition (or earlier with the more open dextral end of the axial sinus). In this view the term ampulla of stone canal is, strictly speaking, a misnomer, and should be replaced by ampullary part of axial sinus or some similar name.

In the adult *S. endeca*, the position may be summed up as follows:—(1) The central set of pore canals open into collecting trunks leading into the ampullary part of the axial sinus which leads directly into the stone canal; (2) the marginal set of pore canals form collecting trunks which lead into the upper end of the axial sinus, and also communicate freely with the ampullary chamber; (3) strictly speaking, none of the pore canals of the madreporite should be described as opening into the stone canal.

An interesting blind diverticulum (Figs. 3, 5, *d.v.*) from one of the spaces communicating with the central chamber falls to be described. It invaginates the wall of the dorsal sac, and, expanding within this cavity, acquires comparatively thick walls, becomes lined by elongated columnar cells, and contains free in its lumen very numerous corpuscles apparently of leucocytic nature. The walls of the diverticulum are richly infiltrated with leucocytes.

So far as I know this diverticulum has not been previously described, though Durham's figure 2 of *Cribrella oculata* (4) shows a somewhat similar cavity. I have seen an indication of its mode of development in young specimens of *Porania* and of *Solaster papposa.* It has some similarities to the ampulla of the stone canal as described by Ludwig, but then Ludwig did not recognise the dorsal sac as quite separate from the axial sinus, and believed that stone canal and axial sinus were shut off from one another.

From the work of various observers, it may be taken as fairly certain that there is an outward current from some of the pore canals of the madreporite. That an important part is played in excretion by wandering cells is well known, and also that they can pass with freedom through the connective tissues and through lining membranes. It was noted above that very many of the intramadreporic collecting trunks contained wandering cells. Probably these have come from the axial sinus, and are waiting their turn to be swept out from the madreporite. I would suggest that the diverticulum above described serves as a channel for the escape of wandering cells from the dorsal sac. This would explain the nature of its walls, as well as the presence of so many leucocytes lying free within its lumen.

2. Position of Anus (Fig. 6).

In the adult *Solaster* the anus is very small, and lies near the centre of the aboral surface. Indeed, it was put down as being central by Joh. Müller. So far as I can find, its position since his time has not been the subject of particular investigation. In the *Klassen u. Ordnungen*, and in text-books generally, there is no indication that it occupies any other position than that which is normal for ordinary starfish, namely, a sub-central one in the first interradius to the dextral side of the madreporic interradius.

I have lately had the opportunity of investigating the question, by three different methods, in a number of specimens both of *Solaster endeca* and of *Solaster* (*Crossaster*) *papposa*.

1. *Serial sections*—(*a*) of very small *S. endeca* (1·8 to 2 mm. across the disc; five examples); and (*b*) of small *S. papposa* (16 to 21 mm. across the disc; three examples).
2. *Examination under the microscope* of small cleared or uncleared *whole* specimens—(*a*) *S. endeca* (2·5 mm.; two examples); and (*b*) small *S. papposa* (16 to 40 mm.; four specimens).
3. *Dissection of large specimens*—(*a*) *S. endeca*, two specimens, one with eight and one with nine rays; and (*b*) *S. papposa*, three specimens with ten, thirteen and fifteen rays respectively.

The result is to show that normally the anus in both species lies in interradius V./VI., the numbering employed being that which I have explained elsewhere (8) to be the natural one in Solaster on developmental grounds. The numbering in question makes the madreporic interradius lie between radii I. and II., the former being on its dextral[1] and the latter on its sinistral[1] side, while the succeeding members of the series, viz., III., IV., V., etc., follow to the sinistral side of II.

(1) *Serial Sections.*

Horizontal series are the best for the purpose, but even they require extremely careful study.

(*a*) *S. endeca.* During the earliest growth stages the anus occupies a comparatively excentric position, and can be located with care by using as guides the most convenient radially disposed structures, viz., the radial cæca of the stomach.

The rectum at first lies within a mesenteric sheet which anchors it on either side, and which I take to be the remains in this region of the layer which separated the epigastric and the hypogastric cœloms. In other interradii this layer soon becomes broken up into scattered strands or threads, but here it persists longer, and, indeed, its sinistral wing, *i.e.*, that extending towards ray V., remains permanently in the form of a fibrous fold connecting the rectum with the upper half inch or so of the radial muscular band belonging to ray V. On the other hand, a part of the dextral wing of mesentery on the interradius in question seems to give rise to a comparatively strong and important band of muscular fibres, which in the adult takes origin from the central knot of the aboral musculature, and passes downwards to the junction of rectum and pyloric sac. The disposition of this band suggests that very probably, along with the fold described above, it functions as a

[1] See note at foot of page 174.

sphincter separating the rectum from the pyloric sac, besides aiding in the evacuation of fæces from the rectum. The band becomes evident a surprisingly short time (less than four weeks) after the anal opening has formed. While one is naturally chary of attempting to explain growth changes on mechanical grounds, it is open to suggest that the constant traction which this band is capable of exercising may have something to do with the final approximation of the anus to the centre of the aboral disc.

Of the five tiny *Solaster endeca* examined by the method of serial sections, one did not give convincing evidence, three showed the anus to be in V. to VI., while the other was a noteworthy exception inasmuch as the anus lay in interradius VI./VII., and there was a group of five (instead of four) roots of radial cæca associated together in that division of the disc which lies between the madreporic and the anal interradii counting sinistrally from the former. This is the only aberrant instance which I have come across by any of the methods.

(*b*) Serial sections of small *S. papposa* (16 to 21 mm.; three examples). Here also the sections were horizontal. The series, however, were far from perfect, owing to the difficulty of cutting the tough aboral body wall. By the time the size above indicated is reached, the anus has moved relatively nearer the centre of the disc. On this account, and also because a vastly greater number of sections, some of which were partly broken up, had to be studied, I could not have relied with certainty on these series for fixing the anal interradius, but in all three it was clear that the anus lay at least in the close neighbourhood of interradius V./VI., and they were therefore of use in confirming the result of the other lines of evidence.

(2) *Examination under the Microscope of small whole Specimens cleared or uncleared.*

(*a*) *S. endeca* (2 to 5 mm.; four examples). Cleared in clove oil, all these specimens showed more or less distinctly the position of the anus and its relation to the origins of the radial (and also, in the case of the oldest, of the rectal) cæca. One of the specimens was remarkable in having only eight rays.

(*b*) *S. papposa* (16 to 40 mm.; four examples). Clearing with clove oil gave a similar but less satisfactory result, the anus being now nearer the centre of the disc, and therefore more difficult to locate. Two of the specimens were large enough to allow the anus and the madreporite to be seen externally even before clearing was resorted to. One of the specimens had eleven rays and the others thirteen.

(3) *Dissection of Adult Specimens.*

The muscular bands which run in the middle line of each ray along the inner aspect of the aboral wall and meet in a knot at the centre of the disc form, perhaps, the most definite and satisfactory guides for locating the position of the anus. On careful dissection, it will be seen that the anus occupies a bay slightly to one side of the centre of the knot, the bay being formed by the divergence from the knot of the radiating muscular bands belonging to rays V. and VI. Two specimens of *Solaster endeca* (one with eight and the other with nine rays), and three specimens of *S. papposa* (with

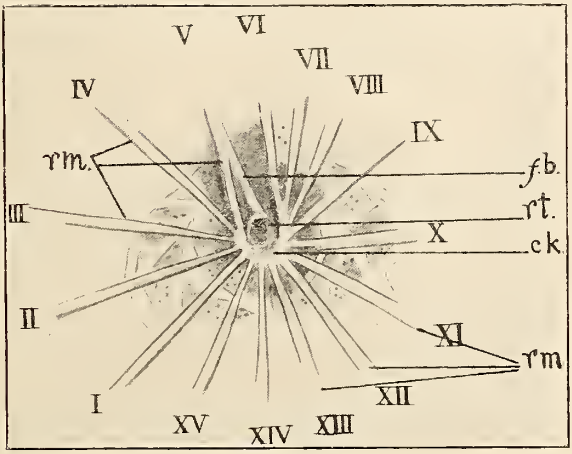

Fig. 6.

The central part of the aboral body wall of a large *S. papposa* seen from the deep aspect and illustrating position of anus.

c. k. . central knot of aboral musculature continued orally as a short band passing to the commencement of the rectum.
f. b. . fibrous band passing from commencement of rectum outwards to join radial muscle of ray V.
I., II., III., etc. the various mid-radial lines. The madreporic interradius is I., II.
r. m. . the aboral muscular bands of the various rays.
rt. . rectum.

ten, thirteen and fifteen rays respectively) showed this condition, which may accordingly be taken as the normal one for the Solasters no matter what may be the number of rays in the individual or in the species (see Fig. 6).

In an ordinary starfish the anus lies in interradius V./VI., according to the method of numbering previously indicated. In my paper on the development of *Solaster endeca* (8), I have shown that the sequence in appearance of the rays is such as to indicate that the Solasters have originated from a five-rayed form. The hydrocoele at an early stage forms an open crescent with five primary radial pouches. Then a sixth pouch is added on the sinistral side of V. After that a seventh is added to the sinistral side of VI., and so on till the full number is completed, the very latest being adjacent to ray I., and on the dextral side of the latter.

It will be seen, accordingly, that the anus in Solaster occupies the same relative position as in other starfish, *i.e.*, it comes after ray V., only here owing to the interposition of new rays, its actual interradius is not V./I. but V./VI.

The principle that a serial succession of parts is liable to variation (9) in the number of its components may help to explain the very great variability of both species (and particularly of *Solaster papposa* (10)) in the number of their arms.

3. The Egg Ducts and their Openings.

As is well known, in most starfish each gonad is provided with a single duct having a single opening on the surface, but in the genus *Asterias* it would seem that while the duct is single the number of external openings becomes multiplied (Ludwig in Bronn's *Klassen u. Ordnungen*, Bd. 2, Abth. 3, Buch. ii. p. 597).

In *Solaster papposa* (*Crossaster papposa*, Müll. u. Trosch.), according to Müller and Troschel (quoted from Ludwig, *loc. cit.* p. 59), the genital openings are also numerous and sieve-like. This was confirmed by Cuénot from the examination of a very large specimen (3, p. 623), though in his former work he had stated that the orifice was single. No account is given by the authors named of the condition of the genital ducts.

In the closely allied *Solaster endeca* (Forbes), it is difficult by macroscopic examination alone to determine with exactitude the number and relations of the egg ducts and their external openings. At the Millport Marine Station, specimens have been observed, by Mr Elmhirst the superintendent, in spawning to extrude as many as four ova at a time from a single interradius. This means that each gonad had at least two external openings. Recently, while working at the growth of the Solaster egg, I made serial sections of the middle portions of two interradii in a large adult, and have accordingly been able to study the points under discussion in the case of four gonads.

Of these four gonads three had two external openings, while the remaining one had three. The external openings formed slit-like pits, and each received the ends of two or three main ducts. Traced inwards these ducts after passing through the body wall divided into branches each of which came into relation with one of the small ultimate clusters of egg tubes (8).

It is conceivable that in the end eversion of the walls of the pit-like external opening might bring the outer extremities of the main egg ducts to the surface, and thus increase the number of external openings. The specimens examined were, however, so large and the ova so near maturity that such an occurrence seems very unlikely. It is much more probable that the condition above described holds good at full maturity and during the actual process of spawning.

In the case of *Solaster papposa,* I have only serial sections through the middle of one interradius, in an immature specimen measuring 3½ inches across the disc and arms. In this interradius there are two comparatively wide external openings each leading into a slit-like cavity. Four or five main ducts open into each of these cavities. Traced inwards the ducts have the same relations to the egg tubes as was described above. This observation on *Solaster papposa* need not be considered as contrary to those of the authors above quoted. The specimen I examined was immature; the single external opening possessed by each gonad was large and had loose walls, so that there was nothing to prevent eversion of these walls at full maturity with consequent multiplication of the external apertures. Indeed, in his first description, Cuénot also (3, p. 623, *note*), from the examination of a young specimen, was led to the conclusion that *Solaster papposa* had only a single external opening for each of the gonads.

4. Aboral Perihæmal Sinus (Fig. 7).

The same series of horizontal sections through part of a large adult *Solaster endeca,* which I used in studying the relations of the pore canals, enabled me also to follow out the aboral perihæmal sinus in the madreporic interradius, and to note what connections were formed by the hæmal tissue enclosed in this sinus, with the axial organ as well as with the genital hæmal strands and the two large hæmal tufts which pass inwards to the roof of the gastric cavity.

The points of chief interest brought out by this series are indicated on Fig. 7, which represents the parts as seen from the aboral aspect, the centre of the starfish disc being towards the lower side of the Fig.

First, in harmony with development and with the more recent teaching on the subject, comes the fact that the aboral perihæmal sinus is entirely shut

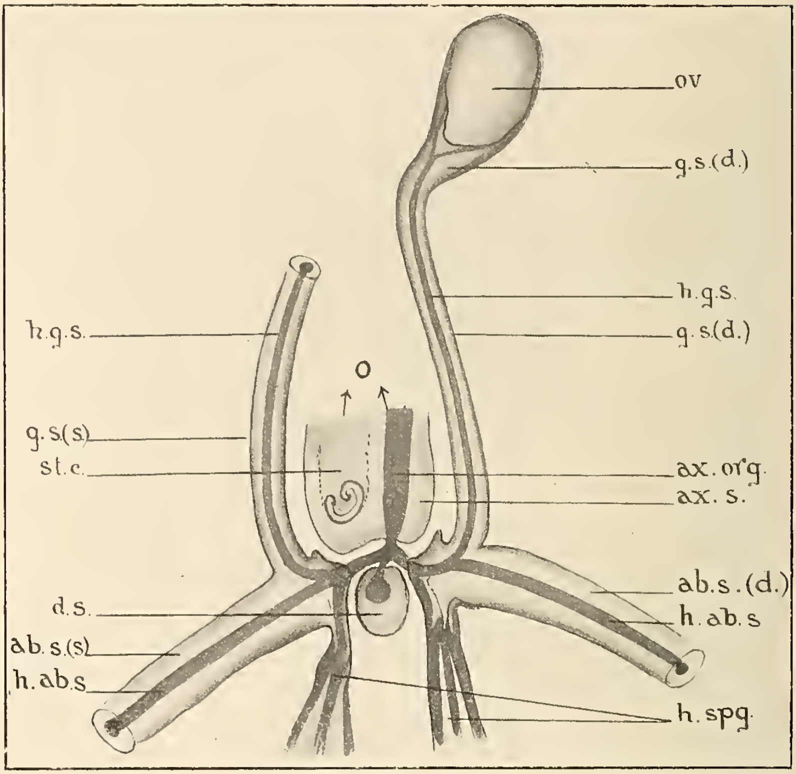

Fig. 7.

Diagram of the perihæmal sinuses and of the hæmal tissue in the madreporic region of a large adult Solaster. The view is from above and slightly from the outside, the centre of the starfish disc being towards the lower part of the page.

ab. s. (*d*) and *ab. s.* (*s*) dextral [1] and sinistral [1] limbs respectively of aboral perihæmal sinus.

ax. org. the axial organ lying vertically within the axial sinus, but for purposes of illustration here shown as if seen more from the outer side than are the rest of the structures. At O it is passing downwards towards the oral hæmal ring. At the aboral end it is continued into the tissue invaginating the dorsal sac.

ax. s. . axial sinus, wider than natural in the diagram, and like the axial organ continued at O on the oral direction. The stone canal with its characteristic internal fold is indicated to the sinistral side of the axial organ, but no attempt has been made to illustrate the relations of the aboral ends of stone canal and axial sinus. (For this see Figs. 1 to 5.)

d. s. . dorsal sac.

g. s. (*d*) and *g. s.* (*s*) dextral and sinistral genital sinuses.

h. abs. . hæmal tissue within the dextral and sinistral limbs respectively of the aboral perihæmal sinus.

h. spg. . dextral and sinistral epigastric hæmal tufts.

h. g. s. . hæmal tissue of genital sinuses.

ov. . ovary. *st. c.* . stone canal.

[1] See note at foot of page 174.

off from the axial sinus. Then, as a new and somewhat surprising circumstance, I find that the aboral sinus itself is not continued right across the madreporic interradius but suffers an interruption there, which I think I can hardly be mistaken in saying is quite complete. Two adjacent blind ends are thus produced. In reality their walls are in close apposition to one another below the dorsal sac, although in the figure, for purposes of illustration, they seem to be more widely separated. On the sinistral[1] side the blind end of the sinus is continued orally down the edge of the interbrachial septum for a considerable distance, running parallel with the axial sinus, but ultimately it becomes smaller and finally disappears before half the distance down the septum has been traversed.

Each of the blind ends is continued directly into a large genital branch (genital sinus). The two genital sinuses pass outwards on the aboral body wall one on each side of the interbrachial septum, and are continued on to the roots of the corresponding gonads, ending finally in spaces between the inner and the outer layers of the gonad walls (8).

There is no interruption to the lumen of the aboral perihæmal sinus in any of the other interradii.

The older teaching (Ludwig, 1, p. 617; Cuénot, 2, p. 591) was that the aboral perihæmal ring opened into the axial sinus. Cuénot, however, noted that in *Asterias glacialis* and *Astropecten aurantiacus* the communication was by a very small channel. Délage and Herouard (11, p. 57) leave the question open, though on functional grounds they incline to the view that a communication ought to exist between these cavities. Macbride has the merit of having first shown that developmentally in *Asterina* (6) the aboral ring and the axial sinus are unassociated with one another, and in the paper on *Asterina* to which a reference has just been given (as well as in vol. i. of the *Cambridge Natural History*), he has described them as being quite separate in the adult starfish.

However, an interruption of the aboral perihæmal sinus in the madreporic interradius does not seem to have been previously noted, and I cannot say at present whether it occurs in any other starfish or is peculiar to *Solaster endeca.* Developmentally in this species as compared with *Asterina,* the extension of the genital rachis and of the aboral perihæmal sinus seems to be much delayed, although both these structures originate in a similar manner and from corresponding regions of the cœlomic wall. Thus in a young Solaster five months after the completion of metamorphosis, the aboral perihæmal sinus was only traceable for a short distance on the sinistral side of

[1] See note at foot of page 174.

the axial sinus, while it had not yet made its appearance on the body wall to the dextral side of this sinus.

The hæmal tissue of the genital sinuses is directly continuous with that of the aboral sinus, and ends by spreading out in branches on the inner of the two layers of which the gonad walls are composed.

Of the two great gastric hæmal tufts one, as shown in Fig. 8, is connected with the hæmal tissue of the aboral sinus on the same side, and the other with the correspondingly situated hæmal tissue on the opposite side. The axial organ is continuous above with the tissue invaginating the dorsal sac, and at the sides with the hæmal tissue of the aboral sinus, and thus with the genital and gastric extensions. The lumen of the aboral sinus is continued for a short distance into the interior of the root of each of the gastric tufts, but particularly into that of the sinistral one.

5. An Interbrachial Branch of the External Oral Circular Sinus (Fig. 8).

While working at the later development of Solaster, I noted that in each interradius, from about the first month after metamorphosis onwards, there could be seen a slight widening of the external oral perihæmal cavity, and that this widening was traceable aborally into a short stem which became lost by dividing up into branches in the thickened connective tissue of the interradial body wall.

After verifying this condition in several specimens of similar age, I examined carefully some series which I had made of portions of a very large adult Solaster, and these enabled me to study the question in four interradii, one of which was the madreporic interradius. In all four I was able to follow out a slender but quite definite branch which, arising from the external oral perihæmal sinus, passes aborally between the ring canal of the hydrocœle and the odontophore, and gaining the inner side of the interbrachial septum continues for a short distance embedded in the connective tissues underneath the cœlomic lining. In the latter part of its course it gives off numerous slit-like branches and then it disappears, no cavity derived from it being traceable in my sections higher up than about a quarter of the whole height of the interbrachial septum.

A Polian vesicle is present in all the interradii examined, except in the madreporic one. It arises by a long slender stem in the mid-interradial line from the ring canal of the hydrocœle, and passes in an aboral direction at first through the tissues at the base of the interbrachial septum. The perihæmal branch just described lies close outside and parallel to this part

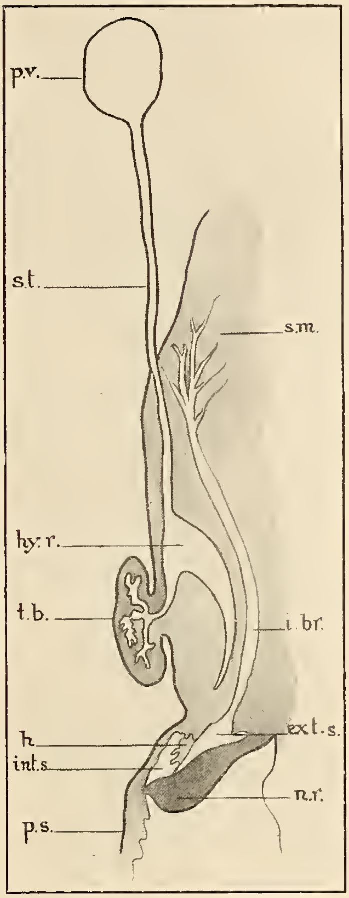

Fig. 8.

Vertical section in mid-interradial line of part of large *Solaster endeca*, to illustrate course and relations of the interbrachial branch of the external oral perihæmal ring.

ext. s. . external oral perihæmal sinus.
h. . the oral hæmal ring.
hy. r. . circular ring of the hydrocœle in cross section giving off the stalk of the Polian vesicle, and also here represented as giving off a branch to one of the Tiedemann's bodies (see p. 190).
i. br. . interbrachial branch of ext. or. perih. sinus, breaking up at *s.m.* into fine terminal divisions.
int. s. . internal oral perihæmal sinus.
n. r. . circular nerve ring.
ps. . peristome.
p. v. . Polian vesicle.
s. m. . terminal divisions of the interbrachial branch of the ext. or. perih. sinus.
st. . stalk of Polian vesicle.

of the stem of the Polian vesicle, and it breaks up into terminal divisions near the level where the stem of the vesicle leaves the interbrachial septum to become free in the body cavity. I was not able to trace any epithelium-lined twigs on to the stem of the Polian vesicle, although it seems to be generally agreed that branches of the radial and the marginal perihæmal canals are continued on to the walls of the sucker feet.

The foregoing relations are illustrated in Fig. 8, which shows also in section the internal circular sinus and the so-called hæmal vessel between them. It will be observed that the ring canal of the hydrocœle is somewhat expanded and prolonged downward in the figure. This only occurs in the middle of each interradius, and I am unable to suggest a reason for it.

Two Tiedemann's bodies are present in each ordinary interradius, arising from the ring canal by separate stalks. For purposes of illustration one of them has been slightly shifted so that its stalk of origin is represented in the figure, which otherwise shows only structures belonging to the mid-interradial line.

Only one Tiedemann's body is present in the madreporic interradius. It lies to the axial organ side of the stone canal, *i.e.*, the dextral or watch-hand side as viewed from the aboral aspect.

Although, as was stated above, there is no Polian vesicle in the madreporic interradius, the interbrachial perihæmal branch is here quite definite and ends in the same manner as in the other interradii. Finally, it is to be noted that all the interbrachial perihæmal branches are unaccompanied by hæmal tissue.

A branch of the external perihæmal sinus, similar in position to that just described, has been noted (1, p. 623) by Greef, Hoffmann, Ludwig and Cuénot, but the presence of this branch does not seem to be very generally recognised, and among the authors named there is wide divergence of opinion regarding its mode of termination. According to Greef it communicates with the aboral perihæmal ring, and according to Cuénot with the body cavity, while Ludwig states that it ends by breaking up into twigs and joining the system of definite lacunar channels, which he and others believe to exist between the inner and outer layers of the body wall. The reality of this system of spaces, as described, has been strongly questioned by Macbride and Cuénot. My own series do not show such spaces, but it should be stated that the methods I used, though suitable for ordinary purposes, could hardly have been expected to bring out lymphatic channels elsewhere, *e.g.*, in the tissues of vertebrates.

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(*Issued separately, 15th June* 1911.)

XX.—A New Flea (*Xenopsylla trispinis*) from South Africa. By James Waterston, B.D., B.Sc.

(Read 27th March 1911. Received 27th March 1911.)

This species belongs to the second section[1] of the genus, the characters of which are—the episternum of metathorax separated from the sternum; the subapical bristle at least as long as the second hind tarsal segment; hind femur angulate ventrally at the widest point; fifth segment of fore- and mid-tarsi with three spine-like bristles ventrally at apex; clasper with two distinct free processes; manubrium long; penis without brush near apex.

Evidently close to *X. cheopis*, Rothsch. and *X. nubicus*, Rothsch., but distinguished by the genitalia and tarsi.

Head—Rostrum reaching apex of forecoxa in ♀ but falling short in the ♂. Row[2] of 7 or 8 bristles on the occiput. First antennal joint in ♂ with row of about 10 minute hairs on outer edge and proximally one or two more. In ♀ these hairs number 6-7 with none behind. At apex of the joint (♀ only) is a single somewhat stronger hair. Above the antennal groove are 3-4 long hairs or bristles in addition to a few minute ones.

Thorax—

Prothorax with a row of 8-10 bristles.
Mesothorax „ „ 10-11 „
Metathorax „ „ 11-13 „

The mesosternite has four or five bristles on each side (one ♀ with 5 and trace of 6th).

The metasternum (*a*) episternite and sternite with one bristle each; (*b*) epimeron with 9-12 bristles in two rows, commonly 5, 5, or 5, 6; but one ♂ shows 2, 5, and one ♀ shows 8, 6. The posterior edge is slightly curved and the ventral angle obtuse (*c.f. cheopis*).

Abdomen—

Tergites—The first has two rows of bristles, containing about 8 each, in both sexes. The anterior row is irregular, especially in the ♂. The second to sixth inclusive have a single row of 18-19 bristles.

[1] "*Revision of Non-combed Eyed Siphonaptera*," Karl Jordan and N. C. Rothschild, vol. i., No. 1, *Parasitology*, 1908, p. 42.

[2] Counting both sides and so elsewhere, unless one side is specially mentioned.

The row on the seventh has generally one less than those of the preceding five tergites.

Sternites—The second in both sexes 2 ?-4 ?. ♂ sternites 3-7 with 8-11 bristles; eighth has about 20 bristles and hairs on each side. ♀ sternites 3-6 have 16-17 bristles; one example with 19 on st. 5. 7th sternite with 16 bristles and about 20 smaller bristles or hairs in all behind. Antepygidial bristle longer than second hind tarsal segment—in ♂ in proportion 5 : 4, in ♀ 3 : 2.

LEGS—Forecoxa, 17-20 bristles on outer surface and edges inclusive. Hind coxæ, with 5-7 teeth on inner surface near apex. Fore femur, 1-2 outside bristles in ♂, 2-4 in ♀. Hind femur, outside 2 (in one ♀ 3) bristles, subapical and ventral; inside row 7-8.

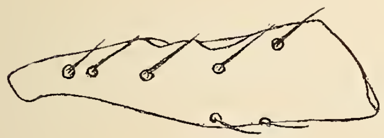


FIG. 1.
Hind tibia, ♀, outer side. The heavy marginal spines are not shown.

FIG. 2.
5th joint, hind tarsus, ventral aspect.

Hind tibia, with row of 5 bristles on outside, dorsally placed, but below the edge and without intermediate bristles. A single bristle below this row, well above the ventral edge in the ♂, practically on it in the ♀, in which sex sometimes 2 bristles occur in this position (see Fig. 1.) Longest apical bristle of the second hind tarsal segment reaches to beyond middle of the fifth ; in one ♂ to base of claw. *All the fifth tarsal joints in both sexes with three subapical ventral spines, of which the middle one is longest.* On each side of the same joint, in all the tarsi, there are 4 stout bristles or spines in a row. Two are near the base, and after an interval, two more occur (see Fig. 2). Behind the central and longest subapical spine on the ventral surface of the fifth tarsal joint there is, in the case of the hind tarsus, one minute hair. More than one occur on same joint in fore- and mid- tarsi.

FIG. 3.

Genitalia ♂. The penis is not drawn.

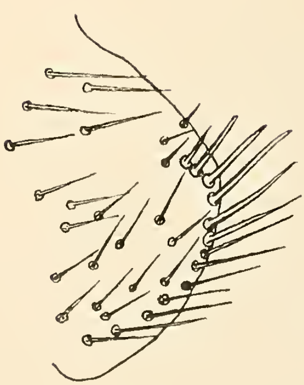


FIG. 4.

8th tergite ♀. All the lateral hairs not shown.[1]

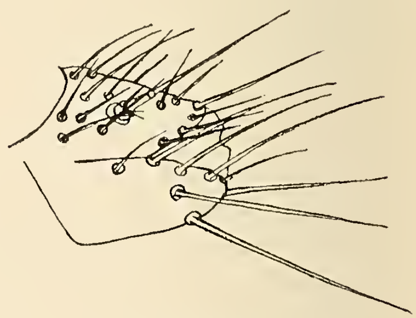


FIG. 5.

10th segment ♀.

FIG. 6.

Receptaculum seminis. The median dark coloured area is outlined only.

[1] All the drawings are from the slide.

Modified Segments—

♂ (see Fig. 3)—manubrium long. The first process of the clasper long, with sub-parallel sides and numerous short hairs. Second process short, broader distally than proximally, with 9-10 bristles disposed mainly on the edges: 2 or 3 at the apical edge, longer, stouter and slightly curved. The 9th sternite is broad in the basal portion, which is angled dorsally and ventrally. It is contracted where it issues from the 8th sternite, and roundly curved for the remainder of its course with numerous ventral hairs throughout. In both ♂♂ there is a curious thickened projection of darker chitin into the clear membranous region of the sternite.

♀ (see Figs. 4, 5, and 6)—The 8th tergite bears along the apical edge a row of some 13 spines or bristles. About half of these occur near the edge ventrally; the remainder, set in a line which curves back somewhat from the edge of the tergite, are remarkably stout. Besides these, each side of the tergite bears about 30 scattered bristles, mainly on the ventral aspect (see Fig. 4). The 10th segment is very bristly (see Fig. 5). The stylet with one long terminal bristle and two minute ones near the base

Length.—♂, 1·8–1·9 mm. ♀, 2·4–2·7 mm.

2 ♂♂ and 12 ♀♀ of this species have been received from the Rev. Robert Godfrey, M.A., Pirie, King William's Town, South Africa. These specimens were taken from nests of the cliff swallow (*Petrochelidon spilodera*), also from the birds themselves, and on the walls of a building at Emgwali, Döhne, Cape Colony, where the swallow nested (30 : xii : 09).

The occurrence of a species of *Xenopsylla* on a bird is noteworthy, and the present instance hardly looks as if it were accidental. *X. conformis*, Wagn., was described from a pair of insects taken "off a small species of owl," from Sultan Bent, River Mourgab, Transcaspia (*Revision Non-combed Eyed Siphonaptera*, Jordan and Rothschild, pp. 63, 64).

My best thanks are due to the Hon. N. Charles Rothschild, M.A., for his courtesy in examining some of the above specimens and confirming them as a new species.

(*Issued separately*, 14*th June* 1911.)

XXI.—Notes on the recent Immigration of Mealy Redpolls (*Acanthis linaria*), including the form known as Holböll's Redpoll. By William Evans, F.R.S.E., M.B.O.U.

(Read 23rd January 1911. Received 31st March 1911.)

The Mealy Redpoll is an irregular autumn and winter visitor to the British Isles, the numbers varying from very few, or none at all in some years, to vast immigrations in others. Immigrations on a large scale are stated to have occurred in the years 1820 or there about, 1829, 1847, 1855, 1861, 1863, 1873, 1885, and 1897; and now we have to add 1910. So far as the records show, it would appear that the "invasion" of 1910 has had few equals, if, indeed, it has not surpassed all others in magnitude, at any rate in Scotland. At various points along the east coast from Shetland to the Forth, the birds were observed in marked abundance, and in England large numbers are recorded from the coasts of Yorkshire, Norfolk, and Kent.[1] The number that came into the Forth Area was quite phenomenal. Heralded by a few at the Isle of May in the middle of October,[2] the first of the large flocks appears to have arrived here about a week later, followed by a stream of others during the remainder of the month and the first week of November. The movement, however, was probably at its height in this district during the closing days of October.

Some idea of the progress of the immigration may be gathered from the following data:—

In Unst, the northernmost of the Shetlands, a few Mealy Redpolls were noticed by Dr T. E. Saxby on October 17th, and on the 22nd he noted them as "fairly abundant" (*in litt.* 17th Jan. 1911). At Ollaberry, however, in the main island, the Rev. James Waterston tells me he had two brought to him on or about October 9th, prior to which some had been seen by the man who shot these, and that between then and the end of the month flocks of considerable size were observed moving about the district. From Mr Eagle Clarke I learn that they appeared in large numbers on Fair Isle, which lies considerably to the south of Shetland proper, during the second half of October, as indicated in his notes in the *Annals of Scottish Natural History* for the present month. They were also observed in the Orkneys, and about Elgin.

In the neighbourhood of Aberdeen, where I hear large numbers were

[1] *British Birds*, January 1911, p. 254.

[2] *Ann. Scot. Nat. Hist.*, January 1911, p. 4.

captured by the local bird-catchers, Mr L. N. G. Ramsay informs me (*in litt.* 13. 1. 1911) that on October 21st he saw a flock of fifteen to twenty on Old Aberdeen links; on the 23rd, three small parties, and on the 30th, several larger ones.

Correspondents in Montrose inform me of their presence around there in abundance during October—nothing like it since 1863. They speak of flocks of fifty up to hundreds about the links, etc., and state that they were first seen about the end of September, and entirely disappeared by the middle of November; but exact dates are not now obtainable. Many were captured.

Reports from St Andrews show them to have been plentiful in October in that district also. On the 28th, Misses Baxter and Rintoul met with a flock of about fifty at Carvenom. But prior to that Miss Baxter had seen them on the south coast of Fife, viz., one near Largo on October 22nd, and four between Fifeness and Crail on the 24th (*in litt.* 19th and 21st Jan.).

On the Isle of May, at the mouth of the Firth of Forth, two Mealy Redpolls were seen on October 14th, and one on the 16th, by Misses Baxter and Rintoul, as recorded in this month's *Annals of Scottish Natural History.* On two or three occasions, from about the 22nd of October till the beginning of November, numbers were present on the island—they are reported as particularly plentiful on October 31st, on which day there were also many on the Bass Rock (*fide* J. M. Campbell).

This brings us to the Lothians on the south side of the Firth of Forth, where they made their appearance in unprecedented numbers, and were taken in hundreds by the bird-catchers at many points along their lines of flight. Although it has been impossible to obtain precise evidence of their movements from place to place, the inquiries I have made in various quarters, go to show that a large proportion of the arrivals occurred on that part of the coast lying between North Berwick and Longniddry, the general trend of their course being then in a westerly or south-westerly direction, the flocks passing on after longer or shorter halts from one suitable feeding ground to another. While many adhered to the coast-line, proceeding almost due west past Musselburgh, Edinburgh (north side), Bo'ness, etc., others took south-westerly or inland courses, following roughly the valleys of the Tyne, the two Esks, Eddleston Water, the Water of Leith, and so on; but records from the south and west of Edinburgh are scanty. Nor were they much in evidence to the south-east of North Berwick, that is round by Dunbar, etc.; from which it would appear that few turned in that direction, or came in on that part of the coast. Indeed, my only definite records from there are:—A party of six or seven near Tantallon Castle about the end of October, two (ad. ♂ shot) at Scoughall, two got at Barnsness, south of Dunbar, on 24th and 25th October and several (one obtained) at Skateraw, on the 29th. Inland to the south, five were seen by Mr T. G. Laidlaw, near Abbey St Bathans on 18th December (*in litt.* 13th Jan.).

Returning to North Berwick, several parties of a dozen to a score or so were, eye-witnesses tell me, observed one day at the end of October or beginning of November coming in from the sea; some of them alighted for a brief rest on the railing of the jetty at the harbour before passing on in a westerly direction. A good many were seen and some caught about Dirleton, while on the seaward part of Archerfield grounds, as many as 200 to 300 congregated for three or four days, from 29th October. West of this, where the bird-catchers made terrible inroads on their numbers, my notes record their occurrence at the following localities:—Near Aberlady, Longniddry (several flocks, one of about thirty birds on 27th Oct.), Prestonpans and Musselburgh district (22nd Oct., a few; 23rd, 24th, etc., many), about Tranent (in great numbers), Ormiston on the Tyne (early in Nov.), Joppa, Liberton, Gilmerton, Blackford and Braid Hills, Hillend at the eastern termination of the Pentlands (on several dates in Nov.; flocks of as many as thirty and seventy seen), near Gladhouse, Peebles (large flock seen early in Nov., some caught), West Linton (reports of Redpolls about here in Nov. probably refer mainly to this species), Leith Docks (small parties 3rd and 4th Nov.), Granton and Cramond (hundreds passing on 3rd Nov.), Craiglockhart, Canal banks at Hailes quarry where two were seen by Mr A. Craig on 26th December (*in litt.* 6th Jan.), North Queensferry and Bo'ness, where scores were taken in November. The earliest date I am able to cite for the Lothians is Saturday, 22nd October, on which day five Mealy Redpolls, caught that morning in the neighbourhood of Musselburgh, were brought to Mr Dewar, bird-dealer, Edinburgh. On the following Monday hundreds were brought into the city, and so great was the supply during the next few days that the catchers were soon glad to accept as little as twopence or even a penny a piece for them, while for a time the dealers were obliged to refuse them at any price. Fresh captures continued to come in plentifully till about the middle of November when they rapidly fell off, and by the end of the month had ceased entirely. A single bird seen by the side of Braid Burn on 18th January is the latest of which I have a definite record. From what I saw and otherwise learned, I am satisfied that altogether the number of Redpolls—of which the great majority, probably not less than eighty to ninety per cent., were Mealies—brought into Edinburgh during the two or three weeks the birds were in the neighbourhood cannot have been less than 2000. Two dealers had each about 400 Mealies through their hands, while a third had close on 300. On one occasion I counted forty-eight in one cage. From Edinburgh many of the birds were passed on to the English markets (Manchester, Birmingham, London, etc.).

Of the movements of those that managed to evade the bird-catchers of this side of Scotland very little seems to be known. Their presence, however, in the counties of Lanark, Renfrew, and Ayr, on 30th October (at Possil Marsh) and during November, is recorded by Mr R. W. S. Wilson in *The Glasgow Naturalist*;[1] and there is also a record from Skye, by Mr H. F. Witherby, in this month's number of *British Birds*.[2] Whether a return movement will manifest itself in the spring remains to be seen.

Rough banks and waste ground, such as one meets with along the sea-braes and in the precincts of old quarries, were the chief resorts of the immigrants in this district, where they fed eagerly on the seeds of the knapweed, or "hardheads" (*Centaurea nigra*), nettle, thistle, etc. Those I myself observed in East Lothian were flitting about clumps of nettle, willow-herb, meadow-sweet, and knapweed; and on the waste ground at the east end of Leith Docks I watched several feeding along with a few siskins on a hawkweed (*Hieracium umbellatum*, var.), which grows there in profusion. At Montrose, I am told, they left the links after a time and moved inland, then feeding on the birches as well as on herbaceous plants.

As regards former irruptions of Mealy Redpolls, it is interesting to recall that one in 1855 was the subject of a communication by the late Dr J. A. Smith to this Society, at its meeting on December 26th of that year. He mentioned, as we learn from the *Proceedings* (vol. i. p. 52), that during the months of November and December several flocks of the Mealy Redpoll had been observed in the neighbourhood of Edinburgh, and numbers taken by the bird-catchers. The birds were larger than the Lesser Redpoll, none of which had been taken along with them; they had not been found in such abundance in the neighbourhood for many years. Specimens were exhibited. Writing in 1871 ("Birds of the West of Scotland," p. 148), Gray mentions the winter of 1863-64 as one in which this species was comparatively common—he had seen specimens that were captured near Forfar, and numbers were taken by the bird-catchers even in the neighbourhood of Glasgow. References to other Mealy Redpoll years will be found in the works of Gould, Yarrell, Dresser, etc. My own notes bear witness to their presence in this district in substantial numbers towards the end of the years 1885 and 1897. Some idea of the magnitude of the 1847 movement may be gathered from Gätke's account of what occurred at Heligoland, as narrated in his highly interesting book on the Ornithology of that island.[3]

[1] Vol. iii. p. 34; see also p. 48 as to a mixed flock on 2nd January.

[2] Vol. iv. p. 255. A record from Mull has since appeared in *Ann. S.N.H.*, 1911, p. 114.

[3] "Birds of Heligoland," English edition, 1895, p. 392.

"The most astonishing migration *en masse*", he there writes, "of this species which I have ever witnessed took place in the autumn of 1847. This migration, I believe, extended over the whole of Germany. It commenced here on the 13th of October with from twenty to thirty examples, its numbers increasing daily until, from the 26th of October until the 3rd of November, they are recorded as hundreds daily in my diary; on the 4th and 5th November, 'countless flocks' and 'innumerable multitudes' are noted; on the 6th, 'fewer than on previous day.' About a hundred each day occurred until the middle of the month, after which time solitary individuals and smaller companies continued to be seen until the middle of February of the following year. On the two principal days above mentioned, the whole island was literally covered with these birds, so that one might have thrown a stone in any direction one chose, and it was sure to hit birds as long as it continued rolling along the ground."

The Mealy Redpoll is a characteristic bird of the birch woods of the northern regions of both hemispheres. In Europe it is a native of Scandinavia and Northern Russia, breeding from about the latitude of Christiania to the extreme limit of the birch growth, and in the main wintering, one gathers, within these bounds. From Professor Collett's "Bird-Life in Arctic Norway,"[1] for instance, we learn that as far north as Tromsö, where it is particularly numerous in the summer-time, some are to be met with in the birch woods during winter also; while according to Wheelwright many winter in Lapland.[2] To what the large-scale migrations that from time to time take place are due, I am not prepared to say. Exceptional climatic conditions, failure of food-supply, abnormal increase in the number of the birds owing to favourable breeding seasons, are probable causes that naturally occur to one; but, so far as I know, there are no data by which to test the matter.

On looking at the cagefuls of Mealy Redpolls in the dealers' shops at the time of the recent invasion, one could not help noticing how much they varied in size. Some were scarcely larger than Lesser Redpolls (*A. rufescens*), of which a considerable number had also been taken, while others were as large as Linnets; and between these extremes every gradation could be observed. In view of the wealth of racial forms into which the Redpolls have been divided by experts, I was on the outlook for examples differing from the type, light-coloured birds with white unstreaked rump and under tail-coverts—the Greenland Redpoll (*Acanthis hornemanni*) and the Hoary or Coues's Redpoll (*A. h. exilipes*)—being especially in my mind.[3] Apart from the rose-pink on the breasts of many of the males, the only difference

[1] English edition, 1894, p. 13.

[2] "A Spring and Summer in Lapland," 1871, p. 299; see also p. 10.

[3] *Exilipes* occurred at Fair Isle (Eagle Clarke, *A.S.N.H.*, January 1911, p. 53); and I am told one was caught at Montrose, but so far no proof has been produced. Another is supposed to have been taken in Norfolk (*cf. Cage Birds* of 11th March 1911).

however, I could see among the birds I examined was one of size, which led me to surmise that the larger examples might be what is known as Holböll's Redpoll (*A. l. holboelli*). Bill and wing measurements of a few bore this out, and a specimen I obtained on the sea-braes at Skateraw, near Dunbar, on 29th October is, Dr Hartert considers, correctly referred to this form. Others—some of them still larger examples—were noted from Prestonpans, Tranent, Musselburgh, Leith Docks, Bo'ness, etc.; and it is recorded from Fair Isle, Shetland (W. E. Clarke, *Ann. Scot. Nat. Hist.*, Jan. 1911, p. 53)[1], and the Isle of May (Misses Baxter and Rintoul, *ibid.*, p. 4). But after examining more or less closely several hundreds of the recent immigrant Redpolls, I am not impressed with the claims of *holboelli* to rank even as a subspecies. No clear line of separation between it and typical *linaria* exists so far as I can see. Ridgway and Hartert, the two most recent authorities on the subject, give the following definitions of it. The former's is, "Exactly like *A. l. linaria* in coloration, but averaging decidedly larger, especially the bill, the latter usually relatively longer" ("Birds of North and Middle America," part 1., 1901, p. 89); the latter's, "Ganz wie *A. f. flammea* [= *A. l. linaria*] aber grösser, der Flügel länger, Schnabel stärker und meist merklich länger. Flügel 75–81½, Schnabel 9–11 mm." ("Die Vögel der paläarktischen Fauna," Heft I., 1903, p. 79).[2] For *A. l. linaria* the wing and bill measurements given by Hartert are 74–78, and 8 mm. respectively, the latter being, no doubt, the *average*, though not so stated. Ridgway's data, derived from the examination of twenty-seven specimens of *holboelli*, and eighty of *linaria*, and published in some detail, give a range of 69–77½, and 9–10½ mm. for wing and bill, respectively, in the case of the former, as against 70–76½, and 7½–9½ mm. in the latter, which represents a considerable amount of overlapping, a point my own observations abundantly confirm. In assigning his specimens to the one form or the other, the "locality," I presume, was the guiding principle. But even this test, as we shall see, does not appear to be free from objection. In any case, it is not available for the separation of our visitors, as regards which size alone has to be relied on.

The following measurements—taken by myself—of birds captured in the Lothians will serve to show the extent to which variation in this respect occurred among the recent immigrants:—74, 7½ (♀); 69, 8 (juv.?); 73½, 8 (ad. ♂); 75, 8; 73, 8½ (♀); 74½, 8½ (74–75 m.m. wings in combination with 8–9 mm. bills were frequent); 75, 8½; 72, 9 (♀); 74, 9; 75, 9 (♂); 75, 9½ (♂); 75, 10 (♀); 76, 10 (♂, juv.?); 78½, 10; 77, 10½ (ad. ♂); 80, 11 (ad.

[1] It has since been recorded from the mainland of Shetland—near Lerwick, on 28th October (J. S. Tulloch, *A.S.N.H.*, April 1911, p. 115).

[2] See Heft VI. 1910, p. xviii, as to the substitution of the name *linaria* for *flammea*.

♂). The last was a remarkably fine, pink-breasted bird from the neighbourhood of Musselburgh. A large bill, it will be seen, was not always accompanied by a proportionately longer wing, and *vice versa;* in which connection it has to be remembered, of course, that the annual moult takes place in the autumn, so that probably all of the visitors were not in possession of full-grown primaries when they reached us.

On the basis of Hartert's minimum combination—*i.e.*, wing 75 mm., and bill 9 mm.—for *holboclli*, I estimate that from a fourth to a third of the birds brought into Edinburgh would be referable to it; and even 10 mm.-billed examples were by no means rare. As already indicated, however, I find it hard, after what I have seen, to believe that they are anything more than large individuals of *linaria.* Could it have been shown that the larger (on the average) birds occupied distinct breeding-grounds from the smaller ones, a strong case for their separation as geographical races would, no doubt, have been made out; but at best, such isolation appears only partially to obtain. According to Hartert (*op. cit.*) *A. l. holboelli* inhabits the extreme north of the Old and New Worlds, as a rule north of *A. l. linaria*, in colonies here and there[1]; and realising that intermediates between the two do appear to occur, and also that the two sometimes nest in the same locality, he is prompted to ask whether *holboelli* should not therefore be considered a species instead of a subspecies. To most ornithologists this will not, I imagine, appeal as a satisfactory way out of the difficulty. To my mind the facts, so far as they are at present known, seem rather to point to the existence of a single species exhibiting much individual variation in the matter of size. How this variation is to be accounted for I do not pretend to say. Naturally one wonders if a difference in food has anything to do with it, and such an explanation has, indeed, been put forward. Sundevall adopted the name *Fringilla linaria alnorum* for the long-beaked birds, believing them to be partial to the seeds of the alder, and *F. l. betularum* for the short-billed ones from their partiality for the seeds of the birch; while Wolley alleged that the bills were shorter in winter than in summer owing to a change from softer to hard food.[2] My observations on caged Redpolls make me doubt if there is much in Wolley's view; but the subject needs fuller investigation.

Whatever view we may take of the status of Holböll's Redpoll, we may be sure this is not the first occasion on which it has occurred in Scotland. The

[1] In the February 1911 No. of *British Birds* (p. 292), Mr H. F. Witherby states that in Russian Lapland in 1899 he "found both forms with nests on the same breeding-grounds, and shot both forms out of the same little family-parties."

[2] *Cf.* Yarrell's "Brit. Birds," 4th ed., vol. ii. p. 139.

Mealy Redpoll in Sir Wm. Jardine's collection, figured by Selby in 1825,[1] was clearly one—as represented in the life-size figure it must have had a bill of 9–9½ mm. and a wing of not less than 76 mm. [but see footnote][2]; and it was shot near Edinburgh (see Jardine's "Birds of Gt. Brit. & Irel.," pt. ii., 1839, p. 291). The Bathgate specimen described by MacGillivray[3] was probably also a *holboelli*, being apparently a still longer billed (10½ mm.), though shorter winged (72 mm.) bird.

The statement, made above, that apart from the pink on the breasts of the old males, the only difference observable among last year's invaders was in their size, requires some slight qualification. As a matter of fact, a large proportion of them were distinctly browner in tint than one connects with the name Mealy Redpoll. These I regard as the birds of the year, and sexed specimens showed that they comprised both males and females. The greyer, pink-breasted birds, or fully adult males, would not exceed, I should say, a fifth of the whole, and allowing for a like number of adult females, we get roughly three-fifths as the proportion of young birds. I assume that these young non-pink-breasted males would breed in that plumage when about a year old, and it may even be that some of them still lack the pink breast in their second breeding season.

From the foregoing notes and remarks it will be evident that there is still much to learn regarding the Mealy Redpoll; it would, in fact, form an excellent subject for a study in bird bionomics.

[Specimens of Mealy, Holböll's, and Lesser Redpolls, all from the Lothians, and of the Hoary Redpoll from North-east Russia, were exhibited.]

[1] "Illust. Brit. Ornithology," part i., 1st ed. (1825), p. 280, footnote, and pl. 53* fig. 2.

[2] Since the above was written, I have ascertained from Mr W. Eagle Clarke that this specimen, which formed part of the Jardine collection, is still preserved in the Royal Scottish Museum, and is undoubtedly a Holböll's Redpoll, having a wing measurement of 78 mm., and a bill of 9 mm. with a depth at base of 6½ mm.

[3] "Hist. Brit. Birds," vol. i. p. 388.

(*Issued separately, 30th May* 1911.)

XXII.—The Possibilities of Bird-Marking, with special reference to the Aberdeen University Bird-Migration Inquiry. By A. Landsborough Thomson, M.A., M.B.O.U.

(Read 27th March 1911. Received 19th April 1911.)

I. General.

In this paper I propose to describe in outline the methods of bird-marking, and to indicate the possibilities of that line of study: to that I shall add an enumeration of the various bird-marking schemes that have been set on foot, a number of examples of striking results achieved by these, and, finally, a few notes on the work, plans and prospects of the Aberdeen University Bird-Migration Inquiry.

In its essentials the method consists in marking a large number of birds in some way or other, for the sake of the data afforded by the subsequent reappearance of a small proportion of these. The principle is identical with that of the well-known method of marking fishes as a means of studying their movements and life-histories. Various kinds of marks have been tried or suggested in the case of birds: parchment tied under the tail with silk, thin metal discs glued to the tail feathers, and indelible stamps on the tail feathers. But all these, besides being clumsy, have the great disadvantage of lasting only until the next moult. For both convenience and permanence, marks on the feet are obviously the best. In early, isolated attempts at marking, such crude means as brass wire or silk thread twisted round the bird's foot were used; but in order to allow of an inscription, a broad metal ring is necessary. As combining extreme lightness with a considerable degree of durability, aluminium is to be preferred, and all the more because it is easily worked and stamped.

Complete rings, such as are used for homing pigeons, are of little use for marking wild birds, as they can only be placed on very young birds in any case, and not even then in the case of birds with nidifugous young,

these having well-developed feet by the time they are hatched. Furthermore, such rings are expensive, as they are cut from aluminium tubing instead of from sheet aluminium, and have to be stamped when in circular shape instead of on the flat. Hence the superiority in every way of the "split ring," which is a band stamped from the sheet, and then folded into a circle. The edges are merely pressed together, and such a ring, if of small diameter, will keep its shape without difficulty. Rings of larger size must either be of fairly thick metal to do this, or must have a clasp of some sort. A very simple pattern is that used at Rossitten, the headquarters of German bird-marking. In it the band is longer, and is not all used in forming the circle; two unequal ends are left to project outwards side by side at the meeting place, the longer being afterwards folded over the shorter, and so forming a clasp which, especially if subjected to pressure with a pair of pliers, will effectually prevent the ring from coming off. It may be mentioned that for Moorhens, Divers, and other water birds, the rings require to be bent into oval shape to fit the much compressed metatarsus. It need hardly be said that the rings do not hurt or even inconvenience the birds in any way.

Birds may be procured for marking in two ways. Either they may be marked as young birds still unable to fly, or they may, when older, be trapped by any non-hurtful means, marked, and released. Notification of their subsequent death or re-capture depends on the address which is stamped on the ring. Some have been content with mere initials, but this is very wasteful—it is obvious that it must greatly reduce the number of "returns," and practically exclude the possibility of records from any great distance. Many rings with various insufficient addresses have been found on birds but never traced to their origin, although widely advertised in ornithological periodicals. And, in any event, there is no great difficulty in stamping a short address even on the smallest rings. In addition to the address, each ring bears an identification number, different, of course, in each case. This number is the key to the whole method. Some have used mere year marks (the year in figures, or some arbitrary sign), but this is only possible where the marking is confined to a single locality and a single species, and if the birds are all marked as young. Thus, to take an actual case, if the rings bearing a certain address are being used solely for young Woodcock on a single estate, a year mark is sufficient. But where the histories of the birds marked differ from each other, separate identification is necessary. Species is not a reliable factor for this purpose, in that marked birds are often reported by quite ignorant persons. It is thus quite essential that the number on the ring should be all that the marker requires to determine the species and history of any marked bird of his that is reported to him. It may be remarked that the number is sometimes stamped on the inner surface of the ring, and only the address on the outer: more often the whole inscription is outside. The rings soon lose their brightness, especially in the case of water birds, and are not usually visible on the birds except with a strong field-glass and under favourable conditions. Marking birds is thus in no way an encouragement to the slaughter of our wild birds: the proportion of ringed birds to the whole bird population will always, however energetic we are, remain so small that any shooting of birds for the sake of chance ringed examples would be ridiculous. It is also worthy of note, that a very large proportion of marked birds are reported as found dead, found injured, or as captured and released.

Turning now to the all-important question of the value of such results as may be obtained by bird-marking, we find that the method differs from other methods in that it approaches the problems from the individual aspect—it begins with individual birds, working from them to general movements. A marking record implies that there are two or more moments in the life of a particular bird when one is able to state with certainty its whereabouts and various other facts. When a large number of such records have been collected and correlated, we have an array of general facts which could not possibly be ascertained by other means.

But to estimate the value of such facts we must for a moment consider the nature of the problems before us, if I may recall a few well-known points. Perhaps the greatest and most difficult problem of migration is that of its origin—its ultimate cause. To a considerable extent, we are sure of the purposes served by migration, its *raison d'être:* and we are perhaps well on the road to an understanding of the immediate factors which stimulate the migrational habit into being with the recurrence of the seasons; but the question of the origin of the habit still lies completely within the realms of conflicting theory. A matter of theory and hypothesis it must doubtless ever remain; but we may at least put our theories to the test of facts, and eliminate those that are found wanting. And, in the meantime, we must seek the facts.

One thing is obvious, and that is that migration is a far too complex and also a far too regular phenomenon to be created anew each season, merely under stress of circumstances; moreover, we know that migration begins before the need is in the least pressing. The more or less indefinite wanderings of some sea-fowl, or the irregular dispersals of some other birds, may be attributed to immediate causes, but a deeper seated origin there obviously must be for the highly developed migrational habit of some of our more typical travellers.

A little consideration will show how our theorising regarding this origin is rendered futile for lack of a certain kind of facts. For instance, we have the perhaps rather far-fetched theory that the migrational habit was established by some great meteorological change in the far past—say, for instance, by a Glacial Epoch (as has been suggested) which drove the birds resident in northern latitudes towards the Equator, and made them form there a second home to which they annually returned after the cessation of the conditions referred to had allowed them to recolonise their original more northerly area, the routes followed by the individuals remaining those followed by the species at the time of this supposed first great movement. Then we have the more recent theory (*cf.* Pycraft, *History of Birds*, 1910, pp. 100-105) that the migrational habit arose from the gradual northward spread of the species from its supposed original southern area in search of fresh feeding and breeding grounds, the birds withdrawing to this original area each winter. Without discussing these theories, let us note how their proof or disproof would necessarily rest on a knowledge of the facts concerning the relation of particular summer-quarters to the corresponding winter-quarters, and of the routes connecting them. Thus it is often suggested that the members of a species "summering" farthest north winter farthest south, and that those midway are more or less stationary: but the observer only sees a general southward movement, and we must single out typical individuals for study before we can answer the question—that is to say, we must mark them. Again, we have several cases of species which are found all the year round in the British Isles, but yet are known in autumn both as immigrants from the north and as emigrants to the south (and *vice versa* in spring). Now, except by marking, we may not be able to say whether it is our own summer birds that emigrate, leaving the newcomers to occupy the area for the winter, or whether our own birds are resident, the immigrants passing on over their heads and journeying farther southwards. And until we know this, we know very little of the true nature of migration.

Here are some of the questions which may be answered in due course by students who follow the marking method, and most of these questions have an important bearing on one or other unsolved problem of bird-migration:—To what extent do birds return to their birthplaces to breed, and under what circumstances are new areas colonised? Do birds have definite winter-quarters, and if so, do they seek them year after year? Do young birds seek the same winter-quarters as their parents? Do birds of the same summer area (and same species) seek the same winter area? What relation do the winter-quarters of the northerly-breeding members of a species bear to those of the southerly-breeding members? Do migrants travel by definite routes, and if so, what is the nature of these routes? And these questions might be multiplied indefinitely.

While urging the importance of bird-marking, we must remember that it is only supplementary to other methods, and must not be practised to their exclusion. But the marking method has at present a special importance, due to the fact that much progress has been made on other sides of the question, and it is now essential that this part of the work should be brought into line.

In passing, let us notice that bird-marking may incidentally serve other ends than those connected with migration. There are various kindred points connected with distribution, for instance. And interesting statistics of mortality rates are sometimes afforded. Furthermore, it might be a valuable aid to the study of plumage sequences to acquire a collection of birds of exactly known ages,[1] which had lived entirely free and natural lives.

II. Historical.

The device of marking birds in some way was not infrequently resorted to, in isolated cases and for special purposes, by naturalists of earlier days, and one often comes across stray records of considerable interest. But, so far as I am aware, it was not until 1890 that the first systematic scheme was set on foot. In that and many subsequent summers, numbers of young Woodcock were marked on the Duke of Northumberland's estate at Alnwick (Northumberland). The rings were inscribed with an "N," and the date (year).

In 1899, Mr H. Chr. C. Mortensen, of Viborg, Denmark, initiated a more ambitious inquiry. Storks, Teal, Starlings, and various Birds-of-Prey are among those which he has studied by this method. Mr Mortensen, I think, may be fairly regarded as the pioneer of scientific bird-marking, inasmuch as his inquiry was the first to be set on foot which was thoroughly comprehensive in scope and exact in methods: the use of identification numbers instead of mere year figures was an important innovation which opened up many fresh possibilities, although, at the same time, involving much more labour in the way of record keeping.

In 1903 Dr Thienemann, director of the German Ornithological Society's station at Rossitten, on the Baltic coast, started an important inquiry, which at present holds first place so far as results are concerned.

In 1908, the method was adopted by the Hungarian (State) Ornithological Central-bureau. Smaller schemes have also been set on foot in various other parts of the Continent.

Also in 1908, the method was taken up in the United States, where, however, it was not previously altogether unknown, and in the following year an "American Bird Banding Association" was constituted. The rings issued by them bear the inscription—"Notify *The Auk*, New York," and a number.

[1] *I.e.*, if marked as young.

Meanwhile some progress had been made in this country. Several years ago Mr Richard Tomlinson began marking Starlings at Musselburgh, near Edinburgh. In 1904, Mr J. H. Gurney marked a number of young Gannets on the Bass Rock (Firth of Forth) with rings inscribed "Bass Rock, 1904." In 1905, Mr John Hamilton, of Baron's Court, Co. Tyrone, Ireland, began marking Woodcock with rings inscribed "B. C.", and with the year in figures. Other proprietors have also marked Woodcock, for instance, Lord Ardilaun at Cong, Galway (rings inscribed "A. Cong"). Sir Richard Graham has used rings inscribed "R. G.," for various species of Duck (mostly hand-reared) at Netherby, Cumberland.

In 1908 Dr C. B. Ticehurst, following Mr Mortensen's methods, started marking various birds in the south of England with rings inscribed "Ticehurst, Tenterden." Various other inquiries on a smaller scale have been set on foot.

In 1909, the first efforts at bird-marking on a large scale in the British Isles were made, two large inquiries being started independently and almost simultaneously. The first in order of announcement was the Aberdeen University Inquiry, which took Rossitten for a model. A few weeks later came Mr H. F. Witherby's scheme in connection with the magazine *British Birds*, and following Mr Mortensen and Dr Ticehurst: about 8000 birds have already[1] been marked. In the same season a marking scheme was started by the journal *Country Life*. It may also be noted that some of the earlier markers merged their work with the new schemes, as Mr Tomlinson did his with the Aberdeen University scheme, and Dr Ticehurst his with the *British Birds* scheme; the work is only profitable if undertaken on a very large scale.

III. Some Results.

The possibilities of bird-marking, however, cannot be better estimated than by a consideration of some of the results which have already been achieved, and a few illustrative cases may appropriately be cited here. Undoubtedly the finest example is the case of the White Stork (*Ciconia alba*). The bird-marking data concerning this species, we owe principally to the Rossitten Inquiry, but Mr Mortensen and the scientists of the Hungarian bureau have also contributed to it. Their combined results may be summarised as follows:—

First of all we have the autumnal migration, taking place in a south-easterly direction—the direction of Asia Minor. This is shown by the records of Storks marked as nestlings and obtained early in the same

[1] *I.e.*, in seasons 1909 and 1910.

autumn. The respective journeys of these birds were from Viborg in northern Denmark to Diekow in Brandenburg; from Viborg to Walkow near Frankfort-on-the-Oder; from Viborg to Marclowitz in Austrian Silesia; and from Weseram in Brandenburg to Hermannstadt in south-eastern Hungary, (Mortensen, *Dansk ornith. Forenings Tidsskrift*, 1907, pp. 147, 155): and from Geschendorf, near Lübeck, to Michelwitz, near Breslau; from Poppendorf in Mecklenburg-Schwerin to Tenczinau in Upper Silesia; from Lippehue in Brandenburg to Kassa Bola in northern Hungary; from Bühne in the Harz Mountains to Sehma in the Erzgebirge, not far from Chemnitz; from Langfelde, near Danzig, to Goubieszow in the Polish Government of Lublin; and finally, from Agilla in East Prussia to Sorquitten in the same province (Thienemann, *Zoolog. Jahrbücher*, suppl. xii., pp. 665-686, and plates 16-18). All these journeys have the same south-easterly direction, and, it may be remarked, cross at right angles the south-westerly routes followed by most species at that season.

No marked Storks have as yet been returned from the Balkan States or from Asia Minor, but three East Prussian Storks have been obtained in Syria, one in the April following marking, and the others in April and July of the second year after marking: a Hungarian Stork has also been reported from Syria. A fourth East Prussian Stork has been obtained in Palestine, in August. Next we have a record of a Stork obtained near Alexandria, in May of the year following that of its marking in East Prussia. Three Storks, marked in East Prussia in summer, have been respectively recorded during their first autumn from Jawa on Lake Fittri near Lake Chad (October), from Rosaires on the Blue Nile (30th October), and from the Island of Ukerewe in Lake Victoria-Nyanza (30th November). Next comes a record from Morogoro in German East Africa, but the exact details of this bird are not yet certain, the number on the ring not having been reported. Fort Jameson, in north-eastern Rhodesia, is the next locality: here a Stork was shot on 9th December 1907, which had been born and reared in Pommerania a few months before; there it had left the nest on 10th August, and had flown away on 25th or 26th August. This bird is now in the little museum at Rossitten. Next we have a record of an East Prussian Stork shot in the Kalahari Desert during its first winter. Finally, we have seven Storks marked in East Prussia and the neighbouring provinces, and obtained in the winter months in the Transvaal, Natal, Basutoland, northern Cape Colony, etc. There are also seventeen records of Hungarian Storks from this same region, one of them for July of the year following marking, and another for as far west as German South-West Africa (Thienemann, *loc. cit.*; and Schenk, *Aquila*, vols. xv., xvi. and xvii.).

We may also mention the records of Storks found in Germany in subsequent summers, summarising the records as follows:—

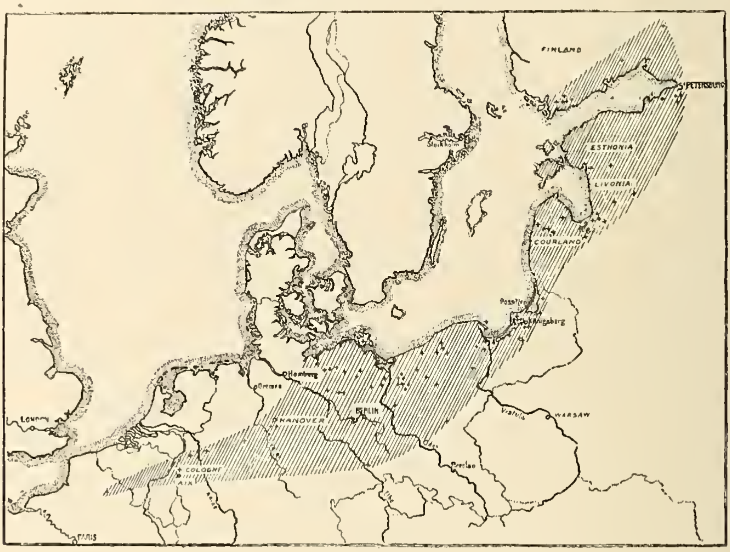
Distance from birthplace.			Season.	
3	English miles (approx.)		Next summer.	
8	"	"	"	"
60	"	"	"	"
17	"	"	Second summer after.	
437	"	"	"	"
9	"	"	Third	"
19	"	"	"	"

A return to the same summer-quarters is thus obviously the rule, but we must note the existence of the exception: the Stork born and marked near Brunswick in 1906, and reported on 30th June 1908 from Sorquitten in East Prussia. As already stated, the localities are about 437 miles apart: they are nearly in the same latitude, and obviously on quite different lines of flight. There are also a few Hungarian records of Storks returning to the same localities.

This record, and those other exceptions, the records from the Lake Chad region and German South-West Africa, indicate the necessity for further study of a case which might otherwise be considered as nearly complete. And this is still more evident with the final record which I shall quote concerning this species. Last season (1910) Storks were marked in large numbers in Holland and western Germany, and in the autumn the first record came to hand: a Stork marked at Cassel had been obtained in the Barcelona district of Spain! (Thienemann). This opens up a fresh line of inquiry altogether from that which has been so well carried out regarding the south-easterly flighting Storks of Denmark and north-eastern Germany. When both have been successfully concluded, we shall be in possession of a collection of facts which, I venture to say, will be a contribution of exceeding value to the study of the migration of birds.

Almost as interesting is the case of the Hooded Crows (*Corvus cornix*) which migrate through the Rossitten district. There they are caught, ringed, and released. And as many as 12 per cent. have been subsequently heard of from localities lying within a broad belt of country extending from southern Finland and the St Petersburg district of Russia, southwards through Livonia and Courland to Rossitten, and then westwards, still for some distance bounded on one side by the Baltic, through northern Germany, and terminating in the north-eastern corner of France (Solesmes) (Thienemann, *Journal für Ornithologie*, 1909, pp. 432-448, and plate vii.).

A similar but not quite so perfect case is that of the Teal (*Nettion crecca*) caught on their early autumn passage at a duck-decoy on Fanö, an island off the south-west of Denmark, where they were marked and liberated. Some of these were reported from Holland, many from the British Isles, notably from the south of England and from Ireland, many from the western sea-board of France, and one each from northern Italy and southern Spain. But a single Swedish record is the only indication we have of the direction of these birds' summer-quarters. The noteworthy feature in this case is, that about 25 per cent. of the birds marked in autumn were reported as shot or



Migration of Hooded Crow (*Corvus cornix*) [after Thienemann].

Each cross in the shaded area represents the locality of the subsequent death or recapture of a Hooded Crow caught, "ringed" and released at Rossitten while on its migration. [Rossitten, named on the map, will be seen at the very south-eastern corner of the Baltic Sea.]

captured during the next few months. Quite apart from migration, these statistics are of much interest (Mortensen, *Vidensk. Meddel. fra den naturh. Foren. i Kjöbenhavn*, 1908, pp. 127-139).

Dunlins (*Tringa alpina*) marked at Rossitten on passage have proved of some interest. A couple of records mark out the route along the Baltic coast, and this is extended by records from Essex, from the Gironde estuary, and from the neighbourhood of the Rhone delta (Thienemann). The theory that these points trace out a route is based on the assumption that there *is* a single, definite fixed route. This, of course, is only provisional, and it will be obvious that if these records have been multiplied considerably, and if all the localities still lie along this route, the assumption may be made with reasonable certainty.

But that this line of reasoning may prove dangerous if pushed too far, is evident. Personally, I regard with some scepticism the following interpretation of the southward wanderings of the Black-headed Gulls (*Larus ridibundus*) of a colony at Rossitten, where they are marked as nestlings. Three routes are followed, we are told: one follows the coasts to the Bay of Biscay; the second goes so far, and then crosses by the Rhine and the Rhone, and extends to the Balearic Isles; the third crosses direct to the Adriatic by the Vistula and the Danube systems, and extends to Tunis. All this is based on about forty records! (Thienemann, *Journal für Ornithologie*, 1909, pp. 449-458, and plate viii.).

The danger of this assumption of the existence of regular routes may be still further realised by the consideration of certain cases in which such regularity has been well shown to be entirely absent. Thus of the Northumberland Woodcock (*Scolopax rusticola*) already mentioned, many were found there at all times of their first and subsequent winters. Others travelled south even to Brittany, others went west into Ireland, and still others went north, far into Scotland—Argyll and Forfarshire (Lord William Percy, *Country Life*, 27th Feb. 1909). Similar results were obtained in Tyrone: some proved resident, some went east, some went south-east to the south of England, and one went north-east to Inverness (*Field*, 17th Oct. 1908, p. 717, and 24th Oct. 1908, p. 745). More recently a west of Ireland (Galway) Woodcock has been reported from Portugal (*British Birds*, iv. p. 280).

Similarly in the case of the Black-crowned Night Heron (*Nycticorax naevius*) of North America, it has been found that it is dispersal rather than true migration which takes place (Bartsch, *Smiths. Miscel. Coll.*, xlv., Pub. No. 1419, Quart. Issue, vol i., pts. 1 and 2, pp. 104-111, pls. xxxii.-xxxviii.: and Cole, *Auk*, xxvii., No. 2, pp. 160-164).

These are just a few of the more striking results obtained at the present early stage of this new study. I hope that they will at least serve to show what may be expected of the method when it has been longer and more widely in use.

IV. The Aberdeen University Bird-Migration Inquiry.

As already stated, this Inquiry was established in 1909 on the lines of the Rossitten Inquiry: I may add that I had visited the Rossitten *Vogelwarte*, or ornithological station, during the previous autumn, and that I have since re-visited it (autumn 1910). It will thus be understood that I am chiefly indebted to Dr Thienemann for guidance in the matter of methods, but I have also derived some benefit from "exchanging notes," so to speak, with Mr Mortensen, Mr Witherby, and Messrs Herman and Schenk of the Hungarian Central-bureau.

The inquiry is carried on as a piece of research work from the Natural History Department of the University of Aberdeen, under the supervision of Professor J. Arthur Thomson. The working expenses are covered by a grant allowed us by the Carnegie Trustees.

In the work of ringing birds, we have the co-operation of a large number of ladies and gentlemen, who have kindly volunteered their assistance. Most of these co-operators live in Scotland, especially in Aberdeenshire, but there are a few in England and Wales and in Ireland. Most of them rely chiefly on young birds, found when still unable to fly, varied by occasional chance captures of adult birds. A few, however, engage systematically in bird-catching during the winter-months: the chief means employed are simple clap-nets, automatic cage-traps, or other harmless appliances; but a number of birds, mostly gulls on the shore, have been caught at night by means of acetylene cycle-lamps, which completely dazzle and bewilder them.

After a good deal of experimenting with different sizes and patterns of rings we have fixed upon the following eight sizes, the measurement in each case is that of approximate internal diameter of the ring (when closed in circular shape):—

$\frac{1}{8}$ inch: for Finches, Swallows, Tits, Robin, Lark, Sandpipers, Lesser Tern, etc.
$\frac{5}{32}$ „ for Common and Arctic Terns, etc.
$\frac{3}{16}$ „ for Lapwing, Snipe, Starling, Blackbird, Thrushes, etc.
$\frac{1}{4}$ „ for Woodcock, Jackdaw, Black-headed and other small Gulls, Kestrel, Teal, Stock-Dove, etc.
$\frac{5}{16}$ „ for Rook, Hooded and Carrion Crows, Owls, Wood-Pigeon, Guillemot, etc.
$\frac{3}{8}$ „ for Mallard, Herring and Lesser Black-backed Gulls, etc.
$\frac{1}{2}$ „ for Great Black-backed Gull, Gannet, etc.
$\frac{5}{8}$ „ for Heron, etc.

The first four sizes are of the simple claspless pattern, the last four are provided with Rossitten clasps: the last three have the edges turned out all round as flanges. The address on all the rings is "Aberdeen University," except that it is contracted to "Aberdeen Univ." on the two smallest sizes. The impossibility of getting a five-figure number on to a very small ring has necessitated the use of letter combinations (*e.g.* "299A") on some of these, and we also use numbers like "0798": otherwise plain numbers are used, although often written in two lines on a medium-sized ring. All our rings are made from aluminium, by Mr Samuel Drake, Halifax.

Each co-operator is provided with a list of the commoner species for which each size of ring may be used. Early in each year he fills up and sends to us an estimate of the rings of various sizes which he expects to be able to use during the season. Rings are sent out by us accordingly, or at any other time that they are specially asked for.[1] Along with the rings we send out schedules (with stamped return envelopes) on which the data about all birds marked are filled in. The following information is asked for, each item in a separate column: (1) Number on ring; (2) Species of bird; (3) Date of marking and release; (4) Locality of same; (5) How obtained ("As young," etc.); (6) Sex and age so far as certain; and any other remarks, including bracketing together members of the same brood, etc., with word to that effect. The marker's name is filled in at the top, and we give each schedule a reference number as it comes in.

Each schedule holds the data of about seven marked birds, and is sent in as soon as it is complete, or when any record in it is a month old, whichever happens first. The data are transcribed into a large ledger, in which the entries are arranged according to the ring numbers. This ledger is provided with five columns corresponding to those of the data schedules, with additional columns for the marker's name, the schedule's reference number, and also for the size of the ring. A final column is left blank for the purpose of entering a reference to the page in the separate "return" book in which such records are entered as they come in.

From this description of methods we may turn to consider a few of the results which have already been obtained at this early stage of the work. It need hardly be said that we make no attempt at drawing conclusions at present, but it may be pointed out that the "returns" here enumerated are selected from the few which have a certain degree of individual interest. The majority of the other results are trivial if taken alone, but will, I am confident, prove interesting enough when they become sufficiently numerous to be classified and correlated.

A brood of five Wigeon ducklings (*Mareca penelope*) was marked by Mr Francis Gunnis on Loch Brora, eastern Sutherland, Scotland, on 19th June 1909. One of these (A.U. 2052) was caught on 3rd September 1909, in a duck-decoy at Westpolder, Ulrum, province of Groningen, north-eastern Holland, as reported by Mr H. J. Louwes of that place. A second member of the brood (A.U. 2050) was shot early in January 1911 on the river Trent, about four miles above Gainsborough, where it forms the boundary between the English counties of Lincoln and Nottingham; it was reported by Mr John Allison, Retford. This emphasises the conclusion which we may draw from Mr Mortensen's experiments with Teal, that a very high percentage of "returns" of great interest may be looked for in the case of marked Duck.

[1] The numbers, sizes, and destinations of all rings sent out are carefully noted, and all "returns" of marked birds are checked by these.

Out of a number of Lapwings (*Vanellus vulgaris*) marked as young birds during the summer of 1910 in the north-east of Scotland, the following interesting "recoveries" have been reported :—

No.	Date.	Locality.	Name of Marker and Reporter.[1]
A.U. 14077	Oct. 1910	20 miles N. of Oporto, Portugal	Lt.-Col. A. V. Anderson Mr Wm. C. Tait
A.U. 12730	About Nov. 18, 1910	Thurles, Co. Tipperary, Ireland	Mr W. W. Nicol Mr James Ryan
A.U. 8545	About Nov. 22, 1910	Frenchpark, Co. Roscommon, Ireland	Mr L. N. G. Ramsay Mr Sidney Harris
A.U. 12731	Dec. 29, 1910	Elvas, Alemtejo, Southern Portugal	Mr W. W. Nicol Mr João F. da Silva Miranda
A.U. 14370	About Feb. 5, 1911	Mitchelstown, Co. Cork, Ireland	Capt. W. H. Ritchie Mr J. A. Fraser
A.U. 14699	Feb. 13, 1911	Croagh, Co. Limerick, Ireland.	Lt-Col. A. V. Anderson Mr George Sherwood

Over a hundred Herring Gulls (*Larus argentatus*) were marked as young birds by Mr Lewis N. G. Ramsay and others, during the summer of 1910 at two localities on the Aberdeenshire coast (Hummel Craig, Collieston, and the Dunbuy Rock, Cruden Bay). Of these the following have been recorded :—

No.	Date.	Locality.	Reported by
A.U. 10963	Sept. 8, 1910	Saltfleet, near Mablethorpe, Lincolnshire	Mr G. W. Hollis
A.U. 10624	Sept. 13, 1910	Aberdeen Harbour	Mr George Allan
A.U. 16055	Sept. 1910	Ryhope, near Sunderland	Mr J. Cope
A.U. 10650	About beginning of Oct. 1910	Tayport, Fifeshire.	Mr James Aimer
A.U. 10952	Oct. 3, 1910	Hunstanton, Norfolk	Mr R. W. Dodman
A.U. 10815	About Oct. 12, 1910	Eden estuary, near St Andrews	(Newspaper cutting)
A.U. 15901	Nov. 15, 1910	Aberdeen	——
A.U. 15937	About Jan. 30, 1911[2]	Near Manchester	Mr W. Yates

[1] Marker's name first in each case.
[2] Found injured ; released in good health, 7th Feb. 1911.

The distinct evidence of considerable southward movement contained in these records is of interest when compared with the evidence of stationary habits obtained by marking large numbers of this species at the colony on Borkum, at the south-eastern corner of the North Sea (Thienemann, *Journal für Ornithologie*, 1910, p. 632). And we have ourselves a record of a Herring Gull (A.U. 12140) marked as a young bird at Loch Aan Eilean, the Lewis, Outer Hebrides, by Mr Andrew Harley, on 7th June 1910, and shot at Stornoway (Lewis) at the beginning of December 1910, as reported by Mr F. A. Lowe.

A Black-headed Gull (*Larus ridibundus:* A.U. 13179), marked on 12th July 1910, by Mr Lewis N. G. Ramsay, on the Sands of Forvie, Aberdeenshire, was killed near Bayon, Gironde, France, about 18th January 1911, as reported by the Mayor of Bayon and by Mr T. Ludovic. Several unimportant short-distance records have also been obtained for this species, including records of three birds out of fifty marked in 1910 at a colony near York, by Mr H. R. Davidson, and recorded in the autumn from Hull (2) and Newcastle respectively.

A Guillemot (*Uria troile:* A.U. 11230), one of a number of sea-fowl marked as young birds on the Dunbuy Rock, Cruden Bay, Aberdeenshire, on 11th July 1910, by Mr Lewis N. G. Ramsay and others, was shot on 29th November 1910, at Marstrand, a dozen miles north of Gothenburg, Sweden, as reported by Dr Jägerskiöld of Gothenburg Museum, where the bird is now preserved.

This enumeration exhausts all the important records for non-passerine birds that have come to hand up to date. Turning now to the Passeres, we find that they make up the majority of the birds we have marked, but that they have afforded an extremely small proportion of "returns." In fact, there are only two outstanding records.[1]

A Song-thrush (*Turdus musicus:* A.U. 14299), one of a brood of five marked in the nest on 4th June 1910, at Skene House, Dunecht, Aberdeenshire, by Miss D. Hamilton, was shot on 6th November 1910 at Leiria, Portugal, "by a party of hunters." Several Portuguese newspapers containing notice of the event were sent to me, and later I received the ring and full details from Mr Ruy Ferreira. This is, so far, the only long-distance record that we have obtained in the case of a passerine bird.[1]

On 29th June 1909, an adult Swallow (*Hirundo rustica*) was caught, ringed (A.U. 4498), and released, at Harwarden Farm, Rusthall, Kent, by Mr Ernest C. B. Parsons. On 14th June 1910, it was recaught by Mr Parsons at the same farm. It may be mentioned that a considerable number of similar

[1] But see final footnote.

records for the Swallow and House-Martin already exist (*c.f. The British Bird Book*, vol. ii. p. 290).[1]

But although these birds afford few records of actual journeys, they give us many minor records. Thus, birds caught in winter frequently turn up again in the same nets, sometimes half-a-dozen times within a few months: such records will, undoubtedly, prove of value when classified. We have also had a few records of birds being caught in a subsequent winter at the same place, although the absence of evidence as to any migration between times, diminishes the value of these. Among our co-operators, Mr Archibald Campbell, Edinburgh, and Mr Arthur G. Davidson, Old Aberdeen, have been particularly successful in this sort of work, the former with Greenfinches, Starlings, Robins, etc., the latter with Blue Tits, Robins, etc.

In conclusion, I may say that there is no doubt that the possibilities of bird-marking vary very greatly with the different species of birds. Some, like the Lapwing and various Ducks, are evidently very repaying: others, like Gulls, while giving a high percentage of "returns," are unfortunately not very interesting as regards migration: others again, like Terns and the small Passeres, afford but a poor percentage of records. Furthermore, it is obvious that the marking of uncommon species—birds that cannot be marked in any great number—is not very profitable unless they afford a high percentage of "returns," seeing that isolated records for any species are not likely to prove of value. Therefore, it is probable that we shall presently concentrate our efforts on a few species, but, in the meantime, until we are better able to make such a selection, the Inquiry will proceed on its present general lines.

[1] Since going to press another record of this nature has come to hand, but in this case the Swallow had been marked as a nestling. This Swallow (*Hirundo rustica:* A.U. 7024) was marked in the nest at Wester Durris Farm, Durris, Aberdeenshire, on 21st August 1910, by Mr A. G. Davidson. On 22nd May 1911, it was found with a broken wing by Mr Duguid at Darnford Farm, Durris, as reported by Mr A. Macdonald.

We have also a second long-distance record for a passerine bird, in this case a Starling and reported from farther north. This Starling (*Sturnus vulgaris:* A.U. 16480) was an adult bird, netted, ringed and liberated at East Warriston, Edinburgh, on 20th March 1911, by Mr Archibald Campbell. On 20th April 1911, it was obtained at Saltdalen, Norway, just above the Arctic Circle. We received the information from Mr Anton Flemsæter, Saltdalen, and a newspaper cutting on the subject (number given wrongly as 16486) was sent by Dr Thv. Heiberg, Christiania, to the Editor of *The Field*, and reached us through Mr H. F. Witherby. The ring was afterwards returned to us by Mr Flemsæter.

(*Issued separately, 19th July* 1911.)

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Do.	Part 2 (1884-85),		7/6	10/	
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Do.	Part 2 (1886-87),		3/6	5/	
Do.	Part 3 (1887-88),		4/6	6/	
Vol. X.	Part 1 (1888-89),		5/	7/	
Do.	Part 2 (1889-90),		10/	12/6	
Vol. XI.	Part 1 (1890-91),		5/	6/6	
Do.	Part 2 (1891-92),		5/	6/6	
Vol. XII.	Part 1 (1892-93),		5/	6/6	
Do.	Part 2 (1893-94),		12/6	15/	
Vol. XIII.	Part 1 (1894-95),		4/6	6/	
Do.	Part 2 (1895-96),		5/	6/6	
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Vol. XIV.	Part 1 (1897-98),		5/	6/6	
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Price of the "Proceedings" continued on page 3 of Cover.

XXIII.—Some Northern Hydroid Zoophytes obtained by Hull Trawlers; with Description of a new species of Plumularian.

By James Ritchie, M.A., B.Sc., Royal Scottish Museum.

(Read 23rd October 1911. MS. received 13th November 1911.)

The specimens recorded below were collected by Mr John Thompson of Hull, in the nets of trawlers belonging to that port which had just returned from their fishing grounds in the North Sea and in the neighbourhood of Iceland. While some of the species thus obtained are by no means uncommon, some have been found in areas little investigated, and others—the majority belonging to the group of Statoplean Plumularians—have been so seldom observed that I have been able to make some additions to our knowledge of their structures. One of the latter I regard as a species new to science. On these accounts it seems well to put on record the results of Mr Thompson's collecting.

SPECIES RECORDED.

GYMNOBLASTEA.

Eudendridæ.

Eudendrium ramosum (Linn.).

CALYPTOBLASTEA.

Halecidæ.

Halecium beanii, Johnston.
Halecium halecinum (Linn.).
Halecium muricatum (Ell. & Sol.).

Campanularidæ.

Campanularia volubilis (Linn.).

Lafoëidæ.

Lafoëa dumosa (Fleming).
Grammaria abietina, M. Sars.

Sertularidæ.

Diphasia fallax (Johns.).
Diphasia rosacea (Linn.).
Selaginopsis hartlaubi, Nutting.

Plumularidæ.

Plumularia pinnata (Linn.).
Antenella secundaria (Linn.).
Cladocarpus bonneviœ, Jäderholm.
Cladocarpus campanulatus, sp. nov.
Halicornaria integra (G. O. Sars).

GYMNOBLASTEA.

Eudendrium ramosum (Linn.).

Several colonies from Flamborough Head, Yorkshire.

CALYPTOBLASTEA.

Halecium beanii, Johnston.

A single colony growing amongst the rhizoids of a clump of *Plumularia pinnata*, dredged to the north of the west part of the Dogger Bank, North Sea.

Halecium halecinum (Linn.).

Great Fisher Bank, North Sea.

Halecium muricatum (Ell. & Sol.).

Typical colonies all bearing the characteristic gonangia from—(*a*) deep water to the north of the Dogger Bank, and (*b*) the south-east part of the Dogger Bank, 18 fathoms.

Campanularia volubilis (Linn.).

A few stems, with hydrothecæ, scattered over the trophosome of *Selaginopsis hartlaubi*, from the neighbourhood of Iceland.

Lafoëa dumosa (Fleming).

A few hydrothecæ on the stems of *Plumularia pinnata*, from the north of the west part of the Dogger Bank, North Sea.

Grammaria abietina, M. Sars.

Two typical colonies from the neighbourhood of Iceland.

Diphasia fallax (Johnston).

Great Fisher Bank, North Sea.

Diphasia rosacea (Linn.).

Two small colonies on *Selaginopsis hartlaubi*, from the neighbourhood of Iceland.

Selaginopsis hartlaubi, Nutting.

This species, till now known only from an incomplete specimen and a fragment, is here represented by two colonies, one of which, however, is young and incomplete. The complete colony (Fig. 1) is 22 cms. high and consists of a stem, for the greater part denuded of hydroclades, divided into nodes by well-marked internodes. The basal nodes (six or so) are irregular in size, are regularly annulated, but have never borne hydroclades nor hydrothecæ. Above these the nodes bear hydrothecæ, and all except the lowest have borne hydroclades; but the length is exceedingly variable—from 7 mm. with two hydroclades to 18 mm. with eight. The stem hydrothecæ are completely immersed, are arranged in two rows, one on each side of the stem, and, contrary to Nutting's statement, have their distal portions inclined alternately to the right and left, analogously to those on the hydroclades, although the inclination is of small moment.

The hydroclades are simple, long (up to 42 mm.), cylindrical and robust. Each narrows much at the base, where it is divided by a strong constriction from a short stem process. As a rule the hydroclades are alternate, but occasionally two, in one case four, occur successively on the same side. No internodes could be distinguished.

The hydrothecæ lie in general in four longitudinal rows, or perhaps in three, at the bases of the hydroclades. The rows are not very evident at first glance, for each zig-zags more or less from right to left, only half the base of one hydrotheca lying in vertical line with half the bases of its predecessor and successor. The hydrothecæ are still more out of the vertical alignment, for they incline alternately to right and left. The distal portion of a hydrotheca overlaps for a short distance the proximal portion of its successor in the same vertical line. The hydrothecæ are altogether immersed, their aperture, which is oval with the long axis horizontal, being flush with the surface of the hydroclade. In shape they are saccate: wide and bulging in their lower half, and thence narrowing gently to the aperture. A very short chitinous tube projects upwards from the floor of the hydrotheca, forming a passage between the hydrotheca cavity and the general cavity of the colony.

The gonosome is unknown.

Dimensions.

Stem,	length	up to 22 cms.
	diameter . . .	1·5 mm.
Hydroclade,	length	up to 42 mm.
	diameter . . .	about 1 mm.
Hydrotheca,	depth (base to highest margin)	0·51—0·55 mm.
	greatest diameter. . .	0·24—0·30 mm.
	horizontal diameter of aperture	0·14—0·20 mm.

Locality.— From the neighbourhood of Iceland.

Distribution.—There are only two previous records of this species, but they indicate an exceedingly wide Arctic and sub-Arctic distribution:

Fig. 1.
Colony of *Selaginopsis hartlaubi*, slightly under nat. size.

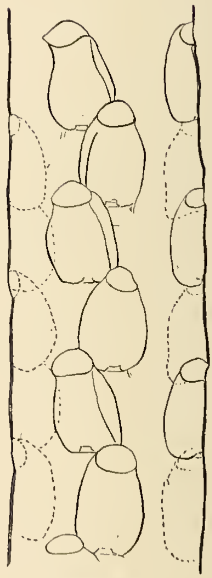


Fig. 2.
Portion of hydroclade of *Selaginopsis hartlaubi*, showing positions of three (out of four) rows of hydrothecæ. × 25.

lat. 56° 40′ N., long. 169° 20′ W., in 43 fathoms, that is, near the Aleutian Islands in the North Pacific (Nutting)[1]; and Kola Peninsula, 50 fathoms (Jäderholm).[2]

Plumularia pinnata (Linn.).

A cluster of weather-beaten but large colonies, dredged to the north of the west part of the Dogger Bank—"below the nor'-west rough"—North Sea.

Antenella secundaria (Linn.).

A few of the simple hydroclades distinctive of this species occur upon the stems of *Plumularia pinnata.* The definite distribution of this species in British waters is little known, owing to the fact that the earlier observers considered it a variety of *Plumularia catharina.*

From the north of the west part of the Dogger Bank, North Sea.

Cladocarpus bonnevieæ, Jäderholm.

A single complete colony of this rare species comes from the neighbourhood of Iceland. As the species has been found on only one occasion, when it was trawled by the Norwegian North Atlantic Expedition to the west of Bear Island, and as that specimen, although mature, appears to have been fragmentary, a few details may be added to Miss Bonnevie's description.[3]

The colony consists of a polysiphonic main stem, 14 cm. high, rising erect from an expanded basal piece, above which its thickness is 1·5 mm. The lower 3·5 cm. of the stem is almost naked, but at that height a strong, polysiphonic branch arises, and above that height stem and branch bear close-set alternate hydroclades which spring from the anterior tube of the fascicle, and lie in one plane. The majority of the hydroclades are simple, about 15 mm. in length, but occasionally a pinna of the same length as a hydroclade springs from the abcauline side of a proximal internode, and itself bears secondary hydroclades, up to 5 mm. in length. These secondary hydroclades occur on all but the three or four proximal internodes of the pinna. Internodal septa occur: one, not prominent, at the base of the supracalycine sarcothecæ, another at the bulging lower half of the hydrotheca, and a third near the base of the internode. Besides these a small septum generally runs across the mesial sarcotheca.

[1] Nutting, "American Hydroids," pt. ii., Smithsonian Inst. Sp. Bull., 1904, p. 133, pl. xl. fig. 8.

[2] Jäderholm, "Northern and Arctic Invertebrates in the Collection of the Swedish State Museum," in Kungl. Svenska Vet.-Ak. Handl., Bd. 45, 1909, p. 103, taf xi. fig. 8.

[3] Bonnevie, Norwegian North Atlantic Expedition, "Hydroida," Christiania, 1899, p. 94, as *Aglaophenia compressa.*

In lateral aspect the hydrothecæ are characterised by their uniform width, the bottom of the cup being if anything rather wider than the aperture. On the margin there is no constant arrangement of "two small denticles, on each side in towards the hydrocladium," such as Miss Bonnevie describes, nor are there always "long portions of it smooth."

In my specimen the whole of the margin is crenulated, but the scallops, varying in intensity, are more strongly developed towards the hydrocladium, and fade away towards the anterior. The anterior portion of the margin is projected into a double tooth, the larger portion of which forms a long, frequently incurved point, which is supplemented by a smaller tooth,

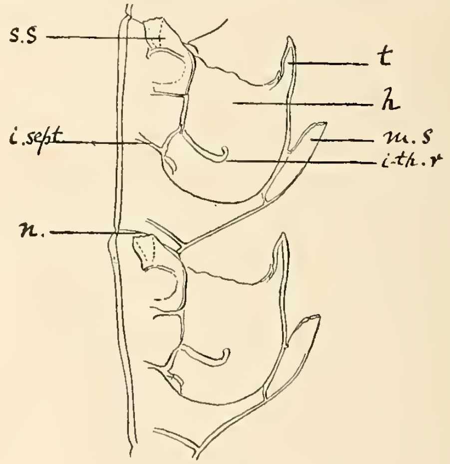


Fig. 3.

Portion of hydroclade, with hydrothecæ, of *Cladocarpus bonneview.* × 50.

s. s.,	supracalycine sarcotheca.	*t.,*	anterior tooth.
i. sept.,	internodal septum.	*h.,*	hydrotheca.
n.,	node.	*m. s.,*	mesial sarcotheca.
		i-th. r.,	intrathecal ridge.

lying on the inner surface near the base. There is a well-developed intrathecal ridge projecting from the adcauline wall across half of the hydrotheca cavity. In all but the youngest hydrothecæ a small septum runs across the cavity of the mesial sarcotheca.

The upper portion of a supracalycine sarcotheca is tilted backwards towards the hydroclade. It is not cylindrical but scoop-shaped, the side towards the internode being open, and the margin is crenulate. A well-marked thickening of chitin indicates the division between the free and adnate portions. Three sarcothecæ, not two as Miss Bonnevie states, accompany the base of each hydroclade: two lie on the anterior of the basal process, one distal, the other proximal; while the third sarcotheca is distal and posterior. The structure of these individuals is similar to that of the lateral sarcothecæ. Two-thirds of the mesial sarcotheca is adnate reaching half way up the hydrotheca; the remaining free portion is scoop-shaped, and has a crenulated margin. This sarcotheca is longer in our specimen than in Miss Bonnevie's figures.

No trace of gonosome was found on the specimen.

Dimensions.

Stem internode,	length . .	0·56 mm.
	diameter . .	0·26 mm.
Hydroclade internode,	length . .	0·52—0·58 mm.
	diameter . .	0·18 mm.
Hydrotheca,	depth . .	0·35 mm.
	diameter at mouth	0·25 mm.

Locality.—From the neighbourhood of Iceland.

The only previous record is: lat. 74·55° N., long. 15·49° E., depth 373 metres (Bonnevie).

The consigning of *Aglaophenia compressa*, Bonnevie, to a definite generic position is a matter of some delicacy. Miss Bonnevie slumped all the Statoplean Plumularians obtained by the Norwegian North Atlantic Expedition under the genus *Aglaophenia*, but we cannot follow her in this simplification. In the separation of the genera of this group, greatest stress has been laid upon the gonosome and the arrangements for its protection. The present species bears simple gonangia "attached at the base of the hydrocladium's first hydrotheca," and this, by itself, would place it in the genus *Halicornaria*, as Broch has indeed done.[1] But besides the unprotected gonangia, others are borne on separate conspicuous branches, arising from the same place, and bearing nematophores. But they also bear two short branches, with hydrothecæ, and from the bases of these branches the gonangia spring. These seem to represent the simple or branched phylactogonia, characteristic of genus *Cladocarpus*, although in the species hitherto known hydrothecæ are absent from these protective structures. The trophosome helps to resolve the difficulty—for it is more typically Cladocarpian than Halicornarian, with its fascicled stem, hydrothecæ with lateral crenulation and prominent anterior tooth, posterior intrathecal ridge, and septal ridges in internodes of hydroclade. We therefore follow Jäderholm in transferring the species to *Cladocarpus*, a proceeding which, making Miss Bonnevie's name a synonym, necessitates the adoption of

[1] Broch, "Die Hydroiden der arktischen Meere," in *Fauna Artica*, Jena, 1909, p. 207, under name *Halicornaria compressa.*

the name *Cladocarpus bonneviecæ*, Jäderholm. The species must be regarded, however, as a link binding *Cladocarpus* to the apparently less specialised *Halicornaria*.

Cladocarpus (?) campanulatus, sp. nov.[1]

Trophosome.—The main stem of the colony reaches a height of 65 mm. and bears numerous branches—the longest 40 mm. in length—from which branches of second degree may arise. In the solitary specimen before me all the branches, with an exceedingly diminutive exception, arise from

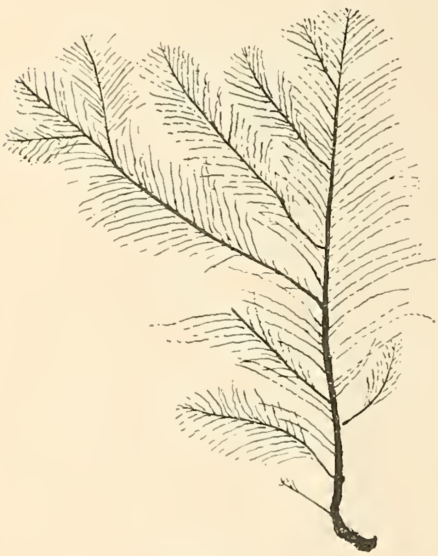


Fig. 4.
Colony of *Cladocarpus campanulatus*, nat. size.

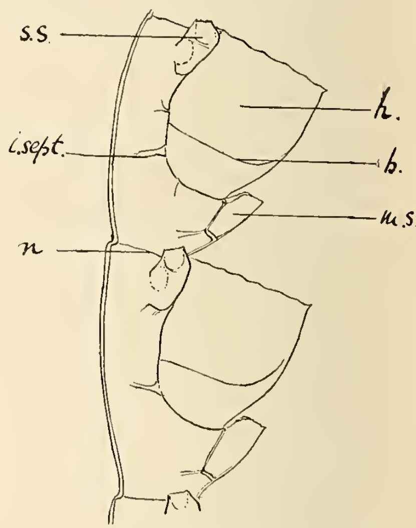


Fig. 5.
Portion of hydroclade, with hydrothecæ, of *Cladocarpus campanulatus*. × 50.
s. s., supracalycine sarcotheca.
i. sept., internodal septum.
n., node. *h.*, hydrotheca.
b., upper border of deeply staining portion.
m. s., mesial sarcotheca.

one side of the colony, but this may be an individual peculiarity without specific import. The stem and branches are fascicled, but considerable distal portions remain free. The anterior tube is divided by indistinct nodes into short internodes, each of which bears a hydroclade on a process arising from its lower two-thirds.

The hydroclades are alternate, close-set, reach a length of up to 10 mm., and are divided into short internodes, each of which bears a hydrotheca. The posterior wall of each internode is convex. The internodal cavity

[1] Diminutive from *campana*, a bell, in allusion to the inverted bell shape of the hydrothecæ.

is traversed by from three to five partial, and ill-developed septa, which are arranged thus: one may be present at the base of the supracalycine sarcothecæ, another, more strongly developed, occurs on the innermost "corner" of the base, between these another may arise, while a fourth may project downwards from about the middle of the base. A well-developed septum, formed of two sections at right angles, separates the mesial sarcotheca from the internodal cavity, and from the angle between the sections a septum springs backwards into the internode.

The hydrothecæ are close-set, almost symmetrical in lateral aspect, wide at the base and opening out gradually towards the aperture, rather deeper than wide. The profile is convex. The margin is carved in the form described by Billard as *sinusoïde*, being uniformly divided into fourteen or fifteen exceedingly shallow denticulations by embayments as shallow. There is no distinct intrathecal ridge, but the walls of the lower two-thirds of the hydrotheca are more strongly built, and, downwards from a definite line, assume a deeper stain in Eosin, so giving a characteristic appearance to the hydrothecæ.

The supracalycine sarcothecæ, which taper downwards, reach just beyond the margin of the hydrotheca. Their aperture is wide and scoop-shaped, and their margin is minutely denticulate. The mesial sarcotheca is adnate to the internode up to the base of the hydrotheca. It is free for about a third of its length, has a scoop-shaped aperture, and a denticulate margin. As has been mentioned, its cavity is separated from that of the internode by a compound septum. Three fairly large cauline sarcothecæ occur on each internode: two anterior—one at the base of the hydroclade process, and one in the superior angle between it and the internode; while a third, which is posterior, opposes the latter of these two. The margins of all are very minutely denticulate.

No trace of gonosome occurred, and in its absence the species has been referred, doubtfully, on account of its trophosome characters to the genus *Cladocarpus*.

Dimensions.

Stem internode,	length . .	0·65—0·71 mm.
	diameter . .	0·31—0·37 mm.
Hydroclade internode,	length . .	0·62—0·65 mm.
Hydrotheca,	depth . .	0·41—0·42 mm.
	diameter at mouth (lateral aspect) .	0·34—0·36 mm.

Locality.—From the neighbourhood of Iceland.

The type specimen has been presented by Mr Thompson to the Royal Scottish Museum, Edinburgh.

The species is a well-marked one, and may be readily distinguished by its symmetrical and dumpy hydrothecæ of which the lower third absorbs stain more readily, by the shortness and infra-thecal position of the mesial sarcotheca, with its peculiar bounding septum, and by the presence of very minute denticulations on the margins of sarcothecæ and hydrothecæ.

Halicornaria integra (G. O. Sars.).

As this species has been recorded very seldom, and is described, and that in a general way, only in a journal to which few British workers can have ready access,[1] I give here an account of the salient characters of the species from a well-preserved specimen found in the nets of a trawler at Hull.

Trophosome.—The colony is 13 cm. high, with a fascicled stem almost 2 mm. in diameter at the base, from which several long branches arise. These bear secondary branches, and from these off-shoots of third and even fourth degree arise. The fascicle tubes accompany the cladate tube of branches and off-shoots on their lower portions, but leave considerable distal sections free. The cladate tube lies on the anterior of the fascicle and is divided into long, equal internodes, from the lower half of each of which arises a single hydroclade.

The hydroclades are alternate, reach a length of 7 mm., and are divided into equal internodes, on each of which occurs a hydrotheca. The cavity of each internode is traversed by from four to eight septa, the number increasing with the age of the internode. The commonest positions of the septal ridges is: one at the base of the supracalycine sarcothecæ, one slightly below the intrathecal ridge—one or two lying between these; one at the base of the hydrotheca, and one below the hydrotheca, almost at the base of the internode. A smaller septum cuts off the mesial sarcotheca, and from it another occasionally runs backwards.

The hydrothecæ are two-thirds the length of a hydroclade internode. They are deep, of almost uniform width, tapering slightly near the bottom, and expanding slightly at the margin. The aperture is circular, and almost at right angles to the hydroclade, and the rim is very faintly crenate, the crenulations being more marked towards the internode. There is a well-developed posterior intrathecal ridge reaching almost half way across the hydrotheca, and recurved at the free margin.

The supracalycine sarcothecæ are short, reaching just beyond the margin

[1] Forhl. Vidensk. Selsk., 1872, Christiana, 1873, p. 100, as *Aglaophenia integra.*

of the hydrotheca. They are almost uniform in width throughout, and are scoop-shaped, opening upwards and towards the internode. The margin is smooth. The mesial sarcotheca is short, adnate to the lower sixth of the hydrotheca, and free for half its length. It also is scoop-shaped, and its rim is entire. Three cauline sarcothecæ, similar in structure to the supracalycine sarcothecæ, occur at the base of the hydroclade process: two anterior, one above and one below.

Gonosome.—Gonangia are present on the stem and branches. They are unprotected by special arrangements of branches, are ovate in shape, with a

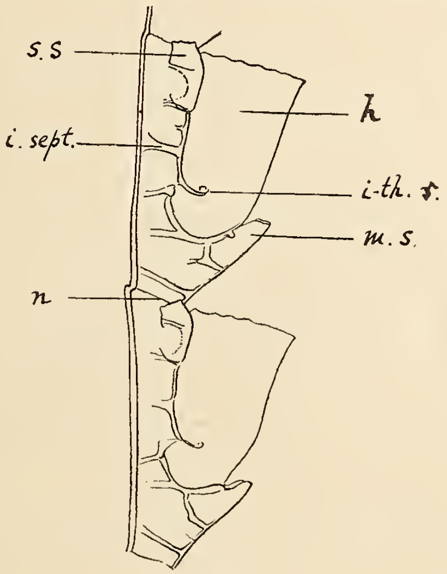


FIG. 6.

Portion of hydroclade, with hydrothecæ, of *Halicornaria integra*. × 50.

s. s.,	supracalycine sarcotheca.	*h.*,	hydrotheca.
i. sept.,	internodal septum.	*i-th. r.*,	intrathecal ridge.
n.,	node.	*m.s.*,	mesial sarcotheca.

horseshoe-shaped aperture, and arise from the anterior of an internode close to the hydroclade process, at the base of the distal cauline sarcotheca

Dimensions.

Stem internode,	length . .	0·71—0·75 mm.
	diameter . .	0·20 mm.
Hydroclade internode,	length . .	0·69—0·73 mm.
Hydrotheca,	depth . .	0·43—0·50 mm.
	diameter at mouth	0·29 mm.
Gonangia,	length . .	1·29—1·54 mm.
	greatest diameter	0·68—0·70 mm.

This species has been recorded from the Norwegian coast—from Hvitingsö and Bodö, at depths between 80 and 100 fathoms (G. O. Sars, *loc. cit.*); from Stavanger to Bodö, 100-200 metres (Bonnevie)[1]; and from Skarnsund, 100-200 metres (Jäderholm)[2]. The provenance of the Hull specimen is unknown, Mr Thompson being unable to state whether the trawler had been at work in the North Sea or off Iceland.

Nutting[3] refers to the resemblance between this species and *Cladocarpus pourtalesii*, Verrill, so far as the hydrothecæ are concerned, and instances as points of distinction the presence, in Sars' figure of *H. integra*, of unprotected gonangia, and of a row of hydrothecæ on the anterior tube of the stem. While the former distinction holds, placing Sars' species in genus *Halicornaria*, the latter is in fault, for hydrothecæ occur only on the hydroclades, and Sars' figure (pl. ii. fig. 13) errs in showing them on the stem. A further distinction, however, applicable to the hydrothecæ, lies in the fact that that portion of the hydroclade internode which lies proximal to the hydrotheca is considerably longer in *Halicornaria integra* than in *Cladocarpus pourtalesii*, and in the former contains not only the septum cutting off the mesial sarcotheca, but also a strongly developed septum near its base.

It is noteworthy that this species, in possessing a fascicled stem, a posterior intrathecal ridge, and septal ridges in the hydrocladial internodes, differs from the several American species, and overthrows the majority of the characters regarded by Nutting (1900, p. 126) as distinctive of the trophosome of *Halicornaria*.

[1] Bonnevie, Norwegian North Atlantic Expedition, "Hydroida," Christiana, 1899, p. 93.

[2] Jäderholm, Kungl. Svenska Vet.-Ak. Handl., Bd. 45, i., 1909, p. 109.

[3] Nutting, "American Hydroids," pt. i., "Plumularidæ" (Smithsonian Spec. Bull.), Washington, 1900, p. 117.

(*Issued separately, 25th January* 1912.)

XXIV.—Note upon a Tachinid Parasite (*Bucentes geniculatus*, D. G.) of Tipula sp. By John Rennie, D.Sc.

(Read 23rd October 1911. Received 23rd October 1911.)

In a collection of Tipula larvæ undergoing examination for Protozoan parasites a dipterous larva was found in the body cavity of a small number of specimens. It was thought worth while to examine the remaining specimens in hand for external signs which might serve to distinguish infected from uninfected individuals. In a certain number of cases it was noted that a yellowish patch was visible beneath the skin, more or less sharply defined, and this was presumed to be the maggot within. Those suspected were sacrificed, and the majority were found to be infected. In the remaining cases the fat body had served to mislead.

At this stage, which was in the month of February of the present year, an attempt was made to keep the extracted maggots alive upon Tipula flesh in salt solution, but this effort was not successful.

With a view to ascertaining whether the parasite occurred widely, Tipula larvæ were obtained from two other sources, and in each case the parasite was found in small numbers. The three localities from which infected larvæ were obtained were Old Meldrum and Clova in Aberdeenshire, and Cornhill in Banffshire. From this it may be presumed that the parasite is generally distributed in Tipula, in the north-eastern counties at all events. From the known habits of the group (Tachinidæ) to which the parasite belongs, it is possible that other insect hosts exist.

The Tipula larvæ were now kept in soil in protected flower-pots, upon which loose, fresh turf was periodically placed and in which oats were also sown. This in due course germinated. From time to time the earth in the pots was turned out and the larvæ examined. Most continued in a healthy condition—firm skinned and curling readily when handled. Some were found in the act of moulting. On 22nd April out of over fifty larvæ, one dead and four very inert specimens were found. These living ones appeared certainly infected; one was sacrificed and from it a maggot obtained. This was preserved alive in a petri dish upon the host tissue. No parasite was found within the dead grub nor within another live suspected one. The remaining suspected larvæ, which were much smaller than the others (about half an inch long), together with some other small examples selected from the general collection, were now placed in soil in a small glass observational jar $3\frac{1}{2} \times 3 \times \frac{1}{2}$ ins. in size, and protected by a muslin cover. The confining of the larvæ to a small quantity of soil served two purposes. It enabled their movements in the soil to be observed through the glass, and it limited the amount of soil to be searched in the event of the maggots leaving their hosts on pupation.

On the following morning (23rd April) it was found that the maggot removed and preserved in the petri dish had pupated. The pupa is reddish in colour, barrel-shaped, about 4 mm. long.

On the 26th April the contents of the glass vessel were examined, and this time only apparently healthy larvæ were found living. The decomposing remains of two larvæ were also found, which were manifestly two of the originally infected forms. In addition, *lying free in the soil were three pupæ* identical with the one obtained from a liberated larva a few days previously.

During the last few days of April and beginning of May, the soil in the flower-pots containing the rest of the larvæ was carefully and systematically searched with the aid of a large hand magnifier, and no pupæ were obtained. Nor did any of the larvæ living show signs externally of containing a maggot.

The four pupæ were preserved in a shallow glass vessel in a thin layer of loose soil, and covered by a glass plate. The soil was kept very slightly moist and exposed to the warmth of the sun from time to time.

On 23rd May, exactly one month after the first pupa was obtained, a fly hatched out, and on the following day the hatching of other two took place. These were placed alive in a wide test-tube along with some grass and a slice of potato. They are exceeding active flies. They flew energetically about the tube, ran up and down upon the grass, brushed their wings and heads with their feet, and generally groomed themselves in a perfectly healthy manner. Meantime their structural features were noted and the species identified as *Bucentes geniculatus*, De Geer. It was hoped that the flies might live for some time, and that it would be possible to observe their habits. One, however, died on the 24th. Meantime endeavours were maintained to provide suitable food for the others, and as the species is known as a frequent visitor to a considerable number of flowers, various flowers rich both in pollen and nectar were placed beside the flies, but while they ran about upon these, they were never seen to feed, although a good deal of time was spent watching their movements closely.

One of the most striking features about these flies is their proboscis, which is very long and bent upon itself like the blade and handle of a clasp-knife. This they were frequently seen to unfold and stretch in front of the head, touching things with it, but they were never seen to probe into flowers, or, as far as could be judged, use it in feeding. Up till the evening of 26th May both flies were lively and apparently well, but during the following day one died, and on the succeeding morning the last one was found also dead.

Description of the Fly.

As already noted the fly has been identified as *Bucentes geniculatus*, De Geer, a member of the Family Tachinidæ. This family is a very large one, comprising an enormous number of species whose larvæ live as parasites upon other insects, chiefly caterpillars.

The fly is blackish looking, rather smaller than an ordinary housefly with numerous bristles on the body, particularly upon the abdomen, and with large, pale squamæ above the halteres. A distinctive generic character is the long, slender filiform proboscis which is geniculated at the base and at the middle. The free extremity is bent downward and directed backward when not in use. In the act of extension, it is bent first downwards and then upward and forward. The first and second joints of the antennæ are tawny in colour, and the arista bears very fine and extremely short hairs. The legs are tawny with black tarsi. The wing characters are as figured. The fly is very common, but the only account I have been able to find regarding its habits is the reference given in Knuth's *Handbook of Flower Pollination*, where it is reported as a visitor to numerous flowers. As these include early and late flowering species (*Viola lutea* and *Mentha aquatica*) the imaginal period probably extends through the whole summer. The latter plant does not flower in this country until August. From the character of its proboscis, the fly is likely to collect nectar from moderately sized flowers with partially concealed nectar. Theobald mentions (*Second Report on Economic Zoology*) having found a Tachinid in a cage in which Tipulæ were being reared, but from this indefinite reference one can only regard the identity of the species as probable.[1]

The Larva.

The internal structure of the larva has not been examined. The largest examples found measured 7 mm. in length, by $1\frac{3}{4}$ mm. at the broadest part of the body. At each segment the body is encircled by four rows of

[1] The following records have since been found in Brauer und Bergenstamm: Die Zweiflüger des Kaiserlichen Museums Zu Wien. Denk. Akad. Wiss. lxi. Bd., 1894, p. 537.

Siphona (*Bucentes*) *geniculata* (Fll. Rdi Ins. p.) in *Mamestra brassicæ* L.

Siphona (*Bucentes*) *cristata* (Beling. Verh. K. K. Zool. bot. G. 1886, 171) in *Tipula gigantea*, Schrk.

minute hooks. There are two sets of spiracles (amphipneustic). The pair at the hinder end of the body is shortly bilobed, the anterior pair, in line with the mouth, is fan shaped and eight-lobed. An interesting fact is that in a number of cases the larva, when found, was holding on firmly to one of the larger tracheal trunks of the host, by means of its hooks. Unfortunately so far the exact relations to the tracheal system have not been made out, and the fact just recorded may have no particular significance. But it may be recalled here how, in the case of *Ugimyia sericaria*, a Tachinid parasite of the silkworm caterpillar in Japan, the maggot early "enters the tracheal system, boring into a tube near a stigmatic orifice of the silkworm, where it forms a chamber for itself by biting portions of the tissues and fastening them together with saliva. In this it completes its growth, feeding on the interior of the silkworm with its anterior part, and breathing through the stigmatic orifice of its host" (Sasaki: quoted from Sharp, Camb. Nat. Hist.). The maggot in the Tipula larva was never found near the stigmata, which are terminal, but was always situated in the middle region of the body. It may also be mentioned here that in several cases two maggots were found.

The hook apparatus of the maggot is moderately complex and may be briefly described. There is a large basal plate bearing a pair of wings or lateral plates with rounded posterior margins. In front of the median plate lies the hook apparatus proper. This consists of a ladder-like arrangement of cross bars bearing at its anterior end a pair of hooks. These hooks have a pair of rounded extensions at their base directed both forward and backward.

(*Issued separately, 22nd January* 1912.)

XXV.—An Aid in the Study of Nematocysts. By T. H. Taylor, M.A.,

Zoology Department, University of Leeds.

(Received 23rd October 1911. Read 27th November 1911.)

Although nematocysts have long been a favourite study with zoologists, there are still many obscure points concerning their structure, function and development, and it is perhaps beyond the reach of any one investigator to give from all points of view a clear and convincing account of these interesting objects. The present note on the subject aims merely at devising an experimental method of studying the process of eversion.

With regard to the structure of the filament itself, there is some difference of opinion as to whether the free end is open or closed. The uncertainty on this point is perhaps due to the fact that nematocysts, at time of discharge, frequently fail to complete the process of eversion, in which case the real end of the filament does not become exposed to view. Moreover, even when eversion is completed and the terminal part of the filament fully extended, the fineness of detail exhibited by this region renders it difficult for the eye to determine whether or not there is an aperture at the end. Failing more direct evidence we may, however, infer from the following considerations that a filament, when completely everted, opens freely to the exterior :—(1) When, as sometimes happens in a favourable preparation, the filament completes its eversion *in air* under a cover-glass, the fluid contents, when passing out, collect into a pool on the glass surface. (2) The forcible ejection of the fluid, setting up eddies in the preparation, scatters any particles which happen to be near the end of the filament. (3) The secretion contained in the capsule, when stained, can be seen to pass through the filament and flow out at the end. (4) Further indication is afforded by the fact that the secretion has the property of precipitating certain dyes. Thus, for example, in Hydra, when the capsules are exploded in a dahlia solution, a little cloud of precipitate immediately appears at the end of each filament. Although it is clear from these facts that a filament when fully everted terminates in an aperture, there is, it should be added, no evidence to show that this is also the case before eversion, when the filament is still coiled up within the capsule.

The large nematocysts of certain Actinians are, in the fresh condition, very favourable for study, and when, as often happens, they become isolated in the field, a good opportunity is afforded of watching how the capsule and filament each behave during discharge. The observer, confining his attention at first to the capsule, can readily ascertain the precise stage in the process at which the fluid secretion becomes ejected to the outside. For at this moment the capsule, hitherto stationary, suddenly jerks forward and begins to shrink in size. The characteristic bright appearance soon fades away, and finally the capsule, spent and shrunken, shows faintly-outlined and dull. In the case of the filament, also, the ejection of liquid is accompanied by a loss of brightness and a diminution in size. More interesting, however, is the sudden and vigorous recoil which occurs in the terminal region, and which frequently flicks the extremity out of sight. In fact, the filament behaves in this respect precisely like a piece of rubber tubing which, having been clamped at one end and distended with water, suddenly, on being freed from restraint, contracts to its normal size. When, on the other hand, eversion is only partial, the fluid contents are not expelled, and in consequence the filament does not recoil,

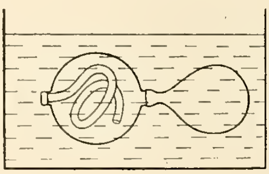


Fig. 1.
Before discharge.

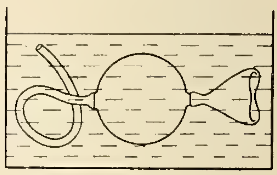


Fig. 2.
After discharge.

nor does it alter in size or optical appearance. It differs, moreover, from one which is completely everted in being as a rule spirally coiled.

In Hydra, which is generally taken as a type for elementary study, the nematocysts expel their contents with such rapidity that the process of eversion cannot be followed. For teaching purposes, therefore, it has been found useful to illustrate, by means of a model, the relation of the filament to the capsule and the mode of discharge.

A rough model, adapted for use under water, consists (Figs. 1 and 2) of a glass receiver fitted with a rubber bulb—the two together representing the capsule—and of a flexible tube which is open at both ends. The receiver is of 250 cc. capacity, and is provided with a pair of opposite tubulures. To one of these is attached the rubber bulb, which is of about the same capacity as the receiver itself; and over the other is fitted the flexible tube which, in default of anything better, consists of a piece of fresh gut. The place of the fluid secretion is taken by a coloured liquid, which is introduced into the receiver through a third orifice (not shown in the figs.). When ready for use the model is submerged under water, care being taken to exclude all air. The bulb is fully expanded and the tube, turned inside out, is retracted into the receiver (Fig. 1).

When, in order to illustrate the process of discharge, the rubber bulb is compressed, the water which is thereby displaced tends to escape through the inturned tube. Owing, however, to the fact that its walls are flexible and collapse under the pressure, this outlet closes and the water is unable to get through. As a result the tube becomes everted to the outside (Fig. 2), the process beginning at the place where the part which is fitted over the tubulure doubles back into the receiver.

This experiment indicates that in a nematocyst, previous to discharge, the pressure of the fluid contents of the capsule squeezes the filament into a "thread"; and, further, that subsequently during discharge the same pressure, acting, however, in the opposite direction, distends the thread, as it becomes everted to the outside, into a hollow thin-walled "tube." The mechanical effect of this arrangement is, no doubt, to facilitate the process of eversion by providing a clear space for the passage of the thread as it pays out from the capsule.[1]

Besides illustrating the process of eversion, the experiment seems also to throw light upon the condition of the nematocyst itself. Assuming that the wall of the capsule is elastic—which is probably true—we may infer that a nematocyst, before it is discharged, is distended beyond its natural dimensions. For supposing that, instead of being distended in this manner, the capsule possesses its natural size, then it is plain that discharge can only be effected by external pressure contracting the capsule and driving out the contents, and that, when the external pressure is removed, the capsule in returning to its original shape will tend to draw the filament back into its former position. That this takes place, when a capsule with elastic walls is compressed, is readily seen on referring to the model. So long as the rubber bulb is kept under pressure, the tube remains extended. When, however, the pressure is released, the elastic recoil immediately comes into play and sucks the tube back again into the receiver (Fig. 1). In a nematocyst, on the other hand, the filament, after eversion has been accomplished, is not withdrawn but remains permanently extended,[2] and

[1] The curious movements of the filament, which are observable during eversion, both in the "skein" (which spins round as it unwinds) and in the "thread" (which appears to vibrate as it runs out through the "tube") cannot be reproduced in this form of model—a much more exact copy of a nematocyst being required for the purpose.

[2] An exception is said to occur in the case of Millepora, in which the filament is stated to be retractile (Willey, *Zool. Results*, pt. ii., 1899, p. 127 ; Hickson, *Camb. Nat. Hist.*, vol. i. p. 248). In this form, moreover, the filament when in the expanded condition is, if one may judge from the published figures, closed at its free end (Willey, *loc. cit.*, pl. xvi., fig. 1 ; *cf.* also Moseley, *Challenger Reports*, vol. ii., pl. xiii.-[Hydrocorallinæ] fig. 1).

we are led to infer that expulsion of the contents is not due to external pressure acting on the capsule, but is caused by the walls shrinking to their natural size after having been stretched.

A resting nematocyst may therefore be regarded as possessing a state of unstable equilibrium, the capsule being over-distended and the fluid secretion in a state of tension. From this point of view, discharge is initiated by the breaking down of the resistance which maintains this unstable condition.[1]

It will be seen that this experiment with the model, as well as the deductions drawn from it, is based upon the view that the immediate cause of the discharge lies in the contraction produced by the surrounding cell. On the view that discharge is due to osmotic pressure set up within the capsule, the argument for the state of unstable equilibrium is less satisfactory. It rests, in fact, only on the observation that the parts of the nematocyst shrink in size when the fluid contents are being expelled. It may, however, be pointed out, as perhaps lending some support to the suggestion, that a tense condition in the nematocyst would help to explain the surprising rapidity with which discharge is usually accomplished.[2]

The action of osmotic pressure in everting a flexible tube may be illustrated by the following experiment. A glass tube, A (Fig. 3), referred to in the description as the carrier, is securely fitted at one end into the stem of a funnel, B, and at the other end into one of the tubulures of a glass receiver, C. To the end of the carrier which projects into the receiver is fitted the flexible tube, a piece of fresh gut serving the purpose. The osmotic cells employed consist of cylindrical parchment dialysers, E and E′, each being closed at both ends with rubber corks, and of about 800 cc. capacity. Two of these are shown in the fig., but the number can be readily increased. The dialysers are nearly filled with a saturated solution of common salt, and are then connected, by means of an inverted Y-tube, with the lower orifice of the receiver. By temporarily disconnecting the glass carrier, more salt solution is then added until, having filled the dialysers, it passes up through the connecting tube into the lower part of the receiver. Finally, the remainder of the receiver, the carrier and the funnel are each in turn filled with tap-water, which is used instead of salt solution in order that the flexible tube may hang down freely. The experiment is started by immersing the dialysers in jars of distilled water, F and F′. As soon as the salt solution begins to absorb water, the parchment membranes become stretched and an upward flow

[1] The mechanism upon which the resistance depends is probably, in part at least, to be found in the valve-like processes situated at the junction of the capsule and filament.

[2] A contributory factor is no doubt the tapering form of the filament.

of the solution takes place. The pressure which is thus produced is transmitted to the receiver, and, as in the case of the model described above, causes the sides of the flexible tube to collapse together. As the pressure increases, the wall of the tube, at the point where the free and the attached portions join, becomes folded into the interior of the carrier, the process continuing until the tube, turned inside out, is extended upwards and opens freely into the funnel.

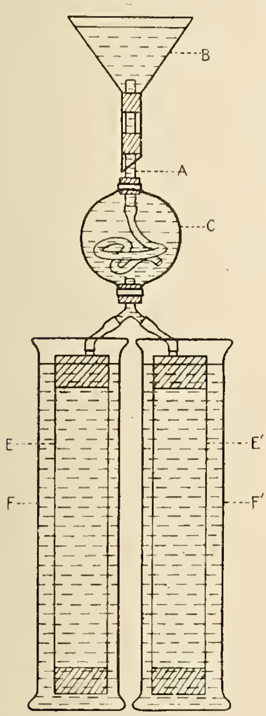


Fig. 3.
Apparatus for Osmotic Experiment.

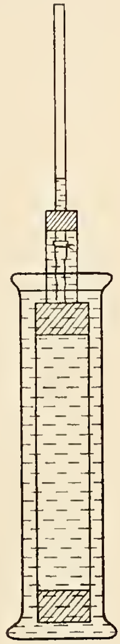


Fig. 4.
Apparatus for Simplified Osmotic Experiment.

The tension of the nematocyst is readily illustrated in this experiment by corking the upper end of the glass carrier, the effect of which, besides preventing the eversion of the tube, is still further to distend the dialysers.

The above experiment can be considerably simplified by delivering the flexible tube directly into the dialyser (Fig. 4). In order, however, that the process of eversion may be seen, the carrier is first telescoped into a wider glass tube which in turn is fitted into the rubber cork of the dialyser. The funnel is in this case unnecessary, provided that the carrier is made long enough to hold the flexible tube, when it is fully extended.

Summary.

1. In a semi-discharged nematocyst, when fresh, the true end of the filament is concealed from view, and in consequence its structure cannot be ascertained.

2. When the process of eversion is complete, the fluid contents are expelled from the end of the filament, which, presumably, at this time opens freely to the exterior.

3. A resting nematocyst is over-distended and in a state of tension.

4. Experiments with flexible tubes are useful for illustrating in detail the process of eversion.

(*Issued separately, 25th January* 1912.)

XXVI.—Note on Pelagic Organisms and Evolution. By J. Graham Kerr.

(Received 27th November 1911. Read 27th November 1911.)

We may probably accept as a general principle that evolutionary change is to a great extent a function[1] of environmental change. So long as the environment remains constant evolution will consist in better and better adaptation to that environment, and no fresh evolutionary path will be struck out.

This principle is of importance when applied to animals which lead a pelagic existence, for a pelagic environment is probably the type of environment which shows less change than any other.

Change of environment may be either of two kinds; it may be temporal or spatial. It may consist in actual change, during the course of time, in the environmental conditions (*e.g.* geological, climatic, bionomical) of a given area. On the other hand, it may consist simply in the transference of the organism in space from one set of environmental conditions to another, *e.g.* change from a terrestrial to an arboreal habit, from life in forest to life in open plains, from life in salt water to life in fresh water, and so on. Now it is clear that with regard to each of these two possible types of environmental change the waters of the ocean away from land and away from the bottom form an environment of extraordinary constancy. Organisms inhabiting them have probably less chance than any others of becoming subjected to changed sets of conditions. It follows then, if the principle enunciated above be a correct one, that pelagic organisms will on the whole tend to evolve merely towards a condition of better and better adaptation to the pelagic environment and that the probabilities are against their striking out new lines of descent.

On such grounds it seems to me essential to exercise the greatest caution in suggesting or in accepting as probable any hypothetical line of descent for an existing group of organisms which derives them from a pelagic ancestor.

A like caution is demanded in interpreting resemblances between pelagic organisms, more especially pelagic larvæ, as expressions of genetic affinity rather than of adaptation to the same set of environmental conditions. Perhaps the need for such caution may be best illustrated by considering a few of the lines along which, on the principle of adaptation, we might expect, *à priori*, pelagic larvæ to evolve.

[1] I use the word in its mathematical sense.

It is very usual for ciliated larvæ to have at first a uniform coat of cilia all over, and it is very generally admitted that this is, in all probability, the primitive condition. Along what lines then should we expect such larvæ to evolve?

The first step we should probably expect to be the establishment of a definite axis along which movement takes place, *i.e.* the larva would take to moving in a particular direction so that an anterior and a posterior pole would be distinguishable. Such development of polarity is one of the first steps in the evolution of the great majority of animals. Now it will carry with it certain consequences. If we start from a larva having the simplest possible shape—that approximating to a sphere—the establishment of a definite axis of movement will mean that the cilia placed round the equator will be most favourably placed for producing onward movement. We should therefore expect that the process of evolution would be in the direction of exaggerating the equatorial cilia and reducing the others. Though comparatively useless for propulsion the cilia at the posterior pole would, on the other hand, be effective for steering. We might therefore confidently expect the evolution of a larva ciliated only round the equator, with possibly a ring or tuft of cilia close to the posterior pole. If an alimentary canal were present we should obviously expect the anus to come to be situated at the posterior pole so that fæcal matter might be left behind. We might, perhaps, also expect the mouth to come to be placed in the region of eddies just behind the equatorial ring of cilia. If the skin were to develop sensitiveness, we should expect this to take place especially at the anterior or apical pole. If excretory organs were developed, we should expect these to open towards the hind end.

As is well known one of the best known types of larvæ, the Trochosphere, answers exactly to these expectations. Much weight is attached to the occurrence of such a larva in different groups as evidence of genetic affinity. My object is rather to emphasise the fact that the very features which serve to characterise the Trochosphere larva, and which are often interpreted as expressive of genetic affinity, are quite satisfactorily explicable as simply adaptations to the pelagic mode of life.

Now in what direction might we expect further evolutionary progress to take place? Clearly one of the most natural directions would be towards increased efficiency of the locomotor apparatus. But how can this be brought about? Obviously not, at least beyond narrow limits, by mere increase in the size and power of the individual cilia. The only other possible method is by increase in the number of cilia. This necessarily involves the increase in length of the ciliated band, and this in turn involves the ciliated band coming to describe a folded rather than a purely equatorial course. Evolution in such a direction is exemplified by numerous larval forms—*e.g.* by the Auricularia, in which the ciliated band merely meanders about on the surface of the body; by the Bipinnaria, in which it extends out on to short, thick lobes of the body; and by the Actinotrocha larva, or the Echinopluteus, or Ophiopluteus, in which it is carried out on long slender processes such as reach their maximum development in forms like the Spatangoid pluteus or the Ophiopluteus of *Ophiothrix fragilis.*

We should expect larvæ in which the ciliated band meanders about on the surface of the body to serve as the starting-point for a further series of evolutionary changes. For in such meandering bands those parts of the bands are placed advantageously, so far as causing movement is concerned, which are placed most nearly perpendicularly to the axis of movement. Such parts of the band may therefore be expected to undergo exaggeration, to become more strongly developed than parts of the band placed less advantageously. Indications of such a process are seen in the tendency of a few of the Ophioplutei to form "epaulettes," and in the Auricularia while metamorphosing into the barrel-shaped larva.

These few examples are perhaps sufficient to serve the purpose of this note—to accentuate the importance, before making use of any pelagic organism for purposes of phylogenetic speculation, of assuming a particularly critical attitude in considering to what extent its characteristics may be merely adaptive in their nature.

(*Issued separately, 26th January* 1912.)

XXVII.—"Scotia" Collections—Further Note on Microscopic Life on Gough Island, South Atlantic Ocean — Rhizopoda. By Dr Eugène Penard, Geneva. (Communicated by William Evans, F.R.S.E.).

(Read 18th December 1911. Received 24th January 1912.)

[Explanatory Note by W. Evans. In the summer of 1907, shortly before his departure for the Antarctic, Mr James Murray examined, for micro-organisms, a small tuft of moss brought from Gough Island, in the South Atlantic Ocean, by the Scottish National Antarctic Expedition of 1902-4. Not having time to examine the material exhaustively, Mr Murray passed on the residue (contained in one small bottle) to Dr E. Penard for more thorough examination. Mr Murray's report was communicated to this Society in November 1907, and published in the *Proceedings* early in the following year (vol. xvii. p. 127). In April 1908, Dr Penard sent to Dr Bruce the following account of the species he had found in the material received from Mr Murray.]

List of Rhizopoda, etc., found in Moss-residue from Gough Island.

The following is a list of the Rhizopods I found in the material received from Mr Murray:—

Arcella discoides, Ehrbg.—One specimen, very small.
Parmulina brucei, spec. nova (see p. 245).—About ten specimens.
Difflugia constricta, Ehrbg.—One specimen.
Euglypha ciliata, Ehrbg.—Rare.
,, *compressa*, Carter.—Rare.
,, *laevis*, Perty.—I refer to this species, though doubtfully, moderately numerous, very small and very broad specimens with fine and distinct alveoli.
,, *strigosa*, Leidy.—Rare.
Helcopera petricola, Leidy.—Large, clear, very light pink colour; very likely this is the species found by Murray, but it differs from var. *amethystea*, Penard, which is still larger.
Nebela caudata, Leidy.—One specimen only.
,, *collaris*, Leidy.—Rather abundant;[1] in several forms (as a rule small).

[1] When I say "abundant," it is only "relatively" to other species, for in fact the specimens were few compared with the average "richesse" of mosses or Sphagnum.

Phryganella hemisphaerica, Penard.—Rare.
Sphenoderia fissirostris, Penard.—Not very rare.
Trinema enchelys (Ehrbg.).—Not rare; always very small form, as generally found in mosses.
„ *lineare*, Penard.

Such are the Rhizopods I found in the Gough Island material. They are few in species, and each species is poorly represented in numbers, yet this note may be of some interest, and for several reasons :—

1. All are species found in Europe (except one, *Parmulina brucei*), and did not differ in appearance, except that they were perhaps on the average a little smaller.
2. They represent, most of them, the typical fauna of mosses, but the scarcity (one specimen only) of *Difflugia constricta*, a species always so abundant in mosses, is remarkable.
3. With the exception of the above, no Difflugias were observed. Murray found one "*Difflugia* spec.," but it was very likely *Phryganella hemisphaerica*. In Europe, and indeed everywhere, Difflugias (except *constricta*) are rare in mosses.
4. One species has never been found before, namely *Parmulina brucei*, nov.; but it will probably be found somewhere else one day or other.[1] I append a description of this species, or rather of its envelope, which was the only part of the organism available. I have taken the liberty of naming it *brucei*, after the leader of the "Scotia" expedition.

For other organisms besides Rhizopods I did not look specially, but I found the following:—A small rotifer (*Brachionus*?), about twenty specimens of *Callidina angusticollis*, Murray, a small diatom which was abundant (*Meridion* sp.), and a good many samples of *Merismopedia*—very likely that "blue-green tabular Alga, with the cells grouped in multiples of four," which Murray mentions.

Parmulina brucei, spec. nova.

Enveloppe chitineuse, jaunâtre, en forme de pyramide ou de cône tronqué, à base deux fois environ aussi large que le sommet. De ce sommet, ou plateau dorsal, partent un certain nombre d'arêtes (14 à 16

[1] I have this year (1911) found this same species, though very likely a special variety of it, in mosses collected by Dr Fuhrmann at an altitude of 3000 metres, on the Andes of America (Colombia).

en moyenne), qui descendent vers la face ventrale, et divisent la surface de l'enveloppe en partitions ou facettes à peu près égales.[1]

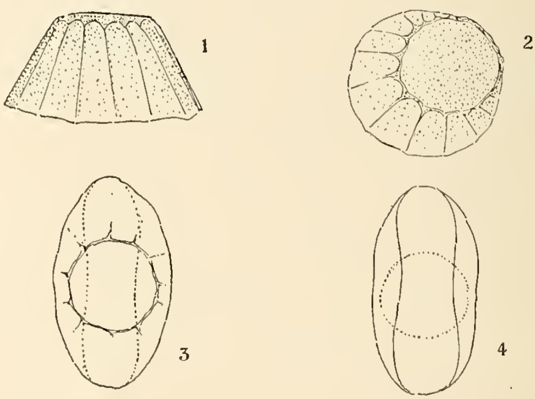
La surface de cette enveloppe est couverte de ponctuations très-nettes, serrées les unes contre les autres, disposées régulièrement.

A partir de l'arête dorsale, la membrane devient toujours plus claire et plus mince, et elle finit par ne plus être qu'une pellicule très-fine, qui se replie brusquement en dedans sur la face ventrale pour border le plasma.

Cette enveloppe est peu déformable, mais peut cependant se refermer sur elle-même, en rapprochant ses bords comme deux lèvres; mais le plateau dorsal, plus rigide, ne prend pas part à la déformation.

Noyau ?

Vesicule contractile ?



PARMULINA BRUCEI.

FIG. 1. Enveloppe, vue de côté.
,, 2. Enveloppe vue de trois quarts, par le plateau dorsal.
,, 3. Enveloppe fermée sur elle-même, vue par le plateau dorsal.
,, 4. La même, vue par la face ventrale.

Diamètre à la face ventrale . .	125–150 μ.
Diamètre du plateau dorsal . .	65– 80 μ.
Hauteur dorso-ventrale . .	70– 80 μ.

Localité.—Gough Island, Mer du Sud, dans les mousses.

[1] Il est possible cependant que ces arêtes ou facettes n'existent pas toujours; elles manquaient dans les exemplaires trouvés plus tard dans les Andes. Dans cette dernière station (Parano, Cruz Verde; Colombie), d'ailleurs, on pouvait constater d'autres différences, surtout dans les ponctuations caractéristiques du plateau dorsal, et peut-être y a-t-il là une variété spéciale.

Obs.—Le genre *Parmulina* est très-proche voisin du genre *Corycia*, au quel j'avais cru tout d'abord devoir rapporter l' organisme de Gough Island ; mais tandis que dans les *Corycia* nous avons une sorte de sac, très souple, très-déformable, ici la membrane est plus forte, presque rigide sur la face dorsale, susceptible de se fermer sur elle-même à la manière d'un chapeau dont on rapprocherait les deux bords, mais pas de se déformer complétement. Probablement aussi le plasma est-il différent, recouvert peut-être d'une pellicule membraneuse. Ce genre, du reste, est encore très-mal connu ; on a quelques renseignements sur la *Parmulina cyathus*,[1] mais la *P. brucei*, qui n'a pas été étudiée à l'état vivant, demande à être revue de plus près.

[1] Penard, "Sur quelques Rhizopodes des mousses," *Arch. für Protistenk.*, vol. 17, fasc. 2, 1909, p. 286.

(*Issued separately, 23rd March* 1912.)

XXVIII.—On *Docophorus bassanæ*, Denny, and *Lipeurus staphylinoides*, Denny. By James Waterston, B.D., B.Sc.

(Received 19th January 1912. Read 22nd January 1912.)

In the *Monographia Anoplurorum Britanniæ* (London, 1842), Denny describes and figures *Docophorus bassanæ*[1] from the Gannet (*Sula bassana*), and in dealing later with the genus *Lipeurus*, introduces as a new species *L. staphylinoides*[2] from the same host. Piaget (*Les Pediculines*, Leide, 1880, vol. i.) treats *L. staphylinoides* as a variety of *L. pullatus*, Nitzsch.[3] "Le *L. staphylinoides* de Denny provenant d'une *S. bassana* me parait une simple variété où les taches de l'abd. mâle sont toutes transverses."

The form named by Denny, *D. bassanæ*, seemed to him so variable as to merit two figures. After describing two stages he says, "I am induced to consider these two insects, although differing considerably at first sight, as the adult and immature state of the same species. I had drawn both and committed them to copper under the impression that they were specifically distinct, but since, upon examining many specimens taken from recent birds, I find such varieties in size, proportion, markings and colour, as to convince me that the fig. 3 of plate 7 is nothing more than the last moult but one; many specimens in still earlier stages exhibit a greater diversity of appearance, and it is only by comparing a series that the identity of the whole can be inferred, sometimes the fasciæ are without the notch, at other times pale brown and extending nearly across the abdomen."

Piaget, who also evidently felt some difficulty in dealing with *bassanæ*, places it, with *brevimaculatus* and *dubius*, last among the species of *Docophorus* which he had personally examined. It forms, in his opinion, a distinct type in the genus, but he adds that *bassanæ* is "only half known" to himself, presumably because he had seen but one sex.

Through the courtesy of Mr A. M. Rodger, The Museum, Perth, I have recently had submitted to me a series of Gannet parasites, amongst which both the species under discussion are represented. There is one adult male of *L. pullatus*, N., which is normal in having the first four abdominal fasciæ mesially divided. There are besides several females corresponding exactly with Piaget's figure, and a number of other examples which are as plainly the insect named *bassanæ* by Denny.

[1] Pp. 110, 111, pl. vi. fig. 3, and pl. vii. fig. 4.
[2] Pp. 180, 181, pl. xv. fig. 2.
[3] P. 340, pl. xxvii. fig. 9.

To any one going over the latter material, the justice of Denny's remark as to the variability of *bassanæ* is evident. But it seems clear, on detailed examination, that the mature form to which the juvenile (and typically *bassanæ*) stages lead up is simply the female of *pullatus*.

One or two points in support of this conclusion may be noted.

1. No one apparently has seen the *male* of *bassanæ*.

2. As regards the female, Denny has figured an adult which *might* stand for the known female of *pullatus*. Piaget figures the immature stage of *bassanæ*, and naturally finds that the genital marks are indistinct.

3. As regards *pullatus*, Piaget, who figures the terminal segments of the female, makes no remark as to the frequency or infrequency of the occurrence of this sex. Denny says that the female of his *staphylinoides* is so rare that he has seen one example only. Possibly his identification of the sex was erroneous. More probably, as it seems to the writer, Denny, having taken as the type of *staphylinoides* a male in which the abdominal bands were continuous,[1] looked for a similar female to match it. The usual females, with two quadrate spots on each abdominal segment, being left unaccounted for, were correctly attributed to the younger stages and became *D. bassanæ*.

4. The chætotaxy of the head (to take one special region), so carefully detailed by Piaget, reads in the case of *pullatus* practically as in *bassanæ*. There is given for *bassanæ* one temporal spine less than for *pullatus*. But undoubted *bassanæ* in this Perth material show the spine not noticed in Piaget's description.

5. Most *Docophori* have a fringe of hairs on the posterior margin of the metathorax, while many species of *Lipeurus* show a fascicle of long hairs rising from a single or double pustule at the postero-lateral angle. This fascicle is pronounced in *pullatus* and is found also in *bassanæ*.

6. Piaget speaking of *bassanæ* makes a significant remark. "Les pattes par suite de leur insertion au bord du thorax et par la plus grande longuer du trochanter, rappellent par leur confirmation celles des *Lipeuri*." But he takes no further step. No more material seems to have come into his

[1] Piaget, as noted already, makes this a var. of *pullatus*. But it may also be an old stage of the type. In the Christmas Island material referred to, there are adults of both sexes with the abdominal bands divided and others with them all entire. Various gradations occur, and the more continuous are the bands the darker is the coloration, so that specimens with no trace of a median furrow on the abdomen are almost black. Two *Lipeuri* closely related to *pullatus* occur commonly in Scotland, viz., *L. brevicornis*, Denny, and *L. longicornis*, P. They are found respectively on *Phalacrocorax graculus* and *P. carbo*. In both species the females, when newly adult, show on the abdomen a broad, clear median space which darkens afterwards so that the segments show a band divided into three quadrate spots, by two narrow lines.

hands in the interval between the publication of the *Essai* (1880) and that of the *Supplement* (1885). Consequently *Docophorus bassanæ*, D., was included by Kellogg in his list of Mallophaga (1908).[1]

7. One further point may be mentioned. On the postero-ventral aspect of the tarsus of *pullatus* (well seen on the mid and hind legs) is an almost apical group of peculiar broad spines which are slightly hooked at the end. These, somewhat less developed, reappear in *bassanæ*.

While examining this material from *Sula bassana* it occurred to me to make a comparison with a long series of *Lipeurus* from a "Booby Bird" (*Sula* sp.) from Christmas Island. This is a large form, perhaps new, closely related to *L. annulatus*, P., and *L. pullatus*, N. Here again one finds a *bassanæ*-like juvenile stage. The tarsal hooks (see 7 above) are replaced by stout, straight bristles, and the juvenile changes in this respect also.

It would seem then that *D. bassanæ*, D., and *L. staphylinoides*, D., are conspecific with *L. pullatus*, N.

Mr Wm. Evans, in recording (*Ann. Scot. Nat. Hist.*, 1906, p. 87) the occurrence of both sexes of *L. staphylinoides*, D., from St Kilda, made the remark that the females bore a close resemblance to Denny's figure of his *Docophorus bassanæ*. I find on inquiring that Mr Evans had then reached the above conclusion, though he did not publish his result. I am glad to have the support of his valuable opinion in a matter where accuracy is so desirable.

[1] Kellogg, in Wytsman's *Genera Insectorum*, 66[me.] Fascicule, "Mallophaga," p. 10, species 25. Kellogg gives as host, "*Sula bassana* (Great Britain) and the Gannet (United States of America)," so that the duplication of *pullatus* must exist in the American literature also.

(*Issued separately, 9th April* 1912.)

XXIX.—Description of a New Species of Hydracarina—*Piersigia intermedia.* By Wm. Williamson, F.R.S.E.

(Received 12th February 1912. Read 26th February 1912.)

For some reason, which is not apparent, errors have been made in the description and figures of *Piersigia limophila* Protz, and these unfortunately have found their way into works such as Piersig's "Deutschlands Hydrachniden" (*Zoologica*, Heft xxii.). A rectification of these, it is anticipated, will appear before long, as the collections of Hydracarina made by Protz are at present undergoing revision by Dr Karl Viets, of Bremen, to whom I may here express my indebtedness for access to the type slides of *Piersigia limophila* Protz and *P. koenikei* Viets. Although the first British specimen of *Piersigia* differed in some measure from the then accepted type description and figures, it was recorded (*Naturalist,* 1903, p. 111) as *P. limophila* on the authority of the late Dr Piersig, who had by that time seen the type and had agreed that it was inaccurately described. After a careful examination of that specimen, as well as of later material, I find that the British specimens possess characters distinguishing them from *P. limophila* and *P. koenikei,* and as they appear to represent an intermediate form, I propose to describe them as *P. intermedia* mihi. In comparison with the other two species, I have observed that in a great measure the dorsal surface of the new species resembles that of *P. koenikei,* and the ventral surface that of *P. limophila,* and that while the genital acetabula of these species appear to possess rather cylindrical stalks, the acetabula of the new species are pyriform.

Noticeable features. of the specimens of *Piersigia* which I have seen, are the length of the gland orifices partially protected by the porose plates, which are very conspicuous especially towards the body margin, and the rather constricted appearance of the third segment of the first three pairs of legs.

Piersigia intermedia *nom. nov.*

Syn.—1903. *Piersigia limophila,* C. F. George, "Naturalist," pp. 111, 112, figs. 1-8.

Female : *Body.*—Elliptical, dorso-ventrally compressed. Length, 2·40 mm.; breadth, 1·92 mm. Colour scarlet with dark patches on the dorsal surface; legs a little paler than the rest of the body. Skin finely ridged, with a sub-cuticular network of chitinous threads. Palpi, legs and epimera porose.

Dorsum.—With a number of symmetrically arranged perforate plates with thick margins, and sclerites. Along each side of the dorsum 6-7 large polygonal plates, and between these plates four ligulate sclerites. Closer to the median line and on each side of it, three ligulate sclerites with a lunate perforate plate and gland aperture on the inner side of each. Nearer to the centre of the dorsal surface a pair of triradiate sclerites, behind these a pair of ligulate sclerites, with another posterior thereto in the median line.

Eyes.—Each capsule, with its double eyes, lying about ·45 mm. apart on the lateral margins of the cephalo-thoracic plate.

Cephalo-thoracic plate.—Composed of a fan-shaped framework of narrow chitinous slips, the intervals between these being for the most part not specially chitinised. Area surrounding each of the gland-pores, particularly on the anterior margin, the bases of the eye-capsules, and the area enclosed by the posterior process, all distinctly porose.

Capitulum.—Breadth at the base about ·29 mm., length about ·33 mm., more or less porose, rather thickset in appearance and without a rostrum. Mouth, having a diameter of ·14 mm., situated at the extremity of the capitulum. Mandibles short and thick, with claws bent almost at right angles; each claw terminating in a small rounded process.

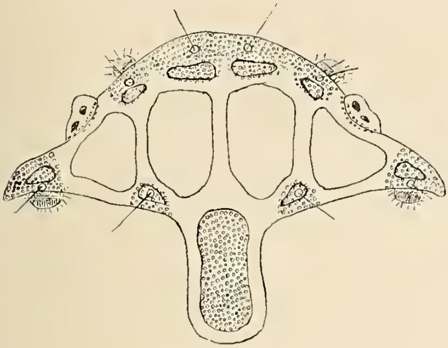
Palpi.—Length of segments from base to tip respectively ·028, ·094, ·132, ·122, ·085 mm. Second and third segments with distal end nearly twice as thick as proximal; terminal segment slightly set into the penultimate one. Inner distal margin of third segment with a row of 6-7 pectinate bristles. Near the middle of the fourth segment, a long fine hair on the flexor surface and one on the extensor surface. Distal end of fifth segment blunt, without claws, with 4-5 long hairs and several smaller ones.

Epimera.—In four groups, two on each side, with an interval of nearly ·28 mm. between the second and third pairs. Fusion of the inner margin of the first and second pairs incomplete. Third pair reaching much nearer to the median line than the almost triangular fourth pair. Posterior angle of fourth pair with a narrow chitinous process.

Legs.—First pair, 1·09 mm.; second and third pairs, 1·27 mm.; fourth pair, 1·53 mm. Claws moderately curved, simple. Without swimming hairs but with numerous spines and bristles; the whorls of spines on the distal end of the middle segments of the first three pairs of legs for the most part pectinate.

Anus.—Situated close to the anterior margin of a large, more or less elliptical, porose plate; margin of plate rather thick.

FIG. 1.



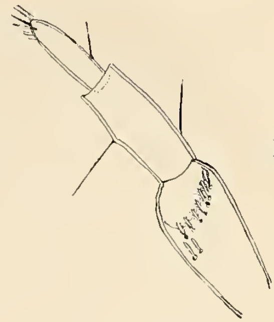


FIG. 2.

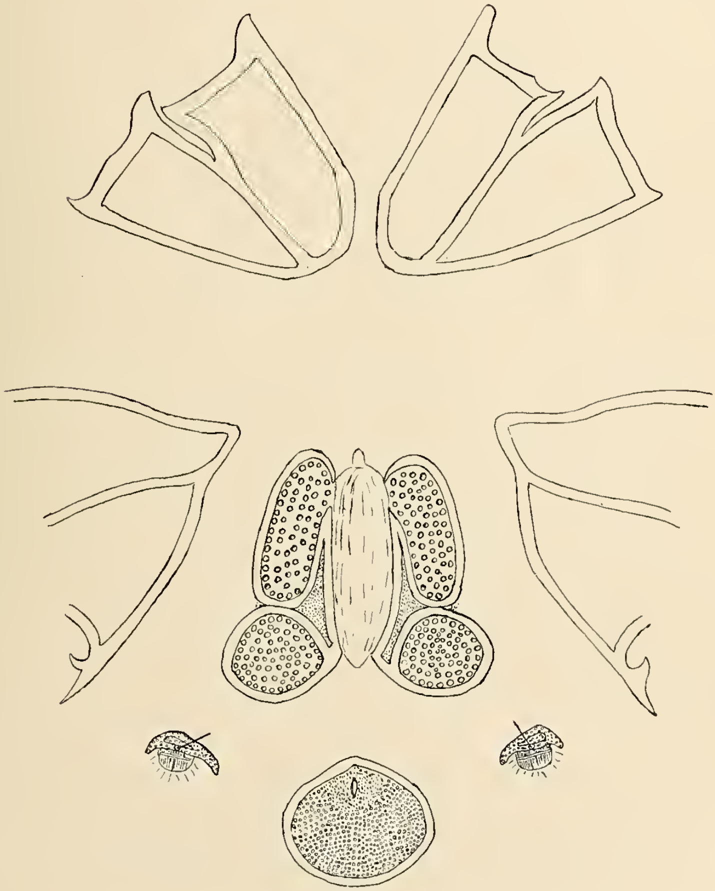


FIG 3.

FIG. 1. Cephalo-thoracic plate, showing two gland orifices on the anterior margin and two on the posterior.

„ 2. Inner side of third, fourth, and fifth segments of right palpus.

„ 3. Epimera, genital area and anal plate. The pores on the epimera are not shown.

Genital Area.—Lying midway between the posterior groups of epimera. Length, ·43 mm.; breadth at the anterior end, ·23 mm., at the posterior end, ·47 mm. Anterior plates elongate, with interrupted inner margin, each with 51-64 acetabula. Posterior plates more or less rounded, each with 62-75 acetabula. Acetabula pyriform. Free area, between the plates and the outer margin of lips of vulva, with many fine pores.

Male and life-history unknown.

Distribution.—England; found by Mr C. F. George, M.R.C.S., in the parish of Manton, near Kirton in Lindsey, Lincolnshire, in 1902, and by Mr C. D. Soar, F.L.S., in the Norfolk Broads in 1905.

(*Issued separately, 24th April* 1912.)

XXX.—Note on Arctic Palæozoic Fossils from the "Hecla" and "Fury" Collections. By G. W. Lee, D.Sc.

(Read 18th December 1911. Received 1st March 1912.)

Extensive as it is, our knowledge of the geological structure of the Polar regions depends more on the observations and reports of explorers than on the systematic study and descriptions of materials brought home. Considering the large number of explorers' reports—a useful list of which is given in "The Cruise of the Neptune"[1]—a short contribution like the present one might at first sight appear superfluous. Closer scrutiny will, however, show that of these reports but a scanty proportion is devoted to the description of the fossils on which subsequent generalisations have been based. Designations formerly thought sufficient are now too broad for the requirements of modern geology: the mention of the occurrence of Upper Silurian, though of great interest, could hardly be used as a datum in detailed palæogeographic correlations.

These remarks do not imply that the present note embodies results of immediate importance in stratigraphic research, but the fauna examined being striking in several respects, it is felt that a knowledge of its nature ought to be made available to workers on Arctic geology, and the following account has been prepared with that end in view.

On two occasions fossils were brought by Parry from the Polar regions, namely, during his first and third cruises in 1819-20 and 1824-5, respectively. Of the former a brief account was given by König in *A Supplement to the Appendix to Captain Parry's Voyage*, London, 1824, while a few remarks on the second lot, due to Jamieson, are incorporated in the *Appendix to the Journal of a third Voyage for the Discovery of a North-west Passage*, London, 1826. The second collection found its way to the Royal Scottish Museum, Edinburgh, and seems to have been ignored by geologists since its examination by Jamieson, until it was noticed last year by Dr Shand, then in charge of the geological department of that museum.

Whether the collection is preserved in its entirety cannot be ascertained, but if not numerically complete, it is at all events quite representative, as can be seen by modernising the names cited by Jamieson and comparing them with those used here.

The fossils are from the shores of Prince Regent Inlet (Port Bowen

[1] *Report on the Dominion Government Expedition to Hudson Bay and the Arctic Islands*, Ottawa, 1906.

and North Somerset). They are not all from the same layer, but judging from the materials at hand, and from the descriptions given by Jamieson, the most fossiliferous bed is a markedly fœtid limestone, greyish-brown, hard and compact. A dark fine-grained limestone is also very fossiliferous, and contains an assemblage of species apparently coeval with those of the fœtid limestone. There are besides a few slabs of sandstone containing fossils the age of which is doubtful. Of these, mention may be made here of bodies referable to castings of various organisms; some suggest worm-castings of "*Arthrophycus*" type, while others, large and massive, cannot yet be assigned to their proper systematic position.

CŒLENTERATA.

Stromatoporids.

Several flattened masses, lighter in hue than the matrix, suggest the presence of Stromatoporids. But if they indeed are Stromatoporids no more precise description can be given, since the microscopical structure is completely obliterated by infiltrated matter.

These bodies occur in the fœtid limestone.

Anthozoa.

Favosites sp. [cf. *F. helderbergiæ* Hall].

1887. *Favosites helderbergiæ*, Hall, Pal. New York, vol. vi. p. 8, pls. 4-6.
1909. *Favosites helderbergiæ*, Clarke, 62nd Ann. Report N.Y. State Museum, p. 49.

Several specimens of a *Favosites* appear undistinguishable from Hall's species—the mode of growth, the size of the corallites and the distribution of the tabulæ being identical. Besides, they offer a diagnostic character emphasised by Dr Clarke, viz. the extreme reduction in the size and number of the septal spines, which appear absent in the sections made. As the specimens are still sufficiently well preserved to show the mural pores, it would seem that the absence of septal spines is not altogether due to the mode of preservation, and points to identity with *F. helderbergiæ* rather than with the closely allied species *F. niagarensis* Hall.

Preserved in the fœtid limestone.

Favosites sp.

This is probably a new species, but the single specimen at hand is so badly preserved that a satisfactory description cannot be given. The characteristic feature resides in the mode of growth, the colony being blade-like, narrow and lanceolate. When complete it exceeded 19 cm. in length, while its width is 15 mm. and its thickness 3 mm. only. The corallites are from 1 to $1\frac{1}{2}$ mm. in diameter, with thin walls. Found in a slab of sandstone characterised by turreted Gasteropods.

Halysites labyrinthica (Goldfuss) [Fig. 8].

1826. *Catenipora labyrinthica*, Goldfuss, Petrefacta Musei Universitatis Regiæ Borussicæ Rhenanæ Bonnensis, p. 75, pl. 25, figs. 5-5*b*.

A silicified specimen of *Halysites* agrees more closely with Goldfuss' species than with any of the species described by American authors. It is characterised by its large meshes and large oval corallites, of which three occur along a distance of 1 cm., as is the case in the original figure (*loc. cit.* fig. 5*a*). Sections made at three different points failed to show the presence of tubules. The tabulæ are 1 mm. apart on an average, but may be somewhat more closely packed. Most of them are straight, only a few being oblique, or slightly concave towards the middle of their course. No septal spines can be detected, but the specimen being silicified it is not possible to say to what extent this feature is to be regarded as original or due to the mode of preservation.

From *H. catenularia* var. *simplex* Lambe[1] the specimen described here differs mainly in the mode of growth, the meshes being wide and irregular, while they are long and narrow in the other species. The present determination might of course have to be modified in the event of a revision of Goldfuss' type showing it to possess characters not expressed in the figure. But, in the meanwhile, weight must be attached to the fact that the original of the first of the two figures given by Goldfuss, viz. fig. 5*a*, is that of a specimen from the Upper Silurian rocks of Drummond Island, Lake Huron, that is, from the same zoological province as the materials collected by Parry.

On page ccli. of *A Supplement to the Appendix of Captain Parry's Voyage*, published in 1824, König gives a short diagnosis of a new species of chain-coral—*Catenipora Parryi*. No figure accompanies the description, which is so brief and insufficient that the name proposed must remain a *nomen nudum*. As the present specimen is without label, there are no means of ascertaining whether it may be the actual type-specimen of König's species.

Although a long range is generally attributed to species of *Halysites*, it must be noted here that Mr J. M. Clarke,[2] commenting on *Halysites catenularia* from the Guelph fauna in the State of New York, makes the

[1] *Contributions to Canadian Palæontology*, vol. iv., part 1—" A Revision of the Genera and Species of Canadian Palæozoic Corals," 1899, p. 70, pl. 4, fig. 3.

[2] *New York State Museum* 57*th Annual Report*, 1903, p. 34.

significant remark that in the size of the corallites and shape of the meshes the forms approach that described by Goldfuss as *Catenipora labyrinthica.*

Occurs in the fœtid limestone.

RUGOSA.

The collection contains a few indeterminable specimens of a turbinate coral suggesting *Streptelasma,* while equally indeterminable fragments of a compound form may perhaps belong to *Diphyphyllum.*

BRACHIOPODA.

The following species occur together in a dark grey, compact limestone:—

Stropheodonta varistriata (Conrad).

The shells referred to this species agree with the form figured by Hall and Clarke, *Pal. New York,* vol. viii., pl. 13, fig. 16. The internal characters are not shown, but there cannot be much doubt as to the systematic position of the species.

Orthotetid.

There are a few specimens of a flat shell of which only the external features are seen. The most conspicuous character is the regular alternation of fine and strong striæ.

Spirifer crispus (Hisinger).

This is represented by a few small and indifferently preserved, but unequivocal specimens. A faintly ribbed form accompanies the more distinctly ribbed type.

Atrypa phoca (Salter).

1852. *Rhynchonella phoca,* Salter, Sutherland's Voyage, pl. 5, figs. 1-3.

The collection contains a few specimens of this characteristic species. They are accompanied by a less globose form, the true nature of which cannot be ascertained.

MOLLUSCA.

Gasteropoda.

The Gasteropods constitute the most striking element of the collection, turreted forms being literally crowded on the surface of a large slab of calcareous sandstone, and forming the main bulk of a large block of dolomitic limestone. In spite of their abundance they are, with one exception, indeterminable owing to their state of preservation.

(All photographs of the natural size.)

Fig. 1. *Discosorus regularis* sp. nov.

„ 2. *Actinoceras* sp.

„ 3. *Discosorus borealis* sp. nov.

„ 4. *Leperditia phaseolus (*Hisinger).

„ 5. *Leperditia* aff. *balthica* var. *guelphica* Jones.

„ 6. Portion of surface of Gasteropod limestone with *Styliolina* sp.

„ 7. *Leperditia* cf. *cæca* Jones (on left of centre of photograph, and mould below top right-hand corner).

„ 8. Portion of surface of *Halysites labyrinthica* (Goldfuss).

Murchisonid ?

The specimens preserved in the calcareous sandstone just referred to, still retain part of the shell-substance, but corrosion has removed the surface features which play such an important part in the classification. All the specimens seem referable to a single species characterised by the shape of the shell, which is high, with numerous whorls. The general aspect is between that of *Hormotoma* and that of *Turritoma*, the whorls being flatter than in the former, and yet not so flat as in *Turritoma*. Taking the shape alone into consideration, these specimens bear a stronger resemblance to *Catozone* Perner, than to any other Murchisonids.[1]

Pycnomphalus solarioides (Hall).

1852. *Pleurotomaria solarioides*, Hall, Pal. New York, vol. ii., p. 348, pl. 84, fig. 4*b*.
1895. *Pycnomphalus solarioides*, Whiteaves, Geological Survey of Canada, Palæozoic Fossils, vol. iii., part ii., p. 88., pl. 13, figs. 3-8.

This species is so well characterised by its depressed spire that it could hardly be confounded with any other North American Upper Silurian Pleurotomarids, and as the specimen at hand, though indifferently preserved, shows the main features of *P. solarioides* as delineated by Hall, Nicholson, and Whiteaves, it can be referred to it without much hesitation. It must however be admitted that such a specimen, if unaccompanied by other typically Upper Silurian forms, would have been difficult to identify, since certain Ordovician Gasteropods—*Liospira* for instance—may have a similar outline.

Pleurotomarid.

A trochiform shell, which may possibly belong to *Lophospira* or to *Trochonema*, has angular carinated whorls not unlike *Pleurotomaria subdepressa* Hall, which differs in being sinistral.

Straparollus ? sp.

A minute discoidal shell of three volutions and only 2 mm. in diameter, may belong to *Straparollus*, but its small size precludes a satisfactory determination. It seems to possess a character occasionally met with in the Euomphalidæ, viz. septate inner whorls.

Cephalopoda.

Genus Discosorus Hall.

1852. *Discosorus*, Hall, Pal. New York, vol. ii., p. 99.
1888. *Discosorus*, Foord, Catalogue of the Fossil Cephalopoda in the British Museum (Natural History), part i., p. 196.

[1] *Système Silurien du Centre de la Bohême*, vol. iv.—"Gasteropodes," tome ii., 1907, p. 108.

Discosorus is a slightly arcuate brevicone Cephalopod characterised by the large size, excentric position and nummuloidal structure of its siphuncle. As suggested by Dr H. A. Foord, it seems to bear the same relationship to *Actinoceras* that *Piloceras* bears to *Endoceras*.

This genus has been seldom recorded, owing probably to the restricted area of its distribution, since the few species known are all from the Upper Silurian rocks of the North American continent.

The specimens described here are embedded in the fœtid limestone already referred to, and as is the case with many of the Palæozoic Cephalopods possessing thick siphuncles, the siphuncle only is preserved. Since no trace of the shell can be detected in the matrix, it is probable that it was disintegrated prior to its being embedded.

Discosorus borealis sp. nov. [Fig. 3].

The larger of the two specimens at hand is an arcuate cone 6½ cm. long, complete but for a small portion of the apex. The section is circular, and the rate of tapering is about 1 in 2·4. The curvature is considerable: upon a chord of 45 mm. subtending the concave side the highest perpendicular is 6 mm. (=radius of 45·1 mm.). In the upper part of the siphuncle—where the diameter varies from 15 to 25 mm.—the distance of the segments from each other averages 6 mm., and the segments are in a plane 75° to the axis. A remarkable feature is the sudden change in the position and size of the segments in the apical region, where they are in a plane 60° to the axis, while the distance separating them is only about 2 mm.

The surface of the segments is rounded and protuberant along the convex side of the siphuncle, and is flattened along the concave side, a character noticed by Dr Foord in his diagnosis of *D. remotus.*

The present species is evidently closely allied to *D remotus* Foord (*op. cit.* p. 197), and might even prove to be synonymous with it, but since the type of Dr Foord's species is too fragmentary to permit of close comparison, the two forms are better kept under a separate designation.

Discosorus regularis sp. nov. [Fig. 1].

This species is known by three specimens of the siphuncle. The best preserved is an arcuate cone 9 cm. long, the apex of which is wanting. The section is circular and the rate of tapering is about 1 in 2·14. The curvature is less than in the preceding species: upon a chord of 50 mm. subtending the concave side the highest perpendicular is 4 mm. (=80 mm. radius). The distance separating the segments is 6 mm. where the diameter is 30 mm., and decreases slightly and gradually towards the apex. The segments are in a plane 65° to the axis; their contour is evenly protuberant, but somewhat asymmetrical on the convex side, where the outline forms a sigmoidal curve.

The other specimens were cut longitudinally. They do not exhibit any internal characters not already known to exist in the genus.

In *D. conoideus* Hall (*op. cit.* pl. 28, fig. 13), the rate of tapering is more rapid, and the segments are thicker and not so oblique to the axis as in the present species. From *D. borealis*, *D. regularis* differs in the lesser degree of curvature, and in the evenly protuberant nature of the segments, which are moreover not crowded near the apex.

Discosorus sp.

A single siphuncle, partly obscured by intractable matrix, resembles closely *D. gracilis* Foord (*op. cit.* p. 198, fig. 26), in the rate of tapering and degree of curvature, while it differs from it in the greater distance of the siphuncular segments from each other. The visible portion of the specimen is 9 cm. long, and sixteen segments occur within that distance, while as many as nineteen occur within 6½ cm. in the specimen figured by Dr Foord. The segments are also more oblique to the axis than is the case in *D. gracilis.*

Actinoceras sp. [Fig. 2].

A silicified fragment from which most of the shell has been removed belongs to a rapidly tapering species with sub-lateral siphuncle. The diameter of the siphuncle is about a third that of the shell. The endosiphon and several tubuli are well shown in transverse aspect.

The septa—of which nine occur within a distance of 30 mm.—exhibit a puzzling feature probably due to a peculiar deposition of silica. In the portion nearest to the siphuncle, the siliceous partitions replacing the septa divide into two leaves before reaching the shell, in such wise that the lower leaf of a given "septum" unites with the upper leaf of the "septum" below. This appearance is probably analogous with that depicted by Barrande in a specimen of *Actinoceras whitei* (Stokes) from the Niagara Group of Drummond Island.[1]

CRUSTACEA.

Ostracoda.

Large species of *Leperditia* occur in extraordinary abundance, their carapaces and external moulds covering the surface of three small slabs of the limestone containing the Brachiopods enumerated above.

[1] *Système Silurien du Centre de la Bohême*, vol. ii.—"Céphalopodes," 4^{me} Série, 1870, pl. 437, fig. 17.

Leperditia phaseolus (Hisinger) [Fig. 4].

1831. *Cytherina phaseolus*, Hisinger, Anteckn. Phys. Geogn., vol. v., pl. 8, fig. 3.
1891. *Leperditia phaseolus*, Jones, Geol. and Nat. Hist. Survey of Canada, Contrib. to Micro-Palæontology, p. 85, pl. 13, figs. 7, 8.

Of common occurrence are specimens agreeing with this species. In the left valve figured (Fig. 4) the length is 11 mm., the hinge 7·5 mm., and the height 6·5 mm., these measurements agreeing with those given by Jones for the Canadian representatives of *L. phaseolus.*

Leperditia aff. *balthica* var. *guelphica* Jones [Fig. 5].

Several specimens of a large *Leperditia* possess the anterior tapering and the salient dorsal angles of *Leperditia balthica* var. *guelphica* Jones (*op. cit.* p. 80, pl. 13, figs. 12, 13), from which, so far as the materials show, they differ in being relatively more elongate. The dimensions of the specimen figured (Fig. 5) are: length 10 mm.; hinge, 8 mm.; height, 5·75 mm.

Leperditia cf. *cæca* Jones [Fig. 7].

A few carapaces and moulds differ from the *Leperditiæ* described above in being much higher relatively to their length, and in being apparently without eye-spot. These characters give this form a marked resemblance to *Leperditia cæca* Jones (*op. cit.* p. 88, pl. 12, figs. 6, 7, 9), from which it differs in having a relatively longer hinge-line.

REMARKS.

Of the species described or enumerated in the foregoing notes, the series embedded in the fœtid limestone and the slabs with Brachiopods and Ostracods are clearly of Niagaran (Upper Silurian) age. But many data are still wanting without which it would be hazardous to refer the assemblage with absolute certainty to any definite formation. Yet the presence of Stromatoporids (?) and numerous Cephalopods, large *Halysites,* and faintly-ribbed *Spirifer crispus* coupled with the occurrence of *Pycnomphalus solarioides* and Ostracods allied to Guelph species, suggest that this portion of the collection was obtained from strata belonging to the Guelph, viz., the uppermost member of the Niagaran. If the bed which yielded the abundant shells of Gasteropods of *Catozone* type was ever found to be closely connected with the strata from which the bulk of the collection is derived, the presumption that the group belongs to the Guelph would then be strengthened, since an abundance of Gasteropods is one of the characteristic features of that formation. However, as conclusive evidence could only be secured by the record of certain typical forms of restricted range (e.g. *Monomerella*, *Pentamerus oblongus*, *Megalomus*, etc.), it must be understood that the above suggestions are made under reservations necessitated by the limited nature of the collection. On the other hand, it must be noted that in the chart of the distribution of the Guelph illustrating the "Palæogeography of North America," Prof. C Schuchert indicates the presence of that formation on the shores of Prince Regent Inlet, though he does not discuss this point in the body of his memoir.[1]

LIMESTONE WITH *Styliolina* [Fig. 6].

A thick slab of earthy limestone shows a peculiar mode of formation, being almost entirely made up of turreted Gasteropods. These are indeterminable and give no clue to the age of the rock. Nevertheless, considerable interest attaches to this limestone, as besides being striking in its constitution, it contains numerous specimens of the small Pteropod *Styliolina*.

In the Devonian of the State of New York the minute *Styliolina fissurella* (Hall) is diagnostic of the Styliolina or Genundewa Limestone, and the genus does not seem to have been recorded from lower horizons in the Palæozoic rocks of North America.

The species considered here is much larger than *Styliolina fissurella*, and yet not so large as *Styliolina spica* (Hall)[2] which it resembles closely in shape. Several specimens attain a length of 6 mm., with a diameter of about 0·75 mm. Although specific identity cannot be established between this form and the known American species, the presence of an abundantly represented *Styliolina* is in itself at first sight suggestive of an horizon in the middle Devonian. On the other hand, Prince Regent Inlet lies so far from the classical New York district, that conditions suitable to the development of *Styliolina* might quite well have taken place there at a different epoch. Reckoning with this contingency, and owing to the absence of record regarding the stratigraphic position of this limestone relatively to that of the Upper Silurian fauna described here, no more can be done than to draw attention to this interesting occurrence, leaving to future expeditions the task of settling its position in the sequence of the Palæozoic rocks of Prince Regent Inlet.

[1] *Bull. Geol. Soc. America*, xx., 1910.

[2] *Pal. New York, Suppl.*, vol. vii., pl. 114, fig. 28, 1888.

(*Issued separately*, 15*th May* 1912.)

XXXI.—Note on Mallophaga from the Little Auk or Rotchie (*Alle alle*); with List of Species taken on Birds and Mammals in the Forth Area. By William Evans, F.R.S.E.

(Read 25th March 1912.)

By the fierce easterly gale of 15th to 18th January last and succeeding storms great numbers of the Little Auk—the *Alle* (or *Mergulus*) *alle* of Ornithologists—were wrecked on the east coast of Britain. Nowhere were the evidences of the disaster which overtook the birds more apparent than on the shores of the Firth of Forth, where hundreds dead or in a dying condition were stranded at every tide. Taking advantage of the opportunity thus offered, I examined on 26th January a number, not long dead, on the beach west of North Berwick, and on the 27th a few more at Dalmeny, and on both occasions found several infested with Mallophagan parasites. These proved to belong to three species, representing as many genera, namely a *Docophorus* or *Philopterus* s.st.,[1] a *Nirmus*, and a *Menopon* (see p. 266, Figs. 1, 2, 3). The first and second were common, the third very scarce.

1. The *Docophorus*.—In 1842, Denny ("Monog. Anopl. Brit.," p. 72, pl. iii., f. 7) described and figured a species of *Docophorus* under the name of *D. merguli*, from a single specimen taken off a Little Auk by Mr Heysham of Carlisle. So far as I can see, no one has since recorded a *Docophorus* from this bird; and though *D. merguli* is included in the works of Giebel ("Insecta Epizoa," 1874), and Piaget ("Les Pédiculines," 1880), they seem to have merely utilised Denny's description. Among my Mallophaga from the Little Auk there are examples of both sexes of a *Docophorus*, which I have no doubt belong to the same species as Denny had before him. His specimen was evidently a male, and while his description and figure are not all that could be desired, they bring out certain characteristics which are present in my specimens. The females are somewhat larger than the males, but are similarly marked except that the penultimate abdominal segment bears a distinct dorsal band not present in the male. Compared with *D. celedoxus* from the Razorbill and Guillemot, the shape of the clypeus—straight or slightly convex, not emarginate—and of the "taches génitales" should serve to distinguish it.

2. The *Nirmus*.—The only record of a *Nirmus* from the Little Auk that I have been able to find is from the other side of the Atlantic,

[1] See Prof. G. Neumann's, "Notes sur les Mallophages" in *Bull. Soc. Zool. de France*, xx., p. 54, 1906.

whence, as I learn from Kellogg's "List of the Biting Lice (Mallophaga) taken from Birds and Mammals of North America,"[1] *N. citrinus*, Nitzsch, has been recorded from it by Osborn. My specimens, however, agree much better—so well, indeed, that I cannot doubt their identity—with *N. maritimus*, Kellogg and Chapman, described in 1899,[2] from several species of Pacific Alcidæ closely related to our Little Auk. Whether this is really different from Denny's *N. alcæ* from the Razorbill, which Giebel and others have, too hastily perhaps, treated as synonymous with Nitzsch's *N. citrinus* from the same bird, I have no adequate means of judging. As Kellogg and Chapman point out, Piaget describes and figures *citrinus* as having the posterior margin of the metathorax rounded, not angular,

Fig. 1.
Docophorus merguli, ♀

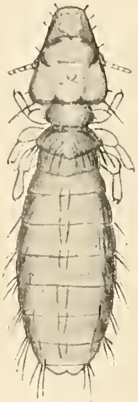


Fig. 2.
Nirmus maritimus, ♀

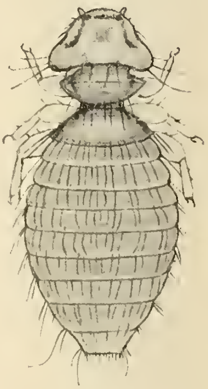


Fig. 3.
Menopon lutescens?, ♀

The lengths of the specimens figured are 1·7, 1·8, and 1·4 respectively.

a character they make use of in differentiating their *maritimus* from it; and certainly the only *Nirmus* (*N. citrinus* I consider it) I have from the Common Guillemot shows practically no angle. Denny depicts his *alcæ* with the metathorax angled posteriorly, which would therefore seem to preclude its identity with *citrinus* and to point to the possibility of its being the same as *maritimus*, though his figure suggests a broader insect. Unfortunately I have no sufficiently well preserved *Nirmus* from the Razorbill with which to critically compare those from the Little Auk, I therefore name the specimens from the latter *N. maritimus*, K. and C., leaving the *alcæ* question to others to settle.

3. The *Menopon.*—No species of this genus appears to have been recorded from the Little Auk. Of the three genera I found on them, this

[1] *Proc. U.S. Nat. Mus.*, xxii., p. 52, 1899.

[2] "New Mallophaga, III.," *Occasional Papers Californian Acad. Sci.*, vi., p. 72, 1899.

was much the rarest, being detected on one or two of the birds only, and then in very small numbers. *Menopon* is a difficult genus, many very closely allied forms having been described, but only one of them—*M lutescens*, Nitzsch—being recorded from a member of the Alcidæ, namely from the Razorbill. Though not agreeing exactly with some from a Razorbill—they are rather smaller and paler—I am disposed to refer my specimens to *M. lutescens*, N., of which they can, I think, be at most nothing more than a variety.

I now come to the second part of my paper, namely, the list of species obtained in the Forth Area. As in the case of a number of other groups, though not specially investigating them, I have collected Mallophaga for a good many years past as opportunities occurred; but I have never shot birds for the express purpose of obtaining their parasites, otherwise a much longer list than that given below would no doubt have resulted. Further, when birds of different sorts have been in contact, as by having been put in the same bag or parcel, specimens from them are unsatisfactory, and it has generally been my practice to reject them. Besides the "hosts" (124) named in the list, a number of other birds have been examined without any of these ectoparasites being found upon them.

As matters at present stand, the difficulties that attend the identification of one's specimens in this group are formidable. A thorough revision of the Mallophaga on the basis of a large series of examples from a wide range of hosts and localities would, one may predict, result in a considerable weeding out of supposed species; while advocates of up-to-date rules of nomenclature have here a fruitful field for change before them.[1] Many of Nitzsch's names being apparently "nomina nuda" till the publication of Giebel's "Insecta Epizoa" in 1874, some of them will, it would seem, have to give place to those proposed by Denny in his 1842 "Monograph." It is not my intention, however, to discuss this question here, even if I were competent to do so, and for the present I am content to follow the arrangement, and, with some few exceptions, the nomenclature of Piaget's "Les Pédiculines," 1880. In his comprehensive list of Mallophaga published in 1908 in Wytsman's "Genera Insectorum," Prof. V. L. Kellogg places the species in each genus alphabetically, but his arrangement of the genera themselves does not differ materially from

[1] In his "Notes" above referred to, Prof. Neumann has proposed some changes in the generic names.

that of Piaget's work, except that he puts *Trichodectes*, with family rank, at the beginning.

In his account of the Entomology of "Dee," published in 1878 in the *Transactions* of the Natural History Society of Aberdeen, Prof. J. W. H. Trail gives (p. 44) a list of 25 species of Mallophaga got on birds in that district. In December 1881, as appears from its *Transactions*, vol. i. p. 23, the late James Simpson showed 9 species at a meeting of the Edinburgh Naturalists' Field Club, but no localities are given. I have met with few other records from Scotland, but I understand the Rev. James Waterston, Ollaberry, Shetland, has a long and valuable list in preparation, which it is hoped he may be able to publish at no distant date.

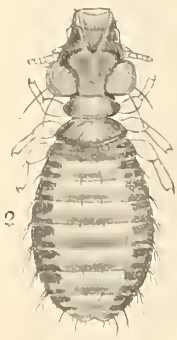


FIG. 4. *Docophorus*, ? sp. n. (*D. aviator*, m., see p. 270.)

In addition to those from the Little Auk mentioned above, my list includes a number of other species of interest—such as *Nirmus alchatæ* (from Pallas's Sand-grouse), *N. cugrammicus* (from the Little Gull), *N. triangulatus* (from two species of Skuas), *N. lineolatus*[1] (from the Kittiwake and other gulls), *Docophorus*, ? sp. n., Fig. 4 (from the Manx Shearwater), *Goniodes damicornis* (from the Wood-pigeon), *Lipeurus pelagicus* (from Storm Petrel and Manx Shearwater), *Trichodectes tibialis* (from Hare), *Colpocephalum bicolor*[1] (from the Turnstone), etc.—several of which have not previously been recorded as "British."

LIST OF SPECIES TAKEN ON BIRDS AND MAMMALS IN THE FORTH AREA.

Note.—To save space the scientific names of hosts are given only once. References to specimens from outside the Forth Area are enclosed in square brackets.

Fam. **Philopteridæ**.

Docophorus platystomus, Nitzsch—From Rough-legged Buzzard (*Buteo lagopus*), Lammermuirs above Gifford, Jan. 1901, Gorebridge, Nov. 1906, and North Berwick, Dec. 1907; [also off one from The Glen, Peeblesshire, in March 1885].

D. aquilinus, Denny—From Golden Eagle (*Aquila chrysaëtus*), trapped on Golland, Ochils, Kinross-shire, March, 1904; [also from Ross and Sutherland birds]. My specimens are undoubtedly the same as Denny's from this bird. Compared

[1] Recorded from the North of England by Messrs Bagnall and Hall, in *Journ. Econ. Biol.* for February 1912.

with those from the Rough-legged Buzzard they are rather larger with the head as broad as long, instead of longer than broad, and the "tache génitale" of the male seems slightly different.

D. atratus, N.—From rooks (*Corvus frugilegus*), Dunipace, Kirkliston, etc.

D. ocellatus, N.—From Hooded Crow (*Corvus cornix*), Longniddry and Dirleton, Dec. 1884, Tyninghame, March 1884 and April 1910, and East of Fife, March 1906. From Carrion Crow (*Corvus corone*), Elie, Oct. 1884, Anstruther, March 1906, and Dalmeny, May 1905.

D. semisignatus, N.—Off young Raven (*Corvus corax*) from Strathyre, 1908 (coll. R. M. Adam); also [Shetland, Dec. 1905, and Oban, Sept.]. Apart from the hosts, I confess I see no good character by which this and the last, or indeed the last two, can be separated.

D. guttatus, N.—From Jackdaw (*Corvus monedula*), Dalmeny, April 1905.

D. subcrassipes, N. (=*picæ*, Denny)—From Magpie (*Pica pica*), near West Calder, Dec. 1887, and Carlowrie, June 1908.

[**D. fulvus**, N.—From Jay (*Garrulus glandarius*), Murthly, Perthshire, April 1887.]

D. communis, N.—From House Sparrow (*Passer domesticus*), Edinburgh, Tree Sparrow (*P. montanus*), North Berwick, Ring Ouzel (*Turdus torquatus*) and Blackbird (*T. merula*), the last two at Barnsness lighthouse, April. From Fieldfare (*Turdus pilaris*), Mortonhall, and Mistle-Thrush (*T. viscivorus*), East Linton; these two seem referable to var. *merulæ*, D., as characterised in Piaget's work. From Pied Wagtail (*Motacilla lugubris*), Dunbar, June 1885; has the clypeus of var. *rubeculæ*, as figured by Piaget. On 20th Oct. 1911, at the Isle of May lighthouse, I took several examples of var. *fuscicollis*, N., from a young Woodchat shrike (*Lanius senator*), which was killed there the previous morning. From Wren (*Troglodytes troglodytes*), Roslin, Sept. 1890; [and Crossbill (*Loxia curvirostra*), Blairgowrie, Nov. 1911].

D. excisus, N.—One from young Swallow (*Hirundo rustica*), Dunbar, Sept. 1895.

D. laticeps, Giebel (=*cincli*, D.)—From Dipper (*Cinclus aquaticus*), Bonaly Ravine, Pentlands, May 1895.

D. leontodon, N.—From Starling (*Sturnus vulgaris*), Aberlady, Feb. 1908, Dunbar and Isle of May, Oct. 1910.

D. auratus, N.—From Woodcock (*Scolopax rusticola*), near Edinburgh, Jan. 1886.

D. limosæ, D.—From Bar-tailed Godwit (*Limosa lapponica*), Aberlady Bay, Sept. 1884, and Aug. 1887; also (?) one from Knot (*Tringa canutus*), Aberlady Bay, August 1885.

D. cordiceps, G. (?=*cephalus*, D.)—One from Greenshank (*Totanus nebularis*), Aberlady Bay, Sept. 1884, and one from Curlew Sandpiper (*Tringa subarquata*), Gullane, September 1887.

D. temporalis, G.—One off Lapwing (*Vanellus vanellus*) from Elie, March 1906, and also, I consider, from Grey Plover (*Squatarola squatarola*), Aberlady Bay, Sept. 1885, and Golden Plover (*Charadrius pluvialis*), West Lothian, Sept. 1911. Very similar to the preceding species—possibly only a variety of it (Piaget).

D. humeralis, D.—From Curlew, Elie, August 1909; and also, I consider, from a Whimbrel (*Numenius phæopus*), near North Berwick, Sept. 1886.

D. testudinarius, D.—Common on Curlew (*Numenius arquata*), Aberlady, Nov. 1886.

D. acanthus, G. (*ostralegi*, D. and *naumanni*, G.)—From Turnstone (*Strepsilas interpres*), Longniddry, Nov. 1885; Oystercatcher (*Hæmatopus ostralegus*), Fife coast, Sept. 1906; and Purple Sandpiper (*Tringa maritima*), Dunbar, Nov. 1906.

D. fusiformis, D. (including *canuti*, D.)—From Ringed Plover (*Ægialitis hiaticula*), Aberlady Bay, Sept. 1884; Little Stint (*Tringa minuta*), and Curlew Sandpiper, Aberlady Bay, Sept. 1885.

Docophorus, sp.?—From Common Heron (*Ardea cinerea*), near Edinburgh, August, one specimen. Closely allied to the preceding; possibly the ♂ of Piaget's *D. productus*.

D. pustulosus, N.—From Pomatorhine Skua (*Stercorarius pomarinus*), South Queensferry, Oct. 1887.

D. melanocephalus, N.—Specimens from Common Tern (*Sterna hirundo*), Aberlady Bay, Oct. 1886, and Firth of Forth, Sept. 1905, agree best with the description of this form.

D. lari, D.—From Glaucous Gull (*Larus glaucus*), and Kittiwake (*Rissa tridactyla*), Kincardine-on-Forth, Jan. 1885; Great Black-backed Gull (*L. marinus*), Gosford, Cramond, Dalmeny (1906); Herring-Gull (*L. argentatus*), and Common Gull (*L. canus*), near Edinburgh; and Black-headed Gull (*L. ridibundus*), Dunbar, Elie, and Loch Leven; ? also from an Arctic Skua (*Stercorarius crepidatus*), off Leith, Sept. 1907.[1] [From Lesser Black-backed Gull (*L. fuscus*), near Fearnan, Loch Tay, May 1892.]

D. celedoxus, N.—From Razorbill (*Alca torda*), Longniddry and Kincardine-on-Forth, Jan. 1885, North Berwick, Jan. 1912: Guillemot (*Uria troile*), Aberlady, Jan. 1910; and Puffin (*Fratercula arctica*), off North Berwick, May 1908.

D. merguli, D.—From Little Auk (*Alle alle*), Longniddry shore, Jan. 1885, Gullane Point, 9th March 1908, North Berwick, Lasswade, and Dalmeny, Jan. 1912; [Orkney, Jan. 1885; St Andrews, Jan. 1912]. See Fig. 1, on p. 266.

D. icterodes, N.—From Mallard (*Anas boschas*), Gosford Bay; Wigeon (*Mareca penelope*), Dunbar; Pochard (*Fuligula ferina*), Duddingston Loch; Tufted Duck (*F. fuligula*), Duddingston Loch, and Fife; Scaup-Duck (*F. marila*), Dunbar; Common Scoter (*Oidemia nigra*), Musselburgh; Barnacle-Goose (*Branta leucopsis*), Kincardine-on-Forth, March 1888; and Goosander (*Mergus merganser*), Aberlady. [Also from Grey Lag Goose (*Anser anser*), Newburgh-on-Tay, Fife, Oct. 1885.]

D. colymbinus, D.—From Red-throated Diver (*Colymbus septentrionalis*), off Prestonpans, Dec. 1904; Black-throated Diver (*C. arcticus*), near Granton, Feb. 1912 (J. F. Cormack, determined by Rev. J. Waterston); and Goosander (ad. ♂), Kincardine-on-Forth, Feb. 1889, one fine specimen, which I refer to this species.

Docophorus, ? sp. n.—Two dried specimens from Manx Shearwater (*Puffinus anglorum*), off North Berwick Sept. 1889; rather like, but quite distinct from, *D. colymbinus*. Several species of Docophorus have been described from other species of Shearwaters, so that mine is possibly not new; perhaps it is Giebel's insufficiently described *D. coronatus* from the Sooty Shearwater. Not having access, however, to the literature containing some of the descriptions, I must leave the final determination of my specimens over for the present. I have provisionally named them *D. aviator*, sp. n. A figure, drawn from one of them, is given on p. 268 (Fig. 4)—length about $1\frac{3}{4}$ mm.

For Docophorus bassanæ, D., see Lipeurus staphylinoides, D., of which I have no doubt whatever it is the female.

Nirmus fuscus, N.—From Rough-legged Buzzard, near Gorebridge, Nov. 1906; and Honey Buzzard (*Pernis apivorus*), Fife, June last.

N. rufus, N.—From Merlin (*Falco æsalon*), Longniddry, Jan. 1885; Kestrel (*F. tinnunculus*), Gosford, May 1890; and Sparrow-Hawk (*Accipiter nisus*), Currie and Gosford. Doubtfully distinct from the preceding species (see Kellogg and Chapman, "New Mallophaga," iii., 1899, p. 85).

[1] And Little Gull (*L. minutus*), Dunbar.

N. varius, N. (including *argulus*, N.)—From Carrion Crow, Leven, Fife, May 1906; and Rook, Dunipace, Stirling, May 1909.

N. uncinosus, N.—From Hooded Crow, Tyninghame, April 1910.

N. marginalis, N.—From Song-Thrush, Longniddry, Nov., and East Linton, July, and Mistle-Thrush, East Linton, July; var.? from Meadow Pipit (*Anthus pratensis*), Gullane Links, Sept.

N. nebulosus, D. - From Starling, Dunbar and Isle of May, Oct. 1910.

N. alchatæ, Rudow—In May 1888 I took three specimens of this species from a Pallas's Sand-Grouse (*Syrrhaptes paradoxus*) shot on Belhaven Links, near Dunbar, on the 17th.

N. cameratus, N. (+ *quadrulatus*, N.)—a good many from Red Grouse (*Lagopus scoticus*), especially the young birds, shot on the Kitchen Moss, Pentlands, 29th Sept. 1906; and from ♂ and ♀ Capercaillie (*Tetrao urogallus*), Touch, near Stirling, Dec. 1907. [Also from Red Grouse, Halmyre, Peeblesshire, Feb. 1889, and Capercaillie, Comrie and Dunkeld, Aug. 1906.] The specimens from the Capercaillie are larger (length 2 mm. as against 1·5 mm.), relatively broader, and somewhat paler than those from the Red Grouse, and should, probably, be treated as a variety. The *Nirmus* of the Capercaillie was called by Nitzsch *quadrulatus*, and Piaget adopted that name, with *cameratus* (of the Red Grouse, etc.) as a synonym, the differences attributed to them being, in his opinion, at most of only varietal account. Granting that they are specifically identical, it is clearly *cameratus* that has priority. In one particular, which may be of significance, Piaget's description of *quadrulatus* from the Capercaillie differs from my specimens from both birds; according to him there are three long hairs on each temple, whereas I find only two, as shown in Denny's figure of *cameratus* and in that accompanying Shipley's paper in the 1911 Report of the Committee of Inquiry on Grouse Disease.[1] Shipley remarks that the variation in size and in colour, that is among examples from the Red Grouse, is very considerable; but his average length of 3 mm. seems to me too high.

N. furvus, N.—From Lapwing, Colzium, Pentlands, March 1890, and Currie, June 1906; and Ringed Plover, Aberlady, Sept. 1905.

N. junceus, D.—From Greenshank, Aberlady, Sept. 1884, and Tyne Estuary, Aug. 1889; I think these are certainly Denny's *junceus* whatever that may ultimately prove to be. I have the same or a very similar species from Green Sandpiper (*Totanus ochropus*), Drem, Aug. 1888, and Linlithgow, Aug. 1890; and ? also, but not quite mature, from Redshank (*T. calidris*), Aberlady, Oct. 1884. Only an examination of Denny's types of *junceus*, *ochropi*, *obscurus*, etc., could clear up their synonymy.

N. strepsilaris, D. (*subcingulatus*, N.)?—The *Nirmi* I have taken from the Turnstone (Aberlady, Aug. 1886, and Dunbar, Sept. 1911) agree best with that of *furvus* among the figures in Piaget's work; but they look different from my specimens of that species from the Lapwing—they are not so yellow and the dark markings are more pronounced. Possibly they are Denny's *strepsilaris*, but if so his figure is rather misleading.

N. vanelli, D.—Specimens of a *Nirmus* from Grey Plover, Aberlady, Sept. 1885, are clearly the same as Denny's insect from the same bird, the *Vanellus griseus*, of his time. Though more pronounced in their markings, I place here also some from Golden Plover, West Lothian, Sept.

[1] Since the above was written I have obtained further specimens from a Capercaillie from near Callander, and also some from Black Grouse (*Tetrao tetrix*) from near Dunipace. Among the former there are examples—males—with three long hairs on each temple, so that the supposed difference in this respect seems to break down. Nevertheless I am disposed, for the present, to keep the Capercaillie *Nirmi* apart under the name *quadrulatus*. Those from the Black Grouse I place, with those from the Red Grouse, under *cameratus*.

N. holophæus, N.—From Knot, Aberlady Bay, Sept. 1884, Oct. 1886, Sept. 1888; Bar-tailed Godwit, Aberlady Bay, Sept. 1884, Aug. 1886 and 1887; and Purple Sandpiper, Dunbar, Nov. 1906. Invariably associated with *N. cingulatus*.

N. numenii, D.—Three specimens from a Curlew, Aberlady, Nov. 1886, are clearly the insect described and figured by Denny under the above name. Very similar to the last, but larger and darker.

N. phæopi, D.—From Whimbrel, Gullane Point, Aug. 1885, and Aberlady Bay, Aug. 1886. Closely related to, and perhaps not specifically distinct from *N. inæqualis*, Piaget.

N. bicolor, P.—One example of what I take to be this species from Ringed Plover, Aberlady, Sept. 1884, and four from another specimen of same bird, Scoughall, Sept. 1886. A very distinct form, its elongated shape being suggestive of a small *Lipeurus*.

N. truncatus, N. (*scolopacis*, D.)—From Common Snipe (*Gallinago gallinago*), Aberlady, Sept. 1887. [Also from Great Snipe (*G. major*), Roxburghshire, Sept. 1886.]

N. bicuspis, N.—From Ringed Plover, Aberlady, Sept. 1884. I suggest that Denny's *hiaticulæ* is referable to this species.

† **N. cingulatus**, N.—From Bar-tailed Godwit, Aberlady Bay, Aug. and Sept. 1884 and 1887; Ruff (*Machetes pugnax*), Luffness, Sept. 1887; Knot, Aberlady Bay, Sept. 1884, Aug. and Dec. 1885, etc., Cramond, Dec. 1890; Dunlin (*Tringa alpina*), Dunbar, May 1885; Little Stint, Aberlady Bay, Sept. 1885, Gullane, Sept. 1887; Curlew Sandpiper, Aberlady Bay and Gullane, Sept. 1885 and 1887; Purple Sandpiper, Isle of May, Sept. 1885; Dunbar, Nov. 1906; and Sanderling (*Calidris arenaria*), Aberlady Bay, Sept. 1885; Mr Waterston tells me he has seen this species from Ringed Plover, Aberlady, and Sanderling, Largo. I have not attempted to distinguish varieties. Some of my specimens from the Knot, and those from the Dunlin, Little Stint, and Curlew Sandpiper, are, I suppose, var. *zonarius*, N.; they are smaller than the others and have the head narrower, strongly recalling Denny's figure of *N. obscurus*.

N. citrinus, N.—Under this name I place a *Nirmus* from a Common Guillemot captured at Aberlady, in January 1910. In the shape of the metathorax it agrees with Piaget's description (see *ante* p. 266).

N. alcæ, D.—From Razorbill, Longniddry, and Kincardine-on-Forth, Jan. 1885. The specimens (three in dry state) seem to indicate a broader insect than the next, but fresh examples are required to prove whether the two are or are not specifically distinct; meantime I keep them apart.

N. maritimus, K. and C.—From Little Auk, Longniddry [and Orkney], Jan. 1885; North Berwick, Lasswade, Edinburgh, Dalmeny [and St Andrews], Jan. 1912. See remarks on p. 266, and Fig. 2.

N. selliger, N.—From Common Tern, Aberlady Bay, Sept. 1884; and North Berwick, July 1912.

N. lineolatus, N. (*ornatus*, Grube)—From Glaucous Gull and Kittiwake, Kincardine-on-Forth, Jan. 1885; Great Black-backed Gull, Dalmeny, Jan., and Cramond, April 1906; and Herring Gull, North Berwick, Oct. 1906.

N. punctatus, N.—One specimen from Black-headed Gull, Loch Leven, May 1912.

N. eugrammicus, N.—Three from Little Gull (*Larus minutus*, *juv.*), Kincardine-on-Forth, Jan. 1885.[1]

N. triangulatus, N. (*normifer*, Grube)—One from Arctic Skua, Aberlady Bay, Sept. 1884; and another from Pomatorhine Skua, South Queensferry, Oct. 1887.

[1] Many from same species of Gull (young bird), Dunbar, 2nd Oct. 1912.

N. fuscomarginatus, D. (*podicepis*, D. = ♀)—From Little Grebe (*Podiceps fluviatilis*), near Dunbar, April 1911, Gladhouse Reservoir, June, Penicuik, Aug.; and Eared Grebe (*P. nigricollis*), Barnsness lighthouse, Oct. 1911; [also from Slavonian Grebe (*P. auritus*), Orkney, Jan. 1885].

Oncophorus attenuatus, N.—From Corn-Crake (*Crex crex*), near Edinburgh, Oct. 1907; and Isle of May, August last.

O. minutus, N. (? *Nirmus fulicæ*, D. + *N. cuspidatus*, D.)—From Moorhen (*Gallinula chloropus*), Dalkeith, Feb.; and Coot (*Fulica atra*), Gosford, May 1890.

Goniocotes compar, N.—From Wood-Pigeon (*Columba palumbus*), Fife, Jan. 1905, and Dunipace, Stirlingshire, Sept. 1911.

Goniodes dispar, N.—From Partridge (*Perdix perdix*), near Edinburgh, Dec. 1907.

G. tetraonis, D. (? *heteroceros*, N.)—From Red Grouse, Pentland Hills, April 1889 and Sept. 1906, Denny Hills, and Kinross; and Black Grouse (*Tetrao tetrix*), Gorebridge, Nov. 1906, and Dunipace, Sept.

G. chelicornis, N.—From Capercaillie, Dunblane, Nov. 1905, Cobbinshaw, Nov. 1906, Touch near Stirling, Dec. 1907, Callander, [Comrie, and Dunkeld]. Larger and paler than the preceding; but the two are very closely related.

G. damicornis, N.—From Wood-Pigeon, near Markinch, June 1911, and Dunipace, Feb. 1912. Colinton (Rev. J. Waterston).

G. dissimilis, N.—From feather of Domestic Fowl (*Gallus domesticus*), in a Martin's nest, Kennetpans, Kincardine-on-Forth, Aug. 1908 (sent to me by Rev. J. Waterston).

G. colchicus, D.—From Pheasant (*Phasianus colchicus*), Tynehead, Dec. 1907, Dunipace [and Longformacus].

Lipeurus quadripustulatus, N.—From Peregrine Falcon (*Falco peregrinus*), near Dunbar, Sept. 1886, a single specimen.

L. baculus, N.—From Wood-Pigeon, East Fife, Feb. 1905; Stock Dove (*Columba œnas*), Gosford, Jan. 1886; and Domestic Pigeon (*C. domestica*), Edinburgh, Dalkeith, Tyninghame, and Dunipace.

L. pelagicus, D. (? *subangusticeps*, P.)—One ♀ from Storm Petrel (*Thalassidroma pelagica*), North Berwick, July 1910, and one ♂, which seems to me to belong to the same species, from Manx Shearwater, off North Berwick, Sept. 1887.

L. leucopygus, N.—One ♂ from Tawny Owl, Dalmeny, March 1892. Doubtless a straggler, the proper host of the species being the Heron, from which bird I have taken a number this year (locality East Lothian).

L. luridus, N.—One specimen from Spotted Crake (*Porzana porzana*), Dunbar, Aug. 1901.

L. longicornis, P.—From Cormorant, Gullane Bay, Oct. 1906.

L. staphylinoides, D. (*pullatus*, P.; *Docophorus bassanæ*, D. = ♀ and juv.)—Adults of both sexes and juveniles from Gannet (*Sula bassana*), Firth of Forth, Aug. 1887, May and Aug. 1906, and Bass Rock, June 1910. Some years ago when recording this species from St Kilda (*Ann. Scot. Nat. Hist*, 1906, p. 87),[1] I alluded to the resemblance of the females to Denny's figure of his *Docophorus bassanæ*. I felt then that the latter was nothing more than the female and immature state of his *L. staphylinoides*, and the examination of further material has convinced me that this is so. Mr Waterston has reached the same conclusion. With one exception, Denny referred all the females he had seen to *D. bassanæ*,

[1] The unidentified *Lipeurus* from a St Kilda gannet, mentioned by me in the same paper, is, Mr Waterston considers, a male of *L. mutabilis*, P., a species attached to the Fulmar Petrel (*Fulmarus glacialis*). Its occurrence on the gannet must be regarded as purely accidental. I may mention that I possess three females of *L. mutabilis* taken off a Fulmar from Sutherland last September. The same Fulmar yielded a few specimens of what I identify as *Menopon brevifimbriatum*, P.

and all the males to *L. staphylinoides.* As pointed out by Piaget, he figured the latter without a pale furrow along the middle of the abdomen, but this I consider of little consequence; I have a specimen of this description. Both of Denny's names are prior to Piaget's, and seeing *bassanæ* comes first in Denny's work, the correct name of the species, if the views expressed above are right, would appear to be *Lipeurus bassanæ* (D.).

L. squalidus, N.—From Pintail (*Dafila acuta*) off Bo'ness, Oct. 1884; Mallard, Gosford Bay, Nov. 1884 [and Edzell, Jan. 1907]; Teal (*Nettion crecca*), Culross, Jan., and Luffness, Sept. 1885; Wigeon, Kincardine-on-Forth, Jan. 1886, Duddingston Loch, Sept. 1906, and Dunbar, Jan. 1907; Pochard, Linlithgow Loch, Feb. 1885; Scaup-Duck, Dunbar, Nov. 1907; and Long-tailed Duck (*Harelda glacialis*), North Berwick, Feb. 1889.

L. temporalis, N.—From Red-breasted Merganser (*Mergus serrator*), East Fife, Dec. 1886; and Smew (*M. albellus*), Dunbar, Jan 1907. Kellogg and Chapman ("New Mallophaga," iii., p. 102) appear to regard this as doubtfully distinct from the preceding.

L. lacteus, N. (*tadornæ*, D.)—From Sheld-duck (*Tadorna tadorna*), near Elie, Sept. 1906, and [Solway Firth, Jan. 1910].

L. jejunus, N.—From Pink-footed Goose (*Anser brachyrhynchus*), Aberlady Bay, 30th Sept. 1892; [Grey Lag Goose, Newburgh-on-Tay, Oct.; and White-fronted Goose (*A. albifrons*), Orkney, Jan. 1885].

L anseris, Gurlt—Mr Waterston informs me that he has seen this commonly at Lochgelly on the domestic goose (*A. domesticus*).

L. mesopelius, N. ?—A ♀ *Lipeurus* off a pheasant from the East of Berwickshire, Jan. 1907, seems referable to this species.

L. ochraceus, N. (? *tetraonis*, Grube)—From Capercaillie, Callander, Nov. 1905, [Dunkeld and Comrie, Aug. 1906].

L. helvolus, N.—From Woodcock, Edinburgh District, Oct.

Ornithobius cygni, (L.) D.—(*Lip. bucephalus*, G.)—Two from Bewick's Swan (*Cygnus bewicki*), Aberlady Bay, 24th Feb. 1891.

O. goniopleurus, D.—From Barnacle-Goose, Cobbinshaw Loch, October 1906 [and Barra, Jan. 1910.][1]

Fam. Trichodectidæ.

Trichodectes latus, N.—Common on dogs (*Canis familiaris*), Dalkeith, June 1905, Dirleton, etc.

T. crassus, N.—From Badger (*Meles meles*), Hopetoun, Linlithgowshire, 10th March 1904.

T. retusus, N.—(+ *dubius*, N.)—From Weasel (*Mustela nivalis*), near Dunfermline, Jan. 1905.

T. subrostratus, N.—Many on cat (*Felis domestica*), Lasswade, April 1910. In list of species exhibited by the late Jas. Simpson at meeting of the Edinburgh Naturalists' Field Club in Dec. 1881 (*Transactions*, i. 23), but no locality is given.

T. scalaris, N.—From Cows (*Bos taurus* ♀), Hunter's Tryste, near Edinburgh, April 1906, Crosswood, etc.

T. parumpilosus, P. (*equi*, D., not L.)—From Horse (*Equus caballus*), Swanston, March 1906, and Crosswood, Pentlands, May 1907.

T. tibialis, P. (*longicornis* D., not N.)—A *Trichodectes* from a Hare (*Lepus europæus*) shot near Leadburn in September 1911, agrees so well with the figures and descriptions of this species (which occurs on Roe and Fallow Deer), that I cannot hesitate to record it as such.

[1] W. Evans, *Ann. Scot. Nat. Hist.*, 1910, p. 121.

Fam. **Liotheidæ.**

Menopon fulvofasciatum, P.—A small *Menopon* from Merlin, Currie, Feb. 1881, is probably the var. *minor* of this species.

M. mesoleucum, N.—♀ from Hooded Crow, near Gorebridge, Oct.

M. rusticum, G. ?—I assign to this form two not quite mature specimens from a Sand Martin (*Cotyle riparia*), near Dunbar, Aug. The hosts given by Piaget are Swallow and Sand Martin.

M. thoracicum, G.—Under this name I place a *Menopon*, with long thorax showing mesothoracic angle, of which several examples occurred on a Blackbird and two on a Swallow, at a farm near East Linton, last July. They are very similar to Piaget's figure of *rusticum*, but must, I think, be referred to *thoracicum*, which was described from the Mistle-Thrush. Colour yellowish white with fine blackish margins and head-spots.

M. carduelis, D.—One from Willow Warbler (*Phylloscopus trochilus*), and one from Redstart (*Phœnicurus phœnicurus*), Barnsness lighthouse, near Dunbar, May 1912. A dark fuscous species, as in Denny's figure. The birds were sent to me together, in the same parcel, which makes the question of the host uncertain.

Menopon spp.—Besides those recorded above I have specimens belonging to this genus from the following other Passeres: Song-Thrush, East Linton, July; Red-backed Shrike (*Lanius collurio*), Isle of May, May 1911; and Pied Wagtail, Dunbar, June 1885. Specimens from a Blackbird, Edinburgh, Sept. 1907, are the same as those from the Song-Thrush. In the present state of our knowledge, the satisfactory determination of these from books seems hardly possible. Those from the Thrush and Blackbird may be Denny's *M. citrinellæ* (which Piaget makes a synonym of *pusillum*, N.); as may also that from the Wagtail, though it is more like his *sinuatum* (= *minutum*, N.). The two specimens from the Shrike are very similar to those from the Blackbird, but they may be Denny's *fuscocinctum* from the former bird—they certainly do not seem to be Piaget's *inæquale*.

M. pallidum, N.—From Domestic Fowl, Edinburgh, Dunipace, etc; and young Pheasant, hatched under domestic fowl, Dalmeny, July 1906.

M. latifasciatum, P.—A *Menopon* from Black Grouse, West Fife, May 1906, seems at most but a variety of this species (described from a Capercaillie).

M. pallescens, N. (*perdicis*, D.)—Two Partridges—old and young—found dead on the railway near Dunbar, last Sept., yielded this in plenty.

M. crocatum, N.—A specimen from a Bar-tailed Godwit, Aberlady Bay, Aug. 1886, is referable to this form rather than to the next. Has been recorded from a Godwit in America.

M. lutescens, N.—From Lapwing's nest, Aberlady, May 1906; Ringed Plover, Scoughall, Sept. 1886; Ruff, Luffness, Sept. 1887; Knot, Aberlady Bay, Dec. 1885 and Sept. 1888; Curlew Sandpiper, Aberlady Bay, Sept 1885 (the last two are small and may be a variety); and [Dunlin, Edenmouth, near St Andrews, Aug. 1886]. Also from Guillemot, Aberlady, Jan. 1910, and North Berwick, Jan. 1912; Razorbill, North Berwick, Jan. 1912; and Little Auk, North Berwick, Lasswade, and Dalmeny, same date. With such diverse hosts as Waders and Auks, some variation is to be expected; Piaget points out some differences in the case of specimens from the Razorbill, and I have above (p. 267) referred to the possibility of those from the Little Auk being a distinct variety (see Fig. 3).

M. tridens, N. (*scopulacorne*, D.)—From Coot, Gosford, May 1890; Spotted Crake, Dunbar, Aug. 1901; Moorhen, Loch Leven, May 1912; and Little Grebe, Dunbar, Jan. 1907.

M. fuscofasciatum, P. ?—A specimen from an Arctic Skua, Aberlady Bay, Sept. 1884, probably belongs to this form.

M. albofasciatum, P.—Two from Sheld-duck, East Fife, Sept. 1906.

M. lunarium, G.?—One specimen of what may be this, from Common Scoter, Musselburgh Bay, Dec. 1887; but the status of this form, which was described from the same species of duck, is not satisfactory.

M. phæopus, N. (*ridibundus*, D.)—From Black-headed Gull, Loch Leven, May 1912; and also, so far as I can judge, from Little Gull, Dunbar, Oct. Denny's figure is much too dark.

M. obtusum, N. (? *transversum*, D).—From Kittiwake, Kincardine-on-Forth, Jan. 1885 Piaget thought this might be merely a variety of the last, and Kellogg treats it as such.

Colpocephalum flavescens, N.—From Rough-legged Buzzard, Gorebridge, Sept. 1906.

C. subpachygaster, P.—Mr Waterston informs me that he has this from a Barn Owl (*Strix flammea*) got at Cramond. [From same species, Wigtownshire.]

C. subæquale, N.—From Raven, Strathyre, 1908, also [Shetland, Dec. 1905 and Oban, Sept.]; Hooded Crow, Dirleton, Dec. 1884; Carrion Crow, Elie, Oct.; and Rook, Kirkliston, March 1909.

C. importunum, N.—Many on Common Heron, Portmore Loch, Oct. 1906; and Loch Leven, August.

C. umbrinum, P. (? *trilobatum*, G.)—One specimen from Little Stint, Aberlady Bay, Sept. 1885, agrees well with Piaget's figure.

C. ochraceum, N.—From Lapwing, Colzium, Pentlands, March 1890, and Currie, June 1906; Jack Snipe (*Gallinago gallinula*), Luffness, Jan. 1886; Oystercatcher and Whimbrel, North Berwick, Aug. 1911.

C. bicolor, P.—From Turnstone, Longniddry, Nov. 1885, Dunbar and Isle of May, Sept. last.[1]

C. maurum, N. (*piceum*, D.)—One ♀, of what I take to be this, from Little Gull, Dunbar, Oct.

Nitzschia pulicaris, N. (*burmeisteri*, D.)—From Swift (*Cypselus apus*), Edinburgh and Dunipace, August, and Linlithgow, June 1912. In some respects my specimens agree with *N. tibialis*, P., which, however, does not seem to me to be a good species.

Trinoton conspurcatum, N.—From Bewick's Swan, Aberlady Bay, Feb. 1891.

T. luridum, N.—From Pintail, off Bo'ness, Oct. 1884; Teal, near Culross, Jan. 1885; and Mallard, near Edinburgh, Aug., and North Berwick, Dec. 1906.

T. lituratum, N. (*squalidum*, D.)—One from Wigeon, Duddingston Loch, Sept. 1906.

Physostomum bombycillæ, D. (*intermedium*, P.)?—One from Snow Bunting, North Berwick, Nov. 1906. I place it under this name, because Denny states that he had seen his *bombycillæ* from the Snow Bunting, as well as from the Waxwing.

Postscript, *22nd Oct.* 1912.—To the above list I have to add:—**Nirmus hæmatopi** (L.), D. (*ochropygus*, N.)—From Oystercatcher, North Berwick.

Reference to the figure of Kellogg's Docophorus-like *Giebelia*, from Pacific Shearwaters, in "Genera Insectorum," suggests the probability of my *D. aviator* from the Manx Shearwater (pp. 268 and 270) belonging to that genus.

[1] I have shown specimens to Mr R. S. Bagnall, by whom the species was first recorded as British in Feb. this year.

(*Issued separately*, *26th October* 1912.)

JOURNAL OF PROCEEDINGS.

SESSION CXXXIX.

Monday, 25th October 1909.—Professor J. Graham Kerr, M.A., F.R.S., President, in the Chair.

The retiring President delivered an address entitled "Remarks upon Certain Points connected with Evolutionary Theory."

Monday, 22nd November 1909.—Lionel W. Hinxman, Esq., B.A., F.R.S.E., in the Chair.

The following Office-Bearers for the Session were elected:

President—Professor J. Arthur Thomson, M.A., F.R.S.E.

Vice-Presidents—Professor T. Hudson Beare, B.A., B.Sc., M.Inst.C.E.; J. H. Ashworth, D.Sc.; Lionel W. Hinxman, B.A., F.R.S.E.

Secretary—O. Charnock Bradley, M.D., D.Sc., F.R.S.E.

Assistant-Secretary—W. A. Jolly, M.B.

Treasurer—W. A. Middleton, C.A.

Librarian—G. W. Lee, D.Sc.

Councillors—D. C. M'Intosh, M.A., B.Sc., F.R.S.E., R. Stewart MacDougall, M.A., D.Sc., F.R.S.E.; Kenneth J. Morton, F.E.S.; W. S. Bruce, LL.D., F.R.S.E.; Professor J. Cossar Ewart, M.D., F.R.S.; E. B. Bailey, B.A.; A. Gofton, M.R.C.V.S.; Professor J. Graham Kerr, M.A., F.R.S.; D. Waterston, M.A., M.D., F.R.C.S.E., F.R.S.E.; Percy H. Grimshaw, F.E.S.; Wm. Evans, F.F.A., F.R.S.E.; Professor T. H. Bryce, M.A., M.D., F.R.S.E.

The Secretary, Treasurer, and Librarian submitted their Annual Reports.

The following Communications were submitted:

1. "Echinoidea and Asteroidea from the Mergui Archipelago and Moskos Islands, Lower Burma." By R. N. Rudmose Brown, Esq., D.Sc.
2. "Asteroidea of Portuguese East Africa, collected by Jas. J. Simpson, M.A., B.Sc., (1907-1908)." By Jas. J. Simpson, Esq., M.A., B.Sc., and R. N. Rudmose Brown, Esq., D.Sc.
3. "Echinoidea from the Kerimba Archipelago, Portuguese East Africa (Mozambique)." By R. N. Rudmose Brown, Esq., D.Sc.
4. "Some Notes on the chance Grouping of Black and White Balls when taken in Pairs from a Bag." By W. J. Millar, Esq. (Communicated by D. C. M'Intosh, Esq., M.A., B.Sc.)
5. "The Distribution of *Palinurus vulgaris* in British Waters." By James Ritchie, Esq., M.A., B.Sc.
6. "Exhibition, with Remarks, of Insects associated with Disease in Man." By J. H. Ashworth, Esq., D.Sc.

Monday, 20th December 1909.—Professor J. ARTHUR THOMSON, M.A., F.R.S.E., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:—Professor Arthur Robinson, M.D., and A. M. Drennan, Esq., M.B., Ch.B.

The following Communications were submitted:

1. "Notes on Professor E. A. MINCHIN'S Preparations of the Early Stages in the Development of *Sepia*." By J. H. KOEPPERN, Esq. (Communicated by Professor J. GRAHAM KERR.)
2. "On a Millepore from Rockall." By Professor J. ARTHUR THOMSON, M.A., F.R.S.E.
3. "On a new Pseudaxonid Genus—*Dendrogorgia*." By JAS. J. SIMPSON, Esq., M.A., B.Sc.
4. "Exhibition of Rare Butterflies from Sikkim." By PERCY H. GRIMSHAW, Esq., F.E.S.

Monday, 24th January 1910.—J. H. ASHWORTH, Esq., D.Sc., Vice-President, in the Chair.

The following Communications were submitted:

1. "An Embryonic Appendage of the Claws of the Amniota, probably of an adaptive nature." By W. E. AGAR, Esq., B.A., D.Sc.
2. "Exhibition of Specimens illustrating the nesting habits of the Tree Frog, *Phyllomedusa sauvagii*." By W. E. AGAR, Esq., B.A., D.Sc.
3. "On some Habits and Hosts of Bird *Ceratophylli* taken in Scotland in 1909: with description of a new species (*C. rothschildi*)." By JAMES WATERSTON, Esq., B.D., B.Sc. (Communicated by J. H. ASHWORTH, Esq., D.Sc.)
4. "The Green Woodpecker, *Gecinus viridis*, as a Scottish Bird." By WM. EVANS, Esq., F.R.S.E.

Monday, 28th February 1910.—Professor J. ARTHUR THOMSON, M.A., F.R.S.E., President, in the Chair.

John Henry Koeppern, Esq., was elected an Ordinary Fellow of the Society.

The following Communications were submitted:

1. "Note on a Peculiar Clutch of Blackbird's Eggs and some other Abnormalities." By Professor J. ARTHUR THOMSON, M.A., F.R.S.E.
2. "Note on *Piona carnea* C. L. KOCH, and *Eurycypris pubera* (O.F.M.)." By WM. WILLIAMSON, Esq.
3. "Exhibition of Drawings of Larval Forms, and Observations on the Classification of Hydracarina." By WM. WILLIAMSON, Esq.
4. "Exhibition, with Remarks, of some rare Marine Invertebrates." By J. H. ASHWORTH, Esq., D.Sc.
5. "Exhibition of *Ixodes unicaratus* (a recently described Tick from the Cormorant); larvæ of *Anopheles* from a pool near Lasswade; and other Invertebrates of Local Interest." By WM. EVANS, Esq., F.R.S.E.

Monday, 28th March 1910.—Professor J. ARTHUR THOMSON, M.A., F.R.S.E., President, in the Chair.

Richard Elmhirst, Esq., was elected an Ordinary Fellow of the Society.

The following Communications were submitted :

1. "Note on an Alcyonarian from the Færoe Channel." By Professor J. ARTHUR THOMSON, M.A., F.R.S.E.
2. "Note on the Posterior Vena Cava of *Polypterus.*" By Professor J. GRAHAM KERR, M.A., F.R.S.
3. "Exhibition, with Remarks, of some British Echinoderms." By D. C. M'INTOSH, Esq., M.A., B.Sc.
4. "The Oligochæta (Earth-worms and their Allies) of the Forth Area." By WM. EVANS, Esq., F.R.S.E.

At an *Extraordinary Meeting* held on 27th May 1910, Professor J. Arthur Thomson, President, in the Chair, a Loyal and Dutiful Address to His Most Excellent Majesty George V., King and Emperor, was unanimously agreed upon by the President and Fellows of the Royal Physical Society of Edinburgh.

SESSION CXL.

Monday, 24th October 1910.—J. H. ASHWORTH, Esq., D.Sc., Vice-President, in the Chair.

Wm. Learmonth, Esq., was elected an Ordinary Fellow of the Society.

The following Communications were submitted :

1. "Two Antipatharians from the Cape." By Professor J. ARTHUR THOMSON, M.A., F.R.S.E.
2. "Note on Variation in the number of Genital Apertures in the Norway Lobster (*Nephrops norvegicus*)." By D. C. M'INTOSH, Esq., M.A., B.Sc.
3. "Exhibition of some Crustacea and Fresh Water Medusae, with Remarks." By J. H. ASHWORTH, Esq., D.Sc.
4. "*Protocalliphora groenlandica* as an enemy of Sheep." By R. STEWART MACDOUGALL, Esq., M.A., D.Sc.

Monday, 28th November 1910.—Professor T. HUDSON BEARE, B.A., B.Sc., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:—George Archdall O'Brien Reid, Esq., M.D., and A. M. Patience, Esq.

The Secretary, the Treasurer, and the Librarian submitted their Annual Reports.

The following Office-Bearers for the Session were elected :

President—Professor J. ARTHUR THOMSON, M.A., F.R.S.E.

Vice-Presidents—J. H. ASHWORTH, D.Sc., LIONEL W. HINXMAN, B.A., F.R.S.E., Professor E. A. SCHÄFER, LL.D., F.R.S.

Secretary—O. Charnock Bradley, M.D., D.Sc., F.R.S.E.

Assistant-Secretary—James Ritchie, M.A., B.Sc.

Treasurer—William Williamson, F.R.S.E.

Librarian—Percy H. Grimshaw, F.E.S.

Councillors—Professor J. Cossar Ewart, M.D., F.R.S.; E. B. Bailey, B.A.; A. Gofton, M.R.C.V.S.; Professor J. Graham Kerr, M.A., F.R.S.; Wm. Evans, F.F.A., F.R.S.E.; Professor T. H. Bryce, M.A., M.D., F.R.S.E.; Professor T. Hudson Beare, B.A., B.Sc., F.R.S.E.; G. W. Lee, D.Sc.; W. A. Jolly, M.B.; Professor Arthur Robinson, M.D., F.R.S.E.; E. B. Jamieson, M.D.; Professor L. A. L. King, M.A.

The following Communications were submitted :

1. "On some points in the Anatomy of *Solaster*." By J. F. Gemmill, Esq., D.Sc., M.D. (Communicated by J. H. Ashworth, Esq., D.Sc.)
2. "Exhibition of Coleoptera taken in Orkney from 7th to 13th September 1910." By Professor T. Hudson Beare, B.A., F.R.S.E.
3. "Exhibition of specimens of several species of Coleoptera recently added to the British List." By Professor T. Hudson Beare, B.A., F.R.S.E.
4. Scottish Dragon-Flies, with Exhibition of Specimens and Maps showing Distribution." By Wm. Evans, Esq., F.R.S.E.
5. "Exhibition of Cocoon formed by an Arctiid Caterpillar from Burmah." By Percy H. Grimshaw, Esq.

Monday, 19*th December* 1910.—Professor J. Arthur Thomson, M.A., F.R.S.E., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:—Professor D'Arcy W. Thompson, C.B., B.A., F.L.S., and Wm J. Caird, Esq.

The following Communications were submitted :

1. "On a large Antipatharian from the North Sea." By Professor J. Arthur Thomson, M.A., F.R.S.E.
2. "On a remarkable Alcyonarian from Formosa." By Professor J. Arthur Thomson, M.A., F.R.S.E.
3. "Note on four Species of Hydracarids." By Wm. Williamson, Esq., F.R.S.E.
4. "Exhibition of *Hydrarachna processifera* Koew., new to Britain." By Wm. Williamson, Esq., F.R.S.E.
5. "Exhibition, with Remarks, of a Nematode from the stomach of a Shrew." By Professor L. A. L. King, M.A.

Monday, 23*rd January* 1911.—J. H. Ashworth, Esq., D.Sc., Vice-President, in the Chair.

Wm. Kilpatrick Hutton, Esq., M.D., was elected an Ordinary Fellow of the Society.

Francis Cowan, Esq., was formally admitted a Fellow of the Society.

The following Communications were submitted :

1. "Notes on the Recent Immigration of Mealy Redpolls, including the form known as Holböll's Redpoll." By Wm. Evans, Esq., F.R.S.E.

2. "Exhibition, with Remarks, of Hydroid Zoophytes collected by the 'Thetis' Expedition off the Coast of New South Wales." By JAMES RITCHIE, Esq., M.A., B.Sc.
3. "Exhibition, with Remarks, of Annelids." By J. H. ASHWORTH, Esq., D.Sc.

Monday, 27th February 1911.—LIONEL W. HINXMAN, Esq., B.A., F.R.S.E., Vice-President, in the Chair.

James F. Gemmill, Esq., M.A., M.D., D.Sc., was elected an Ordinary Fellow of the Society.

Professor D'Arcy W. Thompson, C.B., B.A., F.L.S., and A. M. Drennan, Esq., M.B., Ch.B., were formally admitted Fellows of the Society.

The following Communications were submitted :

1. "The Age and Growth of Fishes." By Professor D'ARCY W. THOMPSON, C.B., B.A.
2. "Ophiuroidea from the Mergui Archipelago, Lower Burma." By D. C. M'INTOSH, Esq., M.A., B.Sc.
3. "The Range of Vision in *Amphibia*." By W. A. JOLLY, Esq., M.B., Ch.B.

Monday, 27th March 1911.—J. H. ASHWORTH, Esq., D.Sc., Vice-President, in the Chair.

The following Communications were submitted :

1. "Exhibition of Sponges from the 'Scotia' Expedition, described by Professor Topsent." By W. S. BRUCE, Esq., LL.D., F.R.S.E.
2. "A New Flea (*Xenopsylla trispinis*) from South Africa." By JAMES WATERSTON, Esq., B.Sc., B.D.
3. "Notes on some recent Inquiries into Bird-Migration by the Ringing Method." By A. LANDSBOROUGH THOMSON, Esq.
4. "Notes on two White-beaked Dolphins recently stranded in the Upper Estuary of the Forth." By WM. EVANS, Esq., F.R.S.E.

SESSION CXLI.

Monday, 23rd October 1911.—Professor J. ARTHUR THOMSON, M.A., F.R.S.E., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society :—

James Miller, Esq., D.Sc., M.D.; Theodore Rettie, Esq., D.Sc.; and John Ritchie, Esq., M.B., Ch.B.

The following Communications were submitted :

1. "Exhibition, with Remarks, of Larval and Adult Fishes from Messina." By J. H. ASHWORTH, Esq., D.Sc.
2. "Note on a Tachinid Parasite (*Bucentes geniculatus*, D.G.) of *Tipula* sp." By JOHN RENNIE, Esq., D.Sc.
3. "Some Hydroid Zoophytes obtained by Hull Trawlers ; with description of a new Species of Plumularian." By JAMES RITCHIE, Esq., M.A., B.Sc.
4. "Recent Researches into the Structure of the Alps." By E. B. BAILEY, Esq., B.A.

Monday, 27th November 1911.—J. H. Ashworth, Esq., D.Sc., Vice-President, in the Chair.

The Secretary, the Treasurer, and the Librarian submitted their Annual Reports.

The following Office-Bearers for the Session were elected:

President—Professor J. Arthur Thomson, M.A., F.R.S.E.

Vice-Presidents—Lionel W. Hinxman, B.A., F.R.S.E.; Professor E. A. Schäfer, LL.D., F.R.S.; Principal O. Charnock Bradley, M.D., D.Sc., F.R.S.E.

Secretary—James Ritchie, M.A., B.Sc.

Assistant-Secretary—D. C. M'Intosh, M.A., B.Sc., F.R.S.E.

Treasurer—Wm. Williamson, F.R.S.E.

Librarian—Percy H. Grimshaw, F.E.S., F.R.S.E.

Councillors—Wm. Evans, F.F.A., F.R.S.E.; Professor T. H. Bryce, M.A., M.D., F.R.S.E.; Professor T. Hudson Beare, B.A., B.Sc., F.R.S.E.; G. W. Lee, D.Sc.; W. A. Jolly, M.B., Ch.B.; Professor Arthur Robinson, M.D.; E. B. Jamieson, M.D.; Professor L. A. L. King, M.A.; J. H. Ashworth, D.Sc., F.R.S.E.; Professor D'Arcy W. Thompson, C.B., B.A.; W. S. Bruce, LL.D., F.R.S.E.; W. E. Agar, B.A., D.Sc.

The following Communications were submitted:

1. "Exhibition of Specimens of *Sympetrum fonscolombii*—a Dragon-fly new to the Scottish List." By Wm. Evans, Esq., F.R.S.E.
2. "An Aid to the Study of Nematocysts: with demonstration of apparatus." By T. H. Taylor, Esq., M.Sc. (Communicated by Professor J. Arthur Thomson.)
3. "Note on Pelagic Organisms and Evolution." By Professor J. Graham Kerr, F.R.S.

Monday, 18th December 1911.—Principal O. Charnock Bradley, Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:—A. Landsborough Thomson, Esq., M.A.; A. P. Jameson, Esq., B.Sc.; Gilbert James Murray, Esq.; Oliver Hilton Wild, Esq.; W. P. F. M'Lintock, Esq., B.Sc.

Theodore Rettie, Esq., D.Sc., was formally admitted a Fellow of the Society.

The following Communications were submitted:

1. "Northern Arctic Palæozoic Fossils collected by Sir William Edward Parry." By G. W. Lee, Esq., D.Sc.
2. "'Scotia' collections—Further Note on Microscopic Life on Gough Island, South Atlantic Ocean." By Dr Eugène Penard, Geneva. (Communicated by Wm. Evans, Esq., F.R.S.E.)
3. Exhibition of a recently described Species of Chameleon from Uganda. By Miss Marion I. Newbigin, D.Sc.
4. "Exhibition of a case of Similar Adaptations in Different Organs, in Crustacea" By James Ritchie, Esq., M.A., B.Sc.
5. "Exhibition and Description of a Model of an *Eurypterid*." By B. N. Peach, Esq., LL.D., F.R.S.

Monday, 22nd January 1912.—LIONEL W. HINXMAN, Esq., B.A., Vice-President, in the Chair.

R. S. Clark, Esq., B.Sc., was elected an Ordinary Fellow of the Society.

W. F. P. M'Lintock, Esq., B.Sc., and R. S. Clark, Esq., B.Sc., were formally admitted Fellows of the Society.

The following Communications were submitted:

1. "On the Mallophagous Parasites of the Gannet known as *Docophorus bassanæ* and *Lipeurus staphylinoides.*" By J. WATERSTON, Esq., B.D., B.Sc. (Communicated by J. H. ASHWORTH, Esq., D.Sc.)
2. "Exhibition of Examples of Fossilization in Precious Opal, from New South Wales." By W. P. F. M'LINTOCK, Esq., B.Sc.
3. "Exhibition of Nest and Eggs of the Mole Cricket, *Gryllotalpa gryllotalpa.*" By R. STEWART MACDOUGALL, Esq., M.A., D.Sc., F.R.S.E.
4. "Note on the Life History of the Anthomyid Fly, *Fannia canicularis.*" By R. STEWART MACDOUGALL, Esq., M.A., D.Sc., F.R.S.E.

Monday, 26th February 1912.—Professor E. A. SCHÄFER, LL.D., F.R.S., Vice-President, in the Chair.

Gilbert James Murray, Esq., was formally admitted a Fellow of the Society.

The following Communications were submitted:

1. "Guide to the Identification of the British Irregular Sea Urchins." By D. C. M'INTOSH, Esq., M.A., B.Sc., F.R.S.E.
2. "Exhibition of the Serin Finch (*Serinus serinus*), the first Scottish example, and of Marsh and Reed Warblers (*Acrocephalus palustris* and *streperus*)." By OLIVER H. WILD, Esq.
3. "Description of a New Species of Hydracarina, *Piersigia intermedia.*" By WM. WILLIAMSON, Esq., F.R.S.E.
4. "Exhibition of Epitokous Forms of Two Marine Worms, *Nereis* and *Scalibregma.*" By J. H. ASHWORTH, Esq., D.Sc.

Monday, 25th March 1912.—Principal O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E., Vice-President, in the Chair.

Miss Lily H. Huie was elected an Ordinary Fellow of the Society.

The following Communications were submitted:

1. "Exhibition of some curious Exotic Insects." By PERCY H. GRIMSHAW, Esq., F.R.S.E., F.E.S.
2. "Note on Mallophaga from the Little Auk or Rotch (*Alle alle*), with List of Species taken on Birds and Mammals in the Forth Area." By WM. EVANS, Esq., F.R.S.E.
3. "Exhibition of Echinoderms collected by the Scottish National Antarctic Expedition." By W. S. BRUCE, Esq., LL.D., F.R.S.E.
4. "Exhibition of the Hydroid Zoophytes collected by Sir Ernest Shackleton's Antarctic Expedition, in 1908. By JAMES RITCHIE, Esq., M.A., B.Sc.

LIST OF SOCIETIES WHICH RECEIVE THE SOCIETY'S "PROCEEDINGS."

Those Institutions from which Publications are received in return are indicated by an asterisk.

ENGLAND.

Birmingham, .	*Philosophical Society, King Edward's Grammar School.
Do.	*Natural History Society, Avebury House, 55 Newhall Street.
Cambridge, .	*Philosophical Society.
Do.	University Library.
Cirencester,	*Editor of the *Agricultural Students' Gazette.*
Newcastle-on-Tyne, .	Armstrong College.
Leeds, .	*Yorkshire Geological and Polytechnic Society, The University.
Do.	*The Conchological Society of Great Britain and Ireland.
Liverpool, .	*Biological Society, University College.
Do.	*Literary and Philosophical Society.
Do.	*Engineering Society, Royal Institution.
London,	British Museum Library.
Do.	*British (Natural History) Museum, South Kensington
Do.	*Royal Society, Burlington House, Piccadilly, W.
Do.	Chemical Society, Burlington House, Piccadilly, W.
Do.	*Geological Society, Burlington House, Piccadilly, W.
Do.	*Linnean Society, Burlington House, Piccadilly, W.
Do.	*Royal Microscopical Society, King's College.
Do.	Museum of Economic Geology, Jermyn Street.
Do.	Editor of *Nature*, 29 Bedford Street, Covent Garden.
Do.	*Zoological Society, Hanover Square.
Do.	*Geologists' Association, University College, W.C.
Manchester,	*Geological Society, 36 George Street.
Do.	*Literary and Philosophical Society, 36 George Street.
Do.	The Victoria University.
Norwich,	*Norfolk and Norwich Naturalists' Society, The Museum.
Oxford,	The Bodleian Library.
Truro,	*Royal Institution of Cornwall.
Watford,	*Hertfordshire Natural History Society and Field Club.

SCOTLAND.

Aberdeen,	University Library.
Cockburnspath,	*Berwickshire Naturalists' Field Club, Old Cambus.
Edinburgh	Advocates' Library.
Do.	University Library.
Do.	*Royal Society.
Do.	Royal Medical Society.
Do.	*Royal Scottish Society of Arts.

Edinburgh, . .	*Royal Scottish Geographical Society.
Do. . .	*Botanical Society.
Do. . .	*Highland and Agricultural Society.
Do. . .	*Geological Society.
Glasgow, . .	*Philosophical Society.
Do. . .	*Natural History Society.
Do. . .	*Geological Society.
Do. . .	*Andersonian Naturalists' Society.
Do. . .	Glasgow and West of Scotland Technical College, Glasgow.
Do. . .	University Library.
Perth, . . .	*Perthshire Society of Natural History.
St Andrews, . .	University Library.

IRELAND.

Belfast, . .	*Natural History and Philosophical Society.
Dublin, . .	*Royal Irish Academy.
Do. . .	*Royal Dublin Society.
Do. . .	*Royal Geological Society of Ireland.

HOLLAND.

Amsterdam, . .	*De Koninklijke Akademie van Wetenschappen.
Leyden, . .	*Museum van Naturlijke Histoire.
Utrecht, . .	Provinciaal Genootschap an Kunsten en Wetenschappen.

SWITZERLAND.

Basle, . . .	*Die Naturforschende Gesellschaft.
Bern, . . .	*Allgemeine Schweizerische Gesellschaft für die gesammten Naturwissenschaften.
Do. . . .	*Die Naturforschende Gesellschaft.
Geneva, . .	*Société de Physique et d'Histoire Naturelle.
Neufchatel, .	*Société des Sciences Naturelles.
Zürich, . . .	*Die Naturforschende Gesellschaft.

GERMANY.

Berlin, . . .	*Königliche Akademie der Wissenschaften.
Do. . . .	*Deutsche Geologische Gesellschaft.
Do. . . .	*Gesellschaft Naturforschender Freunde.
Bonn, . . .	*Naturhistorischer Verein der preussischen Rheinlande Westfalens, und des Reg.-Bezirks Osnabrück.
Bremen, . .	*Verein für Naturwissenschaft.
Breslau, . .	*Schlesische Gesellschaft für Vaterländische Cultur.
Brunswick, . .	*Naturwissenschaftlicher Verein.
Dresden, . .	Königliche Sammlungen für Kunst und Wissenschaft.
Do. . .	*Der Verein für Erdkunde.
Elberfeld, . .	*Naturwissenschaftlicher Verein.
Erlangen, . .	University Library.
Frankfort-on-Main,	*Senckenbergische Naturforschende Gesellschaft.
Do.	*Deutsche Malakozoologische Gesellschaft, Dr Kobelt. Schwanheim.
Freiburg, i. B., .	*Die Naturforschende Gesellschaft.
Göttingen, . .	*Königliche Gesellschaft der Wissenschaften.
Halle, . .	*Kaiserliche Akademie der Naturforscher.

Hamburg . .	Naturhistorisches Museum.
Jena, . . .	*Medicinisch-naturwissenschaftliche Gesellschaft.
Leipzig, . .	*Königliche Sächsische Gesellschaft der Wissenschaften.
Do. . . .	Naturforschende Gesellschaft.
Do. . . .	Editor of the *Zoologischer Anzeiger.*
Munich, . .	*Königliche Baierische Akademie der Wissenschaften.
Stuttgart, . .	*Verein für Vaterländische Cultur in Würtemberg.
Würzburg, . .	*Physikalisch-medicinische Gesellschaft.

AUSTRIA.

Agram, . . .	*Societas Croatica Historico-naturalis.
Hermannstadt, .	*Siebenbürgischer Verein für Naturwissenschaft.
Prague, . .	*Königliche-böhmische Gesellschaft der Wissenschaften.
Trieste, . .	Società Adriatica di Scienze Naturali.
Vienna, . .	*K.k. zoologisch-botanische Gesellschaft.
Do. . .	*K.k. Naturhistorisches Hof-Museum.

ITALY.

Bologna, . .	*Accademia delle Scienze dell' Istituto.
Milan, . . .	*Reale Istituto Lombardo di Scienze, Lettere ed Arti.
Do. . . .	*Società Italiana di Scienze Naturali.
Modena, . .	Società dei Naturalisti.
Naples, . .	Editor of the *Zoologischer Jahresbericht*, Zoological Station.
Padua, . . .	*Società Veneto-Trentina di Scienze Naturali residente in Padova.
Rome, . . .	*Reale Accademia dei Lincei.
Turin, . . .	*Reale Accademia delle Scienze.

SPAIN.

Madrid, . .	*Real Academia de Ciencias exactas, fisicas e naturales.
Do. . . .	Real Sociedad Española de Historia Natural (Museo de Ciencias Naturales), Hipódromo.

PORTUGAL.

Coimbra, . .	*Bibliothèque de l'Université.
Lisbon, . .	*Academia Real das Sciencias.

FRANCE.

Bordeaux, . .	La Société Linnéenne.
Caen, . . .	*Société Linnéenne de Normandie.
Cherbourg, . .	*Société Nationale des Sciences Naturelles.
Paris, . . .	*Académie des Sciences de l'Institut.
Do. . . .	*Société Géologique de France, Rue des grands Augustins, 7.
Do. . . .	*Société Zoologique de France, Rue des grands Augustins, 7.
Do. . . .	Société de Biologie.
Do. . . .	Ecole des Mines.

BELGIUM.

Brussels, . .	*Académie Royale des Sciences, des Lettres, et des beaux Arts.
Do. . .	*Société Royale Malacologique de Belgique.
Do. . .	Société Belge de Microscopie.

NORWAY.

Bergen, . .	*The Museum.
Christiania, .	*Professor Dr N. Wille, "Nyt Magazin for Naturvidenskaberne," Christiania, Norway.
Do. . .	Universitets Bibliothek.

DENMARK.

Copenhagen, .	*Kongelige Danske Videnskabernes Selskab.
Do. . .	*Naturhistoriske Forening.

SWEDEN.

Stockholm, . .	*Kongliga Svenska Vetenskaps-Akademie.
Upsala, . .	*Kongliga Vetenskaps-Societeten.
Do. . .	*Observatoire Météorologique.

RUSSIA.

Dorpat, . .	*Naturforscher Gesellschaft.
Kiev, . . .	*Natural History Society.
Moscow, . .	*Société Impériale des Naturalistes.
St Petersburg, .	*Académie Impériale des Sciences.
Do. .	*Imperial Botanic Garden.

AMERICA.

United States.

Albany, N. Y., .	*New York State Library.
Baltimore, . .	*Johns-Hopkins University Library.
Boston, . .	*American Academy of Arts and Sciences.
Do. . .	*Society of Natural History.
Brookville, Ind.,	*Brookville Society of Natural History.
California, . .	University of California.
Cambridge, Mass.,	*Harvard University Library.
Do.	*Museum of Comparative Zoology.
Chicago, . .	*Academy of Sciences.
Cincinnati, . .	*Society of Natural History.
Newhaven, Conn.,	*Connecticut Academy of Arts and Sciences.
Do.	Yale College Library.
New York, . .	*New York Academy of Sciences.
Philadelphia, .	*Academy of Natural Sciences.
Do. .	*Wagner Free Institute.
San Francisco, .	*California Academy of Sciences.
St Louis, . .	*Academy of Sciences.
Washington, .	*Smithsonian Institute.
Do. . .	*Philosophical Society.
Do. . .	*United States National Museum.
Do. . .	*United States Geological Survey.
Do. . . .	*United States Commissioner of Fish and Fisheries.
Wisconsin, . .	*Academy of Sciences, Arts, and Letters.

Mexico.

Mexico, . .	*Ministerio de Fomento de la Republica, Osservatori Meteorologico.
Do. . .	*Sociedad Cientifica, "Antonio Alzate," Mexico.

Canada.

Hamilton, . .	*The Hamilton Association.
Kingston, . .	*Queen's University.
Manitoba, . .	*Historical and Scientific Society, Winnipeg.
Montreal, . .	*The Natural History Society.
Ottawa, . .	*Canadian Geological Survey.
Do. . .	*Royal Society of Canada.
Toronto, . .	*The Canadian Institute.

Nova Scotia.

Halifax, . .	*Nova Scotia Institute of Natural Science.

Brazil.

Rio de Janeiro, .	Museu Nacional.
Do. .	Instituto de Manguinhos, caixa 926 Rio de Janeiro, Brazil.

AFRICA.

Cape Town, . .	*South African Philosophical Society.

Egypt.

Cairo, . . .	Université Egyptienne, Bibliothèque.

ASIA.

Batavia, . .	*Koninklijke Natuurkundige Vereeniging in Nederlandsch Indie.
Calcutta, . .	Royal Asiatic Society of Bengal.
Tokio, Japan, .	*Imperial University of Japan.

AUSTRALASIA.

Adelaide, . .	*Royal Society of South Australia.
Melbourne, . .	*Royal Society of Victoria.
Sydney, . .	*Royal Society of New South Wales.
Do. . .	*The Australian Museum.
Do. . .	*Linnean Society of New South Wales.
Wellington, .	*New Zealand Institute.

LIST OF FELLOWS

At 1st October 1912.

*Those marked * are Life Members.*

Date of Election.

1905. Agar, W. E., B.A., D.Sc., 1 Eton Gardens, Hillhead, Glasgow.
1905. Anderson, T. J., B.Sc., Nairobi, British East Africa.
1901. Annandale, Nelson, B.A., D.Sc., The Museum, Calcutta.
1902. *Ashworth, J. H., D.Sc., Zoological Laboratory, University.

1907. *Bagnall, R. S., Oldstead, Park Town, Oxford.
1904. Bailey, Edward B., B.A., H.M. Geological Survey, 33 George Square.
1885. Barbour, A. H. F., M.A., B.Sc., M.D., 4 Charlotte Square.
1904. Beare, Professor T. Hudson, B.A., B.Sc., M.Inst.C.E., University.
1880. *Beddard, Frank E., M.A., F.R.S., Zoological Gardens, London.
1881. *Berry, W., Tayfield, Newport, Fife.
1902. Black, J. Wyclif, F.C.S., 67 Falcon Road.
1906. *Bowhill, Jas. Wm., B.A., Morelands, Grange Loan.
1892. Bowhill, Thomas, F.R.C.V.S., 1445 6th Avenue, Fairview, Vancouver, British Columbia.
1893. *Bradley, O. Charnock, M.D., D.Sc., F.R.S.E., Royal Veterinary College.
1876. Brown, J. A. Harvie-, LL.D., F.Z.S., F.R.S.E., Dunipace House, Larbert.
1891. Brown, Richard, C.A., 23 St Andrew Square.
1904. Brown, R. N. Rudmose, D.Sc., 52 Beaconsfield Place, Aberdeen, and University, Sheffield.
1907. Brown, Wm., M.R.C.V.S., Catterloch, Banchory, by Aberdeen.
1876. *Bruce, W. P., Kinleith Mill, Currie.
1894. Bruce, W. S., LL.D., F.R.S.E., F.R.S.G.S., Scottish Oceanographical Laboratory, Surgeons' Hall.
1907. Bryce, T. H., Professor, M.A., M.D., 2 Granby Terrace, Glasgow, W.
1910. Caird, Wm. J., School-house, Sandhaven, Fraserburgh.
1893. Campbell, Kenneth Findlater, C.E., Hon.M.Inst.C.E., M.S.I., Borough Engineers' Office, Huddersfield.
1892. Carlier, Edmond W. Wace, B.Sc., M.D., University, Birmingham.
1876. *Carmichael, His Excellency Lord, of Skirling, Governor-General, Madras, India.
1858. Carruthers, W., F.R.S., 44 Central Hill, Norwood, London, S.E.
1912. Clark, R. S., B.Sc., Oceanographical Laboratory, Surgeons' Hall.
1888. Clarke, Wm. Eagle, F.L.S., F.R.S.E., Royal Scottish Museum.
1895. *Clough, C. T., M.A., H.M. Geological Survey, 33 George Square.
1881. Cook, C., W.S., 11 Belgrave Crescent.
1902. Cowan, Francis, C.A., Westerlea, Murrayfield.
1897. Craig, E. H. Cunningham, B.A., F.G.S., Port of Spain, Trinadad.
1900. *Crampton, Cecil B., M.B., C.M., H.M. Geological Survey, 33 George Square.
1874. Crawford, W. C., M.A., 1 Lockharton Gardens, Colinton Road.

1877. *Dalgleish, J. J., Brankston Grange, Bogside Station, Alloa.
1894. Day, T. Cuthbert, F.C.S., 36 Hillside Crescent.

Date of Election.

1895. Douglas, William, 9 Castle Street.
1909. Drennan, A. M., M.B., Ch.B., Pathology Department, University.

1910. Elmhirst, R., F.L.S., Superintendent, Marine Biological Station, Millport.
1889. Elsworth, R. C., M.D , F.R C.S. (Eng.), St Helen's Road, Swansea.
1880. *Evans, Wm., F.F.A., F.R.S.E., 38 Morningside Park.
1883. Ewart, Professor J. Cossar, M.D., F.R.S., University.

1902. Farquharson, David A., M.B., C.M., Royal Veterinary College.
1884. *Ferguson, James A. E., M.B., Eccles, East Bank, Demerara, British Guiana.
1885. Ferguson, James Haig, M.D., F.R.C.P.E., 7 Coates Crescent.

1906. Geddes, A. Campbell, M.D., Royal College of Surgeons, Dublin, and 71 Merrion Square, Dublin.
1911. Gemmill, J. F., M.A., M.D., D.Sc., 6 Strathmore Gardens, Hillhead, Glasgow.
1906. Gofton, A., M.R.C.V.S., Royal Veterinary College.
1909. Gordon, Mrs Ogilvie, D.Sc., Ph.D., F.L.S., 1 Rubislaw Terrace, Aberdeen.
1909. Gray, Mrs Elizabeth, 59 George Street.
1877. Grieve, Somerville, 21 Queen's Crescent.
1886. Grieve, Symington, 11 Lauder Road.
1893. Grimshaw, Percy H., F.E.S., F.R.S.E., Royal Scottish Museum —*Librarian.*
1893. *Guppy, H. B., M.B., F.R.S E., E.M.A., Rosario, Salcombe, S. Devon.

1899. Hay, Wm. Peach, M.B., C.M., Lincoln Road, Peterborough.
1905. Henderson, D. W., M.A., Higher Grade School, Tranent.
1883. Henderson, Professor, M.B., F.L.S., Christian College, Madras, India.
1883. Hepburn, Professor David, V.D., M.D., C.M., M.R.C.S. (Eng.), F.R.S.E., University College, Cardiff.
1899. Heslop, Charles, 23 Ashby Road, Burton-on-Trent.
1884. Hinxman, Lionel W., B.A., F.R.S.E., H.M., Geological Survey, 33 George Square.
1878. Horne, J., LL.D., F.G.S., F.R.S., 12 Keith Crescent, Blackhall.
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Fellows are requested to intimate change of Address to

Dr JAMES RITCHIE, *Secretary,*

Royal Scottish Museum, Edinburgh.

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