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DEVELOPMENT OF SPONGES FROM DISSOCIATED TISSUE CELLS

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Professor of Zoology, University of North Carolina

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DEVELOPMENT OF SPONGES FROM DISSOCIATED TISSUE CELLS.

By H. V. WILSON,
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This investigation was carried on at the Beaufort Laboratory of the Bureau of Fisheries during the summers of 1907 and 1908. An outline without illustrations of the results has been published in the Journal of Experimental Zoology (On Some Phenomena of Coalescence and Regeneration in Sponges, vol. v, no. 2). In papers read before the Fourth International Fisheries Congress (Washington, September, 1908) and the American Society of Zoologists (Baltimore, December, 1908), I made brief mention of the results and in connection therewith exhibited specimens and photographs. It now seems desirable to publish the facts, with illustrations, in sufficient detail for the account to be useful as a guide in future investigations.

MICROCIONA PROLIFERA.

This species, known as the red oyster sponge, is common in Beaufort Harbor and is the form I have chiefly used in my experiments.

DESCRIPTION OF SPECIES.

Diagnosis.—Incrusting at first, but later forming lobes, and eventually becoming a complex branched body. Color, red. Skeleton in incrusting type a basal horny plate with short upright plumose columns. Skeleton of branched sponge a reticulum of spiculo-fiber. Characteristic megascleres are: (1) Smooth style, 400–160μ long, 8–16μ thick; (2) small spinose style, 80μ by 6μ. Microscleres are isochelæ, 12–16μ long, and toxas 16–40μ long, both, but especially the latter, scantily present.

Verrill and Smith have pointed out that the habitus varies greatly, and have indicated the chief types. The sponge may form thin incrustations, especially on oyster shells and on wharf piles. Such incrustations may be entirely without lobes, or may bear a few projecting lobes as is the case with the specimens shown in figure 2, plate 1. Older specimens are not infrequently found in which the formation of the lobes has gone on with accompanying branching and anastomosis, such growth eventually producing an intricately branched sponge body (fig. 1, pl. 1). Specimens of this type may reach a height of 150 mm.

Structure of incrusting type.—In the incrusting specimens the skeleton consists of a horny basal plate bearing closely set vertical horny columns from which the larger spicules (megascleres) project. A section through such a sponge is shown in figure 5, plate 1. From near the apex of each horny column a few large, smooth, and slightly curved styles project, forming a well-marked tuft. These styles measure 400–160μ long, 8–10μ wide. The longest styles lie nearest the apex of the column and some of them project beyond the surface of the sponge. Mingled with the mature styles are younger spicules of the same type, but slenderer and shorter. Projecting from the sides of some of the larger horny columns are a few small styles, 80 by 5–6μ, some of them distinctly spinose, others with few and feeble spinulations.

The origin of the plumose columns may be studied in sections like figure 5 and may be here briefly sketched. A single long smooth style is formed with its rounded end buried in the basal horny plate, the spicule projecting vertically upward. Spongin accumulates round the base of such a spicule, forming a small mound. The spicule elongates and is, moreover, carried outwards by the elongation of the spongin mound at its base. While this is going on the other spicules of the column develop around and beneath the first-formed one. Small spinose styles are found here and there projecting, independently, upwards from the basal horny plate of the sponge. These are doubtless incorporated in some neighboring horny column that starts a vigorous growth, coming to lie on the side of such a column.

In the incrusting sponges there are only a few microscleres, scattered through the trabeculæ of the interior and in the dermal membrane. They are small isochelæ, about 12–14μ long, and toxas 16–24μ long. The pores are scattered irregularly over the dermal membrane. They open into large spaces (subdermal chambers) lying beneath the membrane. The oscula are small apertures, often 1–2 mm. in diameeter, found here and there over the surface. They lead into canals which extend in a horizontal direction, branching as they go, directly beneath the dermal membrane. Thus the large cavities found beneath the dermal membrane (fig. 5) are of two kinds, some belonging to the afferent and some to the efferent system. The sponge tissue of the interior or parenchyma is reduced to a set of anastomosing trabeculæ lying between the two canal systems. In the trabeculæ are situated the small spheroidal flagellated chambers. The trabeculæ contain numerous granular amœboid cells (amœbocytes), but these are especially abundant in the layer of parenchyma which lies directly upon the basal horny plate. This basal layer of parenchyma (fig. 5) lacks flagellated chambers. Imbedded in the trabeculæ or basal parenchyma are abundant sperm masses and some small ova. Young sponges of this incrusting type are frequently found to contain numerous larvæ in various stages of development.

Structure of a sponge with lobes.—The incrusting sponge as it grows older throws out lobular outgrowths that are more or less cylindrical. The sponges shown in figure 2 exhibit several such lobes. Lobes of this sort have an extensive skeleton which consists of a reticulum of horny spiculo-fiber breaking up near the dermal surface into independent terminal branches. The latter are arranged more or less vertically to the surface and support the dermal membrane. Their structure is essentially like that of the horny columns of the young sponge. It is obvious that such a skeleton arises through the continued growth and anastomosis of the vertical horny columns of the young sponge. With the elongation of the columns to form fibers, many styles come to be entirely included in the horny substance.

The spiculo-fibers in the interior of the lobes consist of abundant spongin together with included and projecting styles. The included styles are chiefly of the smooth type, but the small spinose styles are also found occasionally included. Typical included styles measure 280μ by 10μ, 260μ by 10μ, 160μ by 8μ. The head is sometimes slightly enlarged, the spicule becoming a subtylostyle. The projecting (echinating) styles are few and scattered, spinose or smooth, the two types intergrading. The spinose type has numerous distinct though small spinulations on the shaft, and a minutely tuberculate, slightly enlarged, head. Spicules with only a few scattered spines occur, and finally quite smooth spicules with head end simply rounded and not enlarged.

The terminal branches of the skeletal framework also possess included styles. Such branches break up each into a spreading tuft of long styles. Smaller lateral styles, projecting obliquely, some spinose, some smooth, are also present.

Quantities of young megascleres (very slender) are found throughout the sponge. The microscleres are scantily present. They include isochelæ 12–14μ long, and toxas 30–40μ long. The pores, oscula, canals, and trabeculæ of sponge parenchyma in such a lobe have essentially the same character as in the incrusting type. Amœbocytes are abundantly present throughout the lobe.

Structure of large branched specimen.—Comparison makes it obvious that large branched specimens, like that shown in figure 1, arise through continued growth and anastomosis of lobular outgrowths of younger specimens. Any part of such a sponge therefore repeats the structure of one of these outgrowths, although there are details of structure in which the older sponges differ from the young. Thus the spiculo-fibers in the former are much thicker than in the latter. The megascleres, too, are thicker, and the small echinating styles are abundant. The larger megascleres may be 12–16μ thick and the head end minutely spinulate. The echinating styles are chiefly spinose and about 80μ long, but smooth ones sometimes larger are also present. Microscleres, which are only scantily present, include isochelæ 12–16μ long, and toxas 16–40μ long.

Microciona prolifera Verrill and Smith, Report on the invertebrate animals of Vineyard Sound, Report U. S. Fish Commission 1871–72, p. 447, 1874. H. V Wilson, Sponges collected in Porto Rico in 1899, Bulletin U S. Fish Commission, vol. XX, 1900, pt. 1, p. 396, 1902.

METHOD OF OBTAINING DISSOCIATED CELLS, FUSION OF CELLS, AND FORMATION OF PLASMODIA.

A branched specimen of *Microciona* in good condition is cut with scissors into pieces about one-fourth inch in diameter. The pieces are then strained through fine bolting cloth, such as is used for tow nets. A square piece of cloth is folded like a bag around the bits of sponge and is immersed in a saucer of filtered sea water. While the bag is kept closed with the fingers of one hand it is repeatedly squeezed between the arms of a small pair of forceps. The pressure and the elastic recoil of the skeleton break up the living tissue of the sponge into its constituent cells, and these pass out through the pores of the cloth into the surrounding water. The cells streaming out through the cloth present the appearance of red clouds. They quickly settle down on the bottom of the dish like a fine sediment. By using the branched specimens of *Microciona* large quantities of this "sediment" may be had. The lobes of incrusting specimens or even the sheet-like body of such specimens may be cut up and used, but naturally the dissociated cells are obtained in comparatively small quantity.

If a drop of the "sediment" so obtained be examined at once on a slide with a high power the preparation is seen to consist of myriads of separate cells together with a few spicules. There is a certain resemblance to a blood preparation, which at once suggests itself, sea water occupying the place of the plasma. The cells (fig. 21, pl. IV) fall into several classes. The most conspicuous and abundant are spheroidal, densely granular, reddish bodies about 8μ in diameter. These cells are obviously the unspecialized amœboid cells of the sponge parenchyma (amœbocytes). They put out hyaline pseudopodia that are sometimes elongated, more often rounded and blunt. There is also a great abundance of partially transformed collar cells, each consisting of an elongated body with slender flagellum. The cell body is about 8μ long, hyaline, and without a collar, the latter doubtless having been retracted. The flagellar end is thick and rounded, and contains the nucleus, the body tapering away to a point at the opposite end. The flagella are long and hyaline, and at first are vibratile, the cells moving about. Soon however the flagella cease to vibrate. The third class of cells is not homogeneous. In it I include more or less spheroidal cells ranging from the size of the granular cells down to much smaller ones. Many of these are completely hyaline, while others consist of hyaline protoplasm containing one or a few granules.

Fusion of the granular cells begins immediately and in a few minutes' time most of them have united to form small conglomerate masses which at the surface display both blunt and elongated pseudopodia (fig. 22, pl. IV). These masses soon begin to incorporate the neighboring collar and hyaline cells. One sees collar cells sticking fast by the end of the long flagellum to the conglomerate mass (fig. 22). Other collar cells are attached to the mass by short flagella. Still again only the body of the collar cell projects from the mass while there is no sign of the flagellum (fig. 24). Similarly spheroidal hyaline cells of many sizes fuse with the granular conglomerates.

The small conglomerate masses first formed early begin to fuse with one another, while they still continue to incorporate outlying free cells. The space under the cover glass thus soon becomes occupied with numerous small balls or masses (fig. 24, pl. IV), which are of a syncytial nature. As the sequel shows, these masses continue to unite and eventually restore or regenerate the sponge. They may be spoken of therefore as masses of regenerative tissue, and the observations already described make it plain that they are composed chiefly of the spheroidal granular cells or amœbocytes, but that other cells, collar cells in particular, enter into their composition.[a]

The small syncytial masses of regenerative tissue produced in the way described attach with some firmness to the substratum. In order to watch their further history they must be kept healthy, and with this point in view it is advisable to proceed in the following fashion from the beginning. After the cells squeezed out from the sponge have settled over the bottom of the dish, the water is poured off and fresh sea water added. This should be done shortly, 10 to 15 minutes, after the cells have been squeezed out. By this time the fusion of cells has progressed so far that the tissue exists in the shape of innumerable small conglomerate masses with free cells between. The tissue is easily handled. It may be sucked up with a pipette and then strewn over cover glasses, slides, cloth, watch glasses, shells, etc.

For the purposes of observation it is best to strew the tissue sparsely over slides and covers. But if one wishes really to breed sponges, it is better to strew the tissue more thickly over slides or clean oyster shells. The slides, covers, whatever is to be used, are placed in a large dish filled to about the depth of 2 inches with clean sea water. The tissue is dropped from the pipette. It sinks down through the water on to the slides, to which it at once begins to attach. Attachment is at first easily broken and for about half an hour all disturbance of the water must be avoided. At the expiration of that time the slides should be gently removed from the water and held for a moment in such a position that they drain. The draining off of the water causes the tissue to sink closer to the substratum, to which it makes a firmer attachment. The object with its coating of sponge tissue is now gently replaced in a dish of fresh sea water, where it should lie for about 24 hours. During this period the water should be changed several times, or the object may be kept in a running aquarium, in which it should be protected from any considerable agitation of the water. After a day the attachment of the

[a] For a brief discussion of the question as to the fundamental nature of this regenerative tissue see my paper: On some phenomena of coalescence and regeneration in sponges, Journal of Experimental Zoology, vol. V, 1907, no. 2, p. 250–252.

tissue to the substratum is so firm that the object (slide or shell) may be removed to an out-of-door live box.

The form of live box I have used has a wooden frame 3 feet by 2 feet by 18 inches. The sides, top, and bottom are all made of coarse galvanized-wire netting. There is a door of some size in the top. Round the edge of the box there is a wide strip of wood which projects like a shelf and serves to keep the box floating. After a trial of several places I have found that the best situation in which to keep such boxes is under a wharf where the sponges are somewhat protected from the sun, and where the current is fairly strong and the water therefore clean. In the live box are some crossbars of wood. To these are attached the small galvanized-wire boxes in which are put the objects coated with the sponge tissue. The latter boxes afford an additional protection to the growing sponges. They are especially useful for slides. Shells may have a hole bored through them with a drill and be suspended directly by wires from the crossbars. If the small box is to be made for slides, it will be found convenient to proceed as follows:

Take a rectangular piece of galvanized-wire netting and fold the edges up, thus making a long, shallow box wide enough for an ordinary slide. Prepare a piece to serve as the top. Immerse the box and tie the slides to the bottom. The slides should be exposed to the air as little as possible. After the top has been tied on, the boxes, each with a number of slides, are suspended from the crossbars in the live box. The slides may be removed, if it is desired, from day to day and examined under the microscope in a glass dish of water. Thus the gradual transformation of the coating of sponge tissue into a functional sponge may be followed.

In the course of a week it will be found that the slide is covered with a thin incrusting sponge provided with pores, oscula, canals, and flagellated chambers. If slides or shells on which sponges have been started in this way are kept suspended in the live box for one to two months, they grow thicker and develop the characteristic species skeleton. Sponges were grown very successfully in this way during the past summer by my assistant, Mr. R. R. Bridgers. Among the hundred or so sponges which survived accidents during two months many had at the end of that time developed reproductive bodies (egg or asexual embryos?) and several had developed lobular outgrowths like those of the specimen shown in figure 2.

As already stated, for the purposes of observation it is best to scatter the tissue sparsely over covers or slides. And these may be kept in laboratory dishes or aquaria. Differentiation goes on at a decidedly slower rate than in preparations placed in the live box.

Some stages in the later history of the conglomerate masses first formed (such as that shown in fig. 24) are shown in figures 3, 4, and 6 of plate 1. The conglomerate masses exhibit amœboid changes of shape and throw out pseudopodia all over the surface. Many of the pseudopodia are fine, filose processes, others bleb-like, while others are processes of some size, covered themselves with delicate small pseudopodia. Neighboring masses fuse together. The resultant masses may be rounded or irregular or have the character of networks. Figure 3 is a photograph of a cover-glass preparation. The sponge cells were strewn over the cover, and the preparation preserved 40 minutes later. Independent syncytial masses, some rounded, some irregular, are present. The formation of networks has begun. Between the masses, easily seen at this magnification (× 12), are abundant very minute masses and free cells. In figure 6 is shown, more highly magnified, one of the small syncytial masses of a preparation like figure 3. Other smaller syncytial masses appear in the neighborhood. Figure 4 is a photograph of a cover-glass preparation preserved 10 minutes after the sponge cells were strewn over the cover. The culture drop that was sown on the cover was very thick, and in details this preparation differs from the more common forms. The sponge cells have combined in part to form individual masses but these have very early begun to unite with one another to form extensive reticula. Free cells and minute masses are very abundantly scattered between the masses that are large enough to be distinct at the magnification used.

As regards the further history of the collections of syncytial masses, such as are shown in figure 3, the details of behavior vary, being largely dependent on the amount of tissue which is deposited in a spot and on the strength of attachment between the mass of tissue and the substratum. Very commonly fusion of the masses, large and small, goes on until coarse reticula are produced. Figure 8 gives a good idea of such a reticulum. The figure is a photograph slightly larger than natural size of a typical slide preparation. The small syncytial masses gradually continued to fuse with one another until a reticulum was formed composed of cords for the most part 1–2 mm. thick. The sponge tissue was strewn over the whole slide except at the ends, and practically all of the tissue was absorbed into the reticulum. The cords are compact and, except where they adhere to the substratum, rounded. Their structure is that of a dense syncytium, the outermost layer of which forms a smooth limiting membrane. After the formation of such a reticulum the peripheral cords begin to flatten out, spreading over the slide as thin incrustations which completely fuse with one another. This is the condition of the preparation shown in figure 8. The flattening out of the rounded compact cords continues, gradually involving the more centrally located parts of the reticulum. Eventually the whole reticulum is transformed into a thin, even incrustation which completely covers the slide. A slide preparation in this condition is shown in figure 10, the incrustation interrupted along the lines where the ties were made around the slide.

The sponge tissue strewn over the slide (or substratum in general) does not always form a reticulum of cords such as that just described. It often aggregates around separate centers, forming distinct masses which may be rounded or irregular in shape. Such masses are dense with smooth surface and in structure are quite like the cords. It often happens that on the same slide part of the tissue combines to form a reticulum and part to form discrete masses. This was the case with the preparation shown in figure 7. The separate masses flatten and transform into incrustations as do the cords, and the incrustations as they spread commonly unite as described above.

A third variation may here be mentioned. The small dense syncytial masses of sponge tissue, instead of combining to form an open reticulum, may unite so as to give rise to an expansion interrupted with minute rounded apertures. Such an expansion will be referred to as a perforated plate. This condition is illustrated by parts of the slide preparations shown in figure 8, plate II, and figure 17, plate III, and by the cover-glass preparation, figure 9, plate II. The tissue in this shape flattens and spreads quite as it does in the other types.

These three types, reticula, discrete massive aggregations, and perforated plates, may all be found on the same slide or shell. Moreover, formations that are transitional between the three types are common. The differences are differences of detail. The important fact is that the sponge cells quickly unite to form small, dense, syncytial masses, and that fusion between these goes on until collections of large size (fig. 7, 8, 9, 17) are produced. The larger collections, like the smaller, have the structure of dense syncytia, but unlike the smaller (compare fig. 3 and 6) have a smooth limiting membrane. The larger collections, like the smaller, exhibit amœboid changes of shape, although these are perhaps slower than in the small masses.

The collection of dense syncytial tissue, whatever its shape or size, bears some striking points of resemblance to such an organism as a myxomycete, and such collections may conveniently be called plasmodia. The essential features of the plasmodial state are its simple dense syncytial structure and its slow amœboid power to change shape and position. A plasmodium has only a temporary and chance individuality. It may fuse with others or be subdivided. It is merely a lump or collection of syncytial regenerative tissue.

METAMORPHOSIS OF PLASMODIA.

The flattening of the plasmodial masses, reticula, or perforated plates, and their transformation into thin incrustations constitute a part of what may be called the metamorphosis of the plasmodium. The histological details of the metamorphosis may be reserved for a later study. Only the conspicuous and easily observed steps in the process will be here enumerated.

The first obvious step in the metamorphosis is the appearance of collenchyma (simple connective tissue consisting of branched interconnecting cells) at the periphery of the mass. The collenchyma begins to appear just before or coincidently with the flattening out of the plasmodium. It may be observed in the living mass. With the formation of the collenchyma, a distinct thin epidermal membrane becomes lifted up from the deeper parts of the plasmodium (fig. 31, pl. V). By the time the plasmodium has been transformed into an incrustation (fig. 10, pl. II), the peripheral collenchyma with the overlying epidermal membrane exists everywhere.

Somewhat later flagellated chambers begin to appear in great abundance, and canals develop as isolated spaces which come to connect with one another. A stage in the development of the canals is shown in figure II, which represents a part of a typical slide preparation kept two days in the live box. The opaque regions indicate where the dense plasmodial tissue lingers more or less unaltered. The canals extend horizontally through the incrustation, and are so arranged as to form radial systems. Each system is composed of a few, usually three or four, main canals. At the center where the main canals meet, an osculum is later formed. Such systems are then efferent systems. The finer branches of the canals are at this stage imperfectly developed, and the flagellated chambers have scarcely begun to differentiate. Examination shows that the radial systems interconnect with one another.

The distribution of the radial efferent systems is well shown in figure 12, plate II, and figure 13, plate III, both of them photographs of entire slide preparations, the former taken with transmitted, the latter with reflected light. The preparation shown in figure 12 was kept six days in the live box. The flagellated chambers and canal systems are well developed. The movements of the flagella belonging to the collar cells and the currents passing out of the oscula were directly observed with the microscope.

A slightly later stage in the development of the canals is shown in figure 14, rêpresenting part of a slide preparation that had been kept eight days in the live box. Three of the efferent radial systems appear. A higher magnification would reveal an osculum at the center of each system. The oscula are sometimes mere apertures in the dermal membrane, but they may also terminate short tubes (oscular tubes) which ascend vertically from the incrustation. The terminal ramifications of the efferent canals are well differentiated in this preparation. Pores are scattered over the dermal membrane. The afferent canals are not conspicuous. Between the efferent canals lie immense numbers of flagellated chambers. How abundant the flagellated chambers are in these young sponges may be inferred from figure 19, plate III, which represents a small part of a cover-glass preparation in about the stage of figures 12 and 14. The chambers are thickly crowded between the efferent canals.

When the plasmodia have metamorphosed and the canals and chambers have developed, the skeleton makes its appearance. In sponges that have been kept a few days in the live box one observes spicules (styles) some of which are strewn horizontally through the body, others of which ascend more or less vertically, projecting from the surface. The latter are arranged both singly and in small tufts. The skeleton in this condition is shown in figure 15, plate III, which represents part of a slide preparation kept eight days in the live box. At this stage the horny columns are exceedingly small, consisting of minute aggregations of spongin round the bases of the ascending spicules. All the spicules characteristic of the species are present. As to the size of the spicules, the chief point of difference from the adult condition lies in the slenderness of the smooth styles. Actual measurements made at this stage of growth are as follows: Larger smooth styles, 200–250μ by 5μ; spinose styles, 72μ by 5μ; isochelæ, 14μ long; toxas, 40μ long. The incrustation at this time is very thin, about 1/8 mm. thick.

If the preparations are kept in the live box they gradually thicken, and the skeleton continues to develop. Figure 16, plate III, represents a vertical section of a preparation that was kept six weeks in the live box. In removing the incrustation from the glass plate on which it had grown, it was somewhat torn. The incrustation is about 1/3 mm. thick. There is a distinct basal horny plate. The vertical horny columns are conspicuous. The spicules characteristic of the species are all present, and the smooth styles are as large as those found in many normal incrusting specimens. The smooth styles actually measured in this preparation 250–340μ by 8–10μ. On comparing figure

16 with figure 5, which represents a vertical section of a normal sponge, it will be seen that the regenerated and normal specimens are essentially alike.

In regenerated sponges that are kept one or two months in the live box reproductive bodies make their appearance. In some cases they are found strewn through parts of the incrustation in great numbers, precisely as in the normal sponge. One of these bodies is represented in figure 16. I have not worked out the origin of the reproductive bodies, and so am unable to state whether they arise from eggs or masses of cells.

Some of the *Microciona* slide preparations that were kept one to two months in the live box grew to be 1 mm. thick in regions, and developed lobular outgrowths such as those on the sponges shown in figure 2, plate 1. In a preparation before me such lobular outgrowths vary in height from 1 mm. to 10 mm. and in thickness from 1 mm. to 4 mm.

It is clear from the preceding account that *Microciona* can be perfectly regenerated by this method of growth from dissociated cells.

The question may arise how large or how small a mass of the plasmodial syncytial tissue will transform into a sponge. The question would seem to be a purely physiological one, for the idea of morphological individuality is not applicable to the plasmodial tissue nor indeed even to the sponge itself. Fusion or subdivision may constantly occur both among the plasmodia and in the case of the perfected incrusting sponge, whether large or of microscopic size.

The upper limit to the size of incrustations formed by the fusion of plasmodia is obviously not determined by intrinsic laws of differentiation, but by the success or absence of success with which the different regions of each incrustation meet in the struggle for food and against enemies.

The lower limit can not be stated. Small plasmodia, instead of fusing, may flatten and metamorphose into tiny sponges only a fraction of a millimeter wide. The two cover-glass preparations represented in figures 18 and 20 show numerous such small plasmodia. Experience in rearing sponges grown in this way shows that the very little ones are at a disadvantage. They frequently die and disappear when larger incrustations under the same conditions continue to live and grow. There must of course be a lower limit to the size of the tissue mass which can directly (without further growth) transform into a sponge having osculum, canals, flagellated chambers, etc. Doubtless a mass of tissue below a certain minimum and outside the body of the parent could only become part of a perfect sponge by fusing with some other mass. Inside the body of the parent such a mass would have the ordinary opportunity of growth that falls to the lot of metazoan cells, and conceivably might increase of itself to the size of an asexual reproductive mass (gemmule).

LISSODENDORYX CAROLINENSIS, New Species.

DESCRIPTION OF SPECIES.

This sponge is common in Beaufort Harbor under the wharves. Habitus changes with age. Sponge exists first as a thin incrustation on shells, piles, etc. With continued growth it throws up ascending lobes 10–20 mm. high, which frequently overlap in an intricate way. Eventually a large, amorphous mass may be produced, incrusting at its base but the body of which has been formed by the continued fusion of overlapping lobes. The free surfaces of such masses bear projecting lobes like those of the younger stages, and doubtless the mass continues to increase in size by the growth and fusion of these lobes.

Color, white, frequently with a green or blue cast. Sponge is firm and brittle and generally dirty. It is much infested with worm tubes and overgrown with hydroids and polyzoa.

The whole surface is abundantly covered with tubular translucent papillæ perforated with numerous pores. Papillæ may be simple or slightly branched, often bifurcating. They are contractile and may almost entirely disappear. When dilated they are about 3–5 mm. long and 1 mm. wide. Oscula 1–2 mm. in diameter are scattered over the surface of the incrustation and often develop at or near the ends of lobes. They are sometimes mere apertures in the dermal membrane, but more often are raised up on short collenchymatous tubes. The surface in all stages of growth exhibits numerous ramifying and anastomosing canals which extend just below the dermal membrane. Pores are abundantly scattered over the dermal membrane and, as above stated, over the tubular papillæ.

Spicules: (1) Style, smooth and slightly curved, 160–180μ by 5–7μ; (2) tylote, smooth, 160–180μ by 5μ; (3) sigmas, 20–36μ long; (4) isochelæ, 12–24μ long. Internal skeletal framework a loose irregular reticulum of styles, commonly polyspicular, which may in places develop into spiculo-fibers. Spongin seems to be absent. In wall of larger canals tylotes are found. The peripheral or ectosomal skeleton includes (1) tylotes in radiating loose bands which support the dermal membrane, (2) tylotes which project radially from the dermal membrane singly or in tufts of a few, (3) tylotes strewn horizontally in the dermal membrane.

The microscleres are sigmas and isochelæ. The latter are isochelæ arcuatæ (Levisen, 1893), viz, have at each end a median tooth with two lateral alæ, and the axis is strongly curved. In the interior especially sigmas are found, although round the larger canals there are some isochelæ. In the dermal membrane both isochelæ and sigmas are abundant.

Wall of the pore papillæ contains abundant tylotes strewn horizontally, and a few isochelæ.

FORMATION OF PLASMODIA.

The following experiments show that the dissociated *Lissodendoryx* cells can carry on the process of fusion with the consequent formation of plasmodial masses of considerable size. In one experiment the masses began to die early. In another experiment they gave no signs of dying but remained inactive and did not metamorphose. It is more difficult to get this species-tissue free from dirt than that of *Microciona*. Again the absence of a horny skeletal framework (which by its elastic recoil would tend to scatter the sponge cells) may make it more difficult to dissociate the cells in a healthy condition. Or the failure of the plasmodial masses to go on and metamorphose may be ascribed to a less hardy nature of this species-tissue.

Experiment record, August 11, 1907.—Specimen from under laboratory pier was cut up into pieces, and the pieces strained through bolting cloth into Minot watch glasses. The sponge tissue comes out in clouds made up of cells and minute groups of cells. Practically no skeleton is intermixed. As the tissue settles to the bottom, it is shaken into center of watch glass, and is then strewn with pipette over cover glasses in saucers.

The tissue behaves quite as in the case of *Microciona*. The cells and small cell groups display the same amœboid phenomena, and attach to the glass. They fuse and in the course of a day give rise to plasmodial masses, some rounded, some irregular, others in the shape of networks, essentially as in *Microciona*. The plasmodial masses were kept in the laboratory one day longer. They remained unchanged and were then discarded.

Experiment record, August 22, 1907.—Specimen from Gallant's Point wharf was cut up and pieces strained as above. The tissue was treated in the same way. The cells and cell masses carried out the preliminary steps in the fusion process, but the tissue soon began to die.

STYLOTELLA HELIOPHILA, New Species.

DESCRIPTION OF SPECIES.

This *Stylotella* is the most abundant sponge in Beaufort Harbor. Common on the bottom in shallow water attached to shells, also under wharves attached to piles, stones, etc. Habitus varies. Sponge incrusts the shell or other substratum and grows up in shape of lobes. These may be quite independent of one another. More commonly the ascending lobes fuse where they touch, and thus a more compact mass is produced reaching but rarely exceeding 100 mm. in diameter, in which the original lobes remain conspicuous. The oscula are for the most part at the ends of the lobes or at the ends of tapering more or less conical outgrowths from the lobes. Pores scattered over dermal membrane. Surface is diversified in appearance, owing to the canals which course in the ectosome, and is very generally roughened with minute conulose elevations ½ to 1 mm. high. Color, orange, sometimes with a greenish cast.

The only spicule in the sponge is a smooth style 120–350μ by 4–8μ. Spicules of interior are scattered irregularly. The arrangement may in places approach the condition of a reticulum, or the spicules may combine to form vague spiculo-fibers or tracts. Spongin seems to be entirely absent.

At the surface are abundant more or less radially arranged styles, some of them slightly projecting, in places combined to form vague tufts. In some regions the ectosomal styles are about horizontal, often forming loose tracts which fray out in a brush-like fashion at the end.

FORMATION OF PLASMODIA.

The following experiments show that the dissociated cells of *Stylotella* will unite to form plasmodial masses. The behavior of the tissue is slow and feeble as compared with *Microciona*. In the actual experiments the plasmodial masses did not transform. The tissue is certainly not hardy and dies easily. Possibly it needs the better aeration of the outside water. The syncytial masses produced during the gradual degeneration of this species in aquaria[a] have never transformed for me in laboratory aquaria, but have transformed into functional sponges when removed to the harbor.

Experiment record, August 9, 1907.—Specimen of *Stylotella* kept one day in aquarium was cut into pieces, and the pieces strained in the usual way into large watch glasses. The dissociated cells settle on the bottom and are strewn with pipette over cover glasses. The tissue behaves in essentially the same way as the *Microciona* and *Lissodendoryx* tissue. Small masses are quickly formed, and these establish connection with one another, thus producing fine plasmodial networks. Part of a cover-glass preparation showing such a network is represented in figure 33. The cords of the network have a dense syncytial structure and are $\frac{1}{6}$ to $\frac{1}{3}$ mm. wide.

A number of such cover-glass preparations were made and kept in laboratory dishes. On some covers the plasmodial networks remained unchanged and after a day or two

[a] Wilson, H. V.: A new method by which sponges may be artificially reared, Science, n. s., vol. xxv, no. 649, 1907.

died. On other covers the networks gradually contracted so as to produce thicker sheets of tissue. These in part were continuous and in part perforated with gaps which represented the spaces of the earlier reticulum. The preparations died in this condition. On still another set of covers the plasmodial networks continued to contract, and in the course of a couple of days had so contracted as to be in the shape of numerous distinct, spheroidal masses, many of which were in the neighborhood of 1 mm. in diameter. These, too, died after some days without further change.

Experiment record, August 23, 1907.—Stylotellas were cut up and strained in the usual way. Only the basal denser parts of the sponge were used. The tissue was spread over the bottom of saucers (50 mm. diameter), and these were soon transferred to large crystallization dishes of sea water. On the following morning the tissue covered the bottom of the saucers partly in the shape of reticula, partly in the shape of continuous incrustations having a ridged and exceedingly irregular surface, and partly as small isolated masses of spheroidal or irregular shape. These various kinds of plasmodia developed no further, but gradually died.

RESULT OF INTERMINGLING DISSOCIATED CELLS OF MICROCIONA AND LISSODENDORYX.

As the following experiments show, when the dissociated cells of these two species are intermingled, they do not fuse with one another, but fusion goes on between the cells and cell masses of one and the same species. Perhaps if the mixture were made under conditions such as those which make cross fertilizations possible that normally will not occur, better success might be had. As I have said elsewhere,[a] the more promising task is to find allied forms, the tissues of which will fuse under natural conditions.

Experiment record, August 9, 1907.—Dissociated cells of *Microciona prolifera* and *Lissodendoryx carolinensis* were prepared in the usual way in separate watch glasses. In each case the cells and small cell masses began to fuse quickly. The bulk of the tissue, including all the coarser masses, was then removed with a pipette from each watch glass. There were thus left only the very smallest masses and separate cells strewn over the bottom. These were dislodged with pipette and collected in center of watch glass. The two collections of tissue, the one of *Microciona*, the other of *Lissodendoryx*, were then brought together in the same watch glass, and were thoroughly intermixed by use of the pipette.

The *Microciona* tissue is bright red, the *Lissodendoryx* tissue greenish. The contrast of color is very marked between masses of any size. Between cells or very minute cell masses the difference in color is of course much less conspicuous. The mixture of tissues in the watch glass was kept under constant observation, but the behavior of individual cells and of the most minute cell masses was disregarded. The mixture of tissues was spread evenly over the bottom of the watch glass, and looked like a fine sediment. Fusion began, and the bottom was soon covered, no longer with a continuous "sediment" but with discrete small masses, some red, some green. Pseudopodial activity was observed at the periphery of both kinds.

[a] Wilson, H. V. On some phenomena of coalescence and regeneration in sponges, Journal of Experimental Zoology, vol. V, 1907, no. 2, p. 253.

Fusion of the small masses continued. In general red mass fused with red mass, and green mass with green mass. Nevertheless fusion was also observed in some instances between red and green masses, the two putting out pseudopodia on the confronting surfaces, and the masses later coalescing bodily. Such fusions, as the further history of the watch glass showed, must have been temporary or the combined masses soon died. For as fusion progressed and the masses increased in size, the distinction between red and green tissue became more evident. In the course of one to two days the red tissue went through the preliminary step of metamorphosis, flattening out in shape of small thin plasmodia, which established connection with one another. The green (*Lissodendoryx*) tissue remained in compact masses. In figure 32 the two kinds of masses are shown at this stage of development. The *Lissodendoryx* tissue is stippled, the *Microciona* is unstippled. It will be seen that, while the *Microciona* and *Lissodendoryx* masses are sometimes closely applied, they are distinct bodies.

The *Microciona* masses increased in size, and on August 16 had completed the metamorphosis, viz, had flagellated chambers and some canals. The *Lissodendoryx* masses gradually diminished in number, doubtless dying. Those that survived until August 16 were of about sizes shown in figure 32, but had flattened out somewhat.

In this experiment fusion took place between the cells and cell masses of the same species. Whatever fusion there was between the two kinds of tissue was insignificant in amount.

Experiment record.—In preparing for the last experiment, as stated above, the coarser masses were removed from the watch glasses containing respectively the two kinds of tissue. A quantity of these coarser masses of *Microciona* tissue was now (Aug. 9, 1907) thoroughly mixed with a like quantity of similar *Lissodendoryx* tissue in a watch glass. Fusion went on, and, as before, between masses of the same species. The red (*Microciona*) masses increased greatly in size, and on August 12 had the shape of irregular plasmodia, which were flattened and thoroughly adherent to the glass, the different plasmodia more or less interconnected. In figure 29 some of the interconnected plasmodia are represented (unstippled) at this stage. The green (*Lissodendoryx*) masses resulting from continued fusion did not become so large. Many of them disappeared (died or failed to attach well and were washed off?) during August 9 to 12. Those that remained on August 12 were compact and not flattened. In this condition they appear (stippled masses) in figure 29. It will be seen that in some cases they lie in close contact with the *Microciona* plasmodia, and may even be surrounded by the latter, but no real union between the two kinds of bodies exists. By August 16 the *Microciona* plasmodia had metamorphosed completely, viz, were thin incrustations with flagellated chambers and canals. A good many of the *Lissodendoryx* masses were still left on this date, some in shape of fairly thick compact masses, others flattened out and thin. None had metamorphosed. Possibly if the mixture were made in dishes at once exposed to the water of the harbor, better results might be had.

Experiment record, August 9, 1907.—Dissociated cells of *Microciona* and *Lissodendoryx* were prepared in the usual way and the two tissues thoroughly mixed in equal quantities in a dish of sea water, as soon as possible after the extrusion of the cells, and while only separate cells and fine cell masses existed.

The mixture was then quickly strewn with pipette over eight cover glasses immersed in sea water. The formation of small compact masses, some red, some greenish, in about equal number, ensued. These grew by fusion with their own kind. After a couple of days the *Microciona* plasmodia were thriving, but the *Lissodendoryx* masses had decreased in quantity.

By August 12 the condition of one of the covers was as follows: The *Microciona* masses were thin and incrusting and had begun to metamorphose, viz, had flagellated chambers. The *Lissodendoryx* tissue was in the shape of compact masses, many now beginning to disintegrate, but others spheroidal, smooth, and healthy looking. In places small spheroidal masses of *Lissodendoryx* tissue remain embedded in the metamorphosed *Microciona*. The total amount of *Lissodendoryx* tissue is very small as compared with that of *Microciona*.

The second cover-glass preparation was on August 12 for the most part like the one just described. But in exceptional places the condition was that shown in figure 28, where the *Lissodendoryx* tissue is again represented by stippled and the *Microciona* tissue by unstippled areas. The *Lissodendoryx* tissue forms a somewhat large, flattened, but not very thin mass, which is evidently still in the original dense syncytial condition. On it the *Microciona* tissue has settled in the shape of spheroidal masses, also in original dense syncytial state. Near by a partially metamorphosed *Microciona* plasmodium is shown. Here there has evidently been a relatively long-continued opportunity for fusion between the dense syncytial masses of the two species, but no fusion has occurred. By August 16 the *Microciona* masses have flattened out over the underlying and still unchanged *Lissodendoryx*, and have in part fused with one another.

The remaining cover-glass preparations of this set on August 12 offered nothing different from conditions found on the two covers just described. On August 16 they were all about alike, the *Microciona* plasmodia metamorphosed, the *Lissodendoryx* masses still unchanged. Small compact masses of the *Lissodendoryx* tissue are found here and there in the metamorphosed *Microciona*. They probably die and disintegrate.

RESULT OF INTERMINGLING DISSOCIATED CELLS OF MICROCIONA AND STYLOTELLA.

In endeavoring to bring about fusion between these two kinds of tissue, the same methods were followed and essentially the same results were obtained as for *Microciona* and *Lissodendoryx*. The cells and cell masses of each species tissue fused with one another, and there was an absence of fusion between the tissues of the two species. The *Stylotella* tissue is brown and easily distinguishable from *Microciona* tissue.

The following experiment on plasmodial masses of some size is recorded as perhaps of value for guidance in future work:

Experiment record, August 26, 1907.—Plasmodial masses of *Microciona* and *Stylotella* were placed in contact about 9 p. m., to test whether they would fuse. The *Microciona* plasmodium was of reticular character and had begun to curl up round the edge. Three small irregular flattened *Stylotella* masses were selected, and were placed upon the *Microciona*.

The condition of these plasmodia on the next day at 3 p. m. is shown in figure 30. The *Microciona* reticulum has contracted into a compact ovoidal body. The *Stylotella* masses have fused with one another and form the upper irregular mass lying upon the *Microciona*. The two tissue masses are tightly adherent, but there is no fusion. Other similar attempts to bring about fusion between plasmodial masses of the two species were made with the same negative result.

EARLIER EXPERIMENTS ON MICROCIONA CHRONOLOGICALLY ARRANGED.

For the use of those who may carry on investigations such as are reported in this paper I here append some of the earlier experiments leading up to the method finally practiced. The general account given for *Microciona* is based on a large number of experiments made in the latter part of the summer of 1907 and during the summer of 1908. About 200 specimens of *Microciona* were grown by this method during the two summers. The work of 1908 was under the direct charge of my assistant, Mr. R. R. Bridgers.

Experiment record 1, August 2, 1906.—Question involved: If regenerating tissue that is formed in a degenerating sponge is forcibly freed from the sponge and broken up, will the elements recombine outside the sponge body? They do.

A branched specimen of *Microciona* that had been kept in an aquarium long enough for degeneration to have begun was used. In this state the sponge tissue had died in or retreated from the superficial parts of the lobes, which however contained a core of bright red and dense live tissue. The same tissue forms here and there irregular masses on the surface. I have shown experimentally that in *Stylotella* masses of similar tissue have the power of developing into perfect sponges. The tissue therefore is regenerative tissue.

Lobes of the sponge were teased in a watch glass of filtered sea water with needles in such a way as to liberate and break up the regenerative tissue into cells and small cell agglomerates. Many of the cells are more or less spheroidal and contain granules and spheroidal inclusions of varying size. Many inclusions are reddish and the cell may in consequence appear of an opaque red color. Such cells while under observation throw out hyaline colorless pseudopodia, some rounded, some fine and elongated. An infinite number of smaller cells, some with granular or spheroidal inclusions, some nearly or quite hyaline, are also to be seen.

The cell agglomerates are opaque. They are probably made up of both spheroidal and smaller cells. They certainly include numbers of the spheroidal type. Round the periphery pseudopodial activity was watched. The pseudopodia were for the most part rounded, but some were elongated and pointed. Whatever locomotory motion the mass makes is slow and feeble.

By gently shaking the watch glass the cell agglomerates were brought together, and repeated instances of fusion between the masses were observed.

Experiment record 2, August 3, 1906.—Question involved: Can masses of regenerative tissue such as were produced in experiment 1, be made to unite and to form outside the sponge body smooth gemmule-like masses such as are produced in sponges allowed to degenerate slowly in aquaria? Yes.

A branched *Microciona* in which degeneration had begun was selected. The regenerative tissue forms a core in the lobes and discrete masses here and there. Pieces of the sponge were teased in sea water and the regenerative tissue broken up as before. The cells and cell agglomerates were gently forced with pipette to center of watch glass. Fusion of cells and masses, with amœboid phenomena, began at once, and in half an hour quite large irregular masses existed. In the course of a few hours the masses grew enormously through continued fusion. From this time on they adhered firmly to the glass, retaining irregular plasmodium-like shapes, and the growth was inconspicuous. To bring them together once more and induce further fusion they were on the following day forcibly freed with pipette and needle, and to clean them of cellular débris and bacteria were transferred to a tumbler (covered with bolting cloth) in which they were kept actively moving under a fine glass faucet for about 30 minutes. In the course of this violent agitation a good many masses were lost. Those remaining in the tumbler became in the next few hours noticeably rounder and smoother at the surface. From this experiment 18 more or less spheroidal masses were obtained, some of which measured ½ mm. indiameter. They were similar to the small plasmodial masses produced in this species when the sponges are allowed to degenerate slowly in aquaria.

Experiment record 3, July 17, 1907.—Question involved: When regenerative tissue is removed from a degenerating sponge and induced to form masses of some size, will these masses transform into perfect sponges? Result was negative.

A branched *Microciona* that had been kept in aquarium some days was used. Degeneration had set in and regenerative tissue formed as above. Lobes were teased in watch glasses of sea water. The cells and minute cell masses settle down on the bottom like a fine sediment, resembling in appearance small invertebrate eggs. Some fusion quickly takes place. The material is then brought together in the center of the watch glass, where it forms a loose aggregation about 10 mm. in diameter and 1 mm. or less thick. This is left for half an hour for further fusion to take place and is then immersed in a crystallization dish of sea water. The mass of sponge tissue adheres to the bottom of the watch glass. Two such watch glasses (Minot glass) were prepared. About an hour later, to induce further fusion and concentration, the tissue was freed from the bottom of the glass, and the various masses brought together in as dense a heap as possible.

About two hours later the condition of the aggregate was as follows. The appearance is essentially like that of the rough excrescences of regenerative tissue which occur on the surface of *Microciona* when the latter degenerates in aquaria. Much of it is simply an amorphous mass of dense, syncytial, sponge tissue. But this tissue has a tendency to round off into compact smooth nodules or lobes or free rounded masses.

Many of the latter, often ranging from 400μ down, cohere and make up loose masses of any shape which may be several millimeters in diameter.

Fragments of the entire aggregation about 1 mm. in diameter were now hung in a small bolting-cloth bag which was suspended in a live box floating in the harbor. The bag used was rectangular and flat, 60 mm. by 20 mm. on the side and about 2 mm. deep. The two sides of the bag were held apart by wooden strips, and the bag was divided into two compartments. In each compartment several fragments were placed. The bag was opened July 23, and it was found that the masses had not grown or attached. Some had died. The rest were spheroidal and embedded in a mass of débris.

The result of the experiment does not really indicate that the tissue masses were nonregenerative. A later experiment shows that similar masses obtained from a fresh sponge can actually regenerate. Possibly the masses of regenerative tissue obtained from the degenerated sponge require more careful handling.

Experiment record 4, July 19, 1907.—Results: (1) When the tissue is teased out of a fresh sponge in which no degeneration-regeneration phenomena have occurred, the cells and cell masses combine; (2) the compact masses of tissue so obtained transform into sponges when removed to the harbor.

A branched specimen of *Microciona* kept only one day in aquarium, and as yet showing no signs of degeneration, was used. Sponge was cut in pieces and pieces teased with needles in watch glass of filtered sea water. Cells and minute cell masses were liberated in great quantity. These began to fuse, displaying amœboid activities. About one hour later the fusion is aided by gently forcing the tissue to center of watch glass with pipette. The bulk of the tissue is thus gathered at the center, where it forms a loose heap about 7 mm. in diameter. One hour later the general aggregation in the center consists of rounded and irregular masses and lobes. The watch glass is now immersed in crystallization dish of sea water. Three such watch glasses were prepared. In one a good many small skeletal fragments of the teased sponge were left in the aggregation of tissue. In the other glasses an effort was made to remove all skeletal fragments.

The aggregated heaps of sponge tissue, each consisting of many loosely adhering rounded or irregular masses of compact tissue, were divided up some hours later into seven lots. Each lot was put into a compartment of a bolting cloth bag, and the bags suspended in live box. On July 23 the bags were opened and the sponge tissue in each compartment was found to consist of distinct and separate masses, many of which gave signs of development. Some of these masses were now kept in crystallization dishes of sea water containing *Ulva*, others were returned to the bags. On July 29 a final examination showed that many of the masses in the bags had completely metamorphosed, viz, had oscula, flagellated chambers, and canals. Other masses had no conspicuous oscula or canals, but had partially metamorphosed. None of the masses kept in laboratory dishes had completely metamorphosed.

In metamorphosing some of the masses had flattened out greatly, spreading as incrustations over the bolting cloth, the meshes in which were thus completely covered over. Others had remained as compact masses. One such is shown in figure 26. In this sponge we find a conspicuous system of subdermal cavities, an oscular tube (near one end), and radially projecting spicules. Embedded in the sponge is a considerable fragment of the skeleton of the parent (near pointed end).

Skeletal fragments derived from the parent were present in several but not in all of the masses of tissue which metamorphosed completely. The presence of such a fragment is then not a necessary condition to complete metamorphosis. Nevertheless, the impression from numerous experiments is made on my mind that where the mass of tissue is of some size and does not flatten out into an incrustation the chance of metamorphosis is increased if there is present a piece of the original skeletal framework. This may possibly act as a mechanical support.

Experiment record 5, July 19, 1907.—Result: Tissue teased out of fresh normal sponge quickly attaches to substratum and spreads out as thin sheet. Will such sheets metamorphose, without passing through condition of compact gemmule-like mass? Indications are that they will.

In the preceding experiment when the bulk of the tissue was gathered into center of watch glass, a large number of small masses remained adherent to the bottom. These soon flattened out into thin, irregular plasmodia which were watched for an hour, and were observed to change shape and establish connection with one another. One such plasmodium is shown in figure 25.

These plasmodia were kept under observation and it was found that they did not contract into compact masses but spread as thin sheets over the bottom of the glass. In this condition they were removed to the live box in the hope that they would metamorphose. The plasmodia on July 21 exhibited a slight but significant change. They were no longer homogeneous in appearance, for in many places a distinct surface membrane existed which was separated from the opaque general mass by a space filled with branched cells and colorless transparent matrix. In other words collenchyma had made its appearance. In a day or two some of the plasmodia had what appeared to be flagellated chambers and the beginnings of canals. The conditions in the live box were not good. Sediment was deposited in the watch glasses and the plasmodia did not develop further, eventually dying.

Before disappearing they diminished in size, and became once more homogeneous in appearance (a regressive series of changes). Some of them sent up solid massive processes into the water, as if growing away from the sediment. Others contracted again into minute compact rounded masses. Some of these lose their compact character and break up into separate cells, for the most part spheroidal, that are loosely held together.

Experiment record 6, July 20, 1907.—Question involved: Will smooth rounded gemmulelike masses formed by teased-out sponge tissue transform in laboratory aquaria? They did not.

In the preceding two experiments the contrast in behavior between tissue masses which while small quickly made firm attachment to the glass, and such as did not attach to the glass or were prevented from doing so, was marked. The former spread over glass as thin incrustations. The latter contracted and fused with one another, forming massive bodies and loose aggregations of such bodies. Massive collections of tissue of this sort, as has been recorded, metamorphosed in the live box.

The effort was made to see if such massive collections of sponge tissue would not metamorphose in laboratory dishes. Small massive bodies were selected which for one reason or another had remained quite free, viz, unattached to substratum. These were 500–700 μ in diameter. They had a dense syncytial structure, were homogeneous in appearance, and had a quite smooth surface—in short, were very gemmulelike. They were kept in laboratory dishes with *Ulva*, but would not transform, behaving then in like manner to the masses of regenerative tissue that form in a degenerating sponge or are produced outside the sponge body.

Several similar masses were put on July 1 in *Ulva* dishes. Some made a slight step toward metamorphosis, in that they flattened out at points of the periphery, here spreading for a short distance over the substratum. Regressive changes then occurred, and on July 27 the bodies were again spheroidal and smooth.

The conclusion seems to be that when the sponge cells have once united into a compact mass of any size, this mass is slow and as it were reluctant to transform. Particularly is this so if the mass of tissue has been free long enough to acquire a smooth surface. It has by this time apparently passed into a quiescent physiological state. For such a mass to set up differentiation, the stimuli coming from the open water (excellent aeration and movement of water probably) are necessary.

Experiment record 7, July 21, 1907.—Question involved: Will compact masses formed by the continued union of tissue teased out of the sponge metamorphose in live box? The masses began but did not complete the metamorphosis. Essentially same experiment as 4.

Fresh *Microciona* tissue was teased up and the teased-out tissue allowed to fuse. The bulk of the tissue was collected in center of dish, where numerous compact masses commonly 0.5 to 1 mm. in diameter were formed. Most of these were more or less united to form larger aggregates.

Two of the compact masses were hung in bolting-cloth bags in the live box on July 22. One was smooth, spheroidal, 800μ in diameter. The other was a composite mass of same character as that shown in figure 27, about 3 mm. long, 2 mm. wide, and 0.5 mm. thick. It included a small fragment or two of the old horny skeletal framework. On July 29 the smaller mass had split into two, each of which was a flattened incrustation firmly attached to the bolting cloth. The two incrustations were opposite, and it was evident that the original mass had attached to both surfaces of the bag. The larger mass had likewise split into two, both of which had flattened out and attached to the cloth. These masses went no further in metamorphosis, but eventually died.

Experiment record 8, July 30, 1907.—Result: Teased-out tissue quickly combines to form small masses. These fuse if brought in contact. If not too large they then flatten in peripheral region which spreads over substratum. On same day tissue pressed out through bolting cloth was found to behave in same way.

Fresh *Microciona* was teased up. The teased-out tissue was brought together so that many small spheroidal masses were formed free of all fragments of the old skeletal framework. About a dozen such masses were then brought together with needle and pipette. They fused, giving rise to the lobed mass shown in figure 27. The width of the whole mass is slightly less than 1 mm., the thickness about 0.5 mm. It contains no skeletal fragments, although close at hand lies a bit of the old skeletal framework. The outlines of the lobes gradually disappeared and on the same day the mass had assumed a simple rounded, subspheroidal shape. It incorporated the outlying piece of skeleton and made attachment at points of the periphery to the substratum. Before the end of the day the peripheral part of the body was extended out over the glass in the shape of a thin sheet, showing pseudopodial activities at its edge, where the incorporation of outlying cells and small masses went on. Doubtless this preparation would have completed the metamorphosis had it been kept.

Experiment record 9, July 30, 1907.—Result: Teased-out tissue strewn over cover glasses formed plasmodia which metamorphosed completely. Pressed-out tissue behaved in similar way.

Fresh *Microciona* tissue was teased out and centripetalized in watch glass, and then strewn over cover glasses. Small masses were formed which flattened and fused and soon formed a continuous thin plasmodial sheet. The covers were kept in laboratory dishes of filtered sea water, and the water was changed several times a day. On August 4 flagellated chambers were distinct and the flickering movement of the flagella could plainly be seen with a Zeiss 2 mm. objective. By August 5 well-developed canals were present, and oscula on short upwardly projecting tubes. The discharge of the current from the oscula was watched. On August 1 pressed-out tissue obtained by straining through bolting cloth was prepared and treated in same way with same result.

Experiment record 10, August 1, 1907.—Result: Pressed-out tissue, when it is strewn thickly enough to form plates, etc., 0.5 to 1 mm. thick, does not transform in laboratory aquaria, but the tissue tends to separate from the substratum and contract into massive shapes. Such collections of tissue will transform in the open water. The firmer the attachment to the substratum, the greater is the chance which the collection of tissue has of metamorphosing.

Pieces of *Microciona* were strained through bolting cloth. The tissue thus pressed out was strewn thickly over fine bolting cloth fastened to coarse galvanized wire netting and immersed in dishes of sea water. Irregular plasmodia formed which combined for the most part into fine networks, such as that shown in figure 23, *a*. Isolated masses, rounded or irregular, such as *b* in figure 23, were also formed. By the next morning the plasmodia had changed their character. Concentration of the tissue toward separate centers had occurred, and thus the fine networks had broken up into coarser networks, perforated plates, and more or less compact masses. Various such collections of tissue are represented in figure 23, *e–j*. They are all in the neighborhood of 0.5 to 1 mm. thick and adherent to the cloth. The tissue has considerable rigidity, although without skeleton. Thus it may project up in shape of vertical lobes 1 mm. high, or as vertical ridges or walls 1 to 2 mm. high, or arches may be formed which rest upon the substratum only at the ends.

By the next day concentration, viz, the aggregation of tissue toward certain nodules or bars and the transformation of coarse reticula into compact masses, had gone farther. It is evident that the masses of tissue were too thick to flatten and spread, and thus the opposite tendency, a tendency to separate from the substratum and contract into massive shape, came into activity. In such concentration the edge of a plate or reticular expansion often curls up, as in *g*, figure 23.

On August 3 the plasmodial tissue was still in the shape of networks, plates, and masses attached to the cloth. The cloth, which was fastened to wire netting, was now hung out in the live box, to give the plasmodial tissue a chance to metamorphose. Two such pieces of cloth, each about 4 inches in diameter, were hung out. There was probably some unintentional difference in the handling, for on one piece all the tissue died, while on the other much of it had by August 10 metamorphosed completely into incrusting sponges with oscula, canals, etc.

On August 3 eight compact small masses, some about 1 mm. in diameter, others 2 to 4 mm. long and about 1 mm. thick, were hung out in bolting-cloth bags. These did not do well. The bags silted up. The sponge masses flattened and spread to some degree over the cloth, but did not metamorphose.

Experiment record 11, August 24, 1907.—Result: In this experiment the attachment of the tissue to the substratum was forcibly interfered with. But it sometimes happens that when no such interference has been made the tissue nevertheless contracts into massive aggregates. It may be said in general that in the history of the early formed plasmodial masses a critical moment arrives when the masses will either flatten out and begin metamorphosis or go on contracting and uniting to form massive aggregates. Such massive aggregates will not transform in confinement. The formation of massive aggregates is furthered by strewing the tissue thickly and by breaking the early attachment to the substratum. The attachment to the substratum is strengthened, I believe, by the use of flat surfaces, such as slides. When the slide or similar body is drained the tissue sinks closer to it and is mechanically somewhat flattened. This aids attachment.

Microciona tissue was pressed out through bolting cloth into a saucer. Bottom of the saucer (50 mm. in diameter) was covered with the tissue. Saucer was left to stand 30 minutes, by which time the tissue had attached in some degree. Water was now poured off and fresh sea water added. The tissue was then dislodged with pipette from the bottom and concentrated toward the center. Saucer now immersed in a large dish of water. Fusion quickly takes place and bottom becomes covered with a fine reticulum and small masses.

Local contraction goes on and in some hours the tissue appears in the shape of coarse reticula, perforated membranes, or isolated compact masses (about as in fig. 23). To hasten or insure the formation of small compact masses it is only necessary to cut off a small part of a coarse reticulum or plate. When so freed from the substratum, the tendency to contract becomes active and the irregular little sheet gradually draws and rolls up to form a ball.

The tissue in general (reticula and sheets) was on August 27 broken up with pipette into portions from a few to 20 mm. wide and 0.5 to 1 mm. thick. All these continue to contract and curl up. On August 30 these masses were more compact and still quite free from the substratum. Although kept for several days they remained unchanged and did not attach.

Experiment record 12, August 28, 1907.—Question involved: Does a mixture of very fine pressed-out tissue and fairly coarse tissue offer any advantage, for the growth of sponges, over coarse tissue alone? In general it does. The fine particles as they metamorphose tend to fasten down the larger masses.

Pressed out *Microciona* tissue was prepared in abundance. In the course of 30 minutes it was freed with pipette from bottom of dish and collected in center. It was then strewn over slides. Fusion had gone on rapidly and the bulk of the tissue was already in the shape of rather coarse lumps. On some slides only this coarse tissue was strewn. On a second set of slides, after the coarse tissue had been strewn, a quantity of very fine particles was deposited on and between the coarser masses. On all slides the tissue during the next two to three hours attached and underwent the preliminary steps toward plasmodium formation. During the next few hours there was a marked difference between the two sets of slides. Where coarse tissue alone had been strewn local contraction brought into existence masses (spheroidal, irregular, reticulated, etc.) of considerable size and thickness and without much interconnection. Where coarse and fine tissue had been strewn there was formed a continuous network of small, thin, flat plasmodia exhibiting local enlargements and thickenings which represented the coarse masses produced by the early fusion of the tissue. The indication was that the second set of slides would metamorphose first. Nevertheless both sets went ahead in the metamorphosis at about the same rate.

In this instance the coarser and comparatively massive collections of tissue continued to retain their attachment to the substratum. This is not always the case. In handling large numbers of such preparations during the following summer my assistant, Mr. Bridgers, found that the practice of strewing very fine particles of tissue over the preparation that had just been made was often useful. It sometimes happens that the reticula or perforated plates formed by the tissue that has been strewn over the slide or shell begins to separate from the substratum, curling up at the edges. If very fine tissue has been strewn over the slide, it forms small, flat, and thin plasmodia, which fasten down the larger ones. As already said, if one wishes to get sponges, it is important that the plasmodial masses make firm attachment to the substratum before the preparation is put in the live box.

Experiment record 13, July 2, 1908.—Question involved: What difference in behavior is there between tissue pressed out of a fresh sponge and tissue pressed from a sponge kept several days in the aquarium? Tissue obtained from the sponge kept in aquarium is slow to metamorphose, but can do so in the open water.

A large branched *Microciona* was selected. It was divided into a few parts. One of these was chopped up and strained. The extruded tissue was sown on slides. The preparations developed quickly and were put in live box July 3. On July 4 canals had developed in them.

Two days later the other pieces of the *Microciona* were chopped and strained and the tissue sown on slides. The tissue quickly collected in shape of rounded and irregular masses. These do not combine with one another to any extent and do not flatten out. The tissue remains in this condition for a couple of days in the laboratory. Some of the preparations were then hung in the live box. Much of the tissue died, but a considerable number of the masses flattened and metamorphosed. Other preparations were kept in laboratory dishes for a few days longer. They underwent no visible change.

ADDENDUM.

April 17, 1911.

I am fortunately able to take note of the progress that has been made in this field of inquiry while the foregoing paper was in progress of publication.

Müller, working on the Spongillidae,[a] confirms my account of the behavior of dissociated cells in sponges. The phenomena are essentially the same in these sponges as in the marine forms I have studied, and Müller has been able to rear perfectly formed Spongillas in this way. He has kept some of his Spongillas alive in confinement as long as seven weeks. It is to be hoped that he will find the time to carry on a detailed histological study of the cellular changes involved in this method of regeneration, a side of the subject on which my own observations are very fragmentary.

Müller has also been able, again working on the Spongillidæ,[b] to confirm the essential points in my investigation (intimately linked with the present and leading up to it) on the formation of masses of regenerative tissue in sponges that are kept in confinement.[c] Müller finds as I did that in sponges kept for a considerable time in confinement a slow process of regressive differentiation takes place, resulting finally in the production of masses of a simplified or "embryonic" tissue. Such regressive differentiation would fall under the currently employed rubrics "involution" (Barfurth) and "reduction" (Driesch and Eugen Schultz).

The early steps in the process (contraction of body, gradual suppression of canals, dissolution of flagellated chambers into their constituent cells which become despecialized, division of the body in this simplified state) all seem to be identical in the Spongillidæ and in *Stylotella*, the marine form which I especially studied. The differences concern the later stages and consist (1) in the absence of any extensive death of the sponge body in the Spongillidæ and (2) in certain interesting histological features of

[a] Müller, Karl: Versuche über die Regenerationsfähigkeit der Süsswasserschwämme. Zoologischer Anzeiger, bd. XXXVII, nr. 3-4, 1911.

[b] Müller, Karl: Beobachtungen über Reduktionsvorgänge bei Spongilliden, nebst Bemerkungen zu deren äusseren Morphologie und Biologie. Zoologischer Anzeiger, bd. XXXVII, nr. 5, 1911.

[c] Wilson, H. V.: A new method by which sponges may be artificially reared. Science, n. s., vol. XXV, June 7, 1907.

the small simple masses finally produced in the two forms. In *Stylotella* these bodies are aggregations of syncytial protoplasm quite without cell boundaries, and studded with nuclei that are optically all alike. In the Spongillidæ discrete cells can be distinguished in them, apparently of two kinds. Müller finds that the reduced choanocytes are engulfed and digested by some of these cells, the granular elements. As to this question, concerning the persistence or absorption of the choanocytes, I was not able to reach a definite conclusion.

It is important that Müller was able to get one of his reduction masses to transform into a sponge, and so really to prove that the tissue composing such masses is regenerative tissue and that the masses are therefore not stages in a series of purely mortuary changes, the bizarre character of which, in the case of slowly dying protoplasm, must be familiar to many. Possibly the method I employed in handling the *Stylotella* masses, and which permitted them to transform, whereas in laboratory aquaria they uniformly refused to do so, might prove applicable to the Spongillidæ.

As Korschelt and Heider remark in the latest installment of their textbook[a] (p. 486), it is probable that such bodies occur widely in the sponges. The peculiar capsules formed on the surface of *Spongelia* kept in aquaria and described as early as 1886 by Thomson[b] are in all likelihood bodies of this kind. Thomson recognized them as such, and speaks of them "as a histological modification in response to a change in the environment," and again "it seems possible that they may thus secure the persistence of the organism in unfavorable environment." Maas (*vide infra*) has found them in calcareous sponges. Lendenfeld mentions[c] that he has observed similar formations in *Reniera* and *Sycon*. Urban[d] has recently studied their origin in the Calcarea (Clathrinidæ). Müller raises the question whether it is proper to designate these bodies as "artificial gemmules." I agree with him in finding the terminology unsatisfactory. It draws attention away from the fact that what is formed is a *tissue*, a simplified, regenerative tissue. This may take the shape of small spheroidal masses scattered through the interior of the old sponge, in which case the resemblance to the gemmules of the Spongillidæ, or better, to such simpler ones as are formed in the Chalinidæ, is marked. But identically the same tissue may collect in masses scattered over the general surface of the sponge. And here, while some of them may be spheroidal and small, usually they are flattened and of an irregular shape with lobes, suggesting a lobose rhizopod or myxomycete plasmodium.[e] There are no facts which indicate that such masses regularly subdivide into small spheroidal bodies. Thus in the one case the regenerative tissue collects to form masses, the size and shape of which vary greatly, probably being determined by local conditions, while in the other case, in the Spongillidæ, a reproductive

[a] Korschelt und Heider: Lehrbuch der vergleichenden Entwicklungsgeschichte der wirbellosen Thiere. Allgemeiner Theil, 4te. lief., 2te. hfte., 1910.

[b] Thomson, J. Arthur: On the structure of Suberites domuncula, Olivi (O. S.), together with a note on peculiar capsules found on the surface of Spongelia. Transactions Royal Society of Edinburgh, vol. XXXIII, pt. i.

[c] Lendenfeld, R. von: Zoologisches Centralblatt., bd. 14, 1907, p. 631.

[d] Urban, F.: Zur Kenntnis der Biologie und Cytologie der Kalkschwämme (fam. Clathrinidæ Minch.). Internationale Revue der gesamten Hydrobiologie und Hydrogaphie, bd. 3, 1910.

[e] Wilson, H. V.: A new method by which sponges may be artificially reared. Science, n. s., vol. XXV, June 7, 1907.

body of very definite character is produced, the shape, size, and covering layer of which are all fixed as species characteristics. It seems permissible to regard the first case as the habit, still probably universal among sponges, out of which in certain groups a definite gemmule-forming habit sprang phylogenetically.

Various important and stimulating observations on certain steps in the process of regressive differentiation that takes place in sponges when they are kept in confinement or have been subjected to overfeeding, to the cold of winter, or to foul water, have been recorded by Metschnikoff,[a] who cites also from his predecessors Carter and Hæckel, and others, especially Lieberkühn,[b] Masterman,[c] Bidder,[d] and Weltner.[e] A detailed study of the cellular changes that take place in this process has recently been made by Maas.[f] Maas some years ago announced[g] that when calcareous sponges are exposed to sea water deprived of its calcium, the living tissue breaks up into cords and rounded masses. Whether such masses were able to transform into sponges he was not able to say, although he suspected that such was the case. At the same time (December, 1906), at the New York meeting of the American Society of Zoologists I described the phenomena as they occur in *Stylotella* and exhibited the degeneration-regeneration masses, some of them completely transformed into sponges. And in the Proceedings (Science, May 17, 1907) I published a note to the effect that such masses can be produced and that they will transform into perfect sponges. Later in the year Maas published a communication[h] touching upon this subject in which he announced that the rounded masses of cells produced in the degenerating *Sycon* are able to transform into functional sponges. Apparently the calcium-free water leaves the sponge protoplasm in a state that makes further development difficult, for it is clear from Maas's recent paper[f] that the *Sycon* masses are very slow to transform. Maas's statement with regard to the transformation, moreover, leaves it uncertain as to whether this process is completed or not. The masses in question after some weeks increased in size, developed a gastral cavity, and differentiated new spicules (op. cit., p. 100).

Maas in his recent investigation finds, as I described in 1907, that as the reduction progresses a stage is reached in which the sponge flesh consists of trabeculæ made up of several kinds of cells all interconnected to form a syncytium. Maas goes on and traces the history of the several kinds of cells and finds that a process of phagocytosis occurs. Certain granular amœbocytes incorporate and digest the choanocytes and other cells, a mass of these constituting the last stage in the process, the nodule of

[a] Metschnikoff, E.: Spongiologische Studien. Zeitschrift für wissenschaftliche Zoologie, bd. XXXII, 1879.

[b] Lieberkühn, N.: Beiträge zur Entwickelungsgeschichte der Spongillen. Archiv für Anatomie und Physiologie, J. Müller, 1856.

[c] Masterman, A. J.: On the nutritive and excretory processes in Porifera. Annals and Magazine of Natural History (6), vol. 13, 1894.

[d] Bidder, G. P.: The collar cells of Heterocoela. Quarterly Journal of Microscopical Science (2), vol. 38, 1895.

[e] Weltner, W.: Spongillidenstudien II. Archiv für Naturgeschichte, jahrg. 1893, bd. I. Spongillidenstudien V, ibid, jahrg. 1907, bd. I.

[f] Maas, Otto: Ueber Involutionserscheinungen bei Schwämmen und ihre Bedeutung für die Auffassung des Spongienkörpers. Festschrift zum sechzigsten Geburtstage Richard Hertwigs, bd. III, 1910.

[g] Maas, Otto: Ueber die Einwirkung karbonatfr. Salzlösungen auf erwachsene Kalkschwämme und auf Entwicklungsstadien derselben. Archiv für Entwickelungsmechanik der Organismen, bd. XXII, hft 4, December, 1906.

[h] Maas, Otto: Ueber die Wirkung des Hungers und Kalkentziehung bei Kalkschwämmen und anderen kalkausscheidenden Organismen. Sitzungsberichte der Gesellschaft für Morphologie und Physiologie in München, 1907.

regenerative tissue. The amœbocytes have a heterogeneous origin, some representing the wandering cells of the normal sponge, many more representing transformed (reduced) pore cells. It may be remarked that our knowledge concerning the very existence of specialized pore cells is exceedingly inadequate except in the case of the ascons. I have, for instance, been utterly unable to find them in monaxonids such as *Stylotella* and *Reniera*.[a] It is evident then that the process of regressive differentiation can not pursue quite the same path in *Stylotella* that Maas maps out for the Calcarea. The large question involved is of course: Do the several kinds of cells, preserving their nature, struggle with one another for the mastery, certain kinds or one kind absorbing and digesting others, and so growing and forming the regenerative mass? In support of this idea it is to be noted that Maas and Müller agree in finding that the choanocytes are absorbed and digested by amœbocytes. Or when the flagellated chambers, the canal epithelium, the epidermis perhaps, all break up into cells which wander away from one another and help to form the mesenchyme-like syncytial tissue of the reduced trabecula, does the protoplasm of all these cells undergo a reconstruction, a sort of rejuvenescence, whereby they all pass into the condition of the unspecialized, generalized plasm of that species, the masses of this plasm fusing intimately to form the regenerative tissue? This is the interpretation of the facts which I have favored in my paper on the subject.[b]

Turning now to the phenomena that follow upon the sudden violent isolation of sponge cells, their rapid fusion to form masses physiologically similar to those produced in the slow process of regressive differentiation that goes on in confinement, the same question meets us. Amœbocytes, hyaline elements, and choanocytes all combine to form the plasmodial masses.[c] Do the amœbocytes absorb and digest the other elements? Or do all the cells as a result of the shock pass into the generalized protoplasmic state and persist as parts of the regenerative mass? A careful histological study might enable one to answer this question. Meantime it seems to me that the latter hypothesis receives support from my recent observations on the fusion of isolated cells in hydroids.[d] In hydroids the body is made up of two specialized layers and there are comparatively few cells present which correspond in this matter of regenerative ability to the amœbocytes of sponges. I have found that a *Eudendrium* colony may be cut into pieces and pressed out after the fashion described in this paper, and so broken up into cells, minute cell masses, and possibly cell fragments. Fusion between these elements goes on and plasmodial masses are formed which secrete a perisarc. Such masses throw out hydrorhizal outgrowths which in successful cases develop perfect hydranths. The same phenomena were observed in *Pennaria* when only the stem was cut up, the regenerative mass being thus exclusively derived from the cœnosarc. In these cases it might, to be

[a] Wilson, H. V.: A study of some epithelioid membranes in monaxid sponges. Journal of Experimental Zoology, vol. IX 1910.

[b] Wilson, H. V.: A new method by which sponges may be artificially reared. Science, n. s., vol. XXV, June 7, 1907.

[c] Wilson, H. V.: On some phenomena of coalescence and regeneration in sponges. Journal of Experimental Zoology, vol. V, 1907.

[d] Wilson, H. V.: On the regenerative power of the dissociated cells in hydroids. Proceedings of the American Society of Zoologists, Science, n. s., vol. XXXIII, Mar. 10, 1911.

sure, be contended that ectoderm cells eventually recombined to form ectoderm, and entoderm cells to form entoderm. The obivous facts are that the cells all combine to form a solid aggregate in which ectoderm, entoderm, and a central yolk mass later differentiate after the general fashion of cœlenterate planulas. The probable interpretation of these facts seems to be that the cœnosarcal cells when thus violently treated pass into an indifferent, generalized state. In this state they recombine to form a mass of undifferentiated tissue comparable to a heap of blastomeras, in which differentiation and growth later occur.

DESCRIPTION OF PLATES.

Plate I.

Microciona prolifera.

Fig. 1. Branched specimen. $\times \frac{2}{3}$.

Fig. 2. Two specimens incrusting on shells. Lobular outgrowths have developed. $\times \frac{2}{3}$.

Fig. 3. Cover-glass preparation photographed in alcohol by transmitted light. Sponge cells were strewn over cover and preparation preserved 40 minutes later. The cells have combined to form small masses, and many of the latter have united to form networks. $\times 8$.

Fig. 4. Cover-glass preparation photographed in alcohol by transmitted light. Sponge cells were strewn over cover and preparation preserved 10 minutes later. Sponge cells have combined in part to form individual masses, in part continuous reticula. $\times 8$.

Fig. 5. Vertical section of normal sponge, incrusting type. Photograph from stained balsam mount. $\times 30$.

Fig. 6. One of the small syncytial masses of a preparation like figure 3, stained with hæmatoxylin. Balsam mount. Photographed by transmitted light. $\times 160$.

Plate II.

Microciona prolifera.

Fig. 7. Slide preparation photographed in alcohol by reflected light. Plasmodial masses have partially transformed into thin incrustation. $\times \frac{4}{5}$.

Fig. 8. Preparation similar to figure 7, but plasmodium had more the character of a reticulum $\times \frac{4}{5}$.

Fig. 9. Cover-glass preparation photographed in alcohol by transmitted light. Plasmodium partially transformed into incrustation. $\times 1\frac{2}{3}$.

Fig. 10. Slide preparation photographed in alcohol by reflected light. Slide covered with continuous thin incrustation developed from plasmodia. No canals or flagellated chambers as yet. $\times 1\frac{1}{3}$.

Fig. 11. Slide preparation kept two days in live box, photographed in alcohol by transmitted light. Canals have appeared, but the system is not complete, especially as regards the terminal ramifications. $\times 3\frac{1}{3}$.

Fig. 12. Slide preparation kept six days in live box, photographed in alcohol by transmitted light. Canals well developed. Dark spots are barnacles. $\times 1\frac{1}{3}$.

Plate III.

Microciona prolifera.

Fig. 13. Slide preparation photographed in alcohol by reflected light. Canals have appeared $\times 2$.

Fig. 14. Slide preparation kept eight days in live box, photographed in alcohol by transmitted light. Canal system well developed. Dark spots are barnacles. $\times 4$.

FIG. 15. Slide preparation kept eight days in live box. Photograph made by transmitted light from balsam mount stained lightly in hæmalum. Canal system well developed. Characteristic spicules have appeared. ×20.

FIG. 16. Vertical section of slide preparation kept six weeks in live box. Photograph from stained balsam mount. Characteristic skeleton has developed. Reproductive bodies present. ×73⅓.

FIG. 17. Slide preparation photographed in alcohol by reflected light. Plasmodial masses have partially transformed into thin incrustation. ×⅔.

FIG. 18. Cover-glass preparation photographed by transmitted light. Plasmodia formed by continued union of sponge cells have transformed into incrustations. ×1⅔.

FIG. 19. Small part of cover-glass preparation of metamorphosed plasmodium, showing canals with very abundant flagellated chambers and scattered spicules. ×100.

FIG. 20. Cover-glass preparation photographed by transmitted light in alcohol. Most of the plasmodial masses have metamorphosed into incrustations. A few, two especially, persist as thick rounded bodies which appear as very dark areas in the photograph. ×1⅔.

PLATE IV.

Microciona prolifera.

FIG. 21. Freshly dissociated cells (pressed out through bolting cloth). From a living preparation. Camera, Zeiss 2 mm. Comp. Oc. 6. ×666⅔.

FIG. 22. From preparation shown in figure 21, but 10 minutes later. Many cells have combined to form masses. Camera, Zeiss 2 mm. Comp. Oc. 6. ×666⅔.

FIG. 23. Plates, reticula, and compact masses of the pressed-out tissue. ×1⅓.

FIG. 24. From the preparation shown in figures 21 and 22, about one hour after cells were pressed out of sponge. Mass of regenerative tissue formed by fusion of smaller masses. Camera, Zeiss 2 mm. Comp. Oc. 6. ×666⅔.

FIG. 25. Plasmodium in shape of perforated plate formed by pressed-out tissue. ×13⅓.

PLATE V.

FIG. 26. *Microciona prolifera.* Sponge with oscular tube, subdermal cavities, etc., developed from mass formed by gradual fusion of teased-out tissue. ×13⅓.

FIG. 27. *Microciona prolifera.* Lobed mass formed by continued fusion of teased-out tissue. ×60.

FIG. 28. Plasmodia of *Microciona* and *Lissodendoryx.* *Lissodendoryx* tissue stippled. *Microciona* tissue unstippled. ×16⅔.

FIG. 29. Plasmodia of *Microciona* and *Lissodendoryx.* *Lissodendoryx* tissue stippled. *Microciona* tissue unstippled. ×16⅔.

FIG. 30. Plasmodia of *Microciona* and *Stylotella.* The upper irregular mass is the *Stylotella* tissue, which rests upon the ovoidal *Microciona* mass. ×16⅔.

FIG. 31. *Microciona prolifera.* Small plasmodial mass in early stage of metamorphosis. Collenchyma has been differentiated in several places at the periphery. ×80.

FIG. 32. Plasmodia of *Microciona* and *Lissodendoryx.* *Lissodendoryx* plasmodia are stippled. *Microciona* plasmodia in unstippled water color. ×30.

FIG. 33. *Stylotella.* From a cover-glass preparation, showing plasmodial masses combined to form a reticulum. ×16⅔.

Fig. 1

Fig. 2

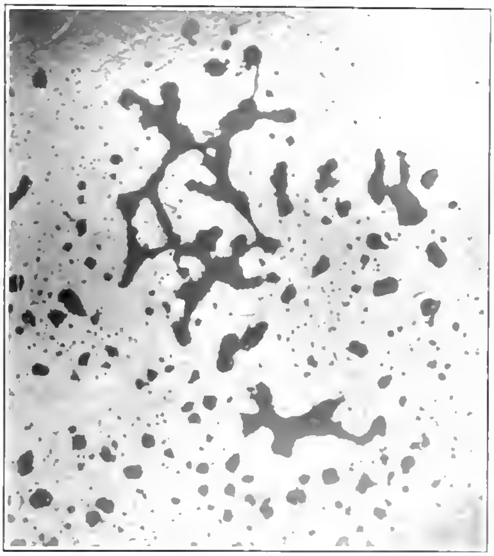


Fig. 3

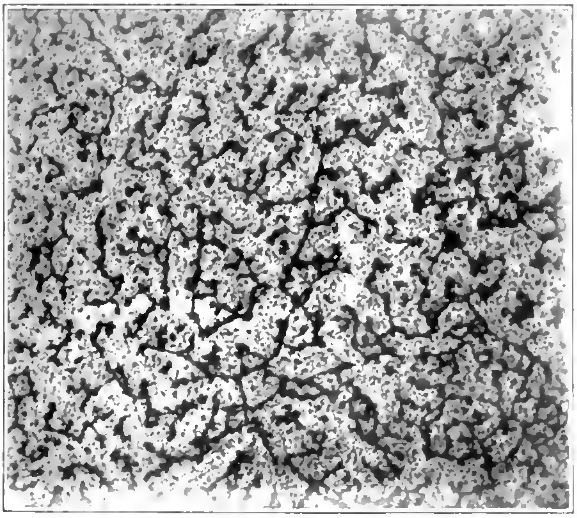


Fig. 4

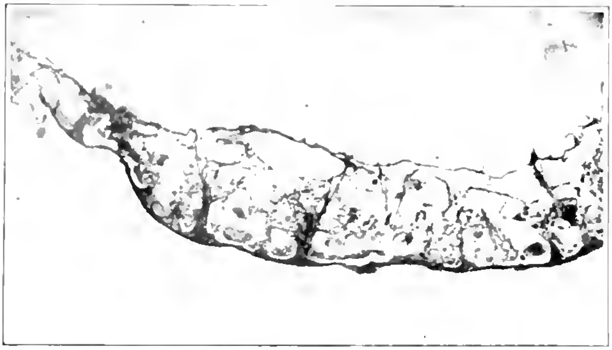


Fig. 5

Fig. 6

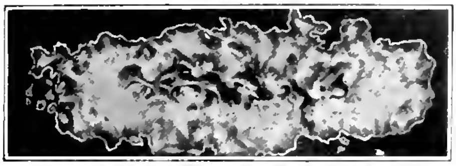


Fig. 7.

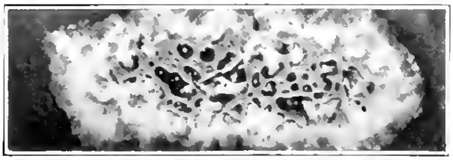


Fig. 8.

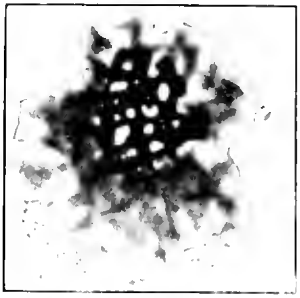


Fig. 9.

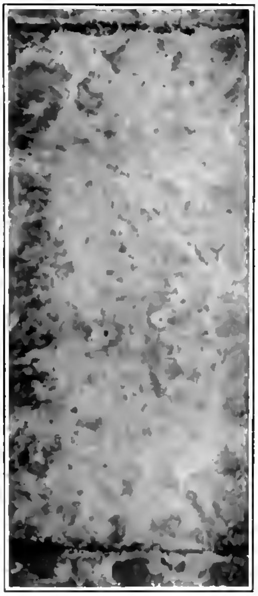
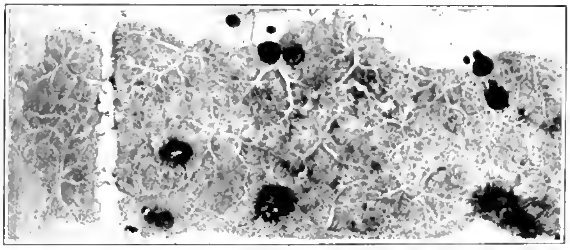


Fig. 10.

Fig. 11.



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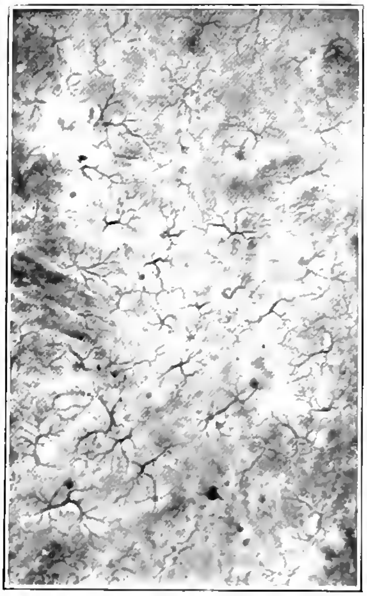


Fig. 13.

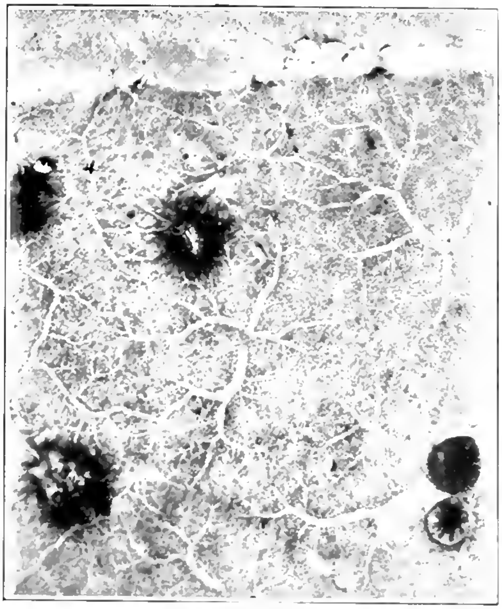


Fig. 14.

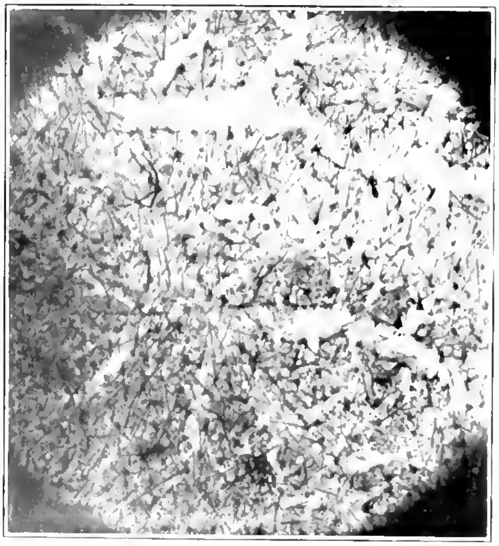


Fig. 15.

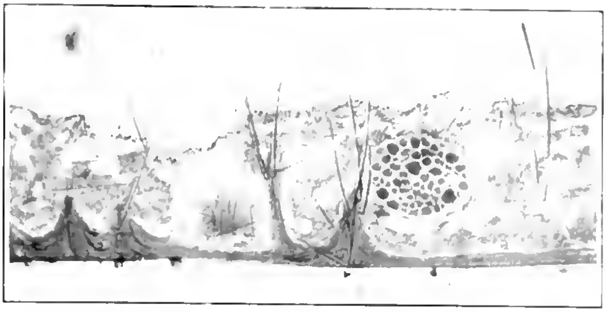


Fig. 16.

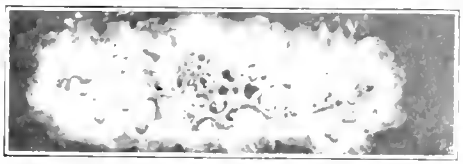


Fig. 17.

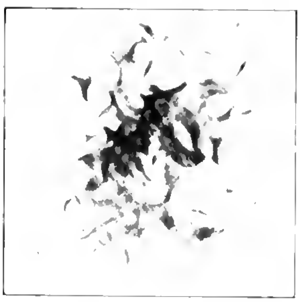


Fig. 18.

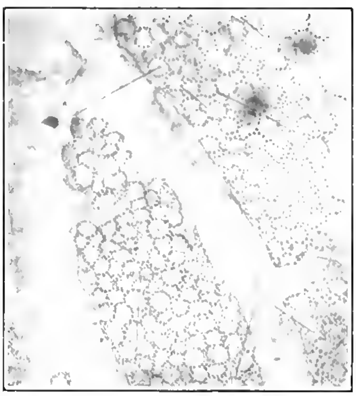


Fig. 19.

Fig. 20.

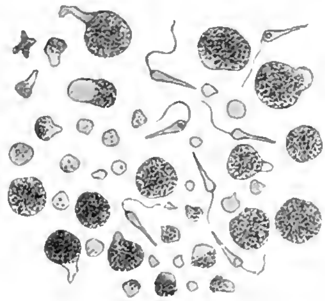
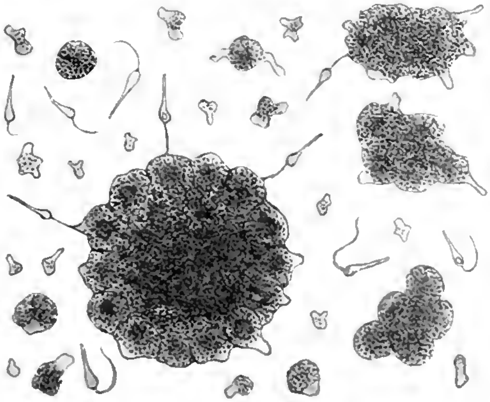


Fig. 21.



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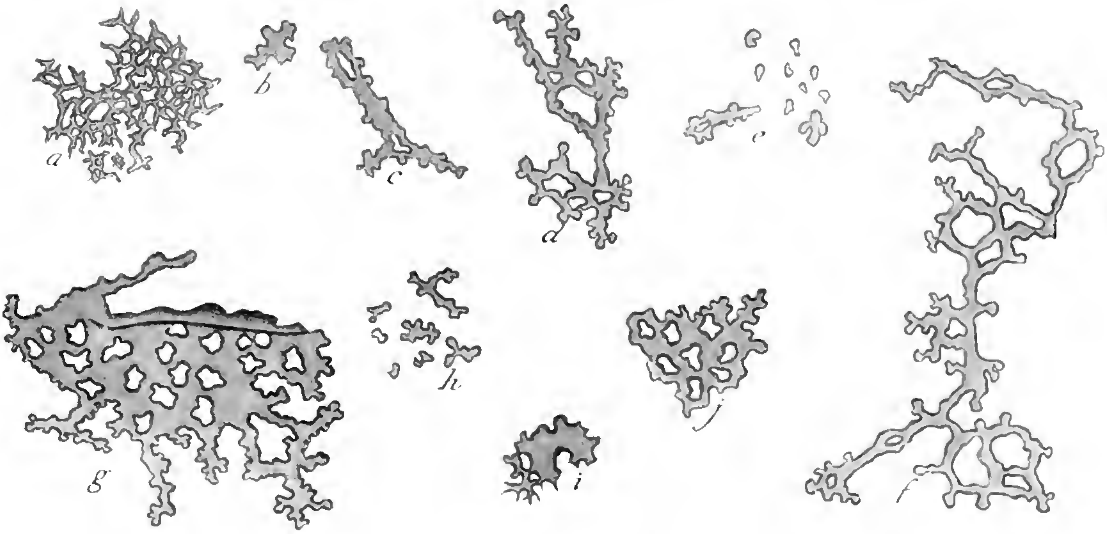


Fig. 23.

Fig. 24.

Fig.

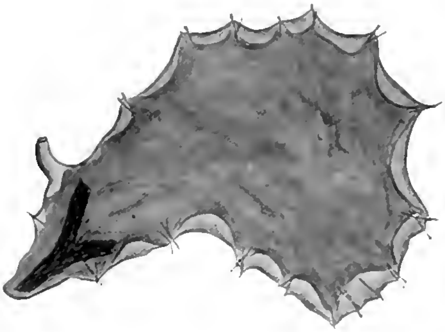


Fig. 26.

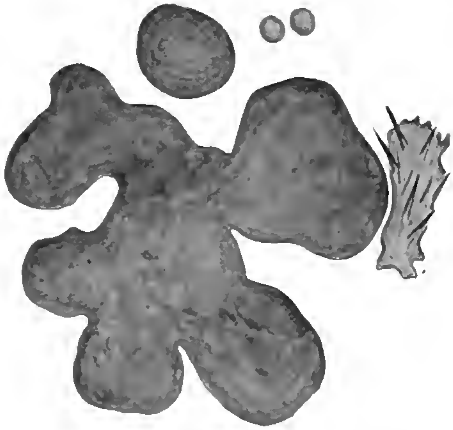


Fig. 27.

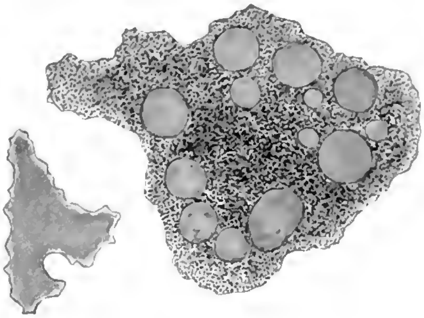


Fig. 28

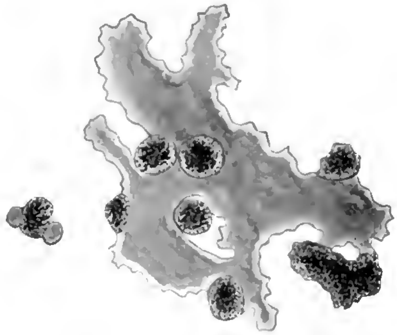


Fig. 29.

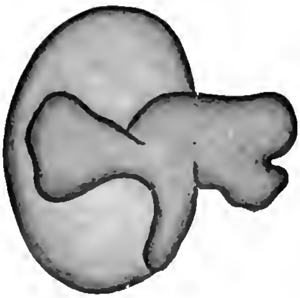


Fig. 30.

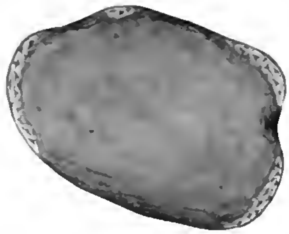


Fig. 31.

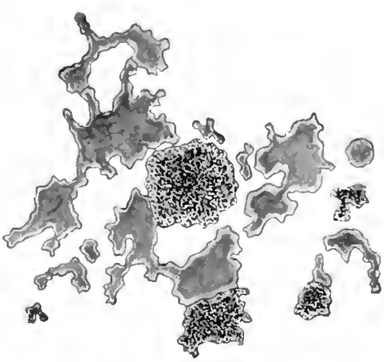


Fig. 32

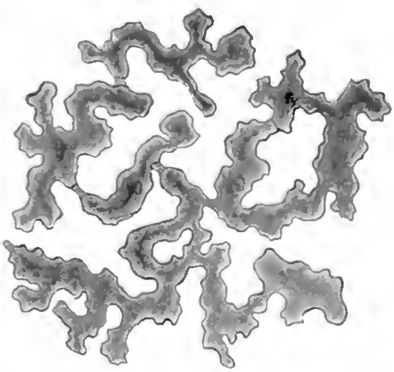


Fig. 33

FISHES FROM BERING SEA AND KAMCHATKA

By Charles Henry Gilbert and Charles Victor Burke

FISHES FROM BERING SEA AND KAMCHATKA.

By CHARLES H. GILBERT and CHARLES V. BURKE.

In the summer of 1906 the United States Fisheries steamer *Albatross* carried on investigations in the northwestern Pacific, especially in the vicinity of Japan. On the outward voyage the vessel passed along the Aleutian chain, touching at Unalaska, Atka, Agattu, and Attu Islands, visited Medni and Bering Islands of the Commander Group, and spent three days at Petropavlovsk, Kamchatka. Shore collecting was carried on in these localities, and some 37 hauls of intermediate net or dredge were made along the route, several of these hauls being highly successful. Rich ground, which would repay thorough investigation, was found on Petrel Bank (north and east of Semisopochnoi Island), in the vicinity of Attu and Agattu Islands, on the submerged plateau about the Commander Islands and on both coasts of Kamchatka. On the western coast of Kamchatka (latitude 51°+) lie valuable codfish banks to which American vessels resort. A detailed comparison of these banks with those in eastern Bering Sea is very highly desirable. The *Albatross* spent but two hours in this locality, at a time when conditions were not favorable for dredging.

The present paper deals with the fishes collected on the northern portion of the cruise as here outlined, and serves again to emphasize the bewildering richness of the northern Pacific in cottoid and liparid forms. Genera like *Triglops*, *Icelus*, *Artediellus*, and *Gymnocanthus*, which are represented in the north Atlantic by one, or at most two, species, contain in the northwestern Pacific numerous forms, some of which may be widely divergent. Such facts are usually accepted as conclusive evidence of the original home and the center of dispersal of the group thus richly represented.

On the basis of the hasty reconnoissance which the *Albatross* was able to make in passing, no sharply defined faunal lines are indicated in the region here considered. In passing from the eastern end of the Aleutian chain westward to Attu and Agattu only minor changes seem to occur. There is no perceptible break between the Aleutians and the Commander Group. The best defined division appears to coincide with the deep channel which separates the Commander Islands from Kamchatka. This is indicated by the failure of certain species to cross this barrier, and by the presence on the two sides of incipient species—representative forms which have only slightly diverged, as though under the influence of prolonged isolation.

The following forms are here described as new:

Archaulus, new genus (Cottidæ).
Archaulus biseriatus.
Icelus uncinalis.
Icelus spatula.
Thyriscus, new genus (Cottidæ).
Thyriscus anoplus.
Artediellus ochotensis.
Artediellus camchaticus.
Artediellus miacanthus.
Triglops metopias.
Stelgistrum beringianum.
Hemilepidotus zapus.
Myoxocephalus batrachoides.
Myoxocephalus parvulus.
Gymnocanthus detrisus.
Eurymen, new genus (Cottidæ).
Eurymen gyrinus.
Eumicrotremus phrynoides.
Cyclogaster (Neoliparis) micraspidophorus.
Cyclogaster beringianus.
Crystallichthys cyclospilus.
Careproctus bowersianus.
Careproctus mollis.
Careproctus candidus.
Careproctus opisthotremus.
Careproctus attenuatus.
Careproctus furcellus.
Elassodiscus, new genus (Cyclogasteridæ).
Elassodiscus tremebundus.
Nectoliparis, new genus (Cyclogasteridæ).
Nectoliparis pelagicus.
Acantholiparis, new genus (Cyclogasteridæ).
Acantholiparis opercularis.
Bathymaster cæruleofasciatus.
Gymnoclinus, new genus (Blenniidæ).
Gymnoclinus cristulatus.
Alectridium aurantiacum.
Anoplarchus insignis.
Xiphistes versicolor.
Lycodes camchaticus.
Chalinura spinulosa.
Ateleobrachium, new genus (Macrouridæ).
Ateleobrachium pterotum.

CLUPEIDÆ.

Clupea pallasi Cuvier & Valenciennes.
Avatcha Bay, Kamchatka.

SALMONIDÆ.

Salvelinus malma (Walbaum).
Unalaska, Atka, Agattu, Attu, and Medni Islands, and in Avatcha Bay, Kamchatka.

Salvelinus kundscha (Pallas).
Avatcha Bay.

ARGENTINIDÆ.

Mallotus villosus (Müller).
Petropavlovsk.

Mesopus olidus (Pallas).
Petropavlovsk.

Leuroglossus stilbius Gilbert.
A small specimen taken in an intermediate net which descended to 300 fathoms, station 4767, Bowers Bank, Bering Sea.

MICROSTOMIDÆ.

Bathylagus borealis Gilbert.
One specimen from station 4767, Bowers Bank; depth intermediate, 300 fathoms. Length 1.2 inches.

Bathylagus milleri Jordan & Gilbert.
Two specimens from stations 4758 and 4759, west of the Queen Charlotte Islands; depth intermediate, 300 fathoms. Length, 37 and 51 mm.

These specimens differ from the description of *B. milleri* in the character of the interorbital ridge and the position of the dorsal fins.

Interorbital deeply grooved, with a faint median ridge which extends backward upon the occiput; occipital region slightly swollen, flat; length of snout about equal to diameter of pupil; fine teeth on lower jaw and vomer. Scales large, about 25 in number, judging from the scars. Dorsal inserted above ventrals; distance from origin of dorsal to adipose fin equal to distance from origin of dorsal to edge of preopercle; origin of dorsal nearer tip of snout than base of caudal by the diameter of the pupil. Anal long, its base $1\frac{1}{5}$ in head. Vent midway between posterior edge of opercle and base of caudal.

Head 3.6; depth 5.75. Dorsal 8; anal 27; pectoral 14; ventral 8. Eye 2.5 in head.

CHAULIODONTIDÆ.

Cyclothone microdon (Günther).

One specimen from station 4764, off Yunaska Island, Aleutian chain; depth 1,130 fathoms, but the specimen probably taken at intermediate depth. A careful revision of this group will probably result in a subdivision into a number of local forms.

Chauliodus macouni Bean.

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′ ″	° ′	*Fathoms.*
4759	53 05 N.	138 31 W.	Int. 300
4781	52 14 30 N.	174 13 E.	Int. 300
4785	53 20 N.	170 33 E.	Int. 300
4793	54 48 N	164 54 E.	Int. 300
4797	52 37 30 N.	158 50 E.	Int. 300

AMMODYTIDÆ.

Ammodytes personatus Girard.

Numerous specimens were taken at Unalaska.

GASTEROSTEIDÆ.

Gasterosteus cataphractus (Pallas).

Taken at Unalaska, Attu, and Bering Islands and in Avatcha Bay, Kamchatka.

Gasterosteus microcephalus Girard.

In a small stream on Attu Island were taken numerous examples of this species, which show no transition to *G. cataphractus*.

Pygosteus pungitius (Linnæus).

Taken at Bering Island and in Avatcha Bay, Kamchatka.

Of the 9 specimens collected at Bering Island, 5 have 10 spines in the dorsal, 4 have 11 spines. Forty-two specimens were collected in Avatcha Bay; of these, 4 have 9 spines in the dorsal, 28 have 10 spines, 9 have 11 spines, and 1 has 12 spines.

SCORPÆNIDÆ.

Sebastolobus alascanus Bean.

LIST OF STATIONS.

Stations	Latitude.	Longitude.	Depth.
	° ′ ″	° ′	*Fathoms.*
4781	52 14 30 N.	174 13 E.	482
4784	52 55 40 N	173 26 E.	135

Vicinity of Attu Island.

Sebastodes alutus (Gilbert).

LIST OF STATIONS.

Stations	Latitude	Longitude.	Depth
	° ′ ″	° ′ ″	*Fathoms.*
4782	52 55 N.	173 27 E.	57-59
4784	52 55 40 N.	173 26 E.	135
4789	54 49 45 N.	167 12 30 E.	56
4791	54 36 15 N.	166 58 15 E.	72-76

Vicinity of Attu Island; the Komandorski Plateau.

Sebastodes glaucus (Hilgendorf).

One specimen, 445 mm. long, was taken with hook and line in Preobrazhenskoi Bay, Medni Island.

Dorsal XIV-15; anal III, 8. Lateral line with 52 tubes. Gill rakers 9+27, the longest three-fourths diameter of eye. Color in life pale brassy, darker on all the fins, especially the caudal; below white, the large ventral scales pearly, marbled and clouded with dusky; sides with 6 vertical bars, the anterior one above the pectoral; head with indistinct dusky bars radiating from eye; snout and chin blackish.

HEXAGRAMMIDÆ.

Hexagrammos octogrammus (Pallas).

Unalaska, Atka, Attu, Medni, and Bering Islands, and Avatcha Bay, Kamchatka.

Hexagrammos stelleri Tilesius.

Avatcha Bay, Kamchatka.

Hexagrammos superciliosus (Pallas).

Atka, Agattu, and Attu Islands.

COTTIDÆ.

Icelinus borealis Gilbert.

Stations 4777 and 4779, Petrel Bank; 4782 and 4784, near Attu Island, Bering Sea; depths 43 to 135 fathoms.

Icelinus (including *Tarandichthys*) differs from all other North American cottoids in having only two articulated rays in the ventral fins. In this respect it agrees with certain Japanese genera (*Stlengis*, *Schmidtina*, *Daruma*, *Ricuzenius*), among which must be sought its nearest allies.

Astrolytes fenestralis (Jordan & Gilbert).

A single specimen from tide pools at Unalaska.

ARCHAULUS, new genus.

Head and body compressed. A series of spinous plates along the lateral line; a double series of plates along the base of the dorsals, widening anteriorly into a band and uniting with its fellow of the opposite side in front of the dorsal fin; head naked. Gill membranes united, free from the isthmus. No pore behind the last gill arch. Teeth on jaws, vomer, and palatines. Preopercle with four simple spines. Ventral fins with one spine and three rays.

Closely allied to *Archistes*, but with the dorsal row of plates double, the anterior widened portion filling entire space between base of dorsal and lateral line and continuous with its fellow across nape, which is entirely invested; and with four distinct preopercular spines.

Archaulus, Gilbert and Burke, new genus of Cottidæ; type *Archaulus biseriatus*, new species.

Archaulus biseriatus, new species. (Fig. 1.)

Type a male, 154 mm. long, from station 4778, Petrel Bank, Bering Sea; depth 43 fathoms.

Head 27 hundredths of total length to base of caudal; depth 27; length of snout 9.5; length of maxillary 9.5; diameter of orbit 7.1; interorbital width 4; least depth of caudal peduncle 7; greatest width of head 16.5; longest dorsal spine 20; length of dorsal base 71; length of anal base 47; length of pectoral 32.5; length of ventral 14; length of caudal 21; chord of arch of lateral line 47. Dorsal IX, 28; anal 23; pectoral 16; ventral I, 3. Plates in lateral line 47.

Head and body compressed, deeper than wide; head narrow above, the sides nearly vertical; supraocular rim much elevated, forming a narrow deep interocular groove; interorbital width 1.8 in orbit; occiput flattened, without spines or ridges; snout blunt, the anterior profile steep; mouth small, slightly oblique, the maxillary reaching vertical from front of orbit; jaws equal; teeth bluntly conic, in wide bands on the jaws, the vomer and the anterior half of the palatines; preopercle with 4 short simple spines; upper spine with strongly striate base, strong, sharp, directed backward and upward, straight or with a scarcely perceptible upward curve; second spine shorter, directed vertically downward; third and fourth spines concealed beneath the integument, directed downward and forward; nasal spines strong. A pair of large supraocular flaps, with narrowly fringed margins, their length equaling the distance between the middle of their bases; a pair of cleft flaps at middle of sides of occiput, and a similar pair more widely separated at the posterior edge of occiput; a delicate nasal filament, two filaments at anterior margin of preorbital, one near tip of maxillary, one on the suborbital stay, a divided filament near the angle of the opercle, a series along the edge of the preopercle, and a few scattered filaments on the plates of the lateral line; both nostrils in short tubes.

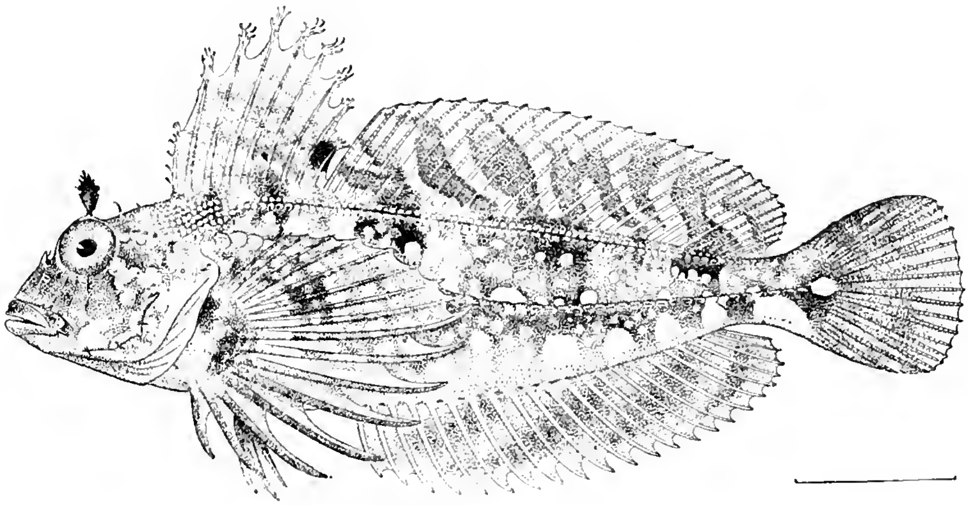


Fig. 1.—*Archaulus biseriatus*, new species. Type.

Anterior half of the lateral line forming a low flat-topped arch, which rises obliquely toward the head; plates along the lateral line 47, greatly diminishing in size posteriorly, but their upper edges free and finely spinous throughout the series; two rows of similar plates along base of dorsals, smaller but more strongly spinous than those of lateral line; the lower series contains 80 to 84 scales, counting forward to the head, and extends on back of caudal peduncle but not to base of fin; its scales are higher than long, attached at lower edge, the free margin sharply convex, the axis of scale directed upward and slightly backward; the upper series consists of much smaller rounded scales, the free spinous margin directed more posteriorly, but not downward as in *Icelinus*, the series ceasing under last rays of dorsal fin, the scales 84 to 88 in number, counting forward to head; these two rows of plates are closely apposed and form a narrow band which becomes abruptly widened under anterior part of spinous dorsal, where it covers the entire area between the spinous dorsal and the lateral line and extends around the front of the dorsal fin to join its fellow of the opposite side, and invests the entire width of the nape; a well-defined patch of small scales immediately behind the lower half of pectorals, and above and behind it a band of larger scales filling the area subtended by the posterior half of the curved portion of the lateral line, all of these scales arranged in more or less definite series, those of the posterior band in regular rows extending obliquely downward and backward from the scales of the lateral line; body elsewhere naked; head naked; scattered pores on top of head, preopercle and preorbital; a series of 4 on mandible, the anterior near symphysis, but distinct from its fellow.

Dorsals narrowly joined at base, the last spine less than half the height of the first ray and about one-third the longest spine, the membrane joining first ray of second dorsal immediately above the base; dorsal spines slender and greatly elevated, with deeply incised membranes, the tips in both males and females provided each with a cleft membranous flap; third and fourth spines longest, 1.5 in head (in females 2.2); dorsal rays long and slender, the longest 1.6 in head; anal rays thickened, the membrane incised; pectoral reaching to below ninth dorsal ray, the rays all simple, the lower 8 thickened, their membranes deeply incised; ventrals reaching to front of anal, or in females little more than halfway to anal; caudal gently rounded; anal papilla long, reaching nearly to front of anal, the vent immediately behind the base of the ventral fins.

Color in life: Light olive above, tinged with salmon or pinkish; five or six crossbars downward from back, somewhat irregular in size and shape, but usually narrowest at dorsal base, widening downward to become confluent with their fellows, and then more or less broken and interrupted to form marblings along the sides of the body; the first dark bar is under the spinous dorsal, the remainder under the soft dorsal; the darker area comes frequently to bound roundish spots of the ground color along dorsal outline, these spots extending less than half way to lateral line; dark bars most intense immediately below the dorsal band of plates; both dark and light areas above lateral line marked with light blue spots and streaks of various shapes and sizes, some of these at times forming a line separating the dark and light crossbars on back; below lateral line are about 7 narrow vertical streaks of brownish or yellowish brown, which narrow downward and reach almost to base of anal; they are very irregular in size, number, and position, and may inclose round spots of light blue; under side of breast and belly white; a dark bar vertically downward from eye and a number of narrower radiating streaks of light blue bordered with darker; a dark blotch on the membranes between the last two dorsal spines, wanting in females; spinous dorsal translucent, the distal portions of spines yellowish or brownish, the fin with many bright carmine spots or streaks; soft dorsal with 9 broad oblique bars of brownish yellow or brownish green with light blue intervals; anal fin dusky or bluish at base, becoming light yellow toward margin; caudal with orange crossbars becoming light yellow toward tips of rays; ventrals whitish in females, blue-black in males; pectoral with a wide pinkish or orange blotch on basal portion of upper half or two-thirds of fin; in males, the lower thickened rays are largely dark blue, the distal portion of upper ray with two or more irregular cross series of brown spots; in the largest male (the type of the species), the lower pectoral rays, the ventral, the anal, and the lower part of the caudal fin very dark, almost black.

Specimens were taken at stations 4777, 4778, and 4779, on Petrel Bank, Bering Sea, at depths of 43 to 54 fathoms.

In 10 specimens, including the type, 5 have dorsal IX, 28, anal 22; 2 have dorsal IX, 28, anal 23; 2 have dorsal IX, 29, anal 23; 1 has dorsal X, 28, anal 23. All have 16 rays in the pectoral fin.

Rastrinus scutiger (Bean).

Taken at stations 4784, off Attu Island, 135 fathoms, and 4790, off Bering Island, 64 fathoms.

In well-preserved specimens it can be seen that delicate folds of the integument pass downward from the posterior margins of the plates of lateral line, and usually disappear among the scales; a few may reach the belly and join their fellows on the median line, and a few others may reach base of anal fin.

In our material the head is 25 to 27 hundredths of the length, the snout 8 to 9, and the orbit 11 to 12 hundredths. The proportions are the same in material previously reported on (Gilbert, Report U. S. Fish Commission, 1893, p. 415) from station 3339, south of the Alaskan Peninsula. In the type the eye is said to be twice as long as snout and two-fifths the length of the head.

The intromittent organ in the male is slender, gently tapering, and ending in a slender curved point. In typical *Icelus* (*bicornis* and *spiniger*) the intromittent organ becomes widened and bilobed distally, and the short terminal cirrus springs from the dorsal side.

Icelus spiniger Gilbert.

LIST OF STATIONS.

Stations.	Latitude.				Longitude				Depth
	°	′	″		°	′	″		*Fathoms*
4777	52	11		N.	179	49		E	43-52
4784	52	55	40	N.	173	20		E	135
4786	54	51	30	N.	167	14		E	54
4787	54	50	50	N.	167	13	30	E	54-57
4788	55	50	24	N	167	13		E	56-57
4789	54	49	45	N	167	12	30	E	56
4791	54	36	15	N	166	58	15	E	72-76
4792	54	36	15	N.	166	57	15	E	72

These localities are from Petrel Bank, Bering Sea, to the extensive plateau from which arise the Commander Islands.

The following table exhibits range of variation in fin rays in 25 specimens from all the above localities:

	Spinous dorsal			Soft dorsal			Anal		
Fin rays	VIII	IX	X	19	20	21	16	17	18
Number of specimens	2	21	2	3	10	12	6	15	4

Icelus uncinalis, new species. (Fig. 2 and 2a.)

Type, a male, 97 mm. long, from station 4784, near Attu Island; depth, 135 fathoms.

Measurements in hundredths of length without caudal: Head 38; snout 11.5; orbit 11.8; interorbital width 2.2; width of head 19; depth at occiput 24; maxillary 18; greatest depth 26; depth of caudal peduncle 5; longest dorsal spine 14; longest dorsal ray 15; caudal 22; pectoral 32; ventral 18; anal papilla 13.

Dorsal IX-19; anal 16; pectoral 18. 41 plates in the lateral line; 35 plates in the dorsal series.

The following table gives range in fin rays among the 12 specimens of *uncinalis* which were obtained:

	First dorsal	Second dorsal			Anal			Pectoral	
Fin rays	IX	18	19	20	14	15	16	17	18
Number of specimens	12	2	6	4	2	7	3	7	17

Head and body robust, compressed, cheeks vertical; interorbital width less than diameter of pupil, shallowly concave; occiput depressed well below the raised interocular region, bounded on each side by a low ridge which bears 2 tubercles, each terminating in a short sharp spine; nasal spines short and sharp; numerous minute scattered pores on top and sides of head; a pair of supraocular tentacles widening upward from a narrow base, the margin multifid; nasal tubes short, the anterior the longer; mouth large, slightly oblique, the mandible included, the maxillary reaching vertical a little behind middle of pupil; teeth minutely villiform, in broad bands in jaws and narrower patches on vomer and palatines; gill membranes wholly free; no pore or slit behind last gill arch.

Dorsals wholly separate, the interspace between base of last spine and origin of second dorsal equaling two-fifths diameter of orbit; origin of anal under third dorsal ray, the last anal ray under the third from the last of the dorsal; caudal truncate or gently rounded; pectoral rays all simple, some of the uppermost of the thickened rays the longest in the fin, extending to base of fourth anal ray; ventrals reaching base of anal papilla.

Anal papilla very large, of nearly uniform width from base to apex, provided at the abruptly rounded tip with a short curved uncinate process which springs from the posterior (dorsal) side and extends a very short distance beyond the tip of the basal portion. This is strikingly different from the shape in the Atlantic *Icelus bicornis*, in which the basal segment is comparatively short and is terminated by a long, gently tapering process, about as long as the basal portion, from the summit of which it springs.

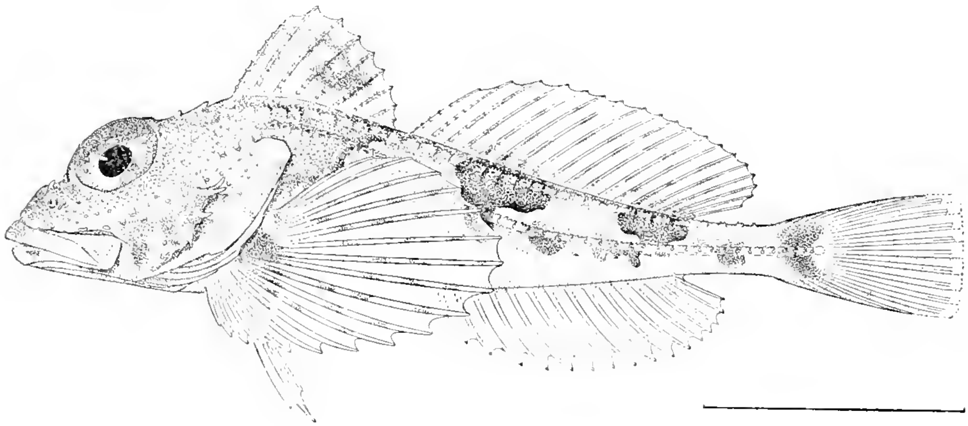


FIG. 2.—*Icelus uncinalis*, new species. Type.

Top and sides of head covered more or less completely with very fine prickles; a band of similar prickles along back, just dorsad of the series of spinous plates; plates of the lateral line with the upper posterior margin free and spinous, some of the middle spines often produced, dividing the margin of the plate into an upper horizontal and a posterior vertical portion; plates of dorsal series similar but usually larger, the spinous margin more rounded; a few spinous scales behind upper part of pectoral, distant from one another, but arranged rather definitely in series running downward and backward; lateral line always complete; dorsal series of scales commonly terminating on middle of back of caudal peduncle.

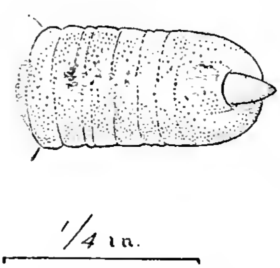


FIG. 2a.—*Icelus uncinalis*, anal papilla, posterior view.

Color in spirits: Olive-gray, with four well-defined dark bars on back, little or not at all broken up by lighter lines, and preserving a characteristic form; anterior bar springing from posterior half of base of spinous dorsal running downward and forward to gill slit above base of pectoral, its anterior margin less sharply defined than the posterior margin; second bar under fifth to ninth rays of second dorsal, the anterior margin nearly vertical, the posterior passing downward and forward usually with a double curve, the bar terminating in a narrow V-shaped process below lateral line; third bar under last 5 or 6 dorsal rays, forming a short sharply defined saddle-shaped blotch which usually fails to reach the lateral line; fourth bar on base of tail, not appearing either above or below on caudal peduncle; there may be fainter dusky marks between the bars and sometimes a series of irregular dark spots or blotches below the lateral line; top and sides of head somewhat darker than the trunk, in strongly marked individuals a faint dark bar on occiput with a light spot anteriorly at the center of the occipital depression; a faint dark bar from eye forward across preorbital and both lips, a second from eye downward across cheeks; spinous dorsal with a narrow black bar confined largely to one or two spines, running upward from the front of the dark dorsal bar; soft dorsal, caudal, and upper pectoral rays faintly barred, a dark blotch at base of middle pectoral rays; under parts white, the ventrals and anal unmarked.

This species is closely related to *Icelus bicornis* from the Atlantic, but differs widely in the form of the anal papilla; the lateral line presents always a continuous and complete series of plates to the base of the caudal fin, whereas in *bicornis* the plates are usually interrupted on caudal peduncle; the space between the lateral line and the dorsal series of scutes is naked, without plates or prickles in *uncinalis*, and a series of plates is never present immediately above base of anal fin.

Icelus uncinalis has not been obtained by previous expeditions, and its occurrence is known only from Petrel Bank, Bering Sea, to the vicinity of the Commander Islands. In eastern Bering Sea it is replaced by an undescribed species which heretofore has been identified doubtfully with *Icelus bicornis*, a species which extends its range southward at least to the coast of Oregon. To the eastward, along the coast of Kamchatka, *Icelus uncinalis* is replaced by another closely allied species, *Icelus spatula*.

LIST OF STATIONS.

Stations	Latitude				Longitude				Depth
	°	′	″		°	′	″		*Fathoms.*
4777	52	11		N.	179	49		E.	43-52
4779	52	11		N.	179	57		W.	54-56
4784	52	55	40	N.	173	26		E.	135
4790	54	38	45	N.	167	11	45	E.	64
4791	54	30	15	N.	166	58	15	E.	72-76
4792	54	36	15	N.	166	57	15	E.	72

Icelus spatula, new species. (Fig. 3 and 3a.)

Type, a male specimen, 69 mm. long, from station 4794, off Avatcha Bay, Kamchatka; depth 58 fathoms.

Measurements in hundredths of length without caudal. Head 37.5; snout 10.5; orbit 12; interorbital width 3; width of head 19; depth at occiput 22; maxillary 18; greatest depth 25; depth of caudal peduncle 4.2; longest dorsal spine 11; longest dorsal ray 16; caudal 22; pectoral 30; ventral 18; anal papilla 13.

Dorsal IX-20; anal 16; pectoral 18 Plates in lateral line 41; plates in dorsal series 32.

The following table gives range in fin rays among 12 cotypes of this species:

	First dorsal.	Second dorsal.		Anal		Pectoral.	
Fin rays ..	IX	20	21	15	16	17	18
Number of specimens	12	9	3	2	10	9	15

Occipital crests and spines higher, the occipital depression deeper than in other species of the *bicornis* group, this being markedly so in comparison with *Icelus uncinalis*, to which it stands most nearly related. A simple slender filament on the summit of each of the anterior occipital tubercles; a longer simple slender supraocular filament, which like the preceding is readily detached and often wanting; no other filaments present. Nasal spines pungent; preopercular spines much larger and stronger than in *uncinalis*, the upper deeply cleft, the second long and slender, directed backward, the third and fourth shorter and more robust, directed downward and forward; the upper two preopercular spines reaching to or almost to edge of opercle; numerous small pores scattered on top and sides of head; pair of symphyseal pores directed mesad, opening separately into a common pit or depression which lies between them; gill membranes wholly free from isthmus; no pore behind last gill arch; mandible well included; broad bands of minute villiform teeth in both jaws, very narrow bands on vomer and palatines; maxillary reaching vertical from middle of eye. Preorbital narrowed posteriorly through the upcurving of the lower margin, narrower than in *Icelus uncinalis*.

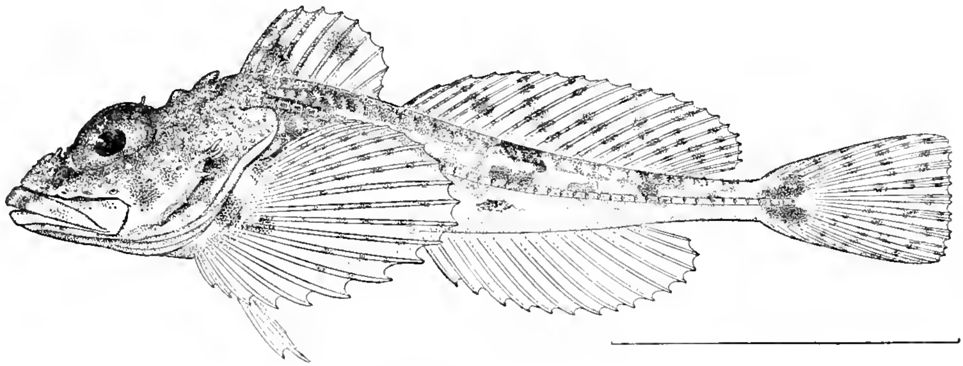


FIG. 3.—*Icelus spatula*, new species. Type.

Dorsal series of plates usually incomplete anteriorly, greatly diminished in size or disappearing under the anterior half of spinous dorsal; it is variable in extent posteriorly, but typically reaches middle of caudal peduncle; a well-defined band of prickles accompanies the dorsal series of plates, leaving a naked strip along base of the dorsal fins; lateral line always complete, the area between it and the dorsal series of plates naked, without prickles or scattered plates; a few large spinous plates behind the pectoral fin; top and sides of head, as far down as preorbital and suborbital stay, covered with minute prickles, which are a trifle coarser and less numerous than in *Icelus uncinalis*.

Dorsal fins separated; spinous dorsal low, not elevated in males, much lower than second dorsal; caudal emarginate when folded, truncate or gently rounded when spread; pectoral reaching base of fourth anal ray; ventrals reaching vent. The dorsal spines and a few of the anterior dorsal rays are accompanied by series of small prickles.

Color in spirits: Less definitely marked than *Icelus uncinalis*, the dorsal bands usually less evident, more broken up by longitudinal wavy lines of the ground color, the effect being often of fine mottlings or reticulations of light and dark, in which the four bars are faintly discernible; usually two narrow dark blotches on spinous dorsal, the soft dorsal and caudal being barred; anal and ventrals unmarked; pectoral with a small dark blotch at base of median rays, the distal and upper parts of fin rather faintly barred; head mottled like the back, with a dark bar before and one below the eye.

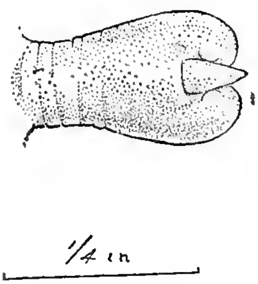


FIG. 3a.—*Icelus spatula*, anal papilla, posterior view.

The species is most closely related to *Icelus uncinalis*, from which it seems geographically to be separated by the deep channel between Kamchatka and the Commander Islands. In addition to the difference in coloration, the higher occipital crests, the larger preopercular spines, and the slightly increased number of rays in second dorsal and anal, the species is distinguished by the form of the anal papilla in the male. This is distinctly spatular in shape, widening from base to the end of the basal segment, which is broad, rounded at tip and emarginate on the middle line, the terminal segment being extremely short, curved like a claw, springing from the dorsal (posterior) side of the basal portion and not extending beyond it.

LIST OF STATIONS.

Stations.	Latitude.	Longitude	Depth
	° ′ ″	° ′ ″	*Fathoms.*
4794	52 47 20 N.	158 44 30 E.	58-69
4795	52 46 50 N.	158 44 30 E.	48-69
4796	52 47 N.	158 43 E.	48

THYRISCUS, new genus (Cottidæ).

Head and body rather deep, compressed; lateral line with a series of plates which have their upper posterior border free and serrate; an axillary patch of spinous scales; skin otherwise smooth and naked. Gill membranes broadly united, wholly free from the isthmus; a short slit behind last gill; top of head without spines or tubercles; preopercle with 4 small simple acute spines. Teeth on jaws and on vomer and palatines. Ventrals I, 3.

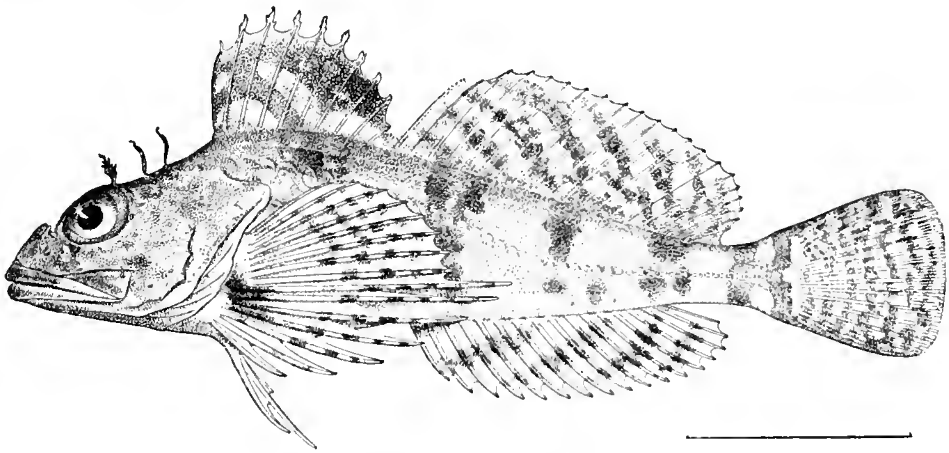


FIG. 4.—*Thyriscus anoplus*, new species. Type.

Nearest *Icelus*, but differing widely in the absence of the dorsal series of plates, the presence of a slit behind the last gill-arch, and the greatly specialized lower pectoral rays.

Type *Thyriscus anoplus*, new species.

Thyriscus anoplus, new species. (Fig. 4.)

Type, a female, 109 mm. long, from station 4782, off Attu Island, Bering Sea; depth, 57 fathoms.

Measurements in hundredths of length without caudal: Head 37; diameter of orbit 10.5; interorbital width 2.3; snout 10.5; maxillary 19.5; width of head 17; depth at occiput 21; greatest depth 26; depth of caudal peduncle 7; length of curved part of lateral line 39; of straight part (to base of caudal) 35; longest dorsal spine 14; longest dorsal ray 19; length of caudal 24; length of upper part of pectoral 25; longest pectoral ray 37; ventrals 19.

Dorsal X-21; anal 17; pectorals 15. Plates along lateral line 42.

Body compressed, especially along base of spinous dorsal; head deeper than wide; interorbital space narrow, flat, with a low median ridge; occiput slightly concave but without distinct ridges or tubercles; no spines or tubercles on supraocular rim; nasal spines small, slender, and pungent, a deep cross-groove behind them; posterior nostril tube very low, anterior tube much longer. Mouth large, horizontal, the maxillary broad, reaching vertical from posterior rim of orbit; lower jaw included, the symphysis slightly produced; teeth minute, in broad bands on the jaws; vomer with an irregular single series; palatine teeth in a short narrow lenticular patch. Preopercular spines very short, slender, acute, the upper scarcely longer than the others, less than half diameter of pupil, directed almost vertically upward; the second spine is directed backward, the third downward, the fourth downward and forward. A broad supraorbital flap with the outer margin fringed; behind this on occiput two long slender filaments, one at posterior edge of occiput, the other in advance; the occipital filaments of the right side are both lacking in the type; a minute filament near end of maxillary and one near opercular tip. Top and sides of head with rather numerous pores, some of which are distributed around the margins of wide outpushings of the sensory canals.

Lateral line with its anterior portion in a wide ascending curve, the middle of which is slightly depressed; the curved portion is a little longer than the straight part, which begins under middle of soft dorsal and runs thence along middle of sides. Plates of lateral line small, those anteriorly larger than the others; the upper posterior margin free and very minutely serrulate; lateral line opening by a single pore under the posterior margin of each plate and directed upward and backward; numerous scattered spinous scales behind the pectorals, the patch extending back below the middle of the curve of the lateral line. Skin otherwise smooth.

Dorsals joined at base, the first dorsal of very slender weak spines; caudal fin slightly rounded, pectoral rays all simple, the lower thickened rays produced and exserted, the longest (upper) of these produced well beyond the rest of the fin and reaching the base of the seventh anal ray. Ventrals very slender, composed of 1 spine and 3 very delicate rays, the inner much shortened.

Color in spirits: Light olive-brown above, light below, the head much darker than the body; back with five darker brown bars, all but the second narrow, the first under middle of spinous dorsal, ceasing at the lateral line, the second a wide double bar under front of soft dorsal, extending to below middle of sides, the third and fourth under middle and end of soft dorsal, and the fifth posteriorly on caudal peduncle, where it joins a bar across base of tail; a series of irregular more or less united brown spots below lateral line, some of which may be connected with the bars; spinous dorsal dusky, with two small pale areas at base and a black blotch in front and behind; soft dorsal and caudal with fine brown crossbars which are oblique on the dorsal; anal with five broad oblique bars of blackish brown; distal portion of pectoral with fine brown crossbars, the basal part white, traversed by a broad brown streak, which extends downward and backward from the middle of base; ventrals unmarked; a dark streak running forward across lips from front of eye.

Only the type known.

Artediellus ochotensis, new species. (Fig. 5.)

Type, a male specimen, 94 mm. long, from station 4798, off the west coast of Kamchatka (latitude 51° 37′ N.); depth 25 fathoms.

Most nearly allied to *Artediellus pacificus*, from which it differs in color, in the simple maxillary barbel, the distinctly separate anterior pair of mandibular pores, the slightly longer dorsals and anal, the less numerous pectoral rays and the more numerous pores in the lateral line.

Measurements in hundredths of length without caudal: Length of head 39.7; length of snout 11; length of maxillary 18; diameter of orbit 9.5; interorbital width 2; greatest width of head 29; greatest depth of body 22; least depth of caudal peduncle 7; distance from tip of snout to hinder edge of gill membrane on median line 23; length of base of dorsal fin 55; of anal fin 33; longest pectoral ray 33; longest ventral ray 19; longest caudal ray 28.

Dorsal VIII-14; anal 12; pectoral 22 (9 forked); caudal with 17 rays, 9 of which are forked. Lateral line with 29 pores, including the pore at point of attachment of opercular membrane.

In 8 specimens, comprising 6 cotypes from the type locality (station 4798) and 2 specimens from station 3647 (near Robben Island, Okhotsk Sea), the pores and fin rays are as follows:

	Dorsal spines.		Dorsal rays.		Anal rays.		Pectoral rays.			Pores in lateral line					
Fin rays and pores	VII	VIII	13	14	12	13	21	22	23	28	29	30	31	32	33
Number of specimens	1	7	2	6	1	7	3	11	2	1	2	7	5	0	1

Mouth more oblique than in *Artediellus pacificus*, the maxillary scarcely reaching vertical from middle of pupil. Teeth as in other species, the outer series in the upper jaw and the inner series in the lower jaw slightly enlarged; a single series on front of vomer, and a small elliptical patch on front of palatines. Upper and lower preopercular spines developed as usual, the upper comparatively small, sharply curved, its tip usually a little below level of upper end of pectoral base; in a young specimen, 43 mm. long, a well-marked denticle is present on the inner margin of the curve; in older specimens, traces of a denticle may persist, or it may entirely disappear; the lower preopercular spine is short, directed downward and forward; between the two spines are 2 small rounded prominences, the upper of which is directly below base of upper spine. Nasal spine present, but minute, less developed than in *pacificus*. Occiput depressed, without trace of ridges or prominences. Anterior nasal tubes long, the posterior short or obsolete. Filaments all simple, unusually well developed and numerous; supraocular pair largest; a series of short filaments or papillæ along upper edge of pupil, with occasional scattered ones on upper part of eyeball; a single pair on occiput, 1 to 3 along anterior border of preorbital, usually 2 long filaments on cheeks in front of base of preopercular spine, 1 to 3 short ones on middle of cheeks, a long one on opercle, and several forming a series above anterior portion of lateral line. Pores on mandible and preorbital large, the anterior mandibular pores facing each other but well separated and distinct. A pair of pores on anterior part of interorbital space, a

FIG. 5.—*Artediellus ochotensis*, new species. Type

median pore usually on middle of interorbital space, and a transverse row of 3 just behind orbits. Anterior pores of lateral line frequently accompanied each by 3 small imperforate papillæ, 1 below the canal and immediately in advance of the pore, the other 2 above the canal and opposite the pore and the lower papilla; although imperforate, the papillæ may be cupped at the apex and are doubtless obsolete pores. Gill membranes with a free fold, the width of which varies; in the type, the fold is very narrow, less than half the diameter of the pupil.

In males the dorsal fins are contiguous and may even be slightly joined at base, but they are well separated in females; spinous dorsal in males moderately elevated, the first 4 spines with membranes incised one-third their height; ventrals unusually long, reaching nearly to vent in both sexes; the upper 8 or 9 pectoral rays forked and longer than the succeeding rays.

Lateral pores very small, in a series along lower margin of the main canal, which opens by a large pore at base of caudal.

Colors in life: Top of head and dorsal region finely vermiculated with light reddish brown; small round dark spots frequently are grouped to outline a bar under spinous dorsal, a second under soft dorsal and a third on caudal peduncle; below lateral line, an irregular series of larger round dark reddish spots; dorsal and caudal coarsely barred with dark reddish brown, the bars breaking up below and merging in the general dusky coloration of that portion of the fin; in females, the pectorals are crossed by very narrow bars formed by series of small dark spots on the rays; usually a small dark blotch on upper part of base and a larger one below; ventrals dusky in males, white in females; in males, the anal is bright chrome-yellow, without bars.

The species is represented in the present collection by the type and 6 cotypes from the Okhotsk Sea, to the westward of Kamchatka. It had been taken previously by the *Albatross* in 1896 off Robben Island in the Okhotsk Sea, and had been confused with *Artediellus pacificus* (Jordan and Gilbert, The Fishes of Bering Sea, Report Fur-Seal Investigations, pt. 3, 1899; stations 3647 and 3648, depth 40 fathoms).

Artediellus camchaticus, new species. (Fig. 6.)

Type, a male specimen, 117 mm. long, from station 4795, off the east coast of Kamchatka (latitude 52° 46′ 50″ N.); depth 48 to 69 fathoms.

Larger than any species of *Artediellus* heretofore known, with developed nasal spine, the mandibular pores of the symphyseal pair distinct, the maxillary barbel simple, all other cephalic filaments reduced or obsolete, the anal fin without crossbars, and the pores of the lateral line very numerous.

Measurements in hundredths of length to base of caudal: Length of head 34.5; length of snout 10.5; length of maxillary 14; diameter of orbit 9; interorbital width 2; greatest width of head 27;

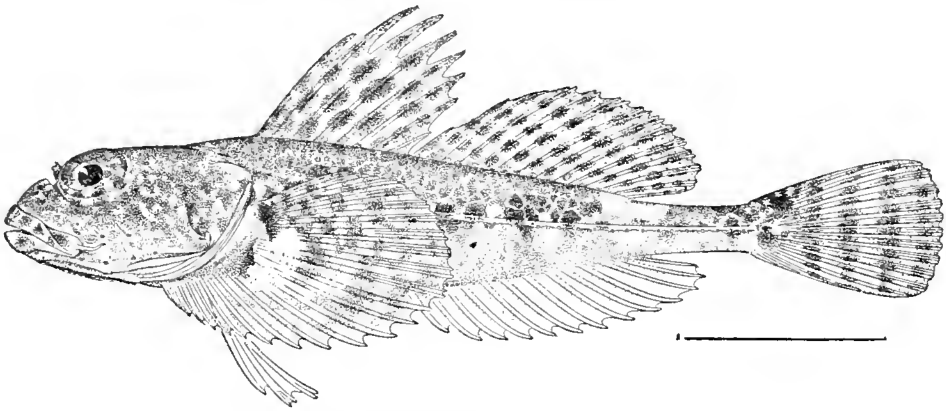


Fig. 6.—*Artediellus camchaticus*, new species. Type.

greatest depth of body 21; least depth of caudal peduncle 6; distance from tip of snout to hinder edge of gill membrane on median line 19; distance from tip of snout to front of anal 54; from last anal ray to last pore of lateral line 19.5; from last dorsal ray to last pore of lateral line 21.2; length of base of dorsal fin 48; of anal fin 30; longest pectoral ray 26; longest ventral ray 18; longest caudal ray 22.5.

Dorsal VIII, 14; anal 13; pectoral 24; ventrals I, 3. Lateral line with 33 pores, including the one at upper attachment of opercular membrane and the terminal pore at base of caudal.

In 25 cotypes, the formulæ are as follows:

	Dorsal spines.			Dorsal rays.			Anal rays.			Pectoral rays.			Pores in lateral line.			
Fin rays and pores	VII	VIII	IX	12	13	14	12	13	14	23	24	25	31	32	33	34
Number of specimens	3	21	1	1	14	10	7	15	3	5	28	17	2	21	19	8

The pectoral rays are in equal number on the two sides in 23 of the 25 specimens examined, the other 2 showing each a difference of 1 ray between the right and left sides. In 17 specimens, the pores of lateral line are in equal number on the 2 sides, while in 8 specimens, a difference of 1 or 2 is found.

Mouth smaller than in other species, but little oblique, the maxillary not reaching vertical from middle of orbit. Anterior series of premaxillary teeth slightly enlarged, as are also a few of the anterior mandibular teeth near symphysis; vomerine teeth in a single curved series; palatines with an elliptical patch. Upper preopercular spine long, only moderately hooked, placed low, its tip well below the level of upper pectoral ray, its posterior margin extending beyond edge of opercle; in the smallest of the cotypes, a slight prominence can be detected on inner side of hook, corresponding to the denticle in *Cottiusculus;* in one specimen, a strong straight spine is present on each preopercle above the hooked spine, its direction parallel with the preopercular margin, directed downwards and backwards; lower preopercular spine small, directed downwards and forwards, the margin of the bone above it with 2 rounded prominences.

Nasal spines small, often concealed beneath thick integument. Occipital region depressed, gently concave, without trace of ridges or prominences. Maxillary barbel simple, slender. Occipital filament minute; all others obsolete, or represented by inconspicuous tubercles; none present on preopercle or on sides of body above base of pectoral. Pores on mandible and preorbital comparatively small; anterior mandibular pair distinct and widely separated, though obliquely facing each other. A pair of pores on anterior part of interorbital space, a median pore on middle of space, and 1 behind orbits, the latter forming the apex of a ∧-shaped row on occiput. Gill membranes with a free margin mesially, the width variable, about three-fourths diameter of the pupil in the type.

Dorsal fins contiguous in males, usually well separated in females. Spinous dorsal elevated in males, the fin when declined reaching base of fourth or fifth ray of second dorsal; the membranes of the first 4 or 5 spines incised, but for less than half their height. Last anal ray slightly behind last dorsal ray, the anal fin longer than soft dorsal. Ventrals longer in males, but failing to reach the vent. The lower 14 or 15 pectoral rays simple, the branched rays the longest.

Color in spirits: Above brownish, everywhere with narrow sometimes reticulating lighter lines, and small light spots; 4 rather indistinct darker bars; 1 on occiput, 1 below middle of spinous dorsal, 1 below posterior half of soft dorsal, and 1 on caudal peduncle; the bars more or less invaded by lighter reticulating lines and small spots. Branchiostegal membranes dusky in males, pale in females, the lower parts generally colorless. Spinous dorsal in the male usually with large roundish brown spots, which are often irregular in size and arrangement, and may be so placed as to form lengthwise streaks; soft dorsal with 5 oblique dark bars; caudal with 3 or 4 dark crossbars, usually wider than the interspaces, often concave on distal side; anal unmarked; ventrals somewhat dusky in males, unmarked in females; pectorals with a large round white or yellowish white spot on basal portion of the middle rays, the upper rays with faint dusky crossbars, the lower blackish with white tips in males, colorless in females; in males, the ventrals and the lower part of pectorals are sometimes dusted sparsely with fine black specks. There is often a broad light V-shaped bar behind occiput, and sometimes in addition a broad light crossbar under end of soft dorsal. Sometimes in males these marks are bright white, as may be also an irregular spot on opercle and 1 or 2 on lateral line.

Numerous specimens were obtained at the following stations off Avatcha Bay, Kamchatka:

LIST OF STATIONS.

Stations	Latitude	Longitude	Depth.
	° ′ ″	° ′ ″	*Fathoms.*
4794	52 47 20 N.	158 44 30 E.	58–69
4795	52 46 50 N.	158 44 30 E.	69–48
4796	52 47 N.	158 43 E.	48

Artediellus miacanthus, new species. (Fig. 7.)

Type, a male specimen, 66 mm. long, from station 4795, off the east coast of Kamchatka (latitude 52° 46′ 50″ N.); depth 48 to 69 fathoms.

Resembling *Artediellus pacificus*, but differing in color, in the fewer pores of the lateral line, the obsolete nasal spines, and the simple maxillary barbel.

Measurements, in hundredths of total length, without caudal; Length of head 37; of snout 10; diameter of orbit 11; interorbital width 3; greatest width of head 24; greatest depth of body 23; least depth of caudal peduncle 7; distance from tip of snout to hinder edge of gill membrane on median line 22; length of base of dorsal 52; of anal 28; longest pectoral ray 30; longest ventral ray 16; longest caudal ray 26.

Dorsal VIII, 14; anal 11; pectoral 22 or 23; caudal 17 (9 rays forked); ventral I, 3. Lateral line with 19 or 20 pores, including the one at upper attachment of opercular membrane; large terminal pore at base of caudal fin. In 25 specimens, including the type and 4 cotypes, and 20 specimens from station 5025, off the east coast of Sakhalin Island (depth 52 fathoms), the fin and pore formulæ are as follows:

	Dorsal spines.		Dorsal rays.			Anal rays.		Pectoral rays.			Pores in lateral line.						
Fin rays and pores.........	VII	VIII	12	13	14	11	12	22	23	24	18	19	20	21	22	23	24
Number of specimens......	12	13	1	12	12	15	10	14	28	8	4	8	12	13	7	4	2

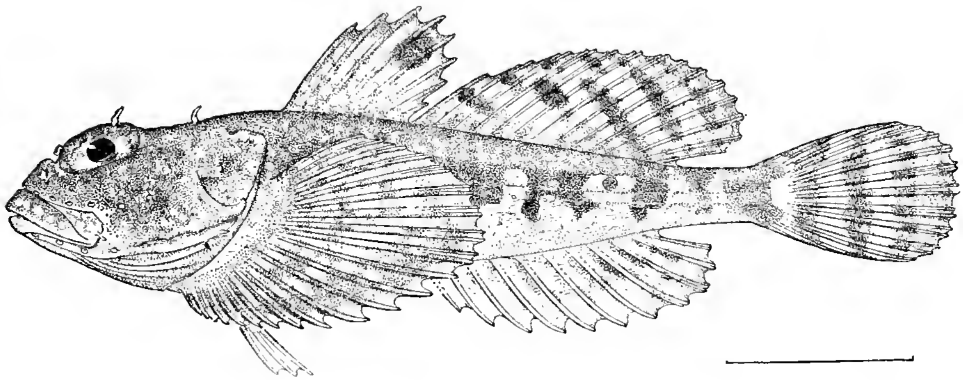


FIG. 7.—*Artediellus miacanthus*, new species. Type.

Lower jaw included, maxillary scarcely reaching margin of pupil; teeth on premaxillaries anteriorly in a wide band which tapers laterally and consists of a rather close-set posterior series curved downward and backward, a slightly enlarged anterior row, and scattered teeth between; mandibular band narrow, mostly of two somewhat irregular series, the posterior series enlarged; vomerine teeth in a single curved row; a small lenticular patch on anterior portion of palatine. Upper preopercular spine comparatively small and slender, strongly curved, the tip often directed upward and forward, on a level with upper pectoral ray; usually no trace of a denticle or cusp on inner edge of spine, but a minute prominence represents such cusp in a few individuals; the lower preopercular spine is strong, directed as usual downward and forward; the space between the upper and lower spines is without any developed spine or marked prominence. Nasal spine wholly obsolete, the nasal bone much reduced and bearing no denticle. Both nostrils bear short tubes. No occipital prominence. Barbels moderately developed, a supraocular pair and a pair at posterior edge of occiput; one or often two or three in a series at upper edge of pupil, and sometimes a few others scattered on upper part of eyeball; a simple barbel on maxillary, usually a small one on cheeks near base of upper preopercular spine, and a small one on opercle; no barbels on preorbital, on margin of preopercle, on nape, or along lateral line. Pores on head noticeably larger than in *Artediellus pacificus*, the anterior mandibular pair never coalescent, though this is always the case in *A. pacificus*. A pair of pores, opposite or nearly so, on anterior part of interorbital space; three in a cross series immediately behind the orbits, the middle one sometimes a little advanced. Gill membranes with a wide free posterior margin.

Dorsals usually closely contiguous in males, more widely separated in females; spinous dorsal less elevated in males than in other species, and the membrane less deeply incised, the first 4 spines only having the tips well exserted. All the dorsal rays and a few of the posterior anal rays are branched toward their tips; the upper 9 pectoral rays are branched and are longer than any of the simple rays, which are rapidly shortened downward and forward; ventral rays all simple.

Lateral line with a single series of small pores along its lower edge, terminating in a much larger pore at base of caudal.

Color in spirits: Grayish, coarsely mottled and blotched above with brownish, the occiput and sides of head often with darker blotches; the dark markings may be intensified under spinous dorsal, under soft dorsal, and on caudal peduncle to form faint bars; often a very few conspicuous irregular blotches below lateral line. Anal fin unmarked in males as in females; spinous dorsal with black margin and a roundish black blotch faintly ocellated with lighter on distal half of posterior rays; soft dorsal with about 5 oblique dark bars; caudal with 4 crossbars not so wide as the light ground; in males the upper part of pectoral light, with faint narrow crossbars, the distal part of all the simple rays black, with a narrow white margin; in females the upper part of pectorals more distinctly crossbarred, the lower portion white; ventrals white in females, slightly dusky in males.

The species is known from the type and 8 cotypes from stations 4794 and 4795 and from numerous specimens from station 5025, as below:

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′ ″	° ′ ″	*Fathoms.*
4794	52 47 20 N.	158 44 30 E.	58–69
4795	52 46 50 N.	158 44 30 E.	69–48
5025	48 43 30 N.	144 56 45 E.	52

Triglops beani Gilbert.

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′ ″	° ′ ″	*Fathoms.*
4794	52 47 20 N.	158 44 30 E.	58–69
4795	52 46 50 N.	158 44 30 E.	48–69
4796	52 47 N.	158 43 E.	48

These specimens, taken off Petropavlovsk, are somewhat duller in color than in specimens from eastern Bering Sea, and have the lateral black stripe of the male more interrupted and broken. The eye averages a trifle smaller and the caudal peduncle more slender. These differences would doubtless disappear in a large series of specimens.

Triglops scepticus Gilbert.

Known hitherto from the vicinity of Unalaska and the region south of the Alaska Peninsula; here recorded to the westward from near Attu and the Commander Islands.

LIST OF STATIONS.

Stations.	Latitude.	Longitude	Depth.
	° ′ ″	° ′ ″	*Fathoms.*
4784	52 55 40 N.	170 26 E.	135
4789	51 49 45 N.	167 12 30 E.	56
4791	54 36 15 N.	166 58 15 E.	72–76
4792	54 36 15 N.	166 57 15 E.	72

Triglops metopias, new species. (Fig. 8.)

Type 144 mm. long, from station 4777, Petrel Bank, Bering Sea; depth 52 fathoms.

Length of head 27 hundredths of total length to base of caudal; depth of body 16.5; diameter of eye 8; length of snout 7.6; interorbital width 4.2; length of maxillary 11.8; width of head 12; distance from tip of snout to edge of branchiostegal membrane 17.9; distance from tip of snout to front of dorsal 26.5; from front of spinous to front of soft dorsal 20; length of base of soft dorsal 43.5; distance from snout to base of ventrals 29; from axil of ventrals to anus 7.6; from anus to front of anal fin 8.2; length of anal base 42.7; length of caudal peduncle 10; longest pectoral ray 23; longest ventral ray 16; longest caudal ray 18.5; middle caudal ray 12.

Dorsal XI-26; anal 27; pectoral 20; ventral I, 3; scutes along lateral line 50. Of the 8 specimens in the collection, 1 has dorsal XI-25, anal 26; 2 have dorsal XI-26, anal 26; 3 have dorsal XI-26, anal 27; 1 has dorsal XI-27, anal 27; 1 has dorsal XI-28, anal 28.

Body heavy at the shoulders, not so elongate as in *Triglops forficata;* occiput broad, gently convex, the sides nearly vertical; interorbital space wide, shallowly concave, abruptly narrowed above middle of orbits as in *Triglops forficata* by the incurving orbital rims; anterior portion of orbital rim forming a convex prominence over front of orbit; a shallow groove behind nasal spines and one behind orbits; snout deeper, shorter, tapering more rapidly than in *Triglops jordani;* mouth slightly oblique, maxillary nearly reaching vertical from middle of pupil; jaws equal in front, sides

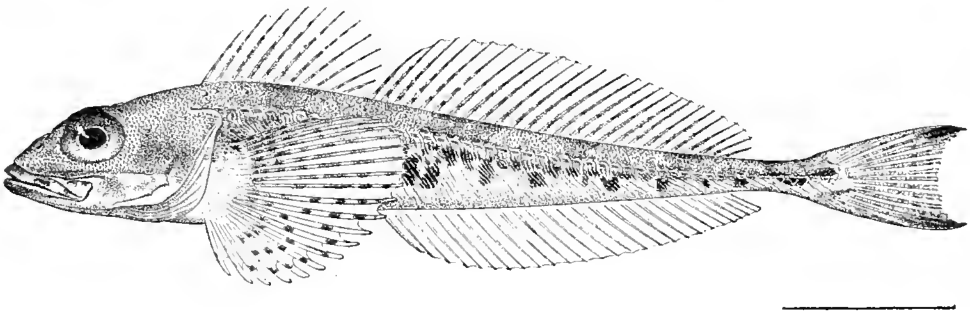


FIG. 8.—*Triglops metopias*, new species. Type.

of mandible included; teeth in narrow bands on jaws and vomer, none on palatines; nasal spines minute; preopercle with 4 small spines, the upper sharp, directed backward, with a slight upward curve, the second backward and downward, the third downward, the fourth forward; the second, third, and fourth are blunt and flattened, the third wider than the second, the fourth still wider, all with stronger ribs which may terminate at the margin in blunt prominences; gill membranes widely joined, free from the isthmus, the posterior margin V-shaped, deeply indented, leaving much of breast before pectorals uncovered.

Upper part of head and body covered with minute plates, each bearing a rosette of spinelets on its posterior margin. This prickly area extends on the body from base of dorsal to lateral line, and covers the head down to the suborbital ring and the suborbital stay, leaving only a narrow lower margin of these naked; maxillary, lower portion of cheeks and subopercle and lower side of head naked; a series of slightly enlarged dorsal scutes, as in *Triglops forficata*, not quite reaching the middle of the soft dorsal, 26 or 27 in number in the type; lateral folds numerous, very irregular, the primary folds ceasing and new ones beginning at any level; in addition to the principal fold descending from the posterior margin of each scute, there are two or sometimes three secondary folds intercalated; the lateral folds fail to reach base of anal fin and do not encircle caudal peduncle below; crossfolds on the breast reduced, only two present in the type, varying from 3 to 6 in co-types, one specimen wholly without folds; a series of pores on lower part of suborbital ring below the prickles; the usual series of pores on the mandible; vent slightly nearer base of inner ventral ray than front of anal.

Dorsals wholly separate; spines very slender, the fifth spine longest, 2.5 in head; pectoral reaching to fourth anal ray, its lower 7 or 8 rays thickened, the membranes incised, but not deeply; ventrals reaching nearly to front of anal, the spine and outer ray closely joined, thickened, bordered with a membranous flap; caudal forked, but not so deeply as in *Triglops forficata*, the middle rays about four-fifths the outer. Series of spinous scales on basal portion of upper pectoral and upper caudal rays; very fine scales on rays of dorsal fin.

Color above brownish gray, below white; breast and abdomen silvery; back crossed with 5 saddle-shaped dark bars which extend down to the lateral line, the first under the first to the ninth dorsal spines, the second under the fifth to the eleventh dorsal rays, the third and fourth equally spaced under the remainder of the soft dorsal, the fifth on the caudal peduncle; an irregular indistinct more or less wavy dark streak below the lateral line, and projecting from its lower margin a series of short dark bars or blotches, one or more of them often double, with their lower ends joined by a horizontal line, thus forming a dusky rectangle with a light central area, the spaces between these blotches silvery; a dark streak runs forward and downward from the base of the upper caudal lobes, a small blotch often at the base of the lower lobe; a dark blotch near the tips of the outer caudal rays (absent in females); a dusky bar extending downward and backward from the eye; a dusky streak on the lower half of the preorbital, extending to the edge of the snout; three blotches on premaxillary, the posterior one continued on maxillary; lower lip dusky; dorsals faintly crossbarred; distal half of anal rays dusky; ventrals pale; branchiostegals without dark bar.

This species differs from *Triglops forficata* in the shorter body, the smaller number of dorsal and anal rays, the less widely forked caudal and in a number of minor characters. From *Triglops jordani*, from Japan, it differs, among other details, in the presence of a distinct series of dorsal scutes, in the incised branchiostegal membranes (these having the posterior border a straight transverse line on *jordani*) and in the presence of wider naked strips along base of anal fin and on lower median line of caudal peduncle.

Seven specimens besides the type were taken at stations 4777 and 4779, Petrel Bank, Bering Sea; depth 52 to 54 fathoms.

Triglops forficata (Gilbert).

Two specimens were taken at station 4779, on Petrel Bank, and numerous specimens at stations 4788, 4789, and 4792, between Medni and Bering Islands, Bering Sea; depths, 54 to 72 fathoms.

The genus *Elanura*, based on the present species, was characterized by the widely forked caudal fin, the elongate body, and the lengthened dorsal and anal fins. Two species more recently discovered, *Elanura jordani* from Japan and *Triglops metopias* of this paper, are intermediate between *Elanura* and typical *Triglops*, for the body is scarcely more elongate than in *Triglops beani*, the dorsal and anal fins are but little lengthened, and the caudal fin, though usually sharply forked, is less widely cleft than in *forficata* and may be only deeply emarginate, as is usually the case in *T. beani*.

Closely related to the *Elanura* group is *Prionistius* (*macellus*), differing in no important respect save the absence of cross folds on the breast. But as these are reduced in *Triglops metopias*, and may even be wholly absent, *Prionistius* can not be retained. The row of dorsal scutes is subject to progressive reduction among these species, *forficata* and *metopias* having them distinct but very small, *jordani* having the series so reduced that the scutes are distinguished with difficulty (the species having been described as without scutes), and *macellus* lacking any trace of them. Different as are the extremes of the series, it seems impracticable to draw a line separating them, and the genus *Elanura* is here withdrawn.

In *Triglops forficata* the caudal fin is much more deeply forked in males than in females, the shape of the caudal in females being similar to the more deeply cleft fins in *jordani* and *macellus*. The cross folds on breast are subject to variation in *forficata*, being usually present in small number, frequently reduced to but one or two and occasionally wholly wanting.

Sternias xenostethus (Gilbert).

Knowledge of this species hitherto has been based on a single male specimen, the type, dredged north of Unalaska Island. It was found very abundant on Petrel Bank, where numerous specimens of both sexes were obtained. The following additional notes are here presented:

Measurements, in hundredths of length without caudal, of a male 90 mm. long: Length of head 27; length of snout 7.5; diameter of eye 8· interorbital width 2; distance from tip of snout to end of maxillary 11; depth of body at nape 16; least depth of caudal peduncle 3; length of pectoral 23; length of ventral 13.

In 10 specimens the fin rays are as follows:

	Dorsal spines.		Dorsal rays.			Anal rays.			Pectoral rays.	
Fin rays	X	XI	22	23	24	22	23	24	17	18
Number of specimens	1	9	1	6	3	1	7	2	13	7

In young individuals, 30 mm. long, the lateral folds equal in number the scutes of the lateral line; with increasing size additional folds are intercalated, one or two of these below each scute. The dense mass of prickly scales on sides of abdomen in males is formed of accessory folds, which arise on the level of the lower axillary region and extend irregularly downward and backward, sometimes reaching median line of belly. This structure is not present in females, which do not produce accessory folds in this region. In females the patch of prickly scales on breast is always reduced in size, and may rarely be almost or wholly wanting. In adult males the mandible protrudes strikingly beyond the premaxillaries and terminates in a strong symphyseal knob. In females the mandible is included within the upper jaw.

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′	° ′	*Fathoms.*
4777	52 11 N.	179 49 E.	43-52
4778	52 12 N.	179 52 E.	33-43
4779	52 11 N.	179 57 W.	54-56

Stelgistrum beringianum, new species. (Fig. 9.)

Type 44 mm. long, from station 4777, Petrel Bank, Aleutian Group; depth 43 to 52 fathoms.

Differing from *Stelgistrum stejnegeri* in having the snout, cheeks, and opercles naked instead of densely covered with minute scales, and in having the large plates of the dorsal band terminating at the end of the dorsal fin instead of reaching to or nearly to base of caudal; the smaller plates of the band terminate just before end of dorsal.

Measurements in hundredths of length without caudal fin: Length of head 39; length of snout 12, diameter of eye 11.5; length of maxillary 17; greatest depth of body 26; depth at front of anal 17; least depth of caudal peduncle 7.

Dorsal IX, 18; anal 12; pectoral 16; ventral I, 3. Plates in lateral line 38.

A minute simple filament on maxillary and a few on plates of lateral line; none others have been detected, perhaps because of the small size of the specimens. Maxillary short, not extending beyond middle of eye. A deep transverse groove behind nasal spines; interorbital gently concave; no marked ridges or prominences on occiput, its center a trifle depressed. Preopercular spines four, the upper short, simple, directed upward and backward, the lower downward and forward, the other two very short, directed downward and backward.

Body with four very conspicuous black bars; one from below middle of spinous dorsal downward and forward to axil of pectorals, tapering rapidly, and ending behind upper pectoral rays; one under anterior third of soft dorsal, tapering downward and slightly forward to lateral line, thence expanding forward and downward in a large irregular blotch; one under posterior third of soft dorsal divided below lateral line into two or three diverging branches; one on back of caudal peduncle, with two or more diverging branches below lateral line, the posterior of which nearly or quite encircles tail; head dusky anteriorly, without defined markings; under side of head punctate with black, sometimes with faint bars on lips and concentrations of the black dots about the sensory pores. Soft dorsal and caudal very faintly and finely barred, the bars sometimes irregular and ill defined; spinous dorsal irregularly blotched with black; a black blotch on base of pectorals, widest below; terminal half of pectorals finely barred, a basal portion unmarked; the anal may be unmarked, or the membranes may be blotched with black.

A single cotype, from the same station as the type, is apparently a male, with darker coloration, including irregular black markings on the anal fin. It has also a broad cleft cirrus above posterior part of orbit, not distinguishable in the type.

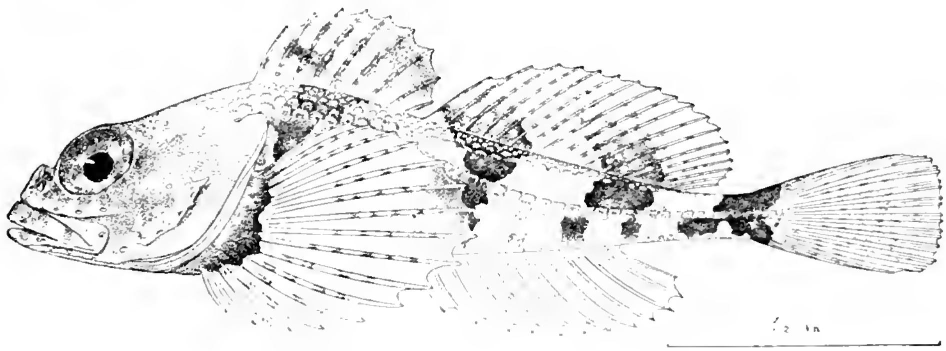


FIG. 9.—*Stelgistrum beringianum*, new species. Type.

Hemilepidotus hemilepidotus (Tilesius).

In this species the lower band of scales is closely approximated to the lateral line throughout its course, the interspace where widest not exceeding the width of one scale. In other species the interspace widens rapidly anteriorly and may equal the width of half the band.

In 21 specimens fin rays are as follows, the terminal split ray of dorsal and anal being counted as one:

	Dorsal spines	Dorsal rays.			Anal rays.			Pectoral rays.		
Fin rays. .	III, VIII	18	19	20	14	15	16	15	16	17
Number of specimens	21	3	15	3	3	15	3	6	33	3

Not taken in the dredge, but found abundantly in shallow water at Unalaska, Agattu, Attu, and Medni Islands. Young were found in tide pools.

Hemilepidotus jordani Bean.

In 29 specimens the fin rays vary as follows:

	Dorsal spines		Dorsal rays.		Anal rays.			Pectoral.		
Fin rays. . .	III, VII	III, VIII	20	21	16	17	18	17	18	19
Number of specimens	1	28	8	21	8	20	1	5	48	5

The last split ray of dorsal and anal are counted each as a single ray.

The species is abundant throughout eastern Bering Sea, extending as far west as the Commander Islands. It is taken in shallow water with hook and line and has been dredged to a depth of 54 fathoms.

List of Stations.

Stations.	Latitude.	Longitude.	Depth.
	° ′	° ′	*Fathoms.*
4777	52 11 N.	179 49 E.	43-52
4778	52 12 N.	179 52 E.	33-43
4779	52 11 N.	179 57 W.	54-56

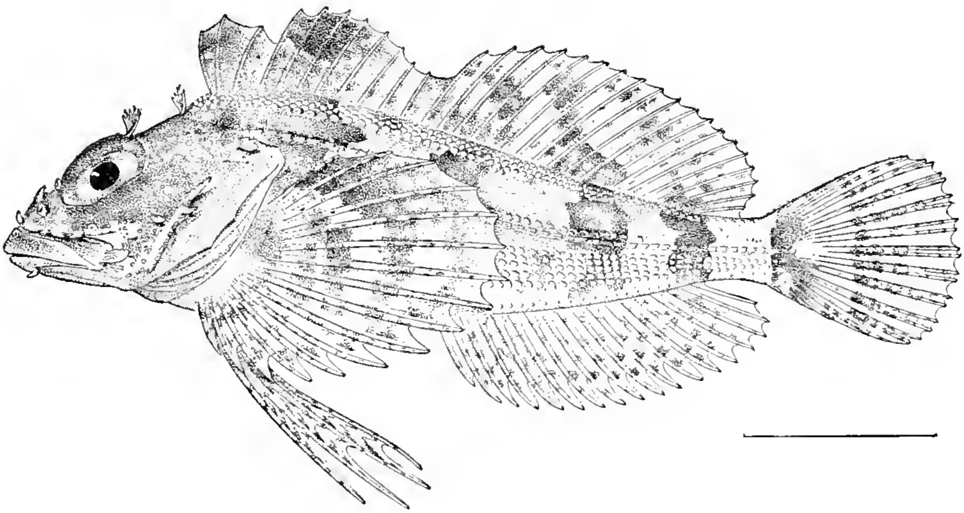


Fig. 10.—*Hemilepidotus zapus*, new species. Type.

Hemilepidotus zapus, new species. (Fig. 10 and 10a.)

Type, a male, 127 mm. long, from station 4782, near Attu Island; depth 57 to 59 fathoms.

Closely related to *Hemilepidotus gilberti* from Japan, agreeing with that species in the ventral fins of the male which are greatly produced and with exserted rays bearing series of elevated papillæ on the inferior surface. It differs from *Hemilepidotus gilberti* in the narrower interorbital and in the reduction in the number of pores in the lateral line and in the rays of dorsal, anal, and pectoral fins.

Measurements in hundredths of length without caudal: Length of head 39; length of snout 11.5; diameter of orbit 12; interorbital width 4; distance from tip of snout to end of maxillary 18; greatest depth of body 30; least depth of caudal peduncle 7.5; length of second dorsal spine 10; third spine 8: membrane at anterior base of fourth spine 4; fourth spine 12; highest (fifth and sixth) spines 13; last spine 7; highest dorsal ray 17; caudal fin 23; ventrals 40; pectorals 34.

Dorsal III, VIII, 20; anal 17; pectoral 16; pores in lateral line (including those on base of caudal fin) 51 and 53. The last ray of dorsal and anal fins is cleft to the base, the halves sometimes separated at base. They are here always enumerated as one ray. The following table gives variation in lateral line pores and fin rays in 15 specimens of the species:

	Dorsal spines.		Dorsal rays.		Anal rays.		Pectoral rays		Pores in lateral line									
Fin rays and pores..........	III. VII	III. VIII	20	21	16	17	16	17	48	49	50	51	53	54	55	56	57	58
Number of specimens ...	4	11	7	8	1	14	28	2	1	2	3	7	4	5	3	2	2	1

Interorbital space narrow, less than width of pupil, very shallowly concave, with an inconspicuous pair of longitudinal ridges. Occiput shallowly concave, with rather coarse ridges radiating from a point behind the orbital tentacle; a few of the ridges may meet mesially, others are directed forward on posterior part of interorbital space. The head undoubtedly becomes much rougher with increasing age, but the roughened area is apparently confined to the occiput and the postocular region above the opercles.

A pair of broad cutaneous flaps with narrow base and deeply cleft margin on posterior edge of occiput; a second similar pair on upper posterior rim of orbit, and a third near upper angle of opercle; a slender pair sometimes present near median line between the pair last mentioned; a slender pair on nasal spines twice or thrice cleft nearly to base; a short pair in front of nasal spines immediately behind upper lip; a line of five short tentacles along margin of preorbital and posteriorly on cheek, a sixth broader one in advance of the interspace between second and third preopercular spine; a broad flap near tip of maxillary, a minute tubercle above the flap; median pair of mandibular pores with a short tentacle on outer side of each; a minute tentacle near middle of lateral margin of lower lip; a few scattered tentacles along plates of lateral line. Top and sides of head with very numerous minute pores, those on suborbital region arranged in three longitudinal series. Posterior nostrils in a very short tube, the anterior tube longer. Preopercular spines shorter than in *Hemilepidotus gilberti;* two very short, spinous points developed on margin of subopercle. Upper band of plates four rows deep anteriorly diminished to two rows on each side of back of caudal peduncle, the band composed of 68 transverse rows. An accessory series of plates above a portion of the lateral line. Lower band of plates anteriorly with six series, posteriorly with two; on caudal peduncle it is separated from plates of lateral line by about half the width of a plate, but this distance increases anteriorly to the width of two plates or more; in advance of the definite band, which ceases at vertical of vent, the anterior portion of sides below the curve of the lateral line is covered with widely spaced plates more or less definitely arranged in oblique series; behind the upper portion of the pectoral a dense axillary patch; a single series of minute plates above base of anal fin, the two series meeting in a patch about the vent and sending a narrow band forward on middle of abdomen.

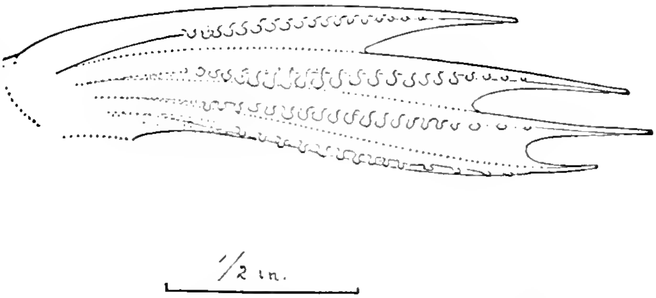


FIG. 10a.—*Hemilepidotus zapus*, ventral fin, anterior face

Dorsal spines rather low and strong, the vertical fins in general not elevated. The ventral fins in the male extend beyond tips of pectorals, with tips exserted for about one-third their length; on its lower face each ray bears a single dense series of stalked, club-shaped papillæ.

Color in life: Entire dorsal region of head and trunk light reddish or pinkish, crossed by four dark bars, which are usually much narrower than the interspaces, and are continued upward on the dorsal, fins, forming a conspicuous black blotch on the spinous dorsal; belly and lower side of head immaculate in both sexes; pectorals with indistinctly marked dark bars, one of which is intensified to form a black blotch on upper rays; axil of pectorals in males white, outlined by a curved black bar above and parallel with the base of the fin, and a broader horizontal black blotch below; two oblique broken black lines across middle of axil; ventral rays in male unspotted, the membranes marked with numerous parallel irregular, V-shaped black lines; caudal with a broad dark bar at base, and one or more irregular bars posteriorly, the latter frequently broken up into finer markings.

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′	° ′	*Fms.*
4778	52 12 N.	179 52 E.	33-43
4779	52 11 N.	179 57 W.	54-56
4782	52 55 N.	173 27 E.	57-59

Specimens from stations 4778 and 4779 differ from the type in the somewhat smaller eye and the noticeably wider, deeper interorbital space. But as they agree in all other respects, we have considered them as cotypes, as well as the second specimen from the type locality.

The figure of *Hemilepidotus gilberti* (Proceedings U. S. National Museum, vol. XXVII, 1904, p. 255) is from the cotype, and not the type. Two additional specimens from Hakodate are in the Stanford University collection. One of these is a male with greatly produced ventral fins. As in the cotype, the ventral rays are conspicuously barred with black, while the membranes are mostly unmarked, and the abdomen is white, with a few faint dusky spots; in females the abdomen is unmarked. In the original description of *Hemilepidotus gilberti* the last divided ray in dorsal and anal has been counted as two rays. In the three specimens before us two have 21 rays in dorsal, one has 22 rays; two have 18 rays in the anal, one has 17; all have 17 pectoral rays. The pores in lateral line range from 55 to 65. The interorbital is broad and shallow, its width about two-thirds the diameter of the large eye. In neither *Hemilepidotus hemilepidotus* nor *H. jordani* are the ventral fins produced and papillated in the male.

Enophrys claviger (Cuvier & Valenciennes).

Three specimens were secured, ranging from 48 to 57 mm. long, with fin rays as follows: Dorsal, VIII-14; anal, 11 or 12; pectoral, normally 18, occasionally 17. It will be noted that the original type and the five additional specimens subsequently reported on (including the three here mentioned) have been of approximately equal size. No specimen of *Ceratocottus diceraus* as small as these has yet been encountered, but a specimen of *Ceratocottus diceraus* 114 mm. long has developed all the characters of the adult. While it is highly probable that *Enophrys claviger* is a distinct species, it is very desirable that the young of *Ceratocottus diceraus* be obtained for comparison.

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′	° ′	*Fms.*
4777	52 11 N.	179 49 E.	43-52
4778	52 12 N.	179 52 E.	33-43

Ceratocottus diceraus (Pallas).

Two specimens, 114 and 155 mm. long were taken with the seine in Avatcha Bay, Kamchatka. This is the type locality for the species, and all specimens which have been described from here lack the bony cross-ridge at posterior border of occiput, which is so strikingly developed in specimens from eastern Bering Sea. This may prove a basis for specific division, but we do not venture upon it until more material is available.

Ceratocottus lucasi has been recently identified as the young of *diceraus* by Evermann and Goldsborough (Bulletin Bureau of Fisheries, vol. XXVI, 1907, p. 305), but we are unable to accept this decision.

The type of *lucasi* is 135 mm. long, hence larger than the smaller specimen of *diceraus* here reported on, and but 20 mm. smaller than the larger one, yet the distinctive features of *lucasi* are maintained.

The preopercular spine in *lucasi* is much shorter and much more slender, and bears but 2 or 3 large distant hooked teeth; the supraorbital rim is sharp and thin, not massive and heavy, as in *diceraus*, and the interorbital space is narrower and more shallowly concave (not deeper, as stated in the original description); the occipital ridges are lower, and the posterior (nuchal) processes shorter and lower; the anterior process of the preorbital entirely conceals and extends beyond the portion of the maxillary over which it projects, and bears two very short spinous points totally unlike the pair of strong spines present in *diceraus;* in advance of the two spinous points the preorbital develops a rounded lobe, which also completely conceals a portion of the maxillary and has no representative in *diceraus*, although it is present in the Japanese species *Ceratocottus namiyei*. The fin rays of the type and cotype of *lucasi* are difficult to determine, because of the mutilated condition of the specimens, and have been incorrectly given; in both specimens they are as follows: Dorsal, VIII–14; anal, 12; pectoral, 18 on each side.

The following comparative measurements in hundredths of length without caudal will indicate some of the differences between the species:

	C. diceraus, Kamchatka.	C. diceraus, Kamchatka.	C. diceraus, Kamchatka (48859 U.S.N.M.).	C. lucasi, type.	C. lucasi, cotype.
Length of preopercular spine	20	21	21	15	14
Length of nuchal process	6.2	6	6.5	4.5	4
Distance from eye to tip nuchal process	21	22	21	19	17.5
Width interorbital space	8	7.1	7.5	5.5	5
Length in millimeters to base caudal	126	93	97	121	110

Through the courtesy of the authorities of the United States National Museum, we have had the privilege of reexamining the cotype of *C. lucasi* (no. 48235, U. S. National Museum) and also the specimen from Avatcha Bay, Kamchatka, which was identified by Jordan and Gilbert with *C. lucasi*, and from which the color description was taken (Fishes of Bering Sea, p. 459). The cotype agrees with the type in all the characters above given by which the species may be distinguished. The preopercular spine is short and bears distally on its inner edge three large hooked spines, of nearly equal size and curved like the hooked spines of brambles; no smaller spines are interspersed, nor are there any on the basal two-fifths of the spine. The interorbital area is narrow and shallowly concave, the orbital rims not massive. A very wide process of the preorbital conceals the proximal portion of the maxillary, its anterior free margin a rounded lobe, its posterior portion bearing a pair of short triangular projections, corresponding to the two very pronounced preorbital spines in *C. diceraus*. The specimen from Kamchatka (no. 48859, U. S. National Museum), which has been heretofore associated with *C. lucasi*, differs widely from that species and is in fact a typical young *diceraus*. Its measurements are given in the third column of the above table.

Myoxocephalus polyacanthocephalus (Pallas).

Unalaska, Atka, Agattu, and Attu Islands.

Myoxocephalus jaok (Cuvier & Valenciennes).

Avatcha Bay, Kamchatka.

Myoxocephalus stelleri Tilesius.

Medni and Bering Islands, and Avatcha Bay, Kamchatka.

Myoxocephalus niger (Bean).

Agattu, Attu, Medni, and Bering Islands.

Myoxocephalus batrachoides, new species. (Fig. 11.)

Type 66 cm. long, from station 4798, latitude 51° 37′ N., longitude 156° 21′ E.; on the codfish banks west of southern part of Kamchatka; depth, 25 fathoms.

Measurements in hundredths of length to base of caudal: Head 41; depth 17; least depth caudal peduncle 6; snout 11.5; longitudinal diameter orbit 7; exposed part of eye 4.5; maxillary 22; interorbital width 6.7; distance between occipital tubercles 6; width of head 32; length of upper preopercular spine 4; highest dorsal spine 11; distance between dorsals 3; longest dorsal ray 17; longest anal ray 14; length of caudal 18; ventrals 16; pectorals 24.

Dorsal X–15; anal 12; pectoral 18; lateral line 41.

Head and body greatly depressed, the head broad, the interorbital space wide, shallowly concave, with a very low median ridge anteriorly; maxillary reaching vertical from posterior border of exposed part of eye; teeth small, in moderate bands on jaws and vomer; nasal spines short, concealed; posterior nostril in a short papilla-like tube, the anterior tube thinner and slightly higher; no filaments on head or body; a strong supraorbital tubercle; occipital ridges low, converging in a curve, terminating posteriorly in an inconspicuous narrow ridge which does not bear a spine; preopercular spines very short, the upper directed slightly upward, not nearly reaching opercular margin; second spine about one-half length of upper, the third a low concealed tubercle, the fourth directed downward and forward as

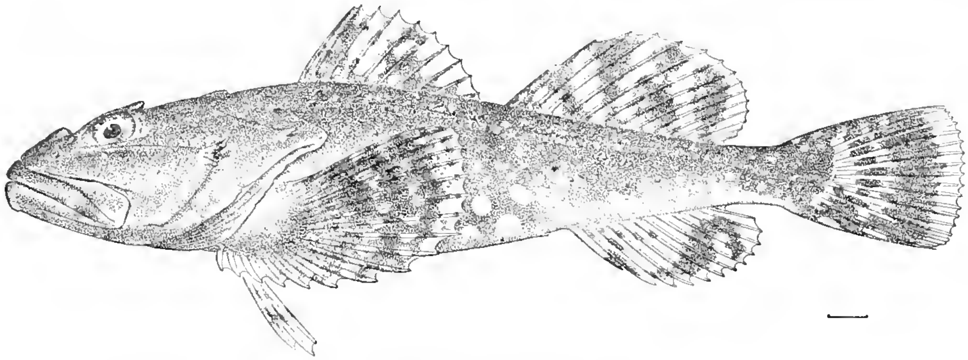


FIG. 11.—*Myoxocephalus batrachoides*, new species. Type.

usual; posttemporal spine strong; opercular spine well developed; a short strong spine on lower angle of subopercle, directed downward and backward; top of head, nape, snout, cheeks, and upper part of opercles with numerous wart-like projections, in which are usually found minute pores of the sensory system of canals; the warts on occiput, nape, and parietal region are the largest; a similar series of warts on sides of trunk, most numerous under second dorsal.

First 4 dorsal spines of nearly equal height, the fin thence rapidly lowering, the last spine short, about one-seventh the length of the first spine; when the fin is depressed, none of the preceding spines reach the tip of the last spine; dorsals well separated, the distance from tip of last spine to base of first ray equaling nearly twice the length of the last ray. Lateral line with a series of concealed plates, opening by a small pore above and below each plate. No spinous plates on body, but a number of scattered long, narrow, spine-like scales concealed in the skin.

Color brownish above, mottled with light olive, traces of a dark bar under spinous dorsal, two under soft dorsal, and one at base of tail; under parts white; a number of white round spots as large as pupil on sides behind base of pectorals, those forward near the axillary region smaller; spinous dorsal with two very irregular dark bars; soft dorsal with four broad oblique bars alternating with narrower white bars, trace of a small fifth bar at base of anterior rays; caudal with a very conspicuous broad dark bar on distal half with a narrower white bar behind it, the basal half of fin largely white, with an incomplete dark bar across it; pectoral black above, axil white, two irregular series of round white spots on the rays forming bars, and a submarginal series of even more irregular white blotches; lower pectoral rays white; ventrals white; anal largely white, with a conspicuous wide curved or V-shaped black bar on posterior half of fin.

Only the type taken.

This species is not to be confounded with any other. In coloration, in the character of the spine-like scales, the short preopercular spine, the wide interspace between dorsals, the presence of supraocular tubercles, the absence of filaments and the fin rays, it is unlike other species.

Myoxocephalus parvulus, new species. (Fig. 12.)

Type 65 mm. long, from tide pool at Preobrazhenskoi Bay, Medni Island.

Measurements in hundredths of length to base of caudal: Head 36; snout 8.8; diameter of eye 7; interorbital width 4; maxillary 14; width of head 27; distance between posterior ends of occipital ridges 5; depth of body 25; least depth of caudal peduncle 5.8; longest dorsal spine 13; longest dorsal ray 16; length of caudal 23; length of ventrals 25; of pectorals 34.

Dorsal IX–14; anal 12; pectoral 17; 35 pairs of pores in lateral line to base of caudal, an additional pair on base of caudal, and an unpaired terminal pore.

A blunt tubercle bearing a small papilla at upper posterior border of orbit, with an indistinct smaller tubercle before it on supraocular ridge; interorbital space narrow, rather deeply grooved, the sides of

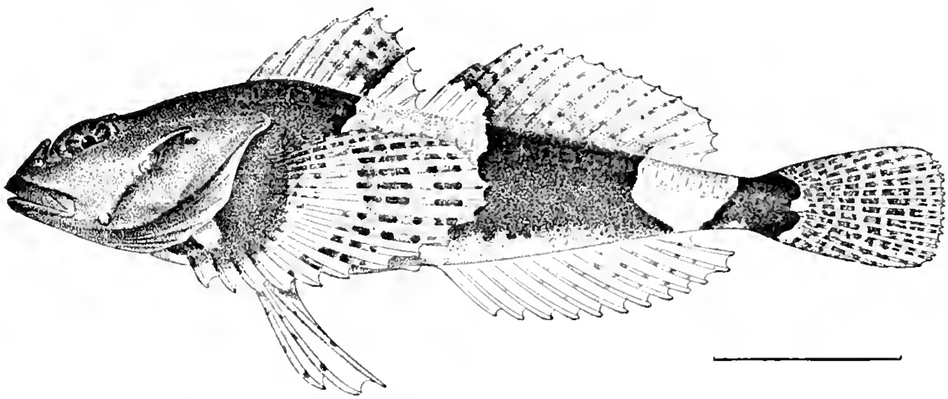


Fig. 12.—*Myoxocephalus parvulus*, new species. Type.

groove forming on median line a sharp angle, which lies between a pair of concealed low ridges; occipital region depressed, especially anteriorly, where it forms a pit-like concavity, the floor of which is below the bottom of the interorbital groove; the occipital ridges converge backward, each terminating in a small tubercle bearing a low papilla; the ridge is frequently interrupted by depressions, thus forming two or three tubercles; no filaments on head, but the maxillary with a low papilla; nasal spines weak, but not concealed; anterior nostril tube longer than the posterior; maxillary extending nearly to vertical from posterior border of pupil; teeth on vomer in a single irregular row, the bands on jaws narrow, the inner series slightly enlarged. Upper preopercular spine short, directed obliquely upward and gently curved, reaching half way from its base to tip of opercular spine; second spine about one-half the length of the first, inclined downward and backward; third spine represented by a small concealed tubercle; the fourth directed downward and forward; a short sharp spine on lower angle of subopercle, and a shorter, blunter one on adjacent angle of interopercle; post-temporal and humeral spines blunt.

Dorsals contiguous; head and body without spines, tubercles, or warts; lateral line opening in two series of pores, one above the other below the plates.

Color dark bluish above, white below, the back crossed by two broad conspicuous bands of gray; the first band includes the last three spines and the first three rays of the dorsals and extends first vertically downward then forward and downward until it joins the white of the abdomen; the second includes the last two rays of the dorsal and about half the caudal peduncle and extends downward in a broad V-shaped blotch, the apex of which nearly reaches base of anal; the ground color is intensified along the margins of the bars which are often narrowly white; a conspicuous small, narrow, white blotch at base of caudal; head unmarked, nearly as dark below as above; dorsals dusky, the rays with faint alternating lighter and darker bars; caudal irregularly barred with light and dark; anterior base of pectoral and prepectoral area blackish, the latter in its lower part with a horizontal whitish blotch, which is concealed by the opercle; distal half of pectoral barred with light and dark, a broad white bar between these and the dark basal area; axil of pectorals dusky, with two conspicuous white spots, an upper small round spot about the size of pupil at base of second, third, and fourth pectoral rays, and a larger, less intensely white, and more nearly quadrate spot below the middle of the axil; ventrals white with a few dark spots, a pair of which near tips of fins may be well marked; anal white with faint dark crossbars.

Most nearly allied to *Myoxocephalus* (*Porocottus*) *sellaris* and *quadratus*, differing in the color, the smaller size of eye, the absence of prickles behind the pectoral and of pores above the anal fin, and in the greater number of dorsal spines.

Two cotypes were taken in tide pools at Nikolski, Bering Island. The fin rays are the same as in the type. In one specimen, the dark ground color is mottled with lighter, the lower side of head is much lighter than in the type, there are light roundish spots included in the dark ground color above base of anal fin and some additional light markings in axil of pectorals.

Myoxocephalus mednius Bean.

Taken at Agattu, Attu, Medni, and Bering Island.

This species is closely related to *Myoxocephalus* (*Porocottus*) *bradfordi;* it averages one less spine in the first dorsal and one more ray in the second dorsal and anal, the light spots behind the pectoral in the male are more numerous and do not tend to coalesce as in *M. bradfordi*, and the multifid tentacles on the head are much shorter and less numerous.

	M. mednius.				M. bradfordi.			
Number of dorsal spines	7	8	9	......	8	9	10	.....
Number of specimens	1	16	5	......	1	18	3	.
Number of dorsal rays	16	17	18	19	14	15	16	17
Number of specimens	4	14	3	1	1	7	12	2
Number of anal rays	12	13	14	......	11	12	13	......
Number of specimens	8	12	2	......	2	17	3	......

Megalocottus platycephalus (Pallas).

Avatcha Bay, Kamchatka.

This species differs from *M. laticeps* from eastern Bering Sea in the narrower deeper interorbital space, the higher occipital ridges which converge backwards much less than in *laticeps*, the more prominent tubercles, the obsolescence of filaments, the much larger plates on sides, and the darker coloration.

The accompanying table gives measurements in hundredths of length without caudal in both species:

	M. platycephalus, Kamchatka.	M laticeps, Nushagak, Alaska.
Length of head	37	37
Length of snout	9	9
Interorbital width	7	8.5
Distance between anterior ends of occipital ridges	7	9
Distance between posterior ends of occipital ridges	5	5
Diameter of eye	6	6
Length of maxillary	16	18
Greatest width of head	27	30
Depth of caudal peduncle	5	6

Zesticelus profundorum (Gilbert).

One specimen from station 4781, between Petrel Bank and Agattu Island; depth, 482 fathoms.

Dorsal V–12; anal 10; pectoral 20; pores in lateral line 17. Upper preopercular spine reaching margin of opercular flap. Lateral line with two series of pores anteriorly. In this specimen there are 3 ventral rays on one side, 2 on the other.

Malacocottus zonurus Bean.

In a specimen 12 cm. long, the stellate granulations are distributed over the top and sides of the head and extend in a band along the back and well up on the soft dorsal.

LIST OF STATIONS.

Stations.	Latitude	Longitude	Depth
	° ′ ″	° ′	*Fathoms.*
4781	52 14 30 N	174 13 E	482
4784	52 55 40 N	173 26 E	135

This extends the known range of the species to Attu Island, the westernmost of the Aleutian chain.

Gymnocanthus pistilliger (Pallas).

Avatcha Bay, Kamchatka.

As has been previously noted (Jordan and Gilbert, Fishes of Bering Sea, Report of Fur-Seal Investigations, pt. 3, 1899, p. 460), typical representatives of this species differ from those obtained from eastern Bering Sea in several respects. The top of the head is more largely covered with rough plates, which always invest the occiput and usually cover a part of the interorbital space; in many specimens from eastern Bering Sea the top of head is bare, or with only two or three scattered plates; in several the occiput is largely covered, but in only one are there any plates on interorbital space.

Among the specimens recently acquired from Kamchatka is one adult male, in which the ventral rays are greatly produced, though less so than in eastern specimens, and the spinous dorsal and the abdomen have much less dark pigment in the areas around the spots.

The fin rays of the new Kamchatkan material are as follows:

	Dorsal spines		Dorsal rays.		Anal rays		Pectoral rays	
Fin rays	X	XI	14	15	16	17	18	19
							18	19
Number of specimens	11	1	5	7	3	9	5	7

Lateral line with 39 pores to base of caudal.

Both lots of Kamchatkan specimens have more frequently 17 anal rays, while 16 is the most common in eastern specimens. We do not venture at present to distinguish these two forms.

Gymnocanthus detrisus, new species. (Fig. 13.)

Type, a female 175 mm. long, from station 4798, off the west coast of Kamchatka; depth 25 fathoms.

Measurements in hundredths of total length without caudal: Head 36; diameter of orbit 9; least interorbital width 5; width across supraorbital tubercles 9; distance between anterior ends of occipital ridges 7; between posterior ends 6; length of snout 10; of maxillary 14; length of upper preopercular spine 7; greatest width of head 21; depth of body 20; depth of caudal peduncle 4.5; longest dorsal spine 16; longest dorsal ray 15; interspace between dorsals from tip of last spine to base of first ray 1; longest caudal ray 19.5; longest pectoral ray 26; longest ventral ray 18.

Dorsal XI–17; anal 18; pectoral 20. Pores in lateral line 42 to base of caudal, 2 or 3 additional pores beyond this point.

Body about as deep as wide at the shoulders; interorbital space very broad, shallowly and evenly concave, curved equally and continuously with the portion of the occiput within the occipital ridges; a small blunt tubercle on posterior border of supraorbital ridge, a sharp constriction behind it; occipital ridges well marked, more or less broken, converging backward to the little marked occipital tubercles; nasal spines large and pungent, both nostrils in short tubes, the anterior the longest. No filaments or papillæ on head.

Maxillary reaching a vertical slightly behind middle of eye; teeth cardiform, anteriorly in broad bands in both jaws, posteriorly narrowed; the teeth are directed obliquely backward and are depressible in that direction; the lateral teeth in the mandible a little enlarged.

Preopercular spine slender, the tip extending nearly to opercular margin, slightly forked; two strong curved cusps above, the anterior much the larger; the 3 lower preopercular spines short, nearly equal in length, the upper one slightly curved, directed downward, the middle one vertically downward, the lower downward and forward; humeral spine short.

Rough plates cover the nape as far back as the dorsal fin and extend forward over interorbital space and to base of nasal spines; a line of plates extends vertically downward along posterior orbital

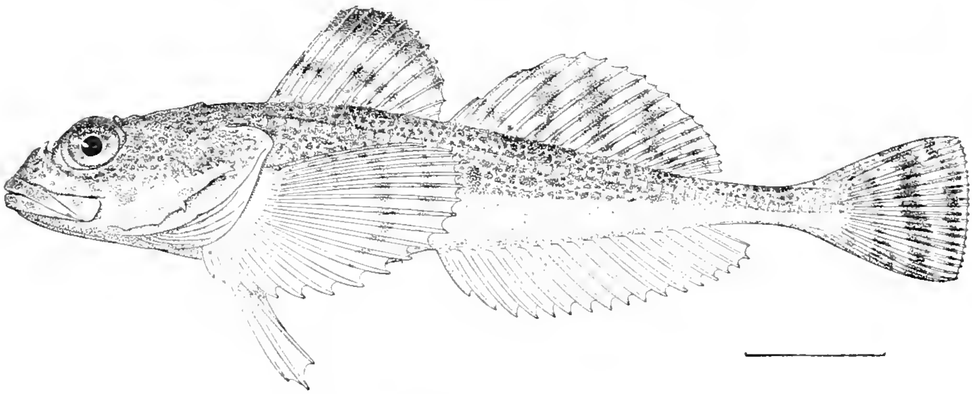


FIG. 13.—*Gymnocanthus detrisus*, new species. Type.

border to suborbital stay, and another along preopercular margin nearly to base of upper spine; the opercular rib is largely plated; a few scattered rough plates behind pectoral, extending along sides two-thirds distance to tip of fin.

Dorsals separate; fourth spine longest; pectoral reaching third anal ray; ventrals not reaching vent; caudal convex, truncate when widely spread.

Color brownish above, with very fine vermiculating lines of olive; lower parts white, with more or less silvery luster; very faint crossbars on back, one at origin and one at middle of spinous dorsal, one between dorsals, two under base of soft dorsal, and one on caudal peduncle; these bars are formed by the darker markings becoming coarser and more intense, but the lighter vermiculating lines are present; front of upper lip colored like top of head; a dark bar across maxillary near its middle; a dusky bar across lower lip on each side symphysis; a broad dark brown margin on spinous dorsal and an irregular dark bar on middle of fin parallel with the margin; 5 bars of reddish brown on soft dorsal running downward and backward; 3 reddish brown bars on the caudal, running a little obliquely downward and backward; 2 broad bars on pectoral, with sometimes a faint third bar nearer base; ventrals and anal plain.

The species is most closely related to *G. herzensteini* Jordan and Starks, and differs in the much wider interorbital, the larger eye, the smaller mouth, the longer preopercular spine, the coloration, and in numerous other details.

In four cotypes from the same station the dorsal has in each case 10 spines and either 16 or 17 rays, anal 18 in each case, pectoral 20. The interorbital space varies in width and in depth of curve, its width in the four cotypes being, respectively, 3.5, 4.2, 4.5, and 5 hundredths of the length.

Sigmistes caulias Rutter.

Three specimens of this little known and apparently rare species were obtained in the tide pools of Agattu Island. It had been known hitherto only from the type locality, Karluk, Kodiak Island.

Two of our specimens are very young, the smallest but 20 mm. long; the adult is 60 mm. long.

Oxycottus acuticeps (Gilbert).

Union Bay, Vancouver Island, and Unalaska, Atka, Agattu, and Attu Islands; found very abundant in the tide pools at the north.

This species differs from all its relatives in the structure of the anal papilla of the male, which instead of tapering uniformly to a slender tip, maintains its width throughout and bears at its end a pair of short lateral horns anteriorly and a median horn behind them. This should serve as generic distinction between *acuticeps* (the type of *Oxycottus*) and *embryum*, which has been associated with it. In the structure of the anal papilla, *embryum* agrees with the species of *Blennicottus*, and is placed in that genus. It differs widely, however, in the physiognomy, the snout and mouth parts, and may merit further separation.

Blennicottus embryum (Jordan & Starks).

Abundant in the tide pools at Unalaska and Attu Islands. Two of our specimens have 16, and one 17 dorsal rays, two have 11 anal rays, and one has 10 dorsal spines.

Blepsias cirrhosus (Pallas).

Unalaska and Attu Islands and Avatcha Bay, Kamchatka.

Numerous young from Kamchatka, 25 to 30 mm. in length. The body is conspicuously banded with blackish, the bands frequently united along middle of sides and occasionally in a line just above base of anal; the bands run out on the dorsal fins, where they can usually be distinguished in adults. The trunk is naked except for 5 distinct lengthwise series of prickles; a double series along lateral line; a series near base of dorsal, terminating under soft dorsal near its posterior end; a similar series above base of anal, which broadens anteriorly at sides of vent; two series on posterior half of trunk midway between lateral line and the series already mentioned above and below it. The breast may be naked or covered with prickles at this age. The barbels on snout and mandible very short.

Nautichthys pribilovius (Jordan & Gilbert).

Dorsal VIII or IX-23 to 26, usually with 24 or 25 rays; anal 17 to 19; pectoral 15 or 16. Cirri present on edge of preopercle and on suborbital stay; a pair of short thick tentacles near tip of snout, and 3 somewhat larger on margin of preorbital; in addition to the broad orbital flap are several delicate filaments on upper posterior portion of eye; a very long slender cirrus surmounts the supraorbital tubercle; similar but shorter ones on occipital crests.

The area immediately behind the pectorals is smooth and without prickles, as in *Nautichthys oculofasciatus;* prickles invest the rays of all fins except anal and ventrals and may sometimes occur on these.

The spinous dorsal is higher and rises more abruptly from the depressed nape than was true of the type of the species; in adults its height frequently equals the length of the head. The principal differences alleged to separate *Nautiscus* from *Nautichthys* are the slightly shallower occipital pit, the lower spinous dorsal (sometimes twice the length of head in *Nautichthys oculofasciatus*) and the slightly shorter dorsal and anal. These differences do not warrant generic distinction.

LIST OF STATIONS.

Stations	Latitude				Longitude				Depth.
	°	′	″		°	′	″		*Fathoms.*
4777	52	11		N.	179	49		E.	43-52
4778	52	12		N.	179	52		E.	33-43
4779	52	11		N.	179	57		W.	54-56
4794	52	47	20	N.	158	44	30	E.	58-69
4795	52	46	50	N.	158	44	30	E.	48-69
4796	52	47		N.	158	43		E.	48

Psychrolutes paradoxus Günther.

Station 4796, off Avatcha Bay, Kamchatka; depth 48 fathoms.

EURYMEN, new genus (Cottidæ).

Tadpole shaped; skin lax, naked; head smooth, without spines or tubercles, the nasal, preopercular and opercular spines wholly wanting; vomer and palatines toothless; gill membranes broadly united, joined basally to the isthmus, the marginal portion forming a free fold; no pore or slit behind last gill; dorsal fins continuous, notched, the spinous dorsal evident, the spines with free tips; ventrals I, 3.

Closely related to *Gilbertidia*, from which it differs in the wide free fold to the gill membrane, and in the greatly increased number of rays in the pectoral fin.

Type species, *Eurymen gyrinus*, new species.

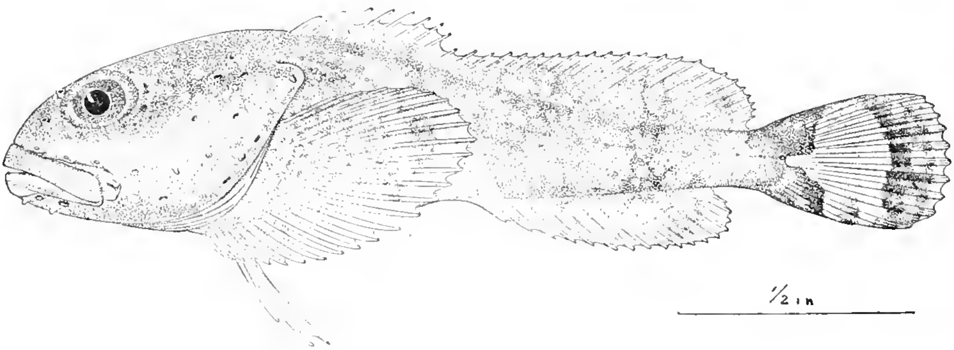


FIG. 14.—*Eurymen gyrinus*, new species. Type.

Eurymen gyrinus, new species. (Fig. 14.)

Type 50 mm. long, from station 4795, off Avatcha Bay, east coast of Kamchatka; depth 69 fathoms.

Measurements in hundredths of length without caudal: Head 44; width of head 30; depth of head 24; interocular width 9; diameter of eye 10; length of snout 13; length of maxillary 21; greatest depth 26; depth of caudal peduncle 8; snout to front of dorsal 43; base of dorsal 64; base of anal 32; base of pectoral 20; length of pectoral 28; length of ventrals 22; length of caudal 23.

Dorsal VIII-23; anal 17; pectoral 26. Pores in lateral line 17.

Head cuboid, a little depressed, with vertical cheeks and depressed broadly rounded snout; interocular space nearly flat, its width nearly equaling diameter of eye; occiput transversely rounded, not ridged; pores scattered on top and sides of head, a series of six on lower edge of suborbitals and preorbital, four on mandible; a short blunt papilla between each two pores on preorbital and mandible; a small cirrus near end of maxillary, one near end of opercular flap, a few scattered on top of head; both pairs of nostrils in tubes, the posterior the longer; mouth wide, oblique, lower jaw included, maxillary reaching vertical behind pupil; teeth in villiform bands on jaws, none on vomer or palatines.

Spinous dorsal beginning over opercular flap, continuous with soft dorsal, a notch between them; the tips of spines protrude, projecting freely from the membrane; short dorsal and anal long, the free portion of caudal peduncle very short; pectoral with broad procurrent base, all the rays simple, the lower slightly thickened and with protruding tips; ventrals nearly reaching vent; caudal rounded.

Color in spirits: Light gray, the head and body thickly sown with minute black pigment specks; a faint dusky bar below spinous dorsal, two below soft dorsal, the posterior most distinct, and one on caudal peduncle and base of caudal fin; the margin of soft dorsal is translucent, unmarked, this border increasing in width posteriorly where it is dark edged below; central part of caudal clear, with a dark bar on lower rays, the terminal part with one bar or two confluent bars, the posterior margin clear; pectorals with faint dusky reticulations, the margin translucent; ventrals unmarked.

Only the type known.

AGONIDÆ.

Percis japonicus (Pallas).

A specimen 2½ inches long from station 4794, off Avatcha Bay, Kamchatka; depth 58 fathoms.

Hypsagonus quadricornis (Cuvier & Valenciennes).

Taken at the following localities, on Petrel Bank and the Komandorski Plateau:

LIST OF STATIONS.

Stations.	Latitude				Longitude				Depth
	°	′	″		°	′	″		*Fathoms*
4777	52	11		N.	179	49		E.	43–52
4778	52	12		N.	179	52		E.	33–43
4779	52	11		N.	179	57		W.	54–56
4788	54	50	24	N.	167	13		E.	56–57
4789	54	49	45	N.	167	12	30	E.	56

Pallasina barbata (Steindachner).

Of this widely varying group, the present collection contains numerous specimens from Unalaska and others from Petropavlovsk. For purposes of comparison, we have examined also all the material in the United States National Museum and the Stanford University collections. In general form and proportions of parts and in the arrangement and sculpture of the plates we find no characters of value for distinction of forms. The variable features are the length of the mental barbel, the numbers of dorsal, anal, and pectoral fin rays, and the number of unpaired median plates on the breast. Each of these characters is subject to a certain amount of variation in any one locality, less, however, than the total variation exhibited by the species. In this respect *Pallasina* differs from the majority of marine fishes, and resembles fresh-water forms, in which isolated colonies take on slightly distinctive combinations of characters. In *Pallasina* certain groups of contiguous localities are marked by fairly distinguishable strains, which seem to intergrade to a degree in orderly geographic sequence. The limited material at our disposal does not permit the determination of the boundaries of these minor groups, nor indeed the question as to their recognition in taxonomy.

The type of *Pallasina barbata* came from the Arctic just north of Bering Strait. The only other available name is *P. aix*, described from Puget Sound. As the form characteristic of Puget Sound and the coasts immediately to the north is one of the best distinguished of the minor groups, we suggest that *aix* be reduced to subspecific rank and used to denote it. The form is characterized by the prevalence of 2 unpaired plates on median line of breast, of 11 anal and 11 pectoral rays, and by the very short mental barbel. The variation is exhibited in the following table, based on 25 specimens from Port Ludlow, the type locality of *aix*, and o from San Juan Island. Both pectorals are listed in each specimen.

	Dorsal spines				Dorsal rays.			Anal rays			Pectoral rays.			Plates.	
Fin rays and plates......	VI	VII	VIII	IX	6	7	8	10	11	12	10	11	12	2	3
Number of specimens	4	17	12	1	2	23	9	5	26	3	1	64	3	29	5

Nine specimens from Sitka show a tendency to 8 dorsal and 12 anal rays, but do not otherwise differ from typical *aix*:

	Dorsal spines.				Dorsal rays.		Anal rays.		Pectoral rays.		Plates.	
Fin rays and plates	V	VI	VII	VIII	7	8	11	12	11	12	2	3
Number of specimens.....	1	2	5	1	3	6	1	8	15	3	7	2

From Funter Bay, Lynn Canal, and from the southern shore of the Alaska Peninsula, our material agrees in having almost equally 11 or 12 anal rays, in having almost exclusively 12 pectoral rays, and in the decided tendency to 3 instead of 2 median plates on breast. The barbel is still short. The following table includes 12 specimens from Funter Bay, 9 from Yakutat Bay, 2 from Chignik Bay, and 1 from Sannak Island. As their range of variation and prevailing mode is the same, they are not given separately.

	Dorsal spines.			Dorsal rays.			Anal rays.			Pectoral rays.		Plates.	
Fin rays and plates	VI	VII	VIII	6	7	8	11	12	13	11	12	2	3
Number of specimens......	4	12	8	1	15	8	14	9	1	3	45	8	16

Unalaska material retains the short barbel and has the unpaired median plates on breast prevailingly 2 in number, as in *aix* generally. The fin rays are more numerous than in any form yet considered, and as the tendency in the *aix* series is toward increase in fin rays to the north, the Unalaska form may be considered an extreme in that series. The following table gives the variation in 20 specimens obtained at Unalaska May 26, 1906:

	Dorsal spines				Dorsal rays			Anal rays				Pectoral rays.			Plates.		
Fin rays and plates........	VI	VII	VIII	IX	7	8	9	11	12	13	14	11	12	13	2	3	4
Number of specimens	4	9	6	1	6	11	3	6	10	3	1	1	29	10	15	4	1

The shores of Bristol Bay and northward to Bering Strait are occupied by typical *barbata*, which has a comparatively long slender barbel, usually 3 plates in the median series on the breast, 12 rays in the pectoral and a reduced number in the dorsal and anal fins. In this series the greatest reduction in the number of rays in the vertical fins takes place at the extreme northern limit of its range, the reverse being the case in the *aix* series. The type of *barbata* had the following characters:

Dorsal VI-7, anal 9; pectoral 12; plates 3.

With this may be compared 14 specimens from Point Clarence, Alaska, immediately south of Bering Strait:

	Dorsal spines				Dorsal rays.			Anal rays.		Pectoral rays.			Plates.	
Fin rays and plates	V	VI	VII	VIII	6	7	8	9	10	11	12	13	2	3
Number of specimens	4	6	2	2	3	10	1	4	10	1	23	4	2	12

Thirteen specimens from three distinct stations in the northeastern part of Bristol Bay agree with tne above except in the wider range (but not the prevailing number) in the anal fin, and the occasional presence of 4 plates.

	Dorsal spines.			Dorsal rays.			Anal rays.				Pectoral rays.		Plates.	
Fin rays and plates	VI	VII	VIII	6	7	8	9	10	11	12	11	12	3	4
Number of specimens	3	7	3	2	8	3	2	7	1	1	1	25	8	5

There agree with the above also two specimens from Herendeen Bay, midway of the northern shore of the Alaska Peninsula, as both possess the following formula:

Dorsal VII–7; anal 10; pectoral 12–12; plates 3.

All of the above, from Bering Strait south to Herendeen Bay, can be distinguished at sight from any member of the *aix* group by the longer slender mental barbel, as figured by Steindachner in the type of *barbata*. (Ichthyologische Beiträge, vol. v, pl. 5.)

There remain for consideration numerous specimens from Kamchatka, largely from the vicinity of Petropavlovsk. These agree essentially in fin formula and number of plates with typical *barbata*, and are widely different from the Unalaska material, which is here considered the northern representative of the *aix* series. The Kamchatkan form differs from typical *barbata* only in the shortening of the mental barbel, which is, however, slender and movable, and thus of the *barbata* type. The table below gives data in the case of 46 Kamchatkan specimens:

	Dorsal spines.				Dorsal rays.			Anal rays.				Pectoral rays.			Plates.		
Fin rays and plates	V	VI	VII	VIII	6	7	8	9	10	11	12	11	12	13	2	3	4
Number of specimens	4	20	17	5	4	25	17	4	11	24	7	5	81	6	2	40	4

Additional complexity is occasioned by considering representatives from the Kurile Islands and northern Japan, but these have not yet received a thorough examination.

Sarritor frenatus (Gilbert).

LIST OF STATIONS.

Stations	Latitude				Longitude.				Depth.
	°	′	″		°	′	″		*Fathoms.*
4777	52	11		N.	179	49		E.	43–52
4779	52	11		N.	179	57		W.	54–56
4792	54	36	15	N.	166	57	15	E.	72

The above localities on Petrel Bank and the Komandorski Plateau.

Sarritor leptorhynchus (Gilbert).

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′ ″	° ′	*Fathoms.*
4786	54 51 30 N.	167 14 E.	54
4798	51 37 N.	156 21 E.	25

The Komandorski Plateau and the codfish banks west of southern Kamchatka.

Bathyagonus nigripinnis Gilbert.

One specimen from station 4797, off Avatcha Bay, east coast of Kamchatka, depth 682 fathoms.

Aspidophoroides bartoni Gilbert.

From Petrel Bank, Komandorski Plateau, off Avatcha Bay, east coast Kamchatka, and off mouth of the Aangan River, west coast Kamchatka, as follows:

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′ ″	° ′ ″	*Fathoms.*
4779	52 11 N.	179 57 W.	54-56
4787	54 50 50 N.	167 13 30 E.	54-57
4789	54 49 45 N.	167 12 30 W.	56
4791	54 36 15 N.	166 58 15 W.	72-76
4792	54 36 15 N.	166 57 15 W.	72
4794	52 47 20 N.	158 44 30 W.	58-69
4795	52 46 50 N.	158 44 30 W.	48-69
4798	51 37 N.	156 21 W.	25

Anoplagonus inermis Günther.

Stations 4777 and 4779, on Petrel Bank; depths 52 and 54 fathoms.

CYCLOPTERIDÆ.

Eumicrotremus orbis (Günther).

Lethotremus vinolentus Jordan and Starks, Proceedings California Academy of Sciences, 1895, p. 827, pl.

This species is so closely allied to *E. spinosus* of the north Atlantic that Collett, after a comparison of specimens from both oceans, has called the two identical. There exist, however, certain evident differences in the distribution of the plates which enable us to distinguish the species at any age after the plates have begun to develop.

In *E. spinosus* the interorbital area has 4 longitudinal series of plates which continue without interruption along the back as far as the interval between the dorsals. The inner two interorbital series are continuous with the series along either side of base of spinous dorsal; the plates increase in size regularly backward, those along base of spinous dorsal being as large, or nearly as large, as the largest on sides of body, and reduced to 3 pairs, of which the first pair are partly in advance of the fin and partly under the first spines, the second is under the middle and posterior part of the fin, and the third largely under the interval between the dorsals.

In *E. orbis* there are also 4 interorbital series, but neither the outer (supraocular) nor the inner pairs are definitely continued posteriorly. The two inner series usually diverge from each other on the posterior part of the head and may leave an interval in which either a short median series or a patch of irregular plates develop; they are not posteriorly in line with the base of the dorsal, the last plates diminish in size, and the series terminates opposite the front of the dorsal. The plates along the base of the dorsal are much smaller than the larger plates along the flanks, and are more numerous than in *E. spinosus;* 1 pair is immediately in front of the origin of the fin, 3 small pairs are under the fin, and a much larger pair opposite the interval between first and second dorsals. The supraocular series contains 4 plates increasing in size posteriorly and often 2 or 3 behind the line of the head, diminishing rapidly in size; the line quickly loses its identity at or in advance of the middle of the length.

In *E. orbis* the throat contains several series and is usually wholly invested with spinous plates, and the spinous dorsal is covered with scattered plates for its entire extent. In *E. spinosus* the throat is covered with soft rounded papillæ, with few or no plates, and the spinous dorsal has but a single series of spinous plates near and parallel to its margin.

Several young specimens of *E. orbis* were taken on Petrel Bank, Bering Sea, at stations 4777 and 4779; depths 52 and 54 fathoms.

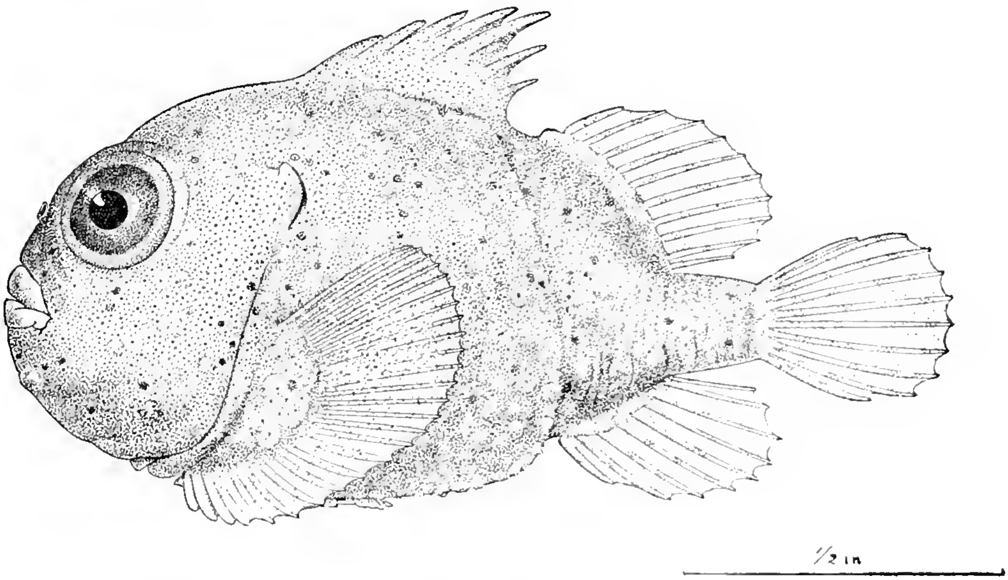


FIG. 15.—*Eumicrotremus phrynoides*, new species. Type.

Eumicrotremus phrynoides, new species. (Fig. 15.)

Type 38 mm. long, from station 4779, on Petrel Bank, Bering Sea; depth 54 to 56 fathoms.

Measurements in hundredths of length to base of caudal: Head 49; eye 20; interocular width 28; distance from anterior to posterior nostril 7; distance between outer angles of mouth 34; width of gill-slit 9; greatest width of body 55, equaling the greatest depth; base of soft dorsal 22; base of anal 18; length of caudal 25; diameter of ventral disk 32.

Dorsal VII–10; anal 9; pectoral 26.

Body tadpole shaped, not greatly compressed anteriorly, its depth and width equal, abruptly compressed behind the spinous dorsal; cheeks nearly vertical; interorbital space wide, gently concave; eyes large, prominent, the upper rim entering the profile; the anterior profile along middle of top of head descends in an almost straight oblique line from occiput to snout; anterior nostril on level of middle of eye, the upper margin of upper lip on level of lower margin of pupil; snout extremely short, the mouth with little lateral cleft; anterior nostril in a short wide tube; posterior nostril tube shorter and much narrower than the anterior, in this respect differing strikingly from *E. orbis* and *E. spinosus*, in which the long slender posterior nostril tube resembles a supraorbital tentacle; teeth small, conical, arranged within the bands in curved series, as in *Cyclogaster*, the outer series along the margin of the jaw laterally, but not reaching the medial line, successive series becoming more and more oblique to the jaw, until the short medial series are nearly transverse to the jaw. In this species there are 7 series in the mandible, a few of the lateral or posterior teeth in each series enlarged.

Tubercles all small and inconspicuous, largely concealed beneath the thick integument, only the rosettes of short spines a little protruding; no definite arrangement of plates is evident, nor are any enlarged; this is true also of the interorbital region, where groups of short spines are scattered irregularly; chin and throat and the caudal peduncle apparently smooth and naked. The lack of development of the spinous tubercles can not be due to small size, for in the young of *E. spinosus* and *E. orbis*, the plates are perfectly formed when much smaller than is the type of *E. phrynoides*.

A single pore at the origin of the lateral line opening at the tip of a short tube; no other pores present, but an irregular series of imperforate papillæ follow approximately the course of the lateral line. This is also the condition in *E. spinosus* and in *E. orbis*. A most careful examination of a large number of specimens in perfect preservation has failed to demonstrate the existence of the full series of lateral line pores which Collett ascribes to *E. spinosus* (Fishes Norwegian North Atlantic Expedition, p. 49). Open pores are present on the head; one immediately behind the lower part of orbit, one beneath the anterior part of orbit, and three pairs on mandible, the anterior pair well separated, at symphysis, immediately behind lower lip. In *E. spinosus* and in *E. orbis* the mandibular pores open through tubes, but in *E. phrynoides* no tubes are present.

Origin of spinous dorsal over gill opening, the fin barely reaching base of second dorsal when depressed; outline of fin angular, the spines gradually increasing in length to the fifth, the sixth and seventh abruptly shortened; the spines are short, enveloped in thick membrane, with numerous soft papillæ, some of which may contain spinous points; second dorsal and anal with thin translucent membrane, the last rays slightly overlapping base of caudal. Disk large, its middle under upper part of base of pectoral. Vent a little nearer disk than anal fin.

Color pale olive, lighter below, a few dark spots scattered over head and body.

The species is not closely allied with any described form. *E. brashnikowi* Schmidt agrees in the poor development of spinous tubercles, but is a compressed form of wholly different shape, with wide lateral cleft to the mouth.

Only the type taken.

Lethotremus muticus Gilbert.

Two young specimens from Petrel Bank, Bering Sea, station 4779; depth 54 fathoms.

The species differs widely from *L. awæ* from Japan, in the broader snout and interorbital, the larger eye, the wider transverse mouth with less lateral cleft, the longer fins, and the total absence of filaments on the head. *Lethotremus vinolentus* Jordan and Starks, based on a specimen 13 mm. long from Puget Sound, is the young of *Eumicrotremus orbis*, in which the larger spinous plates are already in evidence. Owing to the very small size of the type of *vinolentus*, the fin rays were erroneously given; there are at least 9 dorsal and 8 anal rays. *L. muticus* has a single pore in a tube at origin of lateral line, but neither pores nor a series of papillæ indicating the further course of the line; three pairs of mandibular pores without tubes, and one below and one behind eye are evident, and arranged as in *Eumicrotremus*. As we are unable to demonstrate the presence of a lateral line in *Eumicrotremus*, the only character remaining to distinguish *Lethotremus* is the total absence of spinous tubercles.

Cyclopterichthys ventricosus (Pallas).

Adults of this species in an injured and often dying condition were found in abundance in the tide pools on Medni Island. Others were seen at Nikolski, on Bering Island, where groups of their eggs were found fastened to kelp in the tide pools.

CYCLOGASTERIDÆ.

Cyclogaster (Neoliparis) rutteri (Gilbert & Snyder).

A single specimen was collected in the tide pools on Agattu Island. Length 2.5 inches. This specimen appears to be a male, but differs from the description of the type in having the dorsal spines low and bound together with a thick skin.

Head 29 hundredths of length of body without caudal, depth 23; disk 20; eye 4.5; snout 11; gill opening 5.5; maxillary 11. Dorsal v–26; anal 25; pectoral 31.

Body robust anteriorly; deepest in front of first dorsal. Head deep and wide; width a little greater than depth; occiput swollen; profile rising rapidly from the eyes, snout short, rounded; mouth narrow, almost entirely transverse; maxillary reaching vertical from front of eye. Teeth strongly trilobed, arranged in about 8 oblique rows in the half of each jaw. Anterior nostril in a tube; posterior nostril with a raised rim. Gill opening entirely above the base of the pectoral fin.

First dorsal low, separated from the soft dorsal by a shallow notch; anal similar to second dorsal; dorsal and anal slightly joined to caudal; caudal composed of 12 rays; pectoral with a shallow notch separating the two lobes. Disk large, its anterior edge under posterior margin of orbit; distance from tip of lower jaw to disk two-thirds diameter of disk, $2\frac{1}{2}$ in head. Vent nearer disk than origin of anal; distance from disk to vent 4.66 in head.

Color dark slate, paler on the sides of the body; a light bar across base of caudal and posterior edge of dorsal and anal.

Cyclogaster (Neoliparis) callyodon (Pallas).

This species is common among the Aleutian Islands. Collected in the tide pools on Unalaska, Atka, Agattu, Attu, and Bering Islands.

Specimens are usually spotted with fine black specks and have the fins barred, even in the young; they are slender, have the anal fin not continued beyond base of lower caudal ray, the anus is nearer disk than front of anal, and the dorsals are always distinct. In two specimens fin rays are as follows: Dorsal v–28, anal 26, pectoral 29; dorsal v–28, anal 25, pectoral 30. In none of our specimens is there present the silvery streak on side of head described by Pallas.

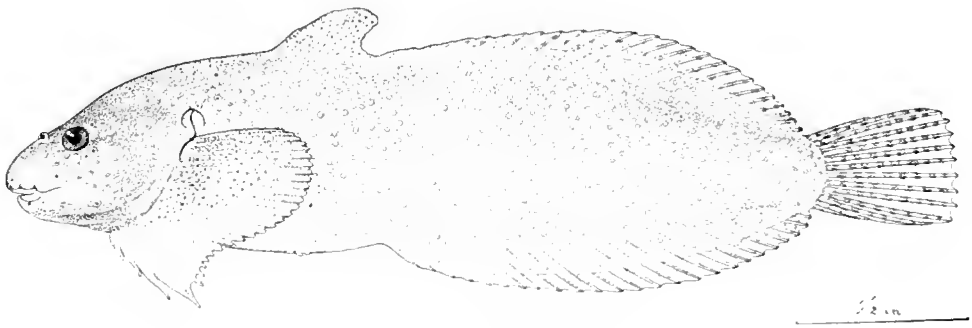


FIG. 16.—*Cyclogaster (Neoliparis) micraspidophorus*, new species. Type.

Cyclogaster (Neoliparis) micraspidophorus, new species. (Fig. 16.)

Type, a male, 73 mm. long, from Nikolski, Bering Island.

A tide-pool species, known only from Agattu and Bering Islands. On account of the character of the gill opening, this species is apt to be confused with *N. mucosus* (=*N. floræ*). It differs from the latter species in the shape of the body, greater depth, more swollen cheeks, slightly larger disk, and the coloration.

Dorsal vi–25; anal 25; pectoral 31. Head 27 hundredths of length without caudal; depth 24; ventral disk 17; eye 3.7; snout 11; gill slit 6.5; maxillary 9.

Body deepest at front of first dorsal; dorsal outline sloping gradually to middle of second dorsal, whence it slopes more rapidly to the caudal. Head rather heavy; occiput swollen; profile depressed over eyes; cheeks swollen. Mouth terminal. Teeth trilobed, arranged in about 8 oblique rows in the half of each jaw. Snout depressed, evenly rounded. Eye small. Posterior nostril with a low flap in front. Gill slit extending down in front of about 5 pectoral rays. Body and fins with scattered "thumb-tack" prickles, these absent on the lower surfaces and the snout.

First 6 dorsal rays set off by a deep notch, caudal truncate; dorsal and anal not distinctly joined to base of caudal, the dorsal connection equal to the skin-covered base, the anal connection a little greater; pectoral notched, the lower lobe of 6 rays, reaching nearly to margin of disk. Disk large, 1.7 in head. Vent separated from disk by less than one-half the diameter of the disk.

Slate colored above, paler below; vertical fins indistinctly speckled and barred; upper half of pectoral speckled.

The swollen occiput is not so noticeable in the cotype, and the color varies to an olive gray, somewhat resembling the typical coloration of *N. callyodon*. The lower lobe of the pectoral appears shorter than in *N. floræ*.

Three cotypes are in the collection, 1 from Nikolski, Bering Island, 2 from Agattu Island.

Cyclogaster (Neoliparis) beringianus, new species. (Fig. 17.)

Type 64 mm. long, from Nikolski, Bering Island.

Head 31 hundredths of length without caudal; depth 24; eye 4; snout 12; gill opening 6.2; ventral disk 13; interorbital width 13; maxillary 12.5. Dorsal v–33; anal 31; pectoral 36.

Body deepest at origin of dorsal, compressed posteriorly. Occiput not swollen; profile descending gradually, the interorbital region not depressed; snout not deep, transversely blunt and rounded; jaws equal; maxillary reaching vertical from front of eye. Teeth strongly trilobed in the young, weakly so in the adult, arranged in narrow bands, 7 oblique rows in the half of each jaw; superior pharyngeal teeth

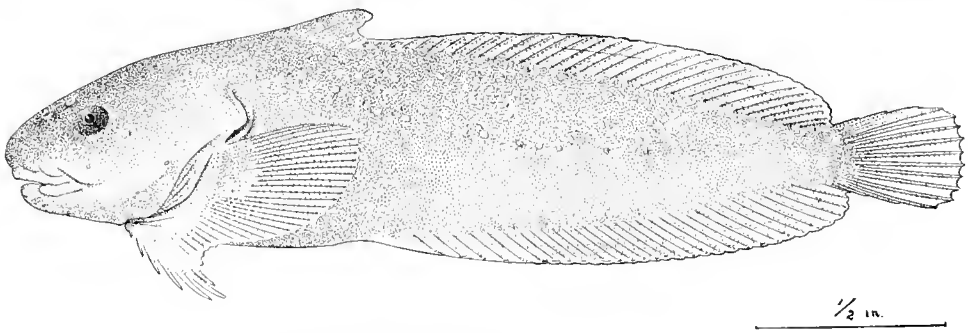


FIG. 17.—*Cyclogaster (Neoliparis) beringianus*, new species. Type.

few and scattered, not closely bunched together, as in *C. greeni*. Anterior nostril in a short tube, the posterior a transverse slit without raised margins. Gill opening extending upward from the edge of the upper pectoral ray. Anterior part of lateral line marked by a series of papillæ which seem minutely perforate, the line narrowly arched above base of pectorals, a few scattered papillæ above the anterior half of the lateral line and on the sides and top of head; the pores have slightly raised rims, which are sometimes divided, forming lips. A series of larger open pores without papillæ on mandible, and one above and behind orbit.

Origin of spinous dorsal over middle of upper pectoral ray, wholly separated from soft dorsal by a deep notch; the spines progressively lengthened and bound together by a thick skin; dorsal and anal slightly connected with the caudal; pectoral notched, the lower lobe composed of 7 rays and reaching slightly beyond the ventral disk. Disk moderate; distance from tip of lower jaw to disk 2 in head. Vent nearer anal than disk.

Color in life: Uniform pale pea-green, without spots or other distinctive markings on body or fins.

This species is closely related to *C. greeni*, but differs in the more reduced gill opening and the fewer superior pharyngeal teeth. It is found in the tide pools with *C. callyodon*, but can be distinguished from the latter by the greater number of fin rays, the coloration, the deeper body, smaller disk, more posterior anus, and in the wider union between anal fin and caudal.

This species was found to be common at Nikolski; numerous cotypes were also taken at Unalaska, Agattu, and Medni Islands. In a specimen from Unalaska the fin rays are: Dorsal v–36; anal 32, pectoral 36.

Cyclogaster (?) cyclopus (Günther).

Two small specimens were taken at Petropavlovsk. Length 30 to 60 mm.

We have compared these specimens with three specimens of *C. cyclopus* from Puget Sound and station 3230, Bering Sea. They differ from the latter in having the profile evenly rounded instead of concave, the interorbital rounded instead of flattened, the snout evenly rounded instead of truncate, the gill opening extending down in front of 3 pectoral rays instead of 5 or more, and the dorsal consisting of 37 instead of 35 rays.

The following characters are from the larger specimen: Head 4 in length; depth 4.66. Dorsal 37 anal 30; pectoral 32. Snout 3 in head; disk 2; gill opening 4.25; maxillary 2.5.

These specimens may well belong to an undescribed species, but our material is not adequate to decide this point.

Cyclogaster cyclostigma (Gilbert). (Fig. 18.)

Head 32 hundredths of length without caudal, depth 30; eye 6; snout 12; gill slit 13; ventral disk 14.5; interorbital width 12; maxillary 15; distance vent from disk 11.5; from anal fin 8.5. Dorsal 39; anal 34; pectoral 40.

Body much compressed posteriorly; greatest depth at origin of dorsal. Head wide; nape prominent; interorbital and snout depressed, snout overlapping the broad mouth; maxillary reaching vertical

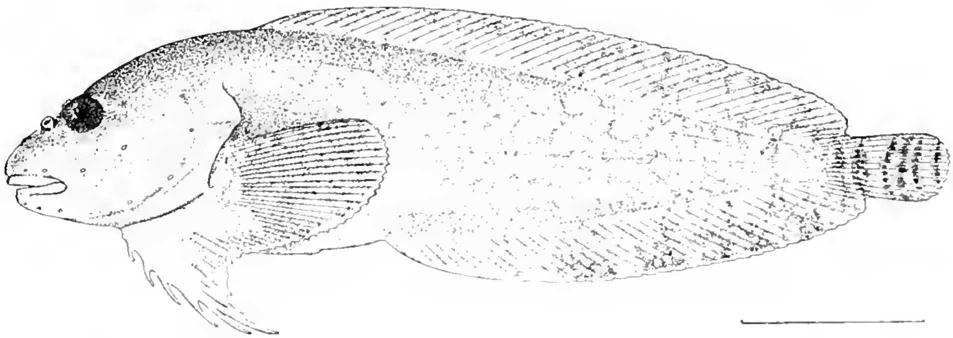


Fig. 18.—*Cyclogaster cyclostigma* (Gilbert). From Albatross station 4777, Petrel Bank, Bering Sea, depth 52 fathoms.

from slightly behind pupil; pupil oval, vertical. Teeth strongly trilobed, 14 or 15 oblique series in the half of each jaw; superior pharyngeal teeth with small lobes. Anterior nostril in a prominent tube, which is 2.5 in eye, posterior nostril with a raised rim. Gill opening large, extending down in front of the upper 14 pectoral rays. Pyloric cæca 30 (from cotypes).

Origin of dorsal distinctly behind base of pectoral; last ray slightly shortened, connecting with 0.2 of the caudal; anal similar to dorsal, connecting with 0.4 of the caudal, caudal rounded, 1.83 in head; pectoral broad, the upper lobe reaching anal, lower lobe composed of 8 rays and reaching nearly to vent. Ventral disk large; distance from tip of lower jaw to disk 2.5 in head, from disk to anal 1.8. Vent slightly nearer anal than disk.

Skin thin and flabby; one or two pores in short tubes near origin of lateral line; no other trace of lateral line in the type, but in the smaller cotypes a series of papillæ not certainly perforate but with depressed centers.

Color in life red on head and body, slightly clouded with darker, white on lower side of head and on belly; on opercular flap a black intramarginal line; fins all red, clouded or mottled with blackish, the color darkest on anal and on posterior part of dorsal; on caudal, the dark markings take the form of irregular crossbars; pectoral dusky toward the margin.

This species is closely related to *C. dennyi;* it can be distinguished from the latter by the broad, depressed snout and the larger, more prominent eye; it has a longer nostril tube, the snout projects farther and the disk has a broader marginal flap. It differs from *C. ochotensis* (Schmidt) in the larger disk and eye, the shorter connection between the dorsal and caudal and in minor characters. Its relationship with *C. gibbus* (Bean) is even closer, but the two are provisionally maintained as distinct. For discussion of synonymy, see *Crystallichthys cyclospilus*.

LIST OF STATIONS.

Stations.	Latitude.				Longitude.				Depth.
	°	′	″		°	′	″		*Fathoms.*
4777	52	11		N.	179	49		E.	43–52
4779	52	11		N.	179	57		W.	54–56
4780	54	49	45	N.	167	12	30	E.	56
4795	52	46	50	N.	158	44	30	E.	48–60
4796	52	47		N.	158	43		E.	48

The above localities extend from Petrel Bank, Bering Sea, to the vicinity of Avatcha Bay, Kamchatka.

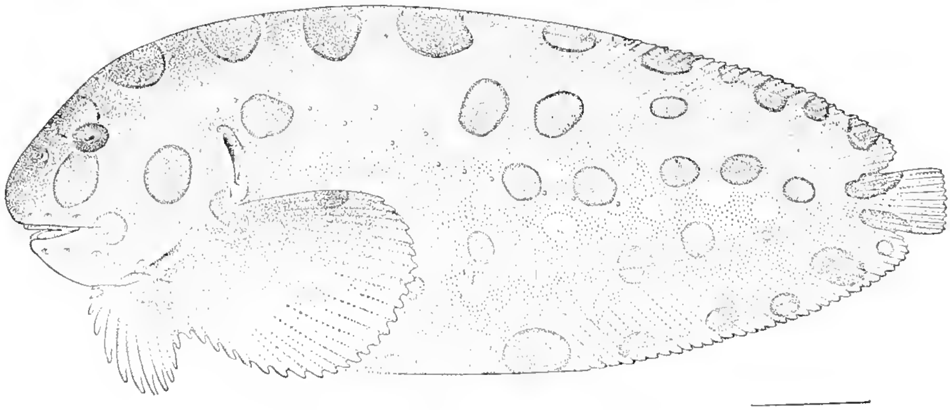


FIG. 19.—*Crystallichthys cyclospilus*, new species. Type.

Crystallichthys cyclospilus, new species. (Fig. 19.)

Liparis cyclostigma Jordan and Gilbert, Fishes of Bering Sea, Report Fur-Seal Investigations, 1899, pt. 3, p. 476, pl. LXXIII; not of Gilbert. Evermann and Goldsborough, Fishes of Alaska, Bulletin United States Bureau of Fisheries, vol. XXVI, 1906 (1907), p. 333, pl. XIX.

Crystallichthys mirabilis Jordan and Gilbert, op. cit., p. 476, pl LXXVI; in part only.

Type 202 mm. long, from station 4779, Petrel Bank, Bering Sea; depth 54 to 56 fathoms.

Measurements in hundredths of length without caudal: Head 29; eye 4; interorbital width 14; snout 14, width of head 16; depth of head 33; maxillary 11.5; distance from eye to base of nostril tube 4; greatest depth 39; length of gill slit 7; diameter of disk 13; distance from anus to disk 3; to front of anal fin 17; upper pectoral rays 19; width of base of pectoral 22; longest ray of lower pectoral lobe 14; distance from tip of lower jaw to disk 9. Dorsal 50; anal 42; pectoral 34; fins counted in dissected cotype from same station.

Body deep, compressed, the cheeks vertical, the greatest depth of head twice its greatest width; eye small, the pupil elliptical, with its long axis horizontal; nostril single, in a prominent tube; mouth nearly terminal, the premaxillaries not greatly overlapped by the short rounded snout; snout evenly convex transversely, without the lengthwise median groove of *Crystallichthys mirabilis;* bands of teeth very wide, with nine oblique series in the half of each jaw; the anterior teeth of each series minute, barely perceptible, those in the posterior two-thirds of the band large and distinctly trilobed. Gill opening small, wholly above base of pectoral. Disk large, its anterior margin under middle of eye, the anus close behind it. Origin of dorsal over the gill slit, its anterior portion wholly concealed in a thick covering of gelatinous material beneath the lax skin; the rays increase regularly in length from the origin, there being apparently no differentiated spinous part; the last rays are slightly shortened, giving a rounded contour to fin, which joins the basal half of the caudal. Anal similar to dorsal, joining basal 0.6 or 0.66 of caudal. The lower pectoral lobe consists of 11 thick rays with exserted tips, the longest reaching the vent.

Skin extremely lax, with much soft gelatinous tissue intervening between it and the muscular mass; small open pores along margin of snout and across cheek and on mandible. An obscure series of slit-like pits, apparently not perforate, mark the anterior portion of the lateral line and exhibit the usual short curve above base of pectorals; no papillæ are present.

Color in life: Varying in different specimens from light rose red to light lemon yellow; the spots accord with the ground color, and are either reddish brown or yellowish brown, usually darker at or toward the margins, the darker portion often forming a distinct brownish red ring, most conspicuous in specimens with a yellow ground color. Surrounding all is a light pearly gray ring, which often spreads over the adjoining parts as a suffusion and seems to cover the ground color. The spots are large and roundish, varying in size, shape, and position; usually a conspicuous median series along anterior part of dorsal profile, either a single one or a pair on occiput, one above and an elongate one below and in front of each eye.

This is the species with which the name *Liparis cyclostigma* Gilbert has usually been associated, and is the species to which it was intended to apply that name. Through an unfortunate clerical error, the name *cyclostigma* became attached to a very different species in no way resembling the one here described, and wholly without strikingly distinctive color marks. As the body of the original description of *cyclostigma*, and also the type as designated, concern the unadorned species, it will be necessary to use the name as a palpable *nomen ineptum*. As a further source of confusion, a color description applying to the present species was added to the diagnosis of *cyclostigma* as the latter was passing through the press.

An examination of the type of *cyclostigma* (no. 48621, U. S. National Museum) shows it to be a true *Cyclogaster*, with two well-defined nostrils, but without anterior or posterior tube. It is a rather elongate form, with broad depressed head, about as wide as deep, and a very broad heavy snout. The color was apparently grayish, vermiculated or reticulated with darker; the vertical fins are mostly black, the dorsal with lighter base, all the rays with whitish tips, the black of the fins more or less variegated with lighter mottlings; pectorals similarly marked, darker on inner margin, the course of the rays externally lined with lighter. The lighter markings on the fins may have been yellowish or greenish in life. Inside of mouth and gill cavity and the peritoneum white.

We append a table of measurements of the type of *C. cyclostigma* given in hundredths of length without caudal: Head 27.8; exposed portion of eye 3.3; orbit 5.9; snout 10.4; maxillary 14; cleft of mouth 11; interocular width 11; depth at occiput 21.5; width of snout 22; greatest depth 25; length of disk 12.9; distance from disk to tip of mandible 17; to vent 12.9; vent to first anal ray 7; snout to dorsal 30.6; length of gill opening 11; width of pectoral base 19; longest pectoral ray 25; longest caudal ray 18; longest ray of lower pectoral lobe 18.5.

In the type description of *Crystallichthys mirabilis* Jordan and Gilbert, it is to be noted that the smaller of the two specimens, taken near St. Paul Island at station 3638, and figured on plate LXXVI, does not belong to *C. mirabilis*, but is the young of *C. cyclospilus*. The specimen of *C. cyclospilus* which has been heretofore erroneously figured as *Liparis* (or *Crystallichthys*) *cyclostigma* (see synonomy) is now in such poor condition that it has been thought advisable to select another specimen as the type of *cyclospilus*.

Crystallichthys mirabilis Jordan & Gilbert.

A single specimen 87 mm. long, from station 4794, off the southern coast of Kamchatka; depth, 58 fathoms. This is the only locality from which the species is known, and is the second specimen to be placed on record. The young specimen from station 3638, near St. Paul Island, Bering Sea, mentioned in the original description, was incorrectly identified and belongs to *C. cyclospilus*.

The young individual here reported on is much more slender than the type; the depth contained 3.6 (instead of 2.5) in the length without caudal. The dorsal contains 53 rays, the anal 44 rays, and the pectoral 37 rays. Teeth are apparently arranged in but 7 oblique rows. Disk moderate, its diameter about one-third length of head, its distance from tip of lower jaw two-sevenths length of head. Snout with a shallow open median groove with vertical sides and horizontal floor; no thin median ridge within the groove, as in the type. Pupil minute, elliptical, with horizontal axis. The dorsal fin is much more widely joined to caudal, attached to the basal half of the fin, while the anal is a trifle more widely joined.

In spirits, colored much as *C. cyclospilus*, but the spots smaller, less conspicuous, and those along base of anal are elongate, and obliquely placed. In life, light translucent olive-gray, slightly flushed with reddish; the spots are red rings of various shape surrounding areas of the ground color.

The species differs from *C. cyclospilus* in the presence of the rostral groove, in the long conical overhanging snout, the large size of the pores on snout and mandible, the color, and in many minor characters.

The principal character on which the genus *Crystallichthys* was founded, the single nostril, is shared also with *Careproctus*, with which its two species, *mirabilis* and *cyclospilus*, are most closely allied. The genus may be provisionally retained, distinguished by the compressed head and body, the inferior mouth overlapped by the conical snout, the highly translucent gelatinous texture, and the peculiar style of coloration.

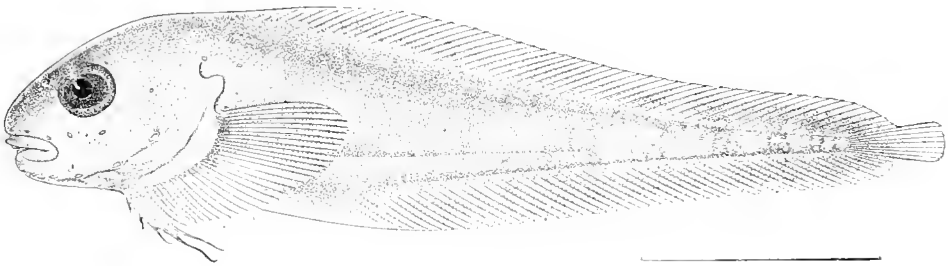


FIG. 20.—*Careproctus bowersianus*, new species. Type.

Careproctus bowersianus, new species. (Fig. 20.)

Type 100 mm. long, from station 4772, on Bowers Bank, Bering Sea; depth 344 fathoms.

Head 28 hundredths of length without caudal; depth 23; eye 7; snout 9; maxillary 9.5; gill opening 6.5; interocular width 10.5; disk 5.2; distance disk to tip of mandible 15; to vent 4; to front of anal 16. Dorsal 53; anal 46; pectoral 37; caudal 9.

Head large, flat above the eyes, cuboid, its width equaling the depth just behind eyes; occiput swollen; snout blunt, slightly overlapping the mouth. Mouth small; the lower jaw included; maxillary reaching vertical from just behind front of pupil; teeth tricuspid, in bands in each jaw; about 10 oblique series in each half of the upper jaw, 12 in the lower; eye large, shorter than snout; pupil large, round; nostril single, in a short tube. Disk small, about 0.75 eye, situated just in front of vertical from gill slit. Gill opening extending down in front of upper two pectoral rays. Vent under origin of dorsal.

Dorsal beginning over tip of opercular flap; distance from tip of snout to origin of dorsal 3.33 in length of body. Origin of anal fin under seventh dorsal ray. Dorsal connected with the caudal for 0.5 the length of the caudal; anal connected with the caudal for 0.4 its length; caudal 2.33 in head. Pectoral 1.66 in head; the upper lobe composed of 32 rays, the lower lobe of 5 rays; upper rays of lower lobe reaching beyond vent.

One or two distinct pores near origin of lateral line; no further evidence of tube or pores.

Color in life: Uniform light rose, the cotype a little dusky posteriorly.

Besides the types a single cotype was taken at station 4771 on Bowers Bank, Bering Sea; depth 426 fathoms.

Careproctus mollis, new species. (Fig. 21.)

Type 84 mm. long, from station 4784, off East Cape, Attu Island, Bering Sea; depth 135 fathoms.

Head 30 hundredths of length to base of caudal; depth 28; eye 5; snout 11; interocular width 12; maxillary 12.5; gill opening 6; disk 8; distance from disk to tip of mandible 15; to front of anal 22. Dorsal 51; anal 47; pectoral 35; caudal 12.

Body thickest and deepest in the region of the gill opening, tapering rapidly backward; head swollen at occiput; profile slightly concave over eyes; snout short, blunt, not projecting over mouth, its length greater than diameter of eye; nostril single, with a well developed tube; mouth terminal; jaws subequal; maxillary reaching vertical from just behind pupil; teeth tricuspid, forming narrow bands in each jaw, arranged in oblique rows; eye medium, about equal to bony interorbital space; pupil small, round; gill opening extending down to fourth pectoral ray; opercular flap forming a sharp angle. Disk larger than eye, its anterior edge under posterior edge of orbit; width of disk greater than length. Vent close behind disk, in front of origin of dorsal.

Dorsal beginning far back; distance from tip of snout to origin of dorsal 3 in length of body; origin of anal under seventh dorsal ray; dorsal and anal rays becoming very slender posteriorly, connected to the caudal for more than half its length; caudal narrow, composed of 12 rays; upper edge of pectoral on

FIG. 21.—*Careproctus mollis*, new species. Type.

a level with the eye; upper lobe of pectoral composed of 30 rays, reaching to anal; lower lobe composed of 5 rays, the upper 3 exserted and extending slightly past vent. Skin nearly all gone; body flesh colored; fins pale.

This species, from the size of disk and gill opening, appears to be related to *C. simus*, but it differs in the shape of the snout, the presence of a nostril tube, and in the smaller eye, gill slit, and ventral disk.

Two small specimens 31 to 45 mm. in length, were taken at station 4781, one in an intermediate haul of 300 fathoms, the other was taken by the dredge in 482 fathoms. In these specimens the skin is present and is dusky along the back and the base of the anal fin.

Careproctus candidus, new species. (Fig. 22.)

Type 73 mm. long, from station 4784, off East Cape, Attu Island, Bering Sea; depth 135 fathoms.

Head 28 hundredths of length without caudal; depth 29; eye 8; snout 12; maxillary 12; gill opening 4.8; disk 9.5; pectoral 25; caudal 14; distance from disk to tip of mandible 10; to front of anal 16. Dorsal 47; anal 39; pectoral 35; caudal 10.

Body deepest at origin of dorsal, tapering rapidly backward. Head short, its profile descending rapidly from occiput to front of eye, then dropping almost vertically to snout; snout very short and deep; nostril single, in a short tube in front of eye; eye large and prominent; pupil elliptical, the long axis nearly horizontal, directed forward and a little downward; mouth small, terminal; maxillary reaching vertical from front of pupil; teeth strongly trilobed, in 8 or 9 oblique series in the half of each jaw. Gill slit small, little more than 0.5 eye, entirely above base of pectoral.

Origin of dorsal above gill slit; fifth, sixth, and seventh spines weak and shortened, forming a notch which separates off the first 5 spines; dorsal and anal joined to caudal for 0.4 its length; caudal very slender, rounded; upper edge of pectoral on a level with middle of eye; the upper lobe composed of 29 rays and reaching to fourth anal ray; lower lobe composed of 6 rays, these rays thickened and partly free, the upper exserted and reaching a point half way between vent and anal fin. Ventral disk nearly as large as eye, the anterior edge under pupil. Vent close behind disk, the distance between disk and vent 6 in head.

Skin thin and transparent, covered with fine dark points; in life, uniform light reddish above, whitish below, the reddish very thin, appearing a little mottled with lighter.

A well-marked species, distinguished by the notch in the dorsal and the large prominent eye.

Three specimens besides the type were taken at station 4784.

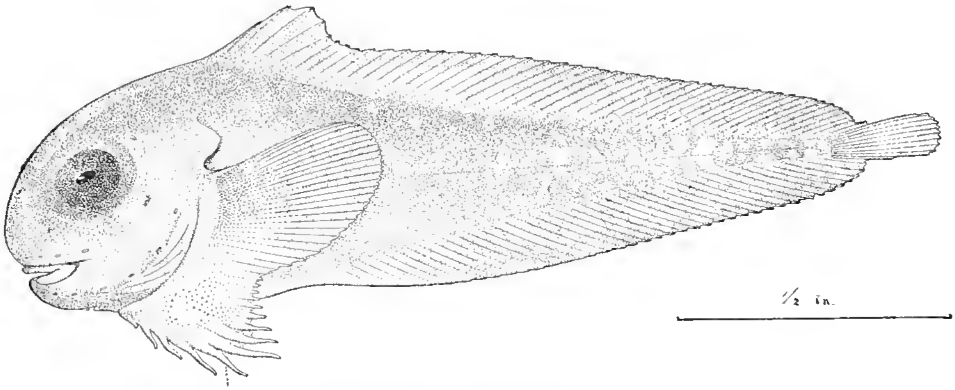


FIG. 22.—*Careproctus candidus*, new species. Type.

Careproctus spectrum Bean.

A single specimen, 50 mm. long, was taken at station 4781 near Agattu Island, in an intermediate haul of 300 fathoms. It may have been taken from the bottom, however, as the net struck during the haul. It differs from the types of *C. spectrum* in having the eye smaller, 4 instead of 3 in head, and the gill opening 2.66 instead of 2.

Head 30 hundredths of length without caudal; depth 24; eye 6.5; snout 9; gill slit 10; maxillary 16; disk 3; distance from disk to tip of mandible 15; to front of anal 19; dorsal 51; anal 48; pectoral 33.

Head large, flat above, contour from occiput almost to end of snout forming a straight line. Snout short, blunt, not overlapping the mouth; mouth large; maxillary 2 in head, reaching vertical from posterior margin of eye. Teeth lanceolate, in narrow bands in each jaw, the inner teeth enlarged and prominent. Gill opening large, extending down to the fifteenth pectoral ray. Eye of medium size; pupil small, circular. Nostril single, without tube or raised rim.

Dorsal beginning above base of pectoral; dorsal and anal joined to caudal for 0.25 its length; caudal slender of 8 rays; upper lobe of pectoral composed of 26 rays, lower lobe of 7 rays, the 4 upper rays of lower lobe exserted, reaching vertical from a short distance behind gill slit. Disk small, under posterior margin of eye. Vent close behind disk.

Body and head stippled with dark brown angular dots; abdomen dark; in life faintly tinged with light red.

Careproctus opisthotremus, new species. (Fig. 23.)

Type 50 mm. long, from station 4780 between Petrel Bank and Agattu Island, Bering Sea; depth 1,046 fathoms.

Head 30 hundredths of length without caudal; depth 17.5; eye 5; snout 8; maxillary 13; gill opening 9; interocular width 9; width of head 16; depth of head 16; disk 8; distance disk to tip of mandible 15; to vent 12; to front of anal 20.

Head depressed, broad, flat above; cheeks vertical; occiput not elevated; snout short, depressed, and blunt, not projecting beyond mouth; mouth large, maxillary reaching vertical from behind posterior margin of pupil; teeth simple, short, and strong; eye small, a little shorter than snout; gill slit extending down in front of 6 pectoral rays; nostril single, in a short tube in front of eye.

Dorsal beginning above opercular flap; anal beginning under tenth dorsal ray; dorsal and anal joined to caudal for nearly 0.33 its length; pectoral inserted very low, its upper ray well below level of eye; upper lobe of pectoral reaching anal, lower lobe composed of 5 rays and reaching midway

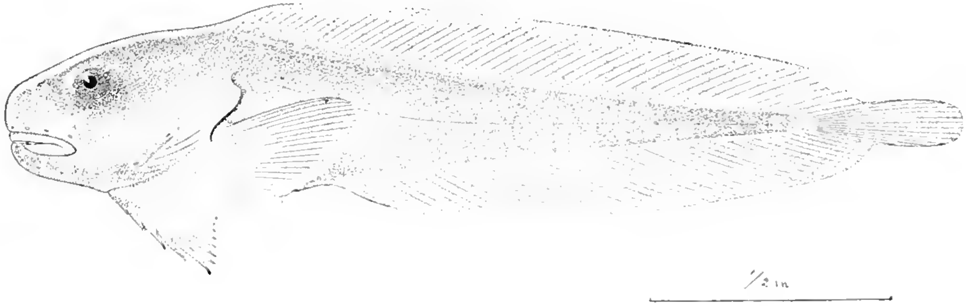


FIG. 23.—*Careproctus opisthotremus*, new species. Type.

between disk and vent. Disk well developed, about equal to snout; distance from tip of lower jaw to disk 2 in head, from disk to anal fin $1\frac{1}{2}$. Vent far back, nearer anal fin than ventral disk.

Integument gone; body apparently flesh colored in life.

This species has the flat, depressed head of *C. melanurus*, but it differs from the latter in the large gill slit, the position of the vent, and in minor characters. Only the type known.

Careproctus attenuatus, new species. (Fig. 24.)

Type 37 mm. long to base of caudal, from station 4781 between Petrel Bank and Agattu Island; depth 482 fathoms.

Head 26 hundredths of length without caudal; depth 17.5; eye 5; snout 7; interocular width 6; gill opening 4; maxillary 11.5; ventral disk 7; distance disk to tip of mandible 14; to vent 7; to front of anal 15. Dorsal about 48; anal 40; pectoral injured, with 30 or more rays.

FIG. 24.—*Careproctus attenuatus*, new species. Type.

Body slender; head depressed, broad; width of head equal to depth of head; top of head flat, sloping gradually to the deep truncate snout; snout not overlapping the mouth; cheeks vertical; mouth horizontal; maxillary reaching vertical from front of pupil; teeth trilobed, in 7 oblique rows in the half of each jaw; nostril single, in a short tube in front of eye; gill opening above base of pectoral, 0.6 diameter of eye; opercle extending in a narrow process over middle of gill slit.

Origin of dorsal above tip of opercular flap; dorsal rays slender; anal similar to dorsal; last rays of dorsal and anal joined to caudal for about 0.33 its length, the caudal injured; pectoral notched, the lower lobe composed of 6 rays and reaching vent, the upper ray inserted immediately below level of pupil. Disk small, situated midway between tip of lower jaw and origin of anal fin Vent midway between disk and anal. Body uniform pale color; abdomen and gill cavity black; tinged with light red in life.

In charactei of teeth and gill opening this species resembles *C. ectenes;* it is readily distinguished from the latter by the shape of the head and snout and the black peritoneum.

Only the type taken.

Careproctus cypselurus (Jordan & Gilbert).

One specimen, 186 mm. long, from station 4797, off the southern coast of Kamchatka; depth 682 fathoms.

Head 23.5 hundredths of total length without caudal; depth 23; exposed portion of eye 4.5; interocular widtn 13; snout 8.5; width of cleft of mouth 14; maxillary 12; width of head 16; depth of head over center of disk 17.5; length of gill slit 7.7; diameter of disk 5, distance from disk to tip of mandible 7.5· to front of anal 21; length of caudal 14 Dorsal 59; anal 55; pectoral 33. Vent at posterior edge of disk. Teeth acute, a few with small cusps; arranged in very numerous short oblique rows.

The genus *Prognurus* Jordan and Gilbert, based on the present species, is distinguished from *Careproctus* solely by the cleft caudal fin. But in species discovered by the *Albatross* in the northwest Pacific in 1906, this condition passes insensibly into the ordinary truncate and rounded form. The group seems not to be tenable, and the name is here withdrawn.

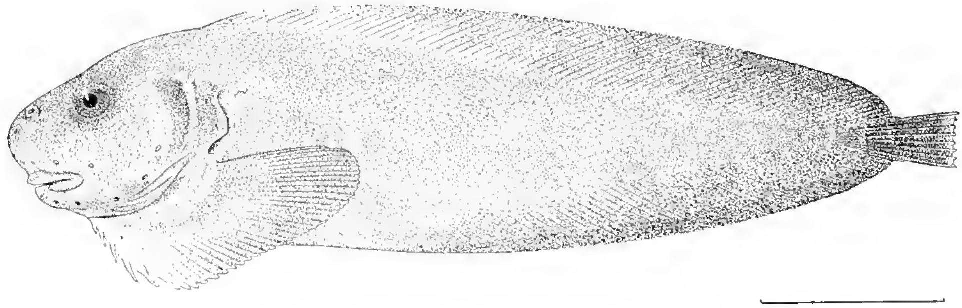


FIG. 25.—*Careproctus furcellus*, new species. Type.

Careproctus furcellus, new species. (Fig. 25.)

Type 130 mm. long, from station 4781, between Petrel Bank and Agattu Island, Bering Sea; depth 482 fathoms.

Head 27.5 hundredths of length without caudal; depth 27; exposed portion of eye 6.2; interorbital width 14; length of snout 8.5; width of cleft of mouth 14; maxillary 12.5; width of head 17; depth of head over center of disk 20; gill slit 9; disk 6; distance disk to tip of mandible 8; to front of anal 24. Dorsal 62; anal 57; pectoral 36.

Body shorter than in *C. cypselurus.* Head broad and flat between the eyes; snout deep, bluntly rounded, projecting slightly over mouth; mouth broad; maxillary extending to vertical from middle of pupil, 2½ in head; teeth in short very oblique series, slender, some with small cusps which give them an arrow-shaped appearance; about 25 series in half of upper jaw; gill opening entirely above base of pectorals, a little larger than eye; eye moderate, pupil oval; nostril in a short tube in front of eye.

Dorsal beginning above tip of opercular flap; dorsal and anal joined to caudal for 0.4 its length; caudal emarginate, nearly truncate when spread, less forked than in *C. cypselurus;* lower pectoral lobe little marked, the lower 6 or 7 rays thickest and with exserted tips, but the longest protruding but little beyond the tips of the rays above them. Disk moderate, its anterior edge under pupil. Vent close behind disk.

Color in life: Rose-red, lighter on belly and under side of head; skin everywhere dusted with fine dark points; gill cavity, abdomen, and pectorals dusky; posterior part of the body, dorsal, anal, and the caudal black.

This species differs from *C. cypselurus* in the length of body, size of eye, ventral disk, and gill opening, and in the much shallower caudal fork.

A second specimen, the cotype, was taken at station 4781.

ELASSODISCUS, new genus (Cyclogasteridæ).

Closely allied to *Careproctus* but differing in the greatly reduced and imperfect condition of the ventral disk, in which character it represents a further step toward the total loss of the ventral fins. Teeth tricuspid, in oblique series. Pseudobranchiæ absent. Branchiostegals 6. Pectoral fin notched. Nostril single. Ventral disk rudimentary, the rays absent, the disk represented by a very small semicircular fold of skin hidden within a pit, one end of the fold protruding papilla-like from the pit; the fold is free from the pelvic girdle but connected with it by strands of connective tissue; pelvic girdle wholly concealed, consisting of two vertical cartilaginous plates. Gills $3\frac{1}{2}$, no slit behind fourth arch, the other slits contracted, with only a portion of the horizontal limb free. Pyloric cæca short, in a single series, 12 in number. Vertebræ 75.

Type *Elassodiscus tremebundus*, new species.

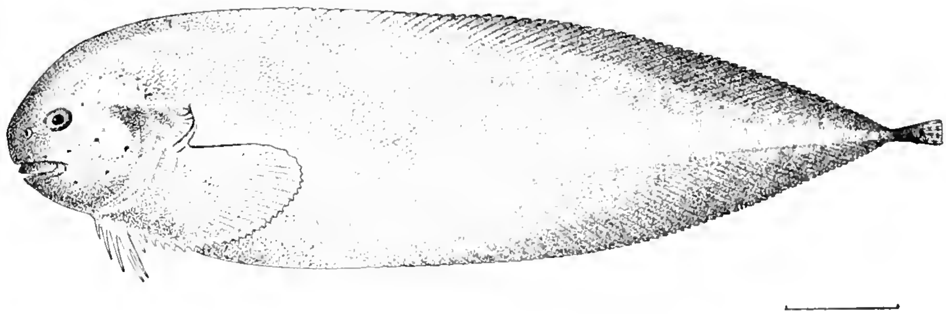


FIG. 26.—*Elassodiscus tremebundus*, new species. Type.

Elassodiscus tremebundus, new species. (Fig. 26.)

Type 215 mm. long, from station 4797, off Avatcha Bay, Kamchatka; depth 682 fathoms.

Head 23 hundredths of length without caudal; depth 26; eye 3.7; interocular space 11; width of head 16.5; depth of head at occiput 21; snout 7; gill opening 7; distance from ventral pit to tip of mandible 10; to vent 4; to front of anal 18. Dorsal 63 to 65; anal 58 to 60; pectoral 32 to 34; fins counted in dissected cotypes.

Body compressed, deep. Head wide and deep; occiput swollen; interorbital space flat and broad; snout short and deep, slightly projecting; mouth broad, the width between angles more than half head; maxillary extending to vertical from posterior margin of eye, $2\frac{1}{2}$ in head; teeth strong, broad, and triangular, evidently but weakly trilobed, arranged in about 10 or 11 oblique series in the half of each jaw; nostril single, in a prominent tube in front of eye; pupil large, round. Gill slit extending down to the upper pectoral ray.

Origin of dorsal over base of pectoral; origin of anal under eighth dorsal ray; anteriorly the dorsal and anal fins are enveloped in a thick gelatinous tissue; both are high, the longest ray in each fin equal to distance from tip of lower jaw to vent, 1.06 in head; dorsal and anal joined to caudal for 0.25 its length. Caudal broad, truncate, sometimes slightly concave, of 8 rays. Upper ray of pectoral on a level with the lower edge of eye, notched, the upper lobe composed of 27 rays, reaching slightly past front of anal, 1.5 in head; lower lobe of 5 rays, reaching a short distance past vent. Ventral disk as described for the genus.

Skin thick, opaque, a single pore near upper end of gill slit, the lateral line otherwise absent.

Color in life translucent, thinly flushed with rose-red, the red due in part at least to blood vessels; lips and gill cavity dusky, the marginal half of the dorsal and anal fins posteriorly and the caudal black; the basal parts of dorsal and anal more translucent beneath the black.

A fine large species, reaching a length of 9 inches. Numerous cotypes were taken with the type at station 4797, off Avatcha Bay, Kamchatka; depth 682 fathoms.

Paraliparis dactylosus Gilbert.

One specimen 94 mm. long, from station 4781, between Petrel Bank and Agattu Island; depth 482 fathoms; the species hitherto known only from the type taken in Monterey Bay.

Head 21.5 hundredths of length without caudal; depth 17; interocular width 8; depth of head 17; width of head 13; eye 5.2; snout 6; gill opening 5; maxillary 9.5; distance from tip of lower jaw to vent 12; from vent to anal fin 17; upper lobe of pectoral 14; lower lobe of pectoral 15; caudal 8.

Maxillary reaching vertical from posterior edge of pupil. Gill opening extending down to fourth pectoral ray. Teeth in narrow bands, weakly trilobed. Vent under posterior edge of preopercle.

Upper edge of pectoral on a level with the lower margin of the orbit; pectoral deeply notched; upper lobe composed of 20 rays and reaching past front of anal fin; lower lobe composed of 6 exserted rays, slightly longer than upper lobe; the two lobes connected by 7 widely spaced rays. Dorsal and anal connected with the narrow caudal for nearly 0.33 its length.

In this specimen and in the type of *dactylosus* the teeth are in moderate bands, the outer teeth smaller, in about 7 or 8 oblique rows in the half of each jaw. Pyloric cæca 18, short, about 0.5 eye.

In life red, the vertical fins posteriorly black.

NECTOLIPARIS, new genus (Cyclogasteridæ).

Ventral disk absent. Vent far forward under the head, in front of pectoral. Pectoral divided. Teeth simple, in narrow bands in each jaw. Pseudobranchiæ absent. Branchiostegals 5. Gill opening restricted to a small slit in front of pectoral. A pelagic genus related to *Paraliparis* but differing from it and the other genera of the family in having 5 branchiostegals and the gill slit restricted to the front of the pectoral.

Type *Nectoliparis pelagicus*, new species.

Nectoliparis pelagicus, new species. (Fig. 27.)

Type 34 mm. long, from station 4785, between Attu and Medni Islands; at an intermediate depth of 300 fathoms.

Head 25 hundredths of length without caudal; depth 22; eye 7.5; snout 6; pectoral 12; caudal 13; distance from tip of lower jaw to vent 13. Dorsal 53; anal 48; pectoral 19; caudal 6. Fin counts are from cotypes.

Head moderate; occiput not swollen, snout short, blunt, not overlapping the mouth; jaws equal; maxillary reaching vertical from front of pupil. Nostril single, in a short tube in front of eye. Teeth small, conical, in narrow bands composed of two or three rows of irregularly placed teeth. Opercular flap bound down and hidden beneath the skin; gill opening a small slit in front of the upper 14 pectoral rays.

Origin of dorsal slightly behind base of pectoral; dorsal and anal joined to caudal for nearly 0.5 its length; pectoral divided into 2 wholly distinct lobes, which are not even joined by free membrane; upper lobe reaching nearly to anal fin, composed of 13 or 14 well-developed rays and 2 or 3 rudimentary rays widely spaced but not quite bridging the gap between the two lobes; lower lobe composed of 3 or 4 rays, short, variable in length in the cotypes, sometimes as long as the upper lobe. Vent far forward at the throat, well in advance of lower pectoral lobe and immediately behind edge of gill membrane; it is directed forward and concealed beneath a projecting ridge.

Body pale, covered with small, irregular-shaped dark spots; epidermis on head and posterior 0.66 of body with the same kind of spots; caudal unmarked; abdomen, gill cavity, and mouth black.

This species appears to be common in the intermediate depths of Bering Sea and the northern part of the Okhotsk Sea.

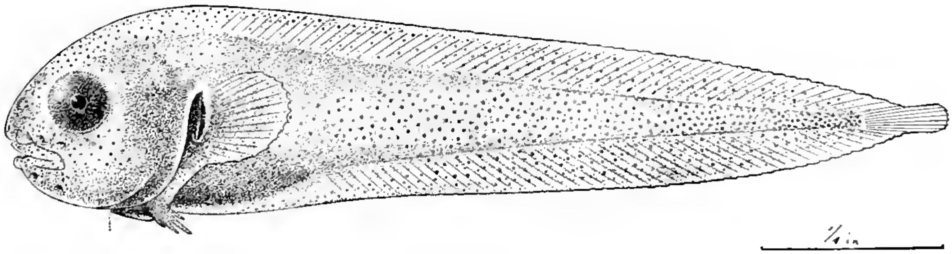


FIG. 27.—*Nectoliparis pelagicus*, new species. Type.

LIST OF STATIONS.

Stations	Latitude.				Longitude				Depth.
	°	′	″		°	′	″		*Fathoms.*
4765	53	12		N	171	37		W	Int 300
4767	54	12		N	179	7	30	E	Int 300
4781	52	14	30	N	174	13		E	Int 300
4785	53	20		N	179	33		E	Int 300
4800	49	06		N	153	06		E	Int 300

ACANTHOLIPARIS, new genus (Cyclogasteridæ).

Ventral disk absent. Pectoral fin broad, not notched. Nostril single. Teeth simple. Pseudobranchiæ absent. Branchiostegals 6. Operculum with its ventral and posterior arms developed as strongly projecting spines. Gill flap supported by the posterior arm of the suboperculum, developed as a slender bony rod crossing the flap at its middle. A deep-sea genus, differing from all other genera of the family in the spinous condition of the opercle.

Type *Acantholiparis opercularis*, new species.

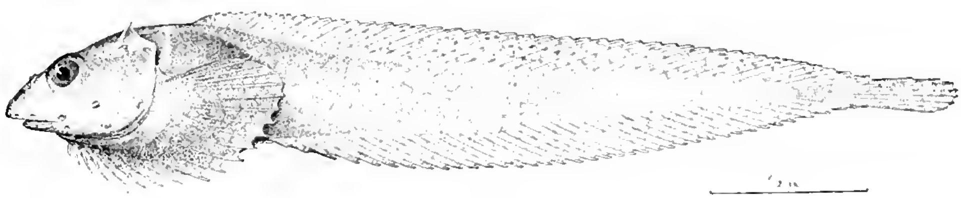


FIG. 28.—*Acantholiparis opercularis*, new species. Type.

Acantholiparis opercularis, new species. (Fig. 28.)

Type 76 mm. long, from station 4797, off Staritschkof Island, east coast Kamchatka; depth 682 fathoms.

Head 23 hundredths of length to base of caudal; depth 14; eye 4.5; snout 7; interocular width 9; width of head 18; depth of head 13; distance vent to tip of mandible 17; to front of anal 15; length of pectoral 17. Dorsal 45; anal 39; pectoral 26.

Body slender; head broad, depressed, flat above; snout flat, projecting a little over the broad mouth; lower jaw included; maxillary reaching vertical from posterior margin of pupil; nostril single, in a slender tube; teeth fine, conical in narrow bands in each jaw; gill opening small, restricted to the area above the pectoral fin.

Dorsal beginning a short distance behind pectoral; anal beginning under sixth dorsal ray; dorsal and anal joined to caudal for 0.25 its length; caudal slender, 1.2 in head, composed of 10 rays. Pectoral broad, not notched, the rays progressively shortened, the anterior rays free nearly to base; longest pectoral rays reaching to opposite origin of anal. Vent about midway between tip of lower jaw and anal fin.

Color dusky, paler posteriorly; abdomen, pectorals, interorbital space, snout, and the lower part of the head darker; in life dusky reddish throughout.

Three specimens were taken, one from station 4761, off the Shumagin Islands, depth 1,973 fathoms; the other two from station 4797, off Staritschkof Island, Kamchatka, depth 682 fathoms.

BATHYMASTERIDÆ.

Bathymaster signatus Cope.

Many specimens were examined, averaging about 30 cm. long. All were similarly colored in life, as follows: Light olive-brown, becoming whitish on belly and posterior part of mandibles; a narrow yellow streak on anterior orbital rim, a second along entire preorbital border, a third along edge of gill membrane; mucous pores on head bright scarlet, including the series along preorbital border, 3 or 4 on preopercle and 3 on opercle in a horizontal series on level of eye; gill membranes mesially blackish blue; dorsal brownish on basal part, light straw-yellow on marginal portion, a black blotch always present on anterior rays; caudal colored like dorsal; ventrals, anal, and lower pectoral rays blackish blue; upper pectoral rays with the distal half light yellow.

In a specimen 248 mm. long to base of caudal, the head is 29.5 hundredths of the length; diameter of eye 7.5; interocular width 5; length of maxillary 14; distance from nape to front of dorsal 5; length of gill-raker 2; depth of caudal peduncle 7; length of caudal 16.5.

Series of canines in jaws very strong, the symphyseal band narrow.

List of Stations.

Stations.	Latitude	Longitude	Depth.
	° ′ ″	° ′ ″	*Fathoms.*
4779	52 11 N	170 57 W.	54–56
4792	54 36 15 N	166 57 15 E.	72

Specimens taken as above on Petrel Bank and the Komandorski Plateau.

Bathymaster cæruleofasciatus, new species. (Fig. 29.)

Type 235 mm. long, from Agattu Island, Aleutian chain.

Differing from *B. signatus* in the coloration, the shorter, less numerous gill-rakers, the fewer pectoral rays, the smaller head with maxillary longer in proportion, the smaller eye, smaller teeth, deeper caudal peduncle, and more anteriorly inserted dorsal fin.

Measurements of type in hundredths of length without caudal: Length to base of caudal 209 mm.; length of head 28 hundredths; length of snout 7; diameter of eye 6; length of gill-raker 1; width of head 14.5; interocular width 4; length of maxillary 15; distance from nape to front of dorsal 6.3; from snout to front of dorsal 23.5; from snout to ventrals 23.5; from snout to anal 45; depth of body 19; depth of caudal peduncle 8.5; length of pectoral 20; length of ventral 12.5; length of caudal 13; longest dorsal ray 12; longest anal ray 8.5.

Dorsal 49; anal 36; pectoral 18; pores in lateral line 98.

Interorbital space narrow, gently rounded; snout sharp, the jaws equal, the lips thick; mouth gently oblique, the maxillary extending beyond vertical from posterior rim of orbit for a distance equaling about half the diameter of the pupil; upper edge of maxillary received within a groove below the preorbital, with the exception of the posterior part, which is free; symphysis of mandible with a broad band of villiform teeth which is bordered in front and behind by a series of strong canine-like teeth; the band rapidly narrows laterally, the anterior series disappears, and the posterior series of enlarged teeth is continued laterally, at first accompanied by a single row of minute teeth, and finally alone; upper jaw anteriorly with a broad band of villiform teeth, with an anterior series of well-spaced canines and a few slightly enlarged teeth mesially in the posterior row; the villiform band is narrowed laterally, but accompanies the series of canines throughout. Vomerine and palatine teeth in broad bands, none of them specialized. All the teeth show a tendency to form one or two minute cusps midway of the length, but these are never well developed.

Pores in head numerous, small, arranged as in *B. signatus*. Anterior nostril in a short tube; the posterior a short slit above front of eye. Gill-rakers very short, 5 above angle and 12 below on outer arch, the longest when depressed covering little more than one interspace.

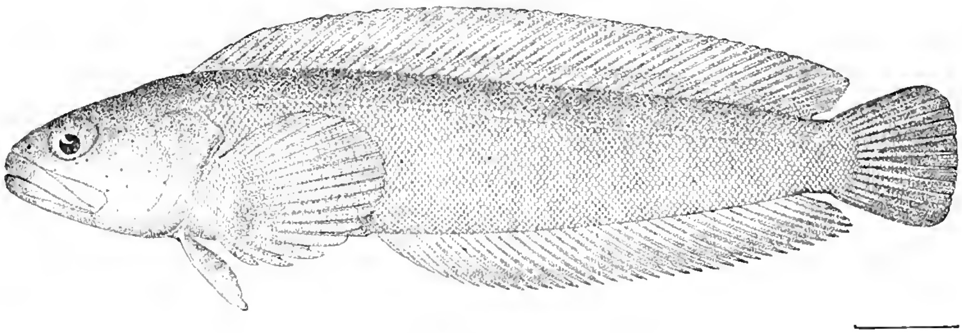


FIG. 29.—*Bathymaster cæruleofasciatus*, new species. Type.

Scales strongly ctenoid, much rougher than in *B. signatus*, covering the entire body with the exception of a narrow streak on median line of nape; series of smaller scales accompany basal portions of dorsal, caudal, and pectoral rays, those on caudal extending beyond middle of fin; ventrals and anal scaleless. Distance of lateral line from dorsal profile less than two-fifths its distance from lower profile; it ceases on middle of length of caudal peduncle.

First two dorsal rays simple and not articulated, the succeeding rays branched finely on distal fourth; anal rays similar to dorsal, but thicker, the membranes cleft, leaving the distal one-third to one-half of each ray free; caudal broad and short, the margin but little convex; the first 3 ventral rays profusely branched and closely connected, forming a thickened lobe in which the outlines of the spine and the 3 rays are not externally apparent; the third ray is the longest, the fourth and fifth shorter, distinct; lower pectoral rays thickened at tips.

Color in life: Warm brown, the sides with irregular deep blue bars with cross-blotches of blue in coarse pattern; vertical fins largely blue, the anal with brownish markings, but without distinct pattern. No yellow or scarlet on head. In spirits, adults appear dark brown on body and fins, much darker in tint than *B. signatus;* young specimens are pale in color, the sides crossed by about 10 broad dark bars which extend on dorsal and anal fins; a dark blotch occurs on anterior dorsal rays in the young, but this invariably disappears, while in *signatus* it persists in adults; in later stages the whole body becomes first an olive-brown, the bars persisting longest along base of dorsal, where they appear as dark spots.

Some individuals retain the coloring of the young longer than others; in our material, those from the tide pools assume the adult coloration sooner than those of equal size from greater depths.

The type was secured with hand line at Agattu Island. Others were obtained at Agattu, Medni, and Bering Islands, and at the following stations on Petrel Bank:

LIST OF STATIONS.

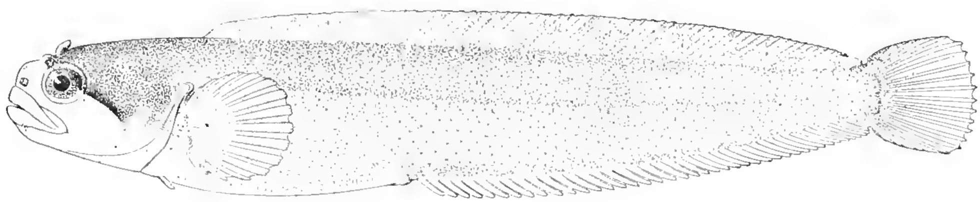
Stations.	Latitude.	Longitude.	Depth.
	° ′	° ′	*Fathoms.*
4777	52 10 N.	179 49 E.	43–52
4778	52 12 N.	179 52 E.	33–43

BLENNIIDÆ.

GYMNOCLINUS, new genus.

Body moderately elongate, compressed, naked. Teeth on jaws and vomer, none on palatines. No lateral line. From 1 to 3 fleshy tubercles on median line of interorbital area and snout. Gill membranes connected, free from the isthmus; branchiostegals 6. Dorsal fin of flexible spines anteriorly, of stiff spines posteriorly; no anal spines; ventral jugular, consisting of a single ray, no spine; pectorals large, rounded, more than half as long as head. Apparently belonging to the *Bryostemma* group of genera, but with no close relationships.

Type *Gymnoclinus cristulatus*, new species.



¼ in.

FIG. 30.—*Gymnoclinus cristulatus*, new species. Type.

Gymnoclinus cristulatus, new species. (Fig. 30.)

Type 37 mm. long, from Nikolski, Bering Island.

Head 25 hundredths of length to base of caudal; depth 19; eye 5.5; maxillary 11; snout 5.5; pectoral 15. Dorsal LXI; anal 43; pectoral 14.

Body compressed; head short; snout deep, abruptly decurved; mouth oblique, maxillary reaching vertical beyond posterior margin of pupil; a single series of widely spaced, conical teeth on jaws and vomer, none on palatines; a fleshy papilla midway between eyes, its height equal to diameter of pupil, preceded by one or two smaller ones. Nostril in a slender tube.

Origin of dorsal above base of pectoral; origin of anal nearer tip of snout than base of caudal by a distance equal to the diameter of the eye; dorsal and anal joined to base of caudal; caudal slightly rounded; pectoral large, rounded; ventrals of a single ray. Vent immediately in front of anal fin.

Color light olive, pale on snout, lower half of head, and abdomen; dorsal with 11 vertical pale bars, which extend a short distance on body; a series of 9 small pale spots along the middle of the sides, the ground color intensified in front of each spot; a dusky spot on the middle of the base of the pectoral; a dark streak running obliquely across the cheek from the edge of the preopercle through the eye and thence nearly vertically across top of head at front of eyes, separating the paler portion of the head from the ground color above. Rare in the tide pools of Bering and Medni Islands.

Pholis dolichogaster (Pallas).

Taken at Medni and Bering Islands and at Petropavlovsk, Kamchatka; not abundant.

Pholis ornatus (Girard).

Vancouver Island (Union Bay), Unalaska, Atka, Agattu, Attu, Medni, and Bering Islands; abundant at all shore stations as far west as the Commander Islands; not known from Kamchatka or the Kuriles.

Alectrias alectrolophus (Pallas).

Specimens were taken at Unalaska, Attu, Medni, and Bering Islands, Petropavlovsk, and at stations 4777 and 4778 on Petrel Bank; depth 52 and 43 fathoms.

The interorbital crest does not develop uniformly in this species. in a specimen 85 mm. long from Unalaska the crest is undeveloped; normally the crest is fully developed in specimens of this length.

ALECTRIDIUM, new genus (Blenniidæ).

Body compressed, with embedded scales posteriorly; lateral line absent. Teeth on jaws, vomer, and palatines; the teeth near the tip of the jaws somewhat enlarged but scarcely caninelike. Gill membranes united, slightly connected with the isthmus, with a broad free fold behind; branchiostegals 5. Dorsal fin composed of flexible spines anteriorly, of rigid spines posteriorly; no anal spines; no ventral fins. Closely related to *Alectrias* but differing in the absence of the lateral line.

Type *Alectridium aurantiacum*, new species.

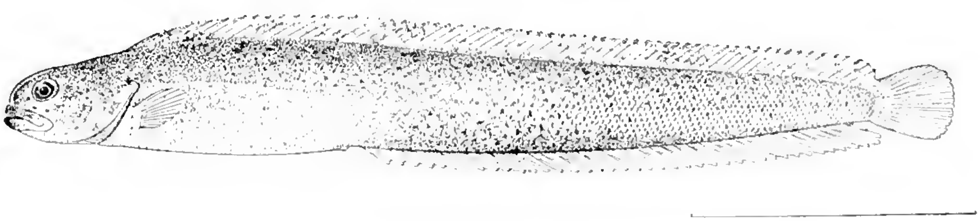


FIG. 31.—*Alectridium aurantiacum*, new species. Type.

Alectridium aurantiacum, new species. (Fig. 31.)

Type 83 mm. long, from Nikolski, Bering Island.

Head 15.5 hundredths of length without caudal; depth 13.5; eye 3; maxillary 6.2, snout 3.2; pectoral 5; caudal 10. Dorsal LXII; anal 43; pectoral 11.

Head and body compressed; interorbital and occipital region compressed, forming a sharp ridge; the ridge represented on the anterior part of the interorbital and the snout by a fold of skin or crest; mouth slightly oblique; lips thin; maxillary extending to vertical from posterior margin of eye. Scales small, present only on the posterior half of the body, embedded in the skin; lateral line absent; a series of pores around eye, extending backward to above opercular flap; another series along edge of preopercle; a few on top of head.

Origin of dorsal above base of pectoral; last spine shortened, connected to caudal; origin of anal nearer tip of snout than base of caudal by a distance equal to head and pectoral, the last ray connected for half its length to base of caudal; caudal rounded.

Color in life, orange chrome above, saturn red below; in alcohol, ochraceous, finely speckled with dark brown; a narrow black line sharply contrasted along edge of opercle and branchiostegal membrane.

Only the type taken.

Anoplarchus atropurpureus (Kittlitz).

Unalaska, Atka, Agattu, and Attu Islands; abundant.

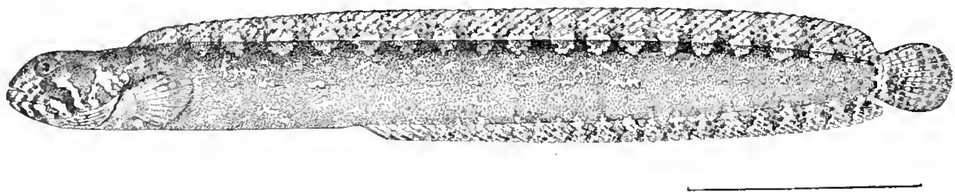


FIG. 32.—*Anoplarchus insignis*, new species. Type.

Anoplarchus insignis, new species. (Fig. 32.)

Type 102 mm. long, from Attu Island.

Head 14.3 hundredths of length without caudal; depth 10.5; eye 2.7; maxillary 5.5; pectoral 6.2. Dorsal LXI; anal 45.

Body slender; head with a low crest; jaws equal; maxillary extending to vertical from posterior margin of pupil; teeth in narrow bands on the jaws, vomer, and palatines, the outer series on the jaws enlarged, largest anteriorly.

Origin of dorsal above base of pectoral; origin of anal nearer tip of lower jaw than base of caudal by a distance equal to the head and 0.5 pectoral; dorsal and anal only slightly connected to the caudal; caudal rounded; pectoral acute, of 9 rays.

Posterior half of body with circular embedded scarcely imbricated scales; pores of lateral line minute, but distinct throughout its course.

Color olive-brown, lighter below; a series of 19 irregular V-shaped grayish spots on the back along the base of the dorsal fin; a series of irregular pale spots along middle of sides; a dark spot at origin

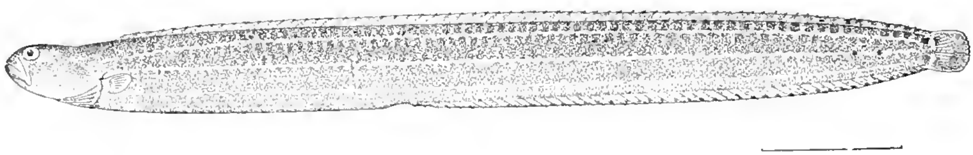


FIG. 33.—*Xiphistes versicolor*, new species. Type.

of dorsal; dorsal and anal pale, spotted, and variegated with brown; caudal finely crossbarred; pectoral pale; cheeks, lips, and chin crossbarred; a narrow black line along edge of gill flap.

This species differs from *A. atropurpureus* in the more numerous dorsal spines and anal rays, in the origin of the anal fin, and in the more variegated coloration.

Seventeen specimens besides the type were taken at Attu Island.

Xiphistes versicolor, new species. (Fig. 33.)

Type 175 mm. long, from Attu Island, Bering Sea.

Head 11 hundredths of length without caudal; depth 9.8; eye 1.7; snout 2; maxillary 3.7; distance snout to dorsal 11.5; length of pectoral 2.7. Dorsal LXXV; anal II, 49. In five cotypes the fin rays are as follows: Dorsal LXXVII, LXXVI, LXXV, LXXV, LXXIV; anal II-51, II-50, II-50, II-50, II-49.

Body eel-shaped; head short, slender; mouth very oblique; maxillary extending to vertical from pupil; teeth strong, conical, the outer series enlarged. Lateral lines as in *Xiphistes ulvæ*, the upper branches of the upper lateral line extending upon the dorsal membrane, the lower line on sides not connected with the abdominal line; 5 lines diverge downward and backward from lower border of orbit.

Color in life extremely variable; one specimen dark brownish olive above, dull olive on under parts, no mottlings; a series of light spots at base of dorsal posteriorly, and a series of 8 or 9 small white spots along middle of sides posteriorly, each with a small dark spot before and one behind it; anal marked posteriorly with reddish brown and yellowish bars; a narrow dark streak from tip of snout through eye and a short distance beyond. A second specimen is uniform brownish orange above, orange below, without darker mottlings or light areas at base of dorsal; the bars of light and of reddish orange on posterior part of anal are conspicuous, as are the ocellated spots on lateral line. A small specimen is finely mottled above and on sides with blackish and light yellowish, the lower part of sides clear yellow; dorsal fin mottled like the back; anal anteriorly yellow like the belly, posteriorly with faint reddish and yellowish bars; caudal with a narrow basal bar, distally more or less mottled; pectoral yellow; cheeks yellow, with two or three small dark spots; a rather poorly defined dark streak forward from eye to tip of snout, and one horizontally backward from eye.

This species resembles *Xiphistes ulvæ* but differs in having 2 anal spines and a shorter head; it differs from *Xiphistes chirus* in the number of dorsal spines and the character of the lateral lines.

Nine specimens from Agattu, 8 from Attu.

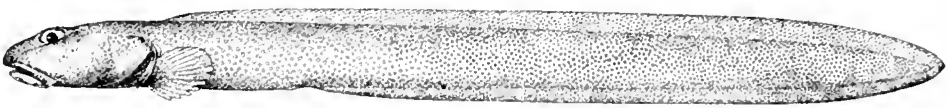


FIG. 34.—*Lycodes camchaticus*, new species. Type

Opisthocentrus ocellatus (Tilesius).

Very abundant at Petropalovsk.

The spots on dorsal fin are never set off very sharply and conspicuously; at the upper edge of each spot is a crescent-shaped light area which is bright orange in life. In adults the light areas on sides are yellow or orange yellow in life, the pectorals and caudal yellow, the anal yellow or dusky yellow, with a white margin and an orange intramarginal line.

SCYTALINIDÆ.

Scytalina cerdale Jordan & Gilbert.

One specimen from Agattu Island. Length 53 mm.

The only other locality from which this species is recorded is Neah Bay, Wash., where it was found to be common.

ZOARCIDÆ.

Lycodes camchaticus, new species. (Fig. 34.)

Type 246 mm. long, from station 4797, off Avatcha Bay, east coast of Kamchatka; depth 682 fathoms.

Measurements in hundredths of total length: Length of head 16.5; depth of body 7; width of head at cheeks 9.5; width at opercles 6; interocular width 1.5; longitudinal diameter of eye 3.2; length of snout 4.8; length of maxillary (measured from tip of snout) 7; distance from tip of snout to nape 11.3; from nape to front of dorsal 7.2; from tip of snout to ventrals 13; to front of anal 32.5; length of ventrals 2; length of pectorals 7; height of gill slit 6.

Slender, of nearly uniform depth throughout, the body everywhere a little compressed; opercular region compressed, like the body, the occiput depressed and flat, the cheeks greatly swollen, the snout depressed, wider than deep. Mouth slightly oblique, the maxillary reaching the vertical from posterior border of orbit; teeth small, conical, none of them enlarged; those on premaxillaries in a single irregular series, within which near the median line, one or two supplementary teeth; those on mandible in a very short broad band; one or two teeth on head of vomer; a short single series on palatines, the premaxillary series shuts outside the mandibular band and also extends beyond it laterally. A series of wide slitlike pores on preorbital and mandible. The gill opening begins on the level of the eye and reaches a point in front of lower pectoral ray.

Scales small, without definite arrangement, continued on vertical fins and on basal half of posterior face of pectorals; they are more crowded on abdomen, and become reduced in size on nape and on upper half of opercle, the rest of head being naked.

Origin of dorsal above middle of pectoral; posterior line of occiput midway between front of eye and origin of dorsal. Ventrals very small, not reaching the line joining lower pectoral rays, this line midway between tip of snout and vent.

Color olive-brown, in life with greenish gilt in varying amount on top and sides of head and front face of pectorals; lower parts darker.

Three cotypes were taken at station 4797, with the type.

Bothrocara mollis Bean.

LIST OF STATIONS.

Stations.	Latitude	Longitude.	Depth
	° ′ ″	° ′	*Fathoms.*
4775	54 33 30 N.	178 44 E	584
4797	52 37 30 N.	158 50 E.	682

Bowers Bank, Bering Sea, and the vicinity of Avatcha Bay, east coast of Kamchatka.

GADIDÆ.

Eleginus navaga (Kölreuter).
Petropavlovsk.

Gadus macrocephalus Tilesius.
Unalaska.

Antimora microlepis Bean.

LIST OF STATIONS.

Stations.	Latitude.	Longitude	Depth.
	° ′ ″	° ′	*Fathoms.*
4771	54 30 N.	179 17 E.	426
4781...........	52 14 30 N.	174 13 E.	482
4797........	52 37 30 N.	158 50 E.	682

Bowers Bank, Bering Sea, and the vicinity of Avatcha Bay, Kamchatka.

MACROURIDÆ.

Macrourus acrolepis Bean.

LIST OF STATIONS.

Stations.	Latitude.				Longitude.				Depth.
	°	′	″		°	′	″		*Fathoms.*
4765	53	12		N.	171	37		W.	1,217
4767	54	12		N.	179	07	30	E.	771
4768	54	20	30	N.	179	09	30	E.	764
4771	54	30		N.	179	17		E.	426
4772	54	30	30	N.	179	14		E.	344–372
4774	54	33		N.	178	45		E.	557–584
4775	54	33	30	N.	178	44		E.	584
4797	52	37	30	N.	158	50		E.	652

Found abundant at suitable depths along the northern side of the Aleutian Islands and the east side of Kamchatka.

The first dorsal is unusually short in this species, II,9 and II,10 being the formulas most frequently met, II, 11 more rarely found.

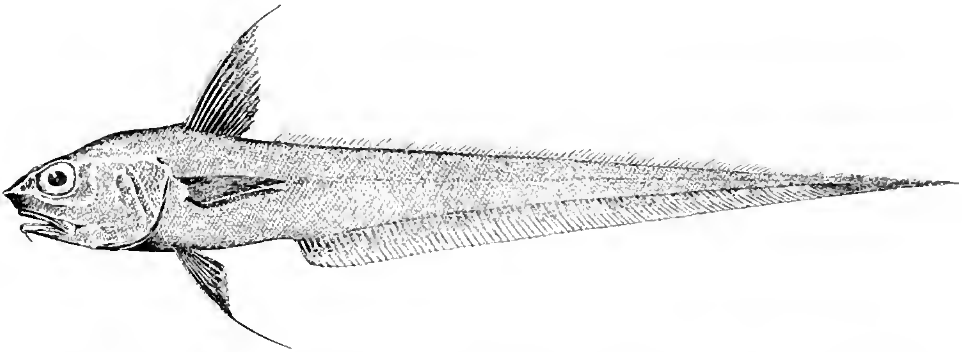


FIG. 35.—*Macrourus lepturus* Gill & Townsend. Type, from Albatross station 3604, south of the Pribilof Islands, depth 1401 fathoms.

Macrourus lepturus Gill & Townsend. (Fig. 35.)

The species is most closely related to *M. acrolepis*, but is unquestionably distinct. It differs from *acrolepis* in the smaller eye, wider interorbital, longer maxillary, longer ventrals, more numerous rays in the first dorsal, the more posterior position of the vent, and the thinner scales with lower less divergent ridges and lower spines.

First dorsal II, 12; pectoral 22; ventral 9. Orbit 4 to 4.33 in head; snout 3.66; interorbital width 4.5; length of maxillary 2.75; length of ventral 1 to 1.25; length of pectoral 1.75; length of second dorsal spine 1.33.

Teeth small, in narrow bands, none of them strongly specialized, the outer series in upper jaw very slightly enlarged.

Base of ventrals nearly midway between orbit and vent, the latter directly in advance of origin of anal. First dorsal inserted over base of pectoral; interval between dorsals equaling two-thirds base of first dorsal; second dorsal spine long, filamentous at tip, with 26 prickles, which begin a short distance above the base and become stronger distally.

LIST OF STATIONS.

Stations.	Latitude.			Longitude.			Depth.
	°	′		°	′		*Fathoms.*
4764	53	20	N.	171		W.	1,130
4765	53	12	N.	171	37	W.	1,217

Two specimens 375 and 550 mm. long, off Yunaska Island, Aleutian chain.

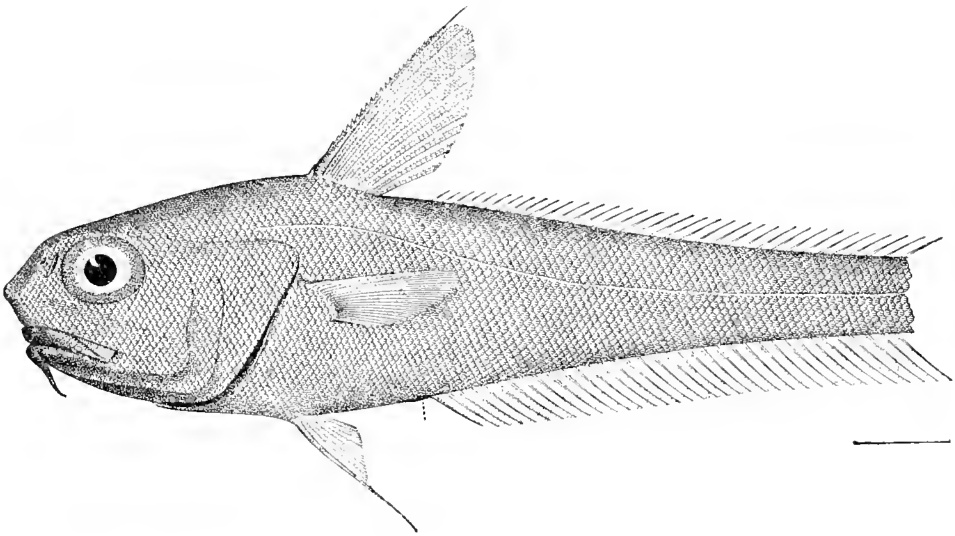


FIG. 36.—*Chalinura spinulosa*, new species. Type.

Macrourus cinereus Gilbert.

LIST OF STATIONS.

Stations	Latitude.				Longitude				Depth.
	°	′	″		°	′	″		*Fathoms.*
4767	54	12		N	179	07	30	E.	771
4768	54	20	30	N	179	09	30	E.	764
4771	54	30		N	179	17		E	426
4772	54	30	30	N	179	14		E.	344-372
4774	54	33		N	178	45		E.	557-584
4775	54	33	30	N	178	44		E	584
4797	52	37	30	N	158	50		E	682

Found at the same depths and in the same localities in Bering Sea with *M. acrolepis*, and even more abundant.

Chalinura spinulosa, new species. (Fig. 36 and 36a.)

Type 41 cm. long, from station 4797, off Avatcha Bay, east coast of Kamchatka; depth 682 fathoms.

Differing from all described species in having a very large eye, the diameter of which greatly exceeds interorbital width or the length of the short rounded snout.

Measurements in hundredths of body length, from tip of snout to anus: Length of body anterior to anus 115 mm.; length of head 70 hundredths; length of snout 18; length of maxillary 27; diameter of orbit 21; interorbital width 15; distance from orbit to angle of interior preopercular crest 22.5; depth at front of dorsal 56; length of barbel 12; distance from tip of snout to front of dorsal 78; length of base of first dorsal 17.5; length of interval between dorsals 9; distance from tip of snout to base of ventrals 75; length of second dorsal spine 56; longest pectoral ray 37; length of filamentous ventral ray 35.

First dorsal II, 9; pectoral 19; ventral 8; branchiostegals 6.

Head high, compressed, with vertical cheeks which bear no keels or ridges; snout short and high, nearly truncate, protruding but little beyond mouth; no ridge on preorbital, no projecting angles bearing rosettes of spines; mouth large, with lateral cleft, the maxillary extending slightly beyond vertical from posterior edge of pupil; teeth in premaxillaries in a moderate cardiform band, widest at symphysis, the outer series anteriorly of enlarged canines, these decreasing in size laterally and disappearing at middle of length of mouth; mandibular teeth cardiform, anteriorly in a narrow band with the inner series a little enlarged, laterally narrowing to a single irregular series. Gill rakers represented by 6 blunt tubercles on anterior arch. Preopercular margin nearly vertical, the angle only very slightly produced. Branchiostegals strong, 6 in number.

First dorsal inserted above base of pectoral; interval between dorsals very short, a trifle more than half length of base of first dorsal; second dorsal spine with a short filamentous tip, its anterior margin with rather coarse appressed spinelets, except a short distance at base and the filamentous tip; pectoral short, reaching slightly beyond front of anal fin; outer filamentous ventral ray reaching base of third or fourth anal ray; vent immediately in front of first anal ray.

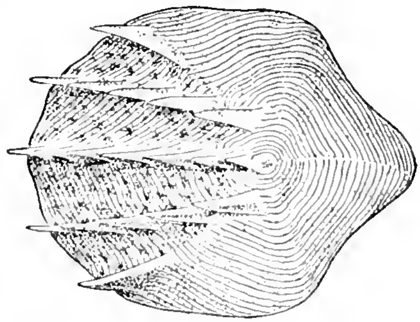


FIG. 36a.—*Chalinura spinulosa*, scale from above lateral line

Scales firm, adherent, those on middle of trunk with 5 strong diverging ridges bearing recumbent spines. About 8 scales in an oblique series between lateral line and base of first dorsal fin; lateral line forming a strong arch anteriorly.

Color dark brown, darker below; gill membranes, gill cavity, and mouth black.

Only the type taken.

The species is closely related to *C. altipinnis* Günther, taken by the *Challenger* at great depths off the coast of Japan. Günther assigns *altipinnis* to the genus *Coryphænoides*, despite the outer series of stronger teeth in the premaxillaries, and the fact that the heterodont dentition of *Chalinura* forms the only distinguishing characteristic of the genus.

Nematonurus clarki Jordan & Gilbert.

LIST OF STATIONS.

Stations	Latitude	Longitude	Depth
	° ′ ″	° ′ ″	*Fathoms*
4768	54 20 30 N.	179 09 30 E.	764
4774	54 33 N.	178 45 E.	557-584
4775	54 33 30 N.	178 44 E.	584

Numerous specimens taken as above on Bowers Bank in Bering Sea.

The length of the interval between the dorsal fins is less in *Bogoslovius* (*clarki*) than in the type of *Nematonurus*; but this is a most variable character among closely related species throughout this group and can not be accorded generic value. In no other respect does *Bogoslovius* differ from *Nematonurus*.

ATELEOBRACHIUM, new genus (Macrouridæ).

A remarkable pelagic form, distinguished by the strikingly pedunculated pectoral fins, and the filamentous first dorsal and ventral fins.

Body shaped like *Macrourus*, but short and deep. Barbel present, minute. Fine teeth in narrow bands in jaws, none on vomer or palatines. First branchial arch with a membranous fold; a wide slit behind fourth arch; gill rakers tuberclelike. Second dorsal spine and the succeeding rays elongate, filamentous, the last 3 shortened. Ventrals widely separated, of filamentous rays, the outer ray apparently detached. Pectoral inserted at the end of a long movable stalk, the base of which is slender, the tip widening into a kidney-shaped lobe, around the posterior margin of which the short rays are inserted.

Type, *Ateleobrachium pterotum*, new species. (Fig. 37.)

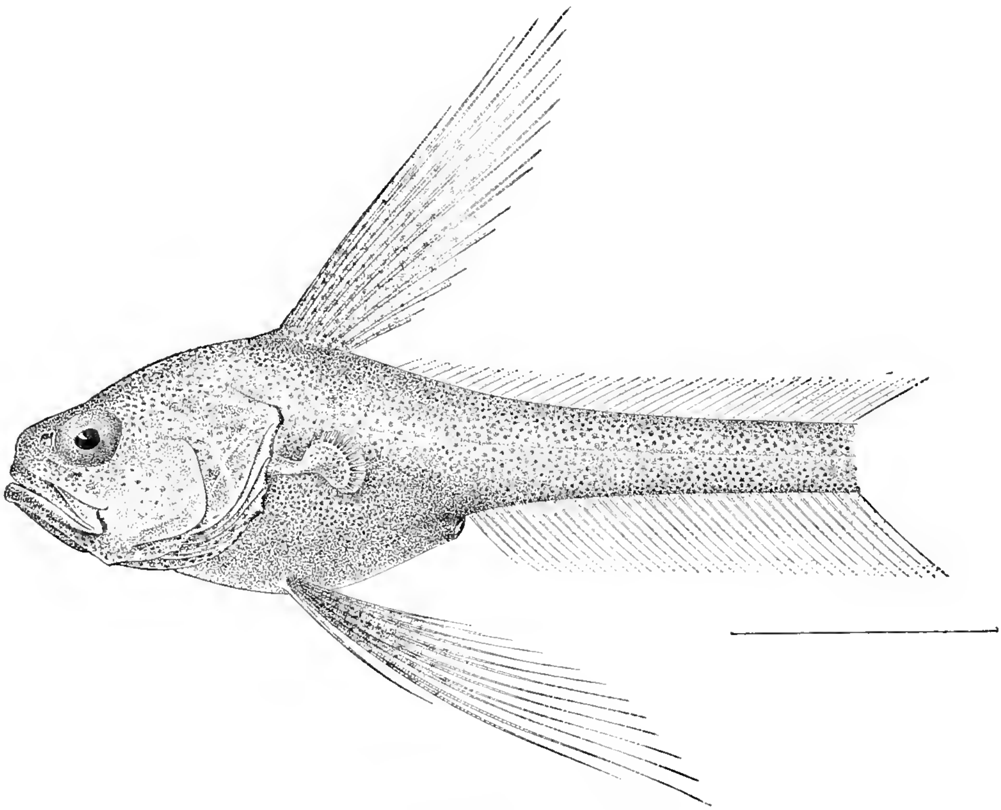


Fig. 37.—*Ateleobrachium pterotum*, new species. Type.

Ateleobrachium pterotum, new species.

Type about 90 mm. long, from station 4707, off Avatcha Bay, east coast of Kamchatka; taken with intermediate net hauled at 300 fathoms.

Measurements in hundredths of length from tip of snout to vent (22 mm.): Length of head 59; length of snout 12; diameter of eye 16; interorbital width 15; length of maxillary 28; depth at origin of dorsal 56; width of head 34; distance from tip of snout to front of dorsal 64; length of first dorsal base 19; interval between dorsals 7; distance from tip of snout to base of ventrals 70; length of brachial peduncle 21.

Head compressed, the nape high, cheeks vertical without projecting lateral ridges; mouth large, the maxillary reaching vertical from posterior margin of pupil. Opercle without evident spine. Barbel small.

First dorsal ray short, the following 6 rays produced and filamentous, their tips reaching middle of tail. Ventrals inserted slightly behind base of pectorals, the rays all filamentous, the longest nearly twice as long as the head. Pectoral rays short, equal, inserted along the strongly convex margin of the kidney-shaped lobe which terminates the stalk.

Color dark brown on the back, lighter on the sides; abdomen black.

Only the type taken.

PLEURONECTIDÆ.

Hippoglossoides elassodon Jordan & Gilbert.

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′ ″	° ′ ″	*Fathoms*
4786	54 51 30 N.	167 14 E.	54
4787	54 50 50 N.	167 13 30 E.	54-57
4795	52 46 50 N.	158 44 30 E.	48-69
4796	52 47 N.	158 43 E.	48

About the Komandorski Islands and off the east coast of Kamchatka

Lepidopsetta bilineata (Ayres).

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′ ″	° ′	*Fathoms*
4778	52 12 N.	179 52 E.	33-43
4786	54 51 30 N.	167 14 E.	54

Dredged on Petrel Bank and the Komandorski Plateau; taken with the seine at Unalaska, Nazan Bay, Atka Island, and in Avatcha Bay, Kamchatka.

Limanda aspera (Pallas).

Avatcha Bay, Kamchatka, and at station 4798, on the codfish banks on the west coast of Kamchatka (51° 37′ N.; 156° 21′ E.); depth, 25 fathoms.

Pleuronectes quadrituberculatus Pallas.

LIST OF STATIONS.

Stations.	Latitude.	Longitude.	Depth.
	° ′ ″	° ′ ″	*Fathoms.*
4795	52 46 50 N.	158 44 30 E.	48-69
4796	52 47 N.	158 43 E.	48

Seined in Avatcha Bay, Kamchatka, and dredged in shallow water outside the bay.

Liopsetta glacialis (Pallas).

Abundant in Avatcha Bay, Kamchatka.

Twenty-seven specimens were preserved, of which the majority are males, with the interorbital space covered with rough ctenoid scales, though these may be reduced in number; females have the interorbital naked, or with a few hidden cycloid scales. Pectoral fin in the male about two-thirds length of head; in females, half head.

Platichthys stellatus (Pallas).

Nazan Bay, Atka Island, and Avatcha Bay, Kamchatka.

SOUND AS A DIRECTING INFLUENCE IN THE MOVEMENTS OF FISHES

By G. H. Parker, S. D.
Professor of Zoology, Harvard University

SOUND AS A DIRECTING INFLUENCE IN THE MOVEMENTS OF FISHES.

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The detection of the direction of a sound by the human ear is not generally accomplished with great accuracy, especially when the source of the sound is placed symmetrically in reference to the two ears. In man the one sense organ concerned in these operations is the ear. In fishes there are at least three sets of organs that may be involved in like operations, the skin, the lateral-line organs, and the ear, for though the function of hearing has been denied to fishes by some recent workers, there seems to be sufficient evidence to warrant the conclusion that at least certain fishes hear. Whether, however, fishes respond to sounds in a directive way or not is a matter that, so far as I am aware, has never been subjected to experimental test. It is the purpose of this paper to discuss the directive influence of sounds on the movements of fishes, and it is believed that work such as this will throw light on the question of the temporary distribution of fishes in reference to such centers of sound production as are afforded by naval gun practice, etc.

In attempting to test the question of the directive influence of sounds upon the movements of fishes, experiments were first tried in a large floating cage anchored in open sea water, but it was soon found that the disturbances produced by the wind and the sunlight were too great to admit of conclusive work, and recourse was finally had to experiments conducted in running sea water indoors. These experiments were carried out in the Biological Laboratory at the Woods Hole Station of the United States Bureau of Fisheries.

The fishes were tested in a tank about 50 cm. wide, 60 cm. deep, and 100 cm. long. The tank was made of wood 3.5 cm. thick; on the inside its walls were painted black, its bottom white. At one end of the tank there was a controllable inlet of sea water and at the other end an outlet. When the water in the tank was high enough to flow out at the outlet it was within a few centimeters of the top. The tank stood on a strong table and its upper edge was provided with a low black curtain so that persons moving about the laboratory could not be seen by the fishes. The tank was illuminated by an incandescent electric light hung directly over its center and some feet above the level of the water, or by diffusely reflected daylight from a white ceiling above. At each end of the tank a cord was attached to the ceiling and from a hook on the end of the cord an iron ball was suspended, the whole device being so adjusted that when at rest the ball just touched the middle of the end of the tank. The ball, like the bob of a long pendulum, could be withdrawn from the end of the tank, and when released it would strike the end a blow that could be kept reasonably constant by a gauge to mark the point at which the ball was liberated. The ball weighed about 4,300 grams and was ordinarily released at such a point that it struck the end of the tank with a calculated velocity of 84 cm. per second; in other words, at the moment of impact with the end of the tank the ball had a momentum of about 361,200 C. G. S. units. This blow produced in the tank a low booming noise which was used as the stimulus for the fish. It probably affected the nerve endings of the skin, of the lateral-line organs, and of the ears of the fishes that were tested.

In experimenting with a given species of fish, five individuals were placed in the tank and allowed to remain there till they were thoroughly accustomed to their surroundings, often a matter of half a day or so. Then the current of water was shut off, and shortly afterwards the stimulus was applied by allowing the ball to fall once every 10 seconds against the end of the tank. This was continued for 50 blows, and between blows the interior of the tank was cautiously inspected from the middle of one side, and a record was made of the distribution of the five fishes by noting the number in the half of the tank at whose end the blow had been struck. This form of observation was facilitated by marking on the white bottom of the tank a transverse line that divided the area in halves and that could be used as a line of reference in deciding on the distribution of the fishes. After 50 trials had been made with blows delivered at one end of the tank, the ball was shifted to the cord at the other end of the tank and an equal number of blows was delivered at that end; the combination of the two sets of records thus obtained showed whether the fishes tended to approach the sound center or retreat from it. The whole operation was then repeated on five new individuals, and this process was kept up until reasonably constant results were obtained. In all, eight species of fishes were tested, and these fell more or less naturally into three classes.

The first consisted of those fishes that on stimulation tended to retreat from the region of sound production. They are well illustrated by the tautog (*Tautoga onitis*), whose reactions are summarized in the following table:

TABLE I.—DIRECTIVE RESPONSES OF TAUTOGA ONITIS TO SOUND.

Lot numbers.	Number of occurrences in a possible 250 in half of tank nearer sound.		Totals.
	West half.	East half.	
1–5	83	80	163
6–10	85	87	172
11–15	79	86	165
16–20	90	84	174
21–25	82	86	168
Grand total	...	.	842

The grand total of occurrences in a possible 2,500 in the half of the tank nearer the sound was 842, or 34 per cent.

In this table are recorded the reactions of 25 fishes in lots of 5 each. Each lot was subjected to 50 individual stimuli from the concussion of the iron ball against the end of the tank, and after each blow the number of individuals in the half of the tank next the sound center was recorded. The addition of these 50 records in the first lot of fishes (1–5) when the blows were delivered at what may be called the west end of the tank was 83; when the blows were delivered at the east end it was 80. Had all the fishes remained all the time in the half of the tank next the sound center, these records would have been 250 each. It is, therefore, quite clear that in both instances the fishes avoided to a considerable degree the half of the tank next the sound center, and this same feature, of course, appears when these records are added together. The same is true for the other four lots of fishes (6–10, 11–15, 16–20, and 21–25), and the grand total shows that out of a possible 2,500 records only 842, or rather less than 34 per cent, were from the half of the tank next the sound center. Had the fishes been indifferent to the direction of the sound, we should have expected 50 per cent of the records to have been from the half of the tank next the sound center and the same proportion from the other half; had they been attracted by the sound, the record would have been something over 50 per cent for the region next the sound center; as it was, they have shown themselves as distinctly repelled by the sound, in that in only about 34 per cent of the total number of possible records were they in the half of the tank nearer the sound center. It is quite clear from these records, then, that *Tautoga onitis* tends to swim away from a sound center.

The same condition as that seen in *Tautoga*, though a little less pronounced, is to be observed in the scup (*Stenotomus chrysops*), as table II shows.

TABLE II.—DIRECTIVE RESPONSES OF STENOTOMUS CHRYSOPS TO SOUND.

Lot numbers.	Number of occurrences in a possible 250 in half of tank nearer sound.		Totals.
	West half.	East half.	
1–5	87	81	168
6–10	93	85	178
11–15	89	92	181
16–20	88	89	177
21–25	96	90	186
Grand total	.....	.....	890

The grand total of occurrences in a possible 2,500 in the half of the tank nearer the sound was 890, or 36 per cent. In *Stenotomus*, though the individuals avoided the sound center in a well-marked way, they were found somewhat more frequently (36 per cent) near the center than were the tautogs (34 per cent).

Young kingfishes (*Menticirrhus saxatilis*), as table III shows, also avoided the region of the sound center, though they were found there somewhat more frequently (39 per cent) than *Stenotomus* (36 per cent).

TABLE III.—DIRECTIVE RESPONSES OF MENTICIRRHUS SAXATILIS TO SOUND.

Lot numbers.	Number of occurrences in a possible 250 in half of tank nearer sound.		Totals.
	West half.	East half.	
1–5	85	109	194
6–10	98	110	208
11–15	102	90	192
16–20	89	86	175
21–25	103	96	199
Grand total	....	....	968

The grand total of occurrences in a possible 2,500 in the half of the tank nearer the sound was 968, or 39 per cent.

Young swellfish (*Spheroides maculatus*), as can be seen from table IV, show much the same condition as the kingfish, though they were found rather more frequently (42 per cent) in the region of the sound center than the kingfish (39 per cent).

TABLE IV.—DIRECTIVE RESPONSES OF SPHEROIDES MACULATUS TO SOUND.

Lot numbers.	Number of occurrences in a possible 250 in half of tank nearer sound.		Totals.
	West half.	East half.	
1–5	101	107	208
6–10	112	103	215
11–15	106	98	204
16–20	101	110	211
21–25	96	105	201
Grand total	....	....	1,039

The grand total of occurrences in a possible 2,500 in the half of the tank nearer the sound was 1,039, or 42 per cent.

The butterfish (*Poronotus triacanthus*) is by no means easily kept in confinement and records were obtained from only one lot of five such fishes. These records show that the occurrences of this fish in the half of the tank next the sound center were 47 per cent of the total; in other words, this fish had apparently a slight tendency to keep away from the sound center. This tendency, however, was so slight and the records were based upon such a small number of individuals that not much confidence can be placed in these results.

Of the five fishes thus far discussed, four (*Tautoga*, *Stenotomus*, *Menticirrhus*, and *Spheroides*) showed unmistakable evidence of the avoidance of a sound center and are in strong contrast with a second class of fishes which we found to approach such a center.

The second class of fishes is well represented by the sea robins (*Prionotus carolinus and Prionotus strigatus*).

TABLE V.—DIRECTIVE RESPONSES OF PRIONOTUS CAROLINUS AND PRIONOTUS STRIGATUS TO SOUND.

Lot numbers.	Number of occurrences in a possible 250 in half of tank nearer sound.		Totals.
	West half.	East half.	
1–5	129	143	272
6–10	152	137	289
11–15	124	162	286
16–20	131	148	279
21–25	139	136	275
Grand total	....	....	1,401

The grand total of occurrences in a possible 2,500 in the half of the tank nearer sound was 1,401, or 56 per cent.

As table V shows, young specimens of *Prionotus carolinus* and *Prionotus strigatus* exhibited unmistakable tendencies to gather near the sound center. In each of the five groups tested the total numbers of occurrences on the side of the sound center were well above 250, the point of indifference. These species, therefore, afford a good example of fishes that move toward a sounding body in contrast to the four species mentioned as forming the first group. It is a matter of some interest to note that sea robins make a grunting noise themselves, and it may be that they hold together in schools by following this noise, in which case their movements toward a sound center such as was used in these experiments would be entirely natural.

The third class of fishes consist of those which move neither toward a sound center nor away from it. This class includes fishes that are much disturbed by sounds, but instead of being directed by these disturbances cease locomotion after a moment or so of swimming and remain quiescent till the sounding has come to an end. The best illustrations of this class are the killifishes, *Fundulus heteroclitus* and *Fundulus majalis*. After they had become accustomed to their surroundings they swam about freely near the surface of the water but when the sounding began they went at once to the bottom of the tank and remained quietly in seclusion in any nook or corner that they could find till the sounding had ceased. The cunner, *Tautogolabrus adspersus*, probably also belongs to this class, though when under the influence of sound it often moves about and its distribution indicates at times some tendency to move toward the sound center.

From all these records collectively it is quite clear that some fishes move away from sound centers, others move toward them, and still others, though much disturbed by sounds, move neither toward nor away from the sources. Throughout these experiments it was generally noticed that after the sounding ceased the fish very quickly returned to a state of normal locomotion and equal distribution. This condition is well illustrated by records taken from *Stenotomus*. Five of these fishes were placed in the tank, and after they had become quiet their distribution was recorded in the usual way; they were then subjected to sound till they assumed a characteristic distribution for this condition; and finally they were allowed to come to rest again. The time occupied in these operations is recorded in the following table:

TABLE VI.—NUMBERS OF INDIVIDUAL STENOTOMUS, OUT OF 5, OCCURRING IN THE HALF OF THE TANK NEXT THE SOUNDING APPARATUS BEFORE THE FISHES WERE SUBJECTED TO SOUND, DURING SOUNDING, AND AFTER THE SOUND HAD CEASED.

Number of the stimulus.	No sound.			Sound.			No sound.					
	7.35	7.40	7.45	7.50	7.55	8	8.05	8.10	8.15	8.20	8.25	8.30
1	2	4	3	0	1	0	0	0	2	3	2	3
2	3	3	2	1	1	0	0	0	2	4	2	4
3	3	4	2	3	1	0	0	1	3	2	2	2
4	3	0	1	3	1	0	0	1	2	3	4	4
5	4	1	2	2	1	1	0	0	1	4	0	3
6	0	3	4	4	1	1	0	1	3	0	2	3
7	3	2	4	3	2	1	0	1	2	4	2	2
8	2	3	4	1	3	1	0	1	0	2	1	3
9	4	5	1	3	2	2	0	1	1	2	3	4
10	5	5	0	1	2	2	0	2	0	3	2	3
Totals	29	30	23	21	15	8	0	8	16	27	20	31

An inspection of this table shows that during the period preceding the application of the sound (7.35 a. m. to 7.45 a. m.) the distribution of the fishes was fairly uniform, that during the application of the sound (7.50 a. m. to 8 a. m.) the fishes gradually withdrew from the sound center, and that within 15 to 20 minutes after the sound ceased a condition of distribution was attained fairly comparable with that seen at the beginning of the test (7.35 a. m. to 7.45 a. m.). The conclusion to be drawn from these observations is that, though the direction of the locomotion of a fish can be very considerably influenced by sound, this influence ceases very shortly after the sound ceases.

In attempting to apply these conclusions to the problems presented in the handling of fishes, several considerations must be kept clearly in mind. It is quite obvious that in one way or another many fishes are stimulated by sound. But most of the sounds that we deal with are generated in the air, and these sounds either fail to enter water or enter it to so slight a degree that they are of little or no significance for the fishes. The surface between water and air is an extremely difficult one for sound to penetrate in either direction, so that most sounds that are generated in the water or in the air stay in the medium of their origin. Hence many of the sounds that are produced by the discharge of guns, etc., in the air enter the water to so slight a degree (as can be ascertained by immersing oneself in the water at the time the sound is produced) as to be unstimulating to the fishes, though they may be deafening to the observer in the air. Such sounds as reach the fishes, however, not only stimulate them to move, but, as these observations show, influence the direction of their movements. But this directive influence is almost as short in duration as the stimulus. It is, therefore, improbable that sounds of brief duration can have much effect on the temporary distribution of fishes within their reach. That fishes should be attracted over any considerable area or repelled from that area by sound would seem to demand some more or less *continuous* source of sound production.

STUDIES ON THE REPRODUCTION AND ARTIFICIAL PROPAGATION OF FRESH-WATER MUSSELS

By George Lefevre and Winterton C. Curtis
Professors of Zoology in the University of Missouri

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INTRODUCTION.

The threatened extinction in the upper Mississippi River and its more important tributaries of those species of the Unionidæ whose shells have been taken in enormous numbers in recent years, both for the manufacture of pearl buttons and for the pearls which they occasionally contain, has led the United States Bureau of Fisheries to undertake an extensive investigation of the possibility of artificially propagating the commercial species and of devising practicable means of restocking depleted waters which present favorable conditions for their maintenance. The general direction of the investigation has been placed in the hands of the writers, who for several years have devoted as much time as their regular duties have allowed to the work, in certain important phases of which, however, many others have collaborated.

It was recognized at the outset that if the investigation was to be of any practical value it must be wide in scope and must extend over a period of at least several years. At that time much remained to be learned concerning the breeding habits and seasons of the commercial species, the biological and physical conditions under which they live, their distribution throughout the Mississippi Valley, and many other essential matters, while it was yet to be discovered whether artificial propagation could be successfully carried out. At the very inception of the work, therefore, a comprehensive plan was outlined which was designed to include every subject that might bear even remotely upon the central problem—the restoration of the exhausted mussel beds—and, although many parts of this program have scarcely been touched, much progress has been made in some of the more important lines.

The plan of work contemplated, besides a thorough investigation of the conditions under which artificial propagation might be possible, a detailed study of the life history and ecology of the Unionidæ, with special reference to the geographical distribution of the group throughout the Mississippi Valley, the breeding seasons and habits, the

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physical conditions of the waters in which different species thrive and attain their maximum growth, food supply, enemies and diseases, rate of growth and the influence of environmental factors upon it, and the behavior of glochidia and fishes as parasites and hosts, respectively.

The results that have already been obtained, although far from complete, will serve as a basis for future investigations, while the lines of attack in the main problems have been definitely indicated. We have proceeded far enough to make it clear that the ultimate end of the investigation is assured, and with adequate facilities for the infection and care of large numbers of fishes and for the maintenance of the young mussels during the early stages of growth following the metamorphosis, the final success of the work can no longer be in doubt. The essential facts in the life history of the Unionidæ are known; the breeding seasons and habits of the commercial species have been sufficiently determined; the general conditions of infection and of the parasitism of the larva have been learned experimentally; and the entire feasibility of artificially propagating at least certain species of fresh-water mussels has been clearly demonstrated; while the requisite conditions for placing artificial propagation on a practical basis are now thoroughly understood.

The writers' personal attention has in the main been directed to a study of the conditions of reproduction in the group and the parasitism of the larva in their bearing upon the problem of artificial infection of fishes with glochidia, while such phases of the investigation as geographical distribution, systematic studies, and a number of special ecological problems have been in the hands of other investigators.

At the recently established biological station of the Bureau of Fisheries at Fairport, Iowa, while construction was still in progress, the work of propagating some of the commercial species was inaugurated, and the excellent facilities of the station, which has been especially designed for the purpose, are now being utilized by members of the staff in attacking fundamental problems of both a scientific and an economic nature.

For the past five summers a number of field parties have been equipped and sent out each year by the Bureau to collect fresh-water mussels and to obtain the fullest

NOTE.—It is a pleasure to state that a generous grant of money made by the National Association of Pearl Button Manufacturers in the interest of the investigations enabled us to purchase a collection of books and pamphlets, dealing with the literature on the Unionidæ, which has been of invaluable assistance in the course of the work. To individual members of this association, especially to Mr. J. E. Kronse, of Davenport, Iowa, Messrs. W. F. Bishop and Henry Umlandt, of Muscatine, Iowa, and Mr. D. W. MacWillie, of La Crosse, Wis., we are indebted for many courtesies and for shipments of live mussels which they have repeatedly secured for us. Many others have at times assisted us by sending us material, and in this connection we take especial pleasure in thanking Prof. U. O. Cox, of the State Normal School at Terre Haute, Ind., who has kindly furnished us on several occasions with valuable lots of gravid mussels from the Wabash River.

To a number of our students, who in various capacities have been of service to the investigations, we owe much, and among them should be mentioned Miss Daisy Young, Messrs. Howard Welch, F. P. Johnson, W. E. Dandy, L. E. Thatcher, and especially Mr. W. E. Muns, who acted as our assistant in this work for over two years.

Lastly, it is a pleasure to acknowledge our obligation to Mr. G. T. Kline, the biological artist of the University of Missouri, who has contributed much to the value of our work by the beautiful and accurate drawings with which he has illustrated this and previous papers published by us.

By permission of the Commissioner of Fisheries, we have had the privilege of publishing, in advance of this more detailed report, the following papers of a preliminary nature: Experiments in the artificial propagation of fresh-water mussels (Proceedings of the Fourth International Fishery Congress, Bulletin of the Bureau of Fisheries, vol. XXVIII, 1908); The marsupium of the Unionidæ (Biological Bulletin, vol. XIX, no. 1, 1910); Reproduction and parasitism in the Unionidæ (Journal of Experimental Zoology, vol. IX, no. 1, 1910); Metamorphosis without parasitism in the Unionidæ (Science, vol. XXXIII, no. 857, 1911).

possible data bearing upon their distribution, their habits, and the physical and biological factors of their environment, as well as information concerning the industries which depend upon the mussel. Surveys of this character have now been carried out on the Mississippi River and nearly all of its more important tributaries from Minnesota to Tennessee, and as a result of these investigations an enormous amount of material and information has been collected which, when examined and analyzed, will not only have the greatest economic value, but will constitute one of the most important ecological studies ever made on any group of animals.

I. HISTORICAL.

As has long been known, the Unionidæ carry their young in the gills, which function as brood pouches until the completion of the embryonic development. At the close of this period the larva or so-called glochidium is fully formed and escapes from the egg membrane while still within the gill. In some species the discharge of the glochidia takes place at once, while in others they remain in the brood pouches for several months without further change before being set free into the water.

The glochidium, long thought to be a parasite infesting the gills and known as *Glochidium parasiticum*, was proved by Carus in 1832 to be the larva of the mussel itself, although many years earlier Leeuwenhoek had given it the same correct interpretation. In 1866 Leydig made the important discovery that the glochidium, after leaving the parent, completes its development as a parasite on fishes.

The earliest observations of importance in the development of our knowledge concerning reproduction in the Unionidæ are those of Leeuwenhoek, made about 1695 [a] and recorded in the Arcana Naturæ. During the two preceding centuries the belief had gained ground that the mollusks had sexes like the higher animals, and this no doubt helped to arouse a certain skepticism regarding the existence of any process of spontaneous generation among the representatives of this phylum. The observations of Redi (1668), in disproval of spontaneous generation in insects, furnished collateral evidence and appear to have been the direct incentive for Leeuwenhoek's examination of the reproductive processes in certain mollusks, among others the fresh-water mussels, and the discovery by Leeuwenhoek of eggs and sperm in these mollusks convinced him that their reproduction must be effected by such means rather than by spontaneous generation.

It is surprising to find how accurate were Leeuwenhoek's conclusions regarding the general course of the development as far as the larval stage, later known as the glochidium, and a survey of the subsequent literature shows that not until the work of Carus, in 1832, were there published conclusions more in accord with the facts as now known, nor a better summary of what we now term the embryonic period. The correctness of these early observations, so far as they went, and of the conclusions drawn from them have not been sufficiently recognized in most accounts of the literature, and for this reason an explicit statement of their important features is desirable.

[a] The date of the publication referred to in the literature list is somewhat later, 1722.

Approaching the subject unhampered by any preconception in favor of the older views, but rather with the belief that the conclusions of Redi would also hold for the bivalves, Leeuwenhoek records, in the 83d and 96th letters of his Arcana Naturæ, the presence of separate sexes in *Anodonta* and *Unio*, as evidenced by the presence of eggs and spermatozoa in separate individuals, and gives some account of the development. That he clearly apprehended the main course of events is evident if we read his description of eggs found floating free in the fluid obtained by puncturing the upper part of the foot upon either side, of similar eggs in more advanced stages within the outer gills, and of various stages in the formation of the glochidial shell. Finally, he observed the snapping of the valves, now so well known as a sign of the last stages in this embryonic development, and upon seeing the rotation of the embryo in the egg membrane he concluded that it must be unattached. He further observed that the individuals, when ready for their egg laying (passage of eggs from ovary to gills), placed themselves in spots where the water was shallow and where they were in direct sunlight—a fact which seems to have been confirmed by other observers of the European species (Schierholz, 1888, p. 8, *Unio* and *Anodonta*). Observing the general similarity between the bivalved larva and the adult, he seems never to have doubted that the glochidia, as they were subsequently called, were the young of the mussel in which they were found and therefore that these mollusks were viviparous, conclusions which so naturally followed from all the facts that it is hard to see how convincing evidence could have been manufactured for any other opinion. Upon removing these fully formed larvæ and setting them aside in dishes of clean water, with a view to observing their further development, Leeuwenhoek met the stumbling block of all observers before the discovery of the parasitism upon the fish was known, for the larvæ lived but a short time, soon becoming infested with a variety of animalcules, which he rightly concluded were the immediate cause of their death.

These conclusions of Leeuwenhoek, so nearly in accord with our present knowledge, were not entirely accepted, because they did not become known to some investigators even a century later and because there was still a considerable recrudescence of the older conception of spontaneous generation. The opinion of Poupart (1706) that these mussels were hermaphroditic gained ground and dominated during the eighteenth century, although the larvæ, when found in the outer gills, were always regarded as the young of the mussel until, in 1797, Rathke offered an entirely different explanation and erected for them a new genus, *Glochidium*, and a species, *parasiticum*. According to this explanation, which came to be known as the Glochidium Theory, it was supposed that these multitudinous larvæ were not the young of the mussels at all, but parasites with which they had become infested. Since Rathke's theory attracted considerable attention at the time and was later supported ardently by Jacobson (1828), and since it has given us the term glochidium, we may note in passing the evidence upon which it was based as stated by its later champion.

1. The form and organization of the little shells is entirely different from that of the adult *Unio* and *Anodonta*.

2. They are of exactly the same form and size in the two genera and in the individuals of diverse size and age.

3. They are always of the same size and shape when they have reached their complete development.

4. Their valves are of a consistency and hardness in no wise related to their size, as should be the case were they the young of *Unio* and *Anodonta*.

5. Their development is not related to any season of the year nor to a certain age of the animal in which they are found; that is to say, one finds in a single locality at the same time individuals containing eggs, others with little bivalves, and some containing even the fully developed organisms.

6. The enormous numbers which are found at one time in an individual are in no wise proportionate to the number of the adults in any locality.

7. One can not conceive of organs so delicate as the gills being able to serve as a sort of brood pouch, and there is no other example in the animal series of such a condition, although these organs are often the seat of animal parasites.

Jacobson's statement is thus a curious jumble of half truths and of statements which have since been shown to be entirely incorrect.

The importance attached to the dispute thus raised was so great that the Academy of Sciences at Paris appointed two of its members, De Blainville and Dumeril, a committee with instructions to examine into and report upon the whole matter. This report (De Blainville, 1828) presents an exhaustive review of the early literature and details certain experiments performed by the committee with a view to testing the matter by direct observation. These experiments, while tending to confirm the earlier views of Leeuwenhoek, were insufficient for the complete overthrow of Rathke's Glochidium Theory, for although the report was unequivocal in its conclusion that the observations of all previous authors and the evidence advanced by Rathke himself did not justify the Glochidium Theory, its lack of evidence from original observations rendered it not entirely conclusive. Viewed in the light of our present knowledge, its skillful and logical arraignment of Rathke's conclusions shows clearly the scant foundation upon which the Glochidium Theory rested, but it was not until the work of Carus (1832) that the question was finally set at rest. This author was able, in the brightly colored eggs of *Unio littoralis*, to see the passage of the eggs from the ovary to the external gills and their development there to the mature glochidia, and thus to prove beyond any doubt that the innumerable larvæ which crowded the outer gills were the young of the mussels in which they were found.

The paper by von Baer (1830) anticipated some of the points which Carus made the more clear, and from this time on the serious difficulty for students of the embryology was found in the failure to secure, either within the gills of the mussel, or upon removal of the embryos to water, any developmental stages beyond the glochidium.

The period from Carus's paper (1832) to the date of the discovery by Leydig (1866) of glochidia embedded upon the fins of fishes shows little progress toward a more complete account of even the embryonic stages. De Quatrefages, who in 1836 described the glochidium as having a very complex structure and possessing many of the organs of the adult mussel, made a distinctly backward step; and his account of hearts, stomachs, livers, intestines, and aortas, all highly developed and double in each individual, reminds one of the description of elaborate systems of organs in the infusoria as given by Ehrenberg in his monograph published during the same year. Pfeiffer (1821, taf. II, fig. E) was the first to observe the minute outline of the glochidium at the umbo of a young shell—a fact which, had it become generally known, would have saved Jacobson his defense of the Glochidium Theory. There remained, however, the unexplained gap between the glochidium and such a stage of the young mussel, and this was filled only by Leydig's discovery of the parasitism. With the clue thus given, the stages by which the glochidium becomes the miniature adult, during the course of its parasitism, were studied by Braun (1878), Schmidt (1885), Schierholz (1878 and 1888), and more recently by Harms (1907–1909). All of these investigators obtained their material in great abundance by the artificial infection of fish with the glochidia, and in their several accounts the structure of the glochidium and the organogeny of the common European species will be found very completely given.

The embryonic stages attracted new attention with the rise of cytological studies, and the paper of Flemming (1875) was exhaustive for the period in which it was written, although Lillie's more detailed and modern account (1895) of the cell lineage and the formation of the glochidium in *Unio complanatus* and *Anodonta cataracta* has rendered Flemming's paper of historical interest only, and has apparently left undone nothing of importance in a description of the early stages in these species.

Further reference to the literature will be made as the several stages of the development are discussed in the species we have followed. Since an excellent summary of the literature, particularly that published since the paper by Carus (1832), may be found in the work of Harms (1909), we omit further elaboration here. The report to the Paris Academy (De Blainville, 1828) gives a good account of the literature for the earlier period, and from this we have obtained a summary of the facts in such early papers as have not been accessible.

II. REPRODUCTION.

The sexes are normally separate in the Unionidæ, but in *Anodonta imbecillis* and in a few other species of this genus the occurrence of hermaphroditism has been occasionally recorded (cf. Sterki, 1898; Ortmann, 1914). Although in the majority of the genera of the Unionidæ the sexes are indistinguishable externally, in a few, notably in *Lampsilis*, the shell of the female differs from that of the male in its greater convexity in front of the posterior ridge and in more or less well-marked differences in the posterior outline of the shell. In such cases the males and females may be readily assorted without recourse to an examination of the soft parts.

At ovulation the eggs pass from the oviducts to the cloaca, and thence back into the suprabranchial chambers, in which they are probably fertilized by spermatozoa brought in by the respiratory current of water. From the suprabranchial chambers they are conducted directly into those portions of the gills in which they are to remain.

Observations on the passage of the eggs from the ovaries to the gills are extremely meager, and further information is needed concerning the factors involved in directing the stream of eggs from the openings of the oviducts to their final resting place in the water tubes of those regions of the gills which function as brood chambers. We owe to Latter (1891, 1904) the most detailed account of this process which we have, and, in lieu of any direct observations of our own on the subject, we may quote his interesting description (1891) which is based upon *Anodonta:*

If a female be taken from the shell at this season (the spawning season) the eggs may be seen through the transparent wall of the oviduct passing singly, but in a steady stream, to the genital aperture. Their motion is due partly to "labour contractions" of the intrinsic muscles of the foot and partly to the ciliated lining of the oviduct itself. One by one the eggs issue from the genital aperture, whence they are conveyed backwards by the abundant cilia which clothe the external surface of the nephridium. Along the middle line of this surface there is a belt of especially long cilia which appear to be devoted to the transit of the eggs; those dorsal and ventral to the belt work obliquely so as to keep the eggs in contact with it. It is probable that the free dorsal border of the inner lamella of the inner gill plate is, under normal conditions, applied to the visceral mass in this region so as to inclose a temporary tube, one of whose walls is formed by the above-mentioned belt of specialized cilia.[a] In the course of about 50 seconds an egg is thus swept back to the slit between the protractor muscle of the shell and the point of fusion of the right and left inner gill lamellæ; here they meet the stream of ova from the other side of the body and so reach the exhalent current and the cloaca.

The process goes on for some 10 days or more in each individual and the number of eggs is immense * * * probably half a million may be taken as a fair average. On reaching the cloaca * * * their direction is reversed and they pass forward into the cavities of the right and left gill plates, which serve as brood pouches. The method by which this change of direction is accomplished is not quite clear. * * * I have, however, observed on several occasions a violent and sudden reversion of the water currents such as would certainly be fully capable of carrying the eggs forward and into the latticed recesses of the outer gills. This reversion is caused by the animal, firstly, closing all the ventral border of the shell by means of the free edges of the mantle assisted by the flexible, uncalcified rim of periostracum and leaving the siphons alone open, and, secondly, relaxing the adductor muscles so as to allow the elastic ligament to make the valves gape apart. These actions cause the hydrostatic pressure within the shell to be less than that of the water without and consequently there ensues a rush of water into the shell through the open siphons. The whole procedure may be likened to a gulp and is achieved by precisely similar physical forces.

This may possibly be the correct interpretation of the process, but additional observations and experiments should be made for verification. Latter also attempts to account for the fact that the eggs in *Anodonta* pass into the outer gill and not into the inner, but his explanation is unsatisfactory and inadequate. It would be a matter of the greatest interest to discover the mechanism which directs the eggs in the different types of the marsupium into certain water tubes of the gills and not into others. Special structural modifications must be correlated with the particular type as the fundamental cause of these differences, and a very pretty problem is here presented in the determination of such correlations. Since in the genus *Quadrula* all four gills

[a] It is to be remembered that this description is based upon the conditions as they occur in *Anodonta*, in which the inner lamella of the inner gill is not fused to the visceral mass, and the inner suprabranchial chamber is consequently freely open to the mantle chamber; in those forms, however, in which this lamella is fused for a part or all of its length, the eggs are received into the anterior end of the inner suprabranchial chamber, into which the genital apertures open directly, and pass back through this chamber to the cloaca.

become filled with eggs, a directive mechanism is probably absent in this genus, and a careful comparison of the conditions in *Quadrula* with the structure of the gills in those genera in which only a portion of the gills is utilized as a brood chamber might well furnish the clue to the discovery of a special mechanism in the latter.

While as a rule the great majority of the eggs, when a gravid gill is examined, are found to be fertilized, different species differ markedly in the percentage of unfertilized eggs present, and, in fact, a large proportion of the latter seems to be characteristic of certain genera. In *Lampsilis*, *Symphynota*, *Anodonta*, and a number of other genera it has been very unusual in our experience to encounter any considerable number of unfertilized eggs, while, on the contrary, in *Quadrula*, *Pleurobema*, and in some species of *Unio* it is often true that even a majority of the eggs in a gravid female have failed of fertilization; in fact, in these genera one expects to find a large percentage of such eggs as the usual thing.

The entire embryonic development takes place in the gills of the female, and at the close of this period the larva or glochidium is fully formed. The differences in the length of time the glochidia are retained in the gills will be discussed later, but after their liberation the completion of their development occurs while they are living as parasites on the fish in all of the Unionidæ, so far as known, except in the genus *Strophitus*, whose glochidium, we have recently discovered, undergoes the metamorphosis in the entire absence of a parasitic stage. This extraordinary case will be referred to later.

As the embryology of the Unionidæ has been described by Lillie (1895) in great detail, and as Harms (1909) still more recently has published an excellent account of the post-embryonic development, we shall omit all reference to the actual developmental events, and confine ourselves to a discussion of those phases of the reproduction and parasitism of the Unionidæ in which we have been especially interested in connection with the problem of artificial propagation.

THE MARSUPIUM.

The term marsupium has been generally used to indicate those portions of the mussel's gills into which the eggs are received from the suprabranchial chambers after ovulation and which serve as brood pouches for the retention and nurture of embryos and glochidia until the discharge of the latter. As no better name seems to be available, we shall employ it in this paper.

USE OF THE MARSUPIUM IN CLASSIFICATION.

Since the extent to which the gills are specialized for this purpose varies in different groups of the Unionidæ, Simpson (1900), in his "Synopsis of the Naiades," has made use of the marsupium as the chief diagnostic character on which his classification is based. Those groups in which the marsupium comprises the outer or all four gills he designates as the Exorbranchiæ, while those in which the inner gills alone receive the eggs are distinguished as the Endorbranchiæ. All of the European and North American species belong to the former group, while the latter contains forms that are found chiefly in Asia, Australia, Africa, Central America, and South America.[a]

As our observations have been confined to the Exobranchiæ, reference will be made only to this group, the following subdivisions of which are recognized by Simpson, each distinguished by special marsupial characters:

Tetragenæ: Marsupium occupying all four gills.

Homogenæ: Marsupium occupying entire outer gills.

Diagenæ: Marsupium occupying entire outer gills, but differing from that of the Homogenæ in that the egg masses lie transversely in the gills.

Heterogenæ: Marsupium occupying only posterior end of outer gills.

Mesogenæ: Marsupium occupying a specialized portion in the middle region of outer gills.

Ptychogenæ: Marsupium occupying entire lower border of outer gills which is thrown into a series of peculiar folds.

Eschatigenæ: Marsupium occupying the lower border only of outer gills, but not folded.

Simpson has established another group, the Digenæ, for the genus *Tritogonia*, but since its marsupium is constituted by all four gills (Sterki 1907), it should at least be included in the Tetragenæ, if not in the genus *Quadrula*, as Ortmann maintains (1909, 1911). For a complete list of the genera occurring in each of Simpson's groups, reference may be had to his Synopsis (op. cit., p. 514–515).

These groups constitute Simpson's subfamily, Unioninæ, his other subfamily, Hyrianæ (Hyriinæ), coinciding with the Endobranchiæ or those Unionidæ whose marsupium occupies the inner gills only. In all of the Unioninæ except the Heterogenæ and Digenæ (*Tritogonia*), according to Simpson, the sexes are indistinguishable externally.

It will be seen from the above classification that three general conditions exist in the Unioninæ, namely, one in which the marsupial adaptation involves all four gills; one in which the entire outer gills only are utilized; and, lastly, one in which some differentiated portion of the outer gills constitutes the marsupial region. It would, accordingly, be a more logical procedure to make these general marsupial conditions the basis of the classification and to recognize only three main groups corresponding to the three general types of marsupium, to which the names Tetragenæ, Homogenæ, and Heterogenæ might be applied; and since all of the remaining forms have a marsupium which may be readily regarded as a secondary modification of one or another of the three types, they could be arranged in appropriate subgroups. If this were done, the Diagenæ would obviously fall within the Homogenæ, while the Mesogenæ, Ptychogenæ, and Eschatigenæ would be placed under the Heterogenæ, as in all of the latter forms the marsupium is some specialized portion of the outer gills.

[a] Besides the Unionidæ, a second family, the Mutelidæ, is recognized by Simpson in his classification of the Naiades or pearly fresh-water mussels. In these forms, which belong to Africa and South America, the marsupium is the inner gills only, and the larva is not a glochidium but the so-called lasidium. The genera embraced in this family are not considered in the present account.

Quite recently Ortmann (1910a, 1911) has proposed an entirely different arrangement of the Naiades which is based upon a study of the anatomy and the larval characters of the fresh-water mussels of Pennsylvania. His system also lays especial stress on the marsupial differentiations, but it involves a number of important modifications in Simpson's classification which he maintains must be radically recast, in the light of the facts which he has discovered, if it is to represent the natural affinities of the group.

It is not our purpose to present a critical discussion of the relative merits of the two systems, as our only interest in this connection is concerned with the marsupium as an accessory organ of reproduction, but as Ortmann has added a number of important facts to our knowledge of this structure, it is necessary to state briefly the basis of his classification so far as it has to do with the several marsupial modifications. In addition to the marsupial structure, he makes use in his arrangement of families, subfamilies, and genera of a number of other characters which he considers of systematic value; for example, the degree of fusion of the inner lamella of the inner gill with the visceral mass; the dorsal aperture (supra-anal opening); the siphons; the differentiations of the mantle edge; the structure of the glochidium; and shell characters. In contrasting his arrangement with that of Simpson, however, reference will be made only to the marsupium.

Confining himself to North American forms, he divides the Naiades into two families, the Margaritanidæ and the Unionidæ. His discovery that in *Margaritana margaritifera* there are no distinct interlamellar junctions in the gills, but only scattered interlamellar connections, and consequently no definite water tubes, he considers of sufficient importance to warrant him in creating a new family for this genus, Margaritanidæ, which he has thus sharply set apart from the remaining genera grouped under the Unionidæ, a procedure of doubtful wisdom.[a] The fact that complete interlamellar junctions are absent in *Margaritana*, which is further characterized by certain other apparently primitive features, is of the greatest interest, but that these differences are of sufficient significance to justify a separate family for *Margaritana* is not at all clear.

The Unionidæ, after the removal of *Margaritana*, he divides into three subfamilies, distinguished as seen below by definite marsupial characters:

1. Unioninæ. "Marsupium formed by all four gills, or by the outer gills only; edge of marsupium always sharp and not distending; water tubes not divided in the gravid female."

This subfamily includes the following genera, which, however, he has recast to a considerable extent by subtractions and additions of species: *Quadrula* Rafinesque (including *Tritogonia tuberculata*); *Rotundaria* Rafinesque (established for *Quadrula tuberculata*); *Pleurobema* Rafinesque (including *Q. coccinea*, *pyramidata*, *obliqua*, *cooperi-*

[a] The condition described by Ortmann for *Margaritana* is quite similar to that which is found in the gills of *Mytilus* (cf. Peck, 1877), in which complete interlamellar junctions are absent and the inner and outer lamellæ are connected only by scattered strands of subfilamentar tissue passing across the interlamellar space. This similarity in gill structure would argue strongly for the primitive position of *Margaritana* among the Unionidæ. In *Lucina* these interfilamentar junctions are larger and are provided with blood vessels, while in *Mytilus* they are non-vascular. Ortmann does not state whether or not they contain blood vessels in *Margaritana*.

ana); *Elliptio* Rafinesque (established for the North American species of *Unio* to distinguish them from the European).

2. Anodontinæ. "Marsupium formed by the outer gills in their whole length, distending when charged, and the thickened tissue at the edge capable of stretching out in a direction transverse to the gill, but not beyond the edge (or only slightly so); water tubes in the gravid female divided longitudinally into three tubes, with only the one in the middle used as an ovisac, and closed at the base of the gill."

The following genera are grouped under this subfamily: *Alasmidonta* Say, *Strophitus* Rafinesque, *Symphynota* Lea, *Anodontoides* Simpson, *Anodonta* Lamarck.

3. Lampsilinæ. "Marsupium rarely formed by the whole outer gill, generally only by or within the posterior part of the outer gill; edge of marsupium, when charged, distending, and bulging out beyond the original edge of the gill, generally assuming a beaded appearance; water tubes simple in the gravid female."

The following genera are grouped together under this subfamily: *Ptychobranchus* Simpson, *Obliquaria* Rafinesque, *Cyprogenia* Agassiz, *Obovaria* Rafinesque (including *Lampsilis ligamentina*), *Plagiola* Rafinesque, *Paraptera* gen. nov. (established for *Lampsilis gracilis*), *Proptera* Rafinesque (established for *Lampsilis alata*, *purpurata*, *lævissima*), *Lampsilis* Rafinesque (including *Micromya fabalis*), *Truncilla* Rafinesque.

It will be seen by a comparison of the genera which Ortmann assigns to his three subfamilies with the several groups of Simpson, that the most significant change introduced by the former arrangement is the disruption of Simpson's Homogenæ and a redistribution of its genera and those of the Digenæ, Diagenæ, and Tetragenæ among the subfamilies Unioninæ and Anodontinæ, the former receiving all of the genera considered by Ortmann, except *Alasmidonta*, *Strophitus*, *Symphynota*, *Anodontoides*, and *Anodonta*, which, by reason of the peculiar secondary division of the water tubes of the gravid female in all of these genera, he insists should be placed in a subfamily by themselves. Apparently his grounds for the rearrangement are sound. In the Lampsilinæ are included all of the genera of Simpson's Heterogenæ, together with those of the Mesogenæ, Ptychogenæ, and presumably the Eschatigenæ—a procedure which is in harmony with the suggestion made above that the genera in which a differentiated portion only of the outer gill functions as a marsupium should be grouped together.

The reader is referred to Ortmann's monograph for further details and for the considerations which have led him to shift a number of species from one genus to another and to establish certain new genera, while renaming others.

This system has the merit of being based upon a careful study of the anatomy of the species with which he has been concerned, and he has clearly demonstrated the fact that shell characters alone are not sufficient for a determination of true relationships. To what extent his classification will replace Simpson's remains of course to be seen, but in any future discussion of the matter the new facts brought to light by Ortmann in his study of the structural modifications of the marsupium must be reckoned with.

GENERAL STRUCTURE OF THE MARSUPIUM.

In connection with our investigations on fresh-water mussels we have had occasion to give quite a little attention to the anatomical and histological structure of the marsupium in a number of genera, and, furthermore, we have been particularly interested in the changes that occur in the gills during the period of gravidity. We have already published a brief account (1910b) of some of our observations on the marsupium, with illustrations of the more important types, but, as Ortmann has since added a number of new facts to the subject, it is advisable to present our results in greater detail and with additional illustrations. For this purpose it will be more convenient to follow Simpson's arrangement, and we shall refer to the species examined by us under the several groups established by him. It will also be convenient in connection with the description of the marsupium to refer somewhat incidentally to certain observations on breeding habits, characteristics of the embryos, and related matters. The finer structure of the marsupium is reserved for a subsequent section of this report.

Tetragenæ.—The marsupium in these forms comprises all four gills, a condition which is undoubtedly the most primitive one among the Exobranchiæ. It is the condition occurring in the genus *Quadrula*, in which, following Ortmann, we include *Tritogonia*. We have encountered it in the following species: *ebena* Lea, *heros* Say, *lachrymosa* Lea, *metanevra* Rafinesque, *obliqua* Lamarck,[a] *plicata* Say, *pustulosa* Lea, *trigona* Lea, *tuberculata* Barnes (*Tritogonia tuberculata*), and *undulata* Barnes.

No special structural modifications are present beyond the usual glandular folded epithelium covering the surface of the interlamellar junctions which, as has been known since the work of Peck (1877), are closer together in the marsupial than in the purely respiratory gill. The gills when gravid, although somewhat distended and padlike in appearance, never become swollen to the extent that is seen in many other genera. Figure 5, plate VII, which is drawn from a gravid female of *Quadrula ebena*, illustrates the typical appearance of the marsupium in this group, although the gills shown in the figure are not as fully distended as is frequently the case.

In *ebena* and *trigona* the ovarian eggs and the embryos are frequently brilliantly colored red or pink and when the marsupium is charged the color shows through the colorless transparent walls of the gills, which present a striking appearance on removing the shell. In all of the other species of *Quadrula* observed by us the pigmentation is absent, but in *ebena* and *trigona* the color is found in a majority of the gravid females, the number of such cases being somewhat greater in *trigona* (over two-thirds of all gravid females examined in this species) than in *ebena*. The red pigment, however, whenever it occurs, does not persist, but on the contrary totally disappears in the later stages of embryonic development, and by the time the glochidia are fully formed no trace of it is left. We have never seen a single case of a red or pink glochidium either in these two species of *Quadrula* or in any other genus in which pigmented eggs and embryos occur. It is true

[a] Ortmann (op. cit., 1911, p. 330) states that only the outer gills serve as the marsupium in *obliqua*, and on this ground he has removed the species to *Pleurobema*. If we have made no mistake in the identification of our specimens, our observations on this species are not in accord with his.

that the marsupium may still be more or less deeply tinged with red, even when it contains fully developed glochidia, but this is due to its containing a variable number of unfertilized eggs, which do not lose the color, and not to the glochidia which are always, as stated, entirely colorless.

The occurrence of unfertilized eggs is very common in all of the species of *Quadrula* which have come under our observation, and their presence is more characteristic of certain species than of others. They are quite rare in *plicata* and *pustulosa*, for example, less so in *metanevra*, common in *ebena*, while in *trigona*, in which they occur more frequently than in any other species of *Quadrula*, they were found in a large majority of cases. The number of unfertilized eggs in different females of a given species varied from cases in which only a few such eggs were scattered among normal embryos all the way to cases in which the marsupium contained no normal eggs or embryos at all. Eggs which have not been fertilized, after remaining in the marsupium, become swollen and stratified (see below), frequently forming exovates and undergoing fragmentation before final disintegration.

There seems to be a definite correlation between the presence of unfertilized eggs in the marsupium and the occurrence of trematode parasites in the testis of the male; in species like *plicata*, in which unfertilized eggs were rare, only occasionally were the testes infested with worms, but in *trigona*, for example, the trematodes were found in a large number of males. It is not at all improbable that the amount of sperm available in a given locality is greatly reduced as a result of the castration of males by this testis infesting parasite.

The abortion of embryos and glochidia, which is so characteristic of the genus *Quadrula*, and the significance of this peculiarity will be referred to later on.

Homogenæ.—The condition in which the entire outer gills only are utilized as a marsupium is present in 16 genera, according to Simpson.[a] We have verified its occurrence in *Alasmidonta truncata* Wright; *Anodonta cataracta* Say, *grandis* Say, *implicata* Say; *Arcidens confragosus* Say; *Pleurobema æsopus* Green; *Symphynota complanata* Barnes, *costata* Rafinesque; and in *Unio complanatus* Dillwyn and *gibbosus* Barnes.

As has already been stated, Ortmann has disrupted the group, placing *Pleurobema* and *Unio* in his subfamily Unioninæ, while segregating *Alasmidonta*, *Anodonta*, and *Symphynota* in his Anodontinæ. This he has done chiefly because of a differentiation of the ventral border of the marsupium and of a secondary division of the water tubes of the marsupium in those genera included in the Anodontinæ. These differences will be referred to below.

The marsupium when filled with embryos or glochidia may be greatly distended beyond its normal dimensions, and in this condition is an enormously swollen padlike structure, with a smooth surface, filling a large portion of the mantle chamber. Figure 3, plate VI, represents the gravid marsupium of *Symphynota complanata*, which may be taken as typical of the Homogenæ, although in *Pleurobema* and *Unio* the distension is not so great.

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[a] *Margaritana* is placed in this group by Simpson, but as it utilizes all four gills as the marsupium it should be included with the Tetragenæ.

In *Pleurobema æsopus* the eggs and embryos, like those of *Quadrula ebena* and *trigona*, are usually, but not always, colored red or pink, but the glochidia are invariably unpigmented. Unfertilized eggs in varying proportions are frequently found in this species either mixed in with embryos at all stages of development or occurring alone; such eggs always show a definite stratification of the egg substances.

Diagenæ.—This group was established by Simpson to receive the genus *Strophitus*, in which the marsupium occupies the entire outer gill and in external appearance is similar to that of the Homogenæ. But it is unique among the Unionidæ in that the embryos and glochidia are embedded in gelatinous cords (called "placentæ" by Sterki, "placentulæ" by Ortmann), which lie transversely in the gills, whereas in all other cases the egg masses are placed vertically, each one occupying an entire water tube. In *Strophitus*, on the other hand, the cords are packed closely together, like chalk crayons in a box, a variable number being contained in a single water tube, while the blunt ends of the cords are distinctly seen through the transparent external lamella of the outer gill. It should be stated that Ortmann (1910b, 1911) has found that the discharge of the cords is not through the lamellæ of the gills, as Simpson (1900) has maintained, but that it occurs in the usual manner through the supra-branchial chambers. A description of the unique cords and the extraordinarily interesting life history of *Strophitus* is reserved for a special section.

Heterogenæ.—In this group the marsupium occupies only the posterior portion of each outer gill, varying in extent from about one-third to two-thirds of the entire length of the latter. In young females the marsupium is shorter and not so fully distended as in older ones. In fact, it is true of all Unionidæ that the marsupium is less heavily charged when the female is young. The differentiation of the posterior region is very conspicuous even in the non-gravid female, as the marsupium is sharply marked off either by a distinct fold or a notch from the anterior respiratory part, and, since it is much deeper dorso-ventrally than the latter, it projects farther down into the mantle-chamber. Its walls are also more membranous in appearance than are those of the respiratory region, and after the discharge of the glochidia it is seen as a flabby collapsed pouch.

When gravid, the marsupium may be enormously swollen, the expansion being greater along the ventral border than above, where, owing to its fixed position, it is incapable of stretching. This greater ventral extension often causes the marsupium not only to assume a fan-shaped form, which is so characteristic an appearance in *Lampsilis*, but also to project forward under the respiratory portion, which in consequence becomes sharply folded over on the outer surface of the marsupium. Not only is the marsupium as a whole expanded in the way described, but each of its swollen water tubes is distended distally beyond the lower extremity of the interlamellar junctions so that the ventral border becomes fluted or corrugated, as shown in figure 2, plate VI. This figure, which illustrates the typical condition in the genus *Lampsilis*, is drawn from a gravid female of *L. subrostrata* when fully charged with glochidia. The folded respiratory portion of the gill, the fan-like expansion of the marsupium, and the corrugated border are all clearly seen.

When the marsupium is less heavily charged, as in young females, the ventral expansion may not be great enough to cause the conspicuous fold just described, and in cases like this the marsupium, which may then appear kidney-shaped, is marked off from the respiratory end merely by a notch by reason of its greater depth. Such a case is seen in figure 6, plate VII which is taken from a gravid female of *L. recta*.

Simpson has included 14 genera in the Heterogenæ, only three of which, however, have come under our observation, namely, *Lampsilis* (including *Proptera*), *Obovaria*, and *Plagiola*. We have recorded this type of marsupium in *Lampsilis alata* Say, *anodontoides* Lea, *gracilis* Barnes, *higginsii* Lea, *lævissima* Lea, *ligamentina* Lamarck, *luteola* Lamarck, *recta* Lamarck, *subrostrata* Say, and *ventricosa* Barnes; in *Obovaria ellipsis* Lea; and in *Plagiola elegans* Lea and *securis* Lea.

No case of pigmented eggs has been encountered by us in this group, and unfertilized eggs in the marsupium are exceedingly rare.

Mesogenæ.—This group is so designated by Simpson to include the genera *Cyprogenia* and *Obliquaria*, in which a variable number of enlarged water tubes in the middle region of the outer gill are specialized as the marsupium, a larger anterior and a shorter posterior portion of the gill retaining the ordinary respiratory character. We have studied the condition in *Obliquaria reflexa* Rafinesque and also in *Cyprogenia irrorata* Lea, in which the structure of the marsupium is essentially the same, although the two cases differ strikingly in general appearance.

The marsupium of *Obliquaria reflexa* is shown in figure 7, plate VII. Here the modified water tubes, which project far down below the border of the rest of the gill, appear enormously swollen when gravid and show a tendency to curve backward, the degree of curvature becoming progressively greater in the tubes from the anterior to the posterior end of the marsupium. A gradual decrease in the length of the tubes takes place in the same direction. The tubes are slightly larger at their distal ends, so that their form is somewhat club-shaped; this is seen more clearly in the shape of the egg masses which form perfect casts of the cavities of the tubes (fig. 42, pl. XI). The corrugation of the lower border of the marsupium is very conspicuous in the figure. The number of water tubes comprising the marsupium in this species is not at all constant, but on the contrary varies in the individuals examined by us from two to eight; according to Simpson, they range from four to seven. During the breeding season each tube is entirely filled with embryos or glochidia which adhere so firmly together that they form a mass of tenacious consistency.

In *Cyprogenia*, the only other genus included in the group, the marsupium may be regarded as a further development of the condition seen in *Obliquaria*. We have observed it in but a single individual of *C. irrorata*, which was kindly sent to us by Dr. R. E. Coker. This specimen, which contained fully formed glochidia, was collected in the Cumberland River, Kentucky, in November, 1910. The tubes of the marsupium, which present a most striking and unusual appearance, spring from near the middle of the outer gill, are enormously elongated, and curved backward into a close coil, a part of the coil passing under the posterior unmodified portion of the gill, as the tubes are turned slightly inward toward the median plane. The marsupium is well shown in figure 8, plate VII. The distension of the marsupial water tubes begins at quite a distance above the ventral border of the rest of the gill, as is seen in the figure. The anterior respiratory portion is sharply separated from the rest of the gill by a cleft which extends almost up to the level of the suprabranchial chamber. At first this was supposed to be an artificial split, but as it occurs on both sides and its edges are perfectly smooth and show no indication of injury, we have concluded that it must be a normal condition. Unfortunately we have had no other specimens with which to compare it.

In our specimen the marsupium is slightly tinged with pink, the color being due to unfertilized pigmented eggs which are scattered among the glochidia. Simpson speaks of the marsupium as being purple.

The unusual form of the marsupium in *Cyprogenia* was originally described by Lea (1827) in *C. irrorata*, but curiously enough he reversed the direction of the coil in his figure, which appears to have been drawn from memory, as such a mistake could hardly have been possible if he had had a specimen before him.[a]

Call (1887) many years later described a similar marsupium in *C. aberti* Conrad, which he very crudely figured. It is strange that, although he reproduces Lea's original figure of *irrorata* by the side of his own, he makes no mention of the error in it. Judging from Call's figure, the number of tubes in the marsupium of *aberti* is much larger than in *irrorata*. He shows about 20, while Lea states that there are 7 or 8 in the latter, and in our specimen there are 7. Simpson gives the number for the genus as 7–23.

Ptychogenæ.—This group contains a single genus, *Ptychobranchus*. The marsupium occupies the lower half of the entire outer gill and is thrown into a series of folds, from 6 to 20 in number, according to Simpson. Each water tube of the marsupium is inflated at its distal extremity to form a globular enlargement projecting beyond the interlamellar junctions—a condition which gives to the free edge of the gill the beaded appearance so characteristic of the genus. This marsupium is well illustrated in figure 1, plate VI, which is drawn from a gravid female of *P. phaseolus* Hildreth. Seventeen conspicuous folds, sharply demarked from each other, are shown in the figure, in which the beaded border of the gill is also clearly seen.

Eschatigenæ.—Simpson has established this group to receive the genus *Dromus* in which the marsupium occupies the ventral half of the outer gill throughout the greater portion of its length. We are indebted to Dr. R. E. Coker for several specimens of *Dromus dromus* Lea, obtained from the Cumberland River in Kentucky in November, 1910, which have furnished the material for our study of this type of marsupium. Three gravid females, all containing glochidia, were included in the lot.

As seen in figure 4, plate VII, the line of demarcation between the dorsal respiratory portion and the ventral marsupial region is quite sharp and regular, owing to a constriction of the gill where the two regions join. Below this line the gill is swollen to an extent varying with the degree to which it is charged with glochidia. The anterior end of the gill is not included in the marsupium and is sharply folded over on the outside of the

[a] We are indebted to Mr. Bryant Walker, of Detroit, for having called our attention to this error in Lea's figure.

marsupium in this region. The depth of this fold varies with the fullness of the marsupium, as the greater is the distension of the latter the farther forward it is tucked under the anterior respiratory region. Posteriorly the two portions of the gill are sharply defined by a deep cleft, as shown in the figure. The surface of the marsupium is thrown into an irregular series of low undulating folds which are more prominent in the more heavily charged females. In two of the females the marsupium is a salmon pink, while the third is colorless, but here, as in the other cases described in which glochidia are present, the color is due to unfertilized eggs.

The record in our notes of the three females is as follows:

No. 1, small specimen, 44 by 39 mm. Marsupium colorless, only slightly distended and not thrown into folds or undulations; no anterior fold, merely a notch; glochidia colorless.

No. 2, larger specimen, 57 by 52 mm. Marsupium salmon pink, much fuller than no. 1, and thrown into distinct folds; deep anterior fold; glochidia colorless, but many pigmented unfertilized eggs and abnormal embryos mixed with them. (This is the specimen from which the figure was drawn.)

No. 3, largest specimen, 58 by 55 mm. Marsupium with just a tinge of pink, more heavily charged than either of the others and showing prominent folds or undulations; deep anterior fold; glochidia colorless, and a few pigmented unfertilized eggs and abnormal embryos present.

It is evident from this comparison that the smaller, and therefore presumably the younger, females are less heavily charged than the larger and older ones; and, furthermore, that those changes in the gill which are the mechanical effects of gravidity, like the folds, vary directly with the degree of distension of the marsupium. This conclusion holds good for all the Unionidæ which we have had an opportunity of examining, and also applies to the experience of other observers.

The glochidia of *Dromus dromus*, which are excessively minute and of unusual form, being kidney shaped, are referred to later.

INTERNAL STRUCTURE OF THE MARSUPIUM.

The marsupium of the Unionidæ furnishes a beautiful illustration of a remarkable diversity of form in the adaptation of an organ for a specialized function. One can not study this structure in the North American Unionidæ without being forcibly impressed with the great variety of detail which one and the same general adaptation is capable of exhibiting. But whatever be the special direction which the modification has taken, even in the most bizarre forms of the marsupium, like that of *Cyprogenia*, there is never any doubt as to the relation between the structural specialization and the function which it is adapted to perform. The structural basis of the marsupium—one might almost say the unit of structure—is the water tube, and it is from an investigation of its finer structure and its relation to other tubes, similarly modified, that an understanding of the unionid marsupium is gained. The fundamental adaptation is a series of compartments in the interior of the gills provided with a specialized glandular epithelium lining the cavity and also with a mechanism in its walls which allows of distension, often to an extraordinary degree.

The various types of marsupium are to be referred to differences in the manner in which these compartments are associated to constitute the marsupium; to different degrees to which the compartments are developed; to differences in the modification of the walls for the purpose of distension; and also to the development of special adaptations in certain forms for increased aeration of the marsupium. Whether in the last specialization the better aeration is needed for the gravid mussel, whose respiration must be considerably interfered with when the entire outer gills are gorged with embryos, as in *Anodonta* and *Symphynota*, or for the embryos themselves, is a question that is discussed later, but from a comparison of the conditions existing in the different types of marsupium it would seem that the respiratory modifications are primarily for the adult and not for the embryos. The reasons for this conclusion should be reserved until the internal structure of the marsupium has been described.

It is chiefly to Peck (1877) that we owe a correct interpretation of the structure of the lamellibranch gill. It was he who first showed that the plate-like gills of the higher forms, consisting each of an outer and an inner lamella, are formed by a series of juxtaposed independent filaments, a fact that was essential to the later recognition of a perfectly regular series of gradations throughout the lamellibranchs from the simple ctenidium of the primitive *Nucula* to the complex double gill of the Unionidæ. In the least modified forms the filaments are straight, either plate-like or filamentous, but in forms above these each filament becomes greatly elongated and bent upon itself to form a compressed U or V, consisting of an inner and an outer limb. One limb, the inner in the outer gill and the outer in the inner gill, is fixed above to the body wall, while the other limb is free in the lower groups (*Arca*, *Mytilus*), fixed in the higher (Unionidæ), although the inner limbs, forming the inner lamella of the inner gill, may not all be fused to the body wall. The filaments constituting a lamella are interlocked either by cilia or by interfilamentar junctions, and the gill may be further strengthened by interlamellar junctions, which are either simple bars (*Mytilus*, *Margaritana*) or continuous septa (Unionidæ, except *Margaritana*).

In his study of the lamellibranch gill Peck described in much detail and with great accuracy the structure of the gills of the Unionidæ, and his account has furnished the basis of all subsequent descriptions. The typical structure of the unionid gill is well known. Each gill consists of two lamellæ, an outer and an inner, composed of series of juxtaposed filaments supported by chitinous rods and fused by the interfilamentar junctions except where the inhalent ostia open into the interlamellar space for the entrance of water. The dorsal edge of the inner lamella of the outer gill and of the outer lamella of the inner gill is fixed to the body wall, while the outer lamella of the outer gill is fused to the mantle (in *Margaritana* it is free posteriorly), and the inner lamella of the inner gill is either free or more or less attached to the visceral mass (cf. Ortmann, 1911). The two lamellæ are continuous along the free ventral borders, and thus form a flattened sac whose cavity opens above throughout its entire length into the suprabranchial chamber; the four suprabranchial chambers lead posteriorly into the cloaca, which in turn opens to the outside water through the exhalent siphon. The entire gill is subdivided by a series of close-set septa, the interlamellar junctions (except in *Margaritana*) which separate the interlamellar space into a series of so-called water tubes. Water in the mantle chamber is driven by the cilia guarding the ostia through the lamellæ into the water tubes, whence it passes into the suprabranchial chambers and out through the exhalent siphon. The walls of the gill are traversed by blood vessels and lacunar blood spaces, and the current of water which passes through the gill is a respiratory current.

The water tubes are lined by an epithelium which is ciliated, at least in some species, on the inner faces of the lamellæ, while it assumes a characteristic glandular nature on the inner faces of the interlamellar junctions. The lamellæ and the interlamellar junctions are richly supplied with elastic and smooth muscle fibers, which are especially highly developed in the junctions of the marsupial gills of the female—evidently in adaptation to the great distensibility of which the latter are capable. In fact, the purely respiratory and the marsupial gills exhibit a number of structural differences, most of which were recognized by Peck (op. cit.) and which are undoubtedly to be accounted for on the ground of the difference in function between the two kinds of gills. Peck clearly described and figured the anatomical differentiation between the respiratory and the marsupial gill in *Anodonta*, and pointed out, among other distinguishing marks, the fact that the interlamellar junctions in the latter are not only thicker and wider and are covered by a peculiar folded epithelium, but that they are set much closer together. It will be well here to quote his description (op. cit., p. 59–60):

> The interlamellar junctions in the outer gill plate (the marsupial gill) are, like the vertical vessels, more numerous than those of the inner plate, occurring at intervals of seven filaments. They are long ridges of dense lacunar tissue, running vertically from base to apex of the gill plate, and have a much greater size, measuring more from one lamella to the other than those of the inner gill plate. In fact, they are capable of very great extension, which takes place when the outer gill plate has its interlamellar space occupied by the glochidian young of Anodon (pl. v, fig. 4). This great depth of the interlamellar functions of the outer gill plate is their most remarkable feature, as compared with those of the inner plate. It is accompanied by a different disposition of the vertical vascular trunks; for, whilst these in the inner gill plate lie *in* the interlamellar junctions, in the outer gill plate they lie in the subfilamentar mass of concreted tissue at the line of origin of the great ridges which act as interlamellar junctions. In consequence of this arrangement there are *two* vertical vessels in the outer gill plate to each interlamellar junction, whereas there is only one to each junction in the inner plate. The arrangement of these parts in the outer gill plate is no doubt correlated with its function as a brood pouch. * * * The difference just noted between the outer and inner gill plates, due to the frequency of interlamellar junctions and their relation to the vertical vessels, is accompanied by a further difference of form, which is obvious when the sections given in plate v, figures 2 and 3, are compared. In the outer gill plate the two lamellæ are parallel to one another and of equal thickness. In the inner gill plate the outer lamella is thicker than the inner, and its surface is thrown into a series of folds.

He figures very clearly the conditions described in both a non-gravid and a gravid outer gill and also in the purely respiratory inner gill, and it is clear from his description that the peculiarities of the outer gill of the female are permanent differentiations and are not merely present during gravidity. We have repeatedly observed the same differences as described by Peck, not only in *Anodonta* but in a number of other genera, and have also determined that the gills of the male are like the inner gill of the female with respect to the frequency of the interlamellar junctions and the character of their epithelium.

Peck's description has formed the basis of all of the textbook accounts of the structure of the unionid gill, and two of his figures, showing the differences between the inner and outer gills of *Anodonta*, are reproduced in Parker and Haswell's Text-book of Zoology, volume I, page 638.

Ortmann (1911) was evidently unacquainted with Peck's work, as he describes essentially the same differences between the marsupial and respiratory gills but without reference to Peck. He is the first, however, to show that the same differentiation holds good throughout a wide range of genera. In this connection he states that he "made a very important discovery, namely, that *in all our Unionidæ the anatomical structure of the gills, which serve as marsupia, is permanently differentiated*" (op. cit., p. 283). He then describes in detail the points of difference, showing that in the marsupial gill of the non-gravid female the interlamellar junctions, besides being more numerous, are thicker and wider and are covered by an epithelium which is folded and thrown into wrinkles, often of considerable proportions, whereas in the male and in the respiratory gill of the female the epithelium is simple and unfolded (cf. Peck). "There is no question," he says, "that this peculiar structure of the septa of the marsupial gills is an adaptation to their function"—a conclusion long ago arrived at by Peck. It should be stated that Ortmann has discovered another differentiating character between the inner and outer gill, namely, a longitudinal furrow along the ventral border of the inner gill which is entirely absent in the outer. This furrow is present in both males and females. A similar furrow is figured by Peck for the gill of *Mytilus*, but the figure in which it is shown is stated to be from the outer gill (op. cit., pl. IV, fig. 10).

Ortmann, in his careful study of the structure of the marsupium, has described a number of constant differentiations, hitherto unrecognized, which distinguish the several groups established by him in his system of classification. We are relieved, therefore, of the necessity of a detailed description in this place, and reference may be had to his interesting paper. It should also be stated that one of our former students, Mr. J. L. Carter, is now engaged in making a comparative study of the unionid marsupium in a large number of genera, and his investigation, which was undertaken primarily for the purpose of following the changes, both anatomical and histological, occurring in the gill from the pre-gravid to the post-gravid condition, is now well under way. Although Ortmann's work has, in part, rendered this investigation unnecessary, nevertheless Mr. Carter's study will contribute a number of facts, especially facts of a histological character, which are not included in Ortmann's observations.

Only a brief reference here to the internal structure of the marsupium is called for under the circumstances, and, since we shall need to compare our observations with those of Ortmann, it will be a matter of convenience to refer to them under the three subfamilies which he has distinguished. As we have not had an opportunity of examining the marsupium of *Margaritana*, we have nothing to add to Ortmann's description of this genus, and shall confine ourselves to the Unionidæ as restricted by him.

Unioninæ.—In this group there is, as Ortmann has shown, the least amount of differentiation and the structure of the marsupium most closely approaches that of the respiratory gill. Aside from the usual permanent differences, namely, the greater frequency of the interlamellar junctions, their increased thickness and width, and the folding of the glandular epithelium, there is little else to distinguish the marsupial from the respiratory gills in this subfamily. Figure 50, plate XIII, which shows a cross section of two water tubes (w. t.) from the gravid outer gill of *Quadrula ebena*, represents the typical appearance in the genera embraced in this subfamily. Only two embryos are drawn in the figure, although actually the water tubes are filled with them. The interlamellar junctions (i. j.) are set very close together, at intervals of about five filaments, and the marsupium is capable of only moderate distention. The epithelium covering the inner surface of the lamellæ is low and ciliated, while that of the interlamellar junctions is high and glandular and exhibits irregular ridges and furrows. The folds of the epithelium are always of course far more pronounced in the non-gravid gill, as in this condition the interlamellar junctions are not stretched as they are when the gill is charged with embryos. The throwing of the epithelium into folds and the bending and crumpling of the septa themselves, when not under tension, is undoubtedly due to the elastic fibers which are wavy and wrinkled in the non-gravid gill, while they are drawn out nearly straight when the marsupium is full.

When highly magnified, as in figure 64, plate XV, the epithelium, resting upon a base of connective tissue and smooth muscle fibers and elastic fibers, is seen to be composed chiefly of greatly swollen cells, whose vacuoles are filled with a clear mucus-like colorless fluid. Scattered among these gland cells and seemingly often lying within the vacuoles are seen several smaller and darker nuclei which are the nuclei of leucocytes (l). In fact, there can be no doubt that the epithelium becomes infiltrated with wandering blood cells from the underlying blood sinuses in the interlamellar junctions, and many indications are present that seem to show that these cells actually wander through the epithelium into the cavities of the water tubes, but what their ultimate fate is, if this be the case, we are as yet unable to say. There is some evidence that they are ingested by the mantle cells of the glochidia in species that carry the larvæ over the winter, like *Lampsilis*, but of this we can not be certain.

The above description of the epithelium of the interlamellar junctions will apply in essential respects to the marsupium of all of the Unionidæ that we have examined, for the same characteristic histological structure is present everywhere.

Anodontinæ.—Ortmann has discovered in the genera which he places in this subfamily a most remarkable differentiation which is evidently an adaptation for increased aeration during the period of gravidity, as it totally disappears after the glochidia are discharged and does not reappear until the onset of the next period. He describes the condition as follows (1911, p. 324, 325):

Here each ovisac of the gravid female is not formed by a whole water tube, but only by a part of it, the middle one, which is separated from two lateral canals by a folding up of the epithelium of the septa (interlamellar junctions). In addition, the ovisacs are closed above at the base of the marsupial gill, thus forming a completely closed sac within each water tube. In one case (*Strophitus*) this sac is again divided into secondary compartments. * * * This peculiar structure of the marsupial gill is developed only in the gravid female, and is absent in the sterile (nongravid) female. These characters are apparently connected with the prolonged breeding season, and the peculiar secondary water tubes serve for the aeration of the embryos in the marsupium.

In a preliminary announcement of his new system of the Unionidæ (1910a) he briefly stated this discovery in the following words:

Water tubes in the gravid female *divided longitudinally into three tubes*, one lying toward each face of the gill, the third in the middle; only the latter contains eggs or embryos, and is much larger than the other tubes. This division into three parts is not present in the sterile female.

The statement of the presence of these lateral compartments of the water tubes of the gravid female, made in this brief form and without illustrations, misled us and seemed at that time not to be in accord with our own observations on the marsupium of *Alasmidonta*, *Anodonta*, and *Symphynota*, three of the genera included by Ortmann in the Anodontinæ. We had, it is true, seen narrow slit-like spaces lying opposite the outer and inner faces of the water tubes, which were evidently not blood vessels, as the ostia opened freely into them. We interpreted them as differentiations within the lamellæ themselves and supposed that they were merely collecting canals into which the ostia opened from the outside and which led by irregular apertures on the other side into the water tubes, as our sections showed here and there interruptions (now known to have a different significance) in the inner wall of these canals. It did not occur to us that these might be the lateral divisions referred to by Ortmann, as, in the sections of the marsupium in which we had seen them, they appeared so evidently to lie wholly within the lamellæ.

We were, however, in error, and our failure to recognize that these were really divisions of the water tubes was due to the fact that the sections studied by us were taken from near the ventral border of the gill, where the spaces are much narrower and more slit-like, and also to the fact that at that time we had not happened to see the lateral divisions in the process of being cut off from the water tubes during the early stages of gravidity. Thinking that Ortmann had made some mistake in his observations, we unfortunately published a note (Lefevre and Curtis, 1910a) to this effect and stated that no such division of the water tubes in the three genera referred to was present. A more careful examination of our material, however, and a study of marsupia at different stages of gravidity showed us that Ortmann was entirely correct, and we wish to express our regret at the overhasty publication of our note. The true facts of the case are as Ortmann has stated them to be, although he has only very briefly described the method of formation of the secondary septa which divide the lateral compartments from the central portion of the water tube in which the embryos are confined. Speaking of the origin of the septa, he says (1911, p. 293):

In specimens where the eggs begin to go into the gills, this structure (the lateral divisions of the water tubes) is sometimes not developed, but it appears soon, and the epithelial folds, which form the secondary septa within the water tubes, begin to grow into the lumen of the water tubes, and the folds of the opposing faces of the two septa finally unite in the middle. The point of union (cross section of the line of union) is often distinctly seen in sections.

At the outset of gravidity, vertical septa begin to grow out in all of the water tubes of the marsupium from the surfaces of the interlamellar junctions close to the inner and the outer lamellæ of the gill. On each side of the gill one septum projects posteriorly, while the other extends anteriorly, and the two meet halfway across the cavity of the water tube. The free edges of each pair of opposed septa then fuse along their entire extent from the ventral border of the gill to the supra-branchial chamber. Specialized elongated epithelial cells forming a serrated border cover the free edge of each septum, and, when the two edges meet, these cells interlock and fuse (fig. 56, pl. XIV). In this way a space, quite narrow and slit-like below, but expanding gradually toward the supra-branchial chamber, is cut off from the water tube on either side, lying between the lamella and the large median division of the tube. As the septa unite, the eggs become confined entirely within the large central space of the original water tube, as Ortmann has stated, and it is this median division alone that functions as the marsupial cavity. We shall speak of the lateral spaces as the respiratory canals, as their function is undoubtedly to conduct a respiratory current of water to the supra-branchial chambers.

In figure 57, plate XIV, one side of a water tube, with the adjacent portion of the lamella, taken from a gravid marsupium of *Anodonta cataracta*, is shown in horizontal section. The gill contains eggs in an early cleavage stage, only four of which, however, are represented in the figure. The septa (s) are seen approaching each other, having not yet quite met. In figure 51, plate XIII, taken from the same species but not so highly magnified as the last figure, the septa have fused and the respiratory canals (r. c.) are completely shut off from the marsupial space (m. s.). In both of these figures the sections were taken near the ventral border of the gill; had they been cut at a higher level, the canals would be seen as much larger spaces. As is clearly shown in figures 56 and 57, plate XIV, the ostia open freely into the respiratory canals, and water must therefore enter the latter directly from the mantle chamber. The condition here should be contrasted with that seen in figures 50 and 53, plate XIII, which show water tubes from the marsupia of *Quadrula* and *Lampsilis*, representatives of Ortmann's Unioninæ and Lampsilinæ; here the ostia lead directly into the cavity of the tubes (w. t.) which are not subdivided and the whole of which becomes filled with eggs. Although it is not shown in figures 51, plate XIII, and 57, plate XIV, the epithelium covering the outer wall of the canals, which is of course the lining of the lamellæ, bears cilia which probably aid in conducting the current of water toward the suprabranchial chamber. Below, the canals are closed, and, since they are shut off from the marsupial cavity after the fusion of the septa, but open freely above into the suprabranchial chamber, there is but one course for the water to take—it must pass upward and enter the suprabranchial chamber. The transition from the more or less flattened epithelium lining the outer and inner walls of the respiratory canals to the large columnar cells on the anterior and posterior surfaces is clearly seen in figure 57.

The same condition appears in figure 58, plate XIV, which shows one end of a canal (the end marked X in the preceding figure) and the adjacent tissues, but under a higher magnification. Among the columnar cells are seen numerous swollen mucus cells, which are similar to those occurring on the interlamellar junctions farther in. The respiratory canals must be capable of expansion and contraction to a considerable degree, as a rich supply of smooth muscle fibers, passing in both a vertical and a horizontal direction, may be seen underlying the epithelium of the canals everywhere except in the septum (fig. 58, pl. XIV). Large blood sinuses (b. s.) are found in the lamellæ just outside of the canals, as seen in this figure, which shows how close the blood must come to the water within the canals (r. c.). There can be no doubt that the water passing through the canals is a respiratory current.

Although the respiratory canals open dorsally into the suprabranchial chambers, the marsupial division of the water tubes is completely closed off from the latter, as Ortmann has stated, by a roof which is developed in connection with the septa forming the respiratory canals. The dorsal free border of each interlamellar junction at the level of the suprabranchial chamber expands both anteriorly and posteriorly, but only over the marsupial division of the tube. The anterior and posterior edges of these umbrella-like expansions fuse with each other in exactly the same way as do the septa already described, and, since they also become continuous laterally with the vertical septa which separate the respiratory canals from the marsupial spaces, the latter thereby come to be completely roofed over and do not open at all into the suprabranchial chambers, unless the covering is broken. Of course, the formation of the roofing membrane does not take place until after the marsupium is fully charged with eggs. Owing to the gorged condition of the marsupium in these genera, the egg masses cause the roof to bulge up into the suprabranchial chamber over the marsupial division of each water tube, and on exposing the chambers the upper ends of the egg masses, covered, however, by the delicate transparent roofing membrane, are seen protruding beyond the dorsal boundary of the gill. In the drawing of *Symphynota complanata* (fig. 3, pl. VI), in which a portion of the suprabranchial chamber is exposed, the condition just described is distinctly shown.

As Ortmann has described, the secondary division of the water tubes entirely disappears after the discharge of the glochidia. The dorsal expansions of the interlamellar junctions, which united to form the roof, give way along the original sutures, and the glochidia are enabled to pass out; the septa separate in a similar manner, and are gradually retracted, and when the marsupium returns to the resting condition no trace of these structures is to be seen.

We have confirmed Ortmann's discovery of the respiratory canals in *Alasmidonta*, *Anodonta*, *Strophitus*, and *Symphynota*. Figures representing the marsupial structure in *Anodonta cataracta* (fig. 51, pl. XIII; 57, 58, pl. XIV) have already been referred to. Figure 56, plate XIV, is a section taken from near the ventral end of a water tube in the gravid marsupium of *Alasmidonta truncata;* the young embryos with which the marsupium is filled are not shown. The respiratory canal (r. c.) at this level is quite small and less slit-like than in *Anodonta*, but it widens out toward its dorsal end. The nuclei of the interlocking cells where the edges of the opposite septa have fused are quite distinct in the section. Figure 52, plate XIII, shows a horizontal section from the gravid marsupium of *Symphynota complanata* at a stage when the glochidia are fully formed. In this species, when the marsupium is fully charged, the interlamellar junctions are so stretched that they become greatly reduced in thickness and appear quite membranous. Figures 49 to 53, plate XIII, showing a gravid water tube in *Alasmidonta*, *Quadrula*, *Anodonta*, *Symphynota*, and *Lampsilis*, respectively, are all drawn under the same magnification, and should be compared in order to observe the relative sizes of the tubes in section in the several cases, as well as the different intervals between the interlamellar junctions as shown by the number of intervening filaments in the lamellæ.

Ortmann interprets the respiratory canals of the Anodontinæ as an adaptation for the better aeration of the embryos in the marsupium (1911, p. 325). They are unquestionably a respiratory device, but for many reasons it would seem clear that they serve primarily for the aeration of the blood of the gravid female and not of the embryos. It is difficult to see how a membrane which shuts the embryos off from the water could *increase* the facilities for aeration or why such a condition should be an improvement, as far as the embryos are concerned, over the marsupium in those genera where there are no respiratory canals and the water comes into direct contact with the embryos. In some of the species of *Lampsilis* (*ligamentina*, for example) the marsupium is as heavily charged as in many of the Anodontinæ, and the glochidia are also carried over the winter, yet the respiratory canals are not present. In either case the embryos probably receive an adequate amount of oxygen. But, on the other hand, it is not difficult to see that the respiration of the gravid female might be seriously interfered with, when the entire outer gill is gorged and swollen with glochidia and these same glochidia must remain in the marsupium for months. In the Unioninæ (Ortmann) the marsupium is gravid for only a few weeks at the longest, and, furthermore, the gills are not so heavily charged, while in the *Lampsilinæ* only a differentiated portion of the outer gill receives the embryos and, although the marsupium may be heavily loaded and remain gravid over the winter, the encroachment of the marsupial upon the respiratory function is not so extensive. In these two subfamilies the need of a special respiratory device is, therefore, not as great as in the Anodontinæ. The close association of the maternal blood with the current of water in the respiratory canals, as shown in figure 58, plate XIV, would add further evidence for the view that the secondary division of the water tubes is an adaptation for the better aeration of the blood of the gravid female, in correlation with the prolonged period of gravidity and the interference with respiration by the excessive crowding of the entire outer gill.

Reference should be made to the special conditions existing in *Strophitus*. Aside from the formation of the respiratory canals in the manner peculiar to the Anodontinæ, Ortmann has briefly described a division of the marsupial cavity of each water tube by the outgrowth of horizontal septa from the interlamellar junctions to form separate closed spaces each one of which incloses a single "placentula" Referring to the peculiar position of the "placentulæ," which lie crosswise in the gill, he says (1911, p. 294):

This arrangement is brought about by further outgrowths of the epithelial layers of the septa (interlamellar junctions), which fill the spaces between two septa, or rather only the middle part, the ovisac, and thus the simple ovisac of *Anodonta* and other genera is here divided into a number of swollen, *secondary ovisacs*, running transversely across the gill, each of which contains a short, more or less cylindrical mass of eggs or embryos. * * * Also in *Strophitus* these structures are not present in sterile females, and after the discharge of the glochidia they soon disappear.

We have observed this secondary division of the marsupial spaces in *Strophitus edentulus*.

We have not studied in detail the histological structure involved in the peculiar differentiation of the ventral border of the marsupium of the Anodontinæ and have, therefore, nothing to add to Ortmann's account (1911, p. 295) of the development of elastic tissue in this region, which allows of the enormous stretching of the gill in these genera when gravid. The lamellæ appear to separate along the mid-ventral border, especially in the middle portion of the gill, but are here connected by an elastic membrane which closes the bottom of the water tubes, with the result that "the edge of the marsupium in these forms *does not appear sharp* as in the *Unio* group, *but blunt, rounded off, or truncated*." This distension of the ventral edge, which is much more conspicuous in some genera than in others, is evidently a device to allow of a greater expansion of the marsupium.

Lampsilinæ.—It will be recalled that Ortmann includes in this subfamily Simpson's Heterogenæ, Mesogenæ, Ptychogenæ, and, although he does not refer to the genus *Dromus*, he would probably also place the Eschatigenæ here. We have already spoken of the general external characteristics which distinguish the marsupia in these groups. A great diversity of form is exhibited by the marsupium, but in all of the genera here concerned certain features, which have been referred to, are possessed in common.

In all of the groups here considered the marsupium is formed by a varying number of specialized water tubes in the outer gill, which are modified in different ways. In most, the water tubes are utilized throughout their entire length, as in *Lampsilis* and *Obliquaria*, but in other genera (*Cyprogenia*, *Ptychobranchus* and *Dromus* for example) it is only the ventral portion of the tubes which retain the embryos.

The respiratory canals, which are present during gravidity in the Anodontinæ, are absent in the Lampsilinæ, and the entire cavity of the water tubes in the marsupial region becomes filled with eggs (fig. 53, pl. XIII). The marsupium may show a high degree of distension when charged, as is seen in many species of *Lampsilis*. It is in the Lampsilinæ that we encounter the most capacious marsupial water tubes, the enlargement reaching the maximum size in *Obliquaria* (fig. 7, pl. VII). In figure 53, plate XIII, which is drawn from a gravid marsupium of *Lampsilis ligamentina*, the characteristic appearance of the water tubes in this genus is shown. The great antero-posterior diameter of the tube (w. t.) is very noticeable, as the interlamellar junctions are repeated at intervals of about a dozen filaments; the relatively large size of the tubes may be readily appreciated by a comparison of this figure with figures 49–52, plate XIII. The interlamellar junctions, when the gill is fully charged, are stretched into thin membranous septa (i. j.).

The dorsal free borders of the interlamellar junctions, while not forming a closed roof over the water tubes as they do in the *Anodontinæ*, in *Lampsilis* at least become distended into rather conspicuous bulb-like expansions which greatly diminish the openings of the tubes into the suprabranchial chamber, although their edges do not fuse.

As the histological details of the structure of the marsupia in several genera belonging to the Lampsilinæ have been studied by Mr. Carter and will be described in his forthcoming paper, a further account may be omitted here.

PHYLOGENY OF THE MARSUPIUM.

It is not without justification that a phylogenetic significance should have been attached to the several types of the marsupium which occur in the Unionidæ, for it would seem clear that those forms in which the structure characteristic of the respiratory gill is least modified, as in *Quadrula*, are more primitive than those in which the specialization of the marsupium has gone much farther, as in *Anodonta*, *Lampsilis*, and many other genera.

Simpson (1900) has considered these facts in some detail and concludes that the oldest type of marsupium phylogenetically is that occurring in the Endobranchiæ in which the inner gills alone are used as brood chambers. It is a slight transition from this condition to that presented by the Tetragenæ with all four gills functioning for this purpose. Basing his supposition largely upon shell characters and geographical distribution, he further concludes that the Homogenæ marked the next step in marsupial differentiation, while the Heterogenæ and all other groups in which a portion only of the outer gills is modified for receiving the eggs are the latest product of the evolution of the Unionidæ.

That this series correctly represents the phylogenetic sequence in the appearance of the marsupial modifications would seem to be borne out by the structural conditions existing in the several types so far as we have examined them, provided that we assume, with respect to the Homogenæ, that genera like *Pleurobema* and *Unio*, in which the marsupium is less specialized, are more primitive and therefore stand nearer the *Tetragenæ* than such genera as *Anodonta*, *Symphynota*, and others, which, as Ortmann has shown, exhibit certain modifications evidently in advance over the marsupium of the former.

Ortmann (1911), although he does not consider the Endobranchiæ, has arrived at conclusions essentially similar to the above. He points out, however, that the absence of complete interlamellar junctions in the gills of *Margaritana* would indicate that the new family which he has created for this genus, Margaritanidæ, is the most primitive group of the Naiades, and this inference, as was indicated above, is further strengthened by the fact that the simple gill structure of *Margaritana* is apparently similar to that of *Mytilus*, which belongs to a lower group of lamellibranchs than the fresh-water mussels.

His conclusions concerning the sequence of his three subfamilies of the Unionidæ may be quoted (p. 328):

> Of the *Unionidæ*, the *Unioninæ* are certainly more primitive than the other two subfamilies, as is evidenced by the simple character of the structure of the marsupial gills. The *Anodontinæ* and *Lamp-*

silinæ are more advanced, but they have advanced in different directions, and each has developed special features of the sexual apparatus. Generally speaking, the *Lampsilinæ* contain the most highly advanced types, as is shown by the restriction of the marsupium to a part of the outer gill, and by the strong expression of the sexual differentiation in the outer shell. Yet there are forms among the *Anodontinæ* which show extremely complex structures (*Strophitus*) unparalleled in any other genus, and the peculiar glochidia of the *Anodontinæ* surely mark a high stage of development.

It is not necessary for our purpose to enter into a further discussion of the subject in this place.

CONGLUTINATION OF THE EMBRYOS.

After extrusion of the eggs from the genital apertures, they are received into the suprabranchial chambers, and thence pass, as has already been described, into the water tubes of the gills, eventually filling up those portions which function as the marsupium. In a short time after entering the latter the eggs usually become conglutinated into masses which are molded into the exact shape of the cavity of each marsupial water tube (Lefevre and Curtis, 1910b). The masses are of course separated from each other by the intervening interlamellar junctions of the gills.

Since it is a matter of convenience to have a word to apply to these compact masses in which the eggs or embryos are held together, whether they be plate-like, club-shaped, cylindrical, or of some other form, we shall employ the term conglutinate in referring to them. Ortmann (1911) has proposed the word placenta, which was introduced by Sterki (1898) for the peculiar cords of *Strophitus*, but this is obviously misleading, as there is no connection whatever between the masses and the maternal tissues. The conglutinates vary greatly in different species in size and shape, and, since each is a cast of the cavity of its water tube, they conform to the special conditions existing in the several types of marsupium. The commonest form is that of a flat plate, either elliptical or lanceolate, being usually slightly blunter and thicker above and more pointed and thinner below. Since we have already seen that the antero-posterior diameter of the marsupial water tubes varies very much in different species, the thickness of the conglutinates must vary to the same extent. In *Quadrula* and *Unio*, for example, in which the interlamellar junctions are set close together, the conglutinates are very thin, being not more than twice the diameter of an egg in thickness; whereas in *Lampsilis*, with its much more capacious tubes, they may be three or four times as thick. In other words, just as many eggs will lie abreast in a horizontal section of the marsupium as the antero-posterior diameter of the water tube will allow.

This commoner lanceolate form of the conglutinate, differing, however, in size and thickness, may be seen in the species of *Quadrula*, *Pleurobema*, *Unio*, and *Lampsilis*. In figure 41, plate XI, two conglutinates of *Lampsilis ligamentina* are represented, one from the flat side, the other on edge. An unusual form of conglutinate has been observed by us in *Quadrula metanevra;* it is bifurcated and consists of two flat lanceolate masses which are united for the upper third of their length, but free below. In those genera, however, in which the form of the water tubes of the marsupium departs more widely from the usual condition, the conglutinates are similarly modified. In *Obliquaria reflexa*, for example, in which the marsupium consists of several elongated and distended water tubes of tubular form, the conglutinates are large, slightly curved cylindrical masses of nearly uniform diameter and generally blunt at each end. Three of them are shown in figure 42, plate XI; the one on the right was taken from the most posterior water tube of the marsupium, which is not as long as the rest, and its conglutinate is correspondingly shorter. The relation will be understood by reference to the figure of the marsupium of this species (fig. 7, pl. VII).

There seem to be two methods by which the embryos are bound together to form conglutinates—they may either be attached more or less firmly to each other by their egg membranes, which are in this case of an adhesive nature, or they may be embedded in a mucilaginous matrix of varying consistency. The former is by far the commoner condition and is seen in figure 17, plate VIII, which is a detail drawn from one of the conglutinates of *Obliquaria reflexa* shown in figure 42, plate XI; the immature glochidia with their valves open are still contained within the membranes, which are closely adhering and by mutual pressure are squeezed into a polyhedral form. In cases like this it is difficult to determine whether there is a glutinous matrix between the embryos or not, but if any is present, it must be in very small amount, since the embryos seem to be held together solely by the adhesive surfaces of their membranes. In those cases, however, in which a matrix is evident (*Lampsilis*), the embryos are not so closely appressed and are embedded, more or less loosely, in a glutinous binding substance. This condition is illustrated in figure 16, plate VIII, which is a portion of a conglutinate of *Lampsilis ligamentina* seen under higher magnification; as the matrix is transparent, it can not be shown in the figure.

The conglutinates differ markedly in tenacity, for, whereas in some cases the mutual adhesion is not strong and the masses consequently break up readily (*Quadrula, Pleurobema, Unio, Lampsilis*), in others (notably in *Obliquaria*) the embryos adhere so firmly that they may be separated only with difficulty by teasing.

In still other species the embryos can not be said to form conglutinates at all, as they are merely suspended in a slimy mucus which is not of such a consistency as to enable the mass to maintain a definite form when removed from the gill. We have observed this condition in *Alasmidonta, Anodonta*, and *Symphynota*, and Ortmann (1911) states that it also occurs in *Anodontoides*.

In most species (*Quadrula, Unio, Lampsilis, Dromus*) in which the conglutinates are found, the adhesion exists only during the embryonic development and by the time the glochidia are fully formed they are found to be free but for the mucus which holds them more or less loosely together. In *Obliquaria reflexa*, however, the conglutination persists, and the fully developed glochidia, still tenaciously adhering, are discharged from the marsupium in the cylindrical masses already described (fig. 42, pl. XI); even after lying in the water for some time they do not separate, and it has perplexed us to understand how the glochidia of this species ultimately become attached to fish, if they pass through a subsequent parasitic stage. Can it be that parasitism has been lost in *Obliquaria* as it has been in *Strophitus*, and that the metamorphosis takes place while the glochidia are in the conglutinates? We have not yet had the material by which to answer this question.

The relation of the embryos and glochidia of *Strophitus* to each other is so unusual that its description is reserved for a special section (see below).

STRATIFICATION OF UNFERTILIZED EGGS.

It has already been pointed out that not infrequently eggs pass into the marsupium without being fertilized and remain there throughout the period of embryonic development, as one may find them in the same gill with fully formed glochidia. In some individuals we have found every egg in the marsupium in this condition. Such eggs have been encountered chiefly in summer-breeding species, and they seem to be especially common in *Pleurobema* and *Quadrula*, nearly every gravid female of which has been found to contain at least some unfertilized eggs. After remaining in the marsupium for a time such eggs generally become swollen and stratified into three distinct layers, a heavier, often pigmented, mass at one pole, a clear or hyaline intermediate zone, and a small granular cap at the lighter pole. As the eggs lie in a constant position in the gills, which are placed vertically in the normal position of the animal, it can not be doubted that the stratification is produced by gravity. It has not yet been determined whether the substances which occur in these layers are the same as would be separated out by centrifuging or not, but this is not at all unlikely. As many of the species of mussels in which we have seen this condition, for example, *Quadrula ebena*, *Q. trigona*, and *Pleurobema æsopus*, have brightly colored red or pink eggs, the stratification is quite striking, the pigment being always at the heavier pole, as it is invariably directed toward the lower border of the gill.

ABORTION OF EMBRYOS AND GLOCHIDIA.

There has been a certain amount of discussion among the conchologists as to whether or not the functioning of all four gills as a marsupium is a constant character in *Quadrula*, and observations have been to a certain extent conflicting. Since Simpson has made use of this feature in characterizing the group Tetragenæ, some importance has been attached to the apparent discrepancy in observations.

While examining mussels on the upper Mississippi River in the summer of 1908, we observed a peculiarity of behavior in all of the species of *Quadrula* collected which may account for the conflicting descriptions of the marsupium in this genus, and also for the fact that in some species gravid females have never been observed at all. Every species of *Quadrula* that came into our hands exhibited to a greater or less degree the habit of aborting embryos and glochidia when taken out of the river, and if they were not opened and examined at once upon capture they were generally found shortly afterwards to be either partially or entirely empty. Some individuals discharged the contents of their gills more readily and completely than others, the abortion involving either all four gills or only the inner or outer ones, or, again, only a portion merely of one or more gills. In the pre-glochidial stages, when the embryos are conglutinated, the entire masses were discharged, while individuals were frequently seen in the act of aborting their embryos or glochidia which were often expelled with considerable force through the exhalent siphon.

This behavior was so characteristic of the genus that, in order to make a correct determination of the condition of the marsupium, it was necessary to open quadrulas immediately after taking them from the water. When this was done, all four gills were invariably found to be charged on opening females which contained embryos in pre-glochidial stages—that is, at any time before normal spawning had occurred. The habit of readily aborting embryos when disturbed has also been observed by us in *Unio complanatus*, which has been repeatedly seen in the act of discharging the contents of the marsupium shortly after being placed in aquaria. In all likelihood it occurs in other species of *Unio*, and it may possibly be characteristic of all forms in which there is but little structural differentiation of the marsupium. We have, however, also observed the discharge of embryos in *Lampsilis ligamentina*, but only after the gravid females have been kept in the laboratory for some time. This species is apparently very much less sensitive with respect to abortion than the quadrulas and *Unio complanatus* and only frees its gills of the conglutinates after long exposure to artificial conditions. The premature extrusion is probably due to imperfect aeration of the water and results from an effort on the part of the female to secure more oxygen; if this be true, one would not expect to find it occurring so readily in those forms which have a differentiated marsupium, like the Heterogenæ, since here the respiratory and marsupial functions of the gills are not so intimately associated.

Both Schierholz (1888) and Latter (1891) have referred to the occurrence of abortion in *Anodonta*, but according to our experience it has never been encountered in a single instance in either *Anodonta* or *Symphynota*, although gravid females have been kept in tanks in the laboratory for weeks or even months. The presence of the respiratory canals, which have been described as occurring in these genera during gravidity, as well as the temporary membrane which roofs over the marsupial division of the water tubes, might well account for the absence of abortion, or at least its rare occurrence, in the forms in which these special conditions exist. The respiratory canals doubtless lessen the evil effects of poor aeration, while the roofing membrane of the water tubes would certainly offer some obstruction, as long as it was present, to a liberation of the embryos.

BREEDING SEASONS.

In connection with our study of artificial propagation of fresh-water mussels, we have found it necessary to collect data bearing upon the breeding seasons of a fairly wide range of species, since the records of previous observers, for North American Unionidæ at least, have been insufficient to enable us to determine the full extent of the seasons, especially in the case of some of the more important commercial species.

Although our observations have been largely confined to species occurring in the upper Mississippi Valley and have been concerned primarily with species of commercial value, we have continuous records throughout the entire year for a number of important genera, and in every case the exact stage of development of the embryos has been determined by microscopic examination. Many thousands of such observations have been made, so that we are now in possession of detailed information dealing with the duration and progress of the periods of gravidity obtaining in over a dozen genera of the Unionidæ.

We have fully confirmed the conclusion reached by Sterki (1895) that the North American Unionidæ, with respect to their breeding seasons, fall into two classes, the so-called "summer breeders" and "winter breeders" — a distinction, however, which had previously been pointed out by Schierholz (1888) for European forms and frequently recorded by later observers. The designation "winter breeders," however, is not strictly appropriate, for in the species which belong to this group the eggs are fertilized during the latter half of the summer and the glochidia, which are carried in a fully developed condition in the marsupium throughout the winter, are not discharged until the following spring and summer. In the case of the summer breeders, the eggs are fertilized during late spring and summer and spawning as a rule is over by the end of August.

In view of these facts, it would seem to accord better with the actual conditions to separate the species with respect to the length of time that the glochidia remain in the marsupium, designating them as those that have a "short period" and those with a "long period" of gravidity, rather than to distinguish them as "summer breeders" and "winter breeders," respectively, for with respect to the latter neither ovulation nor discharge of the glochidia takes place in winter. This suggestion was made by us in an earlier paper (1910b), and subsequently Ortmann (1911) proposed the somewhat awkward terms *tachytictic* and *bradytictic* (meaning quick-breeding and slow-breeding) for Sterki's "summer breeders" and "winter breeders," respectively.

The breeding seasons as here defined are based upon data collected in the middle and northern sections of the United States, and in the absence of adequate records from higher and lower latitudes, it is impossible to say to what extent a colder or warmer climate might affect the period of gravidity That it would have some influence can hardly be doubted, although a distinction between a long and a short season will probably be found to hold true in general.

The breeding season is a generic character, for so far as our observations have gone all of the species belonging to a given genus have essentially the same period of gravidity. The prolonged period, furthermore, is correlated with the more pronounced structural modifications of the marsupium which have been described above.

LONG PERIOD OF GRAVIDITY.

In the forms which fall into this category the eggs are fertilized, as has been stated, during the latter half of the summer, from the middle of July to the middle of August, and the glochidia, instead of being discharged when fully formed, are carried in the marsupium until the following spring or early summer. In fact, in some cases the close of one breeding period may overlap on the beginning of the next, as one may still find in late July a few straggling females gravid with glochidia formed in the previous autumn, while in other individuals of the species at the same time and in the same locality the eggs are passing into the gills for the next season. This seems to be true of several species of *Lampsilis*. We have encountered it in *ligamentina*, Conner (1909) records it for *radiata* and *nasuta*, while Ortmann (1909) states that his observations make it probable for *ventricosa* and *luteola*. Yet, as Ortmann observes, it is generally true that an interval exists between the close of one period and the beginning of the next. This interval, however, varies in length in different species, in some extending from late spring until August, whereas in others it is of much shorter duration. It is also to be noted that the discharge of glochidia does not take place in all of the individuals of a species at the same time, but on the contrary, spawning may extend over a considerable period throughout the spring and early summer (cf. Ortmann, op. cit.).

All of the genera included in Simpson's Heterogenæ, Ptychogenæ, Eschatigenæ, and Diagenæ have the long period of gravidity, as do also a number of genera of the Homogenæ (*Alasmidonta*, *Anodonta*, *Anodontoides*, *Arcidens*, *Symphynota*), while the Mesogenæ are represented in this group by *Cyprogenia*. These genera are embraced in Ortmann's subfamilies *Anodontinæ* and *Lampsilinæ*, and it should be noticed that in all the gills show a high degree of specialization in adaptation to the marsupial function, a specialization which is undoubtedly correlated with the habit of retaining the glochidia over a period of several months.

In the following list are given the species in which we have determined the long period of gravidity:

Alasmidonta truncata.
Anodonta cataracta.
Anodonta grandis.
Anodonta implicata.
Arcidens confragosus.
Cyprogenia irrorata.
Dromus dromus.
Lampsilis (Proptera) alata.
Lampsilis (Proptera) lævissima.
Lampsilis anodontoides.
Lampsilis gracilis.
Lampsilis higginsii.
Lampsilis ligamentina.
Lampsilis luteola.
Lampsilis recta.
Lampsilis subrostrata.
Lampsilis ventricosa.
Obovaria ellipsis.
Plagiola elegans.
Plagiola securis.
Strophitus edentulus.
Symphynota complanata.
Symphynota costata.

Ortmann (1909) has published some observations on the breeding seasons of the Unionidæ of Pennsylvania, supplemented by data from Lea and Sterki; his results in all essential points agree closely with ours. He includes among "winter breeders" several genera which we have not had under observation, namely, *Truncilla*, *Micromya*, *Ptychobranchus*, and *Anodontoides*, while *Arcidens*, which we have recorded, does not appear in his list.

There is given below a brief summary of our breeding records for the genera here concerned. Although in many species we have examined hundreds of individuals and have had them under observation continuously throughout the year, in others the material has been more or less meager and observations scattered, but in most of the forms the records have been adequate for a determination of the general limits of the breeding season.

Alasmidonta.—Embryos from latter part of July to middle of August. No fully formed glochidia have been seen, as gravid females have not been secured after August.

Anodonta.—Embryos from the middle of August to September; ripe glochidia from early October to first of July. A distinct interim exists between close of one period and beginning of next. According to Harms (1909), in European species of *Anodonta* the eggs are fertilized about the middle of August, all of the individuals entering upon the breeding season at nearly the same time, and by the middle of October almost all of the females are gravid with glochidia.

Arcidens.—Glochidia in winter months. Only a few individuals secured.

Cyprogenia.—Glochidia in November.

Dromus.—Glochidia in November.

Lampsilis.—Embryos from first of August to late September; glochidia from late September to first of August. Our most complete record concerns this genus, several species of which (*anodontoides, ligamentina, recta, subrostrata, ventricosa*) we have repeatedly had under observation continuously throughout the year. The gravid period seems to be more extended in *Lampsilis* than in any other genus, for, although June is apparently the month when the liberation of glochidia is at its height, some females bearing glochidia may still be found, but in diminishing numbers of course, until the beginning of August, a time when the next season is just setting in. Since ripe glochidia may be obtained in abundance from October to July, inclusive, and since *Lampsilis* furnishes several species of commercial value, the extended period of gravidity in this genus becomes of the greatest importance in artificial propagation, as material is available for the infection of fish throughout the greater part of the year.

Obovaria.—Glochidia during the fall, winter, and spring months. Spawning must occur before June, as no glochidia have been encountered in June, July, and August, although a number of females have been obtained during these months.

Plagiola.—Ripe glochidia during the winter and as late as the end of July; no embryos have been obtained.

Strophitus.—Embryos from late July to middle of August; glochidia from November to middle of July. The interval between the seasons is very short, much shorter than that observed by Ortmann (1909), who records an interim from May 22 to July 11.

Symphynota.—Embryos during August; ripe glochidia from late September to late June. *S. complanata* is a species which we have had on hand constantly for several years, and we have followed it continuously through the year. Spawning is most active in June.

SHORT PERIOD OF GRAVIDITY.

In the species having the short period of gravidity the entire breeding season is confined to about four months, as it extends only from about the end of April to the middle of August, and the glochidia are discharged as soon as they are fully developed. It is highly probable, however, that the beginning of the breeding season is influenced to a certain extent by temperature, for it would seem that ovulation may be postponed for some weeks by cold weather at this time of the year. It was first pointed out by Sterki (1895) that these summer-breeding forms are confined to a limited group of genera, and Ortmann (1911) has emphasized the fact that it is only the genera having the least specialized marsupia that possess this apparently more primitive breeding season; these are the genera which constitute his subfamily Unioninæ. *Margaritana*, unquestionably a primitive form, likewise breeds only in the summer. In all of these genera the structure of the marsupium approaches most closely that of the respiratory gills; none of the special modifications, so prominent a feature of the marsupium of other genera, is present. There is apparently, however, one exception, for, as will be shown below, our records indicate clearly that *Obliquaria*, which has a highly specialized marsupium, is a summer breeder.

The following are the species which we have observed to have the restricted breeding season:

Obliquaria reflexa.
Pleurobema æsopus.
Quadrula ebena.
Quadrula heros.
Quadrula lachrymosa.
Quadrula metanevra.
Quadrula obliqua.
Quadrula plicata.
Quadrula pustulosa.
Quadrula trigona.
Quadrula (Tritogonia) tuberculata.
Quadrula undulata.
Unio complanatus.
Unio gibbosus.

The following species, which do not appear above, have been determined by Ortmann (1909) to be summer breeders: *Unio crassidens; Pleurobema clava* and *coccinea; Quadrula kirtlandiana*, *rubiginosa*, and *subrotunda*. Our list, on the other hand, supplements his by the addition of several species of *Quadrula*, for which data have previously been either entirely wanting or quite meager.

Obliquaria.—Since all of the forms which carry the glochidia over the winter have a highly specialized marsupium, we should expect that *Obliquaria*, whose marsupium is of such a nature, would also have the long gravid period. This expectation would be further strengthened by the fact that the very closely related genus *Cyprogenia* belongs in the former group, as has been seen. It was therefore with some surprise that we found *O. reflexa* breeding during the summer. Our record is as follows: Embryos from the latter part of May to July 9; glochidia from June 20 to August 8. This is a typical record for a summer breeder, and there can be little doubt that the species must be placed in this group. On the other hand, Sterki (1898, 1903) states that all forms which have a differentiated marsupium carry their glochidia over the winter, and Ortmann (1911) includes *Obliquaria* in his *Lampsilinæ*, all of which he says are "bradytictic," although specific reference to the breeding season of this genus is not made. Since, however, we have not had an opportunity of observing the species during the fall and winter, it is possible that it has the long period, although, if such is the case, its season begins two months earlier than that of any other species in this class—a quite improbable supposition. For the present, at all events, we must consider it a summer breeder.

Pleurobema.—Embryos from early June to early August; glochidia during July.

Quadrula.—Embryos from late May to middle of August; glochidia from early June to middle of August. Hundreds of females belonging to different species of this genus have been examined throughout the rest of the year, but gravid individuals have never been encountered except during the months indicated.

It should be mentioned that in the case of *Q. heros* Frierson (1904) has not found this species gravid in Louisiana until October, when embryos were found. Young embryos were again encountered in November and immature glochidia in January. He concludes that *heros* is an exception in the genus and is not a summer breeder. Our observations on this species are very meager, but since we have found it bearing young embryos in the latter part of May, they would seem not to be in accord with those of Frierson.

According to Harms (1909), *Margaritana*, which breeds in Europe in July and August, produces two successive broods during that time, from sixteen days to four weeks, according to temperature, being required for the development of each. Although we have not determined it beyond all doubt, our records strongly indicate that the species of *Quadrula* also spawn twice during the season, first in June and July and again in July and August. This, however, could not be definitely proven without a most extended series of observations, and possibly not unless individual females were kept in aquaria under close observation throughout the breeding season.

Unio.—Embryos from early June to early August; glochidia from middle of June to middle of August. Conner (1907) records *U. complanatus* as beginning its breeding season in April, and Lea (1863) found it gravid in May; but we have not had an opportunity of examining any species of the genus during these months. According to Harms (1909) the breeding season of *Unio* in Europe begins early in March, or, if the weather is cold, not until the end of May.

III. THE LARVA.

STRUCTURE OF THE GLOCHIDIUM.

As has long been known, two well-marked types of glochidia are found in the Unionidæ; one provided with a strong shell bearing a single stout hook at the ventral margin of each triangular valve; the other with no such hooks and a more delicate shell, the valves of which are shaped like the bowl of a very blunt spoon.

A possible third type, which appears to be a derivative of the second, is seen in the "axe-head" glochidium, originally described and figured by Lea (1858, 1863, and 1874) in *Lampsilis* (*Proptera*) *alata*, *lævissima*, and *purpurata*.

The first type is characteristically parasitic upon the fins and other external parts of fishes from which scales are absent, the second upon the gill filaments. The occurrence of these types in the genera which we have examined is shown by the following list:

Hooked glochidia:	Hookless glochidia:	Axe-head glochidium:
Anodonta.	Cyprogenia.	Lampsilis (Proptera) alata.
Strophitus.	Dromus.	Lampsilis (Proptera) lævissima.
Symphynota.	Lampsilis (majority of species).	Lampsilis (Proptera) purpurata.
	Obliquaria.	Lampsilis capax.
	Obovaria.	
	Plagiola.	
	Pleurobema.	
	Quadrula.	
	Tritogonia.	
	Unio.	

The axe-head glochidium occurs, so far as known, in only a few closely related species which were generally included in the genus *Lampsilis*, but which, after being first placed in the subgenus *Proptera* by Simpson (1900), have been elevated to the genus *Proptera* by Sterki (1895 and 1903), a change which has recently been approved by Ortmann (1911). The species long known to possess this axe-head glochidium are *Lampsilis* (*Proptera*) *alata*, *lævissima*, and *purpurata*, and recently Coker and Surber (1911) have described it for *Lampsilis capax*.

There is considerable diversity in size among glochidia even from the same genus, as represented by the outlines in text figure 1 (A–O), all of which are drawn to the same scale, the most striking cases being the difference between the two species of *Plagiola* (G and H), and that between *Lampsilis recta* and *gracilis* (K and L). Harms (1909), who has studied the exceedingly minute glochidia of *Margaritana margaritifera*, finds that they are exclusively gill parasites, because their small size makes attachment elsewhere impossible.

The type of glochidium is constant for the genus, so far as our observations go, save in the case of *Lampsilis*, as has just been mentioned. In some cases the shape is also characteristic, as shown by *Symphynota* and *Anodonta* (A, B, and C), in which the shell outline is a distinguishing feature.

In *Dromus dromus* the glochidium, which is of the hookless type (text fig. 1, M), is greatly elongated antero-posteriorly thus presenting an interesting modification.

THE HOOKLESS TYPE.

Since the greater part of our experimental infections with glochidia of the hookless type have been made with our common species of *Lampsilis*, we have examined the glochidia in this genus more extensively than any others and shall describe, as representative of what has been observed, the hookless glochidium of *Lampsilis subrostrata* which is shown in figures 13, 14, and 15, plate VIII; and, since it is often necessary in the practical work of infection to examine the glochidia alive in water and to determine the exact stage of their development, we shall first speak of their appearance when in this condition.

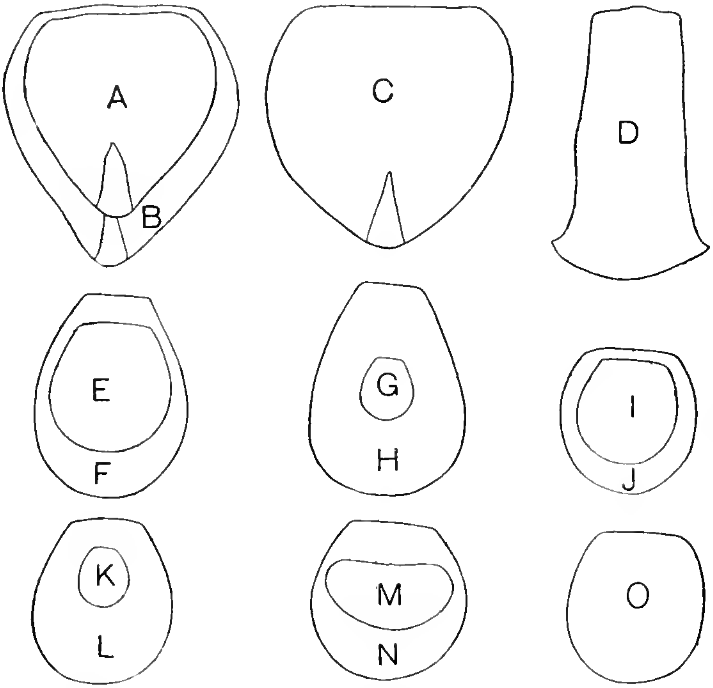

FIG. 1.—Figures showing relative sizes and shapes of the shells of a series of glochidia, belonging to the following species: A, *Symphynota complanata*, 0.30 × 0.29 mm.; B, *S. costata*, 0.39 × 0.35 mm.; C, *Anodonta cataracta*, 0.36 × 0.37 mm.; D, *Lampsilis (Proptera) alata*, 0.41 × 0.23 mm.; E, *Quadrula metanevra*, 0.19 × 0.18 mm.; F, *Q. pustulosa*, 0.30 × 0.23 mm.; G, *Plagiola elegans*, 0.09 × 0.075 mm.; H, *P. securis*, 0.31 × 0.23 mm.; I, *Quadrula ebena*, 0.15 × 0.14 mm.; J, *Q. plicata*, 0.21 × 0.20 mm.; K, *Lampsilis gracilis*, 0.085 × 0.075 mm.; L, *L. recta*, 0.24 × 0.20 mm.; M, *Dromus dromus*, 0.19 × 0.10 mm.; N, *Obliquaria reflexa*, 0.23 × 0.225 mm.; O, *Unio gibbosus*, 0.22 × 0.19 mm.

When examined alive (fig. 13, pl. VIII), this glochidium exhibits a shell which is comparatively firm in structure and which may remain unchanged by the water even many days after its living contents have been destroyed. Evidence of the shell's strength is shown by the fact that its shape remains unchanged after the glochidial muscle has caused the lips of the shell to bite deeply into a host's tissue, and by the fact that it is not easily broken by rough handling, as when the glochidia are tumbled in and out of a pipette during the process of breaking up the conglutinated masses. This strength is due to the carbonate of lime already laid down in the shell and not to the cuticle, which is often referred to by investigators as though it were the sole constituent of the shell of the glochidium; for when the carbonate of lime is dissolved by acid the cuticle becomes wrinkled and the shell partially collapsed. Viewed from the outside and closed (fig. 13, pl. VIII), this shell of the living glochidium exhibits a fine granulation over its entire surface and a distinct border around the free margin. At the hinge margin two denser areas may be observed, which, when examined from the inner face of the valve, are found to be continuous with the border around the free margin (fig. 13, pl. VIII). The test with acid shows that this entire border is calciferous and that there is a thinner layer of carbonate of lime over the whole surface and beneath the cuticle. This layer is often cracked, as one might break the shell of a hen's egg, when preserved specimens are slightly crushed under a cover glass, and it is then seen to be distinct from the cuticle which may wrinkle but does not break. Upon the loss of the lime, the cuticle is no longer firm enough to preserve the shape of the shell and successful permanent mounts must therefore avoid acids at any stage of the preparation.

Along the ventral border of the shell is a flange, formed of cuticle only, and so transparent that it is easily overlooked in a ventral view of the open glochidium (fig. 15, pl. VIII). Viewed laterally (fig. 14, pl. VIII), this flange has at a certain focus the appearance of a hook and may easily be mistaken for one when seen under a low magnification. It is, however, a continuous flange, as shown in the figures, and not a hook; and since its edge is very fine it must, when the glochidium closes its valves, cut into and hold to a delicate tissue like that of the gill filament, thus performing much the same function as the hook in the other type of glochidium. The general spoon-like character of the valves is shown clearly by the figures. The adductor muscle is well seen in the living specimen, being a conspicuous object from whatever angle it is examined. Viewed laterally (fig. 13, pl. VIII), or from the ventral aspect (fig. 15, pl. VIII), the adductor is seen to lie nearer the shell margin at one end of the hinge than at the other, a fact which enables one to recognize at a glance the future anterior border of the shell. There is also in this glochidium of *Lampsilis subrostrata* a slight difference in outline by which these anterior and posterior borders of the shell may be distinguished (fig. 13, pl. VIII), while in the hooked type of glochidium (fig. 10, pl. VIII, and text fig. 1, A, B, and C) this difference is even more pronounced and one recognizes the anterior border of the future adult by its slightly greater length.

The two outer pairs of sensory cells with their fine projections (fig. 14 and 15, pl. VIII) are readily seen in the living glochidium; the two inner pairs, in which the cells project but a short distance from the surface, are more easily found in specimens which have been properly preserved and stained. The position of the two outer pairs may also be seen in the closed glochidium (fig. 13, pl. VIII). Little can be seen of the rudiments of the various organs of the adult without the careful staining of well fixed material. In the living glochidium they appear as a slightly denser area on either side of the median line and posteriorly to the adductor muscle (fig. 13, pl. VIII). The cells of the larval mantle (fig. 15, pl. VIII), which occupy the greater part of the surface exposed within the valves, appear in the living glochidium as a dense mass in which cell outlines can not be recognized.

Further details in the structure of this glochidium can only be studied in specimens which have been properly fixed and stained. After trying various reagents, we have found that they may be stupefied in a few moments by the addition of several small crystals of hydrochlorate of cocaine to the water in a watch glass, after which they may be fixed with no serious shrinkage by using the solution of plain corrosive sublimate obtained by diluting a saturated solution two or three times with water. Acids should be avoided throughout the whole process. Alum cochineal, Delafield's hæmatoxylin, and borax carmine, alone or with Lyon's blue, have been used as stains, each being more suitable for the demonstration of certain structures. In this stained material the shell shows a slight wrinkling of its ventral flange and is the only part not shown to better advantage than in the living specimens.

The lateral pairs of sensory cells (fig. 14 and 15, pl. VIII) are tall chimney-like structures expanded at the base and terminated by several very fine motionless processes. A denser border where these processes are inserted in the cell is presumably due to their continuation within the cytoplasm which has been observed in sections of these and other glochidia. The two median pairs of sensory cells (fig. 14, pl. VIII) project only a short distance and have short processes. The anterior pair is located ventral to the median portion of the larval adductor muscle, the posterior pair near the outer ends of the rudiments of the adult organs (fig. 15, pl. VIII). The designation of these cells as "sensory" by all writers rests upon their structural features as described by the earlier investigators, and upon the fact, recorded by Lillie (1895), of their staining reaction with methylene blue. The actual connection of the cells with the larval muscle fibers has been sought for by investigators, but never discovered. We have not attempted a further demonstration of the function of these cells by the methods practiced in recent experimentation upon the protozoa and other minute organisms, although such a study might yield some interesting results.

Lining the greater part of the surface between the valves, are the large cells composing the larval mantle (fig. 15, pl. VIII). They are filled with fine granules, which, since these cells actually digest the tissue of the host during the early stages of the parasitism, are probably the zymogen granules from which the digestive enzymes originate. The absence of these cells over the area of flexure ventral to the adductor muscle will be noted in figure 15. In this area the ectoderm is thinner and there is no granulation. The adductor muscle is composed of fibers having elongated nuclei and often seen to branch toward the ends where they are attached to the valves. In a glochidium of *Lampsilis subrostrata*, which has been carried over the winter in the parent gills and which has therefore reached the highest stage of differentiation possible for this glochidium, we can identify the rudiments of foot, stomodæum and enteron, and of the heart, pericardium, and kidney, as described by Harms (1909) in his accounts of the structure and organogeny in the hookless type of glochidium. Reference to figure 15, plate VIII, will make clear the following account of these rudiments.

In the median region, just posterior to the adductor, is a triangular area, the oral plate; behind this a narrow band of closely set nuclei extending well out into the valves, where it becomes wider. The ectoderm in the median part of this area becomes the covering of the foot, while the deeper part of the area is endoderm, the rudiment of the enteron. The lateral expansions of this general mass are mesodermal cells which are closely applied to the endoderm and in which are found the rudiments of the kidney, heart, and pericardium. A backward curve in the posterior outline at either side of this mass appears to represent imperfectly developed lateral pits, from the outer borders of which Schierholz (1888), Schmidt (1885), and Harms (1909) agree that the first rudiments of the gills originate, and which are very conspicuous structures in the glochidia of the hooked type. We have never observed any structure resembling the larval thread or its rudiment in the fully formed glochidia of species of the genera *Lampsilis* and *Quadrula*, the glochidia of which we have studied most extensively; and the larval thread is not present in functional condition in any of the species we have studied from the genera listed on page 145, with the exception of *Anodonta* and *Unio*. A discussion of this organ, which has heretofore been assumed to occur in all glochidia, is given after the account of the hooked glochidium which follows.

THE HOOKED TYPE.

Our first infections were performed with the hooked glochidium of *Anodonta cataracta*, which is essentially like the *Anodonta* type of glochidium described for European species, and which has been described in a detailed manner by Lillie (1895). Our later work has been with the young of *Symphynota complanata* and *S. costata*, the glochidia of which resemble one another in structure, as shown by their outlines in text figure 1, A and B, and figures 9 and 10, plate VIII; so that here, as elsewhere noted in the case of hookless glochidia, the outline appears to be a characteristic of the genus, which enables one at once to distinguish the glochidia of *Anodonta* from those of *Symphynota*. There is, however, a marked size difference between the glochidia of these two species of *Symphynota* (text fig. 1, A and B).

In both *Anodonta* and *Symphynota* glochidia, the slightly greater length of one border of the valve between hook and hinge is indicative of the future anterior region. In most hookless glochidia there is a similar slight difference in the anterior and posterior marginal outlines (fig. 13, pl. VIII), but it is more difficult to detect, and in any case the safest guide is the larval adductor muscle, which is always recognizably nearer the anterior end, a position to be correlated with the location of the rudiments of the adult organs in the posterior region. In the living glochidium of *S. complanata* the shell shows calcification beneath the cuticle and is marked as though the calcareous layer were porous.

The external appearance of these hooked glochidia is like that shown for *S. costata* in figure 10, plate VIII. The hooks, with their spines, the fibers of the larval adductor, and the sensory cells are seen when turned in profile view (fig. 9, pl. VIII); but the cellular structure is so obscure in living specimens that the rudiments appear only as a denser area and even the fibers of the adductor muscle are not very distinct. There is no sign of a larval thread or a thread gland, nor do sections of preserved glochidia reveal such a structure. A conspicuous feature of the whole mass of glochidia in *Symphynota*, as taken from the gill of the parent, is the thick, ropy mucus in which they are embedded. This holds them so firmly together that when stirred up in a dish they remain suspended and quite evenly distributed through the water, settling to the bottom only very slowly over a period of four or five minutes. During this suspension in the water the sucking of a pipette will draw in glochidia over a wide area, as they are pulled by the invisible strands into which the mucus has been divided. The significance of this mucus and the absence of the thread gland are discussed under another heading of this paper. The mucus is dissolved by the water in a short time, so that after 24 hours the glochidia are found entirely free and snapping actively upon the bottom. We find that these glochidia can be freed from the mucus by repeated washing, and that it is desirable to do this at once if one wishes to keep them alive for the maximum period. When thus set aside it is possible for them to remain alive for as long a time as two or three weeks.

In killing this glochidium we have used successfully crystals of chloral hydrate or hydrochlorate of cocaine added to the water of a watch glass containing the glochidia, and fixation with Merkel's fluid, or with weak corrosive sublimate, as described for the hookless type.

Stained specimens show the same rudiments of stomodæum, enteron, and mesodermal structures, as described by Lillie (1895) and Harms (1909) for the glochidium of *Anodonta*. The lateral pits are conspicuous and the cells of the larval mantle are well developed laterally, though thinning out over the median part of the larval adductor, where their boundaries are not clear and only a few nuclei are discernible. Sections show two kinds of granules within the larval mantle cells, one staining deeply with iron hæmatoxylin and the other with acid-fuchsin. Near each corner of each valve is a cell which stains deeper than the rest and seems to contain more of the granules. The significance of these six cells we can not determine. The sensory cells (fig. 9, pl. VIII) are slightly different in position from those in *Anodonta*. Lying along a line drawn across from hook to hook are three large cells in line beneath the hooks and a smaller one on either side between the larval adductor and the lateral pit.

THE PROPTERA OR AXE-HEAD TYPE.

This glochidium possesses hooks which are not homologous with those of the *Anodonta* type and is to be regarded as more nearly related to the hookless forms, an interpretation which is borne out by the fact that the "axe-head" can be readily imagined as a modification of the glochidial outline seen in some species of *Lampsilis*, the glochidia of which, like those of *subrostrata* (fig. 13, pl. VIII), show some approach to a rectangular form. Its four hooks are so arranged that those of one valve pass inside the opposite ones, thus bringing the ventral margins close together and giving a very firm hold upon the host's tissue. In other respects it does not show marked differences from the hookless type, and the few experiments we have made with it indicate its attachment to the gills rather than to the fins.

Recently Coker and Surber (1911) have observed "an almost exactly similar glochidium" in *Lampsilis capax*, while in *Lampsilis* (*Proptera*) *lævissima* they find an axe-head glochidium which is of a somewhat different outline and lacks the hooks. They point out the fact that in *Lampsilis gracilis*, a species which in its adult features (form of shell) seems almost to intergrade with *lævissima*, the glochidium is of the ordinary hookless type, although the outlines of the two glochidia are very similar when seen on edge, as in their figures 1a and 2a of plate 1. With respect to the significance of these facts when applied "to a relationship between *lævissima* and *capax*," they conclude that "there would be strong corroborative evidence in adult characters alone" for the closer union of these three species, and this "in spite of the fact that *lævissima* and *capax* are the two extremes in the degree of inflation." The similar degree of inflation of *capax* and *ventricosa* offers, they believe, "only a striking instance of convergence in one character."

THE LARVAL THREAD.

Our observations upon the occurrence of the larval thread (formerly erroneously termed the byssus) are of importance, since the current accounts in textbooks and literature lead one to believe that this structure is a conspicuous feature of all glochidia. Such an assumption is natural because the organ is conspicuous in the European anodontas and unios and in the American species of these genera examined by Lillie (1895).

We find the larval thread present in the species of *Unio* and *Anodonta* which we have been able to examine with care, and the thread is undoubtedly a characteristic of these genera. We have never seen any sign of such a structure in the ripe glochidia of the other genera, above listed, which possess hookless glochidia, nor in the hooked forms of the genus *Symphynota*. Lillie (1895, p. 52) considers the thread a condensed excretory product, which, accepting the account of Schierholz (1888), he thinks has also become an organ which is of use in bringing the glochidium in contact with the fish. This latter function is the one commonly ascribed to the thread. We have not studied the pre-glochidial stages in the development of those species which show no thread-gland in the mature glochidium, although it is important that this should be done with a view to determining whether a homologue of the thread gland is present at any time. We have, however, made repeated examinations of glochidia, either ripe or well along in their development, in several species of *Lampsilis*, particularly in *ligamentina*, *recta*, *anodontoides*, *ventricosa*, *luteola*, and *subrostrata*, and to a lesser extent in species of the other genera mentioned, without finding any trace of the thread which is so conspicuous a feature of the glochidium of *Unio complanatus*.

We have also examined the glochidia of *Symphynota complanata* many times with the same negative results, and a smaller number of observations confirm this for *S. costata*. Since many species thus have no thread in any way functional for attachment to the fish, the question arises whether the thread when present has as important a function in this respect as has been supposed. Our observations upon the glochidia of *Anodonta cataracta* confirm the descriptions of Schierholz (1888) and others who have studied the European species of *Anodonta* as to the tangling of the glochidia into masses by means of their extruded threads, and in this genus the threads do seem effective in drawing other glochidia into contact with the fish when a single one has become attached. This is not, however, effective during the greater part of the period in which the glochidium may remain alive upon the bottom, for the threads are dissolved within a day or two and the glochidia then become entirely free from one another. When taken from the parent gill the glochidia of *Symphynota* are entangled in a ropy mucus, and this acts in a manner similar to the threads of *Anodonta*, but it is usually dissolved after a few hours in the water. In the ripe glochidium of *U. complanatus* the threads are extruded immediately after the glochidia are removed from the parent and placed in water, and, according to Harms (1907b, p. 819), the minute glochidia of *Margaritana margaritifera* extrude their threads while still within the egg capsule.

When this extrusion has taken place in *Unio complanatus* the glochidia and broken egg membranes become united into globular masses from which it is difficult to separate individual specimens, and from observing such glochidia in contact with the fish we are forced to conclude that they are not so likely to become attached to the gills or fins as they are later, when they have been separated by the disintegration of the threads. The glochidia of *Lampsilis*, which when fully ripe fall apart into masses of entirely unconnected individuals, appear much better able to attach to the gills of fishes immediately after their discharge from the parent. We believe, therefore, that the thread is something to be gotten rid of rather than an organ of great importance in the attachment to fish, and this is in agreement with Lillie's interpretation of this organ as an excretory product. It is possible that some homologue of the thread exists in these threadless glochidia, and a comparative study of the pre-glochidial stages might yield material for interesting comparisons.

BEHAVIOR AND REACTIONS OF GLOCHIDIA.

At the time of spawning the glochidia, already freed from the egg membranes, and usually held together in slimy strings, are discharged at irregular intervals. Being heavier than water, they sink rapidly to the bottom, coming to rest with the outer surface of the shell directed downward and the valves gaping widely apart. The belief was formerly general that they "swim" about by rapidly opening and closing the valves, after the manner of *Pecten*, and, in spite of frequent denials by Schierholz (1888), Latter (1891), and others, the same statement is still occasionally encountered. In the recent volume on Mollusca in the Treatise on Zoology, edited by Lankester, this inexcusable error is repeated. "The glochidia," we are again informed, "swim actively by clapping together the valves of the shell" (p. 250). They are, on the contrary, as is now well known, entirely incapable of locomotion and remain in the spot where they happen to fall, although it is true that they may exhibit from time to time spasmodic contractions of the adductor muscle, which cause the valves to snap or wink, each contraction being immediately followed by relaxation and opening of the shell. These movements of the valves, however, are never so vigorous as to cause the glochidium to move from place to place in the water.

The glochidia remain in this helpless situation until they die, unless they happen to come in contact with the host on which they pass through the post-embryonic development as parasites. The stimulus which causes the contraction of the muscle and results in attachment to the host is, in the case of hookless glochidia, usually a chemical one, but in that of the hooked forms it is mechanical. The latter may be readily imitated and glochidia of this type made to grasp firmly the point of a needle or the edge of a piece of paper by simply touching them between the open valves. When once closed in this manner they do not relax, but remain attached to the object until they die.

The following statement made by Latter (op. cit., p. 56) has been frequently quoted, especially in textbooks, but it has apparently never been verified or disproved.

> The Glochidia are evidently peculiarly sensitive to the odor (?) [sic] of fish The tail of a recently killed Stickleback thrust into a watch glass containing Glochidia throws them all into the wildest agitation for a few seconds; the valves are violently closed and again opened with astonishing rapidity for 15–25 seconds, and the animals appear exhausted and lie placid with widely gaping shells, unless they chance to have closed upon any object in the water (*e. g.*, another Glochidium), in which case the valves remain firmly closed.

Although it is not stated that the tail which caused such a commotion among the glochidia had been cut off from the fish, it is probable that such was the case. We have repeatedly tested glochidia in the same manner both with fins and gills of different fishes, and, providing that a bleeding surface is not brought in contact with the water containing the glochidia, absolutely no response on the part of the latter takes place. The result, however, is much as Latter describes if a little of the fish's blood gets into the water in the neighborhood of the glochidia, except that our experience has shown that after snapping for a few seconds they come to rest in permanent closure. It therefore seems possible that the contractions seen by Latter were due to the introduction of some blood with the tail of the fish, as otherwise agitation of the glochidia under similar conditions has not been observed by us.

Since the hooked and hookless glochidia, whose reactions to blood and to certain salts we have studied, show important differences in their behavior, they are referred to separately below

REACTIONS OF HOOKLESS GLOCHIDIA.

It was first observed that glochidia of the hookless type, in marked contrast with the hooked forms, only occasionally exhibit spontaneous contractions and respond either not at all or only sluggishly to tactile stimuli, and the question at once arose as to what causes their closure when they become attached to fish. If the stimulus which brings about a contraction of the adductor muscle in attachment is not a mechanical one, it presumably is chemical in nature, but we were completely in the dark in the matter until it was cleared up by the following experiments, the first of which were made with the glochidia of *Unio complanatus* at Woods Hole, Mass.

When a small drop of blood of either the killifish, *Fundulus diaphanus*, or the white perch, *Morone americana*, was placed over the glochidia contained in a small amount of water in a watch glass, the effect was immediate and very striking. Every glochidium was thrown into rapid and violent contractions, alternating with relaxations, the edges of the valves either quite or nearly touching with each snap. Where the stimulus was strongest—that is, immediately under the drop of blood—the glochidia exhibited two or three strong contractions and then remained closed, but, proceeding outward to zones of diminishing intensity, the snapping occurred intermittently for from 10 to 50 seconds. Here the contractions were quite rapid at first, one or two every second, but soon the intervals became longer, until finally the activity was ended by the closure of the valves. In some cases it was observed that after the first few snaps the muscle did not completely relax, and each subsequent contraction caused the valves to describe a shorter arc. This experiment was repeated time and time again, with invariably the same result, and it was astonishing to see what a small quantity of the fish's blood was required to produce the reaction. It should be emphasized, furthermore, that after the stimulus had caused the final contraction of the muscle the valves remained permanently closed.

The experiment was later performed a great many times with the glochidia of *Lampsilis ligamentina* and *subrostrata*, and identically the same reaction was obtained with the blood of several different fishes and that of the frog, *Necturus*, and man.

Since the hookless glochidia, which are essentially gill parasites and, when taken into the mouth of the fish lodge among the gill filaments, produce abrasions of the delicate epithelium covering the latter, a more or less extensive hemorrhage from the blood capillaries occurs, as may be readily seen from a microscopic examination. It is therefore evident that blood exuding from the gill filaments in the immediate neighborhood of the glochidia must have the same effect as in our experiments, and, by exciting vigorous contractions of the adductor muscle, furnish an efficient stimulus in bringing about a firm and permanent attachment to the filaments. It is true that hookless glochidia will occasionally secure an attachment to the edge of the fins and other external parts of the fish, but it is quite evident that they are not adapted to such locations, as they rarely succeed in remaining there. It is possible that when they do become attached to the fins the closure of the valves is due to the presence of blood on the latter; but, since hookless glochidia occasionally close when touched repeatedly, the attachment in these situations is probably brought about by a sluggish response to contact with the edges of the fins. Their characteristic place of attachment, however, is the gill filaments, and this definite reaction to the fish's blood constitutes a most striking functional adaptation to the special habit of hookless glochidia as gill parasites.

Although the matter has not been exhaustively studied, it is in all probability the salts of the blood that are responsible for these reactions. A series of experiments, however, has been undertaken for the purpose of determining the reactions of glochidia of this type to solutions of several different salts, and, although the investigation has not yet been completed, a brief statement may be made here. Diluted sea water and solutions varying in strength from 0.5 to 1 per cent of NaCl, KCl, KNO_3, and NH_4Cl have exactly the same effect as fish's blood, although the intensity of the reaction varies somewhat in certain cases. Weak solutions of $MgCl_2$ and $MgSO_4$, however, as would be expected, inhibit contractions, and glochidia, after treatment with these salts, may be killed in an expanded condition, if allowed to remain in the solutions for a sufficient length of time.

REACTIONS OF HOOKED GLOCHIDIA.

The larvæ of *Symphynota complanata*, which are provided with stout hooks and as a rule find permanent lodgment only on the fins and other external parts of the fish, were used in studying the reactions of the hooked type of glochidium. In several respects they differ from the hookless forms. When removed from the marsupium and placed in water, they exhibit spontaneous contractions which occur at irregular and rather long intervals, and this irritability may continue in the laboratory for a day or two, or until the glochidia begin to disintegrate. Under such conditions the valves are only partially closed at each contraction of the muscle, which, moreover, is never strong enough to bring the points of the hooks into contact. It is followed at once by relaxation of the muscle and the shell remains widely open until the next snap occurs.

Hooked glochidia, in striking contrast with the behavior of the hookless forms, respond very actively to tactile stimuli, and, as has been stated, close completely and immediately when touched with any object. This reaction must be the main factor in bringing about their attachment to the fish's fins, when they are brushed over by the latter while lying on the bottom. With glochidia like those of *Symphynota complanata* the mere contact is sufficient to produce complete closure of the valves, and, whether they are exposed to the fish's blood or not, attachment is possible as a result of the tactile stimulus alone. They do react to blood, however, and exhibit a few successive contractions, from 5 to 15, before final closure, but the way in which the response occurs is quite different from that shown by hookless glochidia under similar conditions. Instead of being thrown into violent and rapid snapping, the valves closing and opening alternately, there is only partial recovery after each contraction, while the valves are brought closer and closer together by a series of short jerks. The final act of closing is interesting. As soon as the points of the hooks touch, the contraction of the adductor muscle becomes continuous and the hooks are slowly bent inward against each other. Under the steady pressure exerted by the muscle, aided probably by the action of the myocytes, which have been described by Schmidt (1885b), the spines on the outer surface are apposed and the hooks turned in completely between the valves, the margins of which are brought together, if no object intervenes. It will be readily understood that, owing to the turning in of the hooks, the spines are pressed into the fish's tissues, when attachment to the host takes place, and a firm hold is thereby secured.

When the glochidia of *Symphynota complanata* were exposed to salt solutions, the contractions produced were of the kind just described. KCl, KNO_3, and NH_4Cl in solutions of 0.5 to 1 per cent caused a few successive jerks, the contractions being more vigorous and closure occurring sooner with the stronger solutions. NaCl and $Na_2C_2O_4$ in the same strength acted less energetically, and it was necessary to use a 2 per cent solution to produce the same effect as was obtained with the weaker solutions of potassium and ammonium salts. A 0.5 per cent solution of $CaCl_2$ produced no contractions, while a 1 per cent solution after a latent period of 15 minutes caused either partial or complete closure of the valves. $MgCl_2$ and $MgSO_4$, in solutions of 0.5 and 1 per cent, inhibited contractions, and when the glochidia were allowed to remain in them they finally died in the expanded condition. When the Mg salts, however, were used in stronger solutions, closure of the valves occurred after a few spasmodic contractions.

IV. THE PARASITISM.

ARTIFICIAL INFECTION OF FISH.

In any investigation which attempts to ascertain the facts of most importance for the artificial propagation of a species, attention is at once directed to those points in the life history where wholesale destruction of the individuals is most likely to occur. These points of wholesale waste are usually to be found in the earlier part of the individual's existence rather than during its adult life and are often preventable by artificial means. In common with other animals which must overcome the chances of parasitism, the Unionidæ produce enormous numbers of eggs, the great majority of which are by virtue of the brooding habit of the female mussel carried safely through their embryonic period and discharged as glochidia. We have not attempted to estimate the numbers of glochidia carried by full-grown adult females, but anyone who has seen them taken from the gills knows that they must be numbered by the hundreds of thousands, or even millions, and had these glochidia any great chance of survival and development to the adult stage the supply of mussels would far exceed anything which has ever been known in nature. When, however, the next stage of the larval history is sought for in nature, it becomes apparent that we have reached a point in the life cycle where the destruction and waste of individuals is wholesale and probably in excess of that which occurs at any other stage. There is no evidence, save in the case of the species *Strophitus edentulus*, the metamorphosis of which we have discussed under another heading of this paper, that any one of the Unionidæ can pass beyond the glochidial stage without becoming a parasite upon some fish, for the failure of glochidia to develop when left in water has been observed by all investigators since Leeuwenhoek.

The large element of chance involved in this shift from parent to fish, which has already been emphasized in our discussion of the glochidium, is again apparent when fish are examined in nature with a view to determining the abundance of the parasitic larvæ under the conditions of natural infection, for all investigators agree that the parasites exist in numbers which are insignificant when compared with the masses of glochidia which occur in the parent mussels. Only an occasional fish is found to be infected and it thus becomes clear that the purely accidental nature of the infection makes necessary the production of glochidia in such abundance as to overcome by sheer force of numbers the chances of destruction. Fish become infected in nature by occasional glochidia, but the chance that any fish will carry under natural conditions the number of glochidia which our experiments have shown that individual fish are capable of carrying, when artificially infected, is a negligible quantity. Here, then, we have the point of greatest destruction in the life cycle of the Unionidæ; and the point of attack for artificial propagation is clear. The fish must be made to carry more glochidia. Under experimental laboratory conditions it is found that a given fish may carry successfully a load of glochidia so much in excess of what the same fish would ever be likely to carry in nature that there is no reason why a single fish should not be made, under the conditions of artificial infection, to do the work which a thousand fish perhaps could not do in the state of nature. This has been from the first our main point of attack, and, with this in view, we have studied the parasitism, first, by the infection of small lots of fish in aquaria and, later, by the infection of fish in larger numbers in a hatchery. Other points in the life cycle, as for example the stage immediately following the parasitism, may be found by later work to be places of wholesale destruction; we are convinced, however, that there can be no other where the mortality reaches such proportions as it does when the countless glochidia are spread upon the bottom and left to the chance that will bring them in contact with the parts of a fish's body suitable for their parasitism.

Throughout our experimental infections we have made use of small fish, usually those under 6 inches in length, because such fish are more easily collected in numbers and because we have not had proper facilities for the keeping of larger individuals. Where small numbers of fish are used and each individual can be carefully watched, the attainment of what may be termed an "optimum" infection in every case may be secured with no great difficulty, and by following the methods practised by various investigators ever since Braun (1878) and Schmidt (1885), we have obtained unlimited material whenever necessary. If the glochidia are placed in shallow dishes and in water just deep enough to cover all parts of the fish, the latter will usually keep the water sufficiently agitated to insure a proper suspension of the glochidia and tolerably constant results will follow.

It is very necessary that the glochidia be so distributed in the water as to come in contact with the proper parts of the fish, and, in most cases, to guard against over rather than under infection. Active fish, such as the rock bass (*Ambloplites rupestris*), and the large-mouthed black bass (*Micropterus salmoides*), are very favorable for gill infections, since they keep the water so well agitated that the glochidia hardly settle to the bottom at all, while their strong respiratory movements draw the suspended glochidia continually against the gills. With fish like the crappie (*Pomoxis annularis*), which when undisturbed move about quietly and whose respiratory movements are less vigorous, the water must be stirred to keep the glochidia suspended, or be so shallow that the fish are always near the bottom. The smaller gill slit of the crappie is another factor which makes for a very light infection in fish under 2 inches in length, since the glochidia reach the gills by way of the mouth and not from the opposite direction. For fin infections, sluggish fish like the German carp (*Cyprinus carpio*) need little attention, and the darters (*Etheostoma cœruleum spectabile*), which habitually rest upon the bottom for considerable periods, become quickly loaded with glochidia upon both fins and gills; although, as we shall see, the latter fish appears to be particularly adapted for ridding itself of the entire infection.

In the account which follows, we are discussing the results obtained from the infection of fish in small numbers and kept under careful observation in the laboratory.

There is no reason for believing that larger numbers of fish would present any more serious difficulties than are to be expected in the keeping of any fish in large numbers within a restricted space; and, if one could insure as uniform and careful an infection of the larger numbers, we have every reason to believe that such infections would prove as successful as those here described.

INFECTIONS WITH HOOKED GLOCHIDIA.

For the infections with hooked glochidia, we have used principally *Anodonta cataracta* from Falmouth, Mass., the species studied by Lillie (1895). With these we infected German carp under 6 inches in length and, unless otherwise stated, the following account refers to this combination which gives typical results. A smaller number of infections, made with *Symphynota complanata* and *S. costata* upon carp and other fishes, are referred to in a supplementary manner. The glochidia of *A. cataracta* become attached in large numbers to the fins (fig. 19–25, pl. IX and X) and gills of the carp. They are also found upon the other external parts which offer the condition of a soft scaleless epithelium like that of the fins; thus, the region about the anus, the edge of the operculum, the lips and in very heavy infections, even the soft area of the ventral surface between the mouth and pectoral fins may become heavily loaded. Within the mouth cavity, the gill filaments and also the gill bars and rakers become well covered. The glochidia which attach to these mouth parts do not remain, for, although the fish may be carrying many of their fellows upon its external parts, in about one week after the infection all glochidia have disappeared from the gill filaments, which then become as clean as though never infected. Scattered glochidia may remain upon the other internal mouth parts, for specimens are occasionally seen well embedded and in advanced stages of their metamorphosis, but in the main these parts also will become free of glochidia.

The general distribution upon the individual fins may be seen by reference to figures 19 to 25, plates IX and X, which show how great a proportion of the glochidia become attached to the fin margins. If a fish is carefully watched, as its slight movements stir up the glochidia during the infection, the latter are seen continually falling upon the upper faces of the pectoral and pelvic fins. They may even be collected with a pipette and heaped upon a motionless pectoral fin, remaining there for some minutes without more than an occasional specimen becoming attached. The margin of the fin is so much more favorable for attachment, that it is often thickly set with glochidia, when none are found upon the fin surface, and this despite the fact that glochidia must, during infection, strike against the surface of the fin many times for every time that one of them comes in contact with a fin margin. It is, therefore, the margin of the fin for which this glochidium is best suited, and, once fastened there, it is almost certain to remain and become embedded by the growth of the host's epithelium.

Considered in a more detailed way and with reference to the parts of the glochidium, we may explain this more frequent attachment to the margin as due to the fact that when the glochidium strikes against any flat surface the sensory hairs are not stimulated and the glochidium, which, as we have already shown in the case of the hooked forms, responds principally to tactile stimulation, does not receive the stimulus to permanent closure which is given by the presence of any foreign object inserted between the valves. When a specimen does become attached to the surface of a fin, as is sometimes the case (fig. 21 and 22, pl. IX, fig. 25 and 32, pl. X), it presumably gains its hold by catching upon one of the ridges formed by the fin rays, for the hooks could hardly be used upon a perfectly flat surface. Glochidia sometimes hold to the surface of a fin by a shred of tissue, under which their hooks have caught, remaining there after all the neighboring specimens are completely overgrown (fig 25, pl. X), only to be torn off later without having caused any noticeable hypertrophy of the fin tissue. Figures 25 and 32, plate X, show that glochidia may become overgrown either flat against the surface or upon edge, and figure 24, plate IX, shows a young mussel leaving a surface attachment after a parasitism of 74 days.

The behavior and reactions of glochidia are of course significant in connection with the actual attachment when once the glochidium is brought in contact with a suitable part of the fish's body and receives the normal stimulus to close its valves. The bringing of the glochidium against just that part of the fish is a matter of the chance distribution in the water. Hence the distribution of the glochidia to the several fins is determined solely by the number likely to be brought in contact with a given part of the body. Those fins which brush against the bottom are always the more heavily loaded and the numbers elsewhere depend upon the extent to which the glochidia are kept suspended in the water. The importance of the mucus for the glochidia of *Symphynota* and of the larval thread for those of *Anodonta* and *Unio* in tangling the glochidia into masses and drawing others against the fish when a single one has become attached has probably been exaggerated, as explained in the section of this paper which deals with the function of the larval thread.

Optimum infections, as we shall term those which are close upon the limit of the number of glochidia which a fish can safely bring through the metamorphosis, often show the glochidia very closely set one after another, as in figures 22 and 23, plate IX, and figure 25, plate X, and several hundred may be safely carried by a fish 3 or 4 inches in length. Prolonged exposure causes so heavy an infection of the margins (fig. 19 and 20, pl. IX) that the fin tissue appears unable to overgrow the mass of glochidia, and they then remain attached without overgrowth for a week or more.

Figure 19, plate IX shows how on a part of the fin having no overcrowding normal embedding occurred, while in the more crowded areas the glochidia were still uncovered even seven days after infection. In the middle upper margin of this fin it would seem that the overgrowth might well have taken place, for many cases like figure 25, plate X, have been observed in which glochidia as closely set were properly embedded. The failure of overgrowth in this region is probably due to the presence immediately after infection of a greater number of glochidia many of which have since been detached. In all cases of this kind a smaller number will finally become embedded than in an infection where the fin has received more nearly the optimum load (fig. 21, 22, 23, pl. IX, and fig. 25, pl. X), for the great majority drop off when the fin becomes so mutilated that bacterial or fungus infection sets in. These over-infections sometimes cause such hypertrophy that the fins become swollen and the rays so drawn together that it is impossible for them to spread out normally. Often the fins are raw and bleeding for some days and show red areas within where the blood vessels have become abnormal. The fish are likely to die from this or from the similar injury to their gills, and these over-infections are unsatisfactory if one wishes to bring through their parasitism the maximum number of glochidia.

The steps in the implantation of the glochidium by an overgrowth of the fish's tissue may be seen in figures 21 and 22, plate IX, and figure 25, plate X. Figures 21, plate IX, and 26, plate X, show the glochidium 3½ hours after attachment to the fish's fin. Most of the glochidia have bitten deep enough in from the margin to have a good hold for their hooks. The beginning of the hypertrophy appears as a faint mass of tissue, seen with its nuclei in the detailed figure 26, plate X. At the end of 12 hours the overgrowth is well advanced and sometimes, as in figure 27, plate X, shows different stages even in neighboring glochidia. The ragged edge of the host's tissue rises up crater-like about the glochidium, meeting above in a delicate mass, the nuclei of which are shown. Figure 22, plate IX, shows that in 24 hours most of the glochidia are more than half covered, whether upon the edge or the surface of the fins. At the end of 36 hours (fig. 25, pl. X) optimum infections of the carp show all the glochidia which have obtained a proper attachment well embedded, and from this time onward the only change which is visible in whole mounts is a slight increase in the opacity of the cyst, which renders the internal structure of the glochidium less distinct (fig. 23, pl. IX). Some of our infections show embedding in as short a time as 6 hours (*Symphynota*), and Harms (1909) gives 10 to 12 hours as the time which he observed in *Anodonta*, so the time given for the figures above referred to is the maximum for hooked glochidia which have been well located. Glochidia upon the fin surface become embedded in a similar manner and are then in a very secure position (fig. 22, pl. IX, fig. 25 and 32, pl. X).

INFECTIONS WITH HOOKLESS GLOCHIDIA.

Our experiments in artificial infection with hookless glochidia have been more extensive because this is the type of glochidium found in the species of mussels which are of commercial importance. Species of the genus *Lampsilis* (*ligamentina*, *recta*, *anodontoides*, *ventricosa*, *subrostrata*, and *luteola*) have been the most frequently used, but infections have also been made with several species of *Quadrula* and one of *Unio*. The list of fishes employed as hosts for hookless glochidia is also more extensive and we are, therefore, able to make statements which we know to be of wider application than those made for the hooked glochidia.

When the same fish is used, the results for the several species of *Lampsilis* are very uniform and we can thus discuss the parasitism of this genus as a whole; but we do not find the same mussel giving uniform results with all species of fish. The glochidia of this genus have been used successfully for the infection of blue-gill sunfish (*Lepomis pallidus*), yellow perch (*Perca flavescens*), crappie, large-mouth black bass, rock bass, the red-spotted sunfish (*Lepomis humilis*), and the green sunfish (*Apomotis cyanellus*). As with the hooked glochidia, the infections have all been made upon fish under 6 inches in length, upon which these glochidia remain in numbers only on the gill filaments, although during infection some may become attached to and even embedded upon fins and other external parts. Harms (1908) concludes that the hookless type persists in much greater numbers on the fins of small than of large fish, and that the hooked type will survive upon the gills if large fish are used. It is doubtless true that the size of the gills and fins is an important factor in determining the place of attachment for each type, since the hookless form is better adapted for holding to a delicate surface like a gill filament or a fine fin, while the hooked type seems likely to be easily torn from such a surface. When the hookless form does once become established upon an

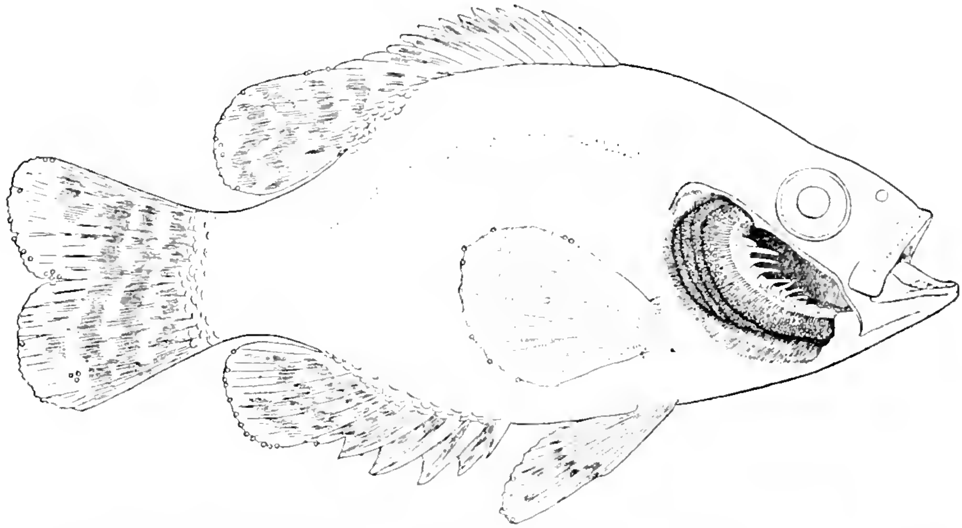

FIG. 2.—Rock-bass (*Ambloplites rupestris*) infected with glochidia of *Lampsilis ligamentina*. About 2,500 were successfully carried through the metamorphosis by each fish in this infection. Note the large number on the gills.

external part, it will develop there without mishap, as shown by the figure of a hooked and a hookless glochidium developing side by side upon the margin of a fin (fig. 29, pl. x). Within the mouth cavity these glochidia become attached to the gill bars and rakers, if these parts are covered by a sufficiently delicate epithelium, though they are always found in the greatest numbers upon the gill filaments. In most of our infections the filaments are more heavily infected toward their outer ends (fig. 43, pl. xi), the distribution varying somewhat with the species of fish. For example, successful infections of rock bass with *Lampsilis ligamentina* show about seven glochidia upon the distal third of the filament to one upon the proximal two-thirds; of large-mouth black bass about 3 to 1, and of yellow perch about 1½ to 1—differences which are probably due to some particular configuration of the mouth parts, which causes the glochidia to fall more upon one region of the filaments than another.

In a fish which will carry a given glochidium successfully, over-infection of the gills is easily accomplished and easily fatal, although species of fish differ greatly in the amount of infection they are able to withstand without serious mortality. In one of our most successful combinations (rock bass infected with *Lampsilis ligamentina*), fish 4 inches in length were estimated to be carrying in the neighborhood of 2,500 glochidia, an average of more than two for every filament of the gills and yet there was almost no mortality among the fish. A rock bass from this infection is shown in text figure 2, which also illustrates the distribution of the glochidia on a single fish. In this case the success of so heavy an infection is perhaps explained by the distribution of the glochidia upon the gill filaments, for we found by count that there were about seven near the tips to one on the proximal two-thirds of the filament, and thus the greater part of every filament was left unchanged and in full functional condition, while in other infections (large-mouth black bass with *L. ligamentina*), where a much greater proportion of the glochidia were upon the sides of the filaments, the mortality of the fish was heavy, although the amount of infection was much less. A gill of the latter fish infected with these glochidia is shown in figure 39, plate XI. The number estimated for this fish, which was 4 inches in length, being only 450, is less than the optimum.

Implantation upon the filaments occurs in a manner similar to that of the hooked glochidia upon the external parts, but much more rapidly. Figures 35, 36, 37, and 38, plate XI, show the appearance at 15 minutes, 30 minutes, 1 hour, and 3 hours, respectively, after infection, and our observations, showing that the cyst is completed within from 2 to 4 hours, agree with what Harms (1909) has found for gill infections. The proliferation will even continue after the gill has been cut from the fish and placed in a watch glass for observation under the microscope (fig. 54 and 55, pl. XIII). An immediate result of the cyst formation is the obliteration of the lamellæ upon either side of the gill filament, which thus becomes smooth and slightly swollen in the vicinity of the glochidium (fig. 43, pl. XI). Figures 34 and 43, plate XI, show the general and detailed appearance of the cysts and the diversity in the angles at which the glochidia are attached.

The older statement that the hooked glochidia are fin and the hookless gill parasites finds, therefore, confirmation from our work, although it would be better to say that the hooked attach most successfully to large strong margins like those of the fins, and the hookless to soft and fine filamentous structures like the gills in fish of moderate size. The reactions of the two types of glochidia to mechanical and chemical stimuli, with respect to the part they play in attachment, have already been discussed.

SUSCEPTIBILITY OF FISHES TO INFECTION.

The susceptibility of different fishes to infection is a matter which has not been sufficiently considered by any previous investigators. We have evidence that some species are much less susceptible than others to one or the other type of glochidium, and that in these cases any considerable infection is an impossibility. The most striking instances of this are the German carp, certain minnows, and the darters.

In the case of the carp, while the fish is admirably suited to carrying the hooked glochidia of *Anodonta* and *Symphynota*, we have never been able to secure a successful infection of the gills with the hookless glochidia of the genus *Lampsilis*. The disappearance of the hooked glochidia of *Anodonta* and *Symphynota* from the gills of the carp may be due to the pulling away of these large and heavy glochidia from the delicate gill filaments, as suggested in our consideration of the survival of the two types of glochidia upon fins and gills, respectively. The disappearance of the hookless glochidia of *Lampsilis* from both gills and fins of the carp can not be explained in this manner; it suggests rather that there may be some reaction of the host's tissues comparable to the processes which confer immunity against parasitic bacteria in higher vertebrates. With minnows (*Notropis cayuga* and *N. lutrensis*) 2 to 4 inches in length, we have not been able to secure any considerable infection with the glochidia of *Symphynota complanata*, for, although they will attach in large numbers during infection, they all drop from the fins and gills within a few days. The fins of these minnows are much more delicate than those of the carp, and the explanation is perhaps that so large a glochidium is easily torn away; but the large-mouth black bass has hardly a delicate fin, and for this fish we have records of infections where no glochidia of *S. complanata* became attached during an exposure sufficient for the attachment of many to the gills. In this latter case, the extreme activity of the fish must be considered as a factor which might keep the hooked glochidia from attachment to the fins.

Darters (*Etheostoma cœruleum spectabile*) 1½ to 2 inches in length can not be infected successfully with the glochidia of *Lampsilis*, for although they may fasten so thickly to the fins that many fish die during the first day after their exposure, the surviving fish will slough off considerable portions of the fins and within a week show only the healed and regenerating parts as an indication of their recent experience. The gill slits were so small in these fish that only an occasional glochidium was found upon them.

Such cases as these are of great importance and should be followed up to determine whether the simple mechanical conditions like over-infection, delicacy of fin, or configuration of the mouth parts can give a satisfactory explanation; or whether the histological changes of which the fish is capable, under stimulation by the glochidium, must be regarded as the cause of its immunity. We have not carried out a sufficient number of experiments to feel sure that the simpler explanations can be excluded. In any case, it is interesting that fish like the minnows and darters, which live close to the bottom, are not likely to become heavily infected by some of our most common glochidia.

BEHAVIOR OF FISHES DURING INFECTION.

The behavior of the fish during infection is a matter of some importance and has been already mentioned in an incidental manner. The rock bass, large-mouth black bass, and blue-gill sunfish, which are very active and which consequently exhibit powerful respiratory movements, are well adapted to artificial infection, and the proper suspension of the glochidia in the water is secured by the movements of the fish alone. The crappie, which are sluggish and easily killed by handling, require some special device to insure the optimum infection and are not well suited for work on a large scale because of their behavior during infection. Fish which rest upon the bottom are sometimes not so favorable as they might seem because they do not move about enough to keep the glochidia in motion. While other features may be of greater importance, the behavior of the fish as affecting the distribution of the glochidia in the water should always be considered in deciding how useful any fish may be for purposes of infection. .

INFECTION OF FISH IN LARGE NUMBERS.

The infection of fish in large numbers has been attempted with a view to determining the feasibility of extending the methods described above to wholesale infections of fish in a hatchery. As a result of two such attempts, we have no doubt that the successful development of the methods needed for infection in connection with the artificial propagation of mussels is only a matter of a little study in a properly equipped station. In December, 1907, about 25,000 small fish, under 6 inches in length, were placed at our disposal at the substation of the Bureau at La Crosse, Wis., and we were able on this occasion to infect by wholesale methods about 12,000 blue-gill sunfish, 3,700 yellow perch, 7,000 catfish, 2,000 crappie, 150 rock bass, 150 carp, and 100 roach. The greater number of these fish were infected with the glochidia of *Lampsilis ligamentina*, and, considering the fact that this was our first experience with so large a number of fish, the results were satisfactory. Smaller lots were infected with the glochidia of *L. anodontoides* and *L. recta*, the results giving every indication that these two species are essentially like *L. ligamentina* in the conditions of their development. The most successful infections were obtained by placing from 100 to 200 fish in a common galvanized iron washtub about two-thirds full of water. It was found that by adding to this body of water the glochidia obtained from two or three specimens of *Lampsilis*, and, when it seemed necessary, stirring the water by hand, tolerably constant results could be secured. Our difficulties were with over- rather than with under-infection. It was also possible to use the same tub a number of times without changing the water or adding to the stock of glochidia. Infection was also attempted by lowering the water in the large retaining tanks of the station to a depth of 4 inches and confining the whole number of fish which had been held in the full tank to this much smaller body of water. This method was found, in the absence of any attempt to keep the glochidia properly distributed through the water, quite inadequate and it became necessary to reinfect these fish in the tubs.

The mortality of the fish in these experiments was decidedly in excess of what one might expect for uninfected fish kept under similar conditions, a result clearly due to the over-infection which is the one thing most to be guarded against. At the end of six weeks some of the remaining fish were liberated in the west channel of the Mississippi River at La Crosse, a locality which we then believed might be suitable for this species of *Lampsilis*.

These infections were made under conditions of limited time and equipment and were wholly tentative, the aim being to make a test of our methods on a large scale. We revisited La Crosse a month after the infection, making careful examinations of the fish and by shipping several hundred to Columbia were able to follow the development of the glochidia under the conditions in our laboratory. The results were probably as favorable as could have been expected under the circumstances.

In December 1908 a similar infection was attempted with about 6,200 large-mouth black bass and 3,800 crappie in the station of the Bureau at Manchester, Iowa. Upon this occasion the glochidia of *Lampsilis ligamentina* were again used in a majority of the infections, similar results being obtained with *L. anodontoides*, *recta*, and *ventricosa*, which were used for the minor infections. The black bass took the glochidia very readily and, having had only a limited experience with this species of fish, we gave them an amount of infection equal to that which had been carried successfully by the rock bass infected at La Crosse in the previous experiments. The infection was estimated at from 2,000 to 2,500 glochidia to a fish 4 or 5 inches in length. This proved entirely too heavy for the large-mouth black bass and the mortality among them amounted to about 55 per cent in the 30 days they were under observation. By the third day after the infection the hypertrophy of the gill tissue was so great as to be at once noticeable to the eye, and this was clearly the cause of death. An infection of not more than 1,000 glochidia per fish would have been more nearly the optimum load.

The crappie did not take the infection well despite longer exposure, the reason for this being the size of their gill slits and their behavior as already discussed, and we do not consider small fish of this species favorable for infection with any of the glochidia from mussels which are of commercial importance.

Thirty days after these infections the surviving fish were liberated in the Maquoketa River near Manchester, in a situation where the conditions were favorable for mussels and where the presence of a dam below the point of liberation, together with the absence of mussels of this species, made it seem possible that at some later period their appearance in this locality might be traced to this experiment. We have never made any subsequent examination of this stretch of the river with this in view, a thing which should be done by one of the parties engaged in the field work of the mussel investigation.

These two experiments in the wholesale infection of fish, while disappointing in some respects, give no indication of any insurmountable difficulties. It is fair to conclude that a little experimentation under hatchery conditions will make it as easy to carry the glochidia through their metamorphosis in large numbers as we have found it in small lots of fish kept in aquaria. The high mortality of the fish, being so clearly a matter of over-infection, is a thing which can be guarded against without reducing too greatly the load of glochidia which the fish may carry. It is then only a matter of discovering the most suitable species of fish and finding out how best to handle them in large numbers.

One thing which seems necessary for the rapid and uniform infection of fish in large numbers is a device which will bring about a uniform distribution of the glochidia in the water during the whole period of the fishes' exposure. Without something of the sort it will hardly be possible to handle large numbers of fish with constant and uniform results. We have tried, though not very extensively, two means of effecting this. The first consisted of a two-bladed propeller fastened in the middle of the bottom of a tub and rotated slowly, there being enough space in the water above the blades to allow the fish room to escape the stroke. This device was not very satisfactory, but as it was operated by hand and the blades roughly constructed, effective use might be made of a more carefully adjusted mechanism of this type. A second and more promising device consists of a branched system of iron pipes bored with many small holes (text fig. 3), through which fine jets of water are forced out at the bottom of a tank. The amount of pressure in these fine jets can be easily regulated from the main supply pipe, and the height to which the glochidia will be driven from the bottom is thus controlled. The tank may be allowed to overflow at the top and the glochidia

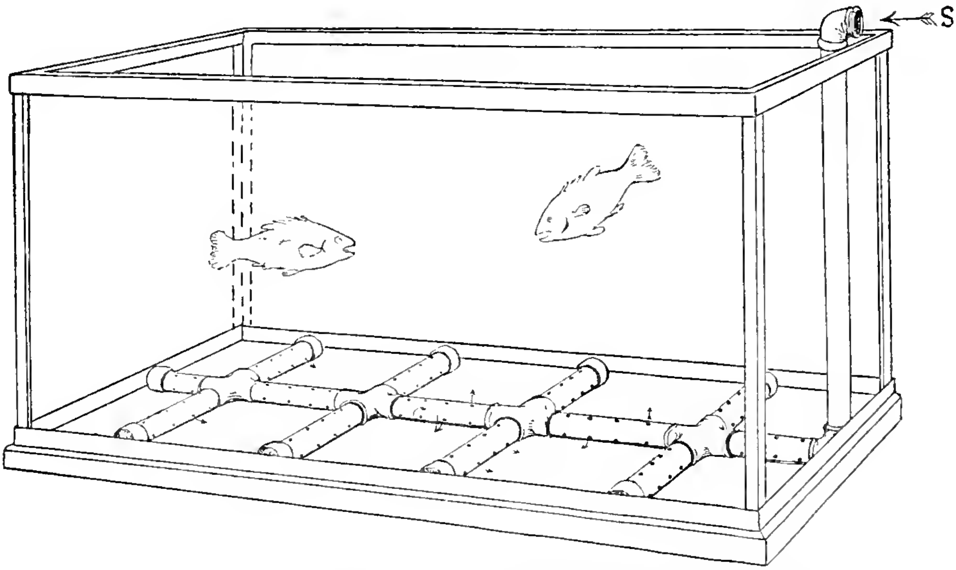

FIG. 3.—Apparatus for keeping glochidia suspended in water while fish are being exposed to them for gill-infections. Tap water entering at S issues in fine jets through the very small holes placed along the top and sides of the pipes on the bottom of the aquarium, and an even distribution of glochidia throughout the water is thereby maintained. By regulating the force of the water entering the pipes at S the glochidia are prevented from rising to the top of the aquarium and escaping with the overflow.

prevented from being carried off in the overflow by so adjusting the force of the jets that the glochidia will not rise quite to the surface. This device keeps the glochidia suspended in a very uniform way, and it may prove to be just what is needed for the uniform infection of large numbers of fish.

CONDITIONS NECESSARY FOR SUCCESSFUL INFECTION.

Three factors should be considered in attempting the infection of any species of fish with glochidia, namely, the uniform suspension of the glochidia in the water, the reaction of the glochidia when stimulated by mechanical or chemical contact with the fish, and the reaction of the fish's tissues after the glochidium has become attached.

In any attempted infection of fish in large numbers, careful tests should first be made upon a few fish in small dishes, with microscopic examination of the infected parts from fish killed during the time of infection and for several days following, or until it is clear that the glochidia have become safely established in their host's tissues. After even limited experience one learns approximately the number of glochidia needed and can determine roughly their suspension in the water by taking samples at random in a pipette, which when held against the light shows clearly the individual glochidia. During infection it is possible to pick out individual specimens and by lifting up the operculum of the living fish, examine the gills with a hand lens. The glochidia are then seen individually and the progress of the infection can be watched. Fin-infecting glochidia may be seen individually if a fish is placed in a small dish against a black background.

It is not difficult to determine by these means the optimum time for the exposure. When 100 fish 5 to 6 inches in length are taken and the contents of a single marsupium of a large *Lampsilis* is placed in an ordinary washtub, infections may be obtained somewhat as follows: Rock bass, exposed 30 to 40 minutes, 2,000 to 2,500 glochidia on gills of each fish; large-mouth black bass, exposed 15 to 20 minutes, 500 to 1,000 glochidia on gills; crappie, exposed 20 to 30 minutes, 200 to 400 glochidia on gills; yellow perch, exposed 20 minutes, 400 to 600 on gills; German carp (with *Anodonta*), exposed 30 to 40 minutes, 200 to 500 on fins. These figures are given as starting points for anyone attempting artificial infections and can not be taken as representing the results of precise determinations of optimum infections for the fish in question, because the means for determining the numbers and distribution of the glochidia have been only approximate. It will probably always be necessary, in the practice of artificial infection on a large scale, to have the fish examined microscopically by a properly trained observer, and this will be particularly true in the beginning of this work in hatching establishments, because the practical details of artificial infection on a large scale have yet to be solved.

DURATION OF THE PARASITIC PERIOD.

According to the experience of previous observers, the duration of the parasitic period varies inversely with the temperature of the water (Schierholz, 1888; Harms, 1907–1909). Although we have found this to be true in general, our experiments have not shown so definite a relation between temperature and parasitism as has been described by Harms, for example, and it is quite possible that other factors, which are obscure, exert a modifying influence upon the length of time the glochidia remain on the fish. Harms found that the glochidia of *Anodonta* completed the metamorphosis in 80 days at a temperature of 8° to 10° C; in 21 days at 16° to 18°; and in 12 days at 20°; while in the case of the hookless glochidia of *Unio* (which are gill parasites) the period was 26 to 28 days at a temperature of 16° to 17°. He is inclined to attribute the somewhat longer time required for the metamorphosis of *Unio* to the fact that the glochidia in this genus when discharged are in a less advanced stage of development than are those of *Anodonta*—a difference that exists between all hookless and hooked glochidia

A few typical cases, selected from our records of infections are given in the accompanying table, which illustrates the far greater variability in the parasitic period than that observed by Harms.

TABLE SHOWING INFECTIONS WITH GLOCHIDIA.

Experiment.	Date.	Mussel.	Fish.	Exposure.	Young mussels liberated.	Duration of parasitism.	Av. temp. during parasitism.
HOOKED GLOCHIDIA.				*Min.*		*Days.*	*°C.*
1	Dec. 3, 1909	Symphynota complanata.	Apomotis cyanellus	15	Dec. 17–19	14–16	16.0
2	Dec. 17, 1909	....do	....do. Pomoxis annularis.	15	Jan. 1–4	15–18	16.3
3	Jan. 7, 1910	.... do	Apomotis cyanellus. Pomoxis annularis.	12	Jan. 18–21	11–14	16.0
4	Apr. 5, 1910	.... do	Apomotis cyanellus	30	Apr. 14–18	9–13	17.8
HOOKLESS GLOCHIDIA.							
5	Feb. 19, 1910	Lampsilis ligamentina	Apomotis cyanellus	9	Mar. 5–12	14–21	17.8
6	Mar. 6, 1909	....do	...do. Micropterus salmoides.	10–15	Apr. 7–11	32–36	19.1
7	Apr. 8, 1909	....do	Apomotis cyanellus. Micropterus salmoides.	10–15	Apr. 27–May 1	19–23	20.3
8	Apr. 13, 1910	Lampsilis subrostrata	Apomotis cyanellus	8–15	May 2–8	19–25	18.1
9	May 2, 1910	Lampsilis ligamentina	....do. Micropterus salmoides.	7–10	May 15–26	13–24	18.1
10	May 3, 1910	Lampsilis subrostrata	Apomotis cyanellus	50	May 17–25	14–22	18.1
11	July 29, 1909	Unio complanatus	Perca flavescens	7–14	Aug. 12–14	14–16	23.0
12	Aug. 5, 1908	Quadrula plicata	Micropterus salmoides	30	Aug. 17	12	24.4

In the case of *Symphynota complanata*, which has hooked glochidia essentially like those of *Anodonta*, the period varied from 9 to 18 days at average temperatures of 17.8° to 16° C., as compared with Harms's 21 days at practically the same temperature. At lower temperatures, about 10°, we have recorded a period of 74 days for *S. costata*.

The absence of a close correspondence between the temperature and the duration of the parasitism has been much more conspicuous in the case of hookless glochidia, which have shown not only a remarkable range in the period but a considerable irregularity in different experiments made at about the same temperature. The shortest period recorded by us was seven days in an infection of black bass with the glochidia of *Lampsilis subrostrata* and *L. recta* in April when the average temperature during the parasitism was 20.5°, but this unusual time was only observed in this one instance. A still more remarkable case, but at the opposite extreme, was an infection of black bass and crappie with the glochidia of *L. ligamentina* and *L. recta* which remained on the fish for 13 to 16 weeks. The infection was made in November and the young mussels were liberated during a period of about three weeks in the following February and March; during the parasitism the temperature varied from about 16° to 18.° The cause of the extreme duration in this case is not known, for in no other experiment at the same temperature has the parasitism lasted for more than 25 days.

As may be seen in the table, with hookless glochidia (aside from the extreme cases mentioned) the variation in the period has been from 12 to 36 days at average temperatures ranging from 24.4° to 17.8°; but even at practically the same temperature the difference may be quite marked, as in experiments no. 8 and no. 9. Experiment no. 6 should be noticed as being a case in which, contrary to expectation, quite a long period (32 to 36 days) was recorded at 19.1°, whereas in other experiments (no. 5 for example) the time was only 14 to 21 days at the lower temperature of 17.8°.

It would seem clear that, although within certain wide limits the duration of the parasitism is dependent upon the temperature of the water, nevertheless other factors may enter into the case to either accelerate the metamorphosis or prolong it over a period which is much longer than the usual duration of the parasitism. These factors would seem to be associated with individual physiological differences in the interaction between the fish and the parasite and are probably nutritive in nature, for on one and the same fish some glochidia may remain several days longer than others.

As may be seen from an examination of the table, in which the period of liberation is given in each experiment, not all of the young mussels leave the fish at the same time, but, on the contrary, the liberation may occupy a week or more. Harms found that it required from 5 to 6 days, the greater number leaving the fish during the middle of the period. Our experience has usually been in accord with these observations, but we have found the period to be somewhat more variable, from 2 to 11 days, or even much longer.

IMPLANTATION AND CYST FORMATION.

As has been described, the glochidium attaches itself to the fish by closing its shell firmly over some projecting region which can be grasped between the valves, like the free border of a fin or a gill filament. In so doing, a portion of the epithelium and underlying tissue, including blood vessels and lymphatics and varying in amount with the extent of the "bite," becomes inclosed within the mantle space of the glochidium. This tissue early disintegrates into its cellular constituents, which are taken up by the pseudopodial processes of the larval mantle cells, and, as Faussek (1895) has described, are utilized as food during the early stages of metamorphosis. In figure 60, plate XV, drawn from a glochidium six hours after attachment to a fin, the disintegrated tissue, consisting of loose epithelial cells, blood corpuscles, and fibers which lie scattered in the mantle cavity, is seen in the process of being ingested by the mantle cells. Figure 61, plate XV, shows a later stage, 24 hours after attachment, in which the detritus has been entirely taken up, and the mantle cells are now heavily charged with food material.

Almost immediately after attachment proliferation of the epithelium begins as the initial step in the formation of the cyst which eventually incloses the entire glochidium. The overgrowth of the larva has been described by Faussek (1895) and Harms (1907–1909) as a healing process on the part of the fish's tissues, resulting from the irritation caused by the wound. The proliferation starts around the line of constriction produced by the pressure of the edges of the valves on the epithelium, and, since the glochidium lies between and prevents the immediate closure of the lips of the wound, the extending epithelium is forced to slide up over the surface of the shell on all sides, until the free margins meet and fuse over the back of the larva, as may be understood by reference to figures 59 to 61, plate XV, and 35 to 38, plate XI.

So rapid is the overgrowth, especially in the case of implantation on the gills, that it would seem that something more than the mere mechanical irritation produced by the glochidium is concerned in causing the proliferation of the epithelium. We have, therefore, carried out a series of experiments with a view to determining whether or not a chemical stimulus is provided by the larva, and by using various methods have studied the action of glochidial extracts on the epithelium of both fins and gills. The results have been entirely negative, although the question has by no means been settled by the experiments which have been thus far attempted. By further improvements in the technique, some of the difficulties involved in the investigation, which is still in progress, may be overcome.

The process of implantation and cyst formation may be readily observed on the filaments of an excised gill, which under favorable conditions will live long enough in a dish of water to enable one to see the glochidium completely covered by the proliferated epithelium. Figure 54, plate XIII, drawn from the living excised gill, shows the distal end of a single filament bearing a glochidium of *Unio complanatus* which has become nearly covered by the walls of the cyst. In this case the gill was cut from the fish two hours after the infection and the drawing was made an hour later; immediately after the excision of the gill this particular glochidium was hardly half covered. The same glochidium was kept under observation, and two hours later (five hours after the infection) the sketch was made which is reproduced in figure 55, plate XIII. By this time the cyst, which is seen to have very thick walls, was completed, and formed a prominent mass near the end of the filament. Shortly afterwards the tissues of the gill began to disintegrate, but for at least three hours they remained alive and the proliferation of the epithelial cells proceeded rapidly, the entire process of cyst formation taking place in a perfectly normal manner.

The histological changes which the epithelium undergoes in the formation of the cyst have been studied in this laboratory by Miss Daisy Young, and, as her results will soon be published in detail, only a brief reference will be made in this place to the essential points involved in the cellular changes occurring during implantation of the glochidium.

Figure 59, plate XV, shows a very early stage, 15 minutes after attachment, in the formation of the cyst on the fin of a fish which had been infected with the glochidia of *Symphynota complanata*. The section is taken transversely through the glochidium and the free border of the fin on which the parasite has a firm grip. The mass of tissue, consisting of epithelial cells, connective tissue, and blood vessels in the mantle chamber of the glochidium, is the edge of the fin which was inclosed between the valves when attachment was effected. Already the proliferation of the epithelium is beginning in the neighborhood of the constriction, where two mitoses may be seen on the right in the figure. At the edges of the wound caused by the closure of the shell some of the epithelial cells are undergoing degeneration, while on the left of the section quite a patch of these cells is sloughing off, a not infrequent occurrence. The region of most active growth and multiplication of cells is just below the line of constriction, and, as the cells at this level increase in number, they appear to push those lying above them up over the outside of the shell, so that the actual covering of the glochidium is due largely to this mechanical gliding of the epithelium over its surface. Sections give no conclusive evidence of amitotic division, while mitoses are generally abundant in the region of active proliferation. An intermediate step in the process of implantation is illustrated in figure 60, plate xv, less highly magnified than the last figure, which shows a glochidium about half covered in six hours after attachment. The free edges of the cyst wall eventually meet over the dorsal side of the glochidium, where they then fuse. Figure 61, plate xv, shows a case of complete implantation on a fin at the end of 24 hours; now the epithelial covering is continuous and the glochidium entirely inclosed. The wall of the cyst is seen at this time to be quite thick, but it usually becomes thinner later on as the cells composing it flatten down. In the last two figures the mantle cells of the larva clearly show epithelial nuclei and cell detritus which have been ingested.

In figures 62 and 63, plate xv, two stages are represented in the formation of the cyst on gill filaments, taken at one hour and three hours, respectively, after attachment. The glochidia are those of *Lampsilis ligamentina*. In figure 62, plate xv, the proliferation has made some progress, especially on one side, and three or four mitotic figures are seen just below the glochidium and near the raw edge of the constricted epithelium. A large mass of the tissues of the filament is also shown in the figure inclosed within the mantle chamber of the glochidium. Figure 63, plate xv, represents a stage when the process is nearly completed and the edges of the epithelial covering have met but not yet quite fused. The cyst wall in this case is much thinner than that shown in figure 61, plate xv, but its thickness is quite variable.

In about one week after attachment, as a rule, the wall of the cyst begins to assume a looser texture, the intercellular spaces becoming infiltrated with lymph, and from this time on to the end of the parasitic period there is little further change in its structure.

Before liberation of the young mussel, the valves open from time to time and the foot is extended. By the movements of the latter the cyst is eventually ruptured, its walls gradually slough away, and the mussel thus freed falls to the bottom.

Portions of the wall of the cyst often adhere to the shell after liberation, while, if the young mussel has hooks, it may hang for a time by shreds of the fin in which the hooks are embedded, as seen in figure 24, plate ix.

METAMORPHOSIS WITHOUT PARASITISM IN STROPHITUS.

In a brief paper (1911) we have recently announced the discovery that in the genus *Strophitus* Rafinesque the metamorphosis takes place in the entire absence of parasitism, and, since the life history of this form is without a parallel in the Unionidæ, so far as is known, reference may be made again to the interesting conditions which obtain in its development.

It has been known for a long time that in *Strophitus* the embryos and glochidia are embedded in short cylindrical cords which are composed of a semitranslucent, gelatinous substance, and that these cords, which are closely packed together, like chalk crayons in a box, lie transversely in the water tubes of the marsupium. The blunt ends of the cords are seen through the thin lamella of the outer gill, which in this genus, as in *Anodonta* and others, constitutes the marsupium. The position of the masses of embryos, while contained within the gill, is so unusual that Simpson in his "Synopsis of the Naiades" established a special group, the Diagenæ, for *Strophitus*—the only genus of the family in which this peculiarity exists. In other genera the embryos are conglutinated more or less closely to form flat plates or cylindrical masses, each one of which is contained in a separate water tube and lies vertically in the marsupium.

So far as we are aware, Isaac Lea (1838) was the first to observe this interesting arrangement which he described and figured, rather crudely to be sure, in *Strophitus undulatus* (*Anodonta undulata*). In several subsequent communications (1858, 1863) he added further details and illustrations, and also mentioned the occurrence of the transversely placed cords, or "sacks," as he called them, in *S. edentulus*. He recorded the former species as being gravid from September until March, and described the extrusion of the cords from the female, as well as the remarkable emergence of the glochidia from the interior of the cords after the latter have been discharged.

The sacks were discharged into the water by the parent from day to day, for about a month in the middle of winter. Eight or ten young were generally in each sack, but some were so short as only to have room for one or two. Immediately when the sacks came out from between the valves of the parent, most of the young were seen to be attached by the dorsal margin to the outer portion of the sack, as if it were a placenta.

The essential points in these observations have since been verified by other investigators. Sterki (1898), following the suggestion of Lea, has called the cords, which differ strikingly from the conglutinated masses of *Unio* and other genera, "placentæ," thus indicating that he considered them to have a nutritive function. He also described the extrusion of the glochidia, when placed in water, and their attachment to the cord "by a short byssus thread whose proximal end is attached to the soft parts of the young." He further states that the glochidia are inclosed in the placentæ when the latter are first discharged, and that after their extrusion they remain attached for some time.

Strophitus edentulus, which Ortmann (1909) regards as identical with *undulatus*, is a rare species in all of the localities in which we have collected mussels, and, until recently, our only observations on this form were made upon a few gravid individuals which were taken in the Mississippi River near La Crosse, Wis., during the summer of 1908. Mention has already been made of our records with reference to the breeding season of *Strophitus*.

After verifying the main observations of Lea and Sterki, so far as was possible at that season of the year, we examined the glochidia carefully with a view to determining whether their subsequent life history would exhibit any peculiarities, as might be suspected from their relation to the cords. At that time we did not observe the normal discharge of the cords by the female; but we removed them from the marsupium, placed them in water, and, after the glochidia had emerged (fig. 46, pl. XII), employed various means to bring about their attachment to fish. None of these attempts, however, was successful, although the fish were left in small dishes containing many cords for as long a time as 12 hours. In the light of these results, which indicated the inability of this glochidium to attach itself to fish, and in view of the fact that the cords so evidently seemed to be a nutritive device, we felt it to be highly probable that in this species the metamorphosis would be found to occur in the absence of parasitism—a prediction which has been recently verified.

On February 6, 1911, a single female of *Strophitus edentulus*, which had been kept in the laboratory since the preceding November, was seen discharging its cords from the exhalent siphon. The discharge continued until March 25, and during that time the cords were thrown out in varying numbers from day to day. They measured from 2 to 10 mm. in length and about 1 mm. in diameter, although they became more or less swollen after lying in the water for a time. Each cord contained from 10 to 24 glochidia arranged in an irregular row. In many cases the glochidia emerged from the cords in a few minutes after the latter were discharged, and then usually remained attached by the thread in essentially the same manner as has been described by Lea and Sterki (fig. 46, pl. XII). The thread, which is apparently a modified larval thread, is continuous at its distal end with the egg membrane, which generally remains embedded in the cord; so intimate, in fact, is the union between the two that at times the membrane, adhering to the thread, is dragged out of the cord when the glochidium is extruded, in which case, of course, the glochidium becomes entirely detached from the cord.

All attempts to infect fish with these fully formed glochidia were again unsuccessful, even when the exposure was of long duration. Within a few days the extruded glochidia died in spite of every effort to provide the most favorable conditions for their maintenance.

When the cords first began to be discharged, one of our students, Miss Daisy Young, happened to notice that not all of the larvæ were extruded, and that among those which remained in the cords some had lost the larval adductor muscle, possessed a protrusible foot, and showed other signs of having undergone the metamorphosis. Upon careful examination this was found to be true, and it was discovered that these young mussels—for such they undoubtedly are—are subsequently liberated by the disintegration of the cord *after having passed through the metamorphosis in the entire absence of a parasitic period*. We, therefore, have concluded that the emergence from the cords in the glochidial stage is premature, due possibly to some change which has taken place in the gelatinous substance surrounding them as a result of free contact with the water, or to release from the pressure to which they are subjected while in the marsupium. It is perfectly evident that these glochidia neither become attached to fish nor undergo any further development; they have simply come out too soon and are lost.

The young mussels, on the other hand, which have developed inside the cords, when liberated by the disintegration of the latter or removed directly by teasing, are found to have reached as advanced a stage of development as is attained by any unionid at the time it leaves the fish. They closely resemble the young of *Anodonta* at the close of the parasitic period, and upon examination have been found to possess the following structures: The anterior and posterior adductor muscles; the ciliated foot; two gill buds on each side; a completely differentiated digestive tract, including mouth, esophagus, stomach intestine, and anus; liver; the cerebral, pedal, and visceral ganglia; otocysts; the rudiments of the kidneys, heart, and pericardium; while they also show a slight growth of the permanent shell around the margin of the shell of the glochidium (fig. 45, pl. XII). The larval muscle has completely disappeared, although some of the mantle cells of the glochidium, as well as the hooks of the shell, are still present. They crawl slowly on the bottom of the dish by the characteristic jerking movements of the foot, after the manner of the young of other species at a corresponding stage, although the valves of the shell gape more widely apart and the foot is shorter and less extensible. We have not succeeded as yet in keeping them alive for more than 10 days, but it is difficult in the case of any species to maintain young mussels of this age under laboratory conditions.

One of these young mussels after removal from the cord is shown in figure 45, plate XII, in which many of the organs of the adult or their rudiments are clearly indicated. A comparison will show that it is essentially as advanced in its development as the young of *Anodonta* when it is liberated from the fish (cf. Harms's figures, 1909, and also our fig. 47, pl. XII, of *Symphynota costata*).

The conclusion is inevitable that we have here to do with a species which has no parasitism in its life history, although the presence of hooks and other typical glochidial structures would indicate that it has originated from ancestors which possessed the parasitic stage like other fresh-water mussels. The cord is undoubtedly to be interpreted as a nutritive adaptation which arises in the marsupium during the early stages of gravidity, since the young embryos are at first contained in an unformed viscid matrix and the cords are a later product.

The whole history of this exceptional species warrants a more detailed study, and Miss Young is now engaged in such an investigation. When her work is completed we hope that it may include the entire course of development, the method of formation of the cords, and the rearing of the young mussels during a much longer period than has thus far been possible.

V. ATTEMPT TO REAR GLOCHIDIA IN CULTURE MEDIA.

Since the relation of the glochidium to the fish is essentially a nutritive one, it seemed to us that it should be possible to rear the larvæ through the metamorphosis artificially, provided a suitable nutritive medium could be found, and accordingly a series of experiments, with this object in view, were undertaken at our suggestion by one of our students, Mr. L. E. Thatcher. Although the result has thus far been entirely negative, we have not despaired of ultimate success, and, since the experiments are to be continued, a brief mention of the methods employed may be made in this place.

It was natural to suppose that the blood of the fish would offer the most favorable nutritive conditions for the development of the glochidia, and hence it has been used in most of the experiments, which, moreover, have been made in the spring, when the water in the laboratory was comparatively warm and the metamorphosis, if it had occurred, would have taken place as rapidly as possible.

The glochidia of *Lampsilis ligamentina* and *L. subrostrata* were carefully removed from the marsupium with a sterilized pipette and then repeatedly washed in distilled water in order to obtain them as free as possible from bacteria and other organisms. A drop of blood was next taken from a fish's heart and placed on a cover glass and a few glochidia immediately introduced into it. The cover glass was then inverted over a hollow slide containing a moist piece of filter paper, and the chamber sealed with vaseline. Every precaution was taken to avoid contamination by bacteria. As soon as the glochidia came into contact with the blood, of course they snapped shut in the manner already described and in doing so inclosed some of the corpuscles, which it was to be presumed would be ingested by the mantle cells. Although in some cases bacteria and infusoria, probably introduced with the glochidia, appeared, in a majority of the cases the cultures remained free from foreign organisms. In the latter event the glochidia lived for a few days, but finally died without showing any indication of further development. Experiments were tried with the blood of the frog and of *Necturus*, and also with extracts of fish's tissues, bouillon and other nutritive media. In all, however, the results were negative. The failure may possibly have been due to insufficient aeration, and experiments are now being devised in which oxygen is to be introduced into the moist chambers, and it is hoped that we shall yet succeed in rearing the glochidia in nutritive media through the metamorphosis.

VI. POST-LARVAL STAGES.

BEGINNING OF THE GROWTH PERIOD AND LIFE ON THE BOTTOM.

The changes occurring during the parasitism and by means of which the glochidium becomes transformed into the young mussel, ready for life on the bottom, are more properly described by the term development than by the word growth. The latter process becomes the conspicuous feature only when the miniature mussel has left the fish. From this time onward there are very few changes to which the term development may be strictly applied; for, with the exception of the outer gill, all the important organs of the animal have been laid down and have assumed something of their definitive structure (fig. 47, pl. XII).

As soon as they are liberated from the fish the young mussels become quite active and move about on the bottom of a dish by means of the foot (fig. 18, pl. VIII, and fig. 48, pl. XII), securing a hold by flattening the ciliated distal end against the bottom, and then drawing up the body after the characteristic fashion of lamellibranchs. In these movements the cilia of the foot play an active part; they beat vigorously while the foot is being extended, and apparently are effective in part at least in causing the protrusion. When the foot reaches its limit of extension, the cilia stop abruptly and remain quiet while the forward movement of the body is taking place, only to resume their activity when the extension begins again. Figure 18, plate VIII, furnishes an excellent illustration of the various positions assumed as the young mussels crawl about in their twisting, jerking movements, and also shows the extent to which the shell has grown beyond the limits of the glochidial valves by the end of the first week of free life.

In the great majority of forms, as appears from the work of other investigators and our own observations, the mussel leaves the fish with only a very narrow margin of adult shell protruding beyond the glochidial outline. The shape is still that of the glochidium, although all other resemblances to this larval stage have disappeared. In the larva of *Symphynota costata* this margin of the adult shell is so narrow, even after some days upon the bottom (fig. 47, pl. XII), as not to protrude beyond the glochidial outline when the young mussel is slightly contracted. Exceptions to this supposedly universal condition have been observed by Coker and Surber (1911) in the young of *Plagiola donaciformis* and *Lampsilis* (*Proptera*) *lævissima*—forms in which there is a considerable growth of the definitive shell and presumably of the other organs during the parasitic period. These cases are unique so far as known, but in view of the small number of species which have been observed at all during this period of their existence other such exceptions may be looked for. No data bearing upon the duration or other conditions of the parasitic life are given in the paper in question, since the material studied was from the gills of a fish which had been preserved after its infection under natural conditions.

These stages immediately following the parasitism and until the mussels are about 20 mm. in length are less known than any others. They have seldom been found by collectors, and the reasons for this are made clear by the work of Isely (1911), to which we shall presently refer. Pfeiffer first observed and figured in 1821 a small shell having the glochidial outline still visible at its umbo, and other cases have been recorded, notably by Schierholz (1888). Such specimens were taken from nature and not from mussels artificially reared. Indeed, no one has yet succeeded in following individual specimens for more than a few weeks beyond the beginning of life on the bottom. Recently Harms (1907, 1908, and 1909) has obtained these stages, by rearing, more extensively than his predecessors and has figured (1907a, p. 811) the young of *Anodonta* with a very substantial increase in size at an age of six weeks after the parasitism, beyond which they could not be reared because of their destruction by small Crustacea. He concludes that the latter constitute a serious danger to the life of the young mussel.

In our own work repeated attempts have been made to rear these stages to a size which can be more easily handled, but without success. Specimens of *Symphynota costata* (fig. 47, pl. XII) and of *Anodonta cataracta* have been kept alive in small dishes containing green plants for a period of from one to two weeks after they had left the fish, and *Lampsilis ligamentina* and *subrostrata* for a period of six weeks. Little or no growth was observed after the first week. The two species of *Lampsilis* formed a conspicuous border of new shell during the first few days of bottom life (fig. 18, pl. VIII, and fig. 48, pl. XII) and then ceased growing although they continued to move actively about. This would indicate that the difficulty lies in the lack of a suitable food supply. Crustacea were not observed to play an important rôle, though we do not doubt the correctness of Harms's observations in this respect.

Figures 18, plate VIII, 47 and 48, plate XII, will illustrate the appearance of the young mussels at this period and an examination of figure 47 will show how extensively the organs of the future adult have been laid down. Nothing remains to suggest the glochidium save the shell, and structure and habit alike indicate that the organism is now ready for a life on the bottom essentially like that of the adult.

JUVENILE STAGES AND THE ORIGIN OF MUSSEL BEDS.

For the sake of completeness, we shall discuss briefly at this point the present state of our knowledge regarding the stages between the one last mentioned and that represented by the young mussels over 20 mm. in length, which are often found upon the natural beds. In common with the experience of other collectors, we have seldom found mussels under 20 mm. It would therefore seem clear that these early stages are not at all common in localities where the slightly later stages and the adults are found. Isely (1911) has published a preliminary note upon his study of this "juvenile" period. We shall refer to his results rather fully, since there are no other recorded observations which deal with these stages save in the way of incidental reference to single specimens. This author states the problem by saying (p. 77) that: "Much difficulty was experienced in finding young mussels for study and experimentation. I have collected many specimens from the size of a nickel (20 mm.) to a quarter (24 mm.), but mussels under the size of a dime (17 mm.) have been rare." The latter he terms the "early juvenile" stages, including in this "the period following the time when the mussel completes the parasitic stage and leaves the fish to lead an independent life until it is about 15 mm. in length. This would cover, in most species, approximately the first year of independent existence. Other periods may be designated as later juvenile and adult life." He then reports the finding of 32 specimens in this early juvenile stage representing four genera and nine species, as follows: (1) *Lampsilis luteola*, two; (2) *Lampsilis fallaciosa*, one; (3) *Lampsilis parva*, four; (4) *Lampsilis gracilis*, three; (5) *Plagiola elegans*, one; (6) *Plagiola donaciformis*, sixteen; (7) *Anodonta imbecillis*, two; (8) *Ptychobranchus phaseolus*, two; (9) unnamed species, one.

All these specimens were found in places where the water was fairly swift, from 1 to 2 feet in depth, and on a bottom of coarse gravel, the particles of which were 10 to 25 mm. in diameter. They were anchored by the threads of a byssus gland "strong enough to support the mussel in a rapid current" and capable of sustaining "the weight of a number of small pebbles without breaking."

Here then, as Isely concludes, we have the clue to the habits and ecology of these so little-known stages. The finding of representatives from so many genera and species, both heavy and light shelled, under identical environmental conditions and the presence of the functional byssus in all cases is pretty good evidence that this is the normal condition for early juvenile life in a wide range of forms. It is, moreover, interesting to find in the Unionidæ, as in many other lamellibranchs (e. g., *Mya* and *Pecten*) a functional byssus in the early stages, though there is no such organ in the adult.

As these results are very important and of convenience for reference in this paper we may here quote Isely's conclusions in full.

The facts noted above are closely related, not only to the ecology of the juvenile mussel, but also to the ecology of the adult.

1. They indicate the conditions essential for the most successful growth and early development of the Unionidæ. This kind of an environment gives a constant supply of oxygen and sufficient food; is frequented by suitable fish; is free from shifting sand and silt accumulation. Those mussels that drop from the fish in these favorable situations develop in large numbers, while the less fortunate, that drop in shifting sand and silt, die early.

2. In the study of the ecological factors that are inimical to mussel life more attention should be given to the consideration of the juvenile habitat. Absence of gravel bars and stony situations may sometimes explain the scarcity of the Unionidæ in certain streams and lakes where frequently water content has been thought the chief unfavorable factor.

3. It is a well-known fact that in many streams certain stretches of mud bottom are found loaded with mussels, while other areas, in the same stream, equally favorable from the standpoint of the habitat of the adult mussels, have only scattering specimens.

This distribution of the adults may be explained by the assumption (which is fairly well established by experimental study and will be discussed in a later paper) that the average mussel seldom travels far up or down the stream from the place where it begins successful development. Stretches favorable for juvenile development thus come to be the centers of dispersal in the streams where they occur. As a result, areas of mud bottom near these favorable habitats become loaded with mussels by migration.

4. In the study of the life history of the Unionidæ we may consider the embryonic, the glochidial, the parasitic, the early juvenile, and the adult as distinct periods for separate and special study.

These results of Isely's are clearly of very great importance in the problem of artificial propagation and it is to be hoped that his observations may be greatly extended in the near future. The number of different species which he has found is a most promising sign that he is on the right track, and we may hope that we shall soon reach a satisfactory understanding of this stage of the life cycle hitherto so little known.

At this point a word regarding the formation of beds may be opportune. It is a familiar fact that many species are most likely to be found congregated in beds which in some of the larger streams must have contained, before the shells came into commercial use, numbers of mussels which are hardly conceivable. Elsewhere in the stream the mussels are found scattered and wandering over the bottom. In the absence of any indication that the individuals of a species are in some manner attracted to one another, the simplest explanation of the formation of beds would be the same as that given in other cases of this sort. The conditions of food supply, current, character of bottom, etc., must differ considerably, and we may reasonably suppose that some places present the optimum conditions over an extended area and that in such a place a bed may be formed. As the mussels wander over the bottom they may by chance enter such an area of optimum conditions and will then move about less actively or come to rest, because in the absence of unfavorable conditions there is no stimulus to continued locomotion. The result is that individuals which enter are likely to remain and more keep coming in. This kind of an explanation has been offered, by the students of animal behavior in recent years, to account for the formation of aggregates in a great variety of the lower organisms; and it appears the most reasonable one in such cases as the one in hand, where there is no evidence that the gregariousness is due to a definite recognition of the presence of other individuals.

RATE OF GROWTH.

It has been quite generally believed, by those investigators who have given their attention to this matter, that the mussel shell grows during the warmer months of the year and that in winter there is no appreciable addition to its margin. When growth begins again in the spring, the winter's rest has left a mark which appears as a dark line on light-colored shells or as a deeper groove in others where the color is not so conspicuous. Finer lines may be found between these rings of growth, but the latter, like the rings of a tree, mark the years. It is certain that these more conspicuous lines or "rings," as we may term them, indicate an alternation of growing and resting periods in the formation of the shell. It is not entirely certain that a single growth period must always correspond to a single year; for, when any lot of shells is carefully examined, some will be found in which the "rings" are distinct and strongly suggestive of an annual increment, while others of the same size may not show these rings in any such distinct fashion, and one is forced to conclude either that the annual rings, if such they be, are not always clearly to be seen or that some mussels may grow at a very different rate from others. The examination of any considerable number of shells leads to the belief that even if the annual-ring theory can be proved conclusively the rings are often not sufficiently distinct from the intervening lines to give an unquestionable record of the age.

Assuming that these rings, when clearly seen, do represent years, it would seem that the shell grows very rapidly during the first few years of the mussel's life and after that much more slowly. To judge from the lines alone, we should say that many of the large *Quadrula* shells had reached one-half their size in ten or a dozen years and then taken forty or fifty for the remainder, so closely set are their later rings of growth; and that shells of these species can not reach the most desirable commercial size in a less period than twenty or thirty years. Since these are regarded as the best of all button shells, the outlook may seem discouraging, because, like hardwood timber, the best shells take too long to grow.

The "ring theory" if proved would not, however, make the situation so discouraging as might seem from the species of *Quadrula;* for we have in some members of the genus *Lampsilis* shells which are almost if not equally desirable, and such evidence as we have from the rings indicates that shells like these may reach a commercial size in a very few years and that even forms like the quadrulas may become marketable within a period of four or five years.

In a recent paper, Israël (1911) has reported his conclusion that there is no winter-rest period and that more than one ring may be formed in a single year. This statement is based upon the examination of the shell margin in mussels collected at various seasons of the year and of mussels which had been placed in wire inclosures on the bottom of the stream after having been accurately measured. The results from these plantings were fragmentary because of the accidental destruction of most of the inclosures. In one case, however, he found specimens which "when placed in the inclosure in August, 1909, and measuring 18 mm. in length, had reached, at the time of their examination in June, 1910, a length of 26 mm." He reports that other similar investigations are in progress, the results of which we shall await with interest.

Since no accurate observations on the rate of growth of fresh-water mussels have ever been made, we have attempted to secure definite data bearing upon this problem. The data obtained are derived from two entirely different lines of observation, as indicated by the headings of the sections which follow, and although meager they show that with better facilities it should not be difficult to follow individual mussels from the juvenile to the adult stages, and thus to determine their rate of growth in an accurate manner.

GROWTH OF MUSSELS IN WIRE CAGES.

While engaged in mussel investigations at La Crosse, Wis., during the summer of 1908, we collected a number of young clams (fig. 68, pl. XVII) belonging to 16 different species, and after weighing and measuring them accurately they were distributed in wire cages, which were then anchored by long wires in midstream to the piers of a bridge over the west channel of the Mississippi River opposite La Crosse. One hundred and sixty-three small mussels, belonging to the following genera and representing both thin and thick shelled forms, were planted out in this manner: *Alasmidonta*, *Anodonta*, *Lampsilis*, *Obliquaria*, *Obovaria*, *Plagiola*, *Quadrula*, and *Unio*.

Some of the cages contained only a single specimen of each species represented in it, in which case an absolute identification would be possible, should the cage be recovered later, while, if two or more individuals of a species were put in a cage together, only specimens of practically the same size were selected. In the latter case it would of course be impossible to subsequently distinguish an individual mussel, and only the average rate of growth could be determined for the individuals present. It was assumed that mussels of the same size and under the same conditions would grow at practically the same rate.

These plantings were made at intervals from June 29 to August 10, 1908. An opportunity did not present itself to make an attempt to recover the cages for over two years, but in November, 1910, Dr. R. E. Coker, who knew of the experiment, made a search while on a visit to La Crosse and was fortunate enough to find 2 of the 11 cages planted by us in 1908. One of the cages was deeply buried in the mud and all of the mussels in it were dead; as they showed little or no growth, they were evidently killed shortly after the planting. In the other cage, however, 6 living mussels were found, as follows: 3 *Lampsilis ventricosa*, 1 *Obovaria ellipsis*, 1 *Quadrula solida*, 1 *Anodonta imbecillis*. These 6 mussels, with the exception of the specimen of *Obovaria ellipsis*, were readily referred to definite individuals as recorded at the time the cage was set out. The comparative measurements and weights are given below.

	June 29, 1908.	November 15, 1910.
Lampsilis ventricosa:		
	(1) 45 by 30 mm., 16 grams	85 by 65 mm., 129.85 grams.
	(2) 47 by 32 mm., 15 grams	81 by 57 mm., 115.5 grams.
	(3) 47 by 30 mm., 16.5 grams	96 by 67 mm., 145.2 grams.
Obovaria ellipsis:		
	(1) 52 by 52 mm., 59.1 grams	57 by 55 mm., 74.6 grams.
	(The identification of this specimen is somewhat uncertain.)	
Quadrula solida:		
	(1) 35 by 36 mm., 27 grams	45 by 46 mm., 46.3 grams.
Anodonta imbecillis:		
	(1) 30 by 25 mm., 8 grams	61 by 28 mm., 13.3 grams.

In each case, the first measurement is the greatest antero-posterior length of the shell, and the second the distance from the top of the umbo to the ventral margin taken approximately at right angles to the lines of growth. An interesting and important feature of these specimens is the fact that the original margin is clearly indicated by a conspicuous line on the shell of each, and as the measurements within this line correspond with the original measurements, the identification is made sure for each individual.

We quote below an analysis of the results sent us by Dr. Coker, who made the second series of measurements after the recovery of the cages:

Lampsilis ventricosa.—They have increased in length by 34 to 39 mm. and in height by 25 to 37 mm., and they now weigh approximately 7, 8 and 9 times as much, respectively, as when first put out. Furthermore, the added area of shell is divided by a conspicuous dark ring and a less distinct ring which, one is tempted to assume, represent the periods of cessation of growth during the two winters. If such an interpretation is made, the growth was accomplished chiefly during 1908 and 1909, while during the present year (1910), the mussel having reached adult size, the growth has been considerably less.

Increase in size stated by percentage (present measurements compared with original measurements). Period, June 29, 1908, to November 15, 1910, 2 years, 4½ months:

		Length	Height	Weight.
Specimen no. 1	per cent	188	217	812
Specimen no. 2	do	172	178	770
Specimen no. 3	do	204	223	880

The proportion of increase is slightly greater in height than in length, and the coefficient of increase in weight is, as might be expected, something like the cube of the coefficient of increase in either dimension.

Obovaria ellipsis.—The specimen has probably gained very little in length or height but materially in weight. It was nearer its adult size, is doubtless a slower growing species, and has probably gained in weight by increase of thickness of shell. But we are not so sure of the identity of this specimen.

Quadrula solida.—Has gained nearly 30 per cent in length and height and 70 per cent in weight.

Anodonta imbecillis.—Has more than doubled in length, with negligible increase in height, while it has increased 66 per cent in weight. This is particularly interesting as showing a marked change in form from the young to the adult.

Text figure 4, A and B, represents outline sketches of two of the three specimens of *L. ventricosa* described above, showing the exact size of each after the completion of the growth in the fall of 1910; the line marked *a* is the margin of the shell at the time the planting was made in 1908; while lines *b* and *c* are the two successive rings indicating cessation of growth. The two areas inclosed between these lines, representing the two chief periods of growth which have occurred, are not of equal extent in the three specimens. In A they are of about equal width, while in B the second area is much greater than the first. The area between line *c* and the margin of the shell is in all three cases very narrow, showing that, as the mussel approaches the adult size, further increase in the shell must take place very slowly. The recovered specimen of *Q. solida* shows only one broad area of growth, and a very narrow one around the margin. This mussel was relatively much nearer adult size when put in the cage than the specimens of *ventricosa*.

Dr. Coker comes to the following conclusion with respect to the age of the specimens of *L. ventricosa:*

> They are very significant, as they show clearly that growth is much more rapid than is generally suspected. Considering what the growth has been since the cages were put out, it is fair to assume that the specimens had only one year's growth at that time. That is to say, they were glochidia in the spring of 1907, and, since they must have been carried in the gills of the mother over the preceding winter, their complete age at this time (Nov. 15, 1910) is a little over four years.

Their age since the metamorphosis would therefore be about three years. Their probable history, on the above assumption, is as follows:

1. Eggs fertilized in August, 1906.
2. Glochidia discharged in spring or early summer, 1907.
3. Liberated from fish in summer, 1907.
4. Collected at age (since metamorphosis) of about one year and placed in cages June 29, 1908.
5. Recovered and remeasured, November 15, 1910.

The rate of growth of these individuals is probably typical of the genus *Lampsilis*, and the experiment indicates at least that commercial mussels may reach a marketable size in three years from the time they leave the fish. With the heavier shelled species (those of *Quadrula*, for example) the rate of growth is probably slower and a longer time must elapse before they are large enough for commercial use.

These experiments, meager as they are, are quite significant and furnish the first definite data, so far as we know, relating to the rate of growth of fresh-water mussels. With the proper facilities and the opportunity of examining the mussels at closer intervals, similar plantings could readily be made and exact information obtained on the growth of all the important species. To prevent the cages from being buried in the sand or mud would seem to be the chief precaution that should be taken in future experiments of this kind.

AN ARTIFICIALLY REARED MUSSEL.

Another experiment, although it does not throw light upon the question of the rate of growth in nature, might be mentioned in this connection on account of its significance for the problem of artificial propagation. A lot of black bass which had been infected with the glochidia of *Lampsilis ligamentina*, *ventricosa*, and *recta* at Manchester, Iowa, on December 2, 1908, were brought to Columbia, Mo., and placed in a large tank containing sand. The fish were left in the tank, where the young clams were allowed to fall off in the hope that some would survive and be later recovered. The sand was examined at intervals thereafter but never thoroughly, as the chance seemed very slight that any of the young clams were still living. On December 26, 1910, however, a single small individual of *Lampsilis ventricosa* was found alive and active in the sand of the same tank. There can be no doubt that it was derived from the infection referred to, as no young clams of this species had ever been in the laboratory, and no subsequent infections were made in that tank. The exact size of this young mussel was 41 by 30 mm. on December 26, 1910. It is still alive, but as late as June, 1911, it was practically of the same size. Since it is over two years old, it is evident that it is quite a dwarf, and, had it been reared under favorable conditions, it undoubtedly would have been much larger by this time. The tank in which it has spent all of its life is supplied with tap water, which is obtained from deep wells and contains little that a mussel could utilize as food, and its small size is undoubtedly due to the fact that it has been underfed from the beginning. The shell shows no indication whatever of lines of interrupted growth, but this is only what might have been expected, as the mussel has never been exposed to low temperatures. It is evident, therefore, that it has been growing continuously, but very slowly, throughout its entire life.

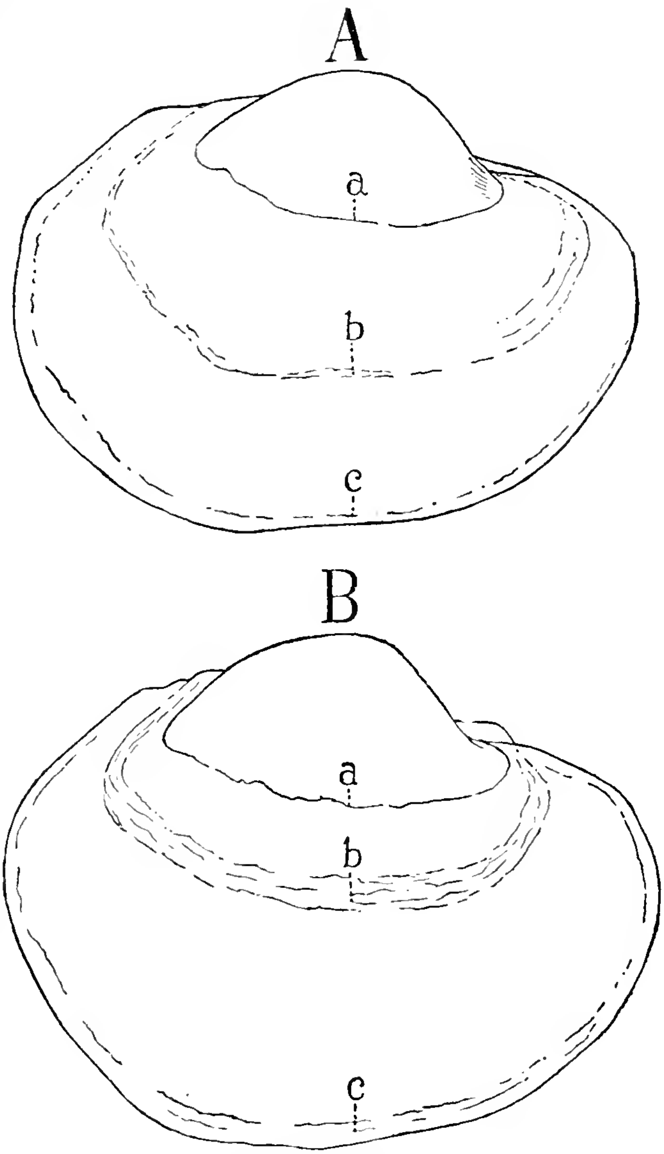

FIG. 4.—Two individuals of *Lampsilis ventricosa* recovered on November 15, 1910, after having been confined in a wire cage in the Mississippi River for two years and four and a half months. The line *a* is the original margin of the shell at the time of planting, June 29, 1908, and the lines *b* and *c* represent the "rings" which are due to the periods of cessation of growth. Natural size.

This individual, however, is of no little interest, as it is the first fresh-water mussel actually reared artificially from the glochidium, and in a sense furnishes a demonstration of the feasibility of artificial propagation. Had the food supply in the tank been adequate, it would now be a mussel of about two-thirds the adult size.

THE ORIGIN AND AGE OF MUSSELS IN ARTIFICIAL PONDS.

A second line of evidence bearing upon the rate of growth has been obtained in connection with an examination of certain artificial ponds in the vicinity of Columbia, Mo. In this region it is customary for the farmers to construct, for the watering of cattle, ponds in which water is held the year round by the impervious clay soil. We have examined many of these small bodies of water and have records of the approximate, if not the exact, dates of their construction. In 12 of these ponds, the ages of which are from 5 to 40 years, we have found specimens of *Lampsilis subrostrata* and *Unio tetralasmus* in some numbers, and in two of the ponds the mussels are present in very great numbers.

The occurrence of the mussels in the different ponds has been considered, first, with a view to the question of their original introduction into a given pond, and, second, their rate of growth. The first of these two considerations will be discussed here as a matter of convenience, although it should more properly be considered in a section dealing with the introduction of mussels into favorable localities.

As to their origin in the ponds, we find the facts interesting because it is quite clear that a majority, if not all of the ponds, must have been stocked with mussels which were first introduced as parasites upon fish. The significant facts in this connection are: That we have never found a pond containing mussels but no fish, although there are a number of ponds containing fish in which we have thus far failed to discover any mussels, and that none of the ponds have outlets or other immediate connections with streams in which the mussels occur, but are situated, for the most part, on high ground far from the watercourses, making it impossible that the mussels could have worked their way into these bodies of water by any ordinary process of migration. Since it is very unlikely that persons have introduced adult mussels into so many places by intent or accident, the mussels must have appeared in these ponds by natural means and the most probable of these is their introduction while parasites upon the fish with which the ponds were stocked. The transportation of small individuals attached to the mud on the feet of birds or of terrestrial animals, so often suggested as a means of dispersal in a case like this, is a possible mode of origin, although it seems hardly a probable one in view of the excellent chance the mussels would have of being introduced while still parasites.

One of the above ponds, which is about 40 by 60 feet in area and 10 feet in depth, is particularly interesting since it contains great numbers of *Lampsilis subrostrata* and also of the sunfishes (*Lepomis humilis* and *Apomotis cyanellus*), which we have found in our laboratory experiments to be very favorable hosts for the glochidia of this mussel. The mussels are of all sizes and the pond has existed for many years. We do not know its exact age nor how long ago fish were introduced. The mussels were first discovered in 1907 and have ever since been found in abundance. Their success is doubtless due, in large part, to the abundance of a fish favorable for their parasitism. Nothing in these specimens, nor in what we know of the history of this pond, gives a clue to the age of the mussels.

Another pond has great numbers of *Unio tetralasmus*. This pond was constructed in 1901 and during the first year was stocked with fish (the exact species unknown). In 1907 it contained a great many mussels as long as 4 inches, and since that year the largest individuals have slightly exceeded this size, which is near the maximum as we know it for this species. It is inconceivable that these unios were introduced as adults, for they are present in great numbers, and the farmer who owned the land was astonished to find them there four or five years after the pond was established, because it was near the entrance to his dooryard and he knew that no one had introduced mussels in any such numbers and that there was no watercourse connecting the pond with any creek in which mussels occurred. These mussels evidently came as parasites upon the fish with which this pond was stocked during the first year and they had reached a length of 4 inches in a period of five years. The abundance of the adults when the pond was six years old and the presence of some smaller specimens made it seem that more than one generation was represented, and hence some may have reached this size in a shorter time. The shell of *Unio tetralasmus* is light and is by no means a good button shell. Still it is not an impossibility, commercially speaking, for we have been assured by one of the leading button manufacturers, Mr. J. E. Krouse, of Davenport, Iowa, to whom we sent shells from which buttons were cut, that a marketable button could be made from them and would be made if there were no other shells available.

The appearance of *Lampsilis subrostrata* and *Unio tetralasmus* and no other species in all the ponds examined suggests the question, why have these two species and no others become established? If they were introduced as glochidia infecting fish, is it likely that the different lots of fish placed in so many ponds were infected solely with the glochidia of these two species? It seems much more probable that other mussels were introduced in the parasitic stages and that they were not able to survive long upon the bottom of these ponds. We have introduced large adult specimens of *Quadrula metanevra* and *Symphynota complanata* into one of the ponds in question and found some of them still alive after two years. This pond had a very soft mud bottom well covered with a layer of black muck filled with the soft coal soot from the smoke of a neighboring power-house chimney and seemed unsuitable for any variety of mussel. It had become, in spite of this, well stocked with *Lampsilis subrostrata* and is the pond referred to in detail in a previous paragraph. The survival here of these specimens of heavy shelled mussels for a period of two years shows that the adults are not at once killed even by unfavorable conditions, and we are therefore inclined to believe that when these species are introduced into the ponds on fish their destruction occurs in the early juvenile stages.

If a small body of water can be so fully stocked by the scant infection of glochidia obtained by fish in nature, we should be able to introduce mussels like these into a pond far more effectively by the use of fish which had been artificially infected and to rear them to adult size within a short term of years. Accordingly, we have attempted the introduction of *Lampsilis ligamentina* into one of the ponds where no mussels had ever been found by placing in the pond several hundred fish well infected with the glochidia of this species; but several examinations of the mud and silt from the bottom, made during the 18 months following, have failed to show anything as a result of the experiment.

The conclusions drawn from these observations are encouraging because they indicate, first, that other species, like those of the genus *Lampsilis*, whose shells are of excellent quality for the best of buttons, may be reared to commercial size in about the same length of time, and, second, that restricted localities can be stocked with mussels by the introduction of fish infected with glochidia. The members of the genus *Lampsilis* have shells which are evidently not much heavier than the shell of *Unio tetralasmus*, a fact which better fits them for life upon soft bottoms where there is little current, and in such localities they often occur. They move about more actively than the heavier shelled species and this, doubtless, enables them readily to seek out the most favorable food conditions in any body of water, instead of remaining long in one place where the conditions are very stable, as do the heavier shelled species. The study of any mussel which can live in small ponds like those in question and from which button shells can be obtained should be followed up with care, since the extensive culture of mussels would be a far simpler matter in ponds than in any stream where high and low water and the shifting of the bottom might so largely interfere with the most carefully located beds. For this purpose the species of *Lampsilis* which give good button shells would seem the most desirable, because they are better adapted for the conditions and because our planting experiments indicate that they reach a marketable size in a shorter time than the quadrulas.

We feel that there is nothing discouraging in what is at present known regarding the rate of growth under the average natural conditions. Moreover, it should be remembered that in most invertebrates where the growth rate has been studied this may be modified to an astonishing degree by the food supply and that the actual size of an individual furnishes no trustworthy clue to its age. It is not at all unlikely that proper study of the food and other conditions necessary for the maximum rate of growth will enable us to obtain shells of commercial size in even slow-growing varieties within a reasonable number of years. To judge from the supposed annual rings of specimens taken in nature, *Quadrula ebena* may take from 20 to 30 years to reach, under natural conditions, the size which is most desirable. The question whether this is a necessity, or only a result of the poverty of food conditions which most mussels meet in nature, is one which must wait upon the proper scientific analysis of the mussel's food and rate of growth in this and other species, and there is no problem in connection with the attempted artificial propagation which has more pressing importance.

VII. INVESTIGATIONS ON THE UPPER MISSISSIPPI RIVER.

A brief reference may here be made to certain field studies which were carried on in connection with our mussel investigations during the months of June, July, and August, in 1908, on the upper Mississippi River. The Bureau of Fisheries put at our disposal for this purpose its substation, a small building provided with tanks and running water, at La Crosse, Wis., and also its steamboat, the *Curlew*, which not only furnished us with living quarters, but was of invaluable service for transportation from place to place on the river (fig. 65, pl. XVI). The boat, which is ordinarily used in the work of reclaiming young fish from the overflow of the river during the floods which occur in the spring and early summer, is equipped with aerated tanks, seines, and other apparatus and provided us with what was essentially a floating laboratory. With these facilities much was accomplished that would have otherwise been impossible. In addition to the usual crew of the *Curlew*, the party consisted, besides ourselves, of Messrs. W. E. Muns, Howard Welch, F. P. Johnson, and W. E. Dandy, students in the University of Missouri, who served as assistants.

The primary object of the expedition was a determination of the breeding seasons of the commercial species of mussels as far as possible at that time of the year and an examination of the depleted mussel beds in the upper Mississippi River, which have been all but destroyed as a result of the ravages of the mussel fisheries.

With a clamming outfit of our own (fig. 69, pl. XVII), consisting of a flat-bottomed skiff and "crow-foot" dredges—the usual apparatus employed by the mussel fishermen—we were able to secure thousands of mussels, which were examined microscopically for the purpose of determining their sex and the stage of development of the embryos. The data thus obtained furnished a mass of detailed information, especially with respect to those species which breed in the summer, but as they are incorporated in the account already given of the breeding seasons, there is no need to refer to the subject again.

The planting of young mussels in cages for a determination of the rate of growth was also made during this summer, with the result as described in a preceding section.

Some attempts were made to infect fish with glochidia, but this phase of the work was greatly interfered with by the high water of the river, which remained at flood stage unusually late in the summer of 1908 and made the seining of fish very difficult. Some infections, however, were carried out with the glochidia of a few summer-breeding species, the fish being retained in the tanks at the La Crosse station throughout the parasitic period and the duration of the parasitism determined.

A thorough survey of the mussel beds from Winona, Minn., to Lansing, Iowa, was made, and records taken at each locality where mussels were collected. No large beds at all were discovered, and in every instance where mussels were found indications of the ravages worked by the clammers were apparent. An account of the distribution of the species throughout this section of the Mississippi River and their relative abundance is not presented here, as the results of our observations in these respects will be incorporated in the work of the several field parties which have been engaged in the study of the geographical distribution of the Unionidæ throughout the Mississippi Valley under the direction of the Bureau of Fisheries during the past four or five years.

While working in the neighborhood of La Crosse, we made a careful investigation of the west channel of the river at this locality, with a view to determining whether places of this nature presented favorable conditions for experimental rearing of young mussels. As is usually the case with the accessory channels of the river in this region, the west channel at La Crosse is dammed across its head for the purpose of confining the water in the main channel, and, although at high-water stages of the river the dam is submerged, during the greater part of the year the volume of water in the channel is greatly reduced and the current retarded. These dams, however, are never tight, and a greater or less quantity of water constantly seeps through them. A thorough study of this channel showed that it contained very few mussels indeed, and of those species that were found living in small numbers under these conditions, the majority belonged to *Lampsilis, ventricosa* being by far the most abundant form. Whenever a channel of the river is dammed, the slackening of the current causes an enormous sedimentation to take place, and in these "sloughs," as such obstructed channels are called, sand and mud bars and shoals have been formed to an extent varying with the length of time since the dam above them was built. The more sluggish species of mussels, like the quadrulas, are especially ill adapted to these conditions and are frequently buried and destroyed by the deposits of silt in the river, an occurrence of which we found abundant evidence. With the more actively moving and burrowing species, as those of *Lampsilis*, the case is different, for apparently they may adjust themselves more readily and by their far greater ability to move from place to place they may avoid the danger of being buried. We found little evidence that the quadrulas, for example, move about at all, while, on the contrary, the tracks of slowly wandering individuals belonging to the species of *Lampsilis* were everywhere conspicuous on the sandy bottoms of the shallow sloughs.

An interesting case of the destruction of mussel beds *in situ* by sedimentation is shown in figure 70, plate XVII, which is a photograph taken on the bank of a slough, near Muscatine, Iowa, which was exposed by a gully washed out by rains and cut directly through an extinct mussel bed. The photograph shows the surface of the cut where the mussels are exposed as they lie embedded in the muddy bank. The bed is buried under about a foot of mud, and it is interesting to note that the valves of the mussels are closed and lying together in pairs. The latter fact proves conclusively that this is not an old shell heap, for the valves of the shells would be found scattered and separated in that event, but a mussel bed which had once existed in the river near the bank. It was probably buried under the deposits of sand and mud which followed the building of the dam across the head of the slough. An investigation of the species represented in the bed showed that they all belonged to *Quadrula*, being chiefly *ebena*, *pustulosa*, and *trigona*, while not a single individual belonging to *Lampsilis* could be found in it. It is probable, as already stated, that it is the sluggish species, like those of *Quadrula*, that are the principal sufferers in catastrophies of this nature, and are caught and smothered in the process of sedimentation, while the propensity to wander possessed by the more active species enables them to move out into deeper water when the deposit of silt becomes a menace.

The result of our study of the conditions obtaining in sloughs like the west channel at La Crosse, which are closed by dams at their heads, proves conclusively that such waters afford a very unfavorable habitat for mussels, and that therefore they are not adapted to experimental uses.

VIII. ECONOMIC APPLICATIONS.

It may not be inadvisable to discuss briefly certain applications of the results obtained in the foregoing investigations to the practical work of artificially propagating fresh-water mussels on a commercial basis. It must be emphasized at the outset that the ultimate object of the investigations—the restocking of depleted waters with commercial species of mussels—is not dependent for its realization solely upon the success of rearing mussels artificially from the glochidia, but that other methods of attaining the same end may be employed which are of equal, if not greater, importance.

PROTECTIVE LAWS.

Much can undoubtedly be done by securing the passage of laws by State legislatures for the closing of certain streams or sections of streams against all clamming for a period of years of sufficient length to allow of a natural increase of the mussels; by laws prohibiting the use of the ordinary "crow-foot" dredge, which takes immature and adult individuals indiscriminately,[a] and by laws prohibiting the discharge of sewage and factory refuse in the neighborhood of mussel beds. By these and other protective measures of a legal nature, a great deal might be accomplished in the way of conserving the supply of mussels in the more important waters, but, since in the case of many rivers the control is in the hands of two or more States, the passage of such laws would require, to be effective, similar action on the part of several legislatures, and such cooperation might not be obtained without the greatest difficulty.

The utter futility of laws which would establish a closed season of the year against clamming is apparent in the light of our knowledge of the breeding seasons of the Unionidæ. We have already seen that there is no month in the year when some species are not bearing embryos or glochidia, and as species of commercial value are found in both groups—those with the long and those with the short period of gravidity—a closed season at any time would be of little or no avail. Several species of *Lampsilis*, for example, which bear embryos or glochidia from August to July, furnish valuable shells for the pearl-button industry, while the species of *Quadrula* and other summer breeders, gravid from May to August, supply shells of the best quality. Any law then, designed to relieve the situation, which prohibits the taking of mussels during a supposed breeding season is based on ignorance of the facts, for the entire year is the breed-

[a] Mussels caught on a hook of the "crow-foot" are generally so badly injured internally in the process that, even if they are afterwards thrown back into the river, the majority probably die. A special form of hook has been devised by Mr. J. F. Boepple which is so constructed that small mussels can not be caught by it. The use of some such selective apparatus should be required by law.

ing time of the Unionidæ. A law, however, which would close a river or large section of a river for a period of five years or more would be most beneficial, for in that time much could be accomplished both by artificial and by natural means to restore normal conditions. Even artificial propagation, unaided by certain protective measures, could hardly become effective on however extensive a basis it might be carried on, for unless some means can be devised for saving the young mussels it is difficult to see how much headway could be made against the destruction of the supply. It therefore becomes of vital importance not only to make illegal the use of any apparatus which will catch or injure young mussels, but to see that the law is rigidly enforced.

Certain requisite conditions for the artificial culture of fresh-water mussels, based upon our knowledge of their life history and habits, may now be briefly referred to.

SELECTION AND MAINTENANCE OF A FISH SUPPLY.

Although only a comparatively few kinds of fishes have been thus far used in our experimental infections, and doubtless as our experience widens many more will be found to be favorable for the purpose, success has been attained chiefly with the black basses, rock bass, and the sunfishes. All of these fishes have proved to be extremely resistant to the injurious effects of gill infections (practically all of the commercial species of mussels have hookless glochidia, which are gill parasites); to be able to carry large numbers of glochidia through the parasitic period; and to be easily kept in confinement—three necessary conditions for the success of propagation. It is to be hoped that other fishes will be found to be equally useful, but at present those just mentioned afford the most promising material for the work. As has already been shown, some species of fishes are very easily killed even by light gill infections, while others, according to our experience, have resisted all attempts to bring about permanent implantation of glochidia on their gills. The latter is particularly true of German carp and catfishes.

Fortunately, the basses and sunfishes can be obtained in large quantities without serious difficulty. In the reclamation work conducted by the Bureau of Fisheries along the upper Mississippi River, immense numbers of young bass are annually seined from the sloughs and "lakes" into which they are carried when the river rises over its banks during the flood stages of early summer. When the water recedes these young fish are caught outside the banks of the river, and only the small fraction of them which is reclaimed in the seining operations is saved from the wholesale destruction (fig. 67, pl. XVI). There is no limit to this supply of material for the work of mussel culture, and doubtless extensive use will be made of it at the Fairport station.

Even more valuable for the purpose are the species of sunfishes which we have used (probably other species of the same group are equally good), for, besides being just as resistant and as readily infected as the black bass, they are more easily kept and are less subject to disease in confinement. An adequate number of breeding ponds, in which sunfishes could be left to multiply naturally, would insure a large and constant supply of these fish for artificial infections.

THE BEST SEASONS FOR INFECTIONS.

It has already been stated that the duration of the parasitic period of the mussel is inversely proportional to the temperature of the water. This fact is obviously important for mussel culture, since the longer the fish have to be kept while carrying the glochidia the greater is the loss from disease and other causes. The loss not only involves the fish but the potential mussels which they are nourishing as well. It therefore becomes desirable to reduce, as far as possible, the length of time that the infected fish must be retained, and this we have seen depends upon the temperature. Late spring and summer, consequently, are the seasons when the maximum efficiency from artificial infections should be obtained, for in the warmer water at that time the duration of the parasitism will be at the minimum—about two weeks or even less. The glochidia of *Lampsilis* are available all through the spring and as late as July, while those of *Quadrula* can be obtained during the summer months, and most of the commercial species of mussels fall in these two genera. Of course infections can successfully be made in the fall and winter and the duration of the parasitism reduced by keeping the water artificially warmed, but the difficulty of maintaining the fish alive under these conditions is greatly increased.

THE MUSSEL SUPPLY.

By far the greater number of species of commercial value, as has already been stated, belong to the genera *Lampsilis* and *Quadrula*, and, as both of these genera are widely distributed, practically all of the mussel-bearing streams of the Mississippi Valley may be drawn upon for a supply of material for cultural purposes. We have found that living mussels may be shipped even long distances with little or no mortality, especially in cool weather, and it is therefore possible to obtain breeding material from places at quite a distance from the station where the infections are to be made, should the local supply be inadequate. We have had on several occasions large numbers of gravid mussels shipped from Terre Haute, Ind., to La Crosse, Wis., to Manchester, Iowa, and to Columbia, Mo., with scarcely the loss of an individual, and have successfully used the glochidia obtained from them in infecting thousands of fishes.

According to our experience mussels thrive very well in confinement, in small ponds and laboratory tanks, and that without any special attention to a food supply. We have for years been keeping both pond and river forms alive in the laboratory for months at a time in tanks containing a few inches of sand on the bottom and supplied by tap water. Under such conditions mussels have frequently been retained in the laboratory from the fall to the following summer. It should therefore be an easy matter to keep mussels for breeding purposes in ponds with natural bottoms in any quantity desired, and, if the ponds are fed with river water, a natural food supply should be present in abundance.

Since, as has been pointed out above, the species of *Quadrula*, *Unio*, and other summer breeders abort their embryos and glochidia with astonishing ease when disturbed, it will be necessary, when making infections with the glochidia of forms exhibiting this peculiarity, to collect the material at a time prior to the fertilization of the eggs and to allow them to enter upon the breeding season after being placed in the ponds of the station. We have had females of different species of *Quadrula* become gravid in the tanks of the laboratory after they had been held in confinement for weeks or even months, and therefore no difficulty should be encountered in obtaining a supply of glochidia from these forms under the conditions mentioned.

REARING AND DISTRIBUTING YOUNG MUSSELS.

After the fish have been infected, one of two things may be done in distributing the young mussels resulting therefrom: Either the fish, after having been retained in tanks or ponds until near the end of the parasitism, may be taken to the stream which is to be restocked and the clams allowed to drop off there, or the liberation may take place in ponds where the young mussels may be reared until they are of considerable size, say until they are a year old, and then distributed as desired. Both methods might be used successfully, but in the first case it is to be supposed that only a very small proportion of individuals thus liberated would succeed in reaching maturity, as they would be exposed to the same destructive agencies as are encountered under natural conditions. The difficulty and expense of transporting the infected fish, the mortality among the fish themselves resulting from shipment, and the subsequent loss of large numbers of the young mussels are considerations which lead one to regard this method as not an efficient one. It should be stated, however, that in using this method of distribution it would not be necessary to liberate the fish and thus lose them for subsequent infections, for they could be confined in wire-bottomed fish cars set out in the streams, and after the mussels had all fallen off and dropped through the bottoms of the cars the fish could be returned to the station. This would of course involve a very large amount of labor and much expense.

It would, therefore, seem to be a far more effective practice to retain the young clams in ponds with natural bottoms until they could with safety be liberated in the streams. After infection, in this event, the fish could be set free in these ponds at once, and allowed to remain there throughout the parasitism of the glochidia, at the close of which they could be seined out and made to do service again. Supplied with river water, the ponds should furnish an adequate amount of food for a practically normal rate of growth of the young mussels, which at the end of a year at latest should be of sufficient size to be placed in favorable localities in the rivers. When ready for distribution, the water in the ponds could be drawn off and the juvenile mussels raked carefully from the sand or mud. If properly packed, it should be possible to ship them in large numbers to considerable distances. It is only reasonable to suppose that a large proportion of the mussels thus reared would reach maturity after distribution, and it is certain that the number coming through would be far greater than would be the case if the first method should be pursued.

IX. CONCLUSION.

Of course, many practical details essential to success will have to be worked out before the artificial propagation of fresh-water mussels will have passed beyond the experimental stage, for the efficiency of the work from an economic point of view will doubtless depend upon the satisfactory solution of certain problems in technique, which, although secondary in character, are nevertheless a prerequisite of success.

However much is yet to be done—and it should be clear that the work is far from completion—the entire feasibility of artificial propagation has been demonstrated beyond the shadow of doubt. Besides filling in the gaps, some of them important ones, in the results already obtained, certain fundamental phases of the mussel investigations remain practically untouched. Chief among these is an exhaustive study of the physical conditions of the waters as affecting the growth of mussels: The relation between the mineral content of the water and shell formation; the relation between the character of the bottom, whether rocky, sandy, or muddy, to the habits of different species; and the relation between the rapidity of current to the life of the mussel and the kind of shell which it secretes. These and many other interesting problems of a similar nature await solution.

The immense mass of data that have been collected by the Bureau of Fisheries with respect to geographical distribution of species and their relative abundance throughout the Mississippi Valley has not been digested, yet the results which will be derived from a careful analysis of this information will have a fundamental economic bearing upon mussel culture. It is essential to know the centers and limits of distribution of at least the more valuable commercial species for the purpose of effectively conducting the operations in restocking streams and of avoiding useless labor in attempting to establish a species where the chances of its survival would be slight.

The whole problem of the food of mussels is as yet untouched. Not only are we ignorant of the specific food forms among the micro-organisms upon which mussels depend, but we do not know whether different species, or rather species living under different physical conditions and species possessing different habits, utilize different food forms. The possibility of artificially rearing cultures of the unicellular organisms used as food—when we know what these forms are—for enriching the water in which young mussels are retained before distribution should be determined, for it is undoubtedly true that results of the greatest practical importance and interest would be derived from such an investigation.

Very little is known at present respecting the enemies and diseases of fresh-water mussels, yet the importance of information of this nature can not be overestimated. Especially should we know the relative susceptibility of different species to parasitic diseases, and whether certain species are immune against the invasion of parasites which in the case of other forms constitute serious enemies.

A most fascinating and valuable field of investigation lies open in the study of the causes of pearl formations, for since these concretions are due, in part at least, to the presence of parasites, the possibility of producing them at will offers an interesting opportunity for experimental study.

The Unionidæ, in short, are a group of animals which, for the great variety of problems, both scientific and economic, presented in their unique life history, their structure, functions, and habits, their many interesting adaptations, and in their economic relations, is scarcely excelled by any other invertebrates except the insects. At present we may be said to possess only an introduction to a knowledge of the family, and the writers of this paper will feel amply repaid for their labor if they have succeeded in exposing some of the problems which here lie open for investigation and at the same time in laying the foundation for the artificial culture of fresh-water mussels.

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EXPLANATION OF PLATES.

[Drawings by G. T. Kline.]

PLATE VI.

FIG. 1. Gravid female of *Ptychobranchus phaseolus*. Actual length 96 mm.
FIG. 2. Gravid female of *Lampsilis subrostrata*. Actual length 50 mm.
FIG. 3. Gravid female of *Symphynota complanata*. Actual length 170 mm.

PLATE VII.

FIG. 4. Gravid female of *Dromus dromus*. Actual length 57 mm.
FIG. 5. Gravid female of *Quadrula ebena*. Actual length 98 mm.
FIG. 6. Gravid female of *Lampsilis recta*. Actual length 122 mm.
FIG. 7. Gravid female of *Obliquaria reflexa*. Actual length 55 mm.
FIG. 8. Gravid female of *Cyprogenia irrorata*. Actual length 38 mm.

PLATE VIII.

FIG. 9. Hooked glochidium of *Symphynota costata*, anterior end view. For measurements see text figure 1.

FIG. 10. Hooked glochidium, as above. Lateral view of living specimen.

FIG. 11. Axe-head glochidium of *Lampsilis (Proptera) alata*, anterior end view. For measurements see text figure 1.

FIG. 12. Axe-head glochidium, as above. Lateral view.

FIG. 13. Hookless glochidium of *Lampsilis subrostrata*, lateral view. For measurements see text figure 1.

FIG. 14. Hookless glochidium, as above. Posterior end view.

FIG. 15. Hookless glochidium, as above. Ventral view.

FIG. 16. Detail of a conglutinate of *Lampsilis ligamentina*. The glochidia, still inclosed in the membranes, are less crowded together than those of figure 17, and are embedded in a mucilaginous matrix.

FIG. 17. Detail of a conglutinate of *Obliquaria reflexa*, showing the membranes closely pressed and adhering together.

FIG. 18. Young mussels (*Lampsilis ligamentina*) one week after liberation from the fish, showing various positions assumed in crawling, the ciliation of the foot, and the new growth of shell.

PLATE IX.

FIG. 19. Fin of a carp about 3 inches long, 7 days after infection with glochidia of *Anodonta cataracta*, showing complete failure of the overgrowth of fin tissue in all places where the glochidia are greatly crowded. See explanation in the text, p. 159, of the conditions along the upper margin.

FIG. 20. Tip of an over-infected fin, as above, 12 hours after infection, showing no appreciable overgrowth because of the crowding. The shadows represent glochidia upon the under surface.

FIG. 21. Pectoral fin of a carp, as above, 3½ hours after infection; an optimum infection.

FIG. 22. Ventral half of caudal fin of a carp, as above, 24 hours after infection; an optimum infection.

FIG. 23. Tip of fin, as above, 32 days after infection. The shadows represent glochidia upon the under surface. The infection is less than the optimum. The glochidia were well overgrown and all alive when the fish was killed.

FIG. 24. Young *Symphynota costata*, attached by only a shred of tissue and about to drop from the fin after a parasitism of 74 days.

PLATE X.

FIG. 25. Fin, as above, 36 hours after infection with glochidia of *Anodonta cataracta*, showing complete overgrowth of all glochidia which have become properly attached.

FIG. 26. Glochidium of *A. cataracta* upon fin margin of carp, 3½ hours after infection. Proliferation of cyst just beginning.

FIG. 27. Glochidia, as above, upon fin margin of carp, showing different stages of cyst proliferation, even in neighboring glochidia.

FIG. 28. Glochidia, as above, 24 hours after infection.

FIG. 29. Hooked and hookless glochidia (*A. grandis* and *L. recta*) embedded and developing on a fin margin.

FIG. 30. Glochidia of *A. cataracta* upon fin of carp, 3 days after infection, showing the cyst completely formed.

FIG. 31. Glochidium of *A. cataracta* upon fin of carp, developing normally after a shift of 90 degrees from the position first taken.

FIG. 32. Two glochidia of *A. cataracta*, overgrown after 36 hours upon surface of a carp's fin.

FIG. 33. Glochidium of *A. cataracta* 35 days after infection. The metamorphosis is more advanced than in figure 30 and the rudiments of the foot and other organs have assumed greater size.

PLATE XI.

FIG. 34. Three gill filaments of the rock bass infected with glochidia of *Lampsilis ligamentina*. The metamorphosis of the glochidia has hardly begun, although they have been attached for 28 days.

FIG. 35, 36, 37, and 38. Stages in the formation of the cyst surrounding a hookless glochidium (*Lampsilis ligamentina*) upon a gill filament of the black bass. Taken at 15 minutes, 30 minutes, 1 hour, and 3 hours, respectively, after infection. The transverse lines on the filaments indicate the lamellæ.

FIG. 39. Anterior gill of a black bass infected with glochidia of *L. ligamentina*, showing distribution upon the gill as a whole and the appearance of the cysts.

FIG. 40. Gill of yellow perch, as above.

FIG. 41. Two conglutinates of *Lampsilis ligamentina* removed from the marsupium. One is shown from the flat surface, the other on edge. Actual length 17 mm.

FIG. 42. Three conglutinates of *Obliquaria reflexa* removed from the marsupium. Actual length 17 mm.

FIG. 43. Part of a gill of black bass infected with glochidia of *L. ligamentina*, showing the distribution and orientation of the glochidia in an infection above the optimum for this fish. Only the row of filaments toward the observer is shown.

PLATE XII.

FIG. 44. *Symphynota costata*, dissected from fin of carp 47 days after infection. The anterior end is to the left. Rudiments of foot, digestive tract, liver diverticula, and the first gill buds are recognizable; also the hooks and the degenerating adductor of the glochidium. Compare with figure 47. Actual size, 0.39 by 0.35 mm.

FIG. 45. *Strophitus edentulus*, from a living specimen which had completed its metamorphosis without parasitism and which was actively crawling about on the bottom. Seen from the ventral side. The anterior and posterior adductors are well developed and within the foot the pedal ganglia and lithocysts may be seen. Two gill buds are found on either side. Sections show that the internal organization is as far advanced as that of the young mussels shown in figures 47 and 48. ×106.

FIG. 46. A single cord discharged from the marsupium of *Strophitus edentulus*, showing glochidia extruded and others still within the cord. ×13.5.

FIG. 47. *Symphynota costata*, a young mussel which had been crawling upon the bottom for 6 days after a parasitism of 68 days. The very narrow margin of the adult shell has been drawn within the

valves. The glochidial shell and its hooks are still in evidence. In other respects the young mussel shows most of the features which are characteristic of the adult. The anterior end is to the right. Anterior and posterior abductors, anterior and posterior retractors, digestive tract divided into esophagus, intestine and stomach with its large diverticula, cerebral, pedal, and visceral ganglia, lithocysts, three gill buds, palp rudiments, the heart and pericardium will be recognized by their resemblance to the adult organs. Sections show the rudiments of the kidneys. From a stained and decalcified specimen. Actual size, 0.39 by 0.35 mm.

FIG. 48. *Lampsilis ligamentina*, a young mussel 1 week after the close of the parasitic period. The margin of the shell is extended well beyond the glochidial outline and shows the first lines of growth. More calcification has rendered the shell so opaque that the internal organs are no longer visible without decalcification. Stained specimens and sections show about the same degree of organization as in the *Symphynota* larva of figure 47. The foot with its cilia is shown extended and attached to the bottom preparatory to drawing the mussel forward. From a living specimen. Actual size, 23 by 20 mm.

PLATE XIII.

FIG. 49. *Alasmidonta truncata*. Horizontal section of a water tube of gravid marsupium, taken near ventral border of gill. The respiratory canals (r. c.) are small clefts, indistinctly shown under this magnification (cf. fig. 56); the marsupial space contains young embryos.

FIG. 50. *Quadrula ebena*. Horizontal section of two adjacent water tubes (w. t.) of gravid marsupium containing young embryos.

FIG. 51. *Anodonta cataracta*. Horizontal section of a water tube of gravid marsupium, showing respiratory canals (r. c.) and marsupial space (m. s); the latter contains young embryos.

FIG. 52 *Symphynota complanata*. Horizontal section of a water tube of gravid marsupium, showing respiratory canals and marsupial space; the latter contains glochidia. Note the thin, stretched interlamellar junctions.

FIG. 53. *Lampsilis ligamentina*. Horizontal section of a water tube (w. t.) of gravid marsupium containing young embryos. Note the thin, stretched interlamellar junctions (i. j.).

FIGS. 54–55. Two stages showing process of implantation of a glochidium of *Unio complanatus* on a filament of a gill excised 2 hours after infection. Figure 54 is taken 3 hours after attachment, while 55 is the same glochidium drawn 2 hours later. The greater part of the cyst was formed while the gill was in a watch glass.

PLATE XIV.

FIG. 56. *Alasmidonta truncata*. Horizontal section through portion of lamella and water tube of gravid marsupium, showing respiratory canals (r. c.) near ventral border of gill; each canal is separated from the marsupial space by a septum (s). The interlocking cells, forming the suture in the septum, are clearly seen.

FIG. 57. *Anodonta cataracta*. Section similar to last, but taken before fusion of folds (s), which are seen not quite touching. The septum is formed by their fusion. Eggs contained in the marsupial space are in an early cleavage stage.

FIG. 58. *Anodonta cataracta*. Region marked X in last figure, highly magnified, showing glandular epithelium of respiratory canals (r. c.), adjacent blood sinus (b. s.), and histological structure of surrounding tissues. Note the muscle fibers.

PLATE XV.

FIGS. 59–61. Transverse sections of glochidia of *Symphynota complanata*, taken 15 minutes, 6 hours, and 24 hours, respectively, after attachment to edge of fish's fin, showing three stages in formation of cyst. In 59 proliferation of epidermis is just beginning; in 60 glochidium is about half embedded; while in 61 formation of cyst is completed. In 59, which is more highly magnified than the other two, and in 60 several mitoses are shown in region of proliferation. In 60 cellular detritus from enclosed edge of fin is being ingested by mantle cells of glochidium.

FIGS. 62-63. Transverse sections of glochidia of *Lampsilis ligamentina*, taken 30 minutes and 3 hours, respectively, after attachment to gill filament. In 62 the development of cyst has made considerable progress, while in 63 the cyst wall is practically completed. In 62 several mitotic figures are seen in the epidermis where multiplication of cells is taking place.

FIG. 64. Highly magnified section of a portion of the glandular epithelium of an interlamellar junction in the gravid marsupium of *Quadrula ebena*, showing the large mucus cells and the nuclei of several leucocytes (l) with which the epithelium has become infiltrated.

PLATE XVI.

FIG. 65. Station of the Bureau of Fisheries at North La Crosse, Wis., and steamer *Curlew*, used in mussel investigations during summer of 1908.

FIG. 66. Interior of station at North La Crosse, equipped as a laboratory.

FIG. 67. Seining young black bass near La Crosse in a "lake" which had been filled by the overflow of the Mississippi River during the early summer. The fish thus obtained were artificially infected with glochidia.

PLATE XVII.

FIG. 68. Dredging for young mussels in a slough near La Crosse.

FIG. 69. The clamming outfit used in the mussel work on the Upper Mississippi River. The two "crow-foot" dredges, with the mussels still clinging to the hooks just after a haul, are seen resting on the stanchions.

FIG. 70. An old mussel bed near Muscatine, Iowa, buried under a foot or more of sand and mud but exposed in cross section by a gully washed out by rains. The mussels are seen *in situ* embedded in the wall of the gully.

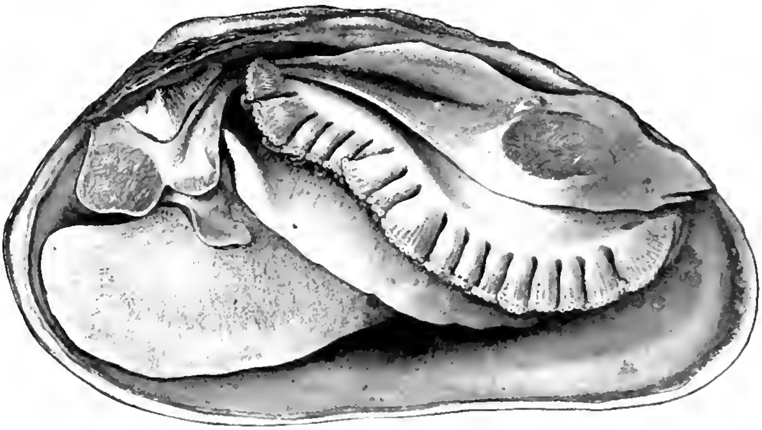


Fig. 1.

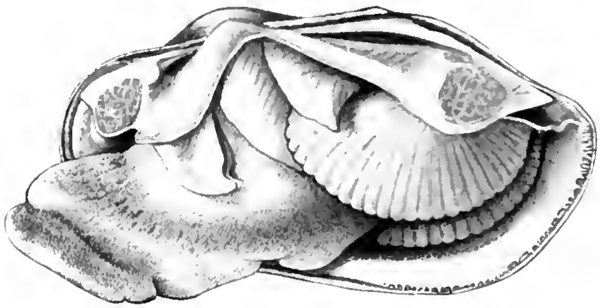


Fig. 2.

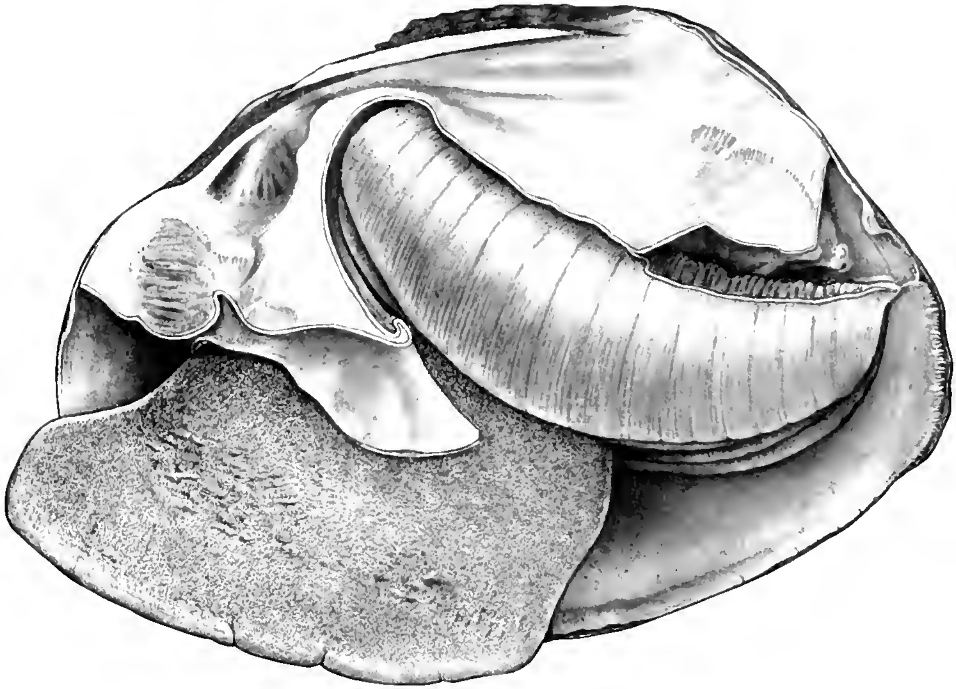


Fig. 3.

FIG. 4.

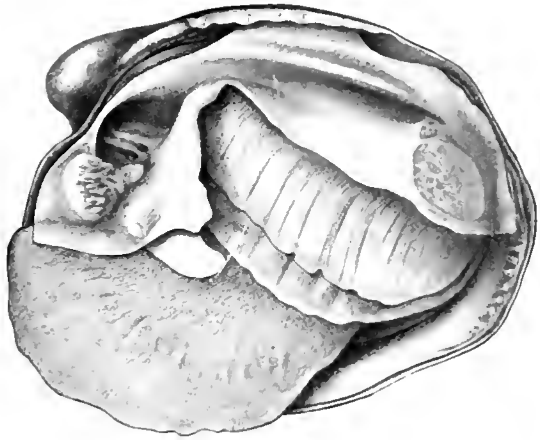


FIG. 5.

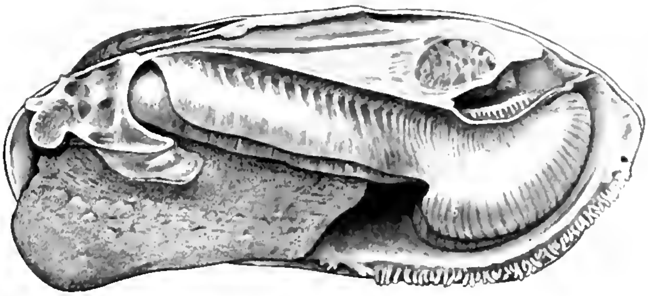


FIG. 6.

FIG. 7.

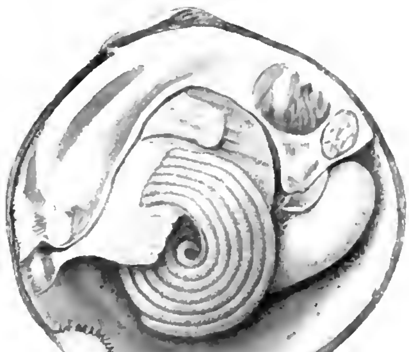


FIG. 8.

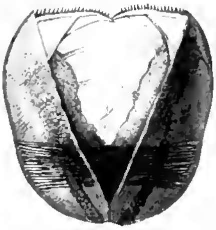


Fig. 9.

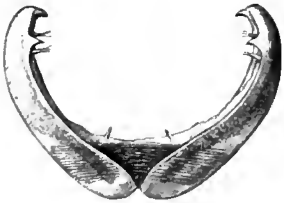


Fig. 11.

Fig. 13.

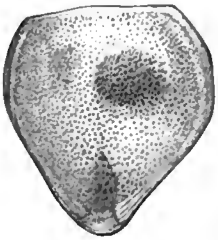


Fig. 10.

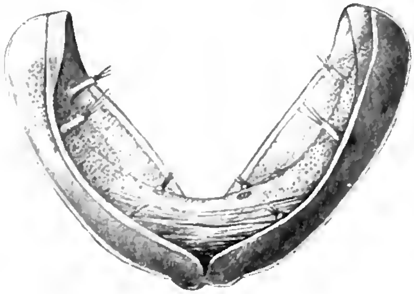


Fig. 14.

Fig. 12.

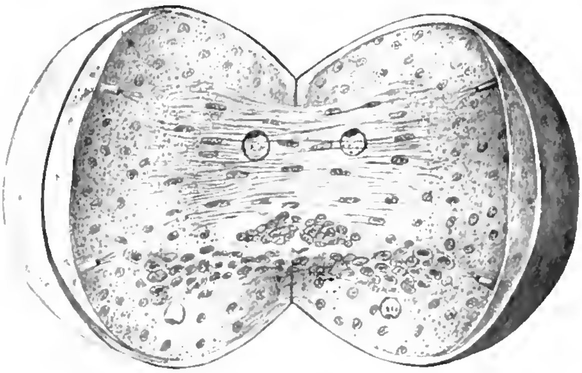
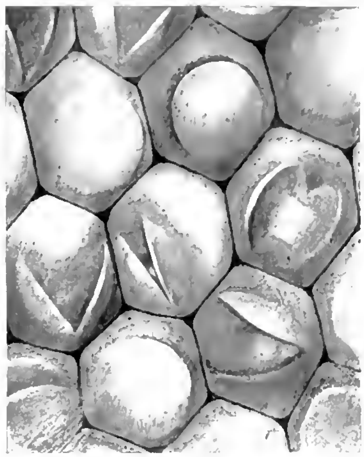


Fig. 15.

Fig. 16.

Fig. 18.



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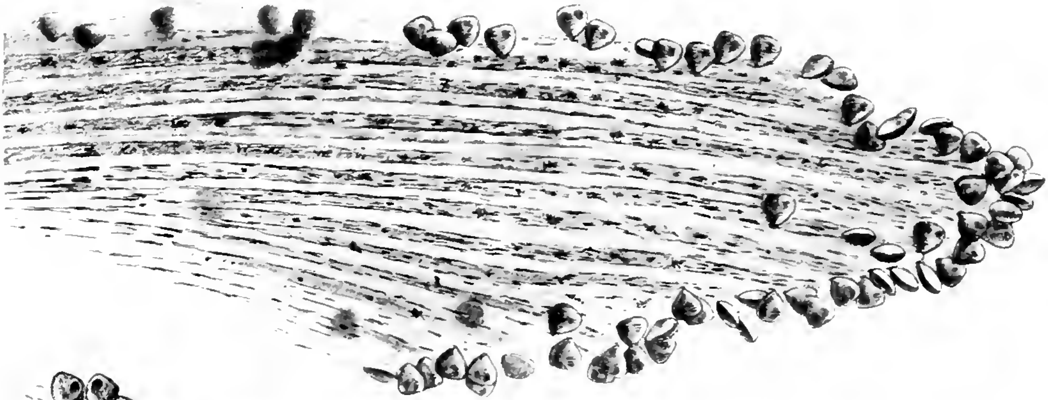

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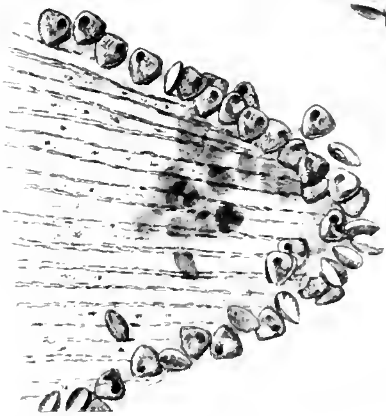

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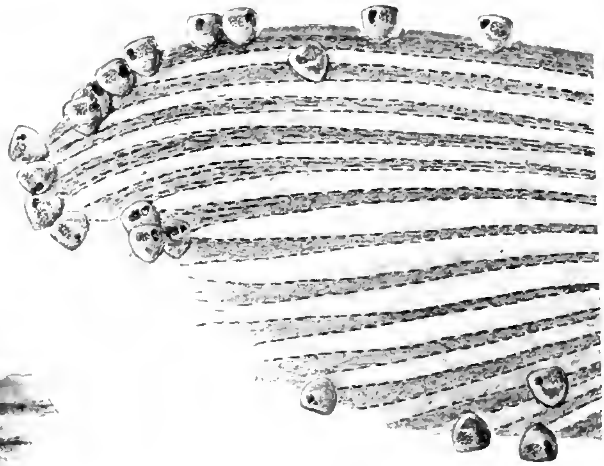


FIG. 21

FIG. 23.

FIG. 24.

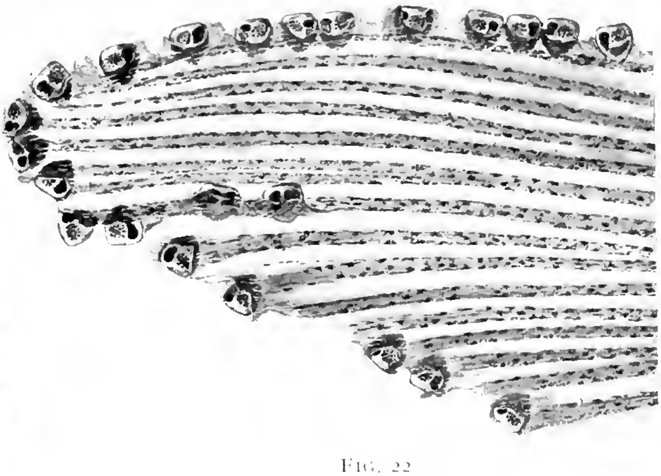
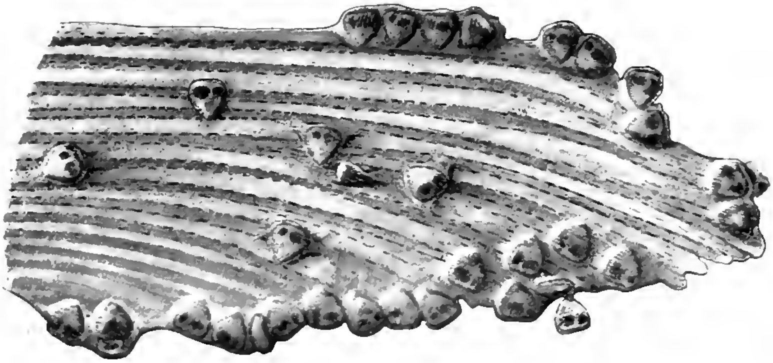


FIG. 22



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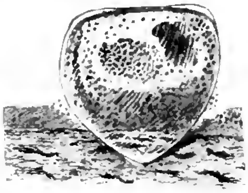

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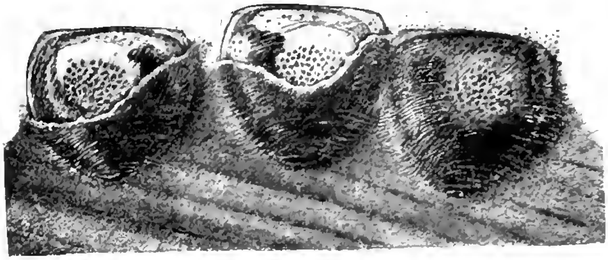

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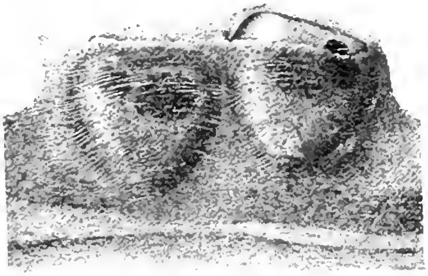

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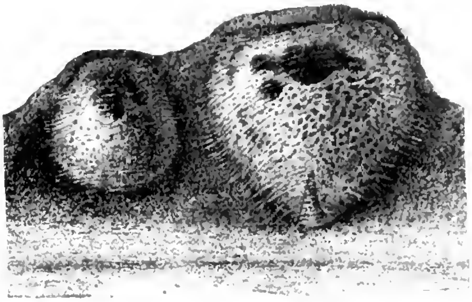

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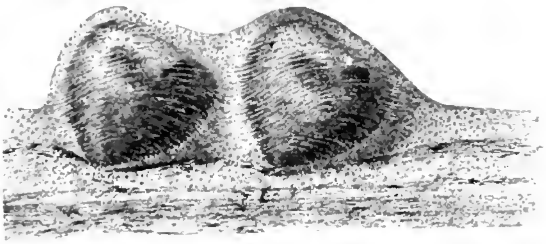

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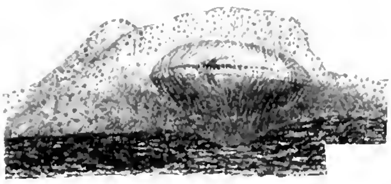

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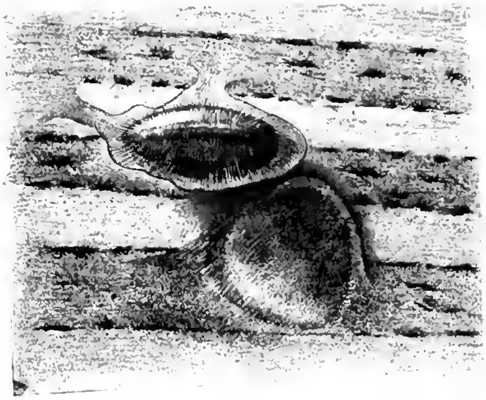

Fig. 32.

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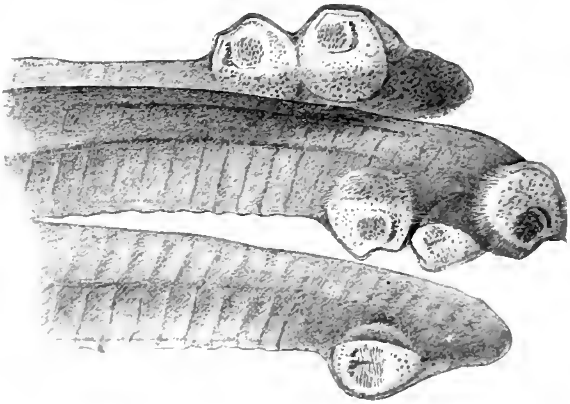
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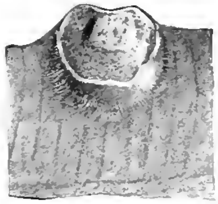
FIG. 35.


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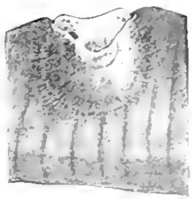
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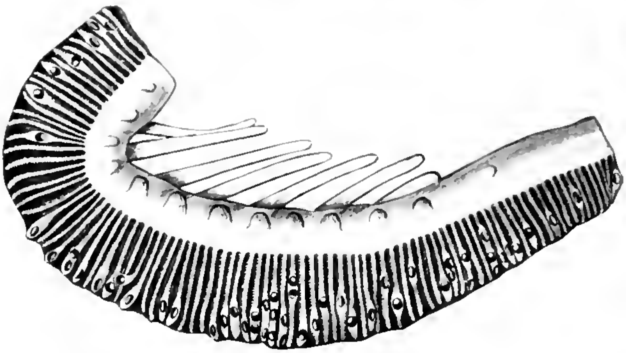
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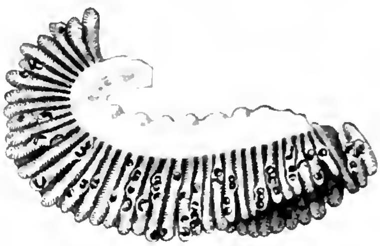
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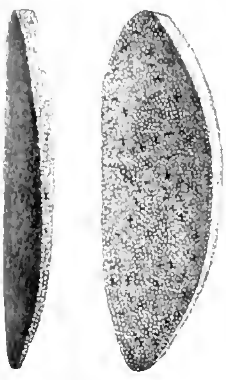
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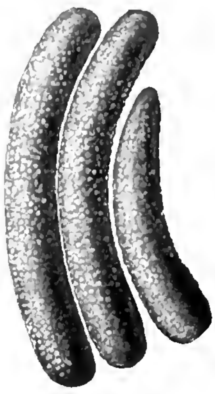
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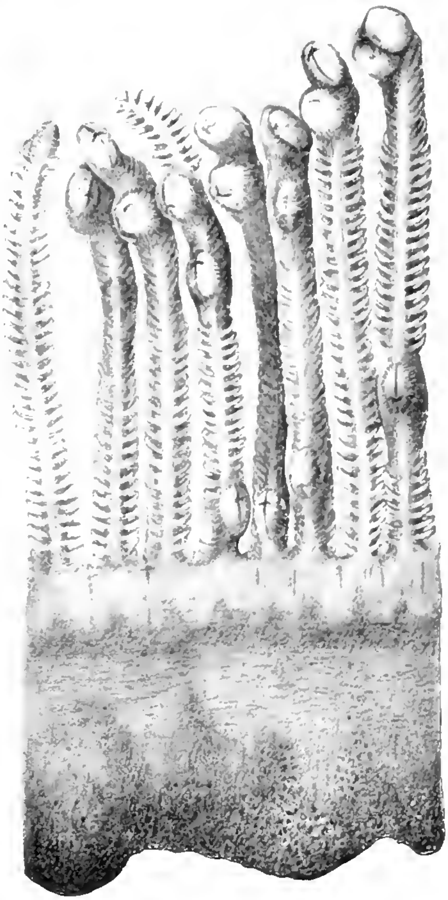
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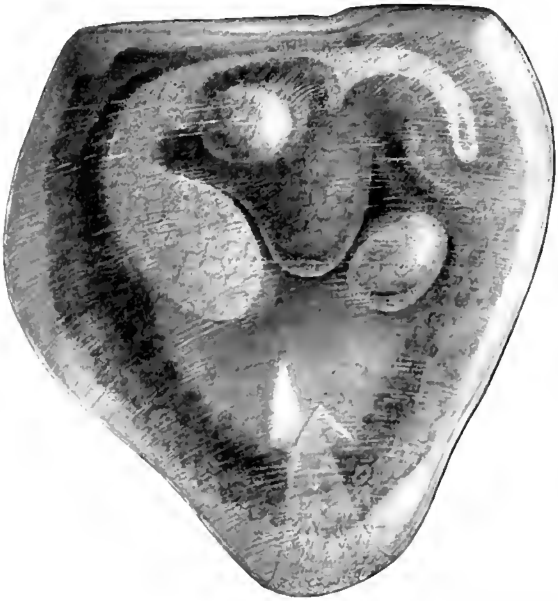

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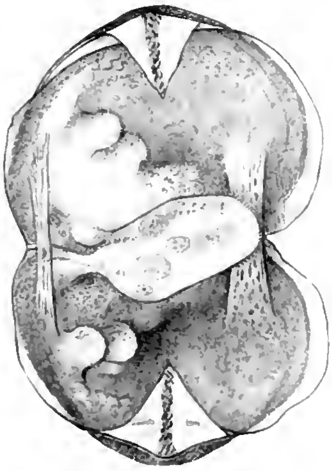

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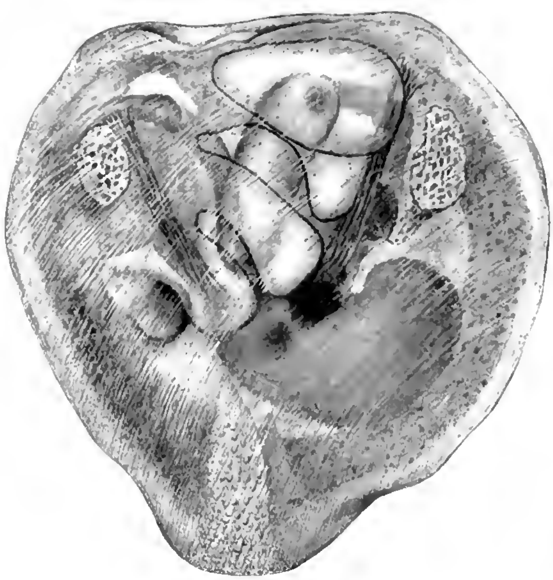

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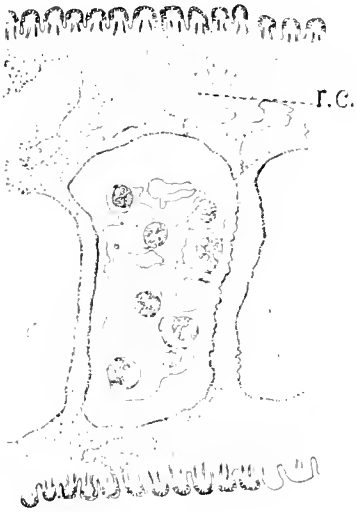

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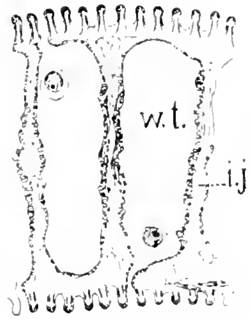

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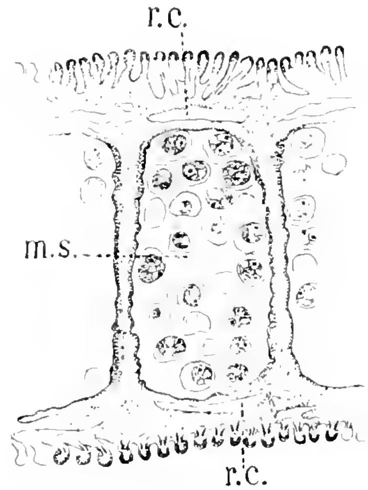

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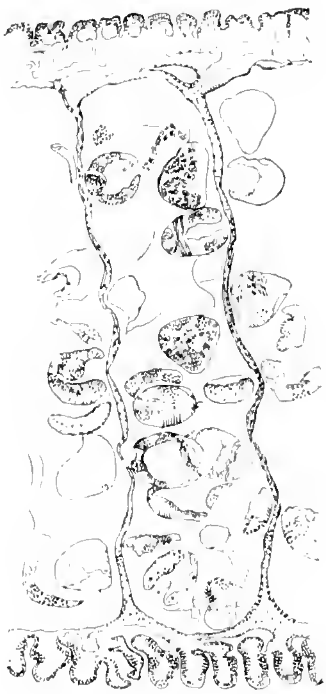

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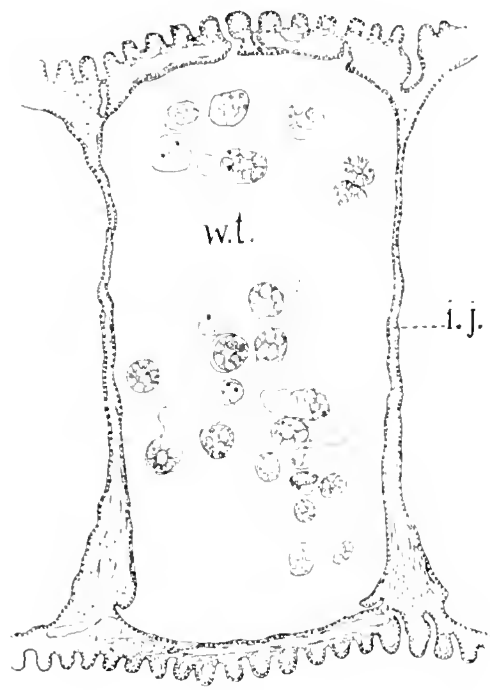
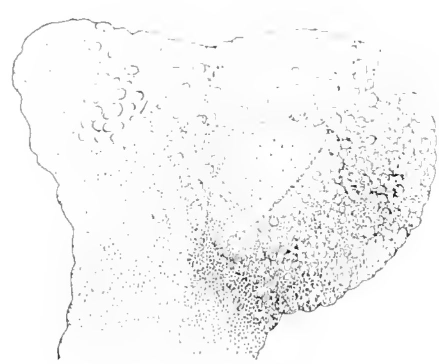


FIG. 53.

FIG. 54.



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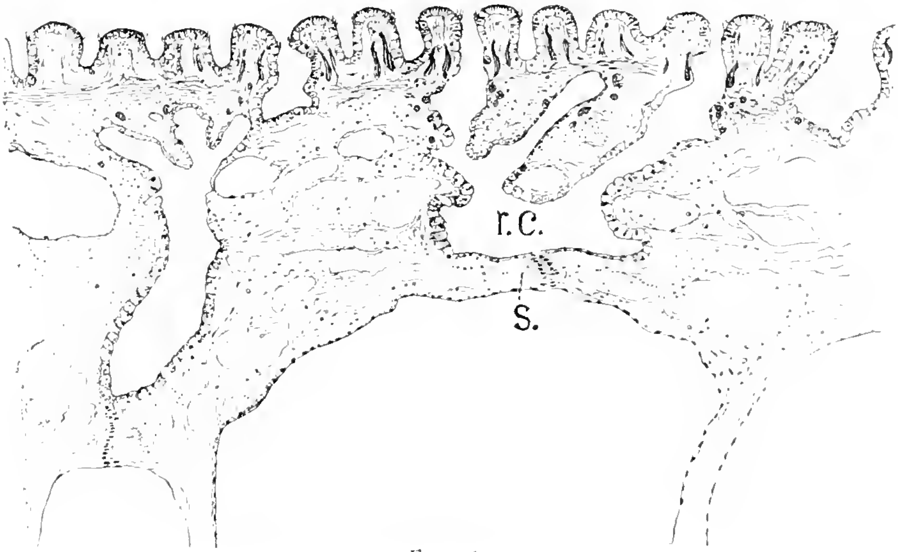
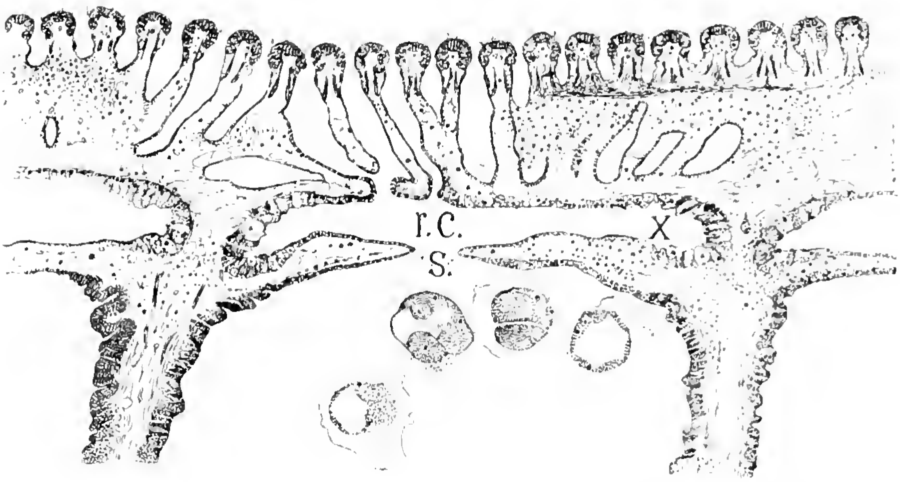


FIG. 56.



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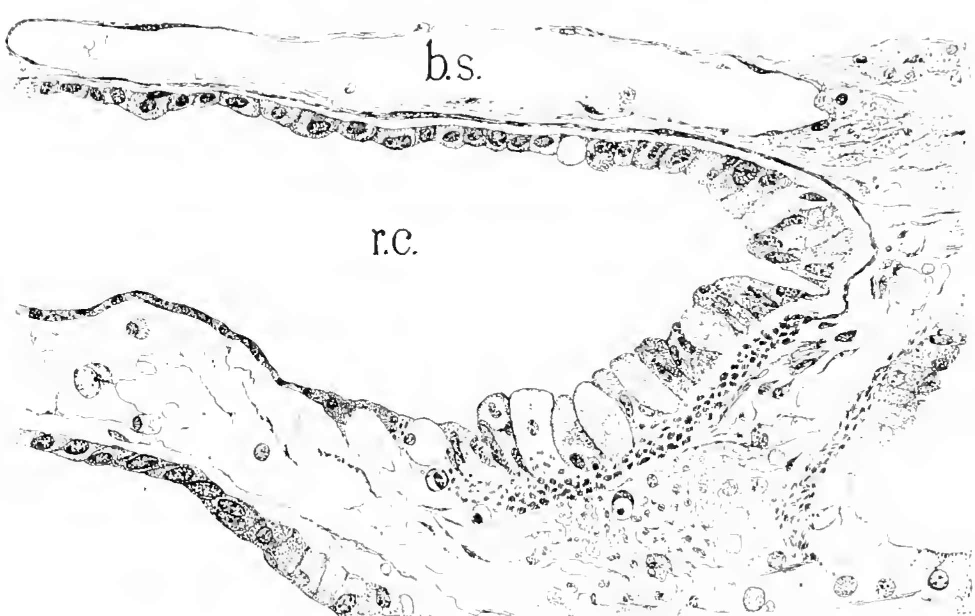


FIG. 58.

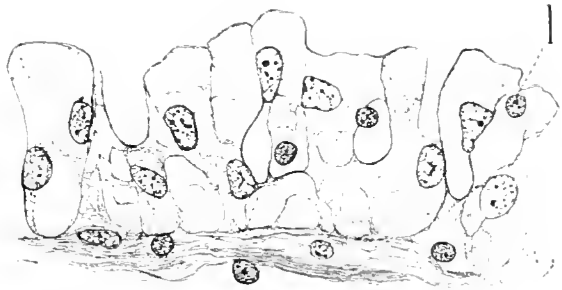
FIG. 59.

FIG. 60.

FIG. 61.

FIG. 62.

FIG. 63.



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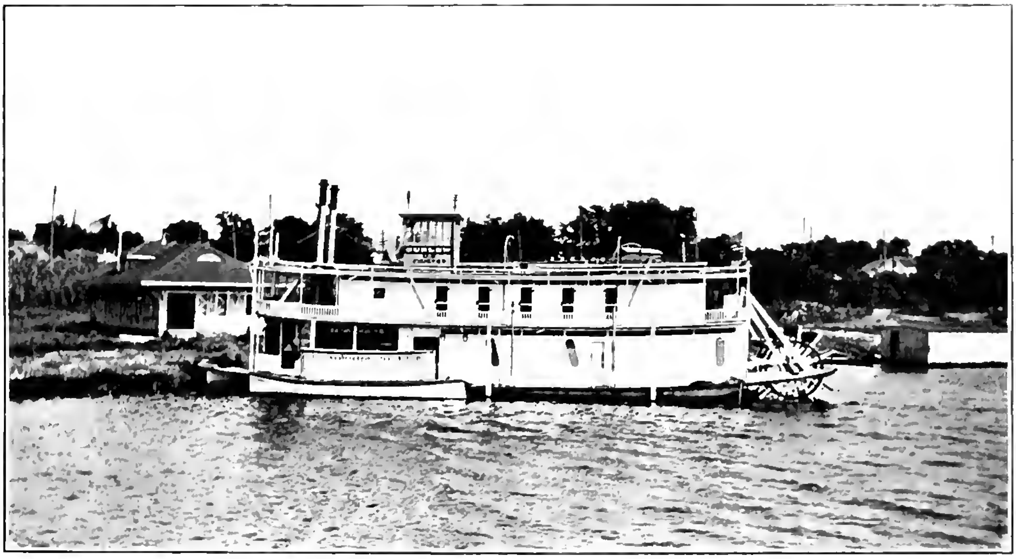

Fig. 65.

Fig. 66.

Fig. 67.

Fig. 68.

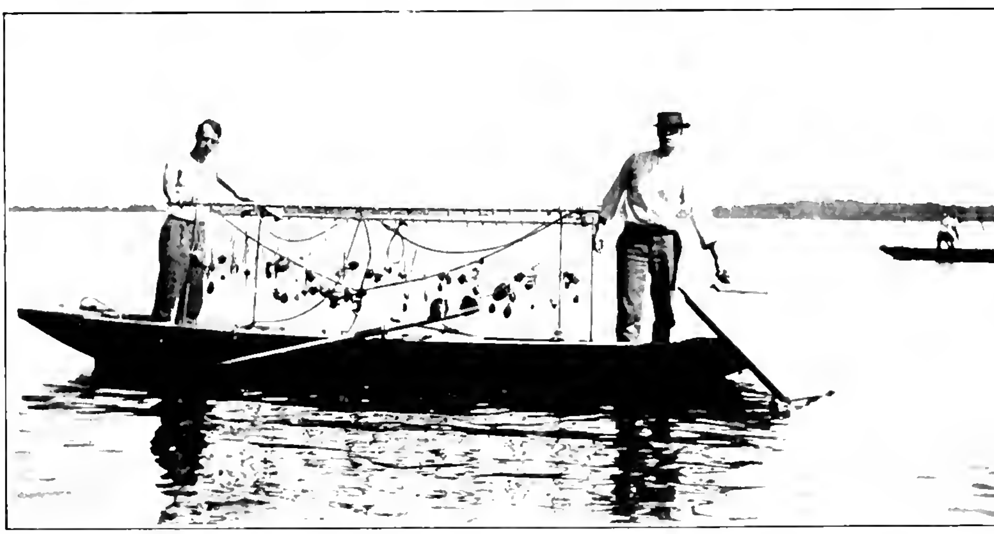

Fig. 69.

Fig. 70.

THE BRYOZOA OF THE WOODS HOLE REGION

By Raymond C. Osburn, Ph. D.,
Assistant Professor of Zoology, Columbia University,
Assistant Director, New York Aquarium.

THE BRYOZOA OF THE WOODS HOLE REGION.

By RAYMOND C. OSBURN, Ph. D.,
Assistant Professor of Zoology, Columbia University,
Assistant Director, New York Aquarium.

INTRODUCTION.

The report on the Bryozoa (=Polyzoa) of the Woods Hole region, presented in the following pages, has grown out of the work of the survey of this region, which has been conducted by the United States Bureau of Fisheries during the years 1903 to 1909.[a] During the progress of this survey so much bryozoan material was obtained that it has seemed advisable to prepare a special paper dealing with this group. As the Bryozoa of our coast have never received the careful study given to most of the other marine animals, the desirability of making such a study, if even for a limited region, is evident.

The first mention of any American Bryozoa is found in the "Fauna Groenlandica" of Fabricius (1780). D'Orbigny (1839) described and listed certain southern species in his "Voyage dans l'Amerique méridionale." On the northern coast of New England and Canada much more attention has been given this group than elsewhere in America. Here Stimpson made the first attempt since the time of Fabricius, and in his list of the invertebrata of Grand Manan in the Bay of Fundy (1853) he recorded 16 species. Eleven of these he described as new, but subsequent studies have reduced all but four to the synonymy. Dawson's and Packard's papers soon followed, dealing, respectively, with the invertebrate faunas of the Gulf of St. Lawrence and the Labrador coast. A majority of Verrill's papers which make mention of Bryozoa deal with the occurrence of the species north of Cape Cod. Various papers by Hincks treat of the St. Lawrence species, and in 1901 Whiteaves prepared a complete list of those known from eastern Canada.

South of the New England region the Bryozoa have received but scant attention. With the exception of Smitt's excellent treatise on the "Floridan Bryozoa," and a brief preliminary account of the species in the vicinity of the Carnegie Laboratory for Marine

[a] The general report of this survey, prepared by Dr. F. B. Sumner, Dr Leon J. Cole, and the present writer, in zoology, and by Dr. Bradley M. Davis, in botany, has been completed and is in course of publication by the Bureau of Fisheries.

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Biology at the Tortugas, Fla., by the present writer (1908), only a few scattering species have received mention, and that incidental. The species of the West Indies have been entirely neglected, but Verrill has recorded a few from the Bermudas.

While the Canadian Bryozoa have been fairly well studied through the efforts of Stimpson, Dawson, Packard, Hincks, Whiteaves, and others, and Smitt's monograph deals with the species of the deeper waters of the Floridan region, the extensive tract from New England to Florida has remained entirely untouched, and the New England region has been treated very inadequately.

A number of short papers and references to New England Bryozoa are found in the literature of the subject, but in nearly all cases these are buried in reports dealing with other groups, and hence are not readily accessible and are easily overlooked. The first of these to appear, and the first to be published in America as well, was a short list by Desor (1848) of species observed by him in the region of Nantucket. This paper is chiefly interesting because it contains the original descriptions of two of our most characteristic species, *Bugula turrita* and *Membranipora tenuis*. In 1853 Leidy listed the marine animals known to him from Rhode Island and New Jersey and mentioned a few Bryozoa. Verrill and Smith's "Report upon the invertebrate fauna of Vineyard Sound and vicinity" in 1884 contains a much larger number, about 32 species. Subsequently Verrill has made incidental mention of a few other species of this region, bringing the total number of Bryozoa recorded from southern New England up to about 40. Since 1879, however, the group has remained untouched in this region except for Nickerson's papers on *Loxosoma davenporti*, and the morphological papers of Davenport and Dublin.

In the present intensive study of a very limited region there has appeared a much larger series of forms than the earlier papers would lead one to expect. The list of species previously known has been more than doubled during our dredging work, and 81 species, besides a number of varieties that have been classed as species at some time in the past, are now known to be represented in our fauna. The great majority of our species are widely distributed over the North Atlantic and elsewhere as well. Only a small number (5) are here described as new. In addition to these there are about seven others which are known to occur only within this intermediate region between Florida and Canada. These 12 species are:

Loxosoma davenporti Nickerson.
Loxosoma minuta, new species.
Bugula turrita (Desor).
Bugula cucullifera, new name (B. cucullata Verrill non Busk).
Membranipora tenuis Desor.
Cellepora americana, new species.
Lepralia americana Verrill.
Lepralia serrata, new species.
Alcyonidium verrilli, new name (A. ramosum Verrill non Lamouroux).
Amathia dichotoma (Verrill).
Hippuraria armata (Verrill).
Hippuraria elongata, new species.

Of characteristic southern species we have almost no representatives. *Barentsia discreta*, which ranges along our coast to the southward and is known from the South Atlantic, is perhaps one. *Anguinella palmata* finds its northern limit for American waters in Buzzards Bay, probably, as it is rare and of small size, while farther south it grows abundantly. Perhaps *Hippuraria elongata* should be added to the list, as it is comparatively scarce at Woods Hole and very common at Beaufort, N. C. It seems probable that others among those now known only from local waters will be found in the future to be more widely distributed.

Our Bryozoa fauna is thus seen to be typically a northern one, since fully one-half of the species are characteristically northern or even arctic in their range. In addition to this about another fourth of the number have such a wide distribution that we may call them cosmopolitan, since they occur in one or more of the great oceans besides the North Atlantic.

The region embraced in the survey above mentioned includes Vineyard Sound between a line drawn from East Chop to Falmouth Heights and one from Gay Head to Sow-and-Pigs Reef, and Buzzards Bay above a line drawn from Sow-and-Pigs Reef to the Hen-and-Chickens Lightship. This region has been thoroughly and systematically dredged during the summers of 1903 to 1909, inclusive, by the United States Bureau of Fisheries vessels Fish Hawk and Phalarope. In all, 458 dredging stations were established, and many of these have been repeatedly redredged. Within this same region shore collections have been made at various points, and the piles of docks in the various harbors have been repeatedly scraped for material. For the purpose of comparison, collections have been made at certain other points within easy reach but situated outside of the region above described. These points are as follows: Crab Ledge, a few miles east of Chatham, on Cape Cod; Great Round Shoal fishing ground, east of Great Point, Nantucket; Nantucket Harbor; and Muskeget Channel. Besides these collections I have been able to examine some material taken by Mr. Vinal Edwards off Sankaty Head, Nantucket, and some collected by the United States Fish Commission 35 years ago on the Nantucket Shoals.

Throughout this whole region the water is comparatively shallow, in no place reaching a depth greater than 25 fathoms, while over the greater part of the area the depth ranges rather uniformly between 6 and 15 fathoms. As might be expected from this, the species which are characteristic of deeper waters are lacking from our fauna. A considerable portion of the bottom of Vineyard Sound is a tide-swept desert of shifting sand, unfavorable for the growth of Bryozoa, but where rock ledges appear, and especially near the shores in the zones of red and brown algæ, they are abundant. The bottom of Buzzards Bay is largely mud covered, the ebb and flow of the tide not producing sufficient current to carry away the silt deposited by the streams which empty into the bay. Naturally such a bottom is unfavorable to the growth of encrusting or sessile animals, and the Bryozoa over a large part of the bay are poorly represented. The piles in the harbors afford usually the best collecting grounds.

Crab Ledge differs noticeably from the Sound and Bay. The depth is in general a little greater (14 to 20 fathoms), but this is not sufficient to have any particular value. The temperature in midsummer is noticeably colder. Records taken on the same day (Aug. 12, 1909) by Dr. Cole and myself showed a mean bottom temperature of 47.2° F. at 17½ fathoms on Crab Ledge, and 69.5° F. at 12 fathoms off West Chop, in the eastern end of Vineyard Sound. The much lower temperature of Crab Ledge, Great Round Shoal, and Nantucket Shoals, due no doubt to their proximity to the deeper water of the open ocean, permits a considerable number of northern species to live on these shoals which are not represented in Vineyard Sound and Buzzards Bay. Crab Ledge in particular is of interest in yielding a number of species supposed to be limited in their distribution to northern waters and which have not hitherto been reported south of Canada.

In comparing the distribution of species in the following pages I have made use of the term "inner waters" to distinguish Buzzards Bay and Vineyard Sound from the other stations which I have designated collectively as the "outer waters."

In the outer waters there are found about 28 species not represented in the inner waters. These are:

Crisia cribraria.
Stomatopora diastoporoides.
Tubulipora flabellaris.
Tubulipora atlantica.
Gemellaria loricata.
Scruparia clavata.
Caberea ellisii.
Menipea ternata.
Cellularia peachii.
Bugula murrayana.
Bugula cucullifera (B. cucullata Verrill non Busk).
Membranipora arctica.
Membranipora cymbæformis.
Membranipora unicornis.
Cribrilina annulata.
Porina tubulosa.
Schizoporella sinuosa.
Schizoporella auriculata.
Cellepora canaliculata.
Mucronella ventricosa.
Rhamphostomella costata.
Porella acutirostris.
Porella proboscidea.
Porella concinna.
Smittia porifera.
Alcyonidium parasiticum.

In the inner waters there are about 12 species not represented in the outer waters, viz:

Loxosoma davenporti.
Loxosoma minuta.
Barentsia discreta.
Bugula flabellata.
Membranipora lacroixii.
Lepralia pallasiana.
Flustrella hispida.
Alcyonidium verrilli (A. ramosum Verrill non Lamouroux).
Amathia dichotoma.
Anguinella palmata.
Hippuraria armata.
Hippuraria elongata.

This leaves more than one-half of the number of species common to both the inner and outer waters.

Comparatively few of our species show a preference for any special habitat. *Loxosoma davenporti* lives as a commensal in worm tubes, and *L. minuta* in the same way on *Phascolcon strombi* living in dead gastropod shells. *Hippuraria elongata* is also a commensal living in the branchial chambers of the blue and spider crabs and on the carapace of *Pinnixia* living in the tubes of *Chætopterus pergamentaceus*. The last condition offers a case of double symbiosis. *Flustrella hispida* occurs only in shallow water along shore where it encrusts *Fucus*, etc. *Membranipora tehuelcha* occurs only on the gulfweed (*Sargassum bacciferum*) drifted into our region from the Gulf Stream.

The majority of our species are rather small, yet some of the erect chilostomes form bushy colonies several inches in height. Conspicuous among these are *Bugula turrita* and *Gemellaria loricata*. The semi-erect *Porella proboscidea* grows on the stems of *Boltenia* and Sertularidæ to a length of several inches and rises frill-like to a height of at least ¾ inch. A number of the encrusting species may cover an area of several square inches. One of the most massive of these is *Schizoporella unicornis*. I have one specimen, from the piles of the United States Fisheries dock at Woods Hole, which measures 11 by 5 inches in extent and is over ½ inch in thickness. *Smittia trispinosa* var. *nitida* also forms nodules, sometimes as large as one's fist, encrusting shells or pebbles. Such a crust consists of many layers of zooecia, the ones underneath being but the dead skeletons of former generations. Of the ctenostomes, *Alcyonidium verrilli* is the only one in our region to attain a considerable size. The largest I have seen were about 6 inches high, the fleshy fronds making a good-sized mass.

While the Bryozoa yield no useful products and thus have no direct value in commerce, they play a part, like most other small marine animals, in furnishing food for fishes. I have seen large nodules of *Schizoporella* and *Smittia* taken from the stomachs of sharks, while among our edible fishes the examination of such species as the "cunner" (*Tautogolabrus adspersus*) and "blackfish" (*Tautoga onitis*) indicates that the various Bryozoa often form no inconsiderable part of the diet.

The list submitted in the following pages is probably fairly complete for the region, though no doubt other species will be added from time to time by close collecting and especially in unusual habitats. Many species are so minute that it is difficult not to overlook them. As previously stated, our list contains 81 species besides several varieties which often appear as species in other lists. Whiteaves list for eastern Canada contains 115 species (46 of these occur also at Woods Hole); the Plymouth, England, list contains 103 species, while Herdman lists 136 in the Irish Sea. It must be remembered, however, that all these regions are not only considerably larger in extent than ours, but that the depth has a greater range. On the other hand, Levinsen's list in the "Zoologica Danica" includes only 68 species for all Denmark, and Graeffe's list for Triest but 56. By comparing these lists and taking into consideration the uniform conditions of depth, temperature, and salinity in our region it will be seen that our Bryozoa fauna is a fairly representative one.

In the classification which I have adopted our 81 species are included in 36 genera, and these in 20 families. The Endoprocta are represented by 5 species included in 2 families and 3 genera. The Ectoprocta are well represented in the 3 suborders of the order Gymnolæmata as follows: Cyclostomata, 8 species belonging to 4 genera and 3 families; Chilostomata, 55 species in 21 genera and 10 families; Ctenostomata, 13 species in 8 genera and 5 families.

To bring together in convenient form the widely scattered descriptions of our Bryozoa I have given under each species a rather full diagnosis of the species as it exists in our region. In making out such descriptions I have often drawn largely from the original published sources, where these were satisfactory, and I have amplified or abbreviated or otherwise modified these as the conditions required. In the case of *Vesicularia familiaris* listed by Verrill, but which I have not seen, I have been compelled to copy from other sources without making a comparison.

For the convenience of the student I have also included keys of families, genera, and species. Because of the brevity of such diagnosis the keys must necessarily be more or less unsatisfactory and must be constantly checked up by a perusal of the descriptions and reference to the figures. It must be borne in mind that the form of the colony is generally of little use in determining the species, owing to the great amount of variation in this respect. It must also be noted that a great deal of variation is exhibited in the amount and form of the calcification of the individual zooecia, especially among the encrusting chilostomes, and the same is true of the form and occurrence of avicularia, spines, and other secondary structures. In the soft-bodied endoprocts and ctenostomes the form of the body depends largely on the amount of contraction. I can testify, after a number of years work, that the group is by no means an easy one for the beginner, and I know of no other in which the student is more likely to be misled by superficial resemblances.

Many of our Bryozoa have never been adequately figured, some not at all. Those which occur also in Europe have been illustrated, but, aside from Hincks' "British Marine Polyzoa," now long out of print, the figures are badly scattered and often are not easily accessible to the general student. To cover this deficiency and to bring together the illustrations of our species, I have figured anew all the forms dealt with in the following list. With the exception of six species all the figures are drawn from local specimens, and at least have the merit of representing the forms as they occur in this region. Nearly all the figures have been drawn by myself, but figures 15, 30, 30a, and 39 are the work of my wife. I must make special acknowledgment for the work of Mr. Howard J. Shannon, who has so faithfully portrayed *Tubulipora atlantica*, *T. flabellaris*, and *T. liliacea*. These figures were drawn under my direction, so I can vouch for their accuracy of detail, but their artistic merit is due entirely to Mr. Shannon's skill and patience.

For the systematic study of the group Hincks' "British Polyzoa" still remains the standard work for North Atlantic species, and is indispensable to the special student. It covers slightly more than half of the species of our region. Hincks' three papers on the "Polyzoa of the St. Lawrence" and Smitt's "Floridan Bryozoa" will also be found most useful in comparison for Atlantic species, and Dr. Alice Robertson's valuable papers (Proceedings California Academy of Science) for Pacific coast species. In the appended bibliography all papers have been listed which contain either the original descriptions or a reference to the occurrence of our species on the Atlantic coast.

The literature on the general structure of the Bryozoa is fortunately more accessible than that dealing with the systematics of the group. Reference may be made to the article by Harmer in the Cambridge Natural History, or for more extended study, to Calvet's "Bryozoaires Ectoproctes marins."

It is scarcely necessary to mention the fact that such changes have been made in the classification and nomenclature of the Bryozoa since the appearance of the earlier papers that many of the species recorded therein are quite unrecognizable except to the special student familiar with the synonymy. I have tried to give a complete synonymy in each case of all the references to the species in American waters. It might also be taken for granted that many errors in identification would be found to occur in these papers. Our knowledge of the Bryozoa is at present none too well organized, but 40 or 50 years ago it was in an extremely chaotic state. For this reason it is not possible to make absolutely certain of the synonymy in all cases, but by obtaining material from the original localities some doubtful cases have been decided with a fair degree of certainty. Prof. Verrill has aided me very materially in this matter by kindly permitting me to examine his collection of mounted slides of specimens determined by himself and by Packard, Stimpson, and Dawson. The Canadian Geological Survey, through the kindness of Mr. Lawrence M. Lambe, has lent me much identified Canadian material for comparison. Dr. S. F. Harmer and Dr. O. Nordgaard have supplied me with many European species. As a result, in the case of nearly all species which occur in other waters, I have been able to make direct comparisons with material from the regions where the species are already well known.

Class BRYOZOA Ehrenberg (POLYZOA, J. V. Thompson).

Minute animals forming colonies (with rare exceptions), asexual reproduction by budding developed to a high degree. A retractile crown, the lophophore, which bears ciliated tentacles, a U-shaped alimentary canal, a simple nerve ganglion; coelom present, but vascular system wanting.

Subclass ENTOPROCTA—Anal opening situated within the lophophore; coelom greatly reduced; tentacles rolled inward in contraction.

Subclass ECTOPROCTA—Anal opening situated outside the lophophore; coelom well developed; the whole lophophore withdrawn in contraction.

SUBCLASS ENTOPROCTA NITSCHE, 1869.

This group of Bryozoa, although widely distributed in all seas, contains but few species. One genus, *Urnatella* Leidy, is known from fresh water. The genera, which are few, are included in the following order:

Order PEDICELLINEÆ Hincks, 1880.

KEY TO FAMILIES.

1. Not colonial, not stolonate; buds separating from parent on reaching maturity, individuals attached by a slightly enlarged base or foot; the lophophore obliquely situated . . . . Loxosomidæ.
2. Buds arising from a creeping stolon and remaining attached to form colonies; lophophore placed transversely . . . . Pedicellinidæ.

Family LOXOSOMIDÆ Hincks, 1880.

Individuals solitary. A contractile peduncle supports the body, from which it is not distinctly marked off. Buds originating on the side of the body, separating from the body on reaching maturity, and securing attachment by means of a pedal gland. The manner of budding and the oblique position of the lophophore indicate this as the most primitive family of Bryozoa.

Genus LOXOSOMA Keferstein, 1863.

KEY TO SPECIES.

Lophophore with 18 to 30 tentacles, pedal expansion small, length about 2 mm . . . . *davenporti*.
Lophophore with about 8 tentacles, foot broad, length less than ½ mm . . . . *minuta*.

Loxosoma davenporti Nickerson. [Pl. XVIII, fig. 1.]

Nickerson 1898, p. 220; 1899, p. 368; 1901, p. 351–380.

Entire animal about 2 millimeters long, somewhat vase-shaped. Pedicel cylindrical, about as long as the remainder of the body, into which it merges gradually. Nickerson describes the foot as being destitute of a lateral expansion and foot gland, but in specimens in my possession there is a small glandular expansion. Lophophore with 18 to 30 tentacles, the body somewhat narrowed just below the lophophore. One or more (usually a pair) of flask-shaped glandular organs attached to the ventral side of the body near the lower end of the stomach.

Found in worm tubes at Cotuit Harbor (Nickerson).

Loxosoma minuta, new species. [Pl. XVIII, fig. 2, 2a.]

Verrill 1879c, p. 31 (*Loxosoma* on *Phascolosoma*).

Body rather regularly oval, about one and one-half times as long as wide, often somewhat cordate below where it joins the stalk. Tentacles apparently stout and about eight in number, but as only contracted specimens have been studied the details of the lophophore can not be stated definitely. The stalk is one-half to two-thirds as long as the body, transversely wrinkled in the contracted state, the upper end but little expanded below the calyx, the lower end spreading out into an evenly rounded foot which is nearly or quite twice the diameter of the stalk. Buds have not been observed. A very small species, averaging not more than a third of a millimeter, while the largest specimens seen measure under one-half millimeter.

Found on *Phascoleon strombi* (=*Phascolosoma cæmentarium*) in the Woods Hole region, and on *Phascolosoma eremita* at the Isles of Shoals, often in considerable numbers among the tubercles of the skin. As *Phascoleon strombi* lives permanently in small gastropod shells, nearly closing the aperture with mud and sand cemented together, the habitat of the Loxosoma is rather unusual. As our sipunculoids were placed in the hands of Dr. J. H. Gerould for identification, I am indebted to him for the material from which the above description is drawn, and I have not seen living specimens. Prof. Verrill informs me that this is the species listed by him as "Loxosoma on Phascolosoma."

Family PEDICELLINIDÆ Hincks, 1880.

Zooecium pedunculate on a stalk which has one or two contractile regions and which rises from a creeping stolon; body separated from stalk by a diaphragm, deciduous, a new body regenerating in place of the one cast off; lophophore terminal and transverse.

KEY TO GENERA.

1. Peduncle not abruptly enlarged at the base near the junction with the stolon .... *Pedicellina.*
2. Peduncle abruptly enlarged at the base .. .. *Barentsia.*

Genus PEDICELLINA M. Sars, 1835.

Pedicellina cernua (Pallas). [Pl. XVIII, fig. 3, 3a, 3b, 3c, and 3d.]

Pallas 1771, p. 57 (*Brachionus cernuus*).
Leidy 1855, p. 143 (*Pedicellina americana*).
Verrill and Smith 1874, p. 707 (*P. americana* Leidy).
Verrill 1879c, p. 31 (*P. americana* and *echinata*).
Jelly 1889 (? *P. nutans* Dalyell).
Ehlers 1889, p. 141 (=? *P. glabra* Hincks).
Jullien 1888, p. 13 (*P. hirsuta*).
Cornish 1907, p. 79.

Stolon slender, more or less transparent, branching. Body cup-shaped, usually with a well-marked gibbosity on one side, tentacles 14 to 24. Peduncle stout, tapering gradually at its upper end. Stout spines often present on both stalk and body, or on either, or entirely absent from both. Abundant in certain situations, as on the piles of docks, where it commonly grows intermingled with other creeping forms. It occurs also at some depth in Vineyard Sound, and I have taken it once at Crab Ledge in 18 fathoms.

A comparison with European material shows that our species is undoubtedly the same as *cernua*. Concerning the species in Europe there has been much difference of opinion. Ehlers (l. c.) makes three species out of it, *P. glabra* Hincks entirely without spines, *P. echinta* Sars with spinous peduncle, and *P. hirsuta* Jullien with spinous body, although he recognizes the possibility of their belonging together. Hincks and Joliet had already noticed the variability in the spines, and Hincks mentioned the smooth form merely as a "variety *glabra*." In American specimens is exhibited the whole range of variability in number and arrangement of spines, and there is such an amount of variation among the individuals of a single colony that I am convinced no separation based upon their presence or absence can be of specific value. Leidy's *P. americana*, along with *glabra*, *echinata*, and *hirsuta*, must be considered synonyms of *cernua*.

I have collected the species, exhibiting the variation in spines, at Beaufort, N. C., and at the Tortugas, Fla. Hincks (1889) has recorded *P. nutans* Dalyell from the Gulf of St. Lawrence, but I have failed to find it in the Woods Hole region.

Genus BARENTSIA Hincks, 1880.

Similar to *Pedicellina* in the form of the body and stolon; the stalk differing from that genus in being suddenly expanded near the base into a muscular organ for swinging the stalk from side to side; stalk above the enlargement more slender than in *Pedicellina*.

KEY TO SPECIES.

1. Stalk without areolæ or perforations ....*major.*
2. The cuticle of the stalk with rounded areolæ or perforations...... ..*discreta.*

Barentsia major Hincks. [Pl. XVIII, fig. 4.]

Hincks 1888, p. 226.
Jullien and Calvet 1903, p. 27 (*B. elongata.*)

Stolon rather stout, creeping, jointed at intervals. Pedicels of great length, very slender below and expanding somewhat above, delicately ringed, of a very light horn color, rising from a stout cylindrical base, which is conical above and of a whitish color and with or without annulations. Polypide or body large, white, expanding from the base upward, slightly gibbous on one side, tentacles numerous; the fleshy peduncle connecting the body and stalk is comparatively long and usually somewhat enlarged just below the attachment of the body.

I am convinced from my studies of living and preserved material that too much stress has been placed by systematists upon the condition of the connection between body and stem, and also upon the presence or absence of annulations on the muscular base, as both of these vary in life with the amount of contraction and in preserved material in the same manner, due, perhaps, to different means of killing or fixation. Thus Jullien described his species *elongata* as new, partly on these characters (l. c.). Hincks specifically states that in *major* the base is not annulated, but this does not apply to all specimens. Calvet in a footnote to Jullien's specific description places *elongata* as a variety of *major*.

The species is well distributed throughout the Woods Hole region, though it is not very common. Taken on piles, on the leg of a spider crab, and dredged at 3 to 13 fathoms on shells and stones.

Barentsia discreta (Busk). [Pl. XVIII, fig. 5, 5a.]

Busk 1886, p. 44 (*Ascopodaria discreta*).

A small, delicate stolon, jointed at intervals where branches or pedicels have their origin. Pedicels becoming slightly larger toward the top, chitinous, irregularly punctured by minute funnel-shaped pores, or areolæ, which on close examination are seen to penetrate the inner but not the outer layer. The muscular cylinder at the base of the pedicel is more or less annulated. Pedicel and stolon horn color varying with age, polypide and cylinder whitish, or the latter light brownish. Polypide small, somewhat gibbous on one side, attached to the pedicel by a flexible, annulate, fleshy portion, which is often more or less bulbous.

The only previous record for this species is the Challenger record "Station 135, off Nightingale I., Tristan da Cunha, 100 to 150 fathoms." It was naturally a surprise to find this species in our region, but it is evidently well distributed, as I have taken it at four places in Vineyard Sound and once in Buzzard's Bay. I have also taken it at Beaufort, N. C., and at the Tortugas, Fla. It is a very inconspicuous form and might easily escape observation, but it seems to be distributed all along our coast.

SUBCLASS ECTOPROCTA NITSCHE, 1869.

Order GYMNOLÆMATA Allman, 1856.

All of the recent marine ectoproctous Bryozoa are included in this order, which is, consequently, a very large one. The fresh-water ectoprocts comprise the order Phylactolæmata Allman, with but a very limited number of genera and species.

KEY TO SUBORDERS.

1. Zoarium well calcified. Zooecia tubular, orifice usually round, without operculum, no appendicular organs (avicularia and vibracula), no external brood pouch, but the ooecium consisting of a modified zooecium .... Cyclostomata.
2. Zoarium usually well calcified. Zooecial orifice closed by a movable lid-like operculum, appendicular organs frequently present, an external brood pouch usually present on fertile zooecia. Chilostomata.
3. Zoarium never calcified. Zooecial orifice with an operculum consisting of a ring of setæ, no appendicular organs or external brood pouch........ Ctenostomata.

Suborder CYCLOSTOMATA Busk, 1852.

This suborder is probably much older than the other groups of recent ectoprocts and is abundantly represented among the paleozoic fossils. A noticeable diminution occurs in the tertiary, but a considerable number have persisted to the present time.

KEY TO FAMILIES.

1. Zoarium erect, articulated, with horny joints, attached by long tubular radical processes . . . Crisiidæ.
   Zoarium entirely or partially encrusting (sometimes only the small basal portion for attachment), not jointed, solidly attached, without radical fibers . . . 2.
2. Zoarium discoid, simple and entirely or partially adnate, zooecia tubular, erect or nearly so, radiating in linear series from a free central area, intermediate space cancellated . . . Lichenoporidæ.
   Zoarium flabellate, lobate or branched, entirely adnate or rising from an encrusting base, zooecia tubular, in contiguous series or in single lines . . . Tubuliporidæ.

Family CRISIIDÆ d'Orbigny, 1852.

The jointed zoarium, the erect, bushlike habit of growth, the attachment by means of jointed tubular fibers, and the swollen, pear-shaped ooecium, which is merely an expanded cell, easily serve to distinguish this family at a glance from any other. There is only one genus.

Genus CRISIA Lamouroux (pars), 1812.

KEY TO SPECIES.

Zoarium bushy, spreading, tips of branches curled inward, ooecium with a well developed tubular ooeciostome, the aperture of which is somewhat elongate transversely and inflexed on the front border . . . *eburnea.*
Zoarium more erect, somewhat flabellate, the branches not curved inward; ooeciostome shorter than in the preceding and conspicuously elongated transversely, twice as long as wide . . . *cribraria.*
Zoarium much as in *eburnea;* ooeciostome not well developed, very short, the aperture round . *denticulata.*

Crisia eburnea (Linné). [Pl. XVIII, fig. 6, 6a, and 6b.]

Linné 1766–1768, p. 1316 (*Sertularia eburnea*).
Verrill and Smith 1874, p. 707.
Verrill 1879c, p. 28.
Cornish 1907, p. 78.

Zoarium forming dense, bushy tufts, usually attached by a single stem, the base of which does not in most cases develop many rootlets; height ½ to ¾ inch, the branches characteristically curved inward. Internodes short, somewhat flattened, in most cases with an odd number of zooecia, 5 and 7 being the dominant numbers. Joints yellow, colorless near the growing points, sometimes dark brown in old parts of the colony. Zooecia almost entirely connate, the free upper portion bearing the aperture bent forward nearly at a right angle to the stem, a pointed process sometimes on the outer angle of the aperture. Ovicell large, curved inward, usually replacing the second, less often the third zooecium of an internode; ooeciostome conspicuous, elongated transversely (1½ times as long as wide), the front margin somewhat inflexed, borne on a very distinct tube which narrows toward the summit.

An abundant species, growing in all depths from low water to the deepest water of the region. Found on piles, attached to hydroid and other stems, on stones and shells, in fact on anything which will give it a foothold. More abundant in Vineyard Sound and outside waters, but plentiful in many parts of Buzzards Bay.

Crisia cribraria Stimpson. [Pl. XVIII, fig. 7, 7a, and 7b.]

Stimpson 1853, p. 18.
Harmer 1891, p. 135 (?=*C. ramosa* Harmer).
Verrill 1879c, p. 28 (*C. eburnea* var. *cribraria*).
Jelly 1889, p. 74 (=*C. denticulata*).
Whiteaves 1901, p. 110 (*C. eburnea* var. *cribraria*).

Stimpson's original description of this species is as follows: "Polydom thickly branched, with the cells so crowded as to form 2 or 3 longitudinal rows, in which they are usually opposite. The back of the polydom is flat or but slightly convex, presenting an irregularly striate appearance. Color white. Taken in 20 fathoms east of Duck I."

The above description is so entirely inadequate, omitting nearly all points of diagnostic value, that it is practically useless, and the accompanying figure is nearly as noncommital, so it is not difficult to see why the species has been altogether misunderstood. Material from the Labrador and Nova Scotia coasts, dredged by Mr. Owen Bryant, in 1908, as well as specimens previously dredged by myself at Crab Ledge, correspond to what is of value in Stimpson's description. A study of the ovicells, which are abundant in both the Crab Ledge and Canadian specimens, shows that the species is certainly distinct from *eburnea*, *denticulata* and *ramosa*. The growth habit is also distinct. As we have no other description than that above quoted, and as there has been so much confusion concerning the species, I include the following more complete description.

Zoarium consisting of nearly erect flabellate branches arising from a narrow base, ¼ to ½ inch in height; the branches show little or no tendency to curve inward and are much stouter and more rigid than is usual in the genus. Occasionally the joint is wanting where it should occur, the region being fully calcified. Internodes long, zooecia even in number, with an average of 18 or 20 zooecia (as many as 26 and as few as 10 have been noted), usually regularly alternate, but sometimes nearly opposite in position; branches broad and flat or slightly rounded on the posterior side; the zooecia overlap to such an extent that the branch is often five times the width of a single zooecium. The zooecia are usually fused in the branch for nearly the whole length, but a very short terminal portion turns abruptly forward and usually slightly inward, so that the apertures seem to lie on the front of the branch, in some cases (usually in the narrower branches) they may project somewhat laterally; a sharp projection often present on the outer border of the aperture. Ooecia large, more elongate than in *C. eburnea*, and more bulging at the upper end, often to such an extent that the aperture is hidden in front view; only one to an internode, occupying the position of the fifth or sixth zooecium of that side of the branch, but sometimes as low as the third or as high as the ninth. Ooeciostome elongate-elliptical transversely, almost slitlike, fully twice as much compressed as in *eburnea*, situated at the top of a stalk which is broadest at its base and which flares out slightly at the top. Radical fibers not very numerous, stout, the joints short. Branches arising alternately, usually two, sometimes three to an internode; the first arises low down, usually between the second and third zooecia, the second between the fourth and fifth zooecia of the opposite side, the third (when present) on the same side as the first, still higher up.

The most distinctive character is the ooeciostome, which distinguishes the species at once from any with which it has been confused. The tube is stout as in *eburnea*, and flares at the top like *ramosa* but not to such an extent; the opening is different from either of these and from *denticulata* as well.

Taken at Crab Ledge (Fish Hawk station 7835) in 18 fathoms, well developed, with numerous ovicells. The species must be considered rare in this region, and has not hitherto been noted south of Canadian waters.

Crisia denticulata (Lamarck). [Pl. XVIII, fig. 8.]

Lamarck 1816, p. 137 (*Cellaria denticulata*).
Stimpson 1853, p. 18.
Verrill 1879c, p. 28 (*C. eburnea* var. *denticulata*).
Whiteaves 1901, p. 110.

Zoarium rather large and straggling, averaging about an inch in height; branches showing but little tendency to curve inward, broad and flattened; internodes usually slightly curved from side to side in a sinuous manner. Zooecia usually alternating, the dominant number 11 to an internode, a short terminal portion is curved forward and a pointed projection is often present at the upper outer angle of the orifice. Ovicell large, always high in the internode and usually near the end of a branch; the ooeciostome differs from that of our other species in that it is not borne upon a distinct tube, but is inconspicuous behind the upper end of the ooecium. The radical fibers have black joints at frequent intervals.

It is with considerable doubt that I record this species for the Woods Hole region. I have taken on a number of occasions in the outer waters, specimens which seem from the zooarial characters to belong to *denticulata*, but as no fully developed ovicells have been seen, I have not been able to arrive at a positive determination. The species has been recorded on the American coast from Florida, the Bay of Fundy and the Gulf of St. Lawrence.

Family TUBULIPORIDÆ Johnston, 1838.

KEY TO GENERA.

Zoarium encrusting or partly free, forming various sorts of expansions, entire, lobate, or branched. Zooecia mostly connate in diverging series. Sometimes a fan-like colony is extended at the edges to appear discoid at first glance .... *Tubulipora*.

Zoarium (in our species) entirely encrusting, irregularly lobate, rather thin. Zooecia longitudinally arranged, in great part immersed in the zoarium, the apertures widely separated....*Stomatopora*.

Genus TUBULIPORA Lamarck (pars), 1816.

KEY TO SPECIES.

1. Zoarium rising free from a small base, well branched, dichotomous, branches more or less triangular in cross section; zooecia disposed in alternate series on either side of the median line of the stem, connate and directed outward (*Idmonea*) .... *atlantica*.

Not such characters .... 2.

2. Ooeciostome large, at least as large as the aperture of the cells, turned sidewise so as to open horizontally (*Idmonea serpens*).......... *liliacea*.

Ooeciostome small, directed upward, conspicuously flattened sidewise, the aperture not more than half as large as the apertures of the cells.......... *flabellata*.

Tubulipora atlantica (Johnston). [Pl. XIX, fig. 9, 9a.]

Johnston 1847, p. 278 (*Idmonea atlantica*, from Forbes' MS.).
Verrill 1879c, p. 28 (*T. atlantica* and *Fasciporina flexuosa*).
Harmer 1898, p. 88–9 (reasons for combining *Idmonea* with *Tubulipora*).
Cornish 1907, p. 78 (*Idmonea atlantica*).

Zoarium erect and spreading, irregularly branched dichotomously, the branches mostly in the same plane, triangular in section, the dorsal side striated and finely punctate. Zooecia 1 to 4 or 5 in each series, connate, the innermost the longest, the apertures directed somewhat outward, leaving a free space in the middle of the front side of the stem. In this space the ooecium develops in a very irregular elongate form, swollen and involving the bases of the zooecia. Although the species has been figured by various authors, no one so far as I am aware has figured or mentioned the ooeciostome. In some well-developed specimens from Crab Ledge I find what I take to be this organ, which Harmer has shown to be of so much importance in the determination of the cyclostomatous Bryozoa. It consists of a tube, similar in size and length to the longest zooecium and connected with it, placed on the upper side of the series and curved toward the tip of the branch. The stalk is flared somewhat trumpet-like at its tip when fully developed, and the aperture, which is round, looks toward the tip of the branch. Numerous specimens of this beautiful species were taken at Crab Ledge on August 12, 1909, dredged by the Phalarope in 14 to 18 fathoms, attached to stones and shells. Although it is a widely ranging species it has not heretofore been noticed in this region.

Tubulipora liliacea (Pallas). [Pl. XX, fig. 10, 10a.]

Pallas 1766, p. 248 (*Millepora liliacea*).
Stimpson 1853 (*Idomonea pruinosa*).
Verrill and Smith 1874, p. 708 (*T. flabellaris*).
Verrill 1875a, p. 414, and 1879c, p. 28 (*T. serpens*).
Harmer 1898, p. 90–4 (synonymy of *Idmonea* and *Tubulipora serpens*, auctt.).
Cornish 1907, p. 78 (*Idmonea serpens*).

Zoarium entirely or mostly adnate, showing but little tendency to the free, erect growth so common to the species in northern waters, irregularly lobate, in young state rather uniformly flabellate growing on hydroid stems, and in similar situations, the colonies becoming nodular masses of extreme irregularity. Zooecia growing in series, more or less alternate and connate, forming prominent radiating ridges, highest at the inner ends. Ooecia usually plentifully developed on older colonies, ooeciostomes opening sidewise, and so not conspicuous when viewed from above. Viewed from the side they appear as large as the zooecial apertures, and of a rounded form.

Occurs throughout Vineyard Sound, but not very common. Taken also on Sow and Pigs Reef, and in Buzzards Bay near Robinsons Hole. Taken in shallow water on piles at Woods Hole, and dredged in 3 to 15 fathoms; found on eel-grass and algae, and occasionally on hydroid and *Bugula* stems and on shells.

There has been much misunderstanding in regard to this and the following, as well as to other species of the genus. Harmer (l. c.) has carefully gone over all the data in regard to these forms, and has fixed upon the nature of the ooeciostome, a character almost entirely overlooked by the older students of the group, as the best means of determining the species. A study of the form of the zoarium and the arrangement of the zooecia has shown that these characters vary almost endlessly, while the ooeciostome is quite constant.

Verrill confused this and the following species, evidently, since both occur on our coast, and I have found them both in material which he dredged for the United States Fish Commission. His reference to the Vineyard Sound material must be placed under this species (as he later recognized), since it is the only one occurring within the waters of the Sound. Verrill's reference to its habits also indicates that he had this species in Vineyard Sound, though he makes no mention of any other species in the waters of the region.

Tubulipora flabellaris (Fabricius). [Pl. XX, fig. 11.]

Fabricius 1780, p. 430 (*Tubipora flabellaris*).
Dawson, 1859, p. 257.
Verrill 1879c, p. 28.
Cornish 1907, p. 78.
Harmer 1898, p. 99 (synonymy).

Zoarium entirely adnate as far as I have observed in our specimens, in the young state more or less flabellate, in the older stages the form often becomes discoidal by the edges spreading around so as to inclose the base of the colony. Zooecia sometimes free, sometimes connate, in series, and radially arranged. Ooecia usually plentifully developed on the older colonies, the ooeciostome directed upward, the orifice conspicuously narrowed or compressed from side to side, slit-like, not half as large as the zooecial apertures.

Taken at Crab Ledge, off Sankaty Head, and Great Round Shoal, on shells and stones, not common. Finely developed colonies on shells dredged on the Nantucket Shoals by the United States Fish Commission in 1875.

Harmer states that "this seems to be an essentially northern species and I have no evidence of its occurrence in British waters." Hincks's species proves to be *T. phalangea* Couch. The distribution is thus seen to be much farther southward in American than in European waters.

Genus STOMATOPORA Bronn, 1825.

Stomatopora diastoporoides (Norman). [Pl. XVIII, fig. 12, 12a.]

Norman 1868, p. 310 (*Alecto diastoporoides*).

Zoarium forming a thin irregular crust, usually with a lobed or sinuate outline, milk-white or semi-transparent when fresh, rather coarsely punctate, often transversely striated, reaching a diameter of about ¾ inch. Zooecia embedded for the greater part of their length, the free part suberect and short and the apertures well separated; orifice rounded to subelliptical. No ooecia have been noted for this species.

A few specimens of this species dredged at Crab Ledge on pebbles. It has not hitherto been recorded south of Canadian waters.

Family LICHENOPORIDÆ Hincks, 1880.

Genus LICHENOPORA Defrance, 1823.

Lichenopora verrucaria (Fabricius). [Pl. XVIII, fig. 13, 13a, 13b.]

Fabricius 1780, p. 430 (*Madrepora verrucaria*).
Verrill and Smith 1874, p 707 (*Diastopora patina*).
Verrill 1875a, p. 414, and 1879c, p 28 (*Discoporella verrucaria*).
Cornish 1907, p. 79.

Zoarium usually a more or less circular disc, sometimes raised into a dome or otherwise modified; usually entirely adherent, but sometimes stipitate, or with the edges projecting; size small, usually about 1/8 inch in diameter. Zooecia comparatively large, raised, in more or less regular radiating lines but not connate; usually with a well-developed rib on the side next to the center of the zoarium and carried upward above the orifice into a pointed process; orifice large and oblique; marginal zooecia not elevated. Ooecium an inflation of the surface; ooeciostome raised, with a rounded or sometimes elliptical trumpet-shaped ooeciostome. The central area, which is free from zooecia, as well as the spaces between the zooecia, is coarsely punctate.

This little species is common at Crab Ledge on the stems of *Bugula*, *Gemellaria* and hydroids, as well as on shells and stones. Taken also off Sankaty Head, Nantucket, Muskeget Channel, Nobska Point in shallow water, Robinsons Hole, and near Gay Head. Recorded for Vineyard Sound off Vineyard Haven by Verrill. The species is a northern and arctic one and probably does not occur much farther south on our coast.

Suborder CHILOSTOMATA Busk, 1852.

KEY TO FAMILIES.

I. Nonincrusting forms, erect or creeping, usually more or less phytoid and flexible.

1. A creeping stolon, with expansions from which arise the tubular zooecia (the polypide is more or less contained within the expansion); zooecium with a lateral membranous area and a terminal orifice .... Æteidæ.
   Zoarium phytoid or spreading, never stolonate .... 2.
2. Zooecia uniserial or in two rows back to back, no appendages (avicularia or vibracula). Eucrateidæ.
   Zooecia in two or more series, all facing the same way, appendages usually present .... 3.
3. Zooecia closely united, appendages sessile .... Cellulariidæ.
   Zooecia more loosely united, appendages pedunculate and jointed .... Bicellariidæ.

II. Incrusting forms, usually forming a well calcified crust on shells, stones, algæ, etc., occasionally erect and foliose or branching, but when so rigid and solidly attached and usually arising from an incrusting base.

1. Front wall of zooecium depressed, membranous or partly bridged over by a calcareous shelf, zooecial borders raised .... Membraniporidæ.
   Front wall of zooecium entirely calcified (except for a small pore in some cases) up to the operculum .... 2.
2. Zoarium entirely encrusting; zooecial wall more or less traversed with transverse or radiating furrows .... Cribrilinidæ.
   Zoarium encrusting or more or less erect; front wall of the zooecium often porous, but never regularly grooved transversely or radiately .... 3.
3. A small pore situated in the midline of the front wall below the orifice .... 4.
   No median open pore, though not infrequently a small rounded avicularium may be so placed .... 5.

4. Zooecial orifice nearly semicircular, not raised into a tube, pore immersed............Microporellidæ.
Zooecial orifice round, raised into a semierect tube, near the base of which the pore is placed, raised on a prominence..Porinidæ.
5. Lower margin of primary orifice with a definite sinus, or when the sinus is obsolete the cells more or less erected and the aperture guarded by a projection bearing an avicularium on the side, Myriozoidæ.
Lower margin of primary orifice straight, or occasionally rounded, without a definite sinus, though the overgrowth of a secondary margin may simulate this condition; the lower or lateral margins of the orifice may bear denticles, and avicularia may be present in relation to the orifice; zooecia not erect..Escharidæ.

Family ÆTEIDÆ Smitt, 1867.

This family is easily distinguished by the slender creeping stolon which is expanded here and there into fusiform enlargements from which arise tubular upright extensions. The zooecium consists of the erect tube plus the expansion. The orifice is at the top of the erect part, and a membranous area occupies one side of the terminal portion. There is only one genus.

Genus ÆTEA Lamouroux, 1812.

Ætea anguina (Linné). [Pl. XXI, fig. 14, 14a.]

Linné 1858, p. 816 (*Sertularia anguina*).
Verrill and Smith 1874, p. 710.
Verrill 1879c, p. 28.

Zoarium delicate, creeping, white, the erect portions of the zooecia arising almost at right angles to the stolonate base. Terminal portion of the tube slightly more expanded, more or less spoon-shaped, finely punctate, one side membranous; stalk about twice as long as the spoon-shaped part, more or less curved or nearly straight, distinctly annulate; dilated basal portion finely punctate. Ooecium subterminal, opposite the membranous area, a round bladder-like transparent sac, through which the cells of the dividing egg may be easily seen.

An abundant species, but inconspicuous on account of its small size and trailing habit of growth. Found on stems of various animals and algæ as well as on shells and stones. Dredged at from 1 to 19 fathoms, and found on piles at low water throughout the region. Old colonies on shells frequently have the erect portions broken off, in which case there is a fairly close resemblance to *Hippothoa divaricata* but the finely punctate character of the expansion, as well as the condition of the aperture, will distinguish it at once.

The ooecia are very rarely present, so that the species was long described as possessing none. Fine colonies taken August 9, 1906 (Fish Hawk station 7567), on *Pennaria* stems, have numerous ovicells, containing embryos from the 4-celled stage to the ciliated larvæ ready for extrusion.

Family EUCRATEIDÆ Hincks, 1880.

Zoarium phytoid; zooecia arranged in a single series or in two series back to back; orifice subterminal more or less oblique; no appendages.

KEY TO GENERA.

Zoarium with creeping base and erect branching shoots; zooecia uniserial, branches arising on the front side of a zooecium below the orifice. Fertile cells dwarfed, arising on the front of normal zooecia, ovicells terminal..*Eucratea*.
Zoarium erect, phytoid; zooecia regularly biserial, back to back, branches arising from the side of the zooecium near the upper end; ooecia none..*Gemellaria*.
Zoarium erect; zooecia uniserial or occasionally biserial, back to back. Branches arising from the back of a zooecium and facing in the opposite direction. Fertile cells small and placed back to back against the ordinary zooecia, ooecium terminal..*Scruparia*.

Genus EUCRATEA Lamouroux, 1812.

Eucratea chelata (Linné). [Pl. xxi, fig. 15.]

Linné 1858, p. 816 (*Sertularia chelata*).
Verrill and Smith 1874, p. 710.
Verrill 1879c, p. 28.

Zoarium branched and straggling, more or less decumbent. Zooecia narrowed below, gradually enlarged upward to the base of the aperture, which slants away to the top of the cell; aperture oval, with a thin, raised, smooth margin; frequently a rudimentary zooecium borne on the front side of the normal cell just below the aperture, and when the ooecium is present it is borne terminally on such a dwarfed cell.

Spreading over algæ, hydroids and other Bryozoa. Not common in the Woods Hole region. Verrill (l. c.) records it off Gay Head in 10 fathoms. In hundreds of dredgings I have never noticed it, but it occurs on the piles at Vineyard Haven and at Woods Hole.

Genus GEMELLARIA Savigny, 1811.

Gemellaria loricata (Linné). [Pl. xxi, fig. 16, pl. xxxi, fig. 97.]

Linné 1761, p. 542 (*Sertularia loricata*).
Lamouroux 1816, p. 7 (*Loricaria americana*).
Dawson 1865, p. 3 (*Gemellaria willisii*).
Verrill and Smith 1874, p. 747.
Verrill 1879c, p. 29 (*G. loricata* and var. *americana*).
Stimpson 1853, 19 (*Gemellaria dumosa*).
Whiteaves 1901, p. 91–92 (as *G. loricata* and var. *americana*).
Cornish 1907, p. 75.

Zoarium erect, phytoid, forming bushy colonies often several inches in height. Zooecia joined back to back in a double series of great regularity. Orifice large, slightly oblique, occupying about half of the front of the cell but varying considerably in this respect, a thin raised smooth margin about the orifice. No ovicells nor appendages.

Common in the outer waters of the region. There is considerable difference in appearance between the rather rigid shorter colonies (1 to 3 inches in height) from the shallower waters of Crab Ledge and Nantucket, and the more slender, elongate colonies (6 to 10 inches) from deeper water off No Mans Land. The cells of the latter are more slender and elongate, but otherwise there is no material difference. I take the shorter form to be Lamouroux's *americana* and Stimpson's *dumosa*, but do not consider it worthy of even a varietal name.

Genus SCRUPARIA Hincks, 1857.

Scruparia clavata Hincks. [Pl. xxi, fig. 17, 17a, 17b, 17c.]

Hincks 1857, p. 175.
Whiteaves 1901, p. 92.
Cornish 1907, p. 75.

Zoarium sparingly branched, decumbent, and straggling. Zooecia uniserial, or biserial and placed back to back, elongate, clavate, rounded above and attenuated below, each cell attached to the dorsal surface of the one below it by a cordate expansion of the base. Aperture suborbicular, slightly produced and contracted below, without raised margin. Ooecia terminal on small cells back to back with the ordinary ones, globose with a few large punctures.

Apparently a rare species. Dredged at Crab Ledge, 18 fathoms, on *Gemellaria loricata*, and at Great Round Shoal, 8 fathoms, on *Bugula murrayana*. Only very small colonies have been noted and it may be that the species does not reach a very great development in this region. The presence of ovicells indicates sexual maturity, even though the colonies consist of only a few cells.

Family CELLULARIIDÆ, Johnston (pars), 1849.

KEY TO GENERA.

1. Zoarium jointed .... 2.
   Zoarium not jointed, vibracular cells very large, placed obliquely on the backs of the zooecia, vibracula long .... *Caberea.*
2. Zooecia few, usually 3 or 5, in each internode, elongated and attenuated below, usually a lateral sessile avicularium and one or two on the front of the zooecium .... *Menipea.*
   Zooecia many in each internode .... 3.
3. Vibracula wanting and usually the avicularia also, but occasionally there is a sessile avicularium, *Cellularia.*
   Vibracula and avicularia present, the former small and situated low down on the back of the cell, the latter sessile on the outer edge and often on the front of the cell .... *Scrupocellaria.*

Genus CABEREA Lamouroux, 1816.

Caberea ellisii (Fleming). [Pl. XXI, fig. 18, 18a, pl. XXXI, fig. 93.]

Fleming 1828, p. 251 (*Flustra ellisii*).
Verrill and Smith 1874, p. 711.
Verrill 1879c, p. 29.
Whiteaves 1901, p. 93.
Cornish 1907, p. 76.

Zoarium more or less fan-shaped, yellowish brown, branches stout, widening upward. Zooecia in 2 to 4 rows, short, quadrangular, aperture elliptical, occupying nearly the whole of the front, with a broad margin. Lateral zooecia with two stout spines on the outer side and one on the inner, median cells with one spine on each side. Avicularia of two kinds, the lateral ones small with a rounded mandible and placed a little way below the top of the cell, the other sort raised and rounded and placed below the aperture. Vibracular cells very large, covering very nearly the whole of the back of the zooecia on which they are situated; vibracula very long, toothed, especially near the tip. Ooecia flattened, smooth, or finely striate with radiating lines.

Occurs in the outer waters of the region, sometimes abundant. Usually attached to shells and pebbles, but sometimes to other sessile forms. Not taken in Vineyard Sound or Buzzards Bay.

Genus MENIPEA Lamouroux, 1812.

Menipea ternata (Solander). [Pl. XXI, fig. 19, pl. XXXI, fig. 96.]

Solander 1786, p. 30 (*Cellaria ternata*).
Desor 1848, p. 66 (*Cellularia densa*).
Packard 1867, p. 273.
Verrill and Smith 1874, p. 711 (*?Cellularia ternata*).
Verrill 1879a, p. 53 (*Cellarina ternata*).
Verrill 1879c, p. 28 (*Cellularia ternata* and var. *gracilis*).
Whiteaves 1901, p. 92.
Cornish 1907, p. 75.

Zoarium dichotomous, straggling, forming delicate, white, bushy tufts. Internodes usually consisting of three cells, but not infrequently five or even seven cells, may be present. Zooecia elongated, much attenuated below, showing much variation in the length of the cell. Two spines are present at the top of the cell, and another, a little separated from these, at the outer margin of the aperture, the shield or scute (a modified spine), more or less developed or occasionally wanting, arches over the aperture. Avicularia of two sorts, a prominent sessile one at the outer upper angle of the cell, and a small one, often wanting, immediately below the aperture. Ooecia somewhat elongated, smooth. Radical fibers simple, arising from the lower parts of the zoarium; long tendril-like structures are common on the upper branches, arising from the sides of the cells above the lateral avicularia, enlarged toward the end.

Found in the outer waters of the region, sometimes abundant, at 8 to 25 fathoms. Attached to shells, stones, hydroids, other Bryozoa, etc. Off Gay Head, S. W., Crab Ledge, Great Round Shoal, off Sankaty Head, etc.

While Desor's description of his *Cellularia densa* is too inadequate to determine the species under any other conditions, I am satisfied from having dredged the type locality that the above synonymy is correct, and Verrill has already placed it here questionably.

Genus CELLULARIA Pallas, 1766.

Cellularia peachii Busk. [Pl. XXI, fig. 20 *bis*.]

Busk 1851, p. 82.
Packard 1867, p. 272.
Verrill 1879a, p. 53, and 1879c, p. 29 (*Bugulopsis peachii*).
Whiteaves 1901, p. 92.

Zoarium dichotomous, phytoid. Zooecia biserial and alternating, elongate, attenuated below, a short spine on the upper, outer angle (often wanting); at the terminus of each internode the cell situated between the bases of the branches has this spine situated mesially at the top. Aperture oval, or narrowed below, margin slightly thickened, frequently minutely granulated, dorsal surface smooth, with several (3 to 5) perforations. Ooecia subglobose, the surface tesselated.

Apparently rare. A few small specimens attached to shells and to *Bugula murrayana*, taken at Great Round Shoal in 8 fathoms. The species has not heretofore been noted south of Canadian waters.

Genus SCRUPOCELLARIA Van Beneden, 1844.

Scrupocellaria scabra (Van Beneden). [Pl. XXI, fig. 20, pl. XXXI, fig. 95.]

Van Beneden 1849, p. 73 (*Cellarina scabra*).
Verrill 1879a, p. 53 (*Cellarina scabra*).
Verrill 1879c, p. 29 (*Cellularia scabra*).
Whiteaves 1901, p. 93.

Zoarium dichotomous, internodes with 5 to 12 cells. Zooecia short, narrowed below, aperture oval, occupying more than half of the front, with a smooth border; one or two stout spines on the outer margin above, and a small one on the inner margin; shield or scute entire, suboval, the surface figured with a lobate or antler-like area, often not well developed. Vibracular cells wedge-shaped, placed transversely across the back of the zooecium (often wanting), with a short vibraculum which is not longer than the zooecium. Radical fibers long and slender, scattered over the whole zoarium. Ooecia somewhat flattened in front, subglobose, a smooth subtriangular space above the aperture, from which fine lines radiate toward the margin.

Rather rare. Crab Ledge and off Sankaty Head, on shells and stones. Woods Hole harbor in drift. The latter specimen must have been carried in from outside waters, for the examination of several hundred dredge hauls in Vineyard Sound and Buzzards Bay did not reveal it.

Family BICELLARIIDÆ Hincks, 1880.

KEY TO GENERA.

Zooecial orifice subterminal, facing partly upward, the margin with several very long, slender spines, one placed just below the orifice . . . . *Bicellaria*.
Zooecial orifice occupying a large part, sometimes nearly the whole, of the front of the zooecium, no spine below the orifice . . . . *Bugula*.

Genus BICELLARIA Blainville, 1830.

Bicellaria ciliata (Linné). [Pl. XXI, fig. 21, 21a, 21b.]

Linné 1758, p. 815 (*Sertularia ciliata*).
Verrill 1879c, p. 29.
Whiteaves 1901, p. 93.

Zoarium dichotomous, branches curved inward at tip, forming feathery tufts of a white color. Zooecia alternate, biserial, turbinate, enlarged above and narrowing rather abruptly toward the bottom, where it is cylindrical, while at the top it is somewhat flared outward around the elliptical, oblique aperture. Four to seven very long spines on the upper margin and one centrally located on the lower margin. Avicularium on outer side of cell below the aperture, small, with a serrate beak. Ooecia helmet-shaped, pedunculate, situated at inner side of aperture, the narrow stalk arising from the side of the cell.

This beautiful species is well distributed in the region, but is never very plentiful. Dredged in Vineyard Sound and Buzzards Bay attached to shells, stones, hydroids, etc., and growing less commonly on piles at Woods Hole, Vineyard Haven, and Nantucket. Ovicells plentiful and containing embryos in July and August.

Genus BUGULA Oken, 1815.

KEY TO SPECIES.

1. Zooecia arranged biserially .... 2.
   Zooecia arranged in more than two series .... 5.
2. Stalk of colony with ordinary root fibers .... 3.
   Stalk of colony with hooked or grapnel-like "uncinate" processes in place of root fibers, *gracilis*, var. *uncinata*.
3. Avicularia rather short, the beak strongly decurved at tip .... 4.
   Avicularia elongate and slender the beak gently and evenly curved to its tip .... *avicularis*.
4. Usually one strong spine at the outer angle of the orifice, ovicell set at an angle with the axis of the zooecium, margin of the beak of the avicularium not serrate .... *turrita*.
   Usually four spines above, ovicell in line with zooecial axis, beak of avicularium with serrated margin .... *cucullifera*.
5. With marginal spines bending over the aperture, ooecium large, subglobular, avicularia of two sorts, the lateral ones very large .... *murrayana*.
   No marginal spines except at the top, ooecium small, hemispherical, avicularia of one sort, small, *flabellata*.

Bugula gracilis var. **uncinata** Hincks. [Pl. XXI, fig. 22, 22a.]

Hincks 1880, p. 86–89.

Zoarium one to two inches in height, of a light yellow color, forming a bushy tuft with flabellate branches somewhat spirally disposed. Zooecia biserial, alternate, slightly narrowed below. Aperture rather narrow, about two-thirds as long as the cell, narrowed below and turned inward toward the axis of the branch. A spine on each angle of the margin and a third, somewhat larger, behind the outer marginal spine. Avicularium small, placed on the outer margin about halfway up the aperture. The curious uncinate (tendril-like or anchor-like) processes developed freely on the basal part of the zoarium, where they replace the radical tubes of other species. Hincks makes no mention of the ovicells and I have not found them in any of my specimens.

Not common but well distributed over the region. Dredged a number of times in Vineyard Sound and Buzzards Bay and found in drift at No Mans Land, also found growing on the Nantucket Cable. Hincks (l. c.) mentions a specimen from Lynn, Mass., which is the only previous record for the species in America.

Bugula turrita (Desor). [Pl. XXI, fig. 23, 23a, 23b, pl. XXXI, fig. 102.]

Desor 1848, p. 66 (*Cellularia turrita*).
Verrill and Smith 1874, p. 712.
Verrill 1879a, p. 52; 1878, p. 304; 1879 b, p. 189, and 1879c, p. 29
Perkins 1869, p. 161 (*Cellularia turrita*).
? Leidy 1855, p. 142 (*Cellularia fastigiata*).

Desor's description, which is very inadequate, but sufficient under the circumstances for the recognition of the species, is as follows: "Polydom dense, like a bush, stem orange colored, divided into a great number of branches so that each stem looks like a small tower or pyramid. Found in depths ranging from 3 to 15 fathoms. Thrown in great quantity upon the beaches of the islands of Nantucket and Marthas Vineyard."

Zoarium, when fully developed, much branched, several inches in height; the branches bear secondary whorled or spirally arranged branches of a flabellate character, which curl inward somewhat at their tips, giving each main branch a pyramidal form; color ranging from pale yellow to bright orange. Zooecia biserial and alternate, elongate, narrowed toward the base; the aperture occupies about two-thirds of the front and is turned somewhat toward the axis of the branch; a short spine usually present at each angle of the margin, the inner one bent somewhat across the aperture, a larger spine (often very stout) usually present behind the outer marginal spine. Avicularium small and rather stout, with curved beak, situated on the outer margin of the aperture at about its middle. Ooecium rather large, globose, arising at one side of the axis of the zooecium on its upper margin and deflected somewhat toward the axis of the branch. Root fibers strong and plentifully developed. Our largest and most abundant *Bugula*.

Found everywhere throughout the region, dredged at all depths, and growing luxuriantly on piles.

Bugula cucullifera, new name. [Pl. XXII, fig. 24, 24a, 24b, 24c.]

Verrill 1879b, p. 188; 1879a, p. 52, and 1879c, p. 29. (*B. cucullata* Verrill.) Verrill's name for this species is preoccupied by *B. cucullata* Busk (1867, p. 241), now regarded as a synonym of *B. serrata* Lamarck.

Verrill's description, somewhat abbreviated, is as follows: Zoarium much branched, branches slender, dichotomously divided, the branchlets diverging but little. Zooecia in two alternating rows, rather large, elongated, narrow, with the long frontal area occupying most of the length. At the distal angles there are usually two rather long slender spines, but often three on the outer angle. The spines are unequal, divergent, more or less curved and directed upward, the one farthest in front is usually longest, curved forward and upward at the base. Avicularia large, elongated, the length greater than the width of the zooecia, situated rather in advance of the middle of the outer margin of the frontal area, the beak reaching beyond the distal end of the zooecium, the head compressed, broad oval; beak long, concave above, strongly incurved or hooked at the tip. Ooecia short, but wide, nearly hemispherical, the front edge turned upward, showing a large opening in a front view, and giving them a hood-like appearance, surface more or less areolated, glistening.

Verrill described this species from Jeffreys Ledge, off Maine, and off Cape Cod, in 51 to 75 fathoms It occurs sparingly at Crab Ledge in 14 to 20 fathoms.

Bugula flabellata (Thompson). [Pl. XXII, fig. 25, 25a, 25b, pl. XXXI, 94.]

Thompson 1847 (*Avicularia flabellata*).
Verrill and Smith 1874, p. 711.
Verrill 1879b, p. 189, and 1879c, p. 29 (*Bugula flustroides*).

Zoarium short, rarely exceeding an inch, branching, the branches arranged in a broad fanlike fashion and more or less whorled, the main stem very short so the larger branches all arise near the base. Zooecia arranged in series of three to six, and more or less alternating; elongate, the membranous area occupying the whole of the front; the lateral margin is free from spines, but from two to four rather stout spines appear on the upper margin, the anterior ones stronger and projecting somewhat forward or curved inward. Avicularia situated only on the outer cells of the series, about one-fourth of the way below the upper end of the cell, moderately large, longer than the width of the cell, with strongly decurved beak. Ovicell situated directly above the cell, the stalk broad, form hemispherical or somewhat hood-like, the opening wide and directed forward and downward. A considerable amount of variation is noticeable in the form of the cell and in the development of the spines. The ovicells in our specimens are more open than Hincks figures them in the English specimens, but the differences are not sufficient to warrant a separation, in my opinion.

Verrill has recorded the species from Vineyard Sound at 6 to 8 fathoms. It has proved rather uncommon in our dredgings, but it grows abundantly on piles throughout the region.

Bugula murrayana (Johnston). [Pl. XXII, fig. 26, 26a.]

Johnston 1847, p. 347 (*Flustra murrayana*).
Desor 1848, p. 66 (*Flustra truncata*).
Packard 1863 (*Flustra murrayana*), 1867, p. 273 (*Menipea fruticosa*).
Verrill and Smith 1874, p. 711.
Verrill 1879a, p. 52, and 1879b, p. 189, and 1879c, p. 29 (as *B. murrayana* and *B. murrayana* var. *fruticosa*).
Whiteaves 1901, p. 93.

Zoarium dichotomously divided into broad foliose or ribbon-like strips, truncate at tip, or sometimes (var. *fruticosa* Packard) the divisions are narrow and linear. Zooecia multiserial in four to twelve rows, alternating, oblong, truncate above and narrowed below. Aperture reaching nearly to the bottom; an erect spine at each angle above, and a varying number (1 to 5) of marginal spines curving over the aperture. Avicularia of two kinds, the smaller ones situated on the front of the cells at the bottom, with the mandible turned upward, the larger ones on the lateral cells only, situated on the outer margin of the aperture, and several times as large as the others; in both the beak is strongly hooked. Ooecia large, wider than the top of the zooecia, subglobose, with radiating striæ. Radical fibers long, stout and wrinkled, arising from the marginal cells near the base of the zoarium. Height ½ to 1½ inches. The light yellowish or brownish colonies stand up like small frills on the shells and pebbles to which they are attached.

Very common in the outer waters of the region; Crab Ledge, Great Round Shoal, off Sankaty Head, etc., in 8 to 25 fathoms. Noted by Verrill off Gay Head in 10 to 20 fathoms. Not taken in Vineyard Sound or Buzzards Bay.

Bugula avicularia (Linné). [Pl. XXI, fig. 27.]

Linné 1758, p. 809 (*Sertularia avicularia*).
Verrill 1879a, p. 52, 1879b, p. 189, and 1879c, p. 29.

This species has been recorded by Verrill from "Long Island Sound to Spitzbergen," but it has not appeared in any of the collections from the Woods Hole region. The species may be recognized by its biserial arrangement of the zooecia, together with the large size of the avicularia, which are elongated and have the long slender beak gently curved to its tip. In our other species of this region the beak is abruptly decurved near its tip.

Family MEMBRANIPORIDÆ Busk, 1854.

This family has a large representation in the waters of this region. All our species are incrusting, and the majority of them have the aperture widely open. I have followed Waters (1898) in merging *Biflustra* with *Membranipora*, so all of our species fall within the limits of one genus.

Genus MEMBRANIPORA Blainville, 1834.

KEY TO SPECIES.

1. Front wall inside of raised margin entirely membranous . . . . 2.
   Front wall partly (sometimes very slightly) bridged over by a calcareous lamina . . . . 3.
2. Ooecia and avicularia absent . . . . 4.
   Ooecia and avicularia present . . . . 5.
4. Entirely devoid of spines, or with very slender erect spinules . . . . *lacroixii*.
   Spines well developed . . . . 6.

6. An area on the front wall below the raised margin perforated with large pores, spines all strong. .*pilosa.*
Area below raised margin not so perforated, spines weaker, the median spine at lower edge of aperture stout, others occasionally absent.................. ... . *monostachys.*
5. Spines few, usually 2, one on either side of the aperture at the upper end, ooecium usually with a strong subereet avicularium on its forward end.......................... *unicornis.*
Spines more numerous .... 7.
7. Spines usually 13 or more, bent downward over the aperture and flattened in cross section, directed strongly forward....... .... *craticula.*
Spines less in number, not strongly directed forward...... .... 8.
8. Spines usually less than 12, nearly erect and pointed, except the most anterior pair, which are blunt at the end and directed somewhat forward .... *lineata.*
Spines 4 to 6, one or two erect, the others broad and flattened and bent downward over the aperture, a small avicularium on either side, occasionally on one side only (sometimes with a large avicularium transversely placed at the base of the cell, variety *armifera*) . . *arctica.*
3. Ooecia present .... 9.
Ooecia wanting.. 10.
9. Ooecium with a strongly raised rib inclosing a somewhat triangular area .... *aurita.*
Ooecial rib not so strongly developed, inclosing a rectangular area... .... *flemingii.*
10. Small avicularia situated on the tops of slender pedicels among the marginal spines, which are long, zooecial walls very high . . . . *cymbæformis.*
Avicularia wanting; spines, when present, in the form of stout tubercles . .. . 11.
11. Calcareous lamina well developed, half closing the area, with strong teeth projecting toward the center ... ... *tenuis.*
Lamina much less developed, lacking the strong teeth of the last species; in this region found only on floating *Sargassum* of the Gulf Stream drift........................... *tehuelcha.*

Membranipora lacroixii (Audouin). [Pl. XXII, fig. 28, 28a, 28b.]

Audouin, 1826, p. 240 (*Flustra lacroixii*).
? Packard, 1867, p. 8.
Dawson, 1859, p. 256.
Hincks, 1880, p. 131.
Waters, 1898, p. 679.
Whiteaves, 1901, p. 97.

Zoarium encrusting, forming a delicate network over stones, etc. Zooecia rather small, the membranous area large and only slightly depressed, i. e., nearly flush with the calcareous margin. The latter is finely granulated on its inner border, and it is slightly raised at the anterior end of the cell in front of the operculum. There are no tubercles, avicularia, or ovicells in this species, and the slender spinules, of which 2 to 12 may be present in the species, are absent from the only specimen I have seen from this region. A colony which was kept for several months living in a standing aquarium at New Haven by Dr. L. J. Cole has the spines well developed. An excellent diagnostic character, mentioned by Waters (l. c.), is found in a pair of rounded uncalcified areas near the anterior end on the underside of the zooecium, with other smaller areas occasionally present, but to discover these it is necessary to remove the zooecia from the substratum.

The species has been so confused in the literature that records of its occurrence are somewhat doubtful. Our species is identical with that which Waters discusses under this name. Packard, Hincks, and Whiteaves have listed it for Canada, and may have been correct in so doing.

A single large colony, several inches in diameter, encrusting a stone, was taken in the estuary of the Weweantic River, at the head of Buzzards Bay, near the low-tide mark, by Dr. E. D. Congdon.

Membranipora monostachys Busk. [Pl. XXII, fig. 29, 29a, 29b, pl. XXX, fig. 87.]

Busk, 1854, p. 61.
Leidy, 1855, p. 9 (*Escharina lineata*).
? Verrill and Smith, 1884, p. 712 (*M. lineata*).

Zoarium forming irregular, often radiate or catenulate colonies on shells, stones, and occasionally on algæ. Zooecia rather small, the basal portion solidly calcified or very finely punctate; membranous area oval to elliptical, border slightly raised, smooth, or slightly granular, and usually studded with sharp spines which bend over the area. In the more usual form of the colony there are 8 or 10 pairs of these spines, one pair situated at the anterior end of the cell and directed somewhat forward, and there is a single basal spine somewhat larger than the others; in the other form of the colony to which the species owes its name the margin is unarmed except for the basal spine, which is much stouter but not elongated. Avicularia and ovicells are wanting. In some of the older zooecia there is not infrequently found a secondary calcareous lamina partly closing the membranous area after the manner of *M. catenularia* (Jameson). Abortive zooecia are not uncommon, and these are sometimes completely closed over.

Occurring with some frequency throughout the region, dredged in 2 to 19 fathoms. It is most common in Vineyard Sound and Buzzards Bay on shells and stones, but I have noted it on algæ, egg-cases of skates, and on the carapaces of crabs and *Limulus;* No Mans Land in drift, Muskeget Channel, Great Round Shoals, and Nantucket and Woods Hole harbors on piles. The *Escharina lineata* of Leidy is certainly this species, judging by the figure he gives (pl. x, fig. 22). I am inclined to the belief also that Verrill's reference to *M. lineata* belongs rather to *monostachys*, for the reasons that he places Leidy's reference in his synonymy, and that his remarks concerning the species refer rather to *monostachys*. The latter, moreover, is common in the region dredged by Verrill, while *lineata* seems to be rare south of Cape Cod.

Membranipora pilosa (Linné). [Pl. XXII, fig. 30, 30a.]

Linné 1766–68, p. 1301 (*Flustra pilosa*).
Leidy 1855, p. 141.
Packard 1867, p. 272.
Verrill and Smith 1874, p. 712.
Verrill 1879c, p. 29 (*Electra pilosa*).
Whiteaves 1901, p. 95 (*Electra pilosa*).
Cornish 1907, p. 76.

Zoarium encrusting algæ, stones, and shells, usually in irregular patches. Zooecia large, the basal portion large and coarsely punctate; membranous area usually regularly oval, sometimes elongated, surrounded by a rather high, smooth border, from which project several (usually 7 or 9) stout curved spines. The basal spine varies greatly in size, and seems to be very closely correlated with the character of the substratum. On flat surfaces, as stones, shells, and the broader algæ, this spine is scarcely longer than the others, while on rounded surfaces, as the smaller algæ, hydroid stems, etc., the spine may be considerably longer than the whole zooecium and more or less horny. Intermediate forms are occasionally found which connect the long-spined typical variety with the short-spined var. *dentata* (Solander).

Very common throughout the region, from low tide to 17 fathoms; more common on the broader algæ and taken wherever these occur.

Membranipora lineata (Linné). [Pl. XXIII, fig. 31, 31a, 31b, 31c.]

Linné 1766–68, p. 1301 (*Flustra lineata*).
Dawson 1859, p. 256.
Packard 1867, p. 272.
Verrill 1879c, p. 29.
Whiteaves 1901, p 96.
Cornish 1907, p. 76.

Zoarium encrusting shells, stones, and algæ, forming small rounded patches. Zooecia of moderate size, the aperture oval or more elongate, surrounded by a rather narrow raised margin, from which project 4 to 6 pairs of spines. These spines are rather slender and pointed, the anterior one or two pairs are bent forward somewhat, and the others are directed upward and curve somewhat over the aperture. A moderate sized avicularium is occasionally present at the base of the zooecium; it is somewhat raised and the beak is rather prominent. Ooecium large, smooth, and shining, with a raised rib crossing it transversely. Seen from the dorsal side the zooecium shows two pairs of lateral pore chambers and a single large anterior one, with spines projecting into the chambers.

This species appears to be rare in this region, and in the course of several years of dredging and other collecting in this group I have found it only a few times. Gay Head on Devils Bridge reef, 2 to 3½ fathoms; Woods Hole harbor on *Fucus*, Vineyard Haven, and Nantucket Harbor on algæ, attached to piles; Crab Ledge, 15 fathoms on stones and shells.

As stated under that species, Leidy's and Verrill's records of *lineata* refer rather to *monostachys*.

Membranipora craticula Alder. [Pl. XXIII, fig. 32, 32a, 32b.]

Alder 1857, p. 144.
Verrill 1879c, p. 29 (as *M. lineata* var. *craticula*).
Whiteaves 1901, p. 96.

Zoarium forming small, usually rounded patches, encrusting shells and stones, rarely on algæ. Zooecia small, arranged usually in radiate series; the membranous area is somewhat elliptical in outline, the raised margin broad and provided with about 14 long spines. The most anterior two pairs are longer and blunter than the others; the first pair is directed well forward, the second pair more erect; and the remaining ones, which are somewhat flattened in cross section, bend forward and downward over the area in a very characteristic manner. On the dorsal side the zooecium strongly resembles *M. lineata*, but there are no spines projecting into the pore chambers. The avicularia are larger than those of *M. lineata* and are raised upon a bulging prominence (dwarf zooecium ?). The ooecia are large, rounded, smooth, and shining, with a raised rib much as in *M. lineata*, except that it is more uniformly bent backward at its middle.

Not uncommon in the outer waters of the region, but not noted in Vineyard Sound or Buzzards Bay. Taken at Muskeget Channel, Great Round Shoal, Crab Ledge, No Mans Land, and Nantucket Shoals. The species is a northern one and has not hitherto been recorded south of Canadian waters.

Membranipora arctica (d'Orbigny). [Pl. XXIII, fig. 33, 33a, 33b, 34, pl. XXX, fig. 86.]

D'Orbigny 1851, p. 571 (*Reptoflustrella*).
Verrill 1879c, p. 29 (as *M. unicornis* var. *sophiæ*).
Whiteaves 1901, p. 96–7 (*M. sophiæ* and the var. *armifera* Hincks).

Zoarium forming more or less circular, grayish or brownish patches on shells and stones, rather coarse, often an inch or more in diameter. Zooecia large, the membranous area oval or sometimes nearly round, the margin furnished with 4 to 6 very stout flattened spines, which are often somewhat contracted at the base and which bend down closely over the area. A pair of small avicularia (occasionally only one) on either side of the opercular opening, with an obtusely pointed mandible directed forward and somewhat toward the midline. Ovicell short, broad, and flattened, in the older parts of the colony deeply immersed, crossed by a raised rib.

In the younger stages a relation is shown to *M. lineata* and *M. craticula*, but *arctica* is a much coarser species; in older stages when the spines are heavily calcified there is a superficial resemblance to species of *Membraniporella*.

Not uncommon at Crab Ledge on shells and stones, 14 to 20 fathoms. Not previously recorded south of the St. Lawrence.

A well-marked variety of this species, var. *armifera*, plate XXIII, figure 34 (Hincks, 1880b, p. 82, *Membranipora armifera*), occurs at Crab Ledge with the typical *arctica*, but it is less common. The general character of the colony and of the zooecia is much the same as in the typical *arctica*, but it differs in the more slender character of the spines, in the presence of a small erect spine situated partly within the margin, just behind and in close relation to the avicularia on one or both sides of the aperture. A large elongate avicularium is sometimes present at the base of the zooecium behind the aperture, situated on a raised base which often overlaps the ovicell of the cell behind so as to appear a part of it. More often the raised base alone is present without an avicularium. Hincks figures the avicularium as pointing forward alongside the aperture, but it may be turned in any direction. He also describes the small lateral avicularia as pointing outward and backward, but in our specimens this condition is seen only in the infertile cells near the center of the colony, while in the zooecia of the same colony bearing ovicells they are directed forward and inward, as in the typical form.

Membranipora unicornis (Fleming). [Pl. XXIII, fig. 35.]

Fleming 1828, p. 536 (*Flustra unicornis*).
Verrill 1879c, p. 29.
Whiteaves 1901, p. 96.

Zoarium encrusting shells, forming rounded whitish colonies. Zooecia large, somewhat translucent, the surface shining; aperture large, oval, somewhat contracted at the anterior end; the margin broad, finely crenulate on its inner edge, and bearing usually four spines near the forward end. The anterior pair of spines is small and erect (often wanting); the other pair is larger and usually unequal, one being much longer than the other, and the longer one may stand nearly erect or bend somewhat over the aperture. The ovicell is large, smooth, and bears a transverse rib. An avicularium is usually present at the base of the zooecium, mounted on a raised projection; when the ovicell is present the avicularium appears to arise from the ovicell, and the mandible is directed somewhat forward, but when the ovicell is absent the avicularium is reversed in position, the mandible pointing backward.

Dredged at Great Round Shoal in 8 fathoms, a number of fine colonies. Not hitherto recorded south of Canadian waters.

Membranipora cymbæformis Hincks. [Pl. XXIII, fig. 36, 36a.]

Hincks 1877, p. 99, 110, 149; 1888, p. 217 (*M. cymbiformis*).
Verrill 1879c, p. 29 (*M. spinifera*).
Whiteaves 1901, p. 96.

Zoarium encrusting the stalks of hydroids, Bryozoa, etc., usually forming small colonies of a very irregular form. Zooecia large, deep, with unusually high walls; the aperture is large and is often slightly bridged over, especially near the base, by a secondary lamina; the margin, which is rather broad, bears about 6 or 8 long erect spines, and usually one or two long pedicellate avicularia which occupy the same position as spines. Ovicells wanting.

Crab Ledge, 14 to 20 fathoms, and off Sankaty Head, ESE, 13 to 20 fathoms, rather common. The colonies are never large, and the best I have seen for study have been on the back of *Bugula murrayana*.

Membranipora aurita Hincks. [Pl. XXIII, fig. 37, 37a, 37b.]

Hincks 1877, p. 213.

Zoarium encrusting, usually on shells, but often on algæ. In the former situation circular colonies are produced and the zooecia are often disposed with extreme regularity, but on the stems of algæ they are generally irregular and the cells sometimes crowded. Zooecia moderately large, considerably narrowed at the anterior third, the walls high, and in the older colonies strongly calcified; entirely membranous in the younger stages, but partly closed by a calcareous lamina when fully calcified (Hincks describes it as entirely membranous); margin broad, finely tuberculate on its inner side, beset with one to four spines which are more or less erect (usually only one or two are found in the adult, and where two are present one is much larger than the other). Ovicell rounded, more or less immersed according to age and calcification, bearing a strong raised rib, which encloses a triangular space on the front of the ooecium and which often rises into a strong umbonate process at the top in old colonies. The avicularia vary in a remarkable manner according to whether an ovicell is present on the zooecium just posterior When no ovicell is present a single avicularium is regularly present with its tip usually pointing backward, but when the ooecium is present there are very constantly two avicularia placed with great regularity on either side of the ovicell and pointing forward and outward. Just how the development of an ooecium, which belongs to another cell, should thus influence the number and position of the avicularia is by no means clear.

Rather common and well distributed, found in Buzzards Bay and Vineyard Sound, Muskeget Channel, Great Round Shoal, and Crab Ledge, dredged in 3 to 18 fathoms. The species is known from England and Denmark, but has not hitherto been reported from American waters.

Membranipora flemingii Busk. [Pl. XXIII, fig. 38.]

Busk 1854, p. 58.
Verrill 1879c, p. 29 (*Mollia flemingii*).
Verrill 1885, p. 530.

Zoarium encrusting shells, stones and occasionally algæ, the outline usually irregular and the cells often crowded and distorted. Zooecia moderately large, usually irregular in outline and in disposition, sometimes so crowded as to be greatly distorted; area expanded below and much constricted at the anterior third, partially bridged over by a calcareous lamina posteriorly and laterally, leaving a somewhat trifoliate membranous area; margin high, granular, with four to six spines, one of which usually attains a much larger size than the others (I have seen no specimens from this region with the flattened scimitar-like spine described by Hincks; the large spine is stout, round and nearly erect). Ovicell rounded, sometimes partially immersed, bearing a raised rib which incloses a somewhat quadrangular space on the front. Avicularia placed one on either side of the ovicell at the base of the zooecium, with the rather elongate mandible turned forward and sometimes a little outward, but in case o ooecium is present there is a single avicularium with its mandible reversed to point backward (often obliquely or even transversely placed). The avicularia are thus similar to those of *aurica* in arrangements and in the influence of the ooecium, but they are not so regular in position and the mandible is more pointed.

Rather widely distributed but not common, taken in Vineyard Sound, Muskeget Channel, Crab Ledge, and off Sankaty Head, dredged in 7 to 20 fathoms. A common European species, recorded from Eastern Greenland, and Verrill has noted its occurrence off Nova Scotia in 234 fathoms.

Membranipora tenuis Desor. [Pl. XXIII, fig. 39, pl. XXX, fig. 87.]

Desor 1848, p. 66.
Verrill and Smith 1874, p. 712.

Desor's description of this species is very inadequate, but there is no other species to which, under the circumstances, he could have referred. I have redredged his type locality and found the species very abundant there. "Cells lobate, more elongated than in *M. pilosa* Pallas, with a plain margin of a pale pink color. Abundant in Muskeget Channel from 3 to 5 fathoms." (Desor, l. c.).

Verrill (l. c.) adds to the above: "Common on pebbles, often covering their whole surface with a delicate, lace-like incrustation, made up of very small, crowded, oval or oblong cells, which have the inner part of the front partly closed over, but with an irregular, mostly three-lobed aperture toward the outer end, which is bordered by small, irregular spinules."

I may state, in addition, that the zooecia are not unusually small for a *Membranipora*, as one might infer from Verrill's description, but are of moderate size. The raised margin is high and finely tubercular on its inner side, and the calcareous lamina is finely punctate; rounded knobs, apparently projecting from the spaces in the angles between the zooecia, are frequently present. Considerable variation is shown in the extent and shape of the calcified lamina, and in the size and shape of the knobs.

Membranipora danica Levinsen (1894, p. 53–54, text-fig. 1 and 2) must be very closely related to, if not identical with *tenuis*, but without the examination of specimens I hesitate to place it positively in the synonymy.

Muskeget Channel (Desor); Vineyard Sound (Verrill). Common and widely distributed throughout the region. Most common on the pebbly and shelly bottoms of Vineyard Sound, Muskeget Channel, and Great Round Shoal; rather scarce in Buzzards Bay, except near shore, owing to the predominance of muddy bottom and the lack of proper attachment.

Membranipora tehuelcha (d'Orbigny). [Pl. XXIV, fig. 40.]

D'Orbigny 1839, p. 17 (*Flustra tehuelcha*).
Waters 1898, p. 674–6 (synonymy of *M. tuberculata* Busk with this species).

Zoarium encrusting on "gulfweed" (*Sargassum bacciferum*), appearing as a beautiful white network against the brown stems and floats of the alga. Zooecia of moderate size, usually rather elongate, and disposed with great regularity when the nature of the substratum will permit. The area is large and elliptical or elongate oval, often somewhat bridged over at the base and on the sides by a calcified lamina, marginal walls high and thin, produced at the anterior angles into a pair of blunt tubercles, which project forward and outward and which are rounded at the top, convex posteriorly, and hollowed out on the anterior (under) side. Ovicells and avicularia absent.

Abundant on the Sargassum drifted into Vineyard Sound from the Gulf Stream, and in the drift on the outer shores of No Mans Land, Marthas Vineyard, and Nantucket Islands. The only bryozoan I have noted on the "gulfweed" and never taken in this region except on this alga. It is distributed world-wide in the tropical and temperate oceans on *Sargas*[illegible].

Family CRIBRILINIDÆ Hincks, 1880.

Genus CRIBRILINA Gray, 1848.

This genus includes all the members of the family occurring within our region. The arrangement of the pores, and especially the development of the calcareous front wall of the zooecium indicates the origin of this wall by the fusion of spines and shows a relation to *Membranipora* through some connecting stage such as we have in the genus *Membraniporella*. The posterior lip of the orifice, as well as the rib over the aperture of the ovicell, may often show their development from spines even in the adult.

KEY TO SPECIES.

Pores disposed in transverse lines or irregularly placed; a small pointed avicularium usually situated on either side of the orifice; ooecium large.......... *punctata*.
Rows of pores more or less radiating, especially on the posterior portion; avicularium wanting; ooecia very small and inconspicuous.......... *annulata*.

Cribrilina punctata (Hassall). [Pl. XXIV, fig. 41, 41a, 41b.]

Hassall 1842, p. 368 (*Lepralia punctata*).
Dawson 1859, p. 256 (*Lepralia punctata*).
Verrill and Smith 1874, p. 713 (*Escharipora punctata*).
Verrill 1875b, p. 41 and 1879c, p. 29 (*Cribrilina puncturata*).
Whiteaves 1901, p. 97.
Cornish 1907, p. 77.

Zoarium encrusting shells and occasionally pebbles. Zooecia small, subcylindrical, perforated more or less irregularly by a variable number of large irregular openings (sometimes in old colonies these may become almost closed), orifice somewhat semicircular, a small mucro in the middle of the lower lip, which may become very strong with age and which is often bifid and may obscure considerably the shape of the orifice; four marginal spines usually present, the posterior pair the larger, and in fertile cells this pair is often curved inward over the opening of the zooecium, the anterior pair in the fertile cells often fused with the mouth of the ovicell. Ooecium subglobose or somewhat elongated, smooth and glossy, perforated by a number of small pores. Avicularia usually two, one on either side of the orifice and pointing obliquely forward and outward.

Taken at various points in Vineyard Sound, but not common. It is found abundantly in the outer waters of the region; Crab Ledge, off Sankaty Head, Great Round Shoal, and Muskeget Channel, dredged in 6 to 20 fathoms. Not noted in Buzzards Bay.

Cribrilina annulata (Fabricius). [Pl. XXIV, fig. 42, 42a, 42b.]

Fabricius 1780, p. 436 (*Cellepora annulata*).
Stimpson 1853, p. 18 (*Lepralia annulata*).
Packard 1857, p. 270 (*Lepralia annulata*).
Verrill 1879c, p. 29.
Whiteaves 1874, p. 11 (*Escharipora annulata*), 1901, p. 98.
Cornish 1907, p. 77.

Zoarium encrusting on stones and shells, forming small rounded colonies of a reddish or brownish color, "*pulcherrima et perfectissima haec omnium visarum*" (Fabricius). Zooecia considerably coarser than in the last species, and usually much less regular in form, the punctures arranged in rows which are transverse anteriorly but toward the posterior end tend to radiate, a median ridge or carina often present; orifice in the young zooecium nearly semicircular or with a small denticle on the lower lip, but in the later stages the lip becomes greatly thickened, and, especially in the fertile cells, where a secondary lip extends over the ovicell, the original nature of the orifice is entirely obscured; usually four short spines project forward on the anterior lip, the anterior pair being smaller and somewhat divergent. The ooecium is small, hemispherical, punctured with a few pores, and overgrown to a varying degree by a secondary lip which is formed by the greatly developed and often fused posterior pair of oral spines. Avicularia wanting. Not infrequently there occur fertile zooecia of smaller size than usual, standing nearly erect between the ordinary zooecia.

Rare and occurring only in the outer waters; Crab Ledge and Nantucket Shoals, 14 to 20 fathoms. These records greatly extend the known southward range of the species, which has not been reported south of the Bay of Fundy (Stimpson).

Family PORINIDÆ d'Orbigny (pars), 1851.

Genus PORINA d'Orbigny, 1851.

This genus is easily determined by the tubular character of the zooecial orifice, together with the presence of an elevated rounded pore on the front wall below the orifice.

Porina tubulosa (Norman). [Pl. XXIV, fig. 43, 43a, 43b, 43c.]

Norman 1868, p. 308 (*Lepralia tubulosa*).
Whiteaves 1901, p. 98.

Zoarium forming small, rounded, white colonies on stones and shells. Body of zooecium recumbent, rather elongate, punctured with small pores which under a high magnification are found to be stellate in appearance; orifice tubular, much extended, more or less erect, thin, often produced irregularly at the margin, a large median pore near the lower part of the tube and surrounded by a projecting ring or tubule. Ooecium small, flattened, situated low down behind the erect tube. In the development of the fertile cell the tubular neck is thus seen to be of secondary formation. Avicularia absent.

Not common, and found only in the outer waters of the region; Muskeget Channel, Crab Ledge, and Nantucket Shoals; dredged in 7 to 20 fathoms. Not previously noted south of the St. Lawrence.

Family MICROPORELLIDÆ Hincks, 1880.

Genus MICROPORELLA Hincks, 1877.

The special median pore, which distinguishes our species in this family, is not always easy to see, since, in some conditions of calcification, it may be more or less hidden in front of an umbonate process. A little experience is necessary also to distinguish it at once from the small avicularia which may have the same position, just below the orifice, in certain other groups. The semicircular form of the zooecial orifice, without any prominence on the posterior, straight, border, is also a good character.

KEY TO SPECIES.

Median pore below orifice sublunate, or more or less semicircular, with a toothed projection extending into the opening from the anterior border. ....*ciliata.*
Median pore circular, with spinules projecting from all sides toward the center ....var. *stellata.*

Microporella ciliata (Pallas). [Pl. XXIV, fig. 44, 44a, 44b, 44c, pl. XXX, fig. 90.]

Pallas 1766, p. 38 (*Eschara ciliata*).
Packard 1867, 270 (*Lepralia ciliata*).
Verrill 1879c, p. 29 (*Porellina ciliata*).
Whiteaves 1901, p. 98.

Zoarium encrusting, on stones or shells, occasionally on algæ, forming silvery or white rounded colonies, often an inch or more in diameter, but usually smaller. Zooecia ovate, or when more crowded, rather elongate hexagonal; when young, thin-walled and silvery and punctured with numerous small pores, when older, and especially in deep water, the calcification proceeds much farther and the walls become much thickened, rough, often flat on the surface or occasionally very gibbous, and the punctures are obscured. Orifice semicircular, the border usually but slightly raised, generally with 4 oral spines curved outward; immediately posterior to the orifice is a special median pore which is usually more or less lunate in form, and with teeth or spinules projecting into it; an umbonate process often occurs just behind the pore, partly or entirely obscuring it from above. Ovicell rounded or slightly elongate, frequently punctured, often sculptured with radiating ridges, and occasionally with an umbonate process at the top. Avicularia, usually one (occasionally two), situated on the side a little way behind the orifice, with a more or less sharply pointed mandible directed, usually, forward and outward.

The species is extremely variable. Depending on the amount and the manner of calcification the zooecium may be thick or thin walled, rough or smooth, flat or gibbous, punctured or entire, umbonate or not. The avicularia vary from short triangulate to very elongate. The pore varies with the size and shape of a projection on its anterior lip; usually this projection is evenly rounded and broad so that the pore is lunate in form, but very frequently the pore is nearly round, with a spinous stalked knob projecting from the anterior border into the pore. This latter condition leads up to the variety *stellata*, in which the pore becomes round and the spinous knob is wanting. There are also enormous differences in the size of the zooecia.

Taken with some frequency in the outer waters of the region. Lower end of Buzzards Bay, both ends of Vineyard Sound, Crab Ledge, Great Round Shoal, and Nantucket Shoals. Dredged in 7 to 20 fathoms.

Microporella ciliata var. **stellata** (Verrill). [Pl. XXIV, fig. 45.]

Verrill 1875b, p. 53, 1879b, p. 190, and 1879c, p. 29 (*Porellina stellata*).

"A large species forming radiate patches on shells, etc. Zooecia arranged in quincunx, large, broad, moderately convex, white shining, mostly imperforate and smooth, the marginal ones more or less perforate in front. Apertures nearly semicircular, the proximal edge straight or nearly so, often with two spines on the distal border; median pore a short distance from the aperture, large, nearly circular, provided with numerous slender, convergent spinules, which nearly reach the center, giving the pore a stellate appearance. Avicularia near the lateral margin, about opposite the median pore, varying in size and form; in the same colony some are short triangular, while others with a long and acute, erect tip show the transition toward vibracula. The zooecia are about twice as large as those of *ciliata*. Casco Bay, Me., U. S. F. C., 1873." (Verrill.)

As every character on which the above description is based is subject to great variation, I can not consider that *stellata* is entitled to rank as a separate species, particularly as a study of a large number of specimens from the North American coast shows so many intergradations. The nearly circular, stellate character of the pore, caused by the absence of any projection on the anterior side, is the only character of any differential importance, and, as I have shown in discussing *ciliata*, this condition is merely the end of a series.

This form occurs with the normal *ciliata* in the eastern end of Vineyard Sound, Muskeget Channel, Great Round Shoal, Crab Ledge, and Nantucket Shoals.

Family MYRIOZOIDÆ Smitt (pars), 1867.

Authors have been at great variance in their use of this family. Smitt (1867) included certain species now placed in the genus *Smittia* of the family Escharidæ, in which family he included the genus *Cellepora*, but later (1872) he included this genus within the limits of this family. Hincks (1880) separated *Cellepora* widely from the Myriozoidæ, following Johnston and Busk in making it the type genus of the family Celleporidæ. On the other hand Jullien and Calvet (1903) have separated the family into two, the Myriozoumidæ to include the genus *Myriozoum*, and Schizoporellidæ to include the remainder of the group, and at the same time have merged the species of *Cellepora* with *Schizoporella*. In the present paper I shall include in this family the genera *Hippothoa*, *Schizoporella* and *Cellepora*, which are all that fall within our region. *Cellepora* appears to the writer to present sufficient relationships with *Schizoporella* to fall within the same family, though it seems best to retain it as a separate genus.

KEY TO GENERA.

1. Adnate, the zooecia more or less distinct and somewhat cylindrical in form, the wall thin and somewhat hyaline, entirely without avicularia.................... *Hippothoa*.
   Encrusting or foliaceous, the zooecia contiguous to form a continuous crust, usually with avicularia.................... 2.
2. Zooecia recumbent, or, when erected, without an aviculiferous rostrum in relation with the orifice, *Schizoporella*.
   Zooecia erected, except sometimes in the very young colonies; an aviculiferous rostrum below or beside the orifice.................... *Cellepora*.

Genus HIPPOTHOA Lamouroux, 1812.

There is a distinct sinus in the posterior border of the orifice, and appendicular organs are wanting; the zooecial wall is not perforated but is more or less rugose transversely; fertile zooecia somewhat reduced in size. The zooecia are always more or less distinct in young colonies, but in older stages of *H. hyalina* they are much crowded.

KEY TO SPECIES.

Zooecia prolonged at base into a tubular portion, usually distinct, not erected.................... *divaricata*.
Zooecia not so prolonged at base, usually forming a crust, often erected in older colonies....... *hyalina*.

Hippothoa divaricata Lamouroux. [Pl. XXIV, fig. 46, 46a.]

Lamouroux 1821, p. 82.
Dawson 1859, p. 256.
Packard 1867, p. 270 (*Hippothoa borealis*).
Verrill 1879c, p. 29.
Whiteaves 1901, p. 100.

Zoarium adnate on stones, shells, and occasionally on algæ. Zooecia elongate pyriform, more or less produced into a peduncle at the posterior end, arranged in a loose branching series; surface smooth or finely striated transversely, often with a median carina; orifice rounded with a sinus in the posterior margin. Ooecia globose, with an umbonate process on top, borne on somewhat dwarfed zooecia. Avicularia wanting.

Rare; taken at either end of Vineyard Sound (Fish Hawk stations 7520 and 7723) and at Crab Ledge in 18 fathoms. Only small colonies of a few cells have been noted. The species is cosmopolitan in its distribution.

Hippothoa hyalina (Linné). [Pl. XXIV, fig. 47, 47a, 47b, 47c.]

Linné 1766–68, p. 1286 (*Cellepora hyalina*).
Dawson 1859, p. 256 (*Lepralia hyalina?*).
Verrill and Smith 1874, p. 713 (*Mollia hyalina*).
Verrill 1879b, p. 193, and 1879c, p. 30
Whiteaves 1901, p. 100 (*Schizoporella hyalina*)
Cornish 1907, p. 77 (*Schizoporella hyalina*).

Zoarium incrusting on stones, shells, algæ, hydroid and Bryozoa stems, etc., in the young colony forming rather regular hyaline patches, especially on flat surfaces, in older colonies very irregular, the cells piled up on each other and often more or less erected, and when on stems forming rough crusts resembling *Cellepora*. Zooecia usually elongate, subcylindrical, and attenuated posteriorly, in young colonies often separated by areolated spaces; surface hyaline, glossy, and transversely grooved; orifice rounded, with a broad, well-defined sinus in the posterior margin, but this is often obscured from above by an overhanging umbonate process. Ooecia globose, punctured, borne on slightly dwarfed zooecia which stand nearly erect among the other cells. No avicularia. The variations are mostly due to the character of the substratum and to crowding.

An abundant species, occurring from low water to 20 fathoms, and distributed throughout the region. Buzzards Bay, Vineyard Sound, No Mans Land, Nantucket, Crab Ledge, and Great Round Shoal. At the last place it was extraordinarily abundant, encrusting the stems of hydroids. It is a cosmopolitan species.

Genus SCHIZOPORELLA Hincks, 1880.

This genus presents a great range of variability, embracing practically all the characters. Perhaps the most constant feature is that which suggested the name, the presence of a distinct notch or sinus in the posterior border of the primary zooecial aperture. In many cases this is obscured in older zooecia by secondary calcification, but the examination of the younger cells of the colony will show the character. The absence of denticles projecting from the lateral or posterior border into the orifice is also useful in separating the genus from certain of the Escharidæ.

KEY TO SPECIES.

1. Avicularia usually present, surface punctured, ovicell without special pore at the summit .... 2.
   Avicularia absent, the ovicell with a special pore, primary orifice usually obscured.........*sinuosa.*
2. Avicularia pointed, usually placed on one or both sides of the lower border of the aperture with the mandible pointing forward and outward, occasionally reversed or otherwise placed .*unicornis.*
   Avicularia rounded or spatulate, not pointed .... 3.
3. A small oval avicularium on a raised projection at either side of the orifice (often on only one side), ovicell with a depressed area traversed by radiating furrows.........................*biaperta.*
   A small rounded avicularium situated centrally immediately below the sinus (occasionally wanting); depressed area of ovicell with regularly arranged pores instead of furrows............*auriculata.*

Schizoporella unicornis (Johnston). [Pl. XXV, fig. 48, 48a, 48b, 48c, 48d, 48e, pl. XXX, fig. 91.]

Johnston 1847, p. 320 (*Lepralia unicornis*).
Desor 1848, p. 66 (*Lepralia variolosa*).
Leidy 1855, p. 142 (*Escharina variabilis*).
Verrill and Smith 1874, p. 713 (*Escharella variabilis*).
Verrill 1875b, p. 41 (*Hippothoa variabilis*); ibid, p. 41, pl. iii, fig. 1 (*Hippothoa reversa*, n. sp.); 1879b, p. 193, and 1879c, p. 30 (*Escharina isabelliana* D'Orbigny, *E. reversa* Verrill, and *E. ansata* Gray).

Zoarium forming a reddish incrustation, often many layers in thickness, on anything which will afford attachment, most frequently on shells, stones, and worm tubes, though the largest colonies I have seen were on the bark of wooden piles; occasionally the colony rises into free expansions of a very irregular form which are low. The color varies in life from pale orange to a dark brick-red, sometimes colorless and shining in deeper water. Zooecia more or less ovate, hexagonal, or rectangular, often broad and squarish, sometimes rather flat and again very gibbous, the surface sometimes smooth and glossy, but more often rough and tuberculate; punctured with a variable number of small pores which have no apparent order of arrangement, occasionally forming irregular areolæ around the margin; an umbo of variable size immediately below the orifice, not infrequently wanting; the cells may be separated by a deep groove, or a raised wall may be present around the border (form *ansata*); orifice semicircular or subcircular, the posterior border nearly or quite straight, with a rather large rounded sinus, no raised peristome or oral spines. Ovicell subglobose, not immersed, punctured, usually rather smooth near the orifice and more or less grooved in a radiating manner on the sides, often very rough when fully calcified, and not infrequently bearing a rounded umbo at the top. Avicularia one or two, placed laterally just behind the orifice, the mandible, which is usually short triangular, but may be elongated, points forward and outward in the usual form, though in the form *reversa* it points backward and outward; usually at least one avicularium is present, but not infrequently they may be lacking over a large part of the colony.

The species shows an endless amount of variation in almost all the characters except the orifice, which is fairly constant. The var. *ansata* (Johnston) with the raised border separating the zooecia is commonly found in deeper water, though the ordinary form may occur alongside of it. Verrill's *Hippothoa reversa* was based on the reversed avicularium and is a pure synonym, since this condition may occur in the same colony with normally placed avicularia, and all sorts of intermediate conditions occur.

One of our most abundant and characteristic species, found almost everywhere except on bottoms of pure mud and sand where nothing exists to afford attachment. Not taken in the outermost dredgings at Crab Ledge and off No Mans Land. Taken from low water to 19 fathoms.

Schizoporella biaperta (Michelin). [Pl. xxv, fig. 49, 49a, 49b.]

Michelin 1841–42, p. 330 (*Eschara biaperta*).
Verrill 1875b, p. 41 (*Hippothoa biaperta*); 1879b, p. 193, and 1879c, p. 30 (*Escharina biaperta*).
Whiteaves 1901, p. 100.

Zoarium incrusting or rising into free expansions. On stones and shells it forms smooth flat colonies with a more or less regular outline, on algæ and hydroid or other stems usually forming shelf-like expansions, often of great beauty; color in life varying from white or translucent to bright pink or red. Zooecia ovate or hexagonal, more or less gibbous, punctured (at least in the younger stages) by small pores; surface smooth and glossy, becoming rough and dull with advancing calcification; separated by a raised border which may be obscured by later calcification; orifice subcircular, the posterior border straight with a rather wide sinus, peristome not raised except in the fertile cells, when it may extend upon the ovicell; no oral spines. Ooecia rounded in outline, often considerably impressed, upper surface flattened, with radiating lines, the flattened area surrounded by a thick border rising from the base. Avicularia one or two with rounded or oval mandible, situated on a rounded prominence at the side of and facing toward the orifice. The mamillate processes bearing large pointed avicularia, which Hincks states are common, seem to be very rare in this region.

A large amount of variation is exhibited, but most of it is traceable to the degree of calcification. The characters of the ooecium and of the oral avicularia afford the best criteria for identification.

An abundant species, well distributed throughout the region, and dredged in 3 to 20 fathoms. Buzzards Bay, Vineyard Sound, Muskeget Channel, Great Round Shoal, Crab Ledge, No Mans Land (drift).

Schizoporella auriculata (Hassall). [Pl. xxv, fig. 50, 50a.]

Hassall 1842, p. 411 (*Lepralia auriculata*).
Packard 1867, p. 408 (*Lepralia globifera*)
Verrill 1875a, p. 414 (*Escharella auriculata*); 1879b, p. 192–3 (*Smittia globifera*); and 1879c, p. 30 (*Smittia auriculata* and *globifera*).
Whiteaves 1901, pp. 100 and 106 (as *Schizoporella auriculata* and *Smittia globifera*).

Zoarium encrusting, often quite irregular, on stones and shells, and occasionally on hydroid stems, in which case it may rise free for a short distance, varying from colorless to reddish or yellowish. Zooecia usually quadrangular and disposed in linear series, with a well-developed raised border, more or less punctate, with a well-defined series of large areolæ around the edge of the cell next to the border; in older stages of calcification the surface may become very rough and ribbed, but the marginal areolæ remain distinct; orifice subcircular with a rather broad but well-defined sinus in the posterior margin. Ooecia large, rounded, raised, or occasionally more or less immersed; the upper surface somewhat flattened, punctate, often radiately striate, with a thin border surrounding the flattened area. A small avicularium with a broadly rounded to somewhat pointed mandible is centrally placed just posterior to the orifice, sometimes projecting forward so as to obscure the sinus and the orifice to some extent. Hincks mentions a large avicularium which sometimes replaces the small one, but I have not seen this in our specimens.

This is the *Lepralia globifera* of Packard which Verrill placed at one time under *auriculata*, but later (1879) separated as *Smittia globifera*. The presence of a well-defined sinus seems sufficient to place it in Schizoporella, and a comparison with European material of *auriculata*, as well as the study of numerous specimens from this region indicates that *globifera* is not entitled to specific rank.

Variations; border sometimes raised high above the cell, even higher than the avicularian prominence; ooecia sometimes raised, again partly embedded; size showing considerable range even in the same colony; avicularium varying slightly in size and in form of mandible, in fully calcified, fertile cells the oral margin may be secondarily raised and a strong rib may extend from the ovicell around to the avicularian prominence.

Crab Ledge in 15 to 20 fathoms; Great Round Shoal in 8 fathoms; Nantucket Shoals in 18 to 25 fathoms; not uncommon.

Schizoporella sinuosa (Busk). [Pl. xxv, fig. 51, 51a.]

Busk 1860, p. 125 (*Lepralia sinuosa*).
Verrill 1879b, p. 193, and 1879c, p. 30 (*Escharina secundaria*).
Whiteaves 1901, p. 100.
Cornish 1907, p. 77.

Zoarium encrusting on stones and shells, forming dark reddish, purplish, or brownish colonies, usually circular in outline. Zooecia ovate or rhomboid, usually sinuate at the border, which is not raised except in very young cells; in the young stage, convex, but later immersed by calcification in an almost even crust; punctured with small pores, surface rather regularly granular; orifice in young cells subcircular, the posterior margin with a well-marked sinus, but with further calcification the primary orifice is overgrown, becoming more or less orbicular with some indication of a sinus at the posterior margin. Ooecia large, deeply immersed in the zoarium, somewhat flattened, with a rounded pore at the top. Avicularia wanting. I have not seen the small avicularium which Hincks describes as present in the variety *armata*. The variations seem almost entirely due to calcification. Taken only at Crab Ledge where it occurs with some frequency in 15 to 20 fathoms. Not previously recorded south of Canada.

Genus CELLEPORA Fabricius (pars), 1780.

This genus is easily distinguished among others of our region by the erected cells, coupled with the presence of a sinus in the posterior margin of the orifice, and a large aviculiferous rostrum behind the orifice.

KEY TO SPECIES.

Rostrum pointed, with the avicularium borne on one side at the base .... *americana*.
Rostrum tall and spout-like, with a rounded avicularium at the top .... *canaliculata*.

Cellepora americana, new species. [Pl. xxv, fig. 52, 52a, 52b, pl. xxxi, fig. 99.]

Verrill and Smith 1874, p 714 (*Cellepora ramulosa*).
Verrill 1879c, p. 30 (*Cellepora avicularis*).

Zoarium encrusting or rising into nodular branches a few millimeters in height, growing on hydroid and Bryozoa stems, algæ, etc., the colonies usually very irregular in form. Zooecia somewhat ovate or pyriform, more or less erect, usually much crowded and irregularly disposed, heaped upon each other and turned in various directions; punctured irregularly around the base, surface smooth and shining; orifice subcircular with a V-shaped sinus in the posterior margin; peristome thin and raised, flaring somewhat outward, in fertile cells present on the sides only, where it projects in labiate processes; a prominent mucronate rostrum just behind and often a little at one side of the orifice, which it overhangs to some extent; an avicularium with an oval mandible is borne at the base laterally and somewhat internally. Ooecia rounded in outline, prominent, flattened above, smooth, with a number of punctures.

This species is evidently related to *C. avicularis* Hincks, and shows this relation in the character of the ovicell, the form of the sinus, the punctured surface, and the manner of growth. It presents a number of important differences, however, such as the higher peristome which becomes bilabiate in the fertile cell, the position of the avicularium which is at the base of the rostrum and is directed laterally and but slightly upward, in the much greater development of the rostrum above the avicularium, in the absence of the small lateral avicularia and the large pointed avicularia described by Hincks for *avicularis*. It may possibly prove to be only a variety of *avicularis*, but after careful comparison with specimens of that species from England, I believe it to be sufficiently different to rank as a separate species.

Abundant in Vineyard Sound, not common but well distributed in Buzzards Bay, dredged in 1 to 19 fathoms; also in drift on the shores of No Mans Land and Nantucket, and near Sandwich on the north shore of Cape Cod.

Cellepora canaliculata Busk. [Pl. xxv, fig. 53, 53a, 53b, pl. xxxi, fig. 98.]

Busk 1884, p. 204.
Verrill 1879c, p. 30 (*C. tuberosa*).
Whiteaves 1901, p. 109.

Zoarium encrusting on stems of hydroids and Bryozoa, usually in rounded "pisiform" colonies, but I have one fine specimen taken at Crab Ledge which has an irregular branching structure. Zooecia somewhat ovate in young colonies, punctured around the base, smooth, in older colonies the cells erect, or nearly so, and very irregularly disposed, orifice rounded with a rather broad sinus; back of the orifice rises a stout, elongate, curved rostrum, bending somewhat over the orifice and bearing at its tip a small round avicularium; from the sides of the thin peristome a broad flange rises to the sides of the rostrum, producing a broad spout at the bottom of which the primary aperture is situated. Ovicell rather large, broader than high, flattened above near the orifice, irregularly punctured.

Taken only at Crab Ledge in 15 to 20 fathoms, where it seems to be well developed but not common. The type locality of the species was near Halifax, Nova Scotia, in 51 fathoms (Challenger); and the species has subsequently been taken in the Gulf of St. Lawrence.

Family ESCHARIDÆ Smitt (pars), 1867.

This rather heterogeneous family is distinguished among the others of our region rather by the absence of certain characters than by the presence of well-marked structures constant for the group. In the form of the primary zooecial orifice the different genera exhibit a wide range. From the families with a semicircular orifice (Cribrilinidæ and Microporellidæ) the absence of a special pore and the formation of the zooecial wall are sufficiently distinctive, while from the Myriozoidæ the absence of a distinct sinus in the posterior margin of the primary orifice is characteristic, though it may require careful scrutiny of the younger zooecia to determine this, since a sinus may appear secondarily in the peristome. In general, the family is characterized by the great development of secondary characters, and the appendages are extremely varied.

KEY TO GENERA.

1. Primary orifice without posterior tooth or shelf, no suboral avicularium, spine or mucro, secondary orifice, when raised, never sinus-like at the posterior margin. . . . . *Lepralia*.
   One or more such characters present . . . . 2.
2. Posterior margin of orifice more or less developed into an overhanging prominence or mucro which never bears an avicularium. . . . . *Mucronella*.
   Posterior margin of orifice not mucronate, or, if so, the mucro bears an avicularium on the side or at the tip . . . . 3.
3. A prominent suboral mucro (usually placed a little to one side of the median line) bearing an avicularium on its side, sometimes a similar projection (without an avicularium) on the opposite of the midline; orifice very large; zooecial wall delicate and shining. . . . . . . *Rhamphostomella*.
   Characters otherwise . . . . 4.

4. A small avicularium situated at the apex of a prominence immediately below the orifice in the median line and often included within the sinus-like fold of the secondary orifice......... *Porella.*
Oral avicularium absent, or, if present, larger and not mounted on a definite rostrum, a prominent tooth or shelf-like projection on the posterior border of the primary orifice (occasionally absent), *Smittia.*

Genus LEPRALIA Johnston (pars), 1849.

Zoarium in our species encrusting, or rarely rising free for a few millimeters; zooecial orifice without mucro or avicularium, peristome raised or not; lateral margin of the orifice with a small denticle on each side toward the posterior border, no sinus, but sometimes the posterior border rounded between the denticles so as to give at first glance the appearance of a very broad sinus.

KEY TO SPECIES.

1. Orifice large, elongate, distinctly widened near its posterior end; ooecia and avicularia wanting, *pallasiana.*
Orifice smaller, more rounded, or if elongate, not widened posteriorly, ooecia and avicularia present, at least occasionally .... 2.
2. Oral margin anteriorly with its inner edge finely serrate, lateral denticle large, bifid; avicularia abundant, usually of two sizes; ooecium broader than long, with a transverse membranous area above orifice.................................... *serrata.*
Without such characters .... 3.
3. Zooecial and ooecial pores small and numerous; zooecial orifice rounded, the transverse diameter often slightly the longer; the projecting marginal denticles give the rounded posterior border the appearance of a very broad sinus.................................... *pertusa.*
Zooecial and ooecial pores few and large; zooecial orifice more quadrangular, usually somewhat widest posteriorly.................................... *americana.*

Lepralia pallasiana (Moll). [Pl. XXV, fig. 54, pl. XXX, fig. 89.]

Moll 1803, p. 57 (*Eschara pallasiana*).
Leidy 1855, p. 9 (*Escharina pediostoma*).
Verrill and Smith 1874, p. 713 (? *Lepralia pallasiana*).
Verrill 1875a (pl. VII, fig. 5 under *L. americana*, n. sp.).
Cornish 1907, p. 77.

Zoarium encrusting shells, stones, submerged wood, and algæ, the colonies circular when the nature of the substratum will permit, sometimes as much as 2 inches in diameter. Zooecia large, often quadrangular or roughly hexagonal, but varying greatly in this respect; somewhat convex and rising toward the orifice, punctured with rather large pores, in young stages smooth and glossy, when older often rough, with thick ridges between the pores; orifice large, considerably longer than wide, widened rather suddenly near the posterior end, with a small denticle on either side just in front of the expanded portion; peristome thin, smooth, and only slightly raised in our specimens. Ovicells are unknown in this species and avicularia are apparently wanting in specimens from this region. An umbonate process is sometimes present below the orifice.

Well distributed throughout the region from low water to 8 fathoms or deeper, best developed in the shallower waters. Woods Hole, New Bedford, and Nantucket harbors, on piles, West Falmouth harbor in shallow water, Cedar Tree Neck at low tide, Buzzards Bay, Vineyard Sound and Great Round Shoal.

The species has been recorded from Canadian waters at Canso only (Cornish). Leidy figured it as *Escharina pediostoma* from Beesley's Point, N. J. Verrill had it among his material, for one of his figures (fig. 5) of *L. americana* is unquestionably *pallasiana*. I have specimens from Long Island Sound and from the north shore of Cape Cod, near Sandwich.

Lepralia americana Verrill. [Pl. xxv, fig. 55, 55a.]

Verrill 1875a, p. 415, name only, with pl. VII, fig. 4 (fig. 5 is *L. pallasiana* instead of *americana*).
Verrill 1875b, p. 42, name only, with distribution; 1879c.
Davenport 1891, p. 47 (*L. pallasiana*).

Zoarium encrusting on shells, stones, etc., forming rather rough whitish to reddish colonies, often everal cells in thickness. Zooecia large, but averaging smaller than *L. pallasiana*, roughly quadrangular or hexagonal, slightly convex and rising, often suddenly, to a more or less prominent umbo behind the orifice; surface in young specimens always rather coarsely cancellated with large pores, very roughly ribbed (sometimes radiately) in older stages of calcification; a raised border often separates the cells in young colonies, but this is frequently overgrown later by the thickening of the crust; orifice usually a little quadrangular, slightly longer than broad, but sometimes nearly rounded, a denticle on either side of the orifice near the posterior end, the aperture not widened behind the denticles, peristome thin, slightly raised, often forming a sort of projecting lip on either side of the orifice. Ooecia large, subglobular, occasionally partly immersed, with a few very large, irregular pores on the upper surface. A rounded avicularium is often present below the aperture at the top of the umbo.

This species differs from *pallasiana* in the form of the zooecial aperture, in the possession of ovicells, in the occasional possession of a raised border separating the cells, and in the more radiately ribbed character of the calcification.

Verrill very evidently confused this species with *pallasiana*. He gives no verbal description, but his figure 4 (see above) is sufficient for identification. His figure 5, labeled "the same without ootheca," is *L. pallasiana*, however.

Under the circumstances, it is manifestly impossible to quote Verrill in regard to the range of the species, as in his earlier papers he placed everything in "?*L. pallasiana*," and later called them all *americana*. In this region the species is well distributed, being rather common in Vineyard Sound, Muskeget Channel and Great Round Shoal, not common in Buzzards Bay, scarce at Crab Ledge, and found occasionally on piles at Woods Hole and Nantucket. I have also seen specimens from Nantucket Shoals and Long Island Sound. In general, it occurs in deeper water than *pallasiana*, but occasionally they are found together.

Lepralia pertusa (Esper). [Pl. xxvi, fig. 56, 56a, 56b, 56c.]

Esper 1791–1797, p. 149 (*Cellepora pertusa*).
Dawson 1859, p. 256.
Verrill 1879b, p. 414 (*Escharella pertusa?*).
Verrill 1870, p. 193 (*Escharina porosa*, n. sp.).
Hincks 1892, p. 154.
Whiteaves 1901, p. 101.
Cornish 1907, p. 77.

Zoarium encrusting stones and shells, and occasionally algæ, forming colonies often of considerable extent, of various shades of red or when young, silvery white. Zooecia ovate or more or less oblong, rhomboid or hexagonal, regularly convex, separated by raised lines, surface smooth and glossy when young, often considerably roughened when fully calcified, punctured with numerous rounded pores, sometimes rising to a rough umbonate process behind the orifice; orifice rounded, a pair of lateral denticles, behind which the oral margin is curved but without a distinct sinus, peristome slightly raised and thickened, smooth. Ooecium large, prominent, subglobular, somewhat flattened above, punctured, smooth, or the upper surface roughened and a smooth border around the base; in specimens from deeper water the whole ovicell is usually roughened when fully calcified and an umbonate process occasionally rises from the top. Avicularia rare, but occasionally a small oval one is seen at one side of the orifice with the mandible turned somewhat obliquely either toward or away from the orifice.

Very material differences exist in the size of the zooecia, but otherwise the variations are almost entirely due to the amount of calcification. I have not observed in our specimens the large avicularia figured by Hincks (1880, pl. XLIII, fig. 4) but a specimen from Cashes Ledge given me by Prof.

Verrill and labeled "*Escharella candida* Stimpson" has these exactly as in Hincks figure. Verrill's *Escharina porosa* is *L. pertusa* with the small avicularia at the side of the orifice, and it may possibly be worthy of a varietal rank, but it seems to intergrade with the ordinary form entirely, and the avicularia are but rarely developed. A comparison with British specimens of *pertusa* shows a close agreement in the essential characters of the species.

Occurs commonly throughout the Woods Hole region, dredged in 3 to 20 fathoms, Vineyard Sound, Buzzards Bay, Great Round Shoal, Crab Ledge. The species is cosmopolitan, and on our coast occurs from Florida to Labrador and Greenland.

Lepralia serrata, new species. [Pl. XXVI, fig. 57, 57a, 57b, 57c.]

Zoarium encrusting, usually on stones and shells, occasionally on algæ, at first smooth in subcircular colonies, later piling up into a rough crust of several layers of cells, occasionally rising free into irregular frill-like projections a few millimeters in height. Zooecia roughly ovate or hexagonal, convex, becoming very gibbous with age when distinct, but usually the cells unite as calcification proceeds and become immersed in the common crust; surface rather smooth in the very young cells, vitreous and shining, with a row of perforations around the margin, later the surface becomes very rough and the perforations may or may not persist; orifice longer than broad, ovate, broader anteriorly, with a large bifid denticle on either side posteriorly, dividing the orifice into a larger, anterior portion, the margin of which is finely and evenly serrate, and a smaller posterior portion with a smooth border; the denticle has its points widely divergent, the posterior point being the larger; four or five stout spines project forward from the oral margin in the young cell, but these are deciduous and their bases are covered by the later calcification; a secondary raised wall, often with a strong projecting mucro, rises high about the aperture, giving it an entirely different appearance, but the primary orifice with its denticles and serrated inner margin can be distinguished at the bottom. The ovicell is very striking and characteristic, very prominent, smooth, nearly hemispherical, with a large, somewhat semilunate membranous area on the side next the aperture, with a calcified area between this and the ooecial orifice. Avicularia immersed, or mounted on a mamillate process, ovate to nearly spatulate in outline, occasionally wanting, but usually one to several, very irregularly arranged, usually small but often large; the avicularian aperture, when the mandibles are removed, often finely serrate like the oral margin.

There is an enormous amount of variation in the extent and character of the calcification, in the shape of the secondary orifice, and in the size and arrangement of the avicularia, but the characters of the primary orifice and ovicell are very constant. Colonies growing on algæ in Buzzards Bay (Phalarope station 131) have very elongate oral spines, as long as the whole zooecium. The specific name chosen refers to the serrate inner border of the primary orifice, a character which is unique in this genus, as far as my knowledge goes. The species shows resemblances to *L. edax* Busk and to *L. contracta* Waters, but there are many differences which distinguish it.

Vineyard Sound and the lower part of Buzzards Bay, common, 5 to 15 fathoms, Muskeget Channel in 7 fathoms, Great Round Shoal in 8 fathoms, Crab Ledge in 14 to 20 fathoms. I have also seen specimens in the United States National Museum collection from Nantucket Shoals and from Long Island Sound.

Genus MUCRONELLA Hincks, 1880.

KEY TO SPECIES.

1. Avicularia present, one on either side of the aperture, which is large; ovicell wanting...... *pavonella.*
   Avicularia wanting, ovicells present.. 2.
2. A pointed mucro behind the orifice, peristome not raised unusually high, zooecia small, but little convex, becoming flat with age.. *peachii.*
   Peristome raised very high, forming a spout-like or tubular erect structure, the mucro very large and broad, zooecia larger, very convex, not becoming flat with secondary calcification. . *ventricosa.*

Mucronella peachii (Johnston). [Pl. XXVI, fig. 58, 58a.]

Johnston 1847, p. 315 (*Lepralia peachii*).
Dawson 1859, p. 256 (*Lepralia peachii*).
Verrill and Smith 1874, p. 714 (? *Discopora coccinea*).
Verrill 1879b, p. 195, and 1879c, p. 31 (*Escharoides coccinea*).
Whiteaves 1901, p. 107.

Zoarium encrusting on stones and shells and occasionally on algæ, usually irregular in outline but the cells arranged with considerable regularity. Zooecia rhomboid, not separated by raised lines or deep grooves, rather flat above, surface in young cells smooth with a row of large pores around the margin; raised ribs then appear between the pores, forming radiate grooves with the pores at the bottom, and, finally, with complete calcification, the original surface is completely covered and the pores may be obliterated; primary orifice longer than wide, rounded anteriorly, nearly straight behind, with an emarginate or bifid tooth, the lateral denticles well developed, peristome slightly raised, produced behind into a mucro and with six slender oral spines. Ooecia globose, smooth, imperforate, prominent at first, but later more or less immersed. Avicularia wanting. The variations are almost entirely due to calcification.

Vineyard Sound; Muskeget Channel; Great Round Shoal; Crab Ledge, and off Sankaty Head; dredged in 6 to 20 fathoms. Verrill records the species as very abundant in Vineyard Sound and Quicks Hole, but the results of our survey indicate that it is not common except locally in the inner waters of the Sound.

Mucronella ventricosa (Hassall). [Pl. XXVI, fig. 59, 59a.]

Hassall 1842, p. 412 (*Lepralia ventricosa*).
Verrill 1879c, p. 31 (*Escharoides coccinea* var. *ventricosa*).
Whiteaves 1901, p. 107.

Zoarium encrusting, forming whitish or silvery patches, usually irregular in outline, with the cells radiating in rather regular linear series. Zooecia large, usually regularly disposed, swollen and ventricose, separated by deep grooves, a series of small areolæ about the margin, the surface smooth in very young cells but soon becoming granular with minute rounded tubercles, which are generally arranged in radiating lines; primary aperture rounded in front, straight behind with a large bifid denticle; peristome raised very high and spout-like, thin on the sides, behind rising into a broad and often massive prominence which may or may not bear a rounded umbo at its apex; four stout oral spines are present in the young cell, generally curving over the aperture in the fertile cell, but usually lost as the peristome rises. Ovicell nearly globose, not impressed in our specimens, the surface granular when fully calcified. Avicularia absent.

The species is easily distinguished from *M. peachii* by its much larger size (averaging about twice as large), by its much more convex form, and by the mode of secondary calcification. It never becomes flattened as in *peachii;* the grooves separating the zooecia are very deep, and the peristome is raised into an erect, almost tubular, form. The mucro is much broader than in *M. peachii*.

Taken rather rarely at Crab Ledge, growing on stones and shells, at 14 to 20 fathoms.

Mucronella pavonella (Alder). [Pl. XXVI, fig. 60.]

Alder 1864, p. 106 (*Eschara pavonella*).
Verrill 1879b, p. 195, and 1879c, p. 30.
Whiteaves 1901, p. 107.

Zoarium encrusting on stones and shells, or forming fan-shaped expansions on hydroid and other stems. Zooecia large and regularly arranged, convex and areolated around the margin, and rising toward the orifice in the young cell, but soon becoming flat with a secondary calcified layer which often closes the areolæ, orifice very large, rounded, with a small posterior tooth, which varies in shape, but which is usually blunt; peristome thin, smooth, unarmed, and but slightly raised. Ooecia wanting. Avicularia oval, somewhat raised, situated one on either side of the orifice and close to it, with the mandible pointing forward.

Crab Ledge, in 14 to 20 fathoms, not common, two colonies on a shell of *Modiolus modiolus* in United States National Museum collections, labeled "Vineyard Sound, 1875, station 4708."

Genus RHAMPHOSTOMELLA Lorenz, 1886.

Among the other genera of this family, *Rhamphostomella* may be easily distinguished by the presence of the large orifice, together with a prominent mucro which bears an avicularium on the side. The zooecial wall is generally thin and delicate.

KEY TO SPECIES.

1. A single suboral rostrum .... 2.
   Two projections behind the orifice, one of which, usually larger, bears the avicularium .... *bilaminata.*
2. Rostrum high, surface of zooecium strongly ribbed .... *costata.*
   Rostrum not so high, surface not strongly ribbed .... *ovata.*

Rhamphostomella bilaminata (Hincks). [Pl. XXVI, fig. 61, 61a.]

Hincks 1877, p. 30 (*Cellepora bilaminata*).
Verrill and Smith 1873, p. 714 (*Cellepora scabra* pars).
Verrill 1879b, p. 195, and 1879c, p. 30 (*Mucronella scabra* pars).
Whiteaves 1901, p. 108.

Zoarium encrusting hydroid stems, etc., often rising into small fan-like or shelf-like expansions. Zooecia large, the walls thin and glassy, imperforate, convex above, occasionally more or less radiately ribbed, but the ribs do not run up on the rostrum; orifice very large, rounded or irregular in front, straighter behind, with a small denticle centrally placed, the thin peristome rises behind the orifice into a double fold with a deep notch between the lip-like projections, and through this notch the denticle is visible; the median lateral surface of one of these projections bears an avicularium, though the avicularium is occasionally wanting and rarely there is one on each side of the notch. Ooecium hemispherical, smooth and punctured, very large, usually obscuring half of the aperture of the cell and the base of the cell in front as far as the rostrum; when fully calcified a rib or margin often rises about the base of the ovicell.

Taken at a number of points in Vineyard Sound and Buzzards Bay; common at Crab Ledge and Great Round Shoal. Verrill's references to *Cellepora scabra* include both this species and *R. costata*, as I have determined by a study of his specimens. I believe, however, that Verrill's record "Vineyard Sound and Quicks Hole" refers to *bilaminata* alone, since it is more common in the region than *costata* and is the only one I have observed in the inner waters of the Sound and Bay. The species ranges northward to Greenland.

Rhamphostomella costata Lorenz. [Pl. XXVI, fig. 62, 62a, 62b, pl. XXXI, fig. 100.]

Lorenz 1886, p. 12.
Hincks 1889, p. 426.
Whiteaves 1901, p. 108.
?Verrill and Smith 1874, p. 714 (*Cellepora scabra*, pars).
Verrill 1879b, p. 195, and 1879c, p. 30 (*Mucronella scabra*, pars).

Zoarium encrusting stems of various sorts, forming frill-like or fan-like expansions which rise free to a height of a half inch or more. Zooecia large, the walls thin, glassy and imperforate, convex above and rising very rapidly to the base of a very high, large rostrum; there is a row of areolæ around the margin and between these there are strong radiating ribs which run up on the rostrum; orifice very large, rounded in front, straighter behind with a small tooth in the middle; peristome very thin and without oral spines in our specimens; the rostrum is enormously developed, the costal ribs run up on it, and it bears on its antero-lateral face a large pointed avicularium with the mandible turned upward; occasionally a large pointed avicularium on the front wall of the cell. Ooecia very large, usually obscuring half of the orifice and the base of the cell in front to the base of the rostrum; surface smooth, punctured.

The cell shows a great amount of variation from the young to the adult, depending on the amount of calcification, and when the ooecia are plentifully developed the general appearance of the colony is much changed. The front of one cell often overlaps the base of the one anterior to it, especially when the cells are crowded. A transverse bar is occasionally developed on the top of the rostrum (var. *cristata* Hincks). The secondary calcified layer covering up the costæ, common in northern specimens, is seldom developed in this region and I have seen the large, pointed avicularia, described by Hincks, only rarely in specimens from this region.

Taken at Crab Ledge, where it is common in 14 to 20 fathoms, and at Great Round Shoal in 8 fathoms, where it is scarce. A specimen in Verrill's collection is labeled "*Discopora scabra*, Nantucket Shoals." The species ranges northward to the Arctic Ocean.

Rhamphostomella ovata (Smitt). [Pl. XXVI, fig. 63, 63a.]

Smitt 1867, p. 31 (*Cellepora ovata*).
Verrill 1879b, p. 195, and 1879c (*Mucronella ovata*).
Whiteaves 1901, p. 108.

Zoarium encrusting stones and shells. Zooecia large, slightly convex, with large punctures and a series of marginal areolæ, between which arise strong costæ running only a short distance toward the center; in older cells the punctures and areolæ are more or less closed over; orifice large, ovate (or subcircular), with the pointed end posterior, the median tooth wanting; peristome slightly raised, and behind the orifice and a little to one side, developed in connection with the peristome, a strong, blunt, smooth rostrum which bears an oval avicularium on its median side. Ooecia subglobular, prominent, smooth, imperforate or very finely punctured, sometimes with a single median pore.

Rare in this region, but occurs occasionally at Crab Ledge in 14 to 20 fathoms. I have seen one specimen from Vineyard Sound, a single colony in the United States National Museum collection, taken in 1875 at station 4708, and others in the same collection from Nantucket Shoals. The species is a northern one and has been reported only from Canadian waters.

Genus SMITTIA Hincks, 1879.

In this genus the presence of a tooth or shelf-like protection on the posterior margin of the zooecial orifice is usually distinctive, but it is not possible to draw the limits sharply. The tooth may occasionally be wanting, as in *S. porifera;* again the shelf is present in *Porella concinna*, a species which Jullien and Calvet place in the genus *Smittia* on this account, but which has generally been placed in *Porella*. The lateral denticles of the primary orifice are well developed, but they may be equally so in *Lepralia*. The avicularia, ooecia, and zooecial walls offer no distinctive characters.

KEY TO SPECIES.

1. Orifice rounded posteriorly, with a small, usually pointed, denticle or none; an avicularium immediately behind the orifice .... *porifera*.
   Orifice more straight on the posterior margin, the denticle broader, without an avicularium close behind the orifice .... 2.
2. Large, pointed avicularia in addition to others .... *trispinosa*.
   Large, pointed avicularia wanting .... *trispinosa*, var. *nitida*.

Smittia porifera (Smitt). [Pl. XXVI, fig. 64.]

Smitt 1867, pp. 9 and 70 (*Escharella porifera*).
Verrill 1879b, p. 192, and 1879c, p. 30 (*S. landsborovii*).
Hincks 1888, p. 225, and 1892, p. 156.
Whiteaves 1901, p. 105 (*S. landsborovii* var. *porifera*).

Zoarium encrusting stones, shells, and stems of various sorts, flat and smooth or more or less irregular. Zooecia large, ovate or more or less elongate, separated in the young colony by slightly raised borders which are usually obliterated later by calcification of the front; surface at first smooth and shining, perforated by numerous rounded pores, becoming rougher with age; orifice rounded, with a small posterior tooth which is pointed or bifid or occasionally entirely wanting; immediately behind the orifice is an oval avicularium with the rounded mandible turned upward; peristome thin, more or less raised, when fully developed partly surrounding the avicularium. Ooecia subglobose, prominent, punctured.

The oral avicularium is sometimes wanting, and I have not noted spatulate avicularia on our specimens.

Occasionally taken at Crab Ledge in 14 to 20 fathoms, and at Great Round Shoal in 8 fathoms.

Smittia trispinosa (Johnston). [Pl. XXVII, fig. 65, 65a.]

Johnston 1838, p. 280 (*Lepralia trispinosa*).
Dawson 1859, p. 256 (*Lepralia trispinosa*).
Packard 1863 and 1869, p. 67 (*Lepralia trispinosa*).
Verrill 1879b, p. 195, and 1879c, p. 31 (*Mucronella jacotini*).
Whiteaves 1901, p. 106.

Zoarium encrusting on stones, shells, etc., forming whitish to yellowish colonies which are at first thin and smooth, but later rough and much thickened. Zooecia more or less ovate to quadrangular, in young colonies disposed with more or less regularity, but in older colonies extremely irregular, separated by a raised border; surface smooth and shining to more or less granular, with a row of areolæ around the border, these areolæ separated by strong, but short, ribs in older specimens; orifice rounded in front, nearly straight behind, with a squared tooth projecting from the posterior border; peristome usually but little raised in our specimens, though occasionally there is a lamina on either side of the orifice projecting upward; two to four oral spines usually present in young cells. Two kinds of avicularia are present, one with a pointed mandible, the other with the mandible rounded to spatulate; the first of these is large and is usually placed at one side of the orifice with the mandible directed forward and inward, but it may be situated anywhere on the cell with the mandible turned in any direction; the oval avicularia are usually small and situated on the basal part of the cell, but they may take the place of the pointed kind at the side of the orifice; moreover, they vary in length of the mandible, and, while they are usually oval, they are not infrequently elongate or spatulate in form. Ooecia large, globose, a little flattened above, smooth or somewhat roughened, with a few large irregular punctures.

The greatest possible variation exists in the occurrence and disposition of the avicularia; sometimes only the pointed ones are present, again only the oval ones, but both kinds are frequently present and several of them on a single cell, or the oval ones may be more or less spatulate, and not infrequently they are all absent.

Not uncommon at Crab Ledge in 14 to 20 fathoms. Taken also in Buzzards Bay near Penikese Island (Fish Hawk station 7672). The species is widely distributed on both sides of the Atlantic.

Smittia trispinosa var. **nitida** (Verrill). [Pl. XXVII, fig. 66, 66a, 66b, 66c, 66d, 66e, pl. XXX, fig. 88.]

Verrill 1875a, p. 415 (*Discopora nitida* n. s. p.) 1879b, p. 195, and 1879c, p. 30 (*Mucronella nitida*)

Encrusting on anything which affords a basis for attachment, most common on stones and shells; at first forming glistening, white colonies of regular appearance, later piling up in masses, and often completely surrounding pebbles and small shells in yellowish nodular masses of considerable size, occasionally rising into low frills on the stems of algæ and in similar situations. The general form and character of the zooecium is that of *trispinosa*, but the cells average smaller, and the aperture is correspondingly smaller than in the typical form. The variations in calcification are about as in *trispinosa*. The peristome is usually raised, sometimes evenly, but generally in older stages it is irregular; the most common form is with a labiate process rising on either side of the orifice. Avicularia are abundantly developed, of two sorts, a small oval (occasionally somewhat pointed) type situated usually on one or both sides of the orifice, and a larger, oval or often spatulate, form irregularly located on the front of the cell behind the aperture. (This form of avicularium was not mentioned by Verrill, but is of frequent occurrence.) An umbonal process is sometimes placed irregularly behind the orifice. Oecia globose, large, in young state shining and pierced by large irregular punctures, in older stages the pores may become closed and the surface roughly granular.

Although Hincks, Waters, and McGillivray have considered this a separate species, I have no hesitation in ranking it merely as a variety of the extremely variable *trispinosa*. My reasons for so doing are as follows: First, the characters of the zooecial wall, primary orifice, peristome, spines, and ooecium are identical in both, and *nitida* runs through all the variations due to calcification that are shown by *trispinosa*. Second, the avicularia intergrade to such an extent that it is impossible to draw a dividing line; *nitida* has usually only the small oval avicularia, but larger spatulate avicularia are not uncommon and are sometimes abundantly developed, and in addition to these specimens are occasionally found, otherwise undistinguishable from *nitida*, which have the large pointed avicularia exactly similar to those of *trispinosa*, while on the other hand specimens of *trispinosa* from Crab Ledge have spatulate avicularia of various lengths showing the transition from the small oval form usually present. In size the zooecia also intergrade completely. I therefore regard *nitida* as a variety of *trispinosa* in which the large, pointed avicularia are wanting, while the oval and spatulate forms are more plentifully developed.

For comparison I have had specimens of *trispinosa* from England, Labrador, Nova Scotia, Beaufort, N. C., and the Tortugas Islands, Fla.

The variety *nitida* replaces the typical *trispinosa* in Vineyard, Nantucket, and Long Island Sounds, Buzzards and Narragansett Bays, and other inshore waters of southern New England. It is extremely abundant from low water to 20 fathoms, and is one of the characteristic Bryozoa of the region. It has been reported also from the British Isles and from Australia, where, without doubt, it constitutes a local form of the cosmopolitan *trispinosa*, as it does here.

Genus PORELLA Gray, 1848.

This genus may be recognized by the form of the zooecial aperture, rounded in front and nearly straight behind, with a rounded avicularium mounted on a rostrum immediately behind the primary orifice, which it usually overhangs somewhat. A shelf-like projection is present on the posterior margin of the orifice in *P. concinna* (for which reason Jullien and Calvet have placed the species in the genus *Smittia*), but otherwise the margin is plain behind and is never sinuate. The secondary orifice, formed by the growth of the peristome, is entirely different in character, usually more or less pyriform, with the pointed end posterior and including the aviculiferous rostrum in its sinus-like fold. Many species of this genus are erect and branching in manner of growth, but all of ours are encrusting or rise merely into low frills.

KEY TO SPECIES.

1. Primary orifice with a broad shelf-like projection on the posterior margin .... *concinna*.
   Primary orifice without such projection .... 2.
2. Rostral avicularium with a somewhat pointed mandible directed upward .... *acutirostris*.
   Avicularium rounded .... 3.
3. Primary orifice large and somewhat rounded posteriorly, large spatulate avicularia often present in addition to the rostral one .... *propinqua*.
   Posterior margin straight, rostral avicularia only; zoarium erected into frill-like expansions. *proboscidea*.

Porella concinna (Busk). [Pl. XXVII, fig. 67, 67a, 67b, 68.]

Busk 1852, p. 67 (*Lepralia concinna*).
Dawson 1858, p. 256 (*Lepralia belli*).
Stimpson 1853 (*Lepralia rubens*).
Packard 1867, 271 (*Lepralia belli*).
Verrill 1879c, p. 30 (*P. lævis* var. *concinna*).
Hincks 1889, 428, 1892, p. 156.
Whiteaves 1901, p. 102.
Cornish 1907, p. 78.

Zoarium encrusting on stones and shells. Zooecia flat above, with or without punctures when fully calcified, the margin more or less sinuate, a row of marginal pores; in the younger cells the front is more or less convex and rises rather suddenly to the rostrum, a row of large areolæ about the margin with strong ribs between them and running a short way inward, but this condition is usually soon lost by calcification, primary orifice rounded in front, straight behind, with a broad tooth, secondary orifice deep, the peristome rising high and evenly, inclosing the primary orifice and the rostrum, sometimes raised on the side into a pair of blunt projections. Avicularium round. Ovicell globose, prominent in the young stage but often much immersed in old colonies, much roughened by later calcification, usually with a single median pore near the orifice. Some of our specimens seem to fall in the variety *belli* (Dawson), pl. x, fig. 68, though they seldom present the finger-like projections at the side of the orifice to as great an extent as more northern specimens.

Not uncommon at Crab Ledge in 14 to 20 fathoms. Not previously recorded south of Canadian waters.

Porella acutirostris Smitt. [Pl. xxvii, fig. 69, 69a.]

Smitt 1867, p. 21.
Hincks 1889, p. 429.
Whiteaves 1901, p. 103.

Zoarium encrusting on stones and shells, usually forming rounded colonies, often of great regularity. Zooecia usually disposed regularly in radiating lines, convex above, smooth or granular, with a row of areolæ about the margin, primary orifice round in front, straight posteriorly; peristome high and thin, connected with but not inclosing the rostrum, running forward upon the ovicell to form a conspicuous border on the front of it. Avicularium with a triangular mandible pointing upward, mounted upon a large rather smooth rostrum which curves forward somewhat over the orifice. Ooecium large, smooth, prominent, globose, the peristome forming a border on its front when fully developed.

The rostrum is very prominent in this species, and the avicularium with its bluntly triangular mandible is the most distinctive character, but the specimen must usually be turned somewhat backward to see this to the best advantage, since the point of the avicularium is directed nearly straight upward.

Very common at Crab Ledge in 14 to 20 fathoms, and at Great Round Shoal in 8 fathoms. Not previously recorded south of the Gulf of St. Lawrence.

Porella propinqua (Smitt). [Pl. xxvii, fig. 70, 70a.]

Smitt 1867, p. 22 (*Eschara propinqua*).
Verrill 1875b, p. 41, and 1879c, p. 30 (*Eschara verrucosa*, var. *propinqua*).
Whiteaves 1901, p. 105.

Zoarium encrusting shells, hydroid stems, etc. Zooecia rather large, convex, surface roughened by tubercles and raised lines, a row of areolæ around the margin; a raised border separates the cells; orifice rather large, rounded anteriorly, and slightly rounded behind the lateral denticles but without a distinct sinus; peristome slightly raised in the infertile cells, much raised when ovicells are present, carried up on the sides of the orifice into flap-like projections which extend forward upon the ovicell and backward to partially or entirely inclose the avicularium. Immediately behind the orifice is a stout umbo, curved forward and projecting somewhat over the primary orifice, and bearing on its tip a rather large rounded avicularium. A second avicularium, which is large and spatulate in form, is often present on the front of the cell, usually turned sidewise. Ooecium large, subglobose, prominent or somewhat immersed, punctured, often very regularly, with rather large pores, the pores usually forming an outer ring and a central cluster.

The species undergoes quite a change in appearance from the young cell to the adult condition with ovicells, mostly due to the development of the peristome, and the calcification of the front of the cell.

I am not at all satisfied that this species should be placed in the genus *Porella*, since the character of the primary orifice is much more like that of a *Lepralia*, especially such forms as *L. pertusa* and *L.*

americana. The orifice in the young cell is nearly round; the lateral denticles are like those of a *Lepralia* and the margin curves backward in an evenly rounded fashion on the posterior border. Hincks placed the species in *Lepralia*. In Jelly's Catalogue it is placed under *Smittia*, for which I can see no very good reason, and Norman and Whiteaves list it as a *Porella*, on account of the rostrum and avicularium. Not uncommon at Crab Ledge and off Sankaty Head in 14 to 25 fathoms. Recorded by Verrill "off Buzzards Bay, 25 fathoms; Nantucket Shoals, abundant; Bay of Fundy, etc."

Porella proboscidea Hincks. [Pl. XXVII, fig. 71, 71a, 71b, 71c, pl. XXXI, fig. 101.]

Hincks 1888, p. 222.
Verrill 1875a, p. 414 (*Eschara verrucosa*), 1879b, p. 194, and 1879c, p. 30 (*Porella verrucosa* Esper).

Zoarium rising erect from an encrusting base, forming bilaminate folded frills, often of singular beauty, rising to a height of one-half to one inch, growing on stems and occasionally on shells and pebbles, white or light yellowish in color. Zooecia of moderate size, convex, with a row of areolæ about the margin and strong ribs running between these toward the center often to the base of the rostrum; a raised border is present in the young cells but is soon obscured by calcification; in older cells the front wall becomes exceedingly thick, covering the ribs, the raised margins, and even the rostrum, producing a rather smooth, flat, continuous layer; the marginal areolæ are usually distinct even in old cells, however. Primary orifice rounded in front, straight posteriorly: peristome rising evenly, embracing the rostrum and continuous with the ovicell, often rising high above both as calcification proceeds: the secondary orifice thus produced is more or less pyriform with the pointed end posterior. Avicularium small, round, situated at the top of a strong rostrum which curves somewhat forward over the orifice, in a few cases a pointed projection rising from the top of the rostrum just behind the avicularium. Ooecium moderately large, subglobose, smooth and imperforate, prominent in the young state, completely immersed when calcification is complete, continuous with the peristome in its formation.

There is no doubt that this is the species which Verrill recorded as *Eschara verrucosa* (Esper) from Cashes and Jeffreys Ledges, as I have seen specimens so marked in his collection. It is not Esper's species, however, as that is the *Umbonula verrucosa* (Esper), and I have compared both English and Canadian specimens.

Abundant at Crab Ledge, 14 to 20 fathoms, Great Round Shoal, 8 fathoms; off Sankaty Head ESE., 23 fathoms; off No Mans Land (Fish Hawk station 7784), 29 fathoms, Nantucket Shoals. The finest specimens I have seen were on the stems of the ascidian *Boltenia*, where, in one case, a colony several inches in length completely encircled the stem and formed a complicated set of frills.

Suborder CTENOSTOMATA Busk, 1852

This suborder is characterized, among the marine ectoprocts, by the entire absence of calcification. The walls may be strengthened by impregnation with argillaceous matter, or they may be more or less chitinous, or, not infrequently remain quite soft. Avicularia, vibracula, and ooecia are absent. The zoarium may be stolonate or encrusting, and may rise in the form of phytoid branches or fleshy lobes.

KEY TO FAMILIES.

1. Zooecia immersed in a gelatinous crust, not stolonate .... 2.
   Stolonate, zooecia not immersed in a gelatinous layer .... 3.
2. Crust armed with horny spines, zooecial orifice bilabiate, with a movable lip acting as an operculum, Flustrellidæ.
   Crust without spines, no labia present, orifice closed by mere invagination of tentacle sheath Alcyonidiidæ.
3. Zooecium with a flattened area, more membranous than the rest of the wall, occupying nearly all of the ventral side .... Triticellidæ.
   Zooecium without flattened ventral area .... 4.

4. Zoarium (in our species) simply and somewhat palmately branched from a creeping stolon, the branches cylindrical, the ectocyst opaque and impregnated with earthy matter, zooecia connecting broadly with stalk at base .... Cylindroecidæ.
   Zoarium creeping or rising and branching to form phytoid tufts, not impregnated with argillaceous matter, the zooecia not communicating widely with the stalk or stolon .... 5.
5. Expanded tentacles forming a perfect circle, gizzard present .... Vesiculariidæ.
   Expanded tentacles not forming a perfect circle, as two of the number are bent outward, gizzard absent .... Valkeriidæ.

amily FLUSTRELLIDÆ Hincks, 1880.

Zooecia immersed in a gelatinous layer from which rise tall chitinous spines. The orifice is distinctly bilabiate, "resembling exactly a common clasp purse. It is bounded above and below by narrow horny ribs, which correspond with the metal clasps of the purse, and which are connected at the sides much in the same way as the latter, so as to allow of their opening and closing" (Hincks, 1880).

Genus FLUSTRELLA Gray, 1848.

Flustrella hispida (Fabricius). [Pl. XXVII, fig. 72.]

Fabricius 1780, p. 438 (*Flustra hispida*).
Verrill and Smith 1874, p. 708 (*Alcyonidium hispidum*).
Verrill 1879c, p 28.
Whiteaves 1901, p 114
Cornish 1907, p. 79

Zoarium forming a brownish incrustation which is hispid with the large spines, each of which arises from a swollen base, and which are arranged around the orifice and along the margin of the cells. Zooecia very large, but their structure is not easily made out except in the young cells where the spines are not yet developed. They are roughly six-sided, the surface smooth and flat, with the bilabiate orifice slightly raised. The beauty of these colonies when the large lophophores are expanded "like a blue mist, hovering as it were, over the masses of Flustrella on the weed" (Hincks, 1880), is very striking. They are not less beautiful when expanded for study under the microscope.

Abundantly developed locally on the stems of *Ascophyllum* and *Fucus* at low water, occasionally on stones and other objects, but not taken in the dredge. It is an eminently littoral species.

Family ALCYONIDIIDÆ Hincks, 1880.

Zoarium consisting of a gelatinous crust (sometimes more or less filled with earthy matter) or occasionally rising into free cylindrical or expanded growths. Zooecia more or less closely united and more or less immersed in the common crust, orifice not protected by external lips but closed merely by the retraction of the tentacle sheath.

Genus ALCYONIDIUM Lamouroux, 1821.

KEY TO SPECIES.

1. Zoarium impregnated with earthy matter .... *parasiticum*.
   Zoarium not containing argillaceous matter .... 2.
2. Zoarium covered with small conical papillæ rising between the orifices of the zooecia, erect or encrusting .... *hirsutum*.
   Zoarium without such papillæ .... 3.
3. Zoarium encrusting .... *mytili*.
   Zoarium erect .... 4.

4. Erect branches rather firm, the gelatinous substance comparatively solid, zooecia closely packed, tentacles about 10 in number .... *verrilli.*
   Branches softer, the gelatinous matter comparatively soft, zooecia not so closely packed, tentacles 15 to 17 in number .... *gelatinosum.*

Alcyonidium parasiticum (Fleming). [Pl. XXVII, fig. 73.]

Fleming 1828, p. 518 (*Alcyonium parasiticum*)
Verrill and Smith 1874, p. 708.
Verrill 1879c, p. 28.

Zoarium encrusting on stones, shells, and stems of various sorts, impregnated with earthy matter which gives the colony the appearance of a coating of mud. The zooecia, which are rather small, appear in the midst of this layer as depressed areas with minute papillæ around the border. In the younger parts of the colony the zooecia project somewhat and the septa are evident. The tentacles are about 15 in number.

Verrill records this species from Vineyard Sound at a depth of a few fathoms. It was not noted in the inner waters of the region during our survey, but was taken at Crab Ledge in 14 to 20 fathoms, and off No Mans Land in 29 fathoms, in considerable abundance. It has not been reported from Canadian waters, but occurs on the European coasts.

Alcyonidium mytili Dalyell. [Pl. XXVIII, fig. 74, 74a.]

Dalyell 1847, p. 36.
Verrill 1879b, p. 188 (*Alcyonidium rubrum*, n. sp.); 1879c, p. 28 (as *A. mytili* and *rubrum*).

Zoarium encrusting on stones and shells, occasionally on seaweed, forming rather firm, dingy white, yellowish, reddish, gray or brown colonies, sometimes quite dark, at other times almost colorless, covered with small, low prominences when the zooids are retracted. Zooecia typically hexagonal, but this form is often modified to a pentagon or quadrilateral; septa showing with more or less distinctness on the surface.

Hincks (1880) says of this species that the ova are borne in special zooecia destitute of polypides, within which the ova are arranged so as to form a ring. This is not entirely true of our specimens, for the eggs are most certainly developed in the ordinary type of zooecium. I have counted as many as 14 developing embryos within a single zooecium, though the number varies greatly and not infrequently there are only one or two; when numerous they may be arranged in a circle. I am inclined to think that the polypide may degenerate as the embryos approach maturity, thus giving the appearance of a special zooecium. There is more than a possibility that the *A. polyoum* of Hassall (1841, p. 484, *Sarcochitum polyoum*) may be the same species, as there seems to be little except the arrangement of the ova to distinguish it from *mytili*. In this case Hassall's name will have precedence.

I believe I am correct in identifying Verrill's *rubrum* with *mytili*. Certainly I have taken the brick-red form, which I have not been able to separate structurally from the pale and grayish-brown specimens, which I have compared with British specimens of *mytili*. Verrill's description is as follows: "An encrusting species, forming broad smooth colonies, covering stones and shells. Zooecia rather large, mostly hexagonal, but often pentagonal, with their boundaries well marked in alcoholic specimens by a distinct line. The retracted zooids in preserved specimens usually form a small papilla in the middle of the zooecia. Color in life, bright brick-red, or sometimes orange red." If further study shall prove that the arrangement of the ova and their method of development in a distinct form of zooecium is characteristic of *mytili*, then *rubrum* must stand as a distinct species, but certainly there is nothing distinctive in the color or the general character of the zooecia.

Widely distributed over the region, from low water to 16 fathoms, sometimes forming extensive crusts on piles, taken also on barnacles, skate egg cases, on the carapace and legs of crabs (especially *Libinia*) and occasionally even in the branchial chamber, as well as on stones and shells. Verrill records *rubrum* from Long Island to Nova Scotia.

Alcyonidium verrilli, new name. [Pl. XXVIII, fig. 75, 75a, 75b, 75c, pl. XXXI, fig. 92, 92a.]

Verrill 1872, p. 289 (*Alcyonidium ramosum*, n. sp.).
Verrill and Smith 1874, p. 708 (*Alcyonidium ramosum*).

In naming this species Prof. Verrill overlooked the fact that Lamouroux (Encyclopedie Méthodique, t. XIV, p. 40) had already applied the name to another species in this genus. As the present species is very evidently not the *ramosum* of Lamouroux, a new name is required, and I have the pleasure of dedicating it to Prof. Addison E. Verrill, who first described it and whose name is so intimately connected with the pioneer work on the Bryozoa of our coast.

"Much branched, when full grown; the branches round, irregularly dichotomous, usually crooked. Surface glabrous, smooth, or nearly so, the cells rather small and crowded, their margins not elevated; zooids with 16 slender tentacles. Color ashy brown, or dull rusty brown. We have often found arborescently branched specimens 12 to 15 inches high, with smooth, cylindrical branches about a third of an inch in diameter."

To the above description by Verrill may be added the following: The branches are not infrequently much flattened, especially at the tips, and the larger branches are often hollow. The texture is firm, and in alcoholic specimens rather brittle. From *A. gelatinosum*, the only species with which it is likely to be confused, it is distinguished by the firmer structure, by greater opacity, by the size of the cells, which are somewhat larger and more crowded, and by the number of tentacles. The statement by Verrill and Smith (l. c.) that the height is ".250 mm. to .350 mm." is a typographical error for 250 to 350 mm.

Verrill records the species from New Jersey to Vineyard Sound. It is not at all common in Vineyard Sound, and occurs, so far as I have observed, only at the extreme western end of the Sound, where only small specimens a few inches in height were taken. The finest examples I have seen were given me by Prof. Verrill from Long Island Sound.

Alcyonidium gelatinosum (Linné). [Pl. XXVIII, fig. 76.]

Linné 1766-8, p. 1295 (*Alcyonium gelatinosum*).
Verrill and Smith 1874, p. 709.
Verrill, 1879c, p. 28.

There is considerable doubt as to the occurrence of this species in the Woods Hole region. Verrill and Smith recorded it questionably; "a few small specimens, apparently belonging to this species, were dredged in the deeper parts of Vineyard Sound," and later collecting has not revealed its presence.

Zoarium erect, branching or simple, the branches subcylindrical or slightly flattened, yellowish or greenish yellow in color, the softest and most pellucid of the genus. Zooecia small, and rather closely packed, their orifices marked by low papillæ, the tentacles about 15 to 17.

Alcyonidium hirsutum (Fleming). [Pl. XXVIII, fig. 77.]

Fleming 1828, p. 517 (*Alcyonium hirsutum*).
Verrill and Smith 1874, p. 708.
Verrill, 1879c, p. 28.

Zoarium of rather firm consistency, encrusting, or erect, compressed, expanded, palmate, much and variously divided, of a yellowish brown color; surface thickly covered with tall imperforate papillæ, among which the slightly prominent orifices are placed. Reaches a height of 5 or 6 inches. More commonly grows as a rather thick crust spreading over algæ, etc.

Verrill has recorded this species from Vineyard Sound, but it has not made its appearance in the collections of our survey.

The *Alcyonidium? pellucidum* of Leidy (1855, p. 142) is an *Amouroucium*.

Family CYLINDRŒCIDÆ Hincks, 1880.

Stolonate, the zooecia arising singly, and broadly continuous with the stolon (*Cylindrœcium*); or somewhat palmately branched, erect portions bear the zooecia, which are cylindrical and broadly continuous with each other (*Anguinella*). Only the latter genus has been observed in this region, but *Cylindrœcium* is found abundantly at Beaufort, N. C., and may be looked for at Woods Hole.

Genus ANGUINELLA Van Beneden, 1844.

Anguinella palmata Van Beneden [Pl. XXVIII, fig. 78, 78a.]

Van Beneden 1844, p. 58.

Zoarium with erect branches bearing the zooecia, which are not at all constricted at the base. The zooecia are cylindrical and bluntly rounded at the apex, irregularly situated on the branch, opaque with impregnated earthy matter, tentacles about 10 in number. Height, according to Hincks (1880), from 3 to 8 inches, but I have seen no specimens on the American coast more than an inch in height, even where it grows abundantly, as at Beaufort, N. C.

The species may be very readily overlooked on account of its peculiar growth habit, which resembles that of a small brown alga, and from the fact that it is rendered obscure by a layer of mud embedded in the ectocyst. I have taken it but once in the Woods Hole region, at Fish Hawk station 7659, in Buzzards Bay, where a few small colonies were dredged.

Family VESICULARIIDÆ Hincks, 1880.

Stolonate, the zooecia arising singly or in clusters from the stolon, or from erect branches; zooecia well marked off from the stalk or stolon, often deciduous.

KEY TO GENERA.

1. Zooecia clustered in double rows arranged spirally on the stems which are erect and branching . *Amathia.*
   Zooecia not so arranged . . . . . 2.
2. Zoarium with a creeping stock, from which may arise erect shoots; zooecia irregularly disposed or occasionally clustered . . . . . *Bowerbankia.*
   Zoarium erect, phytoid, rooted by fibers. Zooecia arranged in a single series on one side of the stem . . . . . *Vesicularia.*

Genus BOWERBANKIA Farre, 1837.

Our species of this genus are creeping, with occasional branches reaching out in a wandering fashion as though in search of a support. The zooecia are irregularly disposed in our species, though in *B. imbricata*, which has been reported doubtfully from Canadian waters, they are arranged in groups.

KEY TO SPECIES.

A pointed or divided process near the base of the zooecium on its outer side . . . . . var. *caudata.*
No projection on the basal portion of the zooecium . . . . . *gracilis.*

Bowerbankia gracilis Leidy. [Pl. XXVIII, fig. 80, 80a, 80b, 80c.]

Leidy 1855, p. 142.
Verrill and Smith 1874, p. 709 (*Vesicularia gracilis*).
Verrill 1879c, p. 28 (*Vesicularia gracilis*).

"Polydome delicate, creeping, branching, white. Cells cylindrical, erect, about 1/5 of a line in length, without appendages at their orifice, the margin of which is retractile with the inhabitant of the cell. Polype provided with 8 ciliated arms. Intestine with a strong gizzard. Pt. Judith." (Leidy.)

In its most distinct form the *gracilis* of Leidy is smaller than *caudata*, the stolon entirely creeping, the zooecia slender and colorless, and attached to the upper surface of the stolon either singly or in clusters, and in such zooecia there is usually no indication of any caudate process. The careful study of any such colony, however, in all large colonies that have come under my observation, has revealed occasional zooecia attached to the side of the stolon, either singly or in pairs after the manner of *caudata*, and in these laterally attached zooecia a caudate process, sometimes as well developed as in *caudata*, is often present. All sorts of intergradations in the size of the process are present, and in size and color also the two forms intergrade. For these reasons, therefore, I unhesitatingly place *caudata* as a variety of *gracilis*. There is, furthermore, no difference in the distribution of these forms in our region, and they often occur together on piles, stones, and seaweed, etc., from low water to the deepest parts of Vineyard Sound.

Bowerbankia gracilis, var. **caudata** (Hincks). [Pl. XXVIII, fig. 79, 79a.]

Hincks 1877, p. 215 (*Valkeria caudata*).
Verrill and Smith 1874, p. 710 (*Vesicularia fusca*).

Stem entirely creeping, except for occasional sprawling branches. Zooecia elongate, subcylindrical, biserial and usually opposite in arrangement, at any rate arising from the side of the stolon, truncate and often squared at the top; base narrowed rather suddenly near the point of attachment, and produced on the lower or outer side into a variously shaped process, usually pointed. A strong gizzard is present and there are eight tentacles. The size of the zooecia varies considerably, and in different states of contraction they present quite different shapes. A little study of the specimen will reveal the caudate process. This appendage shows a large amount of variation; it is not infrequently bifid or trifid, it may project straight downward or more outward, and it is quite variable in size and often difficult to find on old cells. The color varies from pale yellowish to brown, and only the very young cells are usually transparent.

Abundant and widely distributed throughout the region, in all sorts of places and at all depths, but I have found it in greater abundance on old piles in New Bedford Harbor than elsewhere. It grows on algæ, hydroid and Bryozoa stems, on shells, stones, ascidians, etc., sometimes so thickly as to cover the substratum with a close nap. Not noted in the outside waters of the region; evidently a shorewise form.

I place Verrill's records of "*Vesicularia fusca* Smitt" under this species with little hesitation, as a specimen from South End, near New Haven, given me by Verrill as *fusca*, proves to be *caudata*. The latter species is often quite brownish in color, and all the material which I have examined has proved to be either this species or *gracilis*. I have specimens of *caudata* from Long Island Sound, from Eastport, Me., and from Labrador, which agrees with Verrill's account of the distribution of *fusca*, and I have taken the species also at Beaufort, N. C., and at the Tortugas Islands, Fla. It should be added that *caudata* was not described at the time of Verrill's records of *fusca*.

Genus AMATHIA Lamouroux, 1812.

This genus is easily recognized by the phytoid form of the colony, with the short zooecia arranged in a double series which winds spirally on the stem.

Amathia dichotoma (Verrill). [Pl. XXIX, fig. 81, 81a.]

Verrill, in Verrill and Smith 1874, p. 709 (*Vesicularia dichotoma*, n. sp.).
Leidy 1855, p. 143 (*Valkeria pustulosa*).

Verrill's description is complete and accurate, so I quote it in full. "Stems clustered, cæspitose usually 1 or 2 inches high, slender, white, and repeatedly forking. The branches stand in different planes so as to produce miniature tree-like or shrub-like forms, many of which generally rise close together, forming crowded tufts upon rocks, oyster-shells or algæ. When the stem or a branch divides there is a joint formed at the base of each of the forks, by the interpolation of a very short segment of a dark, brownish, opaque substance, which contrasts strongly with the white translucent substance of the rest of the stem. Zooids arranged closely in two subspiral rows of 6 to 12 each, just below each fork of the stem and branches, and not occupying half of the length of the internodes, which are naked and smooth below the crowded clusters of the zooids, these are smooth, greenish brown, broad oval or obovate in contraction, subcylindrical or obovate in expansion, entirely sessile, and but little narrowed at the base, and so crowded as to appear imbricated. The tentacles are eight, long and slender, in expansion usually more than half the length of the cell."

Verrill and Smith do not record the species from Vineyard Sound and I have never dredged it. It is common on the piles at Vineyard Haven and Edgartown, and occurs also in similar situations at Woods Hole and Nantucket. Verrill's records are for Great Egg Harbor, N. J., and Long Island Sound.

Genus VESICULARIA J. V. Thompson, 1830 (pars).

According to Hincks (1880, p. 512) the genus *Vesicularia* is characterized by an erect phytoid zoarium, with the zooecia disposed regularly in a single series on one side of the stem.

? Vesicularia familiaris (Gros). [Pl. XXIX, fig. 82.]

Gros, Bull. Soc. Imp. Moscou, t. XXII, p. 567 (*Plumatella familiaris*).
Smitt 1865, p. 502 (*Vesicularia familiaris*).
Verrill and Smith 1874, p. 710 (*Farrella familiaris* Smitt).
Verrill 1879c, p. 28 (*Farrella familiaris* Gros).

I must confess that I am at a loss to know how to place the species which Verrill has identified with the above. According to his note in regard to it (l. c., p. 487), it is "a singular and delicate species, which occurs both on the underside of rocks and of algæ. The body is small, fusiform, attached by a long and very slender pedicel, flexible. When it surrounds the stems of small algæ, the whitish pedicels project outward in all directions, and thus produce the appearance of a delicate chenille cord." If, as one would suspect from the above description, it is a repent form, it can scarcely be a *Vesicularia*. It has not occurred in our dredgings and I have not seen the species on our coast. Verrill records it from Long Island Sound to Casco Bay.

Family VALKERIIDÆ Hincks, 1880.

Zoarium stolonate, entirely repent or with erect branches, zooecia contracted below, deciduous, tentacles not forming a perfect circle when expanded, as two of the number are bent outward, gizzard absent.

Genus VALKERIA Fleming (pars), 1823.

Valkeria uva (Linné). [Pl. XXVIII, fig. 83, 83a.]

Linné 1758, p. 812 (*Sertularia uva* and *S. cuscuta*).
Verrill and Smith 1874, p. 709 (*Vesicularia cuscuta* Thompson).
Verrill 1879c, p. 28 (as *Valkeria cuscuta* and *Vesicularia uva*).

Zoarium repent, sometimes giving off erect shoots, jointed at intervals, branches arising in opposite pairs, zooecia clustered at intervals on the stems. Zooecium small, slender, pointed below, transparent, gizzard absent, two of the eight tentacles characteristically bent outward when expanded.

This species has not appeared in the collections of our survey of the Woods Hole region, but Verrill has recorded it for Vineyard Sound, as well as from Great Egg Harbor, N. J., and Casco Bay, Me.

Verrill's notes (l. c., p. 404-5) indicate the habits of the species as follows: "A delicate, creeping species, which resembles in miniature the dodder-plant (Cuscuta), and creeps over other bryozoa and hydroids, very much as the dodder creeps over other plants. It occurs both at low water in pools and in shallow water among rocks."

Family TRITICELLIDÆ G. O. Sars, 1873.

The important characteristic of this family is the presence of a flattened, membranous area, occupying the greater portion of the ventral side of the zooecium. The presence of a gizzard has not, I believe, been noted in this family, but in one species, the "*Vesicularia armata*" of Verrill, such an organ is present. In general, the species of this family are commensal on Crustacea, but certain species spread over seaweeds and similar surfaces.

Genus HIPPURARIA Busk, 1874.

The genus *Hippuraria* is distinguished from *Triticella*, which has not yet been noted in American waters, by the clustered arrangement of the zooecia, which in *Triticella* are scattered singly along the stolon. Our species have the zooecia arranged in pairs at the termination of the internodes.

KEY TO SPECIES.

Four strong spines at the top of the zooecium . . . . *armata*
Zooecium unarmed . . . . *elongata.*

Hippuraria armata (Verrill). [Pl. XXIX, 84, 84a, 84b.]

Verrill, in Verrill and Smith, 1874, p. 710 (*Vesicularia armata*, Verrill, n. sp.), Verrill 1879c, p. 28 (*Vesicularia armata*).

"Cells stout, oval, broad at base, with a short and narrow pedicel, attached either singly or in pairs along slender, filiform, creeping stems, which often anastomose, the branches being mostly opposite. Distal end of cells prolonged into four conical processes, each of which, when perfect, supports a long, slender spinule, nearly half as long as the cell. Tentacles not seen. Cells yellowish horn-color, with an oval, dark brown internal organ, visible in most of the cells" (Verrill, l. c.).

Verrill very evidently overlooked the flattened membranous area which is characteristic of this family, but it must be recalled that the papers of G. O. Sars, on *Triticella*, and of Busk, on *Hippuraria*, had not at that time made their appearance. The zooecia arise in pairs on either side of the stem at the end of an internode, each cell arising from a protuberance, from which also the branch takes its origin immediately below the zooecium. The branches are not formed at every internode, though zooecia usually are, and occasionally a branch arises on one side only. They are usually in pairs, however, like the zooecia, and the latter are very rarely suppressed on one side. The prominence is present in all cases, and not infrequently bears the evidence of having lost the zooecium. This, I believe, led to Verrill's statement that they may be attached singly. While the stolon is characteristically creeping and adnate it is not unusual to find erect shoots, an inch or more in height, beautifully symmetrical and frond-like in appearance. A small but distinct gizzard is present, not completely surrounding the gut, but forming several rounded lobes, with pointed teeth projecting into the cavity. A gizzard has not heretofore been noted in this family, and its presence may indicate a separate genus, but the general character of this species is so similar to *Hippuraria* that I have included it in this genus.

"Vineyard Sound on floating seaweed, also in 6 to 10 fathoms, rocky, on *Sertularia argentea*" (Verrill). Vineyard Sound and Buzzards Bay, fairly frequent; dredged in 4 to 15 fathoms, on various bottoms; also from the piles of wharves at New Bedford, Woods Hole, Edgartown, Katama Bay, and Nantucket. Best developed on piles, where the erect branches are of frequent occurrence.

Hippuraria elongata, new species. [Pl. XXIX, fig. 85, 85a, 85b, 85c.]

Zoarium entirely creeping, the stolon slender, transparent to light brownish in color, jointed, the internodes sometimes elongate, but often very short; branches paired, arising from a lateral projection on either side at the end of the internodes, the same projection giving rise to a zooecium; spreading over the gill-chamber or upon the carapace of various species of crabs. Zooecia rather large, elongate, mounted on slender pedicels, tapering slightly toward both ends, the apex truncate or rounded in contraction, a membranous area on the ventral side extending sometimes nearly the whole length of the cell and again not more than two-thirds of the length; the pedicel varies greatly in length, sometimes shorter than the cell and again more than twice as long, thin walled and transparent, with a flexible portion at the top partly involving the base of the zooecium; the pedicel increases in size toward the top, where it merges into the cell rather gradually at the flexible portion. The zooecia arise in pairs from lateral processes at the ends of the internodes just as in *H. armata*, but the internodes are often so short that the zooecia are brought close together and the substratum covered with a close nap of the cells.

A commensal species, found in the branchial chamber of the blue-crab (*Callinectes sapidus*) and spider-crabs (*Libinia* sp.), and occasionally spreading out to a small extent along the bases of the legs, also on the backs of the small crabs (*Pinnixia* sp.), living in the tubes of *Chætopterus*. Taken a number of times in Buzzards Bay and Vineyard Sound. Also abundant at Beaufort, N. C., in similar situations. The walls of the branchial chamber of the larger crabs are sometimes thickly clothed with the zooecia, and not infrequently the gills are more or less infested with them. *Pinnixia* is sometimes completely covered on the backs and legs with the white nap-like colonies.

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EXPLANATION OF PLATES.

PLATE XVIII.

Fig. 1. *Loxosoma davenporti.*
Fig. 2. *Loxosoma minuta*, n. sp., drawn to same scale as fig. 1.
  2a. The same, much enlarged, in contracted condition.
Fig. 3. *Pedicellina cernua*, ordinary form of zooecium.
  3a. The same, smooth form, the *glabra* of Hincks.
  3b. The same, with spinous stalk, the *echinata* of Sars.
  3c. The same, with spinous calyx, the *hirsuta* of Jullien.
  3d. The same, with spinous stalk and calyx.
Fig. 4. *Barentsia major.*
Fig. 5. *Barentsia discreta*, partially expanded.
  5a. The same, detail of stalk.
Fig. 6. *Crisia eburnea*, portion of a branch.
  6a. The same, ooecium.
  6b. The same, ooeciostome much enlarged.
Fig. 7. *Crisia cribraria*, portion of colony, showing the long sinuate internodes.
  7a. The same, ooecium.
  7b. The same, ooeciostome much enlarged.
Fig. 8. *Crisia denticulata*, portion of branch showing ovicell and ooeciostome, from an English specimen.
Fig. 12. *Stomatopora diastoporoides*, colony, size of specimen 5/8 inch.
  12a. The same, detail of portion of colony at edge.
Fig. 13. *Lichenopora verrucaria*, colony, size of specimen 1/8 inch.
  13a. The same, two views of a zooecial tube.
  13b. The same, ooeciostome, at same magnification as 13a.

PLATE XIX.

Fig. 9. *Tubulipora atlantica*, specimen from Crab Ledge. Drawn by H. J. Shannon.
  9a. The same, detail of ovicell and ooeciostome. Drawn by H. J. Shannon.

PLATE XX.

Fig. 10. *Tubulipora liliacea*, a colony from Vineyard Sound, characteristic of the species in this region. Drawn by H. J. Shannon.
  10a. The same, detail of ovicell and ooeciostome. Drawn by H. J. Shannon.
Fig. 11. *Tubulipora flabellaris*, detail of ovicell and ooeciostome. Drawn by H. J. Shannon.

PLATE XXI.

Fig. 14. *Ætea anguina*, a single zooecium showing the basal enlargement.
  14a. The same, showing membranous ooecium with embryo.
Fig. 15. *Eucratea chelata*, after Hincks.

Fig. 16. *Gemellaria loricata*, small portion of colony to show manner of arrangement of the cells.
Fig. 17. *Scruparia clavata*, branch of colony to show arrangement of cells.
17a. The same, mode of branching.
17b. The same, dwarfed fertile cell with ovicell.
17c. The same, detail of aperture.
Fig. 18. *Caberea ellisii*, portion of a branch, with ovicell, avicularia and vibraculum.
18a. The same, vibracula cell from the posterior side.
Fig. 19. *Menipea ternata*, portion of colony with radical fiber.
Fig. 20. *Scrupocellaria scabra*, portion of branch, showing scute, ovicell, etc.
Fig. 20bis. *Cellularia peachii*, a single internode.
Fig. 21. *Bicellaria ciliata*, portion of a branch.
21a. The same, detail of ooecium.
21b. The same, detail of avicularium.
Fig. 22. *Bugula gracilis* var. *uncinata*, portion of a branch.
22a. The same, at base of colony showing uncinate processes.
Fig. 23. *Bugula turrita*, portion of colony.
23a. The same, details of the ovicell.
23b. The same, showing manner of attachment and development of ovicell.
Fig. 27. *Bugula avicularia*, from an English specimen.

PLATE XXII.

Fig. 24. *Bugula cucullifera*, portion of a branch.
24a. The same, side view of ovicell.
24b. The same, avicularium.
24c. The same, portion of a cell with elongate spines.
Fig. 25. *Bugula flabellata*, portion of a branch.
25a. The same, details of ovicell.
25b. The same, avicularium.
Fig. 26. *Bugula murrayana*, portion of colony, showing both kinds of avicularia.
26a. The same, details of ovicell.
Fig. 28. *Membranipora lacroixii*, portion of colony.
28a. The same, drawn from a living cell.
28b. The same, back or dorsal side of cell.
Fig. 29. *Membranipora monostachys*, portion of a colony, showing an abortive cell and a secondary calcified lamina in some cells.
29a. The same, a cell of the commoner many-spined form, enlarged.
29b. The same, a cell of the one-spined, "monostachous" form, enlarged.
Fig. 30. *Membranipora pilosa*, portion of colony of the typical, long-spined form.
30a. The same, the short-spined variety *dentata* of Solander.

PLATE XXIII.

Fig. 31. *Membranipora lineata*, arrangement of zooecia.
31a. The same, details of avicularia and ovicell, more enlarged.
31b. The same, side view of a cell.
31c. The same, back of a zooecium showing details of pore chambers.
Fig. 32. *Membranipora craticula*, arrangement of zooecia and spines.
32a. The same, details of cell, ovicell, and avicularium, much enlarged.
32b. The same, back of zooecium, showing details of pore chambers.

Fig. 33. *Membranipora arctica*, portion of zoarium.

33a. The same, more enlarged, details of cell, ovicell, and avicularia.

33b. The same, young zooecium at edge of colony, not fully calcified.

Fig. 34. *Membranipora arctica* var. *armata*, showing large avicularium at base, and small erect spines at base of lateral avicularia.

Fig. 35. *Membranipora unicornis*, portion of zoarium showing details of various structures.

Fig. 36. *Membranipora cymbæformis*, portion of colony showing general details.

36a. The same, two views of the stalked avicularium, more enlarged.

Fig. 37. *Membranipora aurita*, showing the usual regular arrangement of the cells.

37a. The same, more enlarged to show details of ovicell, and the two basal avicularia pointing forward.

37b. The same, showing the avicularium pointing backward in absence of ovicell.

Fig. 38. *Membranipora flemingii*, enlarged as in 37a, with details of cell and ovicell, and the arrangement of avicularia in presence and absence of the ovicell.

Fig. 39. *Membranipora tenuis*, showing partially calcified area with spinules projecting inward, and occasional prominences at angles of zooecia.

PLATE XXIV.

Fig. 40. *Membranipora tehuelcha*, arrangement of zooecia, with details.

Fig. 41. *Cribrilina punctata*, portion of colony with general details.

41a. The same, with curved spines in front of zooecium, enlarged.

41b. The same, aperture of young cell with oral spines in usual condition.

Fig. 42. *Cribrilina annulata*, portion of colony with details.

42a. The same, details of cell with oral spines and keel.

42b. The same, dwarfed erect cell bearing ovicell.

Fig. 43. *Porina tubulosa*, portion of colony.

43a. The same, more enlarged, details of aperture, ooecium, and pore.

43b. The same, one of the small frontal punctures highly magnified.

43c. The same, diagram of side view of cell, ooecium, and pore.

Fig. 44. *Microporella ciliata*, arrangement of zooecia and general details.

44a. The same, a ribbed, umbonate, heavily calcified ovicell, more enlarged.

44b. The same, elongate form of avicularium, more enlarged.

44c. The same, a series of forms of the pore showing variations leading from *ciliata* to the var. *stellata*, etc., highly magnified.

Fig. 45. *Microporella ciliata* var. *stellata*, the usual heavily calcified condition of this variety.

Fig. 46. *Hippothoa divaricata*, portion of colony.

46a. The same, ovicell.

Fig. 47. *Hippothoa hyalina*, portion of colony.

47a. The same, at edge of young colony showing spaces between cells.

47b. The same, dwarfed fertile cell with ovicell.

47c. The same, details of aperture.

PLATE XXV.

Fig. 48. *Schizoporella unicornis*, portion of colony, the usual form in the Woods Hole region.

48a. The same, an elongate cell from the same colony as figure 48.

48b. The same, smooth, convex form with large umbo.

48c. The same, with reversed avicularium, the *reversa* of Verrill.

48d. The same, ovicell of usual form, and elongate avicularia.

48e. The same, ovicell heavily calcified, ribbed, and umbonate, from deeper water, more enlarged.

Fig. 49. *Schizoporella biaperta*, portion of colony.
49a. The same, details of cell and ovicell, more enlarged.
49b. The same, the large pointed avicularium occasionally present.
Fig. 50. *Schizoporella auriculata*, portion of colony.
50a. The same, details of fully calcified cell and ovicell, more enlarged.
Fig. 51. *Schizoporella sinuosa*, portion of colony near growing edge, showing change in shape of aperture.
51a. The same, details of cell and ovicell in complete calcification.
Fig. 52. *Cellepora americana*, n. sp., aperture and ovicell in front view.
52a. The same, side view showing avicularium.
52b. The same, primary orifice.
Fig. 53. *Cellepora canaliculata*, cell and ovicell in front view.
53a. The same, two views of the rostrum.
53b. The same, primary aperture.
Fig. 54. *Lepralia pallasiana*, portion of colony with details of one zooecium.
Fig. 55. *Lepralia americana*, portion of colony with details of infertile cell, more enlarged than figure 54.
55a. The same, details of a fertile cell and ovicell.

PLATE XXVI.

Fig. 56. *Lepralia pertusa*, portion of colony with cells and ovicell of the usual form.
56a. The same, two cells from the same colony, smaller variety.
56b. The same, heavily calcified ovicell, umbonate process behind orifice, and lateral avicularia.
56c. The same, cells near the edge of the same colony as 56b and at the same magnification, showing variation in size of cells.
Fig. 57. *Lepralia serrata*, n. sp., young cell with oral spines and primary aperture before beginning of secondary calcification.
57a. The same, cell with avicularia, from central part of the same colony as 57, secondary calcification very deep, a large avicularium on a mamillate process.
57b. The same, portion of a colony with ovicells and various avicularia.
57c. The same, details of aperture and ovicell, more highly magnified.
Fig. 58. *Mucronella peachii*, portion of colony showing ovicell and details of secondary calcification.
58a. The same, young cell at edge of colony showing primary aperture, oral spines, and marginal areolæ.
Fig. 59. *Mucronella ventricosa*, fully calcified, with ovicells, same magnification as figure 58.
59a. The same, aperture of young cell with oral spines and developing peristome, more highly enlarged.
Fig. 60. *Mucronella pavonella*, portion of colony showing details.
Fig. 61. *Rhamphostomella bilaminata*, infertile cells.
61a. The same, fertile cell with ooecium.
Fig. 62. *Rhamphostomella costata*, infertile cells.
62a. The same, side view of rostrum showing avicularium.
62b. The same, fertile cells with ovicells and large pointed avicularium.
Fig. 63. *Rhamphostomella ovata*, infertile cells.
63a. The same, fertile cell with ovicell.
Fig. 64. *Smittia porifera*, portion of colony.

PLATE XXVII.

Fig. 65. *Smittia trispinosa*, two cells of typical form, with oral spines and avicularia.
65a. The same, showing connecting links with the var. *nitida* in the variously shaped avicularia, magnified somewhat more than figure 65.

Fig. 66. *Smittia trispinosa* var. *nitida*, portion of colony of typical *nitida* when fully calcified, drawn to same scale as figure 65.

66a. The same, a cell from another part of the same colony as 66; note the difference in the size of the cells.

66b. The same, a cell with large pointed avicularium.

66c. The same, a cell with small oval and large elongate avicularia.

66d. The same, ovicell showing secondary calcification.

66e. The same, heavily calcified cell with thickened peristome, large roughened umbo and very thick zooecial wall (avicularium impressed).

Fig. 67. *Porella concinna*, detail of young cell.

67a. The same, portion of colony in ordinary secondary calcification showing ovicell.

67b. The same, with central raised area due to secondary calcification.

Fig. 68. *Porella concinna* var. *belli*, fertile cell with two lateral avicularia, ovicell with irregular umbo, more highly magnified than figure 67a.

Fig. 69. *Porella acutirostris*, portion of colony showing arrangement of cells.

69a. The same, showing details of infertile cell.

Fig. 70. *Porella propinqua*, portion of colony showing ovicells, oral avicularia and large avicularia—in one case the large avicularium replaces the oral one.

70a. The same, ovicell with raised border.

Fig. 71. *Porella proboscidea*, portion of colony in earlier stages of calcification.

71a. The same, young cell showing formation of ovicell and its connection with peristome.

71b. The same, primary orifice more highly enlarged, seen partly from in front.

71c. The same, older portion of colony, the secondary calcification rising above ovicells and rostra.

Fig. 72. *Flustrella hispida*, young cells at margin of colony, showing spines and bilabiate orifice.

Fig. 73. *Alcyonidium parasiticum* portion at edge of colony, showing the broad tuberculate margin and central hyaline area.

PLATE XXVIII.

Fig. 74. *Alcyonidium mytili*, portion of colony.

74a. The same, a single cell showing retracted polypide and orifice.

Fig. 75. *Alcyonidium verrilli*, n. nom., young cells at edge of colony.

75a. The same, in older part of colony showing thickness of superficial septa.

75b. The same, cross-section of a branch

75c. The same, section of a cell showing details of anatomy.

Fig. 76. *Alcyonidium gelatinosum*, showing the very thin superficial septa, from an English specimen.

Fig. 77. *Alcyonidium hirsutum*, showing papillæ and orifices, from an English specimen.

Fig. 78. *Anguinella palmata*, small colony showing manner of branching.

78a. The same, a single zooecium.

Fig. 79. *Bowerbankia gracilis* var. *caudata*, portion of colony.

79a. The same, details of anatomy.

Fig. 80. *Bowerbankia gracilis*, portion of colony at higher magnification than figure 79; the cells are really smaller than those of *caudata*.

80a, b, and c. The same, cells from the same colony as figure 80, showing (a) absence of caudate process, (b) very small caudate process, (c) well developed process.

Fig. 83. *Valkeria uva*, portion of colony, from an English specimen.

83a. The same, details of anatomy.

PLATE XXIX.

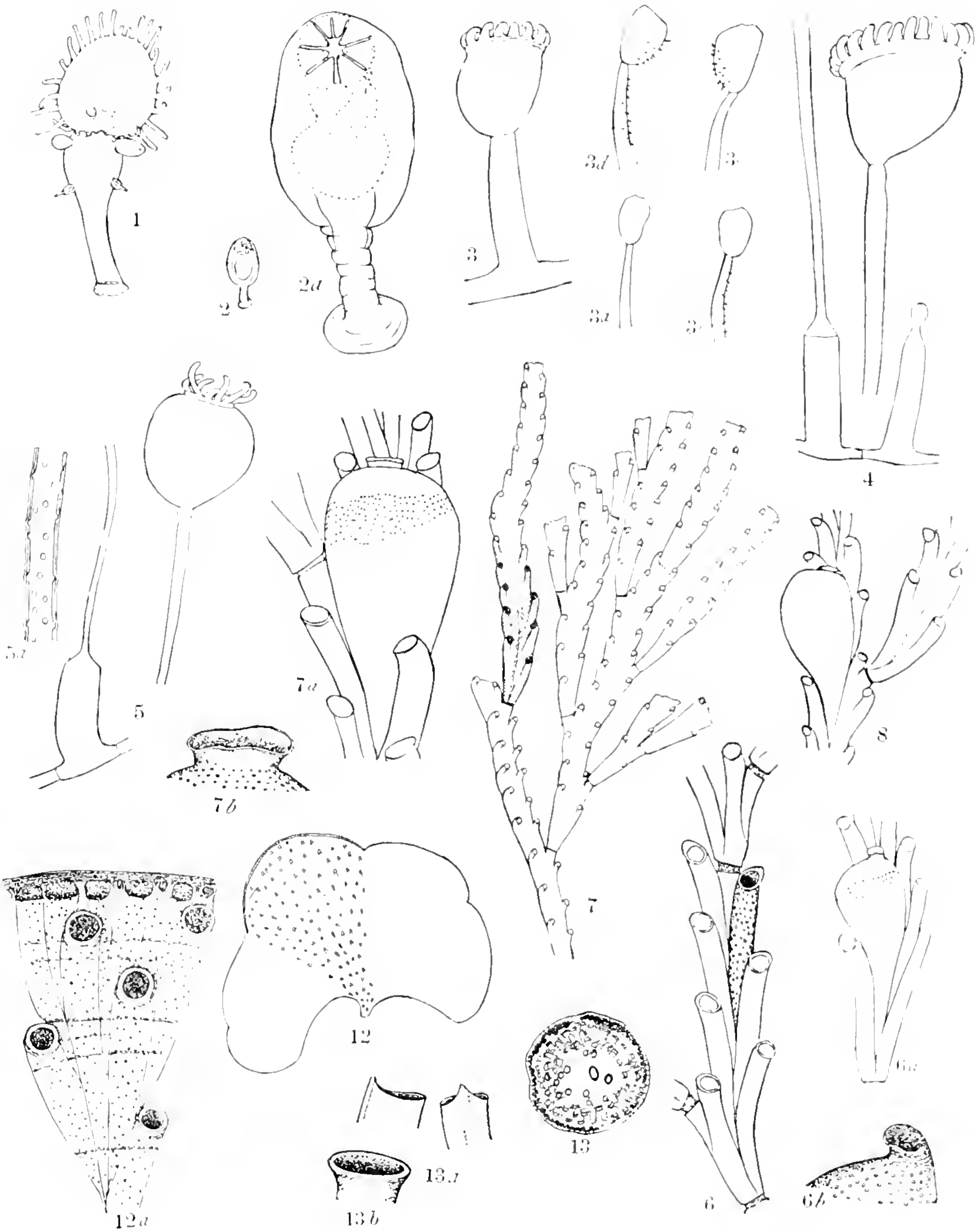
Fig. 81. *Amathia dichotoma*, portion of a branch, showing arrangement of zooecia and mode of branching.
81a. The same, a single cluster of zooecia more highly magnified.
Fig. 82. *Vesicularia familiaris*, a single zooecium, after Smitt.
Fig. 84. *Hippuraria armata*, portion of an erect branch.
84a. The same, a single zooecium in the contracted state much enlarged.
84b. The same, details of alimentary system, (L) lophophore, (O) œsophagus, (G) gizzard, (S) stomach, (I) intestine.
Fig. 85. *Hippuraria elongata*, n. sp., portion of stolon with one zooecium.
85a. The same, small portion of stolon more highly magnified to show manner of branching and origin of zooecia.
85b. The same, outline of the long-pedicellate form of zooecium.
85c. The same, details of anatomy.

PLATE XXX.

Fig. 86. *Membranipora arctica* on shell, twice natural size.
Fig. 87. *Membranipora tenuis*, at the right, and *M. monostachys*, at the left, on pebble, twice natural size.
Fig. 88. *Smittia trispinosa* var. *nitida*, nodular masses about natural size, encrusting shells.
Fig. 89. *Lepralia pallasiana*, colony growing on submerged wood, twice natural size.
Fig. 90. *Microporella ciliata* var. *stellata*, on shell, twice natural size.
Fig. 91. *Schizoporella unicornis*, on mass of tubes of *Hydroides dianthus*, one-half natural size.

PLATE XXXI.

Fig. 92. *Alcyonidium verrilli*, colony with flattened branches, one-half natural size.
92a. The same, with rounded branches, one-half natural size.
Fig. 93. *Caberea ellisii*, natural size.
Fig. 94. *Bugula flabellata*, natural size.
Fig. 95. *Scrupocellaria scabra*, natural size.
Fig. 96. *Menipea ternata*, natural size.
Fig. 97. *Gemellaria loricata*, reduced about one-half.
Fig. 98. *Cellepora canaliculata*, natural size.
Fig. 99. *Cellepora americana*, colonies growing on hydroid stem, natural size.
Fig. 100. *Rhamphostomella costata*, colony growing on *Boltenia* stem, natural size.
Fig. 101. *Porella proboscidea*, at the left a colony on a stem of *Boltenia*, at the right the more usual form of the colony on a hydroid stem, both reduced about one-half.
Fig. 102. *Bugula* turrita, slightly reduced.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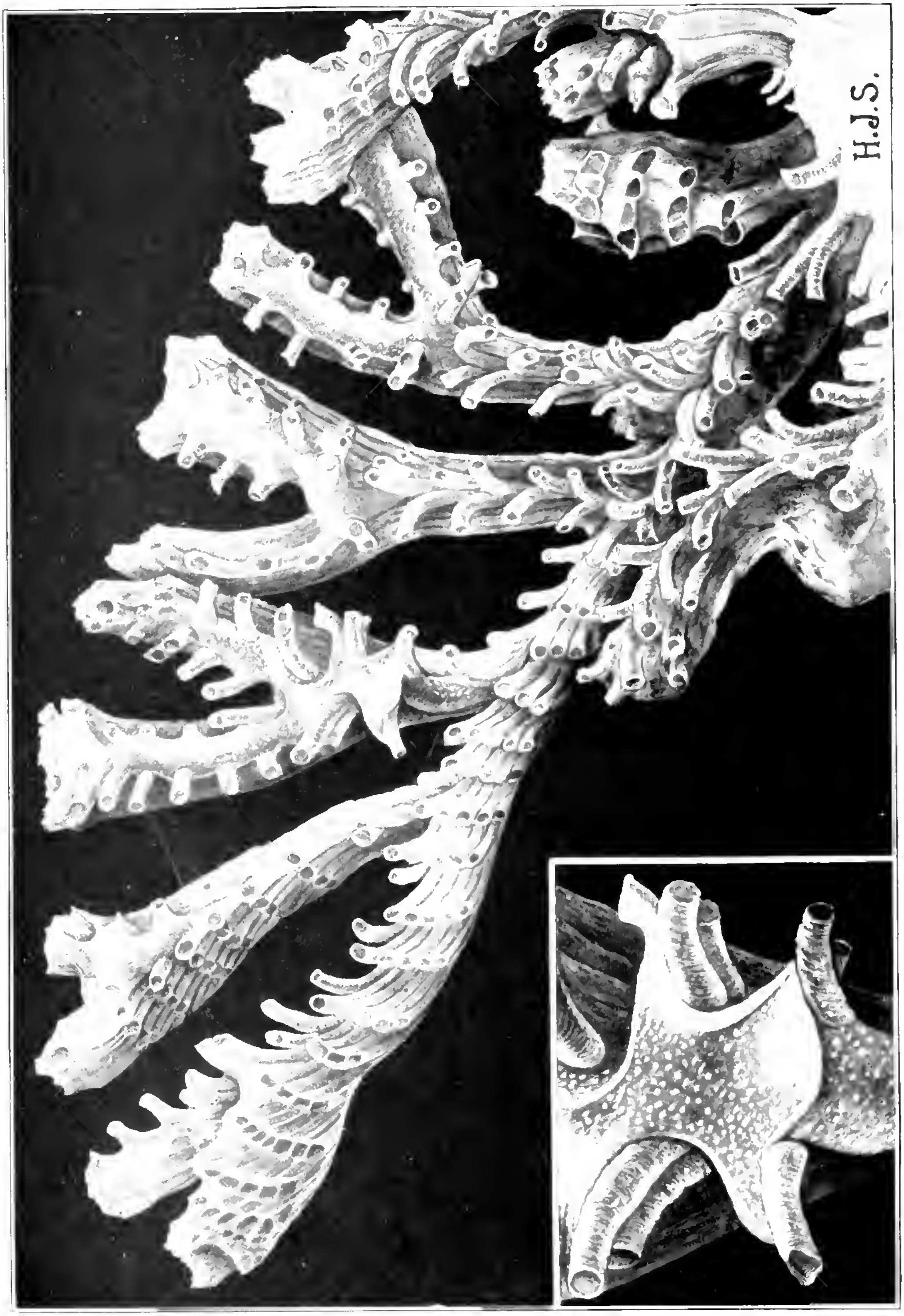

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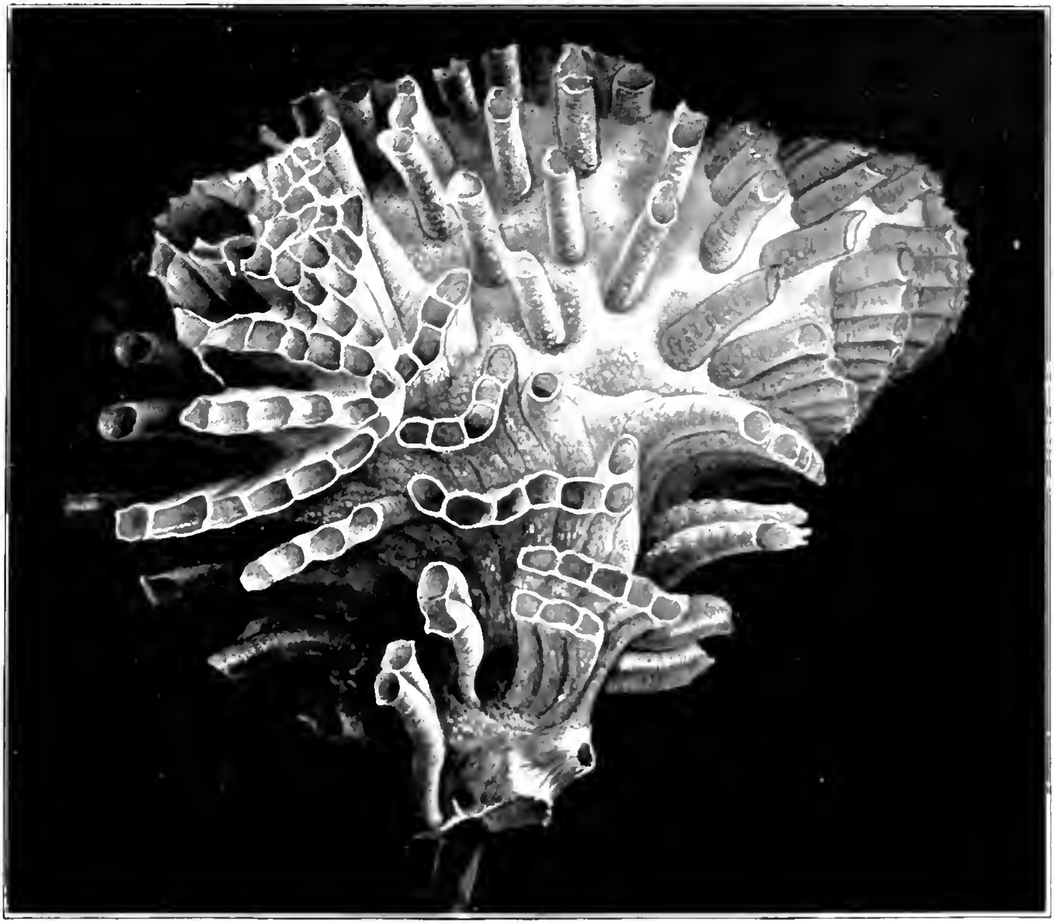

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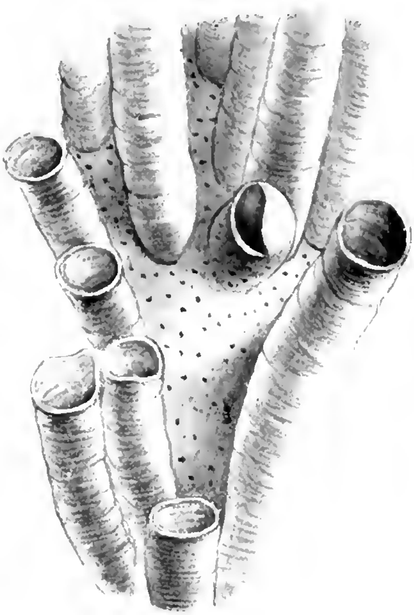

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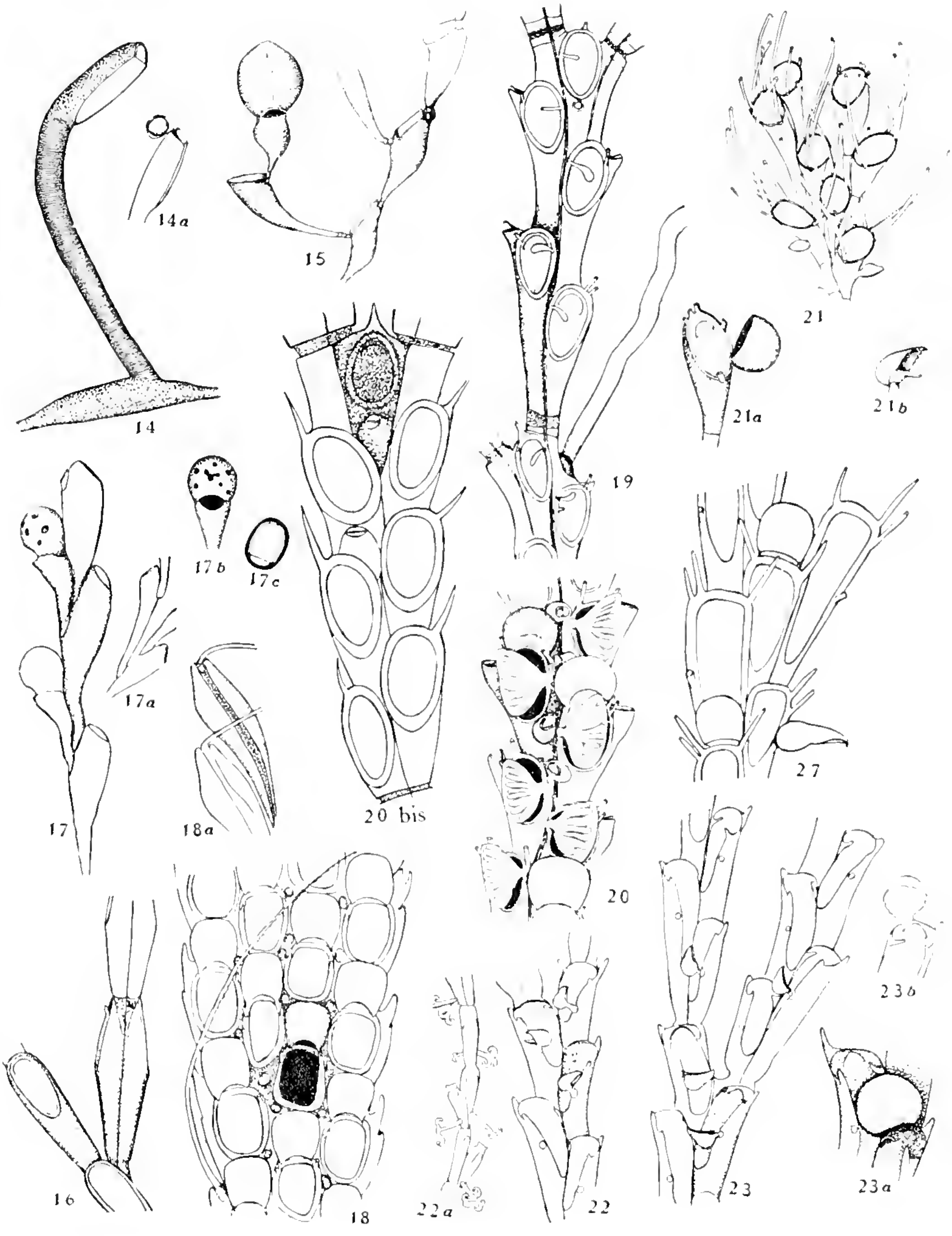
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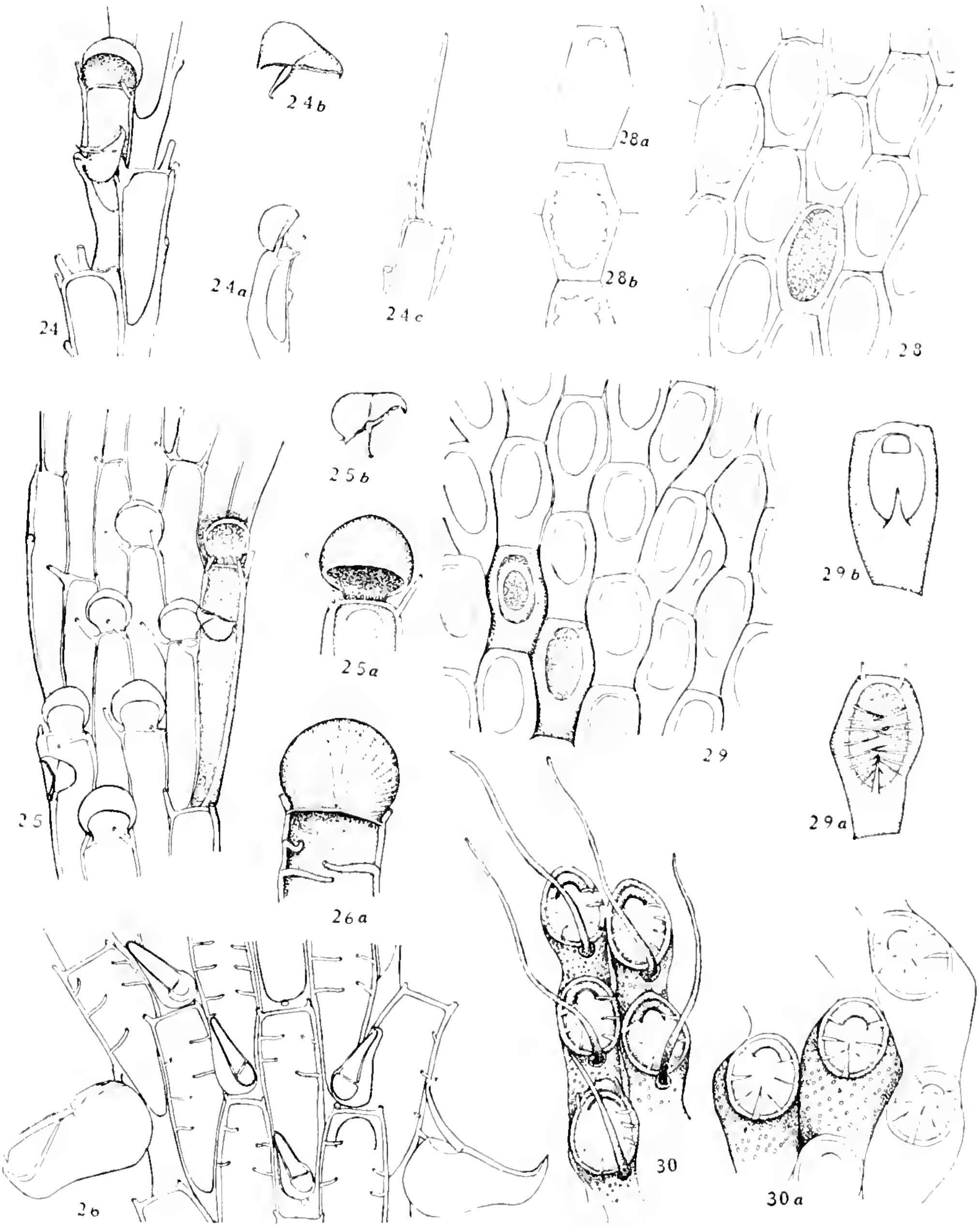
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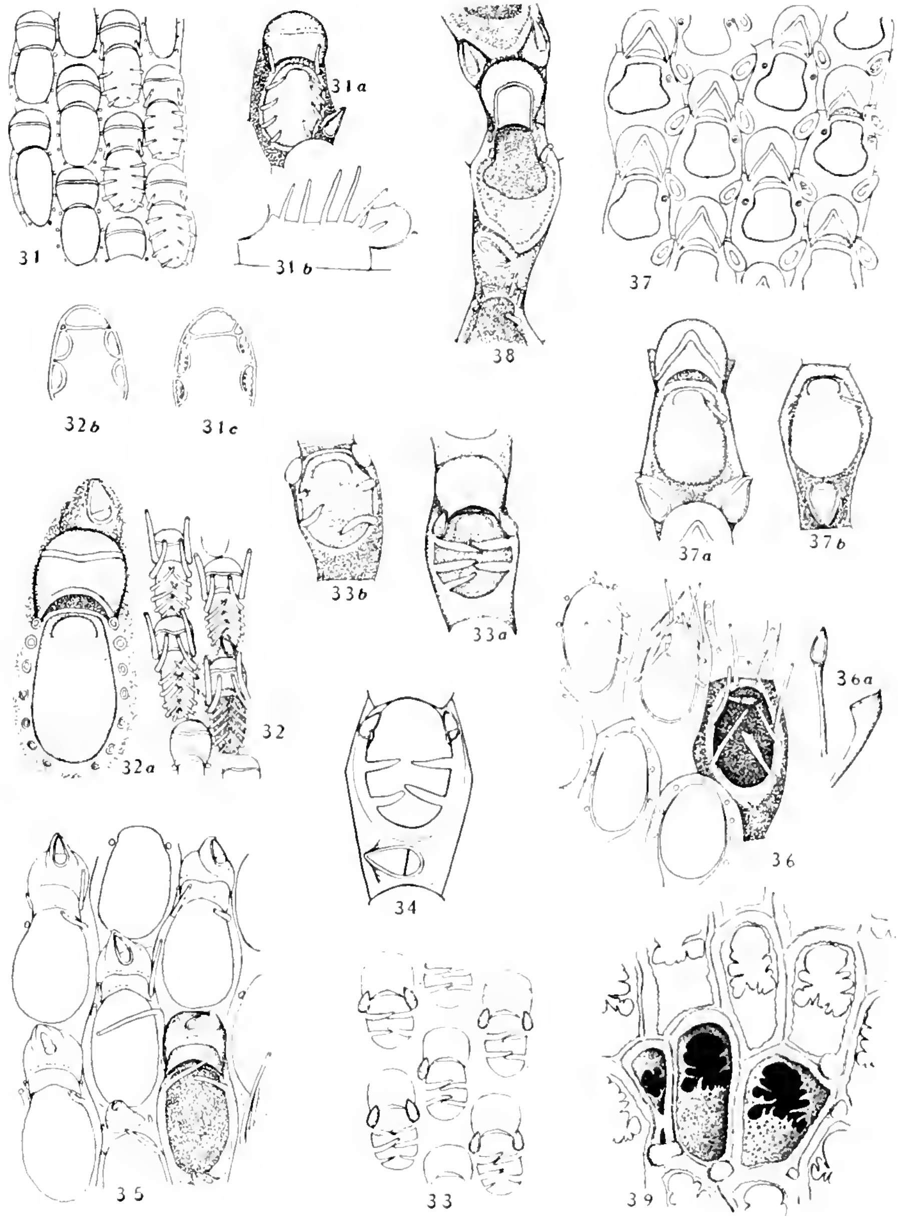
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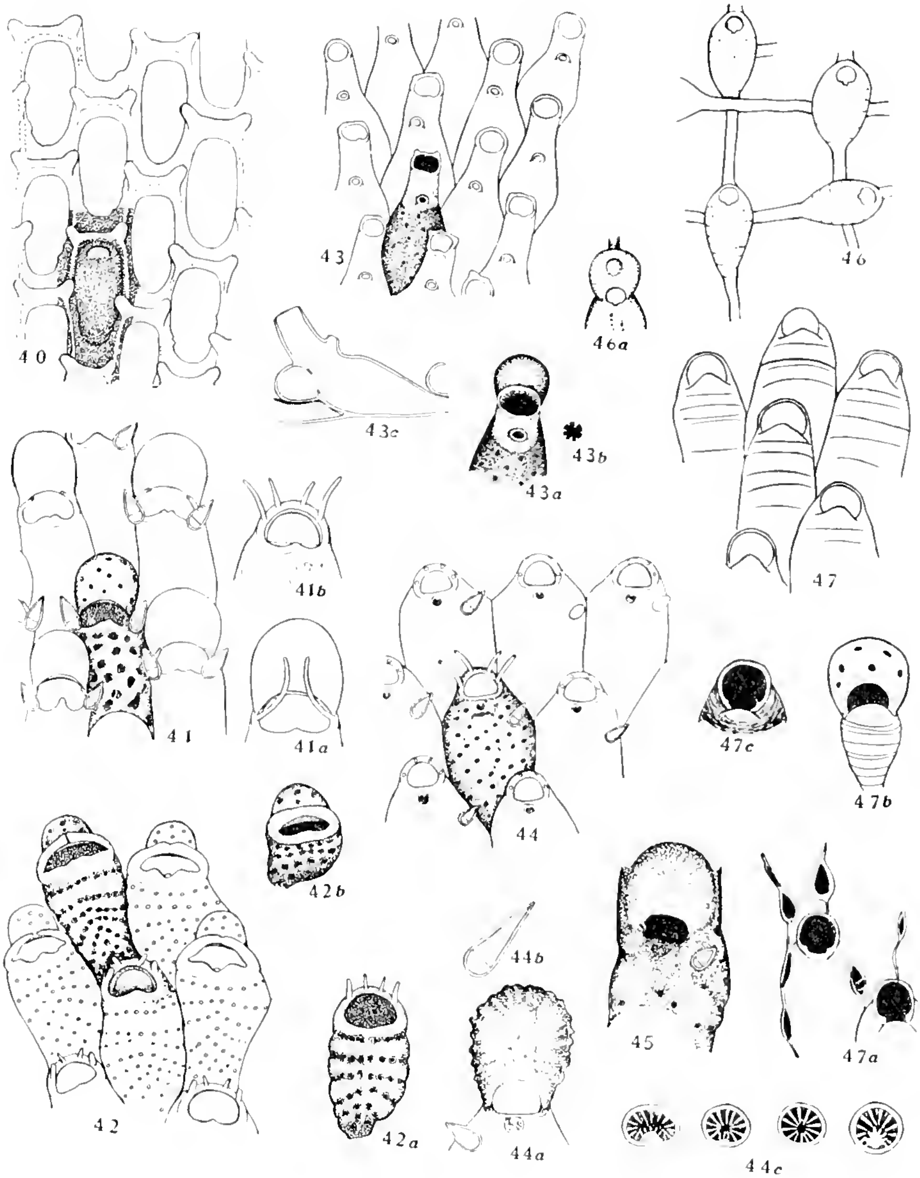
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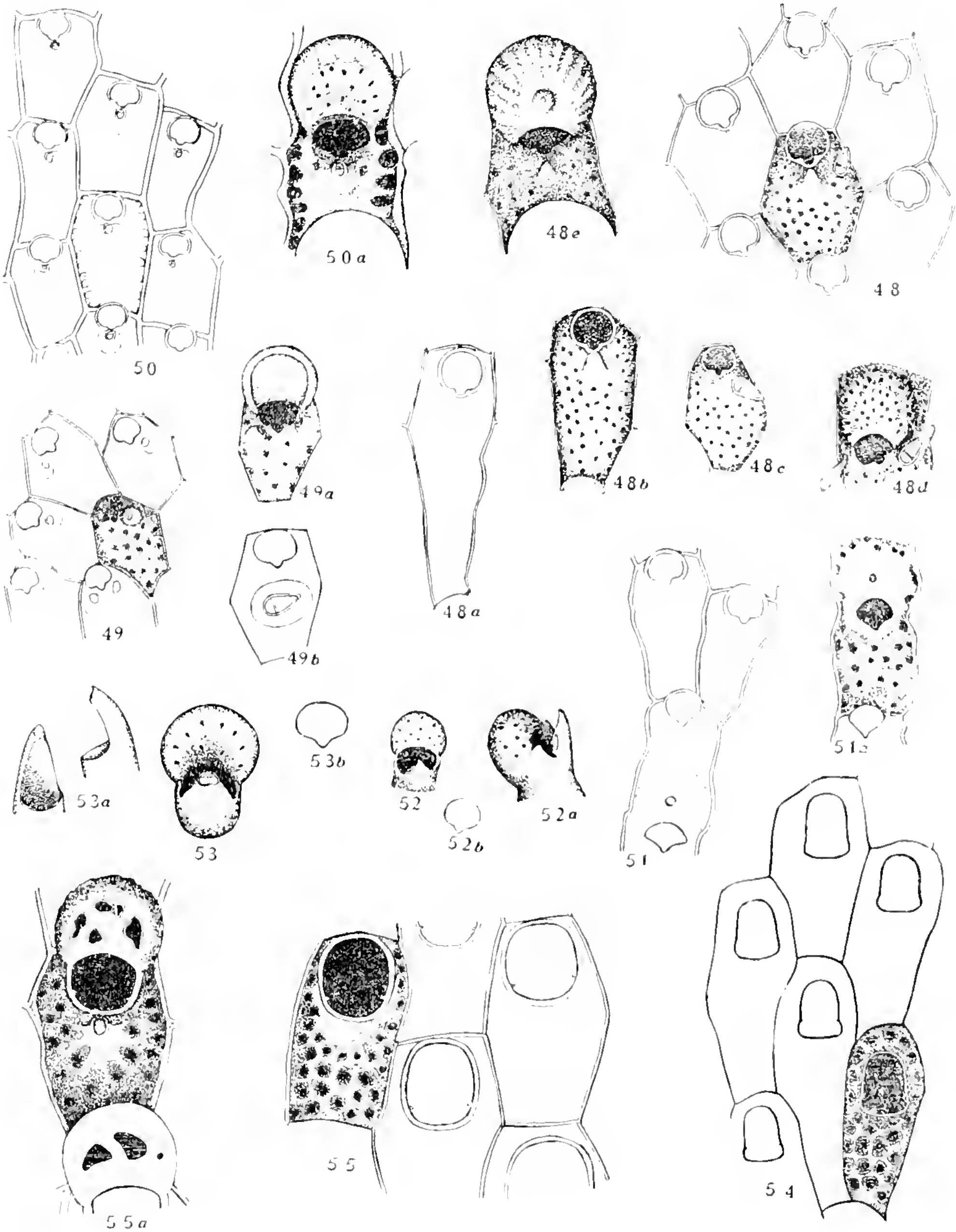
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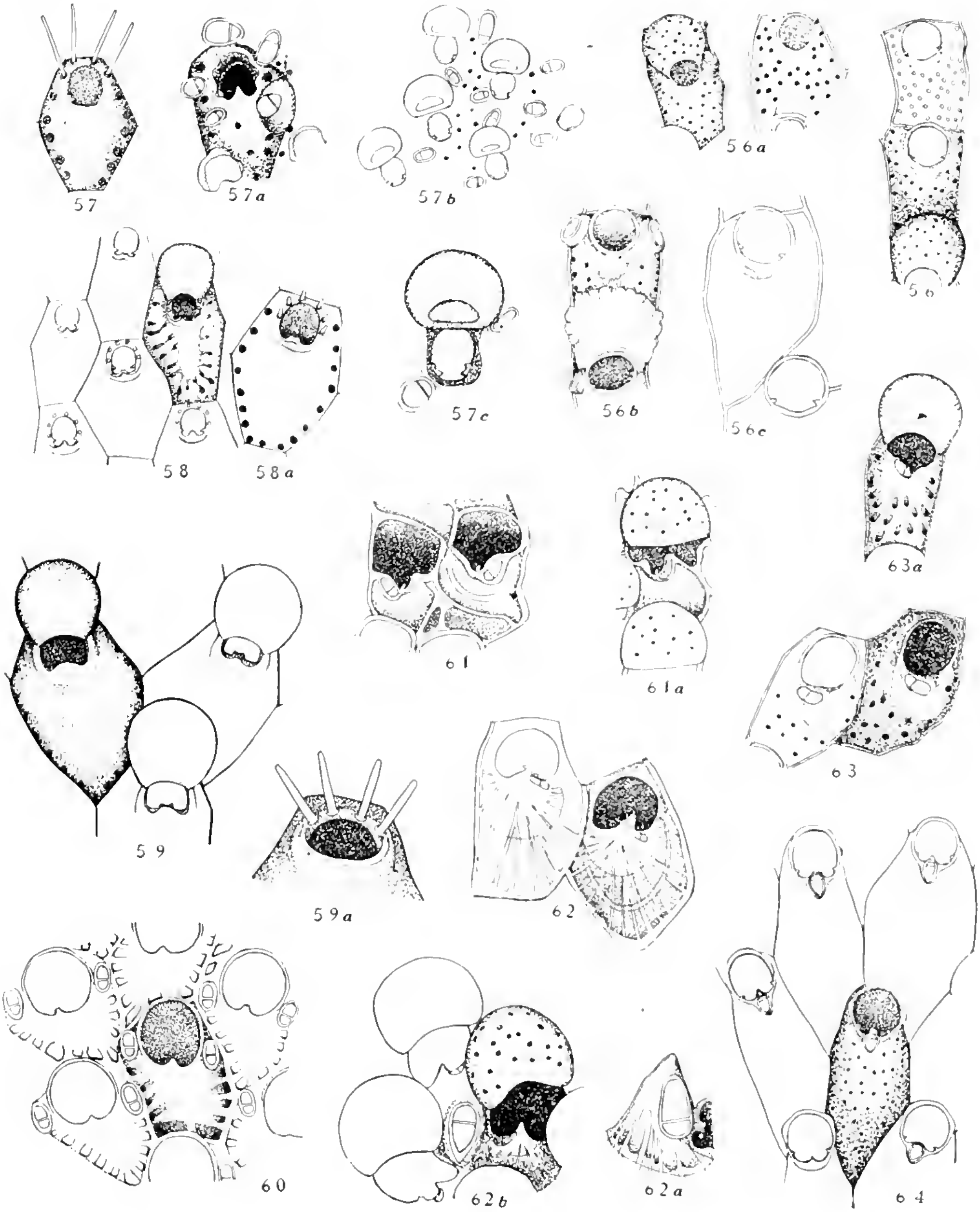
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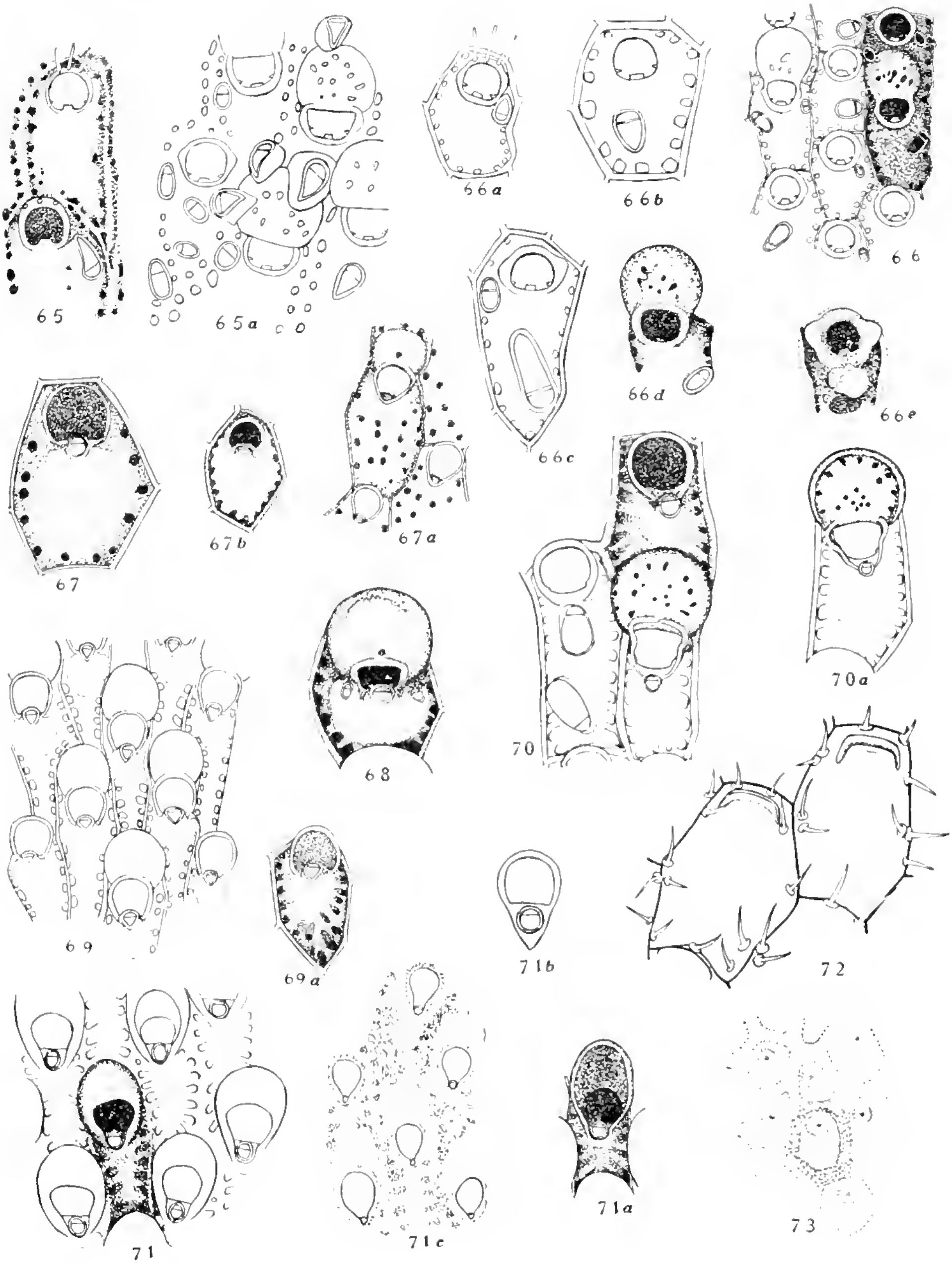
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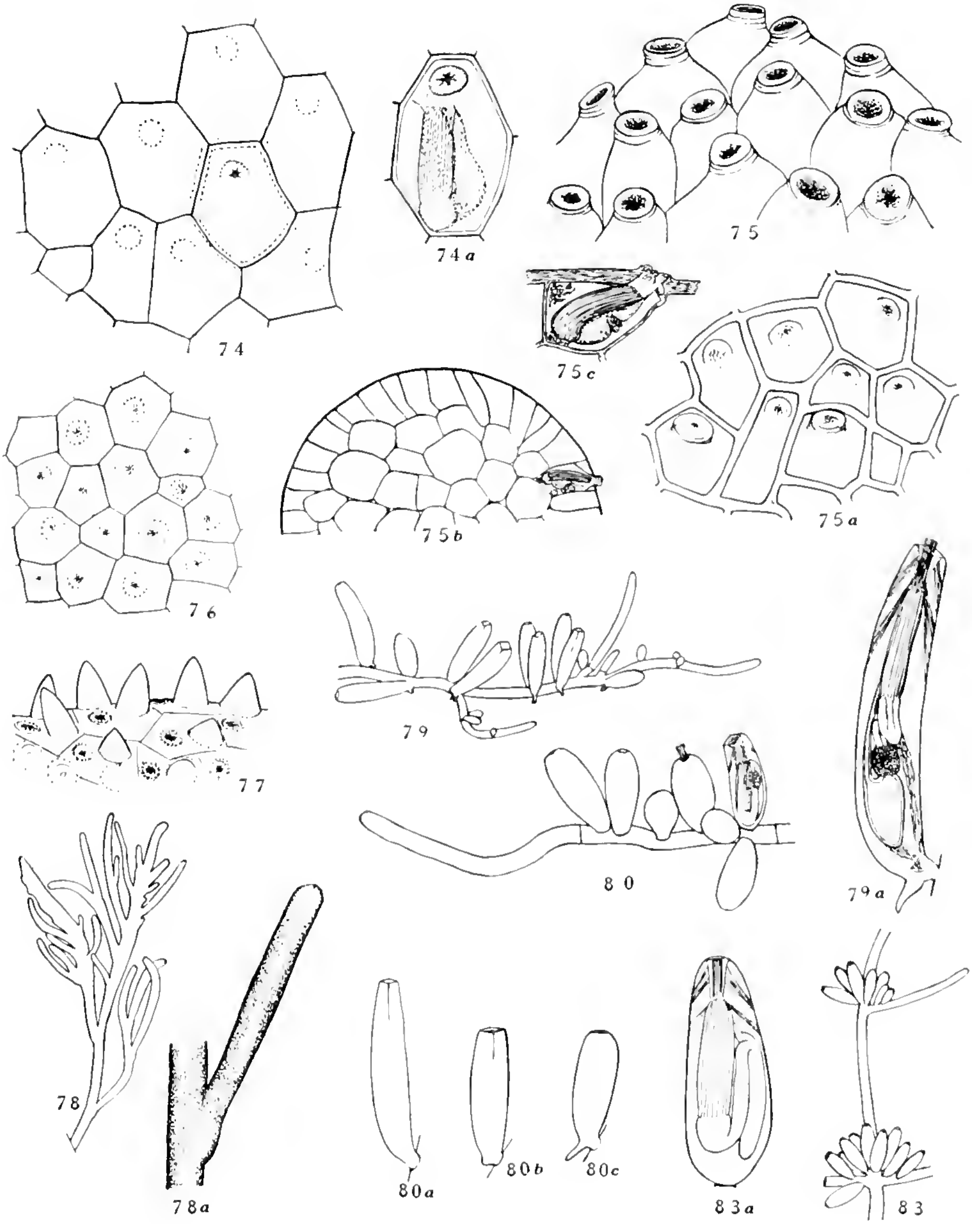
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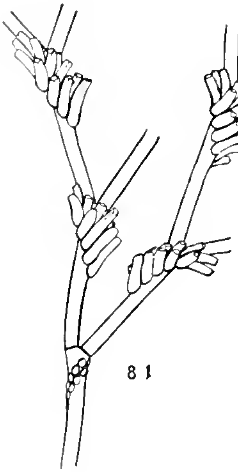

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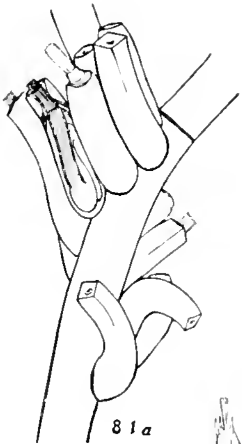

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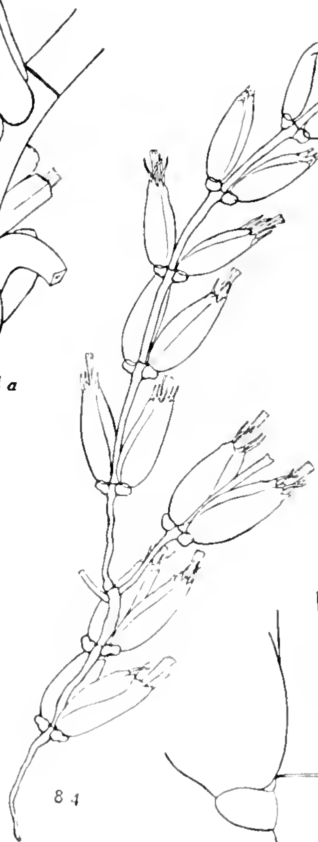

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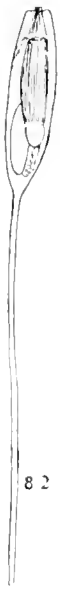

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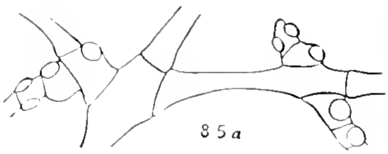

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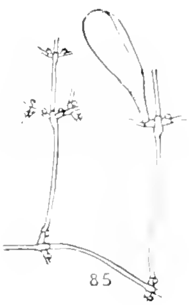

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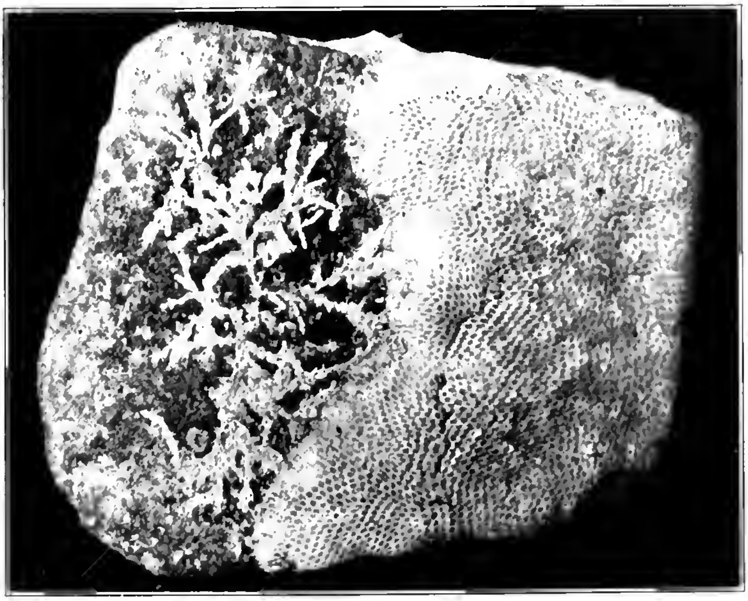

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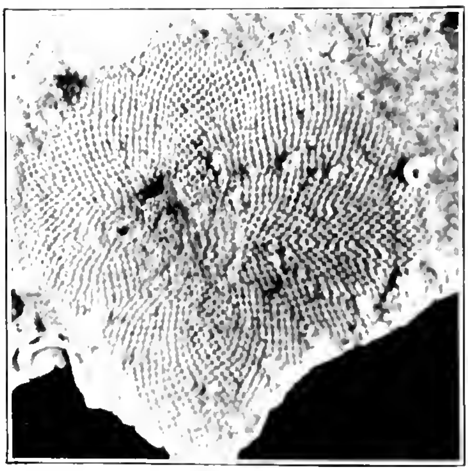

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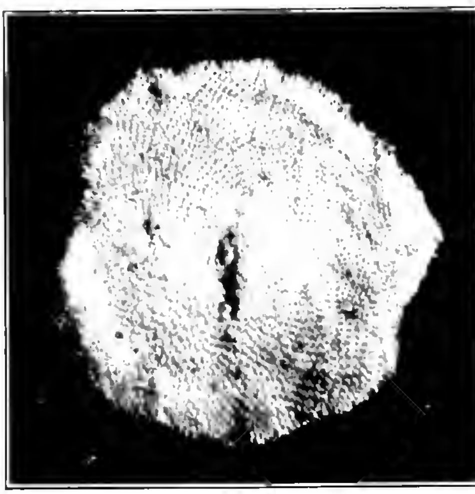

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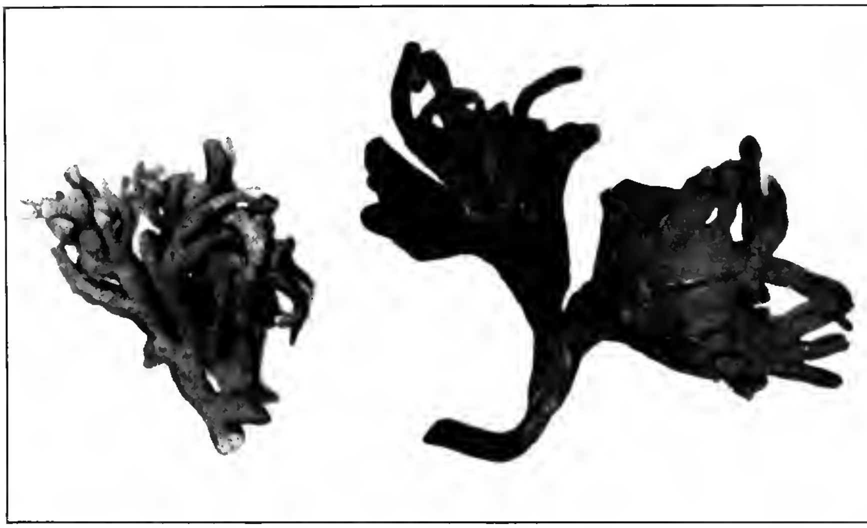

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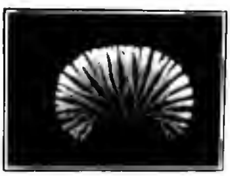

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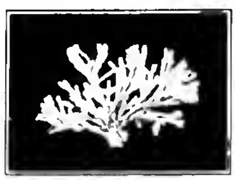

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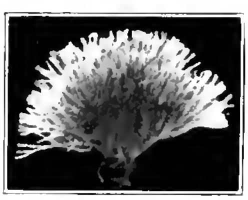

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A REVIEW OF THE CEPHALOPODS OF WESTERN NORTH AMERICA

By S. Stillman Berry
Stanford University, California

A REVIEW OF THE CEPHALOPODS OF WESTERN NORTH AMERICA.

By S. STILLMAN BERRY,
Stanford University, California.

INTRODUCTION.

The region covered by the present report embraces the western shores of North America between Bering Strait on the north and the Coronado Islands on the south, together with the immediately adjacent waters of Bering Sea and the North Pacific Ocean. No attempt is made to present a monograph nor even a complete catalogue of the species now living within this area. The material now at hand is inadequate to properly represent the fauna of such a vast region, and the stations at which anything resembling extensive collecting has been done are far too few and scattered. Rather I have merely endeavored to bring out of chaos and present under one cover a résumé of such work as has already been done, making the necessary corrections wherever possible, and adding accounts of such novelties as have been brought to my notice.

Descriptions are given of all the species known to occur or reported from within our limits, and these have been made as full and accurate as the facilities available to me would allow. I have hoped to do this in such a way that students, particularly in the Western States, will find it unnecessary to have continual access to the widely scattered and often unavailable literature on the subject. In a number of cases, however, the attitude adopted must be understood as little more than provisional in its nature, and more or less extensive revision is to be expected later, especially in the case of the large and difficult genus *Polypus*, which here attains a development scarcely to be surpassed anywhere.

In dealing with genera or higher groups I have nowhere endeavored to give complete diagnoses, but mention is made of such of their more salient characteristics as may serve for at least their temporary recognition by the student unfamiliar with cephalopods.

It has been an unfortunate fact that almost all the work on West American cephalopods has been more fragmentary and desultory than done with an idea to a careful elucidation of the fauna. Some of the early descriptions are so unsatisfactory that it would

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seem much better to have left them unpublished and the majority of the species concerned are nearly or quite unrecognizable. The reason for this neglect is difficult to comprehend. In diversity of structure and the high specialization by which they are enabled to maintain themselves in harmony with the conditions of their environment, the cephalopods are surely without a parallel among the Mollusca. One need only call attention to the beauty of many of the species in life, their interesting habits, the powers of color change, of luminosity, and of vision, not to mention the curious secondary sexual organs and other minor contrivances, to reveal at a glance what an attractive field lies open to the student. It is to be hoped that it will not much longer remain practically untilled, as in the past, at least so far as American scholars have been concerned.

The advantages I have enjoyed while engaged in the preparation of this report have on the whole been quite exceptional, and a considerable amount of material has been gone over. This comprises some 600 specimens, which have been rendered available from the following sources:

1. The cephalopods obtained by the United States Fisheries Steamer Albatross during the Alaska salmon investigations of 1903.

2. The specimens dredged by the Albatross off the California coast in 1904.

3. The miscellaneous series in the zoological collections of Stanford University.

4. The small collection possessed by the department of zoology of the University of California, which has already been reported upon. (Berry 1911a).

5. A small series of octopods sent through the kindness of Dr. William E. Ritter from the Marine Biological Laboratory at La Jolla, near San Diego, California.

6. The private collection of the writer.

Access has also been had to the collections of the Museum of Comparative Zoology and the Peabody Museum of Yale University.

A small preliminary paper containing brief diagnoses of seven supposedly new species has already been published (1911).

NOTE.—The work has been greatly facilitated throughout by the unfailing kindness of many friends and the writer greatly regrets that space does not permit him to state his full indebtedness to each. There are some, however, to whom grateful acknowledgment must be made

First and foremost, he is indebted to Dr. Walter Kenrick Fisher, of Stanford University, under the general supervision of whom most of these studies have been carried on, and whose interest and unselfish aid have been indefatigable.

The Albatross collections were first placed in the hands of Dr. Harold Heath, of Stanford University, and, among other kindnesses, I am under great obligation to him for permitting me to work them up in his stead. Much encouragement has been given by Dr. Charles Henry Gilbert, of Stanford University, in the searching out of interesting specimens and helpful advice.

I am also indebted to Dr. William E. Hoyle, director of the Cardiff Museum, and to Prof. Addison E. Verrill for the gift of much valuable literature and other favors; to Mr. Samuel Henshaw and Dr. Edward Laurens Mark, of the Museum of Comparative Zoology, for kindly placing at my disposal the collections and other resources under their charge; and for divers kindnesses to many others.

Lastly the writer must state his obligation to Mr. Henry Varnum Poor, to Mr. John Howard Paine, and especially to Miss Lora Woodhead, all of Stanford University, for the patient and careful service they have rendered him in the preparation of the illustrations.

CLASSIFICATION.

Although the collections examined contain a fair supply of novel forms, the interest of these is mainly zoogeographical and as a rule they have little light to throw upon the broader problems of morphology and interrelationship. Consequently I have advanced no very new ideas of classification, but have been quite content to follow the general lines laid down in the various works of Hoyle, or in some cases that represented with certain slight modifications in Pfeffer's indispensable Synopsis (1900) and in the Nordisches Plankton Report (1908) of the same author.

For convenience in rapidly referring to any of the species here described, the following key is offered. It is perforce more artificial than natural, and it must be further remembered that the likelihood of the occurrence of forms not previously known to the region is still so great that no attempt should be made to rest an identification upon the key alone.

KEY TO THE CEPHALOPODA KNOWN TO INHABIT THE WESTERN COAST OF NORTH AMERICA.

I. Tentacles absent; suckers sessile, without a horny ring. (Octopoda.)
- 1. A pair of lateral oar-shaped fins present; suckers in a single row. (Cirroteuthidæ.)
  - 2. Dorsal cartilage saddle-shaped; mantle opening wide....... *Cirroteuthis macrope*, p. 273.
  - 2′. Dorsal cartilage horseshoe-shaped (?); mantle opening very small........ *Stauroteuthis* sp. ?, p. 274.
- 1′. No fins.
  - 3. Aquiferous pores present on the head; female with an external shell; hectocotylus involving the entire third arm of the left side and separable........ *Argonauta pacifica*, p. 275.
  - 3′. No aquiferous pores; no external shell; hectocotylus confined to tip of arm. (Polypodidæ.)
    - 4. Suckers in a single row; body soft........ *Eledonella heathi*, p. 276.
    - 4′. Suckers in two rows; body fairly firm. (Genus *Polypus*.)
      - 5. A prominent pigmented spot in front of each eye; hectocotylus very minute........ *Polypus bimaculatus*, p. 278.
      - 5′. No definite oculations.
        - 6. Dorsal arms notably the longest; body with a peripheral fold of the integument........ *P. leioderma*, p. 288.
        - 6′. Dorsal arms not usually the longest; body without a peripheral fold.
          - 7. Hectocotylized portion of arm relatively moderate in size—one-ninth to one-twentieth the total length........ *P. hongkongensis*, p. 280.
          - 7′. Hectocotylized portion of arm extremely large—one-fifth to one-eighth the total length.
            - 8. Surface papillæ small, simple........ *P. gilbertianus*, p. 284.
            - 8′. Surface papillæ large, soft, stellate........ *P. californicus*, p. 286.

II. Tentacles present; suckers stalked, usually provided with a horny ring (Decapoda.)
- 1. Eyes covered by a continuous membrane. (Myopsida.)
  - 2. Body short, rounded, with ovate lateral fins; dorsal margin of mantle free from head; both dorsal arms hectocotylized. *Rossia pacifica*, p. 290.
  - 2′. Body elongate, pointed, with subterminal triangular fins; left ventral arm hectocotylized........ *Loligo opalescens*, p. 294.

1′. Eye with a perforated lid. (Œgopsida.)
  3. Suckers unmodified.
    4. Funnel articulating with the mantle by a triangular cartilage having a ⊥-shaped groove. (Ommastrephidæ.)
      5. Tentacle bearing suckers for more than half its length; fixing apparatus poorly developed.................... *Ommastrephes sagittatus*, p. 298.
      5′. Suckers extending for less than half the length of the tentacle; fixing apparatus a distinct carpal group of pads and suckers.
        6. Mantle fused with the funnel on at least one side..... *Symplectoteuthis oualaniensis*, p. 304.
        6′. Cartilaginous articulation free.
          7. Size moderate, arm tips normal.................... *Sthenoteuthis bartramii*, p. 298.
          7′. Adult very large; arm tips attenuate, with very minute and numerous suckers.................. *Dosidicus gigas*, p. 301.
    4′. Funnel articulating with the mantle by an ear-shaped cartilage having a simple groove; numerous luminous organs present on the ventral aspect.................. *Meleagroteuthis hoylei*, p. 305.
  3′. Some of the suckers modified into hooks.
    8. Sessile arms except ventral pair bearing two rows each of suckers and hooks.................................. *Gonatus fabricii*, p. 308.
    8′. Hooks present on the tentacle club alone; sessile arms with two rows of suckers.
      9. Body firm, loliginiform; cartilaginous articulation free. (Onychoteuthidæ.)
        10. Animal gigantic; gladius terminating in a long solid cone.. *Moroteuthis robusta*, p. 314.
        10′. Animal small or of moderate size; point of gladius compressed and weak.......................... *Onychoteuthis*, sp., p. 312.
      9′. Body delicate; fins long and narrow; mantle margin fused with the body in three places............... *Galiteuthis phyllura*, p. 315.

Phylum MOLLUSCA, Class CEPHALOPODA.

Order Dibranchiata.

OCTOPODA.

Family CIRROTEUTHIDÆ Keferstein, 1866.

Genus CIRROTEUTHIS Eschricht, 1836.

Cirroteuthis Eschricht, 1836, p. 627
Sciadephorus Reinhardt and Prosch, 1846, p. 165.
Bostrychoteuthis Agassiz, 1846, p. 50, 87.
Cirroteuthis Hoyle, 1886, p. 55.
Cirroteuthis Hoyle, 1904, p. 3.

The members of this genus are deep-sea octopods, often of large size, with a rounded or ovoid body of rather gelatinous consistency and a paddle-like fin attached on either side. The web connecting the arms is exceptionally developed. The suckers are placed in a single series alternating with paired cirri on either side. A large saddle-shaped supporting cartilage is present in the medio-dorsal region of the body.

Type, *C. Mülleri* Eschricht, 1836, a species occurring off the coast of Greenland.

Cirroteuthis macrope Berry, 1911. (Pl. XXXII, fig. 1-3.)

Cirroteuthis macrope **Berry**, 1911,[a] p. 589.

Animal (so far as known) of rather small size, subgelatinous in consistency. Body somewhat barrel-shaped, fairly elongate, with a short but very broad oar-like fin on either side near the posterior extremity. This fin comprises two portions: A thick, fleshy, and deeply inserted support, terminating outwardly in an acute point, and a delicate membranous margin. Mantle opening full and very wide, reaching to a point just behind each eye and leaving the funnel well exposed (pl. XXXII, fig. 1).

Head wide, flattened, broadly continuous with the body above, no distinct line of demarcation being visible. Eyes strongly asymmetrical, that of the left side being much the larger, spherical, very large and prominently protruding. Funnel large, broad, well immersed; its integument continuous with that of the head except at the slightly involute tip. Funnel organ very distinct, comprising a small whitish oval pad on either side of the dorsal wall near the apex (pl. XXXII, fig. 3).

Umbrella and arms very fragmentary in the specimen examined; web apparently thin and delicate, attached to the arms nearly if not quite to their tips; suckers minute; cirri arranged as usual but relatively large, having the appearance of long pointed papillæ.

Mandibles black and horny, but not massive.

Radula present and well developed. The arrangement and shape of the seven rows of teeth are shown in the accompanying figures (text fig. 1, and pl. XXXII, fig. 2).

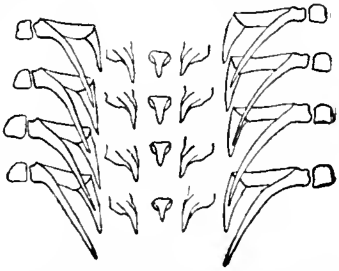

FIG. 1.—*Cirroteuthis macrope*, four rows of teeth from radula; camera outline. [120.]

Dorsal cartilage not removed, but it appears to be more or less saddle shaped, the posterior lobe rounded above, knob-like, and very prominent.

Color in spirits a subtranslucent milky white; the umbrella and scant traces of epidermis remaining on the rest of the body a dark purplish brown.

MEASUREMENTS OF CIRROTEUTHIS MACROPE.[b]

	Type.	Young.
	mm.	*mm.*
Total length	99	30
From tip of body to base of umbrella	58	18
From tip of body to mantle opening	36	14
Extreme width of body	26	10
Width of fin	27	4.5
Length of fin	9	1.0
Total width of head	36	10
Width between eyes	18	7
Median length of funnel (ventral)	16	5

Type, no. 214317, U. S. National Museum (no. 120 of the author's register).

Type locality, station 4393, U. S. Fisheries Steamer Albatross, 2113-2259 fathoms, vicinity of San Diego, California; bottom of soft gray mud. Two specimens.

C. macrope is well characterized by its elongate shape, the extremely wide mantle opening, and the odontophore. As its reference to the present genus seems positive, it was certainly a surprise to discover the presence of an unmistakable radula, when the family has for years been supposed to lack the organ. I first found it in the smaller of the two specimens, and then surmised that it might prove to be

[a] The references of particular importance in the synonymy of each species are indicated by bold-face type.

[b] Where but one set of figures is given in respect to the length of the arms I have chosen for measurement that arm in each pair which for any reason appeared to me to be best preserved or most closely approaching the state which obtains in the living animal. It should be remembered that such data are more approximate than exact, a statement which is notoriously true in the case of the genus *Polypus*.

a juvenile character disappearing in the adult. The occurrence of a correspondingly larger radula in the more mature individual, however, quite disproves this hypothesis and indicates that it has either been previously overlooked, or that the structure is present in some species of the group and much reduced or wanting in others.

The apparently disproportionate development of the two sides of the head may be due to the bursting of the eyes, but if not, closely parallels the remarkable state described for the widely different *Meleagroteuthis hoylei* by Pfeffer and alluded to on page 305 of the present paper. Though attained independently in each species, it may be that the condition is due to some environmental feature or habit common to both. It is a curious fact that in every individual seen it is the left eye which undergoes the enlargement and the right which is reduced.

Genus STAUROTEUTHIS Verrill, 1879.

Stauroteuthis Verrill, 1879, p 468.
Verrill, 1881, p. 382.
Hoyle, 1904, p. 5.

A group closely allied to *Cirroteuthis*, but differing chiefly in the fact that the dorsal cartilage is posterier in position and horseshoe-shaped, with the free ends directed toward the head.

Type, *S. syrtensis* Verrill, 1879, from off Nova Scotia.

? Stauroteuthis sp., juv. (Pl. XXXIII, fig. 1.)

A single individual obtained by the Albatross at station 4325, 191-292 fathoms, in the vicinity of San Diego, Cal., is so young that to name it might lead to little but confusion in the future, yet it is so remarkably well preserved that a brief description at least seems well worth while.

Body short, plump, subgelatinous, slightly compressed above and below; on either side a small paddle-like fin which is slightly constricted and thickened at the base.

Head apparently larger than the body, but so intimately connected with the latter that no exact line of demarcation can be drawn. Eyes relatively enormous, appearing as prominent swellings; eyeball dark bluish in color, with a very large white lens. Funnel very small, broadly triangular in shape, very blunt at the tip. Opening of the branchial cavity much reduced, forming only a small semicircle below the funnel and not extending beyond it on either side.

Arms subequal, the ventral ones somewhat the shortest; connected almost to their extreme tips by the enormously thick and fleshy umbrella; intermediate web absent. Suckers of exceeding minuteness, in a single row, and supplemented by the usual row of paired cirri on each side.

Not wishing for the present to mutilate the specimen seriously, I am unable to add sufficient particulars definitely to settle its generic position, but refer it provisionally to *Stauroteuthis*. In general it suggests Verrill's figure of *Cirroteuthis plena*, but has larger eyes, smaller suckers, and the arms are more immersed in the web. The illustration given by Joubin of *Cirroteuthis umbellata* (=*Stauroteuthis hippocrepium* Hoyle ?) also offers many points of resemblance, but the above remarks as to the arms and web would apply here as well; nor does the small specimen described by Hoyle as *Cirroteuthis meangensis* appear to be the same.

The unique specimen is in the U. S. National Museum (no. 119 of the author's register). Its measurements as contracted in spirits are given below.

MEASUREMENTS OF STAUROTEUTHIS SP., JUV.

	mm.
Total length	32
From tip of body to mantle opening	11
Width of body	14
Width of fins	7
Length of fins	4
Width of mantle opening	5
Width across eyes	20
Diameter of eye	8.5

Family ARGONAUTIDÆ Cantraine, 1840.

OCYTHOIDÆ Gray, 1849.

Genus ARGONAUTA Linné, 1758.

Argonauta Linné, 1758, p. 708.
Ocythoe Gray, 1849, p 30 (not of Rafinesque).

Pelagic octopods of moderate size, the male much smaller than the female and with the hectocotylus involving the entire third arm on the left side, which is developed in an oval sac, much enlarged, and separable. In the female the tips of the dorsal arms are greatly expanded, wing like, and their function is to secrete the large fragile external "shell" or egg case. Mantle connectives well developed. Aquiferous pores present on the head.

No other group at all approaches *Argonauta* in its assemblage of utterly distinctive characters, the nearest being the genera *Ocythoe* and *Tremoctopus*, which are not known to be represented in our waters. The genus comprises the familiar and beautiful "argonauts" found in all warm seas. The delicate egg case is the greatly prized shell popularly known as the "paper nautilus."

Type, *A. Argo* Linné, 1758, a common Mediterranean and Atlantic species.

Argonauta pacifica Dall, 1872.

?*Argonauta Argo* Reeve, 1861, pl. III, fig. 2d.
Argonauta Argo Carpenter, 1864, p. 613,664 (merely listed).
Argonauta Argo Stearns, 1867, p. 345 (merely listed).
Argonauta pacifica Dall, 1869, p. 237 (no description).
Dall, 1872, p. 95.
Argonauta Argo (pars) Tryon, 1879, p. 139, pl. 49, fig. 120 (? fig. 121, after Reeve).
Argonauta pacifica Hoyle, 1886, p. 5 (no description).
Hoyle, 1886a, p. 213 (9), (no description).
Argonauta argo Yates (err. typ.), 1889, p. 178 (merely listed).
Argonauta Argo Yates, 1890, p. 45 (merely listed).
Argonauta pacifica Williamson, 1892, p. 217 (merely listed).
Keep, 1904, p. 271,350 (no description).
Argonauta pacifica Dall, 1908, p. 225.
Argonauta argo pacifica Dall, op. cit., p. 226,228.
Argonauta pacifica Dall, 1909, p. 193 (merely listed).
Keep, 1910, p. 296 (no description).

The essence of the original diagnosis is as follows, comparison being made with the Mediterranean *A. argo:*

"The animal of the Californian species is orange, with a sprinkling of fine purple dots, more crowded and larger on the back. The proportions of the arms are different from those of the *A. argo*. The first pair are a little the longest, the second next in length, while in *A. argo* they are the shortest; the third pair are the shortest and the fourth equal to the third. The web extends along only one-half of the fourth pair, and is proportionately smaller than in *A. argo*; the siphon is shorter with a blunt elbow. The dentition also differs. The central tooth is proportionately larger, much broader, and slightly convex in the middle line in front. The first lateral is smaller and the inner corner produced into a denticle. The second lateral is proportionately larger and the third narrower and smaller than in *A. argo*. The shell is more ventricose, and the arrangement of the sculpture and tubercles is different from that of the Mediterranean species." (Dall, American Journal of Conchology, vol. VII, p. 96, 1872.[a])

Distribution: Monterey, California (Dall); Santa Rosa Island, California (Yates); Santa Cruz Island, California (Cooper, Stearns); Santa Catalina Island, California;[b] San Pedro, California (Tryon); Gulf of California (Dall); Gulf of Panama (Albatross, Dall); near the Galapagos Islands (Albatross, Dall).

[a] For a popular account see the article entitled "A tame nautilus," by Charles F. Holder in the Scientific American for October 16, 1909.

Argonauta pacifica is the common "paper nautilus" of the Southern California coast. Although of more than frequent occurrence, especially in the neighborhood of the Channel Islands, this graceful species is not represented in any of the collections at my disposal, and hence I am unable to describe it further or to represent it by figures. On the authority of Cooper, Carpenter speaks of "Hundreds on beach at Sta. Cruz Is.," and this seems to have been no exaggeration, although the species is somewhat sporadic in occurrence. The beautiful shells are very commonly met with in curio stores, being usually held for fancy prices in the hope of ensnaring the unwary tourist. This is in large part an explanation of the rarity of specimens in the coast museums. Living examples are sometimes to be seen in the aquarium at Avalon, and it is somewhat surprising that no complete description of even the external features of the animal has found its way to print.

The range of the species appears to be a wide one, for it has been reported to occur from Monterey Bay as far to the southward as the Galapagos Islands. We may well expect to hear of its occurrence in even more distant waters, for like all other members of the genus, its habits are pelagic.

Family POLYPODIDÆ Hoyle, 1904.

OCTOPIDÆ D'Orbigny.

OCTOPODIDÆ auctt.

Genus ELEDONELLA Verrill, 1884.

Eledonella Verrill, 1884, p. 144.
Hoyle, 1886, p. 106.

Body of moderate size, soft and saccular, without fins. Mantle opening very wide. A median septum present in the branchial cavity. Arms slender, the third pair much the largest; suckers in a single row, usually large and urceolate; umbrella short. Right third arm hectocotylized.

This genus comprises a small number of deep-sea octopods having a very anomalous distribution, as is to be noted later. The genera *Bolitæna* "Steenstrup" Hoyle and *Japetella* Hoyle are united with *Eledonella* by Chun, but under the name given by Steenstrup, although *Bolitæna* was not diagnosed until two years after the description of *Eledonella*.[a]

Type, *E. pygmæa* Verrill, 1884, a deep-sea species of the North Atlantic.

Eledonella heathi Berry, 1911. (Pl. XXXII, fig. 4; pl. XXXIII, fig. 2–4.)

Eledonella heathi Berry, 1911, p. 589.

Mantle smooth, saccular, inflated, of a subgelatinous to membranous consistency, recalling the condition seen in many of the Cranchiidæ; mantle opening extremely broad and full, extending upward on either side to a point above and slightly past the center of each eye.

Head short, broad, greatly compressed above and below, well defined from the body. Eyes very large, dark in color, rounded and prominent; sessile, the lens much protruding. Funnel broad, thin walled, not extending past the eyes or quite to the base of the umbrella. Funnel organ comprising a flattened Λ-shaped pad, or rather two diverging ovate pads connected in front by a transverse median pad, the anterior point of which is free and flap-like, to a cursory glance having very much the appearance of a valve; the whole apparatus is very loosely adherent to the dorsal wall of the funnel, and in the type became entirely detached while the specimen was being examined. (It is shown in situ in pl. XXXIII, fig. 4.)

Arms of moderate length, rather stout at the base, but their tips slender; decidedly unequal, the third pair much the largest and longest, the others nearly of a length, their order 3, 2, 4, 1. Umbrella present, but thin and delicate widest between the second and third, and third and fourth arms, but extending between all for about a third the length of each. Suckers in a single row on all the arms, large (especially those of the third pair), much elevated, urceolate, and constricted below the aperture,

[a] Since the above was put in type Chun has published a further paper in which he reinstates *Eledonella* and differentiates it from *Bolitæna* on anatomical grounds. A new family, Bolitænidæ Chun 1911, is erected for the reception of both genera.

in a characteristic fashion, so that the general shape is not unlike that of the conventional money bag or a small bean pot. (Pl. XXXII, fig. 4; pl. XXXIII, fig. 3.)

Gills very large and prominent, comprising about eight or nine "lamellæ." A narrow delicate ridge runs along the median ventral line of the interior of the mantle, and I am inclined to regard this as a remnant of a median septum in the branchial chamber, but the membranes are so delicate that the torn surfaces are extremely difficult to identify, and this is by no means certain.

Color in alcohol everywhere nearly white, with a few sparsely scattered brown chromatophores; on the head and outer surfaces of the arms these are very minute and more or less longitudinal in arrangement. Eyes nearly black with white lenses.

The measurements of the unique type are as follows:

MEASUREMENTS OF ELEDONELLA HEATHI.

	mm.
Total length	117
Length of mantle (dorsal)	50
Width of mantle (in wrinkled state)	37
Width of head	29
Length of—	
Dorsal arm	33
Dorso-lateral arm	30.5
Ventro-lateral arm	49
Ventral arm	34.5
Umbrella between—	
First arms	11.5
First and second arms	12
Second and third arms	15
Third and fourth arms	15.5
Fourth arms	12

Type, catalogue no. 214318, U. S. National Museum (no. 118 of the author's register).

Type locality, Albatross station 4396, 2,228 fathoms, red mud bottom, off Santa Catalina Island, Cal. But one specimen, a female, obtained.

Owing to the very unusual range of all the species closely allied to this one, as attested by such weighty authority as Dr. Hoyle, it was with considerable diffidence that I described the present form as new. However, the alleged distribution is so extraordinary that one feels impelled to question whether some of the apparently slight characters have not more value than has generally been vouchsafed to them; or whether, since the form and facies of such creatures is so very different when living from the dismal objects like the limp rag to which they are reduced in the bottle before me, the true differences have not been obscured or annihilated. Therefore one feels bound to regard such variation as appears with the greatest respect until further material comes to hand.

The near relatives of the present form are four in number, belonging to no less than three different genera, although the latter have of late been united by Professor Chun (1902, p. 167). In brief, the essential differences they have to offer are as follows:

1. *Eledonella pygmæa* Verrill, described from a specimen obtained at a depth of nearly 3,000 fathoms in the North Atlantic and not since reported, so far as I am aware. It differs in that the eyes are not very prominent, the dorsal arms are much shorter than the others, and the umbrella is reduced ventrally until it is quite lacking between the ventral arms.

2. *Eledonella diaphana* Hoyle, described from off the north of Papua, but since reported from the vicinity of the Marshall Islands, the Galapagos, off Acapulco, and near the Cape Verde Islands. In this species the third arms are nearly twice as long as the fourth, which are the shortest, the siphon extends for two-thirds of the distance to the umbrella margin, and there is a well-developed median septum in the branchial cavity. I am also unable to reconcile the funnel organ of the California specimen with the description and illustration given for that of *E. diaphana* by Hoyle (1904, p. 22, pl. 5, fig. 11).

3. *Japetella prismatica* Hoyle, type dredged by the Challenger off the Rio San Francisco, Brazil, but a second specimen obtained by the Albatross from 2,232 fathoms, off Tehuantepec, Mexico, was

described by Hoyle in 1904. The order of length of the arms is 3, 4, 2, 1; the siphon extends almost to the margin of the umbrella; the ventral region of the body is prominently ridged, giving it a very characteristic shape, and the funnel organ, although agreeing in the ∧-like form, seems very dissimilar in detail.

4. *Bolitæna microcotyla* "Steenstrup" Hoyle, originally noted from the Atlantic, but also obtained by the Albatross from the region of the Galapagos Islands. This species differs in numerous particulars. It is brownish purple in color, the relation of the head to the body is more intimate, the arms are not so long, their suckers smaller, the umbrella more extensive, the funnel organ W-shaped besides appearing different in structure, and the gills are stated to have but six lamellæ. Furthermore, in *E. heathi* the latter are much longer and larger, and the siphon does not appear to possess any ligaments uniting it on either side with their apices.

Our species more resembles some figures of "*Bolitæna* (*Eledonella*) n. sp.," given by Chun, but not exactly, and a diagnosis of the latter has not yet been published.

It is with much pleasure that I have associated the name of my friend Dr. Harold Heath, of Stanford University, with this interesting form.

Genus POLYPUS Schneider, 1784.

Polypus Schneider, 1784, p. 116.
Octopus Lamarck, 1799, p. 18.
Hoyle, 1886, p. 74.
Polypus Hoyle, 1901, p. 1–5.

Body more or less rounded and compact, variously colored and ornamented, a marginal membrane sometimes present, but no fins. Branchial cavity separated into two chambers by a median septum. Mantle connectives poorly developed, consisting only of shallow folds or grooves.

Arms variable, usually provided with a more or less extensive umbrella. Suckers in two rows except at the extreme base. Hectocotylus confined to the tip of the third arm on the right side.

Polypus is by all odds the largest, most cosmopolitan, and one of the most puzzling genera of living cephalopods. Within it are included most of the common shore devilfishes of almost every coast.

Type, *Octopus vulgaris* Lamarck, a generally distributed species in European waters.

Polypus bimaculatus (Verrill, 1883). (Pl. XXXIV; pl. XXXV, fig. 2; pl. XXXIX, fig. 5.)

Octopus bimaculatus Verrill, 1883a, p. 121, pl. V, fig. 1–1a, pl. VI
Hoyle, 1886, p. 8 (no description).
Hoyle, 1886a, p. 217 (13), (no description).
Brock, 1887, p. 610, 611.
Polypus bimaculatus Hoyle, 1904, p. 16 (mere note).
Berry 1911a, p. 301.

Body pyriform, as long or longer than wide, truncate and broadest posteriorly. Surface ornamented with numerous warty papillæ or tubercles nearly obsolete ventrally; above varying from a nearly smooth state where only the largest cirri can be made out, to the extremely rugose condition figured by Verrill, where the tubercles become unusually pronounced both in size and numbers. A large prominent conical warted cirrus, often accompanied by one or two other much smaller ones, appears just over each eye, persisting in all the specimens seen.

Head not very large, separated from the body by a slight constriction. Eyes moderately large. Funnel conical and rather long; free for much of its length.

Arms fairly stout, three to four times as long as the body, unequal, the dorsal and ventral pairs usually the shortest; extremities attenuate. Umbrella well developed, especially between the lateral arms; somewhat shorter between the dorsal, and ordinarily shortest of all between the ventral arms; continuing as a narrow, not very prominent web along the outer surface of each arm to its tip, although not always readily traceable so far. The outer surface of the web and arms is tuberculated in the same fashion as the body but in somewhat less degree. Hectocotylus of the male (pl. XXXV, fig. 2) excessively minute, involving only the extreme tip of the third right arm; marginal groove terminating in a small, much flattened papilla, beyond which the minute conical tip is naked; its inner surface flattened, but little excavated, and provided with a few (3–5) distinct transverse grooves (in all the specimens examined). Suckers large at the base of the arms but rapidly diminishing in size after passing the margin of the umbrella; one of the suckers on each of the lateral arms near the junction of the umbrella frequently exhibits a considerable enlargement.

Beak strong and black as usual in the genus (pl., XXXIX, fig. 5).

Color in alcohol a dark brownish gray, heavily clouded and maculated with a blackish purple. On the base of the third arm, just in front of and below the eye on either side, is a large, distinct, round oculation, usually decidedly darker in tint than the rest of the animal. In most individuals this spot shows a dark center bounded firstly by a rather narrow dull-bluish ring, and secondly by a wider outer band of the same color as the center, a feature which seems to have been obscured in the specimens described by Verrill. The bluish ring has usually the appearance of being superimposed upon a uniform darker area, and some examples show further a surrounding region of a lighter color.

The young are readily to be distinguished from those of other species even when still of very insignificant dimensions. The most important difference from the adult which they exhibit is that the large cirri are relatively longer, seem very distinct from the other tubercles of the body, and show a strikingly definite bilateral symmetry (pl. XXXIV, fig. 1, 2). In addition to the postocular cirri, the following are usually very prominent: A conical tubercle at the base of each dorsal arm, a median one on the head just posterior to these, two along the median line of the body, and one large and several smaller lateral ones on either side of the latter. A single longitudinal row of small dark chromatophores, larger than those generally distributed over the body, may be seen on the ventral arms of extremely young individuals and there are a few similar ones on the ventral surface of the body. Further it may be added that the arms of juvenile specimens maintain with considerable constancy the relative length formula 2, 3, 4, 1, as given by Verrill.

Five specimens measure as follows:

MEASUREMENTS OF POLYPUS BIMACULATUS.

Sex	♀	♀	♂	♂	juv.
Author's register number	103	123	121	104	124
	mm.	mm.	mm.	mm.	mm.
Total length	[a] 470	[a] 400	[a] 178	[a] 225	65
Tip of body to base of dorsal arms	102	102	50	48	22
Width of—					
Body	58	56	35	20	12
Neck	29	24	24	21	10
Head	36	34	25	23	12.5
Length of—					
Funnel	35	32	17	17	7
Dorsal arm	[a] 385	[b] 235	109	[a] 150	35
Second arm	[a] 405	[b] 150	128	[b] 90	46
Third arm	[a] 410	[a] 390	118	[a] 135	46
Ventral arm	[a] 360	[a] 370	124	125	42
Hectocotylus	......	....	2	2	....
Umbrella between dorsal arms	[a] 33	[b] 55	22	22	8
Umbrella between ventral arms	[a] 27	74	23	17	8

[a] Figures only approximate. It should be remembered that in cephalopods of this type the arms are so elastic and the difficulty of maintaining a constant degree of tension for measurement so great, that the probability of error is relatively very large. Further, the tissues are very variously affected by the conditions of capture and preservation, but it is hoped that these measurements will prove sufficiently true for practical purposes.

[b] Specimens mutilated.

Type locality, San Diego, California.

Distribution: San Pedro and vicinity, La Jolla and San Diego, California; south to San Salvador (Verrill) and Panama (Verrill).

Thirty-two specimens were examined, as follows:

SPECIMENS OF POLYPUS BIMACULATUS.

No.	Locality.	Collector.	Where deposited.	Sex.	Author's register number.
3	White's Point, Cal	Univ. Cal. Mar. Lab., 1902	Univ. Cal. coll.	1 ♂, 2 juv.	80
1	San Pedro, Cal	July, 1895	do.	♂	74
1	do.	Dec., 1905	do.	juv.	86
2	La Jolla, Cal.	San Diego Mar. Biol. Assoc.	Stanford Univ. coll.	♀	102
1	La Jolla, Cal. (probably)	do.	do.	♀	103
3	La Jolla, Cal	do.	Coll. S. S. B.	1 ♂ 2 ♀	104
6	San Diego, Cal	E. C. Starks	Stanford Univ. coll	2 ♂ 2 ♀ 2 juv.	121
1	do.	do.	do.	(?)	122
1	do.	do.	do.	♀	123
4	do.	do.	do.	juv.	124
1	do.	D. S. Jordan	Yale Univ. Mus.	♂	125
1	Off San Diego, Cal.	Univ. Cal. Sta. LXXX h. 3	Univ. Cal. coll	juv.	85
1	No locality	(?)	do.	♀	70
5	do.	Various lots	do.	juv.	75
1	do.	San Diego Mar. Biol. Assoc.	do.	do.	78

This fine *Polypus* has undergone so complete and accurate description at the hands of Verrill that duplication here may appear a futile waste of space, but as his diagnosis is not always readily accessible, I have endeavored to be sufficiently full at least to enable the easy recognition of the species. This is especially important since in the local literature this form seems to have been frequently confused with the widely different *P. hongkongensis* (*Octopus punctatus*), so that some of the southern California citations which I have listed under the latter species may well have had reference to specimens of *P. bimaculatus*. South of Point Conception it becomes the most abundant littoral devilfish, judging from its frequency in collections from that region.

It does not appear to be closely allied to any of our other species. The curious ocular spots in front of the eyes are probably the most prominent distinctive feature. Although sometimes partially obscured by the surface coloration, I have never known this character to fail, so it would seem to be quite diagnostic. The hectocotylization is inconspicuous in the extreme and would be apt to escape a merely casual inspection. The customary component structures are greatly reduced, but I am unable to quite concur with Verrill in his statement that it is "without any appearance of the spoon-shaped cavity and transverse grooves found in other species," since in the majority of my (male) specimens a few such grooves are quite clearly to be made out. Possibly in larger individuals they become obscured.

The smooth and rugose states of *P. bimaculatus* are so different that at first sight they do not appear to represent the same species. The larger warty tubercles, however, seem to exhibit a remarkable constancy, and, although often reduced to mere concentrically lined or laminated callouses, can usually be made out. These structures, like the general relative dimensions, are probably greatly affected by the state of the animal when killed and the manner of preservation.

Polypus hongkongensis Hoyle, 1885. (Pl. XXXV, fig. 3; pl. XXXVI, fig. 1; pl. XXXIX, fig. 3-4; pl. XL, fig. 1.)

Octopus punctatus **Gabb, 1862**, p. 170 (not *Octopus punctatus* Blainville 1826, p. 195, teste d'Orbigny).
Carpenter, 1864, p. 613, 632, 664 (merely listed).
Dall, 1866, p. 243, fig. 27 (dentition).
? Cooper, 1870, p. 70 (listed from Monterey).
Dall, 1873, p. 484 (large specimens from Sitka).
Tryon, 1879, p. 45, 86, 117, pl. 19, fig. 3; pl 34, fig. 43.
Verrill, 1880, p. 252.
Verrill, 1882a, p. 282 (72).
Verrill, 1883a, p. 117, pl. IV, pl. V, fig. 2.
Dall, 1884, p. 341 (listed from Avatcha Bay, Kamchatka).
Orcutt, 1885, p. 535 (listed from San Diego).
? *Octopus hongkongensis* **Hoyle, 1885**, p. 224 (Japanese specimens).
Hoyle, 1885a, p. 99 (Japanese specimens).
Hoyle, 1886, pl. V (Japanese specimens).
Octopus punctatus **Hoyle, 1886**, p. 11, 100, (pl. V) (Japanese specimens).
Hoyle, 1886a, p. 220 (16) (no description).
Williamson, 1892, p. 217 (listed from San Pedro).
Taylor, 1895, p. 98 (listed from Victoria).
Joubin, 1897, p. 110-113, pl. IX.
Joubin, 1897a, p. 98.
Jenkins & Carlson, 1903, p 262 (physiology of nerves).
Keep, 1904, p. 271, 351 (no description).

Octopus punctatus Kelsey, 1907, p. 45 (listed from San Diego).
Baily, 1907, p. 93 (listed from La Jolla).
Polypus punctatus Hoyle, 1909, p. 260 (no description).
Wülker, 1910, p. 7 (Japanese specimens).
Keep, 1910, p. 296 (no description).
Polypus hongkongensis Berry, 1911a, p. 302.

Animal [a] most commonly of rather moderate size but sometimes attaining enormous dimensions; customarily littoral in habit. Body pyriform to subglobose, usually broadest behind, length and extreme breadth about the same. Opening of mantle cavity of moderate width, reaching on either side to a point about midway between the base of the funnel and the ocular aperture.

Head rather small, separated from the body by a slight constriction. Eyes fairly prominent. Funnel long and conical, its base immersed in the integument of the head, its distal half free.

Arms of considerable stoutness and length, ordinarily at least three to four times as long as the head and body taken together; in general subequal, but very variable, the second pair almost always slightly the longest and the ventral pair apt to be the shortest. Suckers small and not very closely placed about the mouth, alternating in a zigzag which shortly develops into two rows continuing to the tips of the arms. In the region where the umbrella joins the arm the suckers reach their maximum, becoming very large, flattened, and disk-like; inner surfaces prominently ornamented by about 20 more or less bifurcating radial ridges, with a lesser number of smaller and shorter ones interpolated between. The remaining suckers diminish rapidly in size and become very minute upon reaching the attenuate tips of the arms; they are likewise more elevated and develop fewer radial ridges. In some of the smaller males examined from a number of the more southern stations (e. g. no. 156, 134, 161) from one to two suckers on a part or all of the arms near the junction of the umbrella are considerably enlarged and much elevated (pl. XXXIX, fig. 3). The condition does not appear to be a constant one and may be physiological.

Umbrella well developed, reaching between the lateral arms for about a quarter of their length, but less extensive between the dorsal arms and usually shortest of all between the ventral pair; margins of the umbrella continuing as a prominent marginal web along the ventral surfaces of all the arms nearly or quite to their tips. A similar but narrower membrane extends from the base for a little way along their dorsal margins as well.

Third right arm in the male hectocotylized; much shorter, stouter, and less attenuate than the others; terminating in a rather small copulatory organ (pl. XXXIX, fig. 4), the relative dimensions of which may best be seen by a glance at the following table giving the measurements of 13 of the specimens examined.[b]

RELATIVE DIMENSIONS OF SPECIMENS OF POLYPUS HONGKONGENSIS.

Author's register no.	Locality	Length of third left arm.	Length of third right arm.	Length of hectocotylus.
		mm.	*mm.*	*mm.*
142	Uyak Bay, Alaska	205	210	14.5
145	Near Port Townsend, Wash	238	187	9
162	..do	(?)	128	12
162	....do	185	140	14
156	..do	152	124	14
151	Point Reyes, Cal	61	53	1.5
146	Monterey Bay, Cal	145	103	11
158	....do	114	102	8
153	....do	130	99	5
161	....do	(?)	70	6
157	Off San Nicolas Island, Cal	(?)	50	3
134	Near San Diego, Cal	102	77	6
81	Off Los Coronados Island, Lower California	153	115	10

As in other *Polypus* the margin of the web on this arm is curled inward to form a tubular groove, which, after running the whole length of the arm, terminates in a minute acutely conical papilla at the base of the terminal organ. The remainder of the hectocotylus consists of a naked smooth tapering

[a] Unless otherwise indicated by the wording or arrangement of the context, the description may be understood to have especial reference to author's number 142, a large male from Uyak Bay, Alaska.

[b] As usual I consider a certain part of the variation shown to be due to the impossibility of accurate measurement.

point, the margins of its inner surface elevated to form two low parallel ridges inclosing a narrow, sharply marked groove; inner surface of groove usually showing a numerous series of small though distinct transverse wrinkles or furrows. I did not discover the longitudinal rows of granules described by Verrill, but suspect this to be a more or less variable feature.

Beak black; strong and powerful.

Surface in the best preserved specimens covered everywhere above by numerous papilliform tubercles with stellate bases, and many heavy, much interrupted, longitudinal wrinkles (pl. XXXV, fig. 3); above each eye a rather small conical cirrus with sometimes a smaller one in front of it, and always a very large pinnacle-like protuberance in a more or less erect condition just behind it. In addition there is usually a series of bilaterally arranged cirri very similar in every way to those of *P. bimaculatus*, those appearing with the greatest frequency being one on the base of each dorsal arm, one on the median line where the umbrella joins the head, one at the posterior point of the body, and four on the anterior part of the body inclosing a diamond-shaped space between them. A number of other cirri appear in some specimens with great regularity, but those above enumerated seem to exhibit the most constancy (see text fig. 2). However, the entire condition is extremely variable. In some specimens all or part of the cirri are reduced to mere callouses, while in many examples the skin is almost perfectly smooth and all surface ornamentation except the large supra-ocular cirri seems entirely wanting.

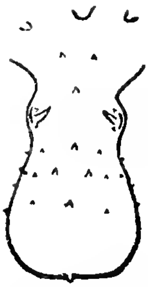

FIG. 2.—*Polypus hongkongensis*, outline sketch of a young animal, showing a nearly typical arrangement of the cirri. [76.]

Color in preserved specimens, as in life, very variable. Ordinarily a dark brownish or purplish black above, heavily blotched and maculated; below and on the inner surfaces of the arms and web the tone is paler and yellower. Chromatophores excessively numerous, very minute and dot-like.

The young usually possess essentially similar characters, often showing the arrangement of the cirri with great clearness. They are generally of a lighter and more variegated color, their chromatophores relatively fewer and larger, and are adorned by two rows of especially large, longitudinally elongated chromatophores running along the lower surfaces of the four ventral arms. (Pl. XL, fig. 1.)

The measurements of 12 specimens from various localities are given in the annexed table.

MEASUREMENTS OF POLYPUS HONGKONGENSIS.

Sex and locality	♂ Uyak Bay.	♂ Uyak Bay.	♂ Sta. 4220	♂ Pacific Grove.	♂ Pacific Grove.	♂ Sta. 4349.	♂ Off Coronado Is.	♀ Sta. 4220.	♀ Sta. 4222.	♀ Pacific Grove.	♀ Pacific Grove.	♀ Pacific Grove.
Author's register	(142)	(145)	(162)	(146)	(153)	(134)	(81)	(162)	(144)	(143)	(153)	(164)
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Total length	365	345	230	220	172	130	220	250	205	313	181	39
Tip of body to base of dorsal arms	81	76	45	52	37	32	49	57	58	80	38	13
Width of body	57	54	39	31	27	22	30	50	41	39	26	11
Neck	38	37	25	23	20	16	22	34	28	24	19	8
Head	42	39	30	25	22	20	28	37	32	27	21	10
Length of funnel	35	31	21	23	16	15	18	25	22	13	17	6.5
Dorsal arm	270	233	101	158	113	85	142	171	147	215	122	25
Second arm	278	265	165	168	125	95	155	188	149	225	137	26
Third arm	265	238	....	145	130	102	153	192	140	212	130	26
Ventral arm	235	190	173	140	112	87	150	183	127	232	120	25
Hectocotylus	14.5	9	12	11	5	6	10	......	......	......	......	......
Umbrella between dorsal arms	62	59	40	20	18	16	22	34	35	42	22	7
Umbrella between ventral arms	45	35	33	18	24	11	25	27	27	42	21	7

Type, a male in the British Museum (Natural History).

Type locality, 345 fathoms, off Ino Sima Island, Japan (H. M. S. Challenger), one specimen.

Distribution: China, Hongkong (Hoyle). Japan, off Ino Sima Island (Hoyle), Aburatsubo (Wülker). Kamschatka, Avatcha Bay (Dall). Alaska—Shumagin Islands; Humboldt Bay, Popoff Island; Karluk, Kodiak Island; Uyak Bay; Sitka (Dall). British Columbia, Victoria (Taylor). Washington, near Port Townsend. California—Crescent City; Point Reyes; San Francisco (Gabb); San Francisco Lightship; Oakland; Half Moon Bay; Monterey Bay at Monterey and Pacific Grove; Avalon and Isthmus Cove, Santa Catalina Island; off San Nicolas Island; San Pedro (Williamson); La Jolla (Baily); San Diego. Lower California, off Los Coronados Islands; Scammons Lagoon (Gabb).

Sixty-three specimens have been seen from various localities as set forth in the following table:

SPECIMENS OF POLYPUS HONGKONGENSIS.

No.	Locality.	Depth in fathoms.	Collector.	Sex.	Where deposited.	Remarks.	Author's register No.
1	Shumagin Islands, Alaska		W. E. Ritter, June, 1899	(?)	Univ. Cal	Fragments	73
1	Humboldt Bay, Popoff Id., Alaska.		July, 1899	♀	do		169
3	Karluk, Kadiak Islands, Alaska.	Shore.	C. Rutter, 1903	♀	Stanford Univ. Coll	Juv	154
1	Uyak Bay, Alaska	Seine.	Albatross, 1903	♂	Cat. 214319, U.S.N.M		142
1	do	do	do	♂			145
1	Vicinity of Port Townsend, Wash.	15-26	Albatross station 4205	♀		Juv	149
1	do	24-25	4209	♂		do	156
3	do	16-31	4220	2 ♂ 1 ♀			162
1	do	39	4222	♀		Juv	144
1	Crescent City, Cal	Shore.	W. F. Thompson, June, 1911		Stanford Univ. Coll	do	214
1	Point Reyes, Cal	do	Nov. 17, 1892	♂	do	do	151
1	San Francisco Lightship, Cal		Mr. Turkington, Dec., 1910	♂	Univ. Cal		168
1	Oakland Wharf, Oakland, Cal		J. W. Wood	♂	do		170
2	Half Moon Bay, Cal	Shore.	F. W. Weymouth, June, 1911		S. S. B. coll		240
2	Monterey Bay, Cal	49-51	Albatross sta. 4453	♂ ♀	U.S.N.M		161
?1	do	40-46	4457	♀	do		155
1	do	36-51	4464	♀	do		150
1	do	43-44	4482	♀			159
1	do	18-20	4489	♂			158
4	do	26-27	4492	♀			160
4	Pacific Grove, Cal		(?)	1 ♀	Stanford Univ. Coll	3 juv	143
3	do	Shore.	H. Heath	1 ♂ 2 ♀	do		140
3	do	do	do	1 ♂ 2 ♀	do		153
4	do		(?)		do	Juv	164
4	do	Shore	S. S. Berry, June, 1906		S. S. B. coll	do	394
1	Near Avalon, Santa Catalina Island, Cal.	46	Univ. Cal. sta. XXIII$_2$		Univ. Cal	do	82
1	Isthmus Cove, Santa Catalina Island, Cal.		XXVIIIa		do	do	77
1	Off San Nicolas Island, Cal	32-33	Albatross sta. 4420	♂	U.S.N.M	do	157
1	Vicinity of San Diego, Cal	101-129	4364	♀	do	do	152
2	do	75-134	4349	♂ ♀	do	do	134
1	Off San Diego, Cal	$30\frac{1}{2}$	Univ. Cal. sta LXVIII		Univ. Cal	do	83
2	do	$30\frac{1}{2}$	do		do	do	87
2	Near Los Coronados Islands, Lower California.	$16\frac{1}{2}-18\frac{1}{2}$	Univ. Cal. station LXIII		do	do	84
1	do	18-24	LVIII		do	do	76
3	do	15-18	LVIII$_1$	1 ♂ 1 ♀	do	do	81
1	(?)		Voy (?)	♂	do		167

The most abundant West American littoral devilfish has had a checkered history. Insufficiently described by Gabb under a preoccupied name from specimens not as well preserved as they might have been, it has remained unrecognizably figured for years (with the exception of the Japanese specimen in the Challenger Report) and local writers have suffered few qualms in using the name as a general term to cover all the species of *Polypus* on the coast. The first reasonably complete account of its characters is that given by Verrill (1883) and is scarcely to be improved upon except as regards his treatment of the surface papillation, which in his specimens was either ill preserved or else not typical. Hence in the Challenger Report (1886) Hoyle found it easy to regard the *Octopus hongkongensis*, described by him the previous year, as identical. In this respect I have had more difficulty, although on the whole I have deemed it best as well as easiest to follow in the path already made for me. Examination of the well-preserved material in the Albatross collection has led me to incline strongly to the opinion that though closely related the two forms are in reality distinct. Although Prof. Joubin has described a supposed *P. punctatus* from Kamchatka, the habitats are still widely separated. If the Japanese specimens are *typically* like the excellent figure in the Challenger Report, I think they are clearly either a different species from the California-Alaska *Polypus* or at least a pretty well defined geographical subspecies. Should this view prove correct, I would suggest for the West American form the name *P. apollyon* (from the Greek ἀπολλύων=destroyer),[a] but for the present at least the safest course seems to be to lump them under *P. hongkongensis*, as given above. Further investigation of material from Japan may show the presence of bilaterally symmetrical cirri having the arrangement seen in their trans-Pacific brethren, but no specimens from the region have been available for comparison, so the whole question must be left unsettled.

It is a distressful fact that we find the time-honored name of Gabb to be untenable, but, unless the citation of d'Orbigny be in error, there would appear to be no alternative, even though the *Octopus punctatus* of Blainville seems really to have been an *Argonauta*, probably *A. hians* Solander. The use of the scarcely appropriate term *hongkongensis* affords but little consolation. In one way, however, it is fortunate that we are able to reject Gabb's name, since I am informed that his type shared the fate of so many other priceless zoological treasures in the San Francisco conflagration of 1906 and is no longer available.

Although the individuals commonly encountered in tide pools and crevices along rocky beaches are not especially remarkable in respect to size, their fellows inhabiting the more secluded nooks offshore are sometimes uninvitingly formidable, and, if all reports may be believed, we are here dealing with possibly the largest known species of the genus. It is not yet entirely certain whether the large examples reported from Alaska are really identical with this, but the following quotation from Dall (1873, p. 484-485) will give some idea of the size attained by them:

"The *Octopus punctatus* Gabb, which occurs at Sitka abundantly, reaches a length of 16 feet or a radial spread of nearly 28 feet, but the whole mass is much smaller than that of the decapodous cephalopods of lesser length. In the *Octopus* above mentioned, the body would not exceed 6 inches in diameter and a foot in length, and the arms attain an extreme tenuity toward their tips."

I have elsewhere remarked (1911a, p. 303) upon certain fragments of a very large specimen in the collection of the University of California, which probably belong to this species and were obtained at the Shumagin Islands, Alaska, by Dr. William E. Ritter. Remains of two almost equally large animals taken by Mr. F. W. Weymouth near Half Moon Bay, California, have since been examined by me. The entire buccal mass of the larger of these measures in alcohol 39 by 52 mm. Unfortunately no further parts were preserved so their reference to the present species can scarcely be taken as established.

Holder (1899) has reported an *Octopus* (*Polypus*) seen near Avalon, California, the arms of which had a radial spread of about twenty feet. There are frequent newspaper tales of conflicts with creatures even larger, which do not seem to belong entirely to the realms of fancy.

The affinities of *P. hongkongensis* are chiefly with *P. gilbertianus* and with the very nearly related *P. döfleini* Wülker from Japan. The latter species is stated to differ from *P. hongkongensis* chiefly in the relative shortness of its arms and the much larger hectocotylus.

Polypus gilbertianus new species. (Pl. XXXV, figs. 4-5; pl. XXXVI, fig. 2; pl. XXXVII.)

Body of moderate size, rounded pyriform in shape, a little broader than long; surface covered everywhere with numerous minute rough papillæ (pl. XXXV, fig. 4), which give the skin a somewhat grainy texture; papillæ extending well over the arms and outer surface of the umbrella, but becoming obsolete ventrally; more numerous, more irregular, and larger in the region of the eyes than elsewhere, and there is a large soft flattened blunt tubercle above and slightly behind the center of each eye.

[a] In which case the above-mentioned male specimen (no. 142) from Uyak Bay, Alaska, should be taken as the type.

Head short, very broad, and separated from the body by the usual slight constriction. Eyes rather large, somewhat protruding. Funnel broad at the base, tapering rapidly to a truncate nearly cylindrical extremity; free distally for a little less than half its length.

Arms rather long, attaining about three and one-half times the length of the body; slender, attenuate slightly unequal, the order of length in general being 2, 3, 4, 1; united at base for about a quarter of their length by the strong umbrella, which is best developed between the lateral arms, shortest between the ventral pair; membrane continuing from the umbrella along the outer surfaces of the arms very pronounced, wide, and traceable nearly or quite to their tips. Suckers in two rows, rather large, little elevated; in the male some four to eight suckers near where the web joins the arm are somewhat larger than the others. Third right arm in the male very much shorter than either its mate of the opposite side or any of the remaining arms, less attenuate, its marginal membrane much wider and furnished with a slightly incurved margin to form the usual narrow canal, terminating in a small conical papilla; hectocotylus relatively large and stout, deeply channeled, the groove narrow and abrupt at first, but widening and flattening distally to some degree; inner surface very rugose, rendering the transverse groovings quite obscure. (Pl. XXXV, fig. 5.)

Beak and radula not examined.

Color of preserved specimens a deep brownish claret slightly mottled with a darker shade above, paler below. Some of the color dissolves out in alcohol and the accompanying station label is stained a heavy pinkish brown.

Young unknown.

MEASUREMENTS OF POLYPUS GILBERTIANUS.

	♂ Type, station 4228.	♂ Cotype, station 4253.
	mm.	*mm.*
Total length	300	355
Tip of body to base of dorsal arms	65	79
Width of body	52	59
Neck	37	42
Head	41	45
Length of funnel	28	34
Dorsal arm	206	265
Second arm	232	275
Third arm	168	195
Ventral arm	213	265
Hectocotylus	21	33
Umbrella between dorsal arm	49	40
Umbrella between ventral arm	37	50

Type, catalogue no. 214.320, U. S. National Museum (no. 139 of author's register.)

Type locality, Albatross station 4228, vicinity of Naha Bay, Behm Canal, Alaska; depth 41-134 fathoms, gravel and sponge bottom.

Distribution, Behm Canal and Stephens Passage, Southeastern Alaska.

The type and one other specimen examined as given below:

No.	Locality.	Depth in fathoms	Collector.	Sex.	Where deposited.	Author's register number.
1	Behm Canal, Alaska	41-134	Albatross station 4228	♂	U. S. Nat. Mus., cat. no. 214320.	139
1	Stephens Passage, Alaska	188-131	4253	♂	....	140

The relationships of *P. gilbertianus* are all with the confusing group of species of which *Octopus punctatus* Gabb was the earliest described member, and I have been quite puzzled as to how best to deal with it. In its red color, as well as its minutely and evenly warted surface without large cirri except over the eyes, it agrees with the description and figure of *P. hongkongensis* in the Challenger Report, but differs in the longer ventral arms and much more prominent hectocotylization. It may be that the old view is right and all these protean forms are referable to *P. hongkongensis*, but among all the Polypi from Alaska to San Diego which I have examined I have seen no specimens save the two noted above having features approximating any of the characters which I have taken to be distinctive of *P. gilbertianus*. For the present at least it seems that the greatest good will be accomplished by keeping them distinct.

It is a pleasure to be able to affix to this fine species the name of Dr. C. H. Gilbert, of Stanford University, as a slight recognition of the friendly aid he has so often lent to the writer.

Polypus californicus Berry, 1911. (Pl. XXXV, fig. 6–7; pl. XXXVIII; pl. XXXIX, fig. 1–2; pl. XL, fig. 2–3.)

Polypus californicus Berry, 1911, p. 590.

Animal of moderate size; its body short, rounded, full, plump, truncate behind, slightly broader than long, its general consistency in specimens preserved in alcohol very firm and compact. Surface densely covered with numerous large stellate papillæ of a very characteristic form and appearance, the skin between them smooth; these are often so thickly palisaded together on the dorsal surface of the body in the adult that the spaces between them are reduced to mere crevices (pl. XXXV, fig. 7); on the head fewer and more distant (pl XXXV, fig. 6), becoming again more numerous though smaller on the base of the arms; further out on the arms as well as over the entire ventral surface the papillæ are much smaller and often nearly obsolete, the transition taking place very suddenly in the lateral region.

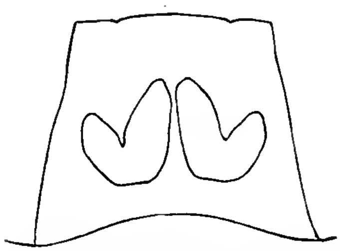

FIG. 3.—*Polypus californicus*, outline sketch of the interior of the funnel viewed from below, showing the funnel organ, × 2.1 [132].

Head short and broad, but narrower than the body, from which it is separated by a slight but definite constriction. Eyes of moderate size, each surmounted by a rather indistinct (due to flattening?) branched cirrus somewhat larger than the neighboring papillæ. Funnel rather long, conical, broadly adherent to the under surface of the head for the greater part of its length, the free extremity extending just past the origin of the arms. Funnel organ large and conspicuous, comprising two thickened, rather narrowly separated, V-shaped cushions, the inner arm of each larger and longer than the outer. Mantle opening broad, full, its margin rounded and thickened.

Arms stout, but only of moderate length, being usually from two and one-half to three times as long as the body and head; relative length very variable, the two sides rarely possessing the same formula, and an identical relative order persisting in hardly any two specimens examined except that the third right arm in the male is constantly less attenuate than the others and about a third shorter. Umbrella well developed, extending between the arms for about one-fourth of their length, and thence continuing along each arm to its extremity as a highly contractile fleshy fold or web; umbrella proper nearly even all around, but slightly shortest between the arms of the dorsal and ventral pairs.

Suckers rather large, in two apparent rows except two or three at the base which are in a single row. In the male some half dozen of the suckers near the junction of the umbrella with the arm are notably the largest, very large, flattened and disk-like (pl. XXXIX, fig. 2). Hectocotylized portion of the third right arm in the male relatively enormous, thickened and massive; in general plan much like the figure given by Verrill for that of *Octopus punctatus*, but much more deeply, narrowly, and sharply channeled, and with the transverse grooving more pronounced; basal papilla very blunt, short, and conical (pl. XXXIX, fig. 1).

Beak and radula not examined.

Color in alcohol a livid pinkish brown, lighter below; quite unlike that of any of the other species here described. Chromatophores numerous, small, round, brownish, and well distributed.

The distinctive characters of the species are assumed very early in the development of the young. In juvenile animals the papillæ are a little more sparsely scattered, the eyes exceedingly prominent, the body more delicate, and the color lighter. Furthermore the chromatophores are relatively somewhat, fewer, but they are very small and do not show the definite arrangement so characteristic of the young of *P. hongkongensis*, *P. bimaculatus*, and other species. Two individuals exhibiting these features are shown in plate XL, figures 2 and 3.

The detailed measurements of eight specimens from the Albatross collections are given in the accompanying table.

MEASUREMENTS OF POLYPUS CALIFORNICUS.

Sex and locality	♂ Sta. 4325.	♂ Sta. 4325.	♂ Sta. 4325.	♂ Sta. 4339.	♀ Sta. 4369.	♀ Sta. 4323.	♀ Sta. 4323.	Juv. Sta. 4366.
Author's register	131	131	131	132	133	135	135	129
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Total length	308	290	265	350	277	250	260	68
Tip of body to base of dorsal arms	89	90	82	108	75	74	72	28
Width of body	67	62	58	68	73	62	63	19
Neck	46	47	42	44	54	48	46	16
Head	50	52	47	48	51	54	53	16
Length of funnel	36	34	33	36	29	29	26	10
Dorsal arm	[a] 156	201	176	[a] 166	203	190	185	49
Second arm	238	206	205	265	200	185	196	51
Third arm	159	149	140	208	203	[a] 171	[a] 180	50
Ventral arm	210	192	272	250	196	170	170	50
Hectocotylus	28	21	25	36	....	....	....	....
Umbrella between dorsal arms	50	47	43	62	50	40	50	15
Umbrella between ventral arms	52	40	41	45	28	29	38	14

[a] Mutilated.

Type, catalogue no. 214321, U. S. National Museum; a male (from no. 131 of the author's register).

Type locality, Albatross station 4325, vicinity of San Diego, California, 191–292 fathoms, bottom of green mud and fine sand; three specimens, March 8, 1904.

Distribution: Offshore in rather deep water, Monterey Bay, off Santa Catalina Island, and in vicinity of San Diego, California.

Sixteen specimens from ten stations have been examined, as follows:

SPECIMENS OF POLYPUS CALIFORNICUS.

No.	Locality.	Depth in fathoms.	Collector.	Sex.	Where deposited.	Author's register.
1	Vicinity of San Diego, Cal.	95–135	Albatross station 4312	Juv	....	127
2	....do........	193–227	4323		....	135
1	.....do.........	191–292	4325		U. S. Nat. Mus., cat. no. 214321 (type).	131
2	.....do.........	do	4325		Cotypes	131
1	do...........	241–369	4339		....	132
1	do........	167–191	4358	Juv	....	128
4	do	130–158	4365	Juv	....	126
1	do	176–181	4366	Juv	....	129
1	do	260–284	4369		....	133
1	Off Santa Catalina Island, Cal	152–162	4413	Juv	....	130
? 1	Monterey Bay, Cal	1,006–1,041	4536	Juv	....	136

This species is well separated from any other form known to me by the color and consistency of its body, prominent hectocotylization, wide mantle opening, adherent funnel, characteristic funnel organ, and very distinctive surface ornamentation; features which enable even very young specimens to be recognized without difficulty. Indeed the very young of practically all our Polypi are apt to be more readily separable upon casual examination than the adults of the corresponding species. The surface papillation which is the subject of so great change and variation in other species is here surprisingly constant and strongly inclines one to the belief that at least within certain limits this should be regarded as one of the most important diagnostic characters of the group, at least so far as distinguishing between species is concerned.

Polypus californicus appears to be the most common offshore *Polypus* of the Southern California coast, but no specimens have as yet been taken from a depth less than about 100 fathoms. The single abyssal specimen accredited in the above table to Monterey Bay is not only young but has undergone so much contraction that its identity must not be regarded as fully established, and hence the great extension in bathymetric as well as geographic range which it represents may be an error.

Polypus leioderma Berry, 1911. (Pl. XXXV, fig. 1; pl. XL, fig. 4-5.)

Polypus leioderma, Berry 1911, p. 590.

Body of rather small size; very firm, short, plump, and compact; wider than long, broadest posteriorly; truncately rounded. Integument smooth except for a number of short, rather obscure, simple papillæ or cirri scattered over the dorsal surface of the head, neck, and anterior part of body; there is one such tubercle over each eye, the remainder likewise showing a bilateral arrangement and widely scattered, the most notable being a nearly equidistant row of four between the eyes, two along the median line just behind, and a number of lateral ones. Bounding the body laterally, and extending from a point just posterior to the mantle margin and above the gill on either side, is a narrow and thin but distinct keel-like fold of the integument, which, though somewhat obscured in places, is still clearly traceable all the way round. There are also a number of deep transverse folds in the nuchal region, but these seem due to contraction and not of a permanent nature.

Head short, broad, poorly defined by a slight constriction from the wider body. Eyes large and protruding. Funnel long, rather slender, extending well past the base of the arms.

Arms decidedly unequal, two to three times as long as the body, their order of length 1, 2, 3, 4; the dorsal arms decidedly the stouter and longer and the ventral arms the reverse. Umbrella well developed, extending between the first, second, and third arms for over a fourth of their length, and thence continuing along their outer margins to their tips as a very broad prominent contractile membrane; shorter between the third and fourth arms, and even more reduced between the ventral arms where it attains scarcely half its former length, although the webbing to the extremities of the arms is the same. Suckers in two rows, rather small, and relatively very numerous.

Beak and radula not examined.

Color over the body a very pale gray-buff, somewhat suffused with a purplish brown; arms and umbrella darker. Chromatophores small and pale in color; of two distinct types, one being larger, sparser, and darker than the other. The two largest specimens obtained have the following dimensions:

MEASUREMENTS OF POLYPUS LEIODERMA.

	♀ Type, station 4293.	♀ Station 4526.
Total length	210	92
Tip of body to base of dorsal arms	45	29
Width of body	40	20
Neck	36	17
Head	31	19
Length of funnel	25	14
Dorsal arm	150	65
Second arm	138	61
Third arm	129	55
Ventral arm	117	49
Umbrella between dorsal arms	47	18
Umbrella between ventral arms	17	10

Type, catalogue no. 214322, U. S. National Museum; a female (no. 137 of the author's register).

Type locality, Shelikof Strait, Alaska, Albatross station 4293, 112-106 fathoms, bottom of blue mud and fine sand; one specimen.

Distribution: Shelikof Strait, Alaska; Gulf of Georgia, British Columbia; Monterey Bay, California, in rather deep water.

Four specimens have been seen, all obtained by the Albatross.

No.	Locality.	Depth in fathoms.	Collector.	Sex.	Where deposited.	Author's register.
1	Shelikof Strait, Alaska	106–112	Albatross station 4293	♀	U. S. Nat. Mus., cat. no. 214322 (type).	137
1	Gulf of Georgia	111–170	4194	♀	U. S. Nat. Mus	173
2	Monterey Bay, Cal.	204–239	4526	♀	U. S. Nat. Mus	138

After comparison with such specimens, figures, and descriptions as have been available, I have been unable to refer the four specimens upon which I have based this species to any of the named forms either from the west coast of America, from the Hawaiian Islands, or from Japan. From all its congeners in this region it differs strikingly in the carinated membrane surrounding the body and in the remarkable smoothness of its skin. The shortness of the arms relative to the body, their formula, and the reduction of the umbrella between the ventral arms are also to be noted. Probably none of the specimens at hand are quite mature. As there are unfortunately no males in the collection, the character of the hectocotylization and other sexual features are not yet known.

The smallest specimen, having a total length of but 32 mm., exhibits all the characters of the adult, although in a juvenile way. It is in every way more delicate, and the chromatophores are fewer, darker, and much more distinct.

Polypus (sp.) juv.

There is a small specimen in the Albatross collection (my register no. 141) which is of uncertain identity, though clearly not the young of any of the species described in this paper.

It has a small ovoid body, more or less pointed behind, ornamented above with a few obscure, roundish, flattened papillæ; mantle opening wide and full. Head small; eyes large; funnel broad, compressed. Arms rather short, subequal, connected at the base by a delicate umbrella. Suckers elevated, in two rows. The tip of the third right arm appears to show faint traces of future hectocotylization.

Chromatophores numerous, of various sizes, very distinct; especially minute and dot-like on the ventral surface, where they are relatively fewer in number and show a bilaterally symmetrical arrangement; two alternating rows of similar small ones appear on the ventral arms. Parts of the animal show a slight metallic luster.

Total length, 28 mm.; length of body, 11 mm.

From Albatross station 4550, 50–57 fathoms, Monterey Bay, California, bottom of green mud and rock.

The specimen shows certain resemblances to one in the University of California collection from Catalina Harbor, California, which has already been noted by me (1911a, p. 303), but I doubt if they are identical.[a]

[a] I am not acquainted with the *Polypus digueti* (Perrier and de Rochebrune), which I have treated as extralimital for the purposes of the present paper. The principal portion of the original description is as follows (1894, p. 770):

"OCTOPUS DIGUETI E. PERR. ET ROCHBR.

"Corps bursiforme, court; tête modérément large, assez brusquement tronquée en avant, au-dessus des yeux; ceux-ci d'une extrême petitesse; bras tous d'égale longueur, subquadrangulaires, se terminant en point aiguë; ombrelle étroite, envoyant des prolongements mince's jusque vers la première moitié externe des bras; ventouses disposées sur deux rangs, celle de la base des

DECAPODA.

MYOPSIDA.

The eyes are without free lids, although sometimes with a thickened fold forming a pseudo-lid; their transparent covering membrane continuous with that of the head. The tentacles are usually completely retractile. The oviduct is developed on the left side only. In some cases glandular luminous organs are present.

Family SEPIOLIDÆ Leach, 1817 (em.).

Genus ROSSIA Owen, 1834.

Rossia Owen, 1834, p. 93.

Sepiolid decapods having the mantle free all round and (in addition to the funnel cartilages) articulating with the head in the nuchal region by an ovate cartilage. Sessile arms short, with two to four rows of spherical suckers. Tentacular arms almost entirely retractile. Both dorsal arms hectocotylized. Gladius present but much reduced.

A glandular luminous organ is known to be present in at least part of the species, situated just behind the funnel.

Type, *Rossia palpebrosa* Owen, 1834, a species of the Arctic region.

Rossia pacifica Berry, 1911. (Pl. XLI–XLII; pl. XLIII, fig. 1–4; pl. XLIV, fig. 1, 5.)

Rossia pacifica Berry, 1911, p. 591.

Body smooth, sepioliform, moderately large; the mantle full, somewhat flattened above and below; rounded behind; some specimens relatively short, others more slender. Fins large, subcordate, with a free anterior lobe, their attachment more or less oblique to the general plane of the body. Mantle margin free all round, articulating with the head by an elliptical cartilage in the nuchal region, and a deep elongate groove with a prominent raised margin on either side of the base of the funnel; the ridges corresponding to the latter on the inner surface of the mantle nearly straight and notably long and heavy.

Head very large, as wide as or wider than the body, and much flattened. Eyes large, the lower lids free. Funnel short, conical, broad at the base, the extremity truncate; interior capacious, transversely plicate, finely striate longitudinally; a delicate, rounded, flaplike valve on the dorsal wall near the tip. Funnel organ prominent, comprising a large median liver-shaped pad and two elongate-pyriform, flattened pads laterally placed on the interior surface of the ventral wall; the latter broad and curving inward at the base, the margins slightly raised, and the center apt to be occupied by a somewhat sunken triangular area (pl. XLIV, fig. 5).

Arms stout, thick, rather short, unequal, the order of length 3, 4=2, 1; third pair joined with the fourth by a well-developed web, functioning as a sheath for the tentacles; slight rudiments of an umbrella also to be detected between all the other arms except the ventral pair; obscure carinations

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bras, larges, espacées, celles de la dernière moitié de ces organes, très petites et excessivement rapprochées. Couleur dans l'alcool, d'un violet sombre sur les régions supérieures, jaunâtre en dessous, finement pointillée de violet pâle. Longueur totale du corps y compris la tête $0^m,033$. Largeur maxima $0^m,021$. Longueur moyenne des bras $0^m,055$.

"Cette forme présente une certaine analogie avec *l'Octopus punctatus* Gabb., également de la basse Californie, mais il en diffère par une taille toujours petite, tandis que *l'O. punctatus* peut acquérir de fortes dimensions; également aussi par la longueur uniforme de tous les bras, par la petitesse exceptionnelle des yeux, la disposition de l'ombrelle et des ventouses, enfin par l'aspect plus trapu du corps et sa coloration, dont il faut tenir compte pour la distinction des espèces du genre *Octopus*."

It is stated to come from Lower California and to live as a commensal organism between the valves of certain lamellibranch mollusks inhabiting those coasts, very much after the manner of the common mussel-crab (*Raphonotus*). Should the truth of this be verified, the species and its unique habit are most remarkable.

or keels present along the outer surfaces of all the arms in some specimens, but prominent only on the third pair. Suckers spherical, oblique; in two rows at the base and tip of all the arms, but in the adult often extremely crowded along the middle, where they are apparently ranked in three to four rows; indications of this condition always present, at least in fully grown individuals, but in a few specimens (notably a female from Albatross station 4457) the two-rowed condition persists over all except a very small portion of the arm; sucker openings circular, minute; horny rings well developed, with entire margins.

The detailed structure of the arms in the two sexes differs greatly. In the female, the arrangement of the suckers on none of the arms is essentially unlike that on the others, and suckers occupying analogous positions in the different rows differ very little, if any, in form or size. The males present a greatly modified condition. Here both dorsal arms are hectocotylized; strongly recurved, their suckers greatly reduced; the latter usually in two rows [a] until just before the tip is reached, when they become increased to four for a small space, then reduced to two again at the extremity; bases of the sucker pedicels (especially those of the outer row) much enlarged and transversely compressed to form a prominent series of transverse folds or ridges very similar to those already described by Steenstrup and others as obtaining in *R. macrosoma* (pl. XLIII, fig. 2). There is a narrow marginal membrane on the inner side of these arms and a much wider and more prominent one along the outer margin. Above the latter and constructed parallel with it so as to form a deep fossa is a second membrane extending distally from the base of the arms for more than half their length (pl. XLIII, fig. 3). The suckers of the remaining arms are much enlarged, but otherwise much as in the female; those of the second and third pairs best developed and most densely placed; largest at the middle of the arm, gradually decreasing in size toward the tips, but subequal in all the rows at the same point on the arm (pl. XLIII, fig. 2). In young males the suckers are two-rowed and very irregularly unequal in size.

Tentacles variable; sometimes longer than the body, but often completely retracted; stout, the inner surfaces flattened and with a distinct median groove. Tentacular club elongate, but little expanded; the sucker bearing area bordered by a narrow marginal membrane, outside of which dorsally and parallel is a second much larger and wider membrane, the latter when expanded nearly half as wide as the club itself (pl. XLIII, fig. 4). Suckers small, unequal; largest dorsally at the base, thence gradually decreasing in size ventrally and toward the tip; in but two to three rows at the extreme base, but thence multiplying to as many as seven or eight near the middle; cup-shaped, with wide apertures, moderately long peduncles, and horny rings furnished with numerous small blunt teeth.

Gladius slender, lanceolate, shorter than the mantle, very thin and delicate posteriorly.

Skin everywhere smooth, without papillæ, although some specimens show a number of definite but more or less obscure grooves or plicæ running longitudinally on the dorsal surface of the mantle.

Color in life unknown; in alcohol reduced to the usual brownish buff, heavily punctate above and in less degree below with purplish chromatophores, which extend even over the fins, though fewer on their under surfaces and margins.

The more important measurements of twelve specimens of both sexes are given in the appended table.

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[a] In a few specimens (station 4377) the four-rowed condition extends over the greater portion of the arm

MEASUREMENTS OF ROSSIA PACIFICA.

Locality	Boca de Quadra, Alaska.	Admiralty Inlet, Alaska	Behm Canal, Alaska.	Monterey Bay.	Monterey Bay.	Monterey Bay.	Monterey Bay.	Monterey Bay.	Monterey Bay.	Var diegensis.		
										San Diego.	San Diego.	San Diego.
Sex	♀	♂	♂	♂	♂	♂	♀	♀	♀	♂	♂	♀
Station	Sta. 4223	Sta. 4220	Sta. 4234	Sta. 4446	Off Salinas R.	Sta. 4492	Sta. 4492	Sta. 4457	Sta. 4446	Sta. 4377	Sta. 4356	Sta. 4356
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Total length, excluding tentacles	105	69	75	80	76	73	80	88	96	50	52	72
Length of mantle (dorsal)	48	31	32	33.5	31	30	37	42	45.5	22	23	32.5
Width of body	31	19	18	22	21	22	26.5	27	25.5	16	14	19
Across fins	68	36	39	44.5	40	43	48	51	52	31	31	44
Length of fin (extreme)	33	19	19	23	19.5	20	24	28.5	27	15	15	21
Length of fin at plane of attachment	25.5	17	15	17.5	15	16.5	19	22	23	11	11	16
Width between eyes	22	18	18	18	18.5	18	21	23	23	16	13	18
Length of dorsal arm	34	26	24	30	26	28	28	29	30	20	18	23
Second arm	36	28	29	32	32	31	30	37	34	22	20	24
Third arm	42	29	33	36	38	33.5	34	39	35	23	23	27
Ventral arm	39	25	29	33	32	29	30	35	34	20	21	23.5
Tentacle, excluding club	57	10	12.5	....	53	15	11	45	9	15	15	9

Type, cat. no. 214323, U. S. National Museum.

Type locality, Albatross station 4233, Behm Canal, Alaska; 39–45 fathoms, bottom of soft gray mud and rock, July, 1903; 12 specimens.

Distribution: Alaska—Chignik Bay; Kasaan Bay; Behm Canal; Boca de Quadra. Washington—Admiralty Inlet; "Puget Sound". California—Monterey Bay and vicinity of San Diego (var. *diegensis*).

A very considerable amount of material has been examined, comprising in all some 122 specimens, as follows:

SPECIMENS OF ROSSIA PACIFICA.

No.	Locality.	Collector or station.	Depth in fathoms.	Sex.	Where deposited.	Remarks.	Author's register.
	Alaska:						
3	Chignik Bay	Albatross station 4286.	57–63	2♂ 1♀			26
1	Kasaan Bay	4243	42–47	♂			22
2	do	4242	9–24	♂ ♀			12
7	Behm Canal	4234	45	6♂ 1♀			29
11	do	4233	39–45	7♂ 4♀	Cat. no. 214323, U.S. N. M.	Type lot	21
1	do	4227	62–65	♂			8
5	do	4226	31–62	2♂ 3♀			23
2	Boca de Quadra	4223.	48–57	♂ ♀			13
	Washington:						
1	Admiralty Inlet	4222	39	♂			14
1	do	4220	16–31	♂			5
1	do	4218	16	♂			6
16	Puget Sound	Shrimp fishermen, 1909.	....	6♂ 10♀	Stanford Univ., Cal.		55–56
	California:						
7	Off Salinas R., Monterey Bay.	H. Heath, June 25, 1908	....	2♂ 5♀	do		24
2	do	Fish trawl	20–30	♀	do		2
11	Monterey Bay	Albatross station 4492	26–27	4♂ 7♀	do		27
2	do	4480	53–76	♀			4
1	do	4475	58–142	♀			10
1	do	4473	54–65	♀			3
3	do	4457	40–46	♀			15
1	do	4455.	56–62	♀			7
2	do	4453.	49–51	♂			9
2	do	4452.	49–50	♂ ♀			25

SPECIMENS OF ROSSIA PACIFICA—Continued.

No.	Locality.	Collector or station.	Depth in fathoms.	Sex.	Where deposited.	Remarks.	Author's register.
	California—Contd.						
4	Monterey Bay.	Albatross station 4440.	52– 59	2♂ 2♀			28
1	Vicinity of San Diego	4377	127–299	♂		Var. diegensis.	20
11	....do	4365	130–158	5♂ 6♀		....do.	11
5	....do	4364	101–129	2♂ 3♀		..do	18
1	....do	4358	167–191	♀		....do	1
7	....do	4357	131–155	4♂ 3♀		....do	17
9	....do	4356	120–131	2♂ 7♀	Cat. no. 214376, U. S. N. M.	...do., types	19
1	....do	4310	71– 75	♂		....do	16

It is strange that I can find no reference in the literature to any Pacific *Rossia*, especially since *R. pacifica* appears to be a most abundant species and has long been known to workers in this region, even appearing as "*Rossia* sp." in a few local lists and manuscripts (if I am correct in assuming that the animals so referred to are the same as those here described). At first some doubt was felt as to the proper status of the present form, but extended study of a very large series of individuals has convinced me that it is distinct from any of the species previously described. The characters relied upon are small and may seem trivial, but appear to be constant even in specimens from widely distant localities, so that no other view seems feasible. The genus is a remarkably homogeneous one, and though a large number of species have been described, many of them differ from one another only relatively and in slight degree. The true value of many of them is certainly not yet established beyond all doubt. Our species appears to be nearest to *R. macrosoma* (Delle Chiaje) d'Orbigny, originally described from the Mediterranean, but there are numerous small discrepancies, notably in the structure of the arms in the male. I have not had the opportunity to examine actual specimens of the European species, but in the excellent figures given by Jatta (1896, pl. 15, fig. 6) only the outer two rows of suckers on the lateral arm suffer enlargement, whereas in *R. pacifica* all are usually subequal. The hectocotylization is similar to that figured for *R. macrosoma*, but differs slightly in detail. Furthermore, the tentacular suckers do not seem to be so thickly distributed in *R. pacifiica*, especially at the base of the club.

R. pacifica is one of the most abundant of the littoral West American cephalopods, and it is remarkable that it has escaped a diagnosis so long. The specimens taken show a wide range from southern Alaska to San Diego, and their abundance at both extremes indicates that they will eventually be found to extend far outside of these limits.

There is considerable variation in the shape of the body, the females as a rule being rather shorter and perhaps more plump than the males; but when sex is taken into consideration the measurements in the table (from specimens selected quite at random) are seen to be surprisingly constant, with the exception of the last three columns. The latter were taken from quite deep water in the vicinity of San Diego, California. None of the specimens observed from this region agree entirely with the type, and it is not impossible that they are incorrectly referred to this species. They differ in being uniformly much smaller, in every way more slender and delicate, the fins relatively larger, and the suckers of the sessile arms borne predominantly in two rows, only here and there (notably in the case of the hectocotylized arms) assuming the four-rowed condition. The constant character of these divergences may well be recognized to advantage, so that the subspecific name *diegensis* is here proposed. Should further material from the wide unexplored area intervening between Monterey Bay and San Diego fail to show intergrading forms it is likely that the southern specimens represent a new species. (Pl. XLII, figs. 2–6; pl. XLIII, fig. 1.)

A specimen from Albatross station 4377 is peculiar in that the body is extremely full and short, the head relatively larger than usual; the suckers, irregular in size and in two rows on all the arms, show that this too is only a slightly variant *diegensis*. It should be stated that the four-rowed state seems at best but a secondary one and more apparent than real.

Family LOLIGINIDÆ d'Orbigny, 1835 (em.)

Genus LOLIGO Schneider, 1784.

Loligo Schneider, 1784, p. 110.
Lamarck, 1799, p. 10 (pars).
Verrill, 1881, p. 307.
Hoyle, 1910, p. 410.

Ten-armed cephalopods of moderate size, with an elongate, tapering, cylindrical body and large terminal triangular or sagittate fins. Mantle connectives of simple structure, the funnel cartilages elongate with a median groove. Funnel attached to the head by a pair of muscular bridles and equipped with an internal valve. Sessile arms angular; umbrella rudimentary or lacking, but the swimming membranes along the arms usually well developed. Only the distal portion of the left ventral arm hectocotylized. Suckers in two rows, alternating, bowl-shaped, furnished with a toothed horny ring surrounded by a raised margin.

FIG. 4.—*Loligo opalescens*, inner aspect of tentacle club. [101.]

Distinguished from its nearest ally, the West Indian and Panamic *Lolliguncula* (perhaps better to be regarded as a subgenus of *Loligo*), chiefly by the fact that the female receives the spermatophores of the male upon a specially developed pad below the mouth, whereas in the last-named group they are received upon a calloused patch within the mantle near the left gill.

Loligo is an important and abundant genus of cosmopolitan distribution, and in number of species is exceeded by *Sepia* alone among the decapods.

Type, *Loligo vulgaris* Lamarck, 1799, a common European species. It is still more or less of a mystery to me how any genus can logically take as its type a species not recognized at the time it was founded and only subsequently established by another author.

Loligo opalescens Berry, 1911. (Pl. XLIII, fig. 5–8; pl. XLIV, fig. 2–4; pl. XLV; pl. XLVI, fig. 4–5.)

? *Loligo Stearnsii* Hemphill, 1892, p. 51, (nomen nudum).
? Hoyle, 1897, p. 370 (8) (no description).
Ommastrephes tryoni Keep, 1904, p. 271, 351 (no description; *not* of Gabb).
Loligo pealii Jenkins & Carlson, 1903, p. 264 (physiology of nerves).
? *Loligo stearnsii* Williamson, 1905, p. 129 (mere note).
Kelsey, 1907, p. 42 (merely listed).
Ommastrephes tryoni Keep, 1910, p. 297 (no description).
Loligo opalescens Berry, 1911, p. 591.

Body of moderate size; firm, cylindrical, narrow, elongate, slightly swollen near the middle, thence tapering acutely to a rather sharp point behind. Fins large, about half as long as the mantle; sagittate; very slightly lobed in front, barely continuous behind, obtusely angled considerably in front of the middle; their margins thin, entire. Mantle margin truncate, deeply emarginate between the prominent lateral angles on either side of the funnel; produced above into a prominent, squarish, rostrum-like process, rounded at the extremity, which is made up chiefly of a continuation of the dorsal connective cartilage of the mantle around the tip of the gladius. Locking apparatus well developed, comprising the just-mentioned cartilage in the nuchal region, besides a prominent elongate cartilaginous groove and ridge on either side of the funnel; the latter simple, with a raised and reflexed margin (pl. XLIV, fig. 3, 4).

Head small, narrower than the body, squarish, ornamented above posteriorly by three parallel longitudinal folds of integument, the grooves between which correspond to the cartilaginous ribs of the rostrum. Eyes large, not protruding. Siphon rather large, broad, and plump, with dorsal bridles and a large terminal valve.

Arms stout and rather short in the male, sometimes a little longer in the female;[a] unequal, the dorsal arms considerably the shortest, but the proportions of the others somewhat variable, usually

[a] Perhaps due to the different preservation of the material.

3=2, 4, 1. Umbrella rudimentary between all the arms except the ventral pair, where it is totally lacking; continued upon the dorsal margins of the dorsal arms as a prominent membranous keel; inner margins of second arms bluntly carinate, third arms obscurely so; outer margins of second and third arms with a fleshy keel running to their tips; ventral arms provided with a very broad and prominent web along the outer margin, ensheathing the base of the tentacle, and thence gradually narrowing toward the tip; a similar but much less developed keel extends along the inner margins of the ventral arms. Along the sucker-bearing surface of all the arms runs a delicate membranous swimming web, strengthened by numerous slender transverse trabeculæ of a muscular nature, occurring in alternation with the sucker pedicels. Save on the ventral pair, where it becomes much reduced, this web is exceedingly prominent on all the arms, but attains its maximum development on the third pair, where its diameter is seen in well-preserved specimens to be as great or greater than that of the arm itself (pl. XLVI, fig. 4, 5). Suckers small, somewhat kettle-shaped, regularly alternating in two rows, obliquely poised on rather short conical pedicels; margin of cupules hood-like, with a small sinus in the superior margin; horny rings with nine to twelve bluntly rounded, squarish teeth on the upper margin; papillary area wide and very prominent in microscopical preparations (pl. XLIII, fig. 8).

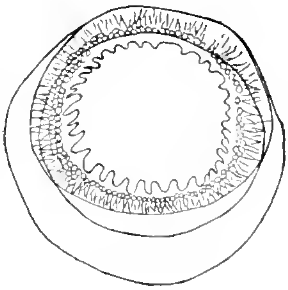

FIG. 5.—*Loligo opalescens*, camera drawing of oral aspect of tentacular sucker of ♀; from a mount in balsam. [101.]

Left ventral arm in the male conspicuously hectocotylized; along the proximal two-thirds of the arm the suckers (about twenty pairs) are unmodified, but along the distal third their pedicels become transversely flattened and elongate, the cups showing a simultaneous diminution in size, a condition especially true of the suckers at the extreme distal end of the outer row, where the cups are reduced to mere rudiments. Toward the end of the inner row the pedicels decrease in size and resume their normal shape, the cups decreasing comparatively little, so that the suckers at the extreme distal end of the row are more nearly normal. The outer row is still further unique, in that some six to eight of the more proximal suckers undergoing modification are much more elevated and have broader pedicels than either those opposite or those succeeding or following them; indeed, throughout the modification of each pedicel and sucker in this row is more complete than that of the corresponding sucker of the inner row (pl. XLIII, fig. 7).

Tentacles of moderate but variable length, highly contractile; the club but slightly expanded, lanceolate, furnished with a pronounced keel and a narrow swimming membrane (text fig. 4). Suckers in four rows, those of the two outermost very small; those of the two median rows much larger, their horny rings armed all round with about thirty-five small, rather elongate, bluntly conical teeth (text fig. 5).

Buccal membrane seven pointed, each point bearing two distinct rows of very minute crowded suckers, seven to nine in a row. The latter have well-developed papillary areas and horny rings with five or six irregularly squarish teeth. There is also an inner buccal membrane like a thickened, radially rugose cushion surrounding the beak (pl. XLIII, fig. 6).

Gladius thin, broadly lanceolate; midrib slender; slight lateral but no marginal thickenings (text fig. 6).

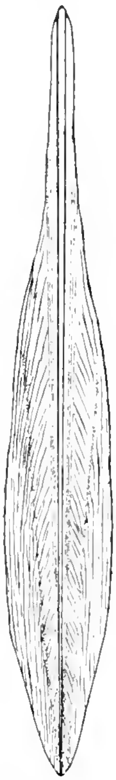

FIG. 6.—*Loligo opalescens*, dorsal aspect of gladius. [69.]

Color in life not observed; color in alcohol a pale buff, with numerous very distinct and beautiful brownish chromatophores scattered profusely over the whole dorsal surface, and in somewhat less degree over the ventral as well.

The young are quite different in general appearance, but are not easily confused with any of the other species inhabiting the same region. Besides other features which are in the main obviously due to juvenility, they differ from the adults chiefly in the much shorter, broader, more rounded fins which gradually assume the typical sagittate outline as they increase in size. A well-advanced embryo is shown in plate XLIII, figure 5.

The more important dimensions of the type, two cotypes, and one other specimen, are appended in the annexed table.

MEASUREMENTS OF LOLIGO OPALESCENS.

	Puget Sound.			Off San Diego, station 4324.
	Type. ♂	Cotype. ♂	Cotype. ♀	Immature.
	mm.	*mm.*	*mm.*	*mm.*
Total length, excluding tentacles	177	181	222	114
Length of mantle (dorsal)	132	126.5	146	80
Fins at plane of attachment	61.5	58.5	70.5	34
Width of body	23	21	25	16.5
Across fins	59	56	69	37
Of head	20	19	23	15
Length of dorsal arm	35	44	52	21
Second arm	41	49	63	24
Third arm	42	49	66	30
Ventral arm	40	46	59.5	26
Tentacle	40	41.5	113	49
Tentacle club	16	16.5	27	13

Type, no. 2076 of the invertebrate series in the collection of Stanford University, a male. Cotypes in the U. S. National Museum and in the author's collection.

Type locality, Puget Sound, Washington (shrimp fishermen), 3 specimens.

Distribution: Washington—Puget Sound, near Deception Pass. California—Monterey Bay, San Diego.

Three hundred and thirty-six specimens, mostly in a rather indifferent though recognizable state of preservation, have been inspected.

SPECIMENS OF LOLIGO OPALESCENS.

No.	Locality.	Collector.	Depth in fathoms.	Sex.	Where deposited.	Remarks.	Author's register.
3	Puget Sound, Wash.	Shrimp fishermen		♂ ♀ ♂	Inv. ser. no. 2076, Stanford Univ. Coll. U. S. Nat. Mus. Coll. S. S. B	Type. Cotype Cotype	101
1	Near Deception Pass, Wash.	Fish trap (C. H. Gilbert).		♂	Stanford Univ. Coll.		107
3	Off Salinas River, Cal	Paladini fish trawl	20–30	Juv.	do		68
24	Monterey Bay, Cal	San Francisco market (C. H. Gilbert).		♂ ♀	do Coll. S. S. B		69
2	do	Albatross station 4446	52–59	Juv.			63
3	do	4447	42–52	Juv.			62
2	do	4449	22–29	Juv.			64
.	do	Albatross			Stanford Univ. Coll	Embryonic	163
6	Off Pacific Grove, Cal.	Stanford Univ. Mar. Lab.		3 ♂ 3 ♀	do		59
282	do	do		♂ ♀	Not preserved		61
6	Vicinity of San Diego, Cal.	Albatross station 4324.	10	Juv.			65
2	San Diego, Cal	E. C. Starks		Juv.	Stanford Univ. Coll	From stomach of a yellowtail.	66
2	do	do		Juv.	do	From stomach of an albacore.	67

Loligo opalescens is the common squid of the Pacific coast of the United States. It is in many ways suggestive of *L. pealii* Lesueur, its congener from the other side of the continent, and also in some respects recalls *L. gahi* from the Chilean coast, but appears sufficiently distinct from either. The hectocotylized arm in particular is extremely constant in its details, which are unlike those of any other species known to me.

A few words should be said in regard to the synonymy of this species. The first published reference which I have been able to find regarding the occurrence of any *Loligo* on the west coast of North America is a short paper by Hemphill in Zoe for 1892 (vol. III, p. 51-52). It is entitled "Note on a California Loligo" and, alluding to the occurrence of some species of this genus in the San Francisco markets, publishes the name *Loligo Stearnsii* Hemphill for its reception. The article would be of little importance to us now were it not for the fact that the name applied has found its way into print on a number of subsequent occasions; hence as a matter of interest the entire paper is reprinted in the Appendix following this report. It will be observed that the only "diagnosis" offered is to be found in the lines, "The arms are not webbed," and "it closely resembles *Loligo Gahi*." As it is upon these 10 words alone that the validity of the name *L. stearnsii* must rest, it would seem that Dr. Hoyle was fully justified in his refusal to recognize it as more than a mere *nomen nudum*. The present writer was at first inclined to rehabilitate Hemphill's name and furnish it with the needful description, especially since he could not but believe that the form in hand was really the one here dealt with, but in view of the suspicion that we have more than one *Loligo* on the coast, not to mention the obvious discrepancy in the statement that "the arms are not webbed," the safest course appeared to be to discard the title *L. stearnsii* entirely and adopt an entirely new name.

The known range extends from Puget Sound south to San Diego, Cal., and in its proper season is everywhere abundant, usually occurring in great shoals by the thousand. In Monterey Bay the squid appear to be chiefly abundant in the summer time, although hauls are sometimes sent into the San Francisco markets as late as the middle of November. It used to be taken in vast quantities by the Chinese of Monterey, who dried the animals on shore, packed them in bales, and exported them to China. The fishing was done by night, torches being used to attract the creatures to the surface, whence they were scooped in by wholesale.

ŒGOPSIDA.

The animals belonging to this division are characterized by having a perforate eyelid free all round, permitting the sea water to bathe the cornea without obstruction. The opening frequently has a pronounced indentation or sinus in front. Both oviducts are normally developed.

High specialization of minor organs seems characteristic of the Œgopsida. This is strikingly seen in the frequent modification of many of the suckers into hooks, and the development of more or less complex luminous organs showing an almost unparalleled variety of structural detail. Photophores have been described as occurring in over one-half of the recognized genera. The curious arrangement of modified suckers known as the "fixing apparatus" which is to be found on the tentacles is also to be noted.

Perhaps the best discussion of the group as a whole is that given by Pfeffer (1900, p. 147-154).

Family OMMASTREPHIDÆ Gill, 1871.

Genus OMMASTREPHES d'Orbigny, 1835.

Ommastrephes d'Orbigny, 1835, p. 45 (fide Hoyle).
Ommatostrephes Loven, 1846.
Todarodes Steenstrup, 1880.
Ommatostrephes Pfeffer, 1900, p. 178, 179.
Ommastrephes Hoyle, 1902, p. 198.

Animals of moderate size, much resembling *Loligo* in shape and general appearance. Funnel connective apparatus massive, subtriangular, with a deep ⊥-shaped groove and corresponding ridges on the inner surface of the mantle. Funnel groove with a foveola. Arms stout, angled, with marginal membranes; suckers in two rows, the horny rings strongly denticulate with nearly equal teeth, or a single median tooth enlarged. Terminal portion of left ventral arm hectocotylized. Tentacles long, bearing suckers for more than half their length; fixing apparatus poorly developed, comprising only a few pads and small suckers. Gladius narrow and elongate, lacking the broad wing-like lateral expansions of the *Loliginidæ*.

Type, *Loligo sagittata* var. *a* Lamarck, 1799 = *Ommastrephes sagittatus* (Lamarck) d'Orbigny; a widely distributed species, the typical form of which is from the Atlantic.

Ommastrephes sagittatus (Lamarck, 1799) d'Orbigny.

Loligo sagittata Lamarck, 1799, p. 13 (fide Hoyle).
Ommastrephes sagittatus Tryon, 1879, p. 177, pl. 78, fig. 341 (after Forbes and Hanley), 345 (after Vérany); pl. 79, fig. 344 (after d'Orbigny), 346 (after Vérany).
Whiteaves, 1887, p. 134 (mere note).
Taylor, 1895, p. 99 (mere note).

Mention is here made of *O. sagittatus* on account of the statement by Whiteaves that three specimens of a squid collected at Victoria, British Columbia, by Dawson "correspond very well with Tryon's description and figures of this species in the first volume of his 'Manual of Conchology.'" The writer has personally encountered no specimens from the west coast of America which belong to this species or are even referable to the genus, but that is not proof that it may not well be expected to occur, especially since the same form, or rather its variety or subspecies *sloanei* Gray (*pacificus* Steenstrup), is known to be abundant in Japanese waters.

Genus STHENOTEUTHIS Verrill, 1880

Sthenoteuthis Verrill, 1880, p. 222.
Ommatostrephes Steenstrup, 1880.
Stenoteuthis Pfeffer, 1900, p. 179, 180.

Very similar to *Ommastrephes* in almost every way, but the sucker-bearing area includes *less* than one-half the total length of the tentacles, and there is a well-developed fixing apparatus on the carpus which includes both pads and a number of small suckers with smooth horny rings. The larger suckers on the club itself are strongly toothed, one tooth in each quadrant being considerably greater than the others.

From the nearly related *Dosidicus* the genus is to be distinguished by its normal arm tips and the fact that the strongly developed swimming membranes are on none of the arms exceeded by the supporting lappets (trabeculæ, *Querbrucken*).

The species of *Sthenoteuthis* and *Dosidicus*, together with *Ommastrephes* s. s., *Symplectoteuthis*, *Illex*, *Hyaloteuthis*, and *Todaropsis*, were formerly considered to rank under the all-embracing *Ommastrephes*, but while undoubtedly involved in extremely close relationship with one another, all these groups are now dealt with by most authorities as separate entities. I have felt bound to follow the prevailing opinion.

Type, *Architeuthis megaptera* Verrill, 1878, a species of the New England region. Doctor Pfeffer considers it to be identical with the European *Sthenoteuthis pteropus* (Steenstrup, 1856).

Sthenoteuthis bartramii (LeSueur, 1821) Verrill. (Pl. XLVII; pl. L, fig. 4–5.)

The references belonging to *S. bartramii sinuosa* Lönnberg, *S. caroli* (Furtado), and *Loligo æquipoda* Rüppell, respectively included in the synonymy of *S. bartramii* by Pfeffer and Jatta, are omitted here. Otherwise the following bibliography is made as complete as the literature at my disposal will allow.

Loligo Bartramii LeSueur, 1821, p. 90, pl. VII.
Férussac, 1823, p. 67, no. 12 (fide d'Orbigny).
sagittata Blainville, 1823, p. 140 (fide d'Orbigny).
Bartramii Blainville, 1823, p. 141 (after LeSueur).
sagittata Blainville, 1823a, p. 128 (fide d'Orbigny).
Bartramii Blainville, 1823a, p. 129 (after LeSueur). Férussac, in d'Orbigny 1826, p. 63.

Ommastrephes cylindricus d'Orbigny, 1835, p. 54, pl. 3, fig. 3-4.
Bartramii d'Orbigny, 1835, p. 55.
cylindricus d'Orbigny, in d'Orbigny and Férussac, 1835, p. 54, pl. III, fig. 3-4 (fide Hoyle).
Loligo vitreus Rang, 1837, p. 71, pl. 36 (fide d'Orbigny).
Ommastrephes Bartramii d'Orbigny, 1838, p. 59, no. 15 (fide d'Orbigny).
cylindricus d'Orbigny, in d'Orbigny and Férussac, 1839, p. 347; Calmars, pl. II; Ommastr., pl. II, fig. 11-20 (fide Hoyle).
d'Orbigny, 1845, p. 420, pl. 29, fig. 1-2; pl. 30, fig. 7-8.
Gray, 1849, p. 62.
d'Orbigny, 1853, p. 59.
H. and A. Adams, 1854, I, p. 34 (name only); pl. 4, fig. 1-1a.
Tryon, 1873, p. 12, pl. II, fig. 8.
Verrill and Smith, 1874, p. 341 (635).
Ommastrephes Bartramii Tryon, 1879, p. 180, pl. 80, fig. 361-362.
Sthenoteuthis Bartramii Verrill, 1880, p. 223.
Ommatostrephes Bartramii Steenstrup, 1880, p. 79, 81, etc., fig.
Sthenoteuthis Bartramii Verrill, 1881, p. 288, 429.
Verrill, 1882a, p. 322 (112), 432 (222).
Verrill, 1883, p. 106 (dimensions).
Ommastrephes bartramii Hoyle, 1886, p. 32 (no description).
Bartramii Hoyle, 1886a, p. 242 (38), (no description).
Stenoteuthis Bartrammi Girard, 1890, p. 265 (mere note).
Ommastrephes Bartrammi Joubin, 1894, p. 4 (merely listed).
bartramii Jatta, 1896, p. 64, pl. X, fig. 1-16.
Ommatostrephes bartramii Lonnberg, 1897, p. 705.
Ganatus amoenus Lucas, 1899, pl. XII, (fig. inaccurate in detail).
Stenoteuthis bartrami Pfeffer, 1900, p. 180.
Sthenoteuthis bartrami Hoyle, 1902, p. 204.
Ommastrephes Bartrami Joubin, 1903, p. 4 (short note).
Stenoteuthis Bartrami Rey, 1905, p. 172, fig.
bartramii Pfeffer, 1908, p. 97, fig. 109-115.
Sthenoteuthis bartrami Hoyle, 1909, p. 273 (no description).

Animal of rather large size, loliginiform. Mantle cylindrical, thick and heavy, tapering to an acute point between the fins; anterior mantle margin truncate, entire all round. Nuchal articulating apparatus a rather broad, elongate, cartilaginous plate with two very prominent longitudinal ridges and three smaller ones (pl. XLVII, fig. 2), the plate on the mantle having grooves to correspond; funnel locking apparatus more complex, comprising a massive triangular cartilage with a deep ⊥-shaped excavation which fits closely over a heavy ridge of similar shape on the inner surface of the mantle (pl. XLVII, fig. 3). Fins large, broadly sagittate, very firmly attached.

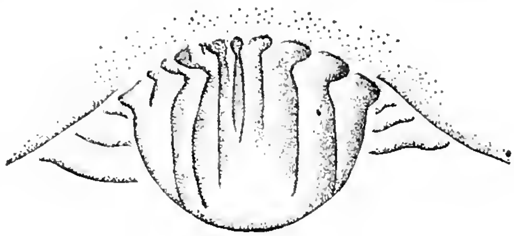

Fig. 7.—*Sthenoteuthis bartramii*, foveola. [114.]

Head large, somewhat elongate. Eyes large, with enormous apertures. Funnel large and wide, with stout dorsal supporting bridles and a large prominent valve; funnel groove broadly excavated and provided at the apex with the curious series of pocket-like folds termed the foveola (text fig. 7).

Arms stout, thick, unequal, the dorsal pair the shortest; all are furnished with a swimming membrane strengthened by strong transverse muscular trabeculæ, and are outwardly keeled, a circumstance attaining its maximum development on the third pair of arms; here the ventral swimming web becomes an extremely broadened delicate membrane, far overreaching the transverse supports along the whole length of the arm (pl. XLVII, fig. 1). Umbrella very rudimentary. Suckers (pl. L, fig. 4) large, flattened, obliquely placed on stout pedicels in two alternating rows, larger horny rings with about 28 to 30 stout acute teeth differentiated in two sizes which occur in partial alternation.

Tentacles robust, of moderate length, laterally much compressed and keeled on the dorsal edge, inner surface flattened, bordered by a narrow swimming web with trabeculæ similar to those of the sessile arms. Club elongate, attenuate distally, little enlarged; armed with two median rows of very large basin-shaped suckers and two lateral rows of very small ones, all becoming subequal and very minute at the extremity. The larger suckers have blackish horny rings armed with about 32 stout acute teeth, one tooth in each quadrant being very considerably larger than the others (text fig. 8). Fixing apparatus conspicuous, consisting of about three fleshy knobs alternating with the small suckers of the dorsal row along the carpal portion of the club, and succeeded proximally on each tentacle club of the specimen in hand by four small smooth-ringed suckers (pl. L, fig. 5.)

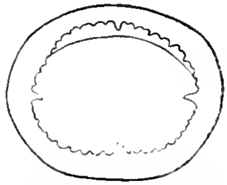

FIG. 8.—*Sthenoteuthis bartramii*, horny ring of large tentacular sucker. [114.]

Buccal membrane seven-pointed, the inner surface very rugose.

Beak, gladius, and radula not examined.

Color in alcohol a brownish buff, heavily clouded above with blackish purple, due to the great multitude and crowded condition of the chromatophores over the dorsal surface.

The above description is taken from a specimen in the Stanford University Collection (author's register no. 114), which was blown on board a vessel off Komandorski Island, Bering Sea. It is an adult in fair condition and does not appear in any way distinguishable from the specimens of this species I have seen from the tropical Pacific. Its chief measurements follow:

MEASUREMENTS OF STHENOTEUTHIS BARTRAMII.

	mm.
Total length, including tentacles	[a] 435
Excluding tentacles	[a] 380
Length of mantle (dorsal)	[a] 220
Width of mantle	[a] 55
Length of fin	90
Width across fin	154
Of head	45
Length of dorsal arm	77
Second arm	87
Third arm	97
Ventral arm	96
Tentacle	163
Tentacle club (sucker-bearing portion)	81

Distribution: Northern Europe to Mediterranean; Gulf Stream (Verrill); West Indies, Brazil; Uruguay (Museum of Comparative Zoology); Cape of Good Hope (Gray); Marshall Islands (Museum of Comparative Zoology); Fiji Islands (Museum of Comparative Zoology); off Komandorski Island, Bering Sea (Stanford University Collection).

Although I have seen no individuals captured within the actual limits of the geographical area under consideration, this species is so widespread in its habitat that there would be little doubt of its existence somewhere off our coasts. Furthermore, it is known to be abundant in Bering Sea, and, surprising as this may seem, appears to be at least in part the *Gonatus amœnus* of various Alaskan authors. According to Lucas, it is of considerable economic significance as one of the most important articles of food of the fur seal in that region. The figure given by this author, while yet leaving much to be desired, seems unmistakably to represent the present species. It is obviously not a *Gonatus*, the true importance of which form in such a connection is still not to be conjectured.

The data accompanying the Stanford specimen confirm Verrill's remark that "This is an exceedingly active species, swimming with great velocity, and not rarely leaping so high out of the water as to fall on the decks of vessels. On this account it has been called the 'flying squid' by sailors."

[a] Estimated.

Genus DOSIDICUS Steenstrup, 1857.

Animals of large size, attaining a total length of several feet; general shape loliginiform; arms stout at the base, extremities very attenuate and bearing a large number of suckers very much reduced in size; swimming membrane in general much reduced, its trabeculæ persisting as stout, tentacle-like processes from the margins of the arms. Other characteristics mainly as in *Sthenoteuthis*, which is undoubtedly very nearly allied.

But a single recent species is generally recognized.

Type, *Dosidicus Eschrichtii* Steenstrup, 1857 (=*Dosidicus gigas* (d'Orbigny) Pfeffer), originally described from the coast of Chile.

Dosidicus gigas (d'Orbigny, 1835) Pfeffer. (Pl. XLVIII–XLIX.)

Ommastrephes gigas **d'Orbigny, 1835**, p. 50, pl. IV.
giganteus **d'Orbigny, in d'Orbigny and Férussac, 1839**, p. 350, pl. 20 (fide Hoyle).
d'Orbigny, 1845, p. 425, pl. 30, figs. 1–4.
Gray, 1849, p. 60 (after d'Orbigny).
Dosidicus Eschrichtii **Steenstrup, 1857**, p. 11 (fide Pfeffer).
Ommastrephes giganteus H. and A. Adams, 1858, p. 35 (name only).
Ommastrephes giganteus Carpenter, 1864, p. 613, 664 (name only).
gigas Tryon, 1879, p. 179, pl. 80, fig. 357–360 (after d'Orbigny).
Dosidicus Eschrichtii Tryon, 1879, p. 175.
Steenstrup, 1880, p. 79, 80, 89, fig. (fide Hoyle)
Steenstrupii Pfeffer, 1884, p. 20, fig. 27.
Ommastrephes gigas Hoyle, 1886, p. 32, 214 (no description).
Dosidicus Eschrichtii Hoyle, 1886, p. 33, 217 (no description).
Steenstrupii Hoyle, 1886, p. 34 (no description).
Ommastrephes gigas Hoyle, 1886a, p. 242 (38), (no description).
Dosidicus Eschrichtii Hoyle, 1886a, p. 244 (40), (no description).
Steenstrupii Hoyle, 1886a, p. 244 (40), (no description).
Martialia Hyadesi Rochebrune and Mabille, 1889, p. H9, pl. I (fide **Pfeffer**).
Ommatostrephes gigas Yates, 1889, p. 178 (merely listed).
Ommastrephes gigas Yates, 1890, p. 45 (merely listed).
Ommastrephes gigas Brazier, 1892, p. 16 (merely listed).
Martens, 1894, p. 234 (dimensions).
Plate, 1897, p. 213.
Hoyle, 1897, p. 9 (merely listed).
Dosidicus gigas **Pfeffer, 1900**, p. 180.
Steinhaus, 1903, pp. 44–45.
Ommastrephes gigas Keep, 1904, p. 271, 351 (no description).
Kelsey, 1907, p. 46 (merely listed).
Dall, 1909, p. 195 (merely listed).
Dosidicus gigas Hoyle, 1909, p. 273 (no description).
Berry, 1910, p. 130 (no description).
Berry, 1911a, p. 304, fig. 1–4, pls. 20–21.

Animal very large, when adult attaining a length of several feet; robust and massive. Body loliginiform, cylindrical in front, tapering to a fairly blunt point behind. Fins large, broadly sagittate. Mantle margin truncate, entire all round; articulating with the body by an elongate cartilage in the nuchal region and a large apparatus with a deep ⊥-shaped groove on either side of the funnel, differing only in slight detail from that already described for *Sthenoteuthis bartramii*.

Head small in proportion to the body and slightly narrower than the latter; squarish. Eyes large; openings very large and conspicuous, with a deep anterior sinus. Below the head is deeply excavated for the reception of the large and powerful funnel, the integument bordering the depression heavily ridged and angled. Funnel supported above at base of funnel groove by a pair of muscular bridles as in *Sthenoteuthis*, etc.; apex of groove with a very conspicuous foveola constructed as follows: The median seven folds straight, massive, simple, pleat-like; next two broad, membranous, curving inward at base so that they are evenly continuous posteriorly to form a horseshoe-shaped pouch; outside this about five smaller oblique folds on either side, likewise membranous, gradually diminishing in size, and forming a series of small lateral pockets which are not necessarily in exact correspondence on the two sides. The funnel has a conspicuously large terminal valve (text fig. 9).

Arms robust at the base but becoming very attenuate toward the long and slender tips; order of length 3, 2, 1, 4, the first three pairs nearly equal, the ventral pair much the shortest; all furnished with an acute membranous keel along the outer margins attaining its greatest prominence on the much flattened and compressed third arms. Along the ventral margin of the sucker bearing area of the third arms is a broad tenuous swimming membrane supported by numerous stout, transverse, conical processes (trabeculæ) having their origin just in front of the base of the sucker pedicels and apparently in close relation with them; along the dorsal margins of these arms and along both margins of the remaining arms this membrane becomes much reduced, but the trabeculæ persist and extend out past it as conical tentacle-like processes of a very characteristic appearance; distally the membrane is better developed and extends to the tips of the trabeculæ, even exceeding them to as great a distance again on the ventral edge of the third arms (pl. XLIX, fig. 3).

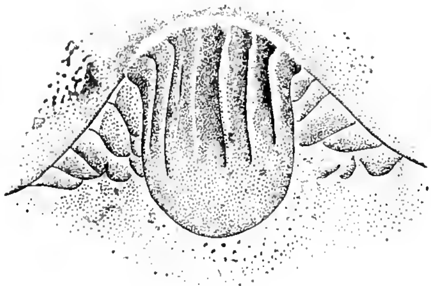

FIG. 9.—*Dosidicus gigas*, foveola. [72.]

Suckers large, oblique, hood-shaped, ranking in two regularly alternating rows; pedicels short, stout, their bases much swollen (pl. XLIX, fig. 5); horny rings with about nineteen sharp conical teeth, very small at the lower, edge the upper median and two extreme lateral teeth notably the largest (text fig. 10). Above condition prevalent on the arms for only about half their length; at this point begins the region of attenuation, simultaneously the suckers being suddenly reduced to a size quite incommensurate with not only their former proportions but the gigantic dimensions of the entire animal as well; a reduction to a diameter of about 1 mm. is attained almost at once, and thence they become smaller and smaller until at the tip of the arm their structure is barely to be perceived by the unaided eye. At the same time they become much more crowded and their pedicels and marginal membranes also undergo reduction, but not to such an extent as the suckers themselves (pl. XLIX, fig. 4, 6). On the second arms (e. g.) the reduction begins gradually at the tenth pair of cupules, becomes suddenly accelerated at the sixteenth, and distal to this point, occupying but about one-half the total length of the arm, over 150 pairs of suckers are to be made out without a lens.

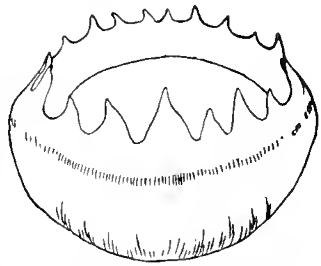

FIG. 10.—*Dosidicus gigas*, horny ring from large sucker near base of second arm, × 4. [72.]

No hectocotylization known to occur.

Tentacles stout, robust, and relatively not very long; laterally compressed, outwardly keeled; inner edge flattened and equipped with a narrow marginal membrane on each side as well as short trabeculæ very suggestive of some of those already noted on the sessile arms. Club large, somewhat expanded, lanceolate; about three-sevenths as long as the entire tentacle; the outer keel reaching a high state of development toward the extremity; about fifteen pairs of large, deep suckers along the middle, with a row of much smaller basin-shaped suckers along the marginal web on either side; supports of marginal web bifurcate, the lateral suckers having their origin far out upon the web at the point of bifurcation, at its inner end each trabecula connected by a further pair of bifurcating ridges with the similar ridges from the trabeculæ just anterior and posterior of the opposite side; distally the suckers of all four rows become more nearly equal, much reduced, and much crowded, those of the ventral row being slightly the largest and those of the dorsal row the smallest. Dorsal margin of the carpal region of the club conspicuously armed with a fixing apparatus, comprising four heavy, fleshy pads, alternating with three comparatively small suckers, the horny rings of which are smooth; the median rows of suckers cease just below the most distal pad, but those of the ventral row persist to a point nearly opposite the most proximal tubercle (pl. XLIX, fig. 2). Horny rings of the large median suckers with about twenty-one sharp teeth, one tooth of each quadrant larger than its neighbors (text fig. 11); horny rings of lateral suckers much deeper on the upper side and with but sixteen to seventeen teeth (text fig. 12).

Buccal membrane conspicuously seven-pointed; rugose within, but bearing no suckers.

Radula and gladius not examined.

Color in life unknown; in alcohol dark purplish above, pale below; everywhere punctate with small chromatophores not appreciably larger than those occurring in vastly smaller animals.

The chief dimensions of the only specimen available are as follows:

MEASUREMENTS OF DOSIDICUS GIGAS.

	mm.
Total length, including tentacles	1,245
Excluding tentacles	1,180
Length of mantle (dorsal)	635
Width of mantle	162
Length of fins (extreme)	330
Along line of attachment	300
Width across fins	515
Of head	160
Length of dorsal arms	425
Second arm	446
Third arm	450
Ventral arm	375
Tentacle	495
Tentacle club	215
Diameter of large sucker from second arms	13
From tentacle	11

Distribution: North Queensland, New South Wales, and Lord Howe Island, Australasia (Brazier); Chile (d'Orbigny, Gray, Martens, Steinhaus, Pfeffer); Peru (d'Orbigny). California—Monterey Bay, Santa Rosa Island (Yates), San Clemente Island (Carpenter), San Diego (Kelsey).

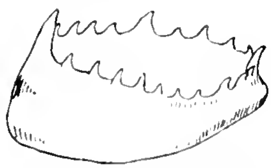

FIG. 11. *Dosidicus gigas*, horny ring from a median sucker of the tentacle club, × 5. [72.]

The single specimen examined is a finely preserved adult in the possession of the University of California (no. 72 of the author's register).

In the foregoing description I have purposely entered into considerable detail, as the species seem somewhat unusual in collections, and the above-mentioned specimen is in such excellent state as to render the possibility of misstatement comparatively remote. It should be added here, however, that the apparent rarity of the animal seems to be due rather to the difficulties attendant upon its capture and preservation than to its actual scarcity in our waters, for as a matter of fact the species would seem to be not an uncommon one. It has appeared rather frequently in local lists, usually under the cognomen of *Ommastrephes gigas*, and I have at hand a number of unpublished records of instances where creatures of undoubtedly the same form have been stranded on the beaches near Pacific Grove, California, during storms.

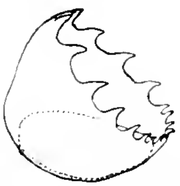

FIG. 12.—*Dosidicus gigas*, horny ring from a lateral sucker of the tentacle club, × 7. [72.]

Once its salient characteristics are noted, *D. gigas* can not be confounded with any other species of cephalopod now known; yet until the present specimen was reported upon (Berry, 1911a, p. 304) its identification from this region can not be said to have been unquestionably established. The assumption now is, however, that in this instance the old records were correct.

In identifying the *Ommastrephes gigas* of d'Orbigny with the *Dosidicus eschrichtii* of Steenstrup, I have followed Pfeffer, whose course in the matter seems to me a very logical one, although I have not had the opportunity to examine all the statements of the various authors involved nor any further material. The recorded distribution is somewhat remarkable, but not particularly to be wondered at, considering the open-sea habits of this powerful species, and the fact that it belongs to the widely dispersed family of the Ommastrephidæ.

Genus SYMPLECTOTEUTHIS Pfeffer, 1900.

Symplectoteuthis Pfeffer, 1900, p. 178, 180.

Animal like *Ommastrephes* in general features, differing from its allies *Dosidicus* and *Sthenoteuthis* chiefly in that the cartilaginous locking apparatus at the base of the funnel is fused with that of the mantle and the swimming membrane of the third arms is much less developed than in those groups. Arms frequently so compressed that the suckers have the appearance of being in a single series.

Type, *Loligo oualaniensis*, Lesson 1830 (=*Symplectoteuthis oualaniensis* (Lesson) Pfeffer), a tropical Pacific species of wide distribution.

Symplectoteuthis oualaniensis (Lesson, 1830) Pfeffer.

Loligo oualaniensis Lesson, 1830, p. 240, pl. I, fig. 2.
? *Ommastrephes Tryonii* Gabb, 1862, p. 483, pl.
? *Ayresii* "Gabb" Carpenter, 1864, p. 613, 664 (name only).
Oualaniensis Tryon, 1879, p. 180, pl. 81, fig. 368 (after d'Orbigny).
? *Tryonii* Tryon, 1879, p. 180, pl. 81, fig. 372–373 (after Gabb).
? *Ayresii* Tryon, 1879, p. 182.
oualaniensis Hoyle, 1886, p. 33, 167; 1886a, p. 243 (39)
Symplectoteuthis oualaniensis Pfeffer, 1900, p. 180
Hoyle, 1904, p. 32, fig. F.
Not *Ommastrephes tryonii* Keep, 1904, p. 271, 351 (=*Loligo oregonensis*), nor Keep, 1910, p. 297 (same).

The claims of this species to a place within our fauna, whether identical with that described by Gabb or not, are not yet by any means fully established. Brief mention is made here chiefly for the sake of completeness, as no specimens have been examined. One thing is clear, that all authors who have used the term *Ommastrephes tryonii* subsequent to its description have not been unanimous in their allusion to the same species or even the same genus as that described by Gabb, whatever the latter may prove to be. Usually a species of *Loligo* is the squid referred to under this name in the lists. It may be said in explanation of this confusion, however, that the original diagnosis of *tryonii* is sadly inadequate in almost all essential respects. As a possible preventive of further error and for the benefit of those who may not chance to have access to the publication in which it originally appeared, I have taken the liberty to reprint it in full (Appendix, art. II).

Ommastrephes Ayresii is a manuscript name of Gabb. It was published by Carpenter without description, and has been since repeated in several local lists despite the fact that it has no standing.

S. oualaniensis is reported from the vicinity of Cocos Island by Hoyle; this is probably the nearest locality to our region from which we have the species indubitably recorded.

Family HISTIOTEUTHIDÆ Verrill, 1881.

Genus MELEAGROTEUTHIS Pfeffer, 1900.

Meleagroteuthis Pfeffer 1900, p. 170.

Body of moderate size, short and ovate, with short posterior rounded fins. Head strongly asymmetrical. Arms of moderate length, with two rows of small distant suckers having toothed horny rings. Umbrella rudimentary. Luminous organs extremely numerous, especially on the ventral surface, although a few exist dorsally as well; on the dorsal and second arms three rows, on the third pair four, on the ventral arms about eight rows.

Meleagroteuthis is extremely close to *Calliteuthis*, differing but little save in the arrangement and number of its luminous organs. On such a ground the wisdom of separating the two further than subgenerically seems very doubtful, for if minute characters of this sort be generic, one wonders what features should be taken as specific. One of the lesser characters depended upon, the complete toothing of the sessile arm suckers, is at least in part broken down by the specimens described below.

Type, *Meleagroteuthis hoylei* Pfeffer, 1900, described from deep water off the western coast of Central America. But the one species is known.

Meleagroteuthis hoylei Peffer, 1900. (Pl. L, fig. 1–3; pl. LI; pl. LII, fig. 5–7.)

Meleagroteuthis hoylei **Pfeffer, 1900,** p. 170 (very incomplete description).
(no species named) Hoyle, 1904a, p. 13, 20.
hoylei **Joubin, 1905,** p. 64–69 (luminous organs).
Pfeffer, 1908a, p. 292 (full description).
Hoyle, 1909, p. 272 (merely listed).
Hoyle, 1910, p. 411 (merely listed).

Animal of moderate size, its general outline, including the arms, more or less spindle-shaped. Body short, robust, bluntly conical, widest near the front, and tapering to a rounded point behind; texture firmly semigelatinous; mantle thick, its anterior margin rounded, somewhat emarginate below the funnel with very obtuse lateral angles, barely produced above to form an obscure anteriorly projecting angle in the median line. Locking apparatus well developed; nuchal cartilage a somewhat spoon-shaped plate; on either side of the base of the funnel a heavy, deeply excavated, pyriform cartilage, terminated by a broadly reflexed, membranous margin (pl. LI, fig. 5).

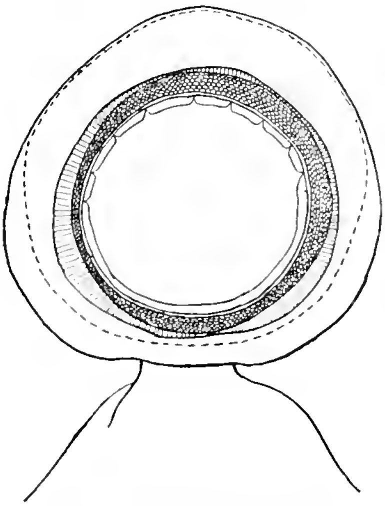

FIG. 13.—*Meleagroteuthis hoylei*, sucker from dorsal arm; camera drawing from mount in balsam. [109.]

Fins short, broad, semicircular, together forming a transverse ellipse; about two-fifths as long as the mantle; well lobed in front and behind; posteriorly not attached as far as the extreme tip of the body, but broadly continuous with one another above it.

Head enormous, rounded, strongly asymmetrical, deflected to the right so that its longitudinal axis shows a divergence of some 30° from that of the body; this state apparently brought about chiefly through the extraordinary development of the left eye, which includes nearly one-half of the total bulk of the head, the diameter of its lid opening more than twice that of the right (pl. LII, fig. 6–7); right eye well developed, but of very moderate size. (The distribution of the phosphorescent organs shows various eccentricities apparently correlated with this condition; but see below.) A small, slender, but fairly prominent papilla (the so-called "olfactory process") situated well back of each eye and posterior in direction. Funnel short, broad, prominently constricted in front and with a sharp downward flexion; within equipped with a flap-like valve and an elaborate "funnel organ," comprising a large Λ-shaped dorsal pad and two elongate lateral pads (pl. LI, fig. 4.)

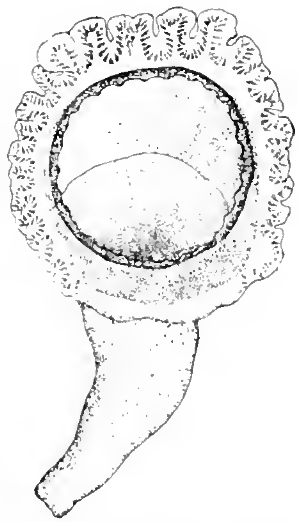

FIG. 14.—*Meleagroteuthis hoylei*, sucker from near middle of tentacle club; camera drawing from mount in balsam. [109.]

Arms considerably longer than the mantle, in general subequal, but the dorsal and ventral arms slightly the shortest, so that the order of length may perhaps be stated as 3=2, 1, 4; connected at base by a very short umbrella, which continues along the outer edges of the ventral arms to their tips; all the arms squarish, a narrow keel-like membrane bordering the sucker-bearing area, the first three pairs with a membranous carina along their distal portions. Suckers deeply basin-shaped, obliquely placed on short pedicels, and ranked along the margins of the arms so that the two rows are very widely separated (pl. LI, fig. 2); horny rings apparently smooth to the eye, but under a high power exhibiting some seven to eight very short, wide, squarely truncate teeth on their superior margin (text fig. 14, pl. LII, fig. 5).

No hectocotylization observed.

Tentacles very variable in length, elastic; outer surface rounded except along the distal portion of the club, where there is a conspicuous membranons keel; inner surface flattened. Club spatulate, its widest expansion near the base; tip strongly and obliquely recurved. Suckers rather small, flattish, crowded, very obliquely placed on short pedicels in seven to eight rows; largest near the middle of the expanded portion; apertures large, crowned above by a broad, lobed frill; horny rings armed with about thirty delicate, acute teeth of exceeding minuteness (text fig. 14). Sucker-bearing area bordered by a narrow membrane. Fixing apparatus very remarkable, comprising two series of suckers and pads extending from the club at its point of broadest expansion far down upon the stalk; first, about seven pads and as many minute suckers alternating in single file run along the extreme dorsal margin of the proximal portion of the club and the distal end of the stalk; the second set of suckers and pads are also minute and in single file, but they extend along the ventral margin of the stalk and alternate bypairs, the first two suckers being opposite the last two of the other series; in the proximal set there are eight suckers and six pads, rather closely placed distally, but becoming quite distant down the stalk (pl. LI, fig. 3).

FIG. 15.—*Meleagroteuthis hoylei*, integument from anterior ventral margin of mantle showing photophores; drawn from a mount in balsam, ×(?). [109]

Buccal membrane well developed, wide, seven-pointed (pl. L, fig. 3).

Gladius extremely delicate, with a slender midrib and broad lateral expansion.

Radula not examined.

Integument smooth, delicate; the outer epidermis rather loose and easily delaminated or rubbed off in preserved specimens. Everywhere punctate with small purplish chromatophores, so that the whole animal except the pale margins of the fins is of a livid purple-brown color.

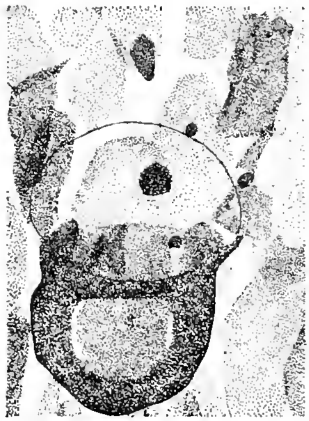

FIG. 16.—*Meleagroteuthis hoylei*, individual photophore enlarged from preparation shown in fig. 16, ×(?). [109]

Photophores exceedingly numerous, but apparently distributed with a surprisingly constant regularity. Owing to their great multitude this is somewhat obscure on the ventral surface of the mantle; dorsally more sparse; none on the ventral surfaces of the fins, but a few extend out on their bases above; a very distinct, close set row borders the anterior mantle margin below the funnel (text fig. 15). On the ventral surface of the head the organs appear ranked in about twenty-four longitudinal rows; on the dorsal surface about half as many, composed of much smaller and more widely spaced organs. These rows are continued from the head out upon the arms as follows: Upon the first and second arms, three rows; upon the third pair, four; upon the ventral arms, about eight; on none of the arms do more than two or three of these rows persist to the tips. In addition, a distinct single ring of photophores circumscribes the border of each eyelid. The asymmetrical appearance of the head in gross aspect extends in an equally striking degree to the arrangement of its phosphorescent organs; those of the right side in general more crowded and more sharply defined, although actually no more numerous. The greatest differences present themselves in the development of the circumocular rings; that of the right side consists of about sixteen to twenty very distinct close set organs, while on the left side they are farther from the margin of the lid, much farther from one another, and so greatly reduced that some of them (especially the more dorsal and posterior ones) are with difficulty made out at all (pl. LII, fig. 6–7). No luminous organs were observed upon the funnel.

The individual photophores appear as small, slightly elevated, ovoid tubercles of but little over a millimeter in length, and consisting of two fairly distinct divisions—a dense dark, more or less horseshoe-shaped area with a lighter core, and an anterior part of a pale or nearly white color, overlying which are usually two or three correlated chromatophores. The latter, though small, are somewhat more than ordinary in size. (Text fig. 16.)

MEASUREMENTS OF MELEAGROTEUTHIS HOYLEI.

	Albatross station 4544	Albatross station 4538.	Albatross station 4416.
	mm.	*mm.*	*mm.*
Total length, including tentacles	203	168	179
Excluding tentacles	145	141	176
Length of mantle (dorsal)	51	48	59
Width of mantle	29	28	31
Across fins	31	28	36
Length of fin	21	21	72
Width of head	34	28	40
Longitudinal diameter of right eye opening	7	8	7
Longitudinal diameter of left eye opening	17	14	17
Length of dorsal arm	73	71	83
Second arm	74	75	88
Third arm	74	76	87
Ventral arm	70	73	78
Tentacle	126	94	77
Tentacle club	17	15	16

Type locality, Gulf of Fonseca, west coast of Central America.

Distribution: Monterey Bay, California; off Santa Barbara Island, California; Gulf of Fonseca, west coast of Central America (Pfeffer); Paternoster Islands, Dutch East Indies (Joubin).

SPECIMENS OF MELEAGROTEUTHIS HOYLEI.

No	Locality.	Depth in fathoms.	Station.	Where deposited	Author's register.
1	Monterey Bay, Cal	724–1,000	Albatross station 4544	U. S. Nat Mus	109
1	do	795– 871	4538		110
1	Off Santa Barbara Island, Cal	323– 448	4416		108

The earliest description of this species is contained in the brief diagnosis of the genus *Meleagroteuthis* given by Pfeffer in his "Synopsis der œgopsiden Cephalopoden" of 1900 (p. 170):

"Leuchtflecke sehr dicht stehend, auf den dorsalen und dorsolateralen Armen in drei Reihen, auf den ventrolateralen in vier, und auf den ventralen in acht Reihen. Auf der Aussenseite der dorsalen und lateralen Arme und auf der dorsalen Mittellinie des Mantels je eine Reihe knorpeliger Tuberkel. Segel nur ganz schwach entwickelt."

In 1905 Professor Joubin published an account of the structure of the photophores of a supposedly identical form from the other side of the Pacific, but no further information was forthcoming until three years later, when Doctor Pfeffer issued his "Teuthologische Bemerkungen" (1908, p. 292–294) in which he gives us a more complete description of his type, but appends no figures.

The interesting discovery of somewhat larger specimens of apparently the same species by the Albatross as far north as Monterey Bay considerably extends the known range and enables me to add numerous important details to the information previously published as well as to present a fairly complete series of illustrations.

It will be noticed that my description fails to tally, however, with that of Pfeffer in quite a number of more or less weighty particulars. The umbrella in the Albatross specimens seems to be less developed, but I am inclined to think that this is to be explained by the larger size of the latter. More difficult to understand is the fact that I have been unable to identify any structures corresponding to the rows of tubercles ("Höckerreihe") described by Pfeffer with much stress as occurring on the arms and the dorsal surface of the mantle along the median line; but this, too, may turn out to be a juvenile character.

In other respects Pfeffer's account fits the Californian examples with fair accuracy, even to the extraordinary asymmetrical development of the head and its organs. The latter is certainly a most astonishing condition, the function of which, in the light of our present knowledge at least, seems utterly inexplicable, nor am I aware that any theory regarding it has ever been advanced.

Despite its known abyssal habit, it came as more or less of a surprise to find this beautiful Panamic species associated in the Albatross collection with the Arctic *Gonatus*, and indeed taken in at least one instance in the selfsame haul. It is without a doubt one of the most important and interesting additions to the Californian fauna which has lately come to notice. It is in every way distinct, a most remarkable creature, and not to be confused with any other form.

Family GONATIDÆ Hoyle, 1886.

Genus GONATUS Gray, 1849.

Gonatus Gray, 1849, p. 68.
Lestoteuthis Verrill, 1880, p. 251.
Chiloteuthis Verrill, 1880, p. 293.
Cheloteuthis Verrill, 1881, p. 109.
Gonatus Hoyle, 1886, p. 174.
Hoyle, 1889, p. 117.

Animal of moderate size, loliginiform. Arms short, stout; the ventral pair with four rows of suckers, the remaining arms with two lateral rows of suckers and two median rows of hooks. No hectocotylization. Tentacles with numerous rows of suckers and a few median hooks; fixing apparatus comprising a large series of pads and suckers extending from a point low down upon the stem nearly to the middle of the terminal expansion.

This curious group is known to include but a single aberrant species, but the latter is so unique in its remarkable assemblage of characters that its treatment in a genus by itself is clearly justifiable.

Type, *Onychoteuthis? amæna* Møller, 1842 (=*Sepia loligo* Fabricius, 1780=*Gonatus fabricii* (Lichtenstein) Steenstrup), a circumpolar species of quite wide distribution.

Gonatus fabricii (Lichtenstein, 1818) Steenstrup, 1880. (Pl. LII, fig. 1-4; pl. LIII; pl. LIV, fig. 1-4; pl. LV.)

Sepia loligo **Fabricius, 1780,** p. 358.
Onychoteuthis Fabricii **Lichtenstein, 1818,** p. 13 (fide Hoyle).
Lichtenstein, 1818a, p. 223.
Onychoteuthis Fabricii Møller, 1842, p. 76.
Onychoteuthis? amæna **Møller, 1842,** p. 76.
Onychoteuthis Kamtschatica **Middendorff, 1849,** p. 515, pl. XII, fig. 1-6.
Gonatus amæna **Gray, 1849,** p. 68.
H. and A. Adams, 1858, I, p. 36, pl. IV, fig. 2.
amænus **Sars, 1878,** p. 336, pl. XXXI.
amæna Tryon, 1879, p. 168, pl. 73, fig. 290 (after Adams).
Enoploteuthis Kamtschatica Tryon, 1879, p. 174, pl. 77, fig. 333-335 (after Middendorff).
Lestoteuthis Kamtschatica **Verrill, 1880,** p. 251.
Gonatus amænus Verrill, 1880a, p. 362 (merely listed).
Verrill, 1881, p. 291, pl. XLV, fig. 1-2.
Chiloteuthis rapax **Verrill, 1881,** p. 293, pl. XLIX, fig. 1.
Gonatus Fabricii **Steenstrup, 1881,** p. 9, pl. I.
Cheloteuthis rapax **Verrill, 1881a,** p. 110, pl. III, fig. 1-1f.

Gonatus Fabricii Verrill, 1881b, p. 297.
Lestoteuthis Fabricii Verrill, 1881, p. 387–393, pl. XLV, fig. 1–2; pl. XLIX, fig. 1; pl. LV, fig. 1.
Lestoteuthis Kamtschatica Verrill, 1882a, p. 280 (70).
Cheloteuthis rapax Verrill, 1882a, p. 286 (76), pl. XV, fig. 3–3f, 4.
Gonatus Fabricii Verrill, 1882a, p. 289 (79), pl. XV, fig. 1–1c, 2–2d.
Lestoteuthis Fabricii Verrill, 1882a, p. 416 (206), pl. XLV, fig. 1–1d.
Gonatus Fabricii Steenstrup, 1882, p. 143.
Lestoteuthis Fabricii Verrill, 1882, p. 316 (merely listed).
Gonatus amœnus Dall, 1884, p. 341 (merely listed).
Lestoteuthis fabricii Dall, 1886, p. 209 (merely listed).
Gonatus fabricii Hoyle, 1886, p. 41, 174.
Hoyle, 1886a, p. 252 (48), (no description).
Jatta, 1889, p. 66
Hoyle, 1889, p. 117–135, pl. XIII–XIV (anatomy).
Gonatus fabricii Lönnberg, 1891, p. 38.
Fabricii Appellöf, 1893, p. 9 (fide Pfeffer).
Joubin, 1894, p. 5 (merely listed).
fabricii Vanhöffen, 1897, p. 193 (fide Pfeffer).
Fabricii Hoyle, 1897, p. 372 (10), (merely listed).
antarcticus Lönnberg, 1898, p. 51, pl. IV, fig. 4–5.
fabricii Posselt, 1898, p. 279 (fide Pfeffer).
Fabricii Lönnberg, 1899, p. 792 (merely listed).
Not *Gonatus amœnus* Lucas, 1899, p. 61, pl. XII (= *Sthenoteuthis bartramii*).
Dall, 1899, p. 544 (merely listed).
Lestoteuthis fabricii Dall, 1899, p. 544 (merely listed).
Gonatus fabricii Pfeffer, 1900, p. 163.
Friele and Grieg, 1901, p. 124 (fide Pfeffer).
Fabricii Massy, 1907, p. 381.
fabricii Pfeffer, 1908, p. 71, fig. 80–84
Fabricii Massy, 1909, p. 27.
fabricii Hoyle, 1909, p. 267 (merely listed).
antarcticus Hoyle, 1909, p. 267 (merely listed).

I. (Pl. LII, fig. 3, 4; pl. LV, fig. 2.) A number of immature squids clearly referable to this much-abused species were obtained by the Albatross off the California coast. They agree in the following characteristics:

Body small, fragile and delicate, in general loliginiform, pointed behind. Fins short, very broad, continuous posteriorly where they form a distinct point; widest in advance of the middle, outer angles rounded. Mantle margin truncate above, not produced in the median line; laterally angled below and broadly but not deeply emarginate beneath the funnel.

Head short, broad; with extremely large, swollen, conspicuous eyes.

Sessile arms of moderate length, their armature comprising both suckers and hooks ranked in four rows; ventral pair bearing four rows of suckers only, all the others with two median rows of hooks and two lateral rows of small, broad pediceled suckers, a condition unique among known cephalopods. Umbrella wanting.

Detailed structure of tentacles subject to considerable variation, but always rather short, robust, obscurely carinated along the outer margin, and with a broad, prominent web along the outer edge of the distal portion of the club. Club flattened, broadly expanded; armed at the tip with four rows of small crowded suckers, at the expanded portion the four-rowed condition becomes obscure, the rows separating and passing down either margin, leaving the center of the club bare save for an extremely large elongate hook, supplemented just distally by a much smaller moderate-sized one; near the median line below occur usually a single series of about five more or less distinct hooks or hook-like suckers of small size, the two distal of which are apt to have more the appearance of true suckers than the others; nearly opposite the latter the inner suckers of the dorsal margin of the club exhibit a tendency to pass over toward the center, in one specimen terminating in a single row of three small suckers near the base of the third hook; the most marginal row, however, persists, undergoing remarkable transformation to become the fixing apparatus comprising both pads and suckers in regular alternation; the first eight pads and six suckers of this series the largest, pushing their way well inward, the suckers further characterized by a series of elevated transverse fleshy pads extending outwardly from the base of the pedicels; the latter complication ceases at the proximal end of the club, but the pads and suckers continue in alternation, although much reduced, down the stalk of the tentacle for over half its length; the suckers of the ventral row also are peculiarly differentiated, and perhaps worthy of note (though not to be distinguished in all specimens) would seem two rows of five to eight extremely minute acetabula which sometimes parallel the much larger suckers of the marginal row just below the large median hook; proximal to these the suckers become more uniform and continue down the stalk much as on the opposite side, but more irregularly and without the interspersal of pads. Hardly any two published figures agree in their representation of the finer details of the tentacular arms, so that the numerous small discrepancies exhibited by the Albatross specimens from these as well as from one another can hardly be regarded as significant until more is known regarding their development and function. (Pl. LII, fig. 3, 4.)

No hectocotylization observed and sexes not known to be otherwise outwardly differentiated.

Gladius not examined, but for completeness a description of that of the Atlantic form as given by Hoyle (1889, p. 119) is appended:

"*The Gladius* is narrow and linear anteriorly, but broader and lanceolate in the hinder two-thirds, whilst it ends posteriorly in a hollow cup or cone, which has several diaphragms within it, and is not covered outside and behind by a solid chitinous spine, as is the case with most, perhaps all, Onychoteuthids; at all events no species hitherto known has such a hollow cone."

Radula not examined; it is stated to include but five rows of teeth.

Color in spirits very pale, the chromatophores exceedingly obscure.

II. (Pl. LII, fig. 1, 2; pl. LIII; pl. LIV, fig. 1–4; pl. LV, fig. 1, 3–7.) At first sight very different from the foregoing appear two vastly larger examples from the region of Puget Sound which, while somewhat dubiously referring them to the same species, I describe in corresponding detail in the succeeding paragraphs.

Animal of moderate size, robust, powerful in appearance. Body loliginiform, subcylindrical, somewhat compressed dorso-ventrally; slightly inflated between the anterior margin and the fins; thence tapering rapidly at first, then more gradually, to an acute attenuate point between the fins. Fins large, over half as long as the mantle, broad, rhomboid; obtusely angular in advance of the middle, anterior lobes projecting well forward; posterior margins continuous around the tip of the body, forming an obtuse point. Anterior mantle margin evenly truncate above, projecting only very slightly in the median line; broadly emarginate below, with well-marked though somewhat rounded lateral angles. Mantle connectives the customary three in number, comprising a median elongate cartilage in the nuchal region, and on either side of the funnel a wedge-shaped lateral one, having a bifurcate groove and corresponding to a flattened ridge of similar shape on the inner surface of the mantle coincident with the lateral angles of its margin (pl. LV, fig. 5–6).

Head rather large, rounded above, flattened beneath. Eyes large; the lid openings large, with a prominent slit-like sinus in front. Funnel broadly conical, rounded at the tip, supported above by a pair of very wide thin bridles; opening wide, valved; funnel groove broad, rounded in outline, rather shallow; funnel organ conspicuous, comprising a median lobate Λ-shaped pad and two ovate lateral ones (pl. LIV, fig. 4).

Sessile arms stout, of moderate length; slightly unequal, the dorsal and ventral pairs the shortest; extremities attenuate. True umbrella wanting save between the second and third arms, where it is very rudimentary; outer edges of third and fourth arms angled and keeled, and insignificant indications of a similar membrane persistent on the second arms as well. Armature of ventral arms comprising four rows of small suckers, their horny rings furnished with a few very slender acute teeth on the upper margin; remaining arms agreeing in the possession of an entirely different arrangement; here two marginal rows of small suckers persist as on the ventral arms, but the two median rows are transformed into stout hooks of a somewhat larger size than the suckers (pl. LV, fig. 1, 3–4).

Tentacles stout and rather short; the club broadly expanded and armed with a great multitude of small basin-shaped suckers arrayed in numerous indistinct rows; horny rings with about twenty low acute teeth (pl. LIV, fig. 2); suckers largest near the middle of the club, but becoming extremely minute distally, along the margins, and at the base of the club, whence they extend well down upon the stalk, gradually diminishing all the while (pl. LII, fig. 1–2). No hooks present in whatever form, but the curious fixing apparatus so characteristic of *Gonatus* is evident as a series of small, rounded, whitish, bead-like tubercles or pads extending along the dorsal margin of the sucker bearing area from its proximal end upon the stalk well past the point of widest expansion of the club, and occurring in regular alternation with the minute suckers of the outermost row (pl. LV, fig. 7).

Buccal membrane well developed; eight pointed, there being two lappets between both the dorsal and the ventral arms, but none between the second and third pairs; copiously wrinkled within.

Color in spirits (formalin and alcohol) everywhere a pale muddy white.

The measurements of one of the best of the Albatross specimens, as well as the two large ones just described, are given in the annexed table.

MEASUREMENTS OF GONATUS FABRICII.

Locality	Albatross station, 4512.	Puget Sound, Wash.	Victoria, B. C.
Author's register no	98	88	90
	mm.	*mm.*	*mm.*
Total length, including tentacles	67	295	305
Excluding tentacles	61	275	250
Length of mantle (dorsal)	35	153	133
Width of mantle	10	45	37
Across fins	28	100	100
Length of fin	17	80	72
Width of head	10	42	41
Length of dorsal arm	16	85	83
Second arm	20	90	87
Third arm	20	95	91
Ventral arm	16	80	84
Tentacle (total)	30	124	149
Sucker bearing area of tentacle	21?	62	76

Distribution: Davies Strait, off coast of Greenland (Fabricius, Møller, etc.); Iceland; Faroe Islands; Jan Mayen; Porsangerfjord, Norway (Sars); coast of Finmark (Sars); off the coast of Ireland (Massy); Nice and Toulon, France (Joubin); south of Cape of Good Hope (Steenstrup); off Seal Island, Nova Scotia (Verrill); south of Newport, Rhode Island (Verrill).

Punta Arenas, Patagonia (Lönnberg, *G. antarcticus*); Japan (Steenstrup); Kuril Islands (Middendorff); Bering Island (Dall).

British Columbia—Vancouver Island (?). Washington, Puget Sound (?). California, Monterey Bay (Albatross) and off San Nicolas Island (Albatross). Lower California, off Los Coronados Islands (Albatross).

In all, the following 11 specimens have been examined, the greater part of them obtained by the Albatross.

SPECIMENS OF GONATUS FABRICII.

No.	Locality	Depth in fathoms.	Collector.	Where deposited.	Author's register no.
1	Near Victoria, B. C	Salmon traps.	J. B. Babcock, 1907	Stanford Univ. Coll	90.
1	Puget Sound, Wash		Shrimp fishermen, 1909	do	88.
3	Monterey Bay, Cal	724–1,000	Albatross station 4544.		100 juv.
1	do	755– 958	4530		97 juv.
1	do	750– 766	4517		96 juv.
1	do	309– 409	4512		98 juv.
1	do	32– 309	4468.		95 juv.
1	Off San Nicolas Island, Cal	581– 594	4424		99 juv.
1	Off North Coronado Island, Lower California.	257– 408	4379		89 juv.

From the foregoing descriptions it will at once be seen that the two large specimens from the Puget Sound region differ strikingly in several very important particulars from *Gonatus fabricii* as represented by the Albatross collection or as understood and described (or misdescribed) by the array of authors cited at length in the synonymy. The most notable divergence appears in the extraordinary structure of the tentacles, which I am utterly unable to bring into correlation with that of the smaller animals. This difference, if it shall later prove to be not ontogenetic and more than superficial, will certainly warrant their recognition as a very remarkable new species, even if the other characters noted (e. g., the shape of the fins, etc.) fail. However, the Albatross specimens, while coinciding with very fair exactness with the diagnoses and figures of Steenstrup, Verrill, and Hoyle, have nevertheless an obvious appearance of immaturity, and exhibit variation of such a nature as to indicate that development to the adult stage might well be productive of still greater changes.

All these considerations lead me to believe that it would be unsafe to risk further confusion of the already appalling synonymy by the addition of another name, and that it will be better to await the discovery of specimens intermediate in size. Examination of such material should quickly prove or disprove the possibility that the Puget Sound animals are but adults which have lost the hooks and definite arrangement of the suckers so characteristic of the young. One important item of evidence weighing against this hypothesis should not, however, be overlooked. The tentacles of the large specimens described by Verrill (1881, p. 391, pl. LV, fig. 1) and Pfeffer (1908, p. 72) agree with those of the Albatross specimens and are totally different from those of the two in the Stanford collection. The entire question is a momentous one which I do not feel competent to decide without a more complete series than is now at hand, especially in the absence of any Atlantic material for comparison.

The smaller specimens, at any rate, seem without doubt to be true *Gonatus fabricii* and greatly extend the already wide range of the species in the Pacific.

In the hope of performing some small service to the next worker who endeavors to elucidate the puzzling history of this interesting species, I have given as extended a list of references as the literature at my command will allow.

Family ONYCHOTEUTHIDÆ Gray, 1847.

Genus ONYCHOTEUTHIS Lichtenstein, 1818.

Onychoteuthis Lichtenstein, 1818, p. 1591.
Lichtenstein, 1818a, p. 223.
Pfeffer, 1900, p. 156, 158.

Body of moderate size, cylindrical, tapering, with broad sagittate fins. Head moderate. Arms stout; suckers in two rows showing no modification into hooks. Tentacles stout and rather long; the club armed with two rows of hooks on the central part; fixing apparatus a very definite, compact, rounded group of small suckers and pads on the carpal region. No hectocotylization. Gladius showing through the mantle as a well-defined dark streak. (For a further discussion of the genus see Pfeffer, 1900, p. 158, and Hoyle, 1904, p. 18.)

The occurrence of photophores within the mantle cavity has been reported by Doctor Hoyle.

Type, *Onychoteuthis bergii* Lichtenstein, 1818 (=*Onychoteuthis banksii* (Leach, 1817) Férussac), a tropical species of wide dissemination.

Two alleged species of *Onychoteuthis* have been reported to occur off the Pacific coast of the United States, but the exact status of neither can be taken as yet to be established. There is another well-recognized species, however—the *O. banksii* of Leach—the distribution of which is so cosmopolitan that we need not be surprised to find specimens within our limits.

Onychoteuthis lobipennis Dall, 1872.

Onychoteuthis ? lobipennis Dall, 1872, p. 96.
Onychoteuthis lobipennis Verrill, 1880, p. 252 (mere note).
Verrill, 1882a, p. 281 (71), (mere note).
Hoyle, 1886, p. 39 (merely listed).
Hoyle, 1886a, p. 250 (46), (merely listed).

"*Onychoteuthis ? lobipennis*, n. s.

Body short and inflated, somewhat cup shaped. Ventral posterior portion rounded and produced, giving the animal a decidedly pot-bellied appearance. Anterior portion slightly constricted or concave behind the edge, which is oblique, roundly excavated in front, and produced into a sharp point in the median line behind. Back slightly keeled. Fins rounded ovate on each side, not continuous around the posterior extremity, which is produced into a conical point. Nuchal collar prominent, keeled in the median line behind and on each side of the funnel; margin interrupted by the funnel, otherwise entire. Head rather swollen. Eyes large, blue in life, with a black inner ring. Color yellowish white, with brown ocellated spots on the back and sides, and brown specks on the arms and head. Sessile arms subequal, tentacular arms somewhat longer. Length of pairs: i, .8; ii, .9; iii, 1.3; iv, .9; v, .8 in. Length of back, along dorsal keel, .7; do., on ventral surface, .5; max. diam., .43; width of back, .46; width of fins, .66 transversely; .23 longitudinally. Length of head and collar on the dorsal line, .4; total length, 2.2 in. Diameter of eye, .2 in. Cupules in two rows. Two hooks in the median line of the extremities of each of the tentacular arms between the cupules. Mouth surrounded by a six-keeled frill of integument.

Habitat, caught in the towing net off San Francisco, Cal., in lat. 37° 22′ and long. 140° 10′, one specimen, Dall, July 17, 1865. Coll. reg. No. 302.

This pretty little species is doubtfully referred to the genus *Onychoteuthis*. It is well characterized by its pot-bellied appearance and narrow rounded fins. The posterior part of the funnel is very globose."—(Dall, in American Journal of Conchology, vol. VII, p. 96–97. 1872.)

No further information has been forthcoming in regard to this species since the appearance of the original description as above quoted. It seems likely that the specimen in hand was immature, and it has been suggested that if adult it might be found to possess affinities with *Lestoteuthis kamtschatica* (*Gonatus fabricii* (Lichtenstein)), although this appears to me somewhat doubtful.

Onychoteuthis fusiformis Gabb, 1862.

Onychoteuthis fusiformis Gabb, 1862, p. 171.
? Carpenter, 1864, p. 613, 632, 633, 664 (listed from San Clemente Island).
Hoyle, 1886, p. 39 (merely listed).
Hoyle, 1886a, p. 250 (46), (merely listed).
? Taylor, 1895, p. 98 (merely listed).
Keep, 1904, p. 351 (merely listed).

This species is here included because it has been reported from San Clemente Island, California, on the authority of Cooper, by Carpenter, and from Oak Bay, British Columbia, by Taylor, but in each case the determination seems at best a very doubtful one.

The paper by Gabb containing the original description is reprinted in the appendix of the present report. Gabb's specimen is said to have been taken off Cape Horn.

Genus MOROTEUTHIS Verrill, 1881

Moroteuthis Verrill, 1881, p. 298.
Verrill, 1881, p. 393.
Pfeffer, 1900, p. 156.

Besides the peculiarities of the gladius as hereinafter mentioned, this genus has for lesser characters the enormous size of its single species; the presence of about 36 hooks in two rows on the tentacle club; and the very numerous pads and suckers of the fixing apparatus. Otherwise the characters are very much as in *Onychoteuthis* or *Ancistroteuthis*, to each of which *Moroteuthis* has at various times been referred.

Type, *Ommastrephes robustus* "Dall" Verrill 1876 (=*Moroteuthis robusta* (Dall) Verrill), a species of southwestern Alaska.

Moroteuthis robusta (Dall) Verrill, 1876.

Onychoteuthis Bergi ? Dall, 1873, p. 484 (measurements, but no description).
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Tryon, 1879, p. 183 (after Verrill).
Onychoteuthis robusta Verrill, 1880, p. 195, 246, pl. XXIII–XXIV (full description).
Lestoteuthis robusta Verrill, 1880, p. 251–252 (mere note).
Ancistroteuthis robusta Steenstrup, 1880, p. 17.
Moroteuthis robusta Verrill, 1881, p. 393; Verrill, 1881b, p. 298, note.
Verrill, 1882a, p. 231 (21), 275 (65), 281 (71), 419 (209), pl. XIII–XIV.
Ancistroteuthis robusta Steenstrup, 1882, p. 150.
Hoyle, 1886, p. 40 (no description).
Hoyle, 1886a, p. 251 (47), (no description).
Thompson, 1900, p. 992 (description of tentacles and other details).
Moroteuthis robusta Pfeffer, 1900, p. 161.
Pfeffer, 1908, p. 68, fig. 78–79 (after Verrill).
Pfeffer, 1908a, p. 294.
Hoyle, 1909, p. 268 (no description).

As the only opportunity the writer has had to examine the giant squid of Alaska extended merely to a few fragments of one of Dall's specimens in the Yale University Museum, the liberty is taken to append herewith an abridgment of the excellent description given by Thompson (1900, p. 992–998). For further and more detailed information reference may be had to this careful paper and to the several articles by Verrill cited in the synonymy.

"The general shape of the body is almost evenly conical, very slightly attenuated between the fins, which latter extend over just about one-half the length of the mantle. The head is rather small and narrow, the eyes not prominent. The broadest part of the fins is about 27 inches from the apex, which they reach, and toward which their trapezoidal outline is sharply narrowed.

* * * The funnel possesses a large internal valve. * * *

The upper mandible is very sharply hooked; the lower has no tooth on its cutting edge. The radula has the usual seven rows of teeth.

The buccal membrane or "circumoral web" is well developed, expanding to a radius of about four inches. * * *

The suckers are in two rows, and commence on the dorsal arm about 2 inches, and in the others about 3 inches from the base. In the two rows the suckers are obliquely opposite. * * * There are on the ventral arm about fifty distinct pairs, beyond which for about 2 inches at the distal end of the arm the paired arrangement is not clearly maintained. * * *

Of the left tentacle only about seven inches is preserved. * * * Of the other tentacle about twenty-three inches is preserved in connection with the body. It is a broad, flattened strap, about an inch and a half in breadth. The distal end of the tentacle, including the tentacular club (which has hitherto remained unknown) is, very fortunately, preserved; it has all the appearance of having been directly continuous with the attached portion, and measures nearly 24 inches in length, the terminal club occupying the last eight inches. The club is laterally compressed, and has on each side a web or frill. * * *

The arrangement of the connective organ is as follows:—The first inch and a half or inch and a quarter of the club is occupied by a group of intermixed suckers and pads, in which we can discern an arrangement of six oblique rows containing 3, 4, 4, 4, 3, 3 elements, respectively; of these the first or external one has two pads and a sucker between, the last has two suckers and a pad between; the rest consist alternately of suckers and pads exclusively. * * * Beyond this portion of the connective organ commences a double row of hooks, of which there are about eighteen pairs. In our specimen many of these are missing. Of those that are left the largest belongs to the ninth pair, and beyond it they become much smaller. The lowermost hooks are about three-eighths of an inch long and nearly of equal breadth in their flattened bases. The largest, toward the middle of the club, are about five-eighths of an inch long, and with bases about five-sixteenths of an inch broad. The extreme tip of the club bears a group of thirteen small suckers within a square of about a quarter of an inch. * * * "

The gladius is remarkable in that it terminates posteriorly "in a conical, hollow, many ribbed, oblique cone, which is inserted into the oblique, anterior end of a long, round, tapering, acute, *solid*, cartilaginous terminal cone, composed of concentric layers, and corresponding to the solid cone of *Belemnites* in position and relation to the true pen." (Verrill.)

Type locality, Unalaska, Alaska, W. H. Dall, 1872.

Distribution: The individual described by Thompson as well as the three original specimens found by Dall in 1872, was cast up on the beach at Unalaska, Alaska, and it does not appear to have been reported elsewhere.

This is the largest species of cephalopod, perhaps of any invertebrate, known to inhabit the Pacific coast of North America, and is stated to attain a total length of over 14 feet (Dall's largest specimen minus part of the tentacles measured 427 cm.) or a mantle length of over 7½ feet.

As may be seen by a glance at the synonymy, its true generic position has been a matter of more or less debate, but the consensus of opinion seems now to be clearly that its claims to a genus by itself are entirely justified. Its nearest relative among described forms appears to be the *Moroteuthis* (or *Moroteuthopsis*) *ingens* (Smith) from the Magellan region.

Family CRANCHIIDÆ Gray, 1849 (em).

Subfamily GALITEUTHINÆ NEW NAME.

CRANCHIONYCHIAE Joubin, 1898.

As stated by Joubin, this group has the facies of an interesting connecting link between the Onychoteuthidæ on the one hand and the highly aberrant Cranchiidæ on the other. Whether this represents its actual relationships, however, or is rather to be regarded as an instance of converging development (parallel adaptation) does not yet appear.

Genus GALITEUTHIS Joubin, 1898.

Galiteuthis Joubin, 1898, p. 280.
Taonidium Chun, 1906, p. 86 (pars).

Body of moderate size, elongate, attenuate, with long, narrowly separated, lanceolate fins; mantle delicate, membranous, immovably adherent to the head in the nuchal region and at a point on either side of the funnel. Arms short; suckers unmodified, in two rows. Tentacles long; club bearing two rows of hooks along the middle succeeded distally by minute suckers, and with a well-developed fixing apparatus on the carpal region supplemented by a further series of suckers and pads extending down the stalk.

Type, *Galiteuthis armata* Joubin, 1898, described from a specimen taken in the Mediterranean at Nice, France.

Galiteuthis phyllura Berry, 1911. (Pl. XLVI, fig. 1–3; pl. LIV, fig. 5–6; pl. LVI.)

Galiteuthis phyllura Berry, 1911, p. 592.

Animal of moderate size, exceedingly delicate and translucent. Mantle membranous, smooth, thin, elongate; tapering gradually to the beginning of the fins, whence it continues between them to their tips as a slender, attenuate, spit-like process containing little but the gladius; anterior mantle margin thin, entire, closely and broadly adherent to the body in the nuchal region and undergoing a similar firm fusion with the base of the funnel on either side below, so that the water finds ingress to the mantle cavity by three openings; of these the two lateral are very broad and full, but the mantle margin is drawn more tightly across the funnel so that the ventral opening is considerably smaller. Fins remarkably developed, lanceolate, as broad as the body at its widest point, but leaf-like, thin, and excessively long and slender; nearly half as long as the body, attached for their entire length, and barely separated in the median line by the delicate integument covering the gladius.

Head (except the eyes) small, rather elongate above and below. Funnel large, with a strong ventral flexion; membranous, thin, much wrinkled in the preserved specimens; true valve lacking, its place taken by a thickened fold or pseudo-valve on the dorsal wall just in advance of the median pad of the funnel organ. Funnel organ highly complicated, comprising three distinct components, as follows: A large, rounded ovate, flattened pad on each ventro-lateral wall; between them a large, conspicuous, median, liver-shaped pad, its convex outline directed forward; from its center rises a long papilla, robust at the base, but tapering and terminated by the anal aperture; lateral lobes of this pad broad and rounded, each of these also giving rise near its center to a rather large, soft, bluntish papilla, which appears to terminate blindly in a rounded, finger-like extremity. The general arrangement of the entire apparatus is represented in the annexed diagram (text fig. 17), as well as in figures 5-6 of plate LIV. Eyes relatively enormous, globular, sessile, nearly approaching in the median line below; openings small.

Sessile arms moderately short, about one-fourth as long as the body, unequal, their order 4, 3, 2, 1; rather slender and delicate, each bordered by a broad, extremely delicate, hyaline membrane strengthened by numerous fairly slender, transverse trabeculæ having their origin near the base of the suckers (pl. XLVI, fig. 1). Suckers small, subspherical, obliquely placed on very short pedicels in two regularly alternating rows of about 20 to 25 each; horny rings well developed, but delicate and smooth (text fig. 18).

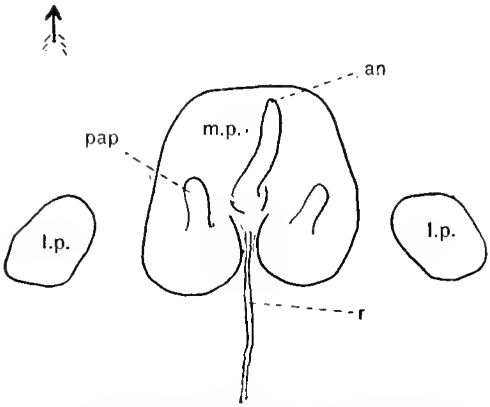

FIG. 17.—*Galiteuthis phyllura*, diagram to illustrate the relations of the component parts of the funnel organ; *an*, anal opening; *r*, rectum; *l. p.*, lateral pads; *m. p.*, median pad; *pap*, papilla.

Tentacles long, somewhat stouter at the base than the sessile arms and about twice as long; inner surface flattened and with a median groove, on either side of which appears a row of minute flattened suckers (about 18 in all), regularly but distantly alternating with as many small, more or less obscure, circular pads (pl. XLVI, fig. 3). Distally the pads and suckers move closer together and their ranks exhibit a tendency to separate in alternation to form four rows, the entire apparatus terminating on the carpal portion of the club in a compact group of about eight suckers and the same number of pads, still minute although much larger than those of the stalk. Club slightly expanded, furnished with a thin marginal membrane; expanded portion armed with two alternating rows of large delicate hooks, 12 in all, succeeded at the extremity of the club by a group of very minute suckers. Hooks of very characteristic appearance; sheaths hood-like; bases broadly expanded; a single isolated sucker of exceeding minuteness occurring near the proximal end of the dorsal row (pl. XLVI, fig. 2).

Buccal membrane well developed, suckerless.

Gladius not removed, but in large part easily apparent through the dorsal integument; fragile; excessively slender and attenuate.

Radula not examined.

Color in alcohol a soiled white, the chromatophores appearing as indistinct brownish spots thickly scattered over the dorsal surface of the head and on the tentacles (notably on the inner surface of the club); much less numerous but more distinct on the ventral portion of the head and the dorsal surfaces of the fins; on the mantle only a few large ones sparsely distributed.

The chief dimensions of the single specimen seen are as follows:

MEASUREMENTS OF GALITEUTHIS PHYLLURA.

	mm.
Total length including tentacles	[a] 350
Length of mantle (dorsal)	[a] 230
Fins	114
Width of mantle	[a] 35
Across fins	35
Of head	35
Length of dorsal arm	33
Second arm	41
Third arm	47
Ventral arm	57
Tentacle	100
Tentacle club	16

Type, cat. no. 214325, U. S. National Museum (no. 113 of author's register).

Type locality, Albatross station 4529, off Point Pinos, Monterey Bay, California, from a depth of 780 to 799 fathoms, hard mud and sand bottom; one specimen.

Distribution, Monterey Bay, California.

The relationships of the present form are entirely with the only other described member of the genus, the *G. armata* of Joubin, from the Mediterranean. The two descriptions, however, fail to parallel in a number of minor details, especially in the accounts of the structure of the tentacles, where Joubin's figures differ very strikingly in their representation of the hooks and fixing apparatus. Furthermore, in neither his figures nor description am I able to find any allusion to the remarkable apparatus on the stalk. The latter seems altogether too evident to have been overlooked by him unless it was either absent on the Mediterranean specimen, or entirely obscured through poor preservation.

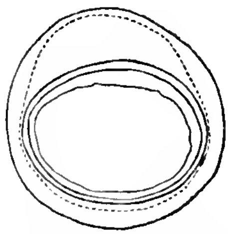

FIG. 18.—*Galiteuthis phyllura*, horny ring from sucker of sessile arm; camera drawing from mount in balsam. [113.]

Nevertheless it was with no little doubt and some misgiving that I eventually proposed a new specific name for the reception of the specimen in hand. This was done on account of my firm belief that in cases of habitats of little known species so far removed from one another, where the only alternatives seem to be (1) the description of a slightly differentiated form as new, or (2) uniting them and leaving to future generations to work out such differences as may exist, the exigencies of modern science are best served by the adoption of the former course. This seems on the whole a rule less apt to create confusion than the other, for more complete knowledge regarding these animals is as likely to reveal further differences heretofore unnoted, as to establish their identity. In the same connection it should be remembered how very few of the molluscan species of our west coast, so many of which were once supposed to be inseparable from Mediterranean forms, have actually proved to be so; and it does not appear that the distribution of recent cephalopods has been brought about under such different conditions as to constitute an exception to the rule. *G. armata* is stated by Joubin to be pelagic, and there is no telling at just what point our specimen became entangled in the Albatross dredge, so that this may be true. If so, a possible reason at once appears for such an exception as that mentioned above, and indicates that further evidence may reduce *G. phyllura* to the position of an absolute synonym of the older species.

In any case *G. phyllura* constitutes a very remarkable addition to the fauna of the North Pacific, and one which can not fail to be recognized when it is recaptured. Those possessing the opportunity to observe the offshore hauls of the coast fishermen, or who tramp the beach after the winter storms, should endeavor to maintain a watch for further evidence of the presence of this curious creature in our seas.

[a] Measurements inaccurate due to extreme contraction of mantle.

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The following somewhat lengthy bibliography is added in pursuance of a twofold purpose: First, to present in full the titles and references cited in briefer form in the preceding pages; and, secondly, to bring together as complete a catalogue as possible of all the published work on West American cephalopods, however fragmentary and unimportant a particular item may seem. It is obvious that only professedly scientific articles are as a rule intended to be included, but there are one or two exceptions. It is not to be hoped that this effort has been entirely successful, but it can not fail to prove of a certain usefulness.

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[a] I have followed Hoyle in giving 1834 as the date of Owen's contribution to this work. Most authors give it as one year later, and this is the date on the copy examined by me.

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LIST OF THE ALBATROSS STATIONS AT WHICH CEPHALOPODS WERE TAKEN, WITH THE SPECIES COLLECTED AT EACH.

Station 4194, Gulf of Georgia, British Columbia; June 20, 1903; 111–170 fathoms; temperature at surface 63° F., at bottom 43.8°; soft green mud. *Polypus leioderma.*

Station 4205, Admiralty Inlet, vicinity of Port Townsend, Washington; June 29, 1903; 26–15 fathoms; temperature at surface 57° F., at bottom 50.8°; rock and shells. *Polypus hongkongensis.*

Station 4209, Admiralty Inlet, vicinity of Port Townsend, Washington; June 30, 1903; 25–24 fathoms; temperature at surface 53°, at bottom 50.3°; rocky, coarse sand, and shells. *Polypus hongkongensis.*

Station 4218, Admiralty Inlet, vicinity of Port Townsend, Washington; July 1, 1903; 16 fathoms; temperature at surface 54°, at bottom 51.8°; soft green mud. *Rossia pacifica.*

Station 4220, Admiralty Inlet, vicinity of Port Townsend, Washington; July 1, 1903; 16–31 fathoms; temperature at surface 54°, at bottom 50.8°; green mud, sand, and broken shells. *Polypus hongkongensis, Rossia pacifica.*

Station 4222, Admiralty Inlet, vicinity of Port Townsend, Washington; July 1, 1903; 39 fathoms; temperature at surface 54°, at bottom 50.8°; gray sand and broken shells. *Polypus hongkongensis, Rossia pacifica.*

Station 4223, Boca de Quadra, southeast Alaska; July 6, 1903; 48–57 fathoms; temperature at surface 59°, at bottom 44.6°; soft green mud. *Rossia pacifica.*

Station 4226, vicinity of Naha Bay, Behm Canal, southeast Alaska; July 7, 1903; 31–62 fathoms; temperature at surface 61°, at bottom 44.8°; rocky. *Rossia pacifica.*

Station 4227, vicinity of Naha Bay, Behm Canal, southeast Alaska; July 7, 1903; 62–65 fathoms; temperature at surface 61°, at bottom 43.8°; dark green mud and fine sand. *Rossia pacifica.*

Station 4228, vicinity of Naha Bay, Behm Canal, southeast Alaska; July 7, 1903; 41–134 fathoms; temperature at surface 63°, at bottom 47.8°; gravel and sponge. *Polypus gilbertianus.*

Station 4233, vicinity of Yes Bay, Behm Canal, southeast Alaska; July 8, 1903; 39–45 fathoms; temperature at surface 61°, at bottom 44.7°; soft gray mud and rock. *Rossia pacifica.*

Station 4234, vicinity of Yes Bay, Behm Canal, southeast Alaska; July 8, 1903; 45 fathoms; temperature at surface 61°, at bottom 43.7°; gray mud, rocky. *Rossia pacifica.*

Station 4242, Kasaan Bay, Prince of Wales Island, southeast Alaska; July 11, 1903; 9–24 fathoms; temperature at surface 58°, at bottom 58.9°; fine gravel, broken shells, rocky. *Rossia pacifica.*

Station 4243, Kasaan Bay, Prince of Wales Island, southeast Alaska; July 11, 1903; 42–47 fathoms; temperature at surface 57°, at bottom 49.1°; green mud. *Rossia pacifica.*

Station 4253, Stephens Passage, Alaska; July 14, 1903; 188–136 fathoms; temperature at surface 52°, at bottom 40.9°; rock and broken shells. *Polypus gilbertianus.*

Station 4286, Chignik Bay, Alaska; August 10, 1903; 57–63 fathoms; temperature at surface 55°, at bottom 47.2°; green mud and rock. *Rossia pacifica.*

Station 4293, Shelikof Strait, Alaska; August 15, 1903; 112–106 fathoms; temperature at surface 57°; blue mud and fine sand. *Polypus leioderma.*

Station 4310, vicinity of San Diego, California; March 3, 1904; 71–75 fathoms; temperature at surface 61°, at bottom 49.7°; fine gray sand, green mud. *Rossia pacifica diegensis.*

Station 4312, vicinity of San Diego, California; March 4, 1904; 135–95 fathoms; temperature at surface 60°; fine gray sand, rock. *Polypus californicus.*

Station 4323, vicinity of San Diego, California; March 7, 1904; 227–193 fathoms; temperature at surface 63°, at bottom 45.8°; soft green mud. *Polypus californicus.*

Station 4324, vicinity of San Diego, California; March 7, 1904; 10 fathoms; temperature at surface 64–60°; gray sand. *Loligo opalescens.*

Station 4325, vicinity of San Diego, California; March 8, 1904; 191–292 fathoms; temperature at surface 62°, at bottom 46–43°; green mud and fine sand. *Stauroteuthis* (?) sp., juv., *Polypus californicus.*

Station 4339, vicinity of San Diego, California; March 10, 1904; 241–369 fathoms; temperature at surface 59°, at bottom 41.5°; green mud. *Polypus californicus.*

Station 4349, vicinity of San Diego, California; March 12, 1904; 75–134 fathoms; temperature at surface 58–59°, at bottom 50°; green mud and fine sand. *Polypus hongkongensis.*

Station 4356, vicinity of San Diego, California; March 15, 1904; 120–131 fathoms; temperature at surface 57–58°, at bottom 48.2°; green mud. *Rossia pacifica diegensis.*

Station 4357, vicinity of San Diego, California; March 15, 1904; 134–155 fathoms; temperature at surface 58–59°, at bottom 46.8°; green mud. *Rossia pacifica diegensis.*

Station 4358, vicinity of San Diego, California; March 15, 1904; 167–191 fathoms; temperature at surface 59–60°, at bottom 45.4°; green mud. *Polypus californicus, Rossia pacifica diegensis.*

Station 4364, vicinity of San Diego, California; March 16, 1904; 101–129 fathoms; temperature at surface 59°, at bottom 48°; gray sand, rock, green mud. *Polypus hongkongensis, Rossia pacifica diegensis.*

Station 4365, vicinity of San Diego, California; March 16, 1904; 130–158 fathoms; temperature at surface 59°, at bottom 47°; green mud. *Polypus californicus, Rossia pacifica diegensis.*

Station 4366, vicinity of San Diego, California; March 16, 1904; 176–181 fathoms; temperature at surface 59°, at bottom 46°; green mud. *Polypus californicus.*

Station 4369, vicinity of San Diego, California; March 16, 1904; 260–284 fathoms; temperature at surface 60–59°, at bottom 43°; green mud, gray sand, rock. *Polypus californicus.*

Station 4377, vicinity of San Diego, California; March 17, 1904; 127–299 fathoms; temperature at surface 60°; green mud and sand. *Rossia pacifica diegensis.*

Station 4379, vicinity of San Diego, California; March 18, 1904; 257–408 fathoms; temperature at surface 59°, at bottom 41.1°; green mud, brown specks, and rock. *Gonatus fabricii.*

Station 4393, vicinity of San Diego, California; March 30, 1904; 2113–2259 fathoms; temperature at surface 58–59°; soft gray mud. *Cirroteuthis macrope.*

Station 4396, vicinity of San Diego, California; March 31, 1904; 2228 fathoms; temperature at surface 59°, at bottom 35°; red mud. *Eledonella heathi.*

Station 4413, off Bird Rock, Santa Catalina Island, California; April 11, 1904; 152–162 fathoms; temperature at surface 62°; dark gray sand. *Polypus californicus.*

Station 4416, off Santa Barbara Island, California; April 12, 1904; 448–323 fathoms; temperature at surface 59°; dark green mud and rock. *Meleagroteuthis hoylei.*

Station 4420, off San Nicolas Island, California; April 12, 1904; 594–581 fathoms; temperature at surface 58–59°; fine gray sand. *Polypus hongkongensis.*

Station 4424, off San Nicolas Island, California; April 13, 1904; 594–581 fathoms; temperature at surface 59–60°; fine gray sand. *Gonatus fabricii.*

Station 4446, Monterey Bay, California; May 11, 1904; 59–52 fathoms; temperature at surface 58°, at bottom 47.2–47.7°; green mud. *Rossia pacifica, Loligo opalescens.*

Station 4447, Monterey Bay, California; May 11, 1904; 52–42 fathoms; temperature at surface 59–58°, at bottom, 47.5–47.9°; green mud. *Loligo opalescens.*

Station 4449, Monterey Bay, California; May 11, 1904; 29–22 fathoms; temperature at surface 57°, at bottom 49°; green mud and gray sand. *Loligo opalescens.*

Station 4452, Monterey Bay, California; May 11, 1904; 49–50 fathoms; temperature at surface 54°, at bottom 47.8–48.5°; green mud and fine sand. *Rossia pacifica.*

Station 4453, Monterey Bay, California; May 11, 1904; 49–51 fathoms; temperature at surface 54°, at bottom 48.5–49°; dark green mud. *Polypus hongkongensis, Rossia pacifica.*

Station 4455, Monterey Bay, California; May 12, 1904; 62–56 fathoms; temperature at surface 54°, at bottom 48°; green mud. *Rossia pacifica.*

Station 4457, Monterey Bay, California; May 12, 1904; 46–40 fathoms; temperature at surface 53–54°; dark green mud. *Polypus hongkongensis, Rossia pacifica.*

Station 4464, Monterey Bay, California; May 13, 1904; 51–36 fathoms; temperature at surface 53°, at bottom 49.5°; soft dark gray mud. *Polypus hongkongensis.*

Station 4468, Monterey Bay, California; May 13, 1904; 51–309 fathoms; temperature at surface 54°, at bottom 44.5°; fine sand. *Gonatus fabricii.*

Station 4473, Monterey Bay, California; May 14, 1904; 59–65 fathoms; temperature at surface 55°; gray sand and mud. *Rossia pacifica.*

Station 4475, Monterey Bay, California; May 16, 1904; 142–58 fathoms; temperature at surface 54–55°; soft green mud. *Rossia pacifica.*

Station 4480, Monterey Bay, California; May 16, 1904; 76–53 fathoms; temperature at surface 54°; dark green mud and sand. *Rossia pacifica.*

Station 4482, Monterey Bay, California; May 17, 1904; 43–44 fathoms; temperature at surface 53°; soft green mud. *Polypus hongkongensis.*

Station 4489, Monterey Bay, California; May 18, 1904; 20–18 fathoms; temperature at surface 55°; dark gray sand. *Polypus hongkongensis.*

Station 4492, Monterey Bay, California; May 18, 1904; 26–27 fathoms; temperature at surface 54°; soft green mud, rock. *Polypus hongkongensis, Rossia pacifica.*

Station 4512, Monterey Bay, California; May 23, 1904; 530–309 fathoms; temperature at surface 55°, at bottom 45°; hard green mud. *Gonatus fabricii.*

Station 4517, Monterey Bay, California; May 24, 1904; 766–750 fathoms; temperature at surface 56°; green mud and sand. *Gonatus fabricii.*

Station 4526, Monterey Bay, California; May 26, 1904; 204–239 fathoms; temperature at surface 57°; soft gray mud. *Polypus leioderma.*

Station 4529, Monterey Bay, California; May 27, 1904; 780–799 fathoms; temperature at surface 58°; hard mud and sand. *Galiteuthis phyllura.*

Station 4530, Monterey Bay, California; May 27, 1904; 958–755 fathoms; temperature at surface 58°; soft gray mud. *Gonatus fabricii.*

Station 4536, Monterey Bay, California; May 31, 1904; 1006–1041 fathoms; temperature at surface 58°, at bottom 38.5°; hard sand and mud. *Polypus californicus* (?) juv.

Station 4538, Monterey Bay, California; May 31, 1904; 871–795 fathoms; temperature at surface 59°; hard gray sand. *Meleagroteuthis hoylei.*

Station 4544, Monterey Bay, California; June 2, 1904; 724–1000 fathoms; temperature at surface 58°; gray sand and mud. *Meleagroteuthis hoylei, Gonatus fabricii.*

Station 4550, Monterey Bay, California; June 7, 1904; 50–57 fathoms; temperature at surface 57–58°; green mud and rock. *Polypus* (sp.) juv.

APPENDIX.

For the benefit of students without immediate access to large zoological libraries, it has been thought serviceable to offer accurate reprints of several of the earlier and more inaccessible papers having a direct bearing on the teuthology of the west American region and containing the original descriptions of several of our species.

[From Proceedings of the California Academy of Natural Sciences, vol. II, 1862, p. 170–172.]

DESCRIPTION OF TWO SPECIES OF CEPHALOPODES IN THE MUSEUM OF THE CALIFORNIA ACADEMY OF NATURAL SCIENCES.

By W. M. Gabb.

Octopus punctatus.—Body ovate, rounded at the extremity. Head moderately large, without any well-marked neck; compressed above, about one-fifth as long as the body, abruptly truncated in advance of the eyes, so that the constriction below the arms is barely more than half as wide as the greatest diameter of the head. Eyes of medium size; not prominent; color destroyed by alcohol. Abdominal aperture wide, the ends being directly behind the eyes; lip simple and acute. Siphon broad at the base, rapidly narrowing and extending a little beyond the origin of the arms. Arms subquadrate in section, the largest about four times the length of the body; proportionate length beginning with the dorsal side, 2, 1, 4, 3, varying very little in length, and being of about the same thickness. Cupules moderate, about half the diameter of the arms, largest just beyond the termination of the umbrella; short, robust, tapering almost imperceptibly, and slightly constricted just below the top. Umbrella small, not extending between the arms for one-fourth of their length, but continued as a very narrow membrane, for about one-half of their length along the side farthest from the dorsal side. Mouth very small, surrounded by small lips. Surface smooth, flesh-colored, and profusely marked by very minute reddish-brown, or chocolate-colored points. These points are so closely placed on the dorsal surface of the body and arms as to produce a nearly uniform, dirty-brown appearance; on the inside of the arms, the inner surface of the umbrella, and the whole ventral surface they are sparsely scattered. Length of body and head to origin of the arms, 3.5 inches. Circumference of body, at its broadest part, 4.3 inches. Length of body to the opening in the abdomen, 2.5 inches. Breadth of head, 1.1 inches. Length of the longest arm, from the mouth, 10.8 inches. Length of shortest, 9.25 inches. Circumference of one arm, 2 inches. Diameter of largest cupule, .3 in. Length of siphon, .7 in. Diameter at base .7 in. Diameter at apex (flattened), .3 in.

Locality.—Common in the neighborhood of San Francisco. Also found on the coast of Lower California, having been brought from Scammon's Lagoon, in abundance, by Capt. C. M. Scammon. The specimen from which the species is described is comparatively small. Dr. W. O. Ayres told me that he had seen them several feet in length, and spoke of one in which the arms were seven feet long.

It appears to approach most nearly to *O. megalocyathus*, Couthouy (Gould, Mollusca of Wilkes' Expedition, p. 471), but differs in the absence of the lateral membrane, the size of the mouth, the size of the cupules and the general coloration. There may be other differences, but I have not had an opportunity of examining the figures of Couthouy's species.

Onychoteuthis fusiformis.—Body slender, fusiform, prolonged and sharply acuminate posteriorly, truncated sinuously above, having a slight projection in the median dorsal region, and being equally emarginate on the ventral side. Head small, narrower than the body, subquadrate; eyes moderate and prominent, lachrymal sinus large. Sessile arms, not half so long as the body, nearly of the same size; formula of relative size, counting from the dorsal side, 1, 2, 4, 3, the second and last, being almost exactly of the same length, the dorsal the smallest. The dorsal arms are connected at their base by a minute membrane, which does not run up their sides; the second and third arms, and the tentacles have this membrane on one side, running to the extreme tips; the ventral and the adjoining arms are united by a larger membrane, but like the dorsal, the ventral arms are unprovided with it beyond the base, and are not united to each other; the tips are laterally compressed. The cupules on the sessile arms are strongly constricted at their base, and are pedunculated; they are arranged in a double series, without being either in pairs, nor yet alternating. They commence a short distance from the base of the arms, and are continued to the extreme tips, becoming smaller and scattered as they approach the end. Tentacles, nearly two-thirds the length of the body, exclusive of the head, the club forming about one-third of the whole; the club is little if at all widened; tentacle naked to the base of the club, where the "sucker" is placed, consisting of a small, irregularly rounded disc, bearing eight or nine sessile cupules. Beyond, as far as the extreme tip, are large and small, strongly hooked claws, arranged in an irregular line, and each one pierced near the base, and above grooved for half its length on the concave side. Mouth small, surrounded by a thin, simple lip, and outside of that, by a seven-lobed fold of skin, two lobes of which are placed opposite the base of the ventral arms—one opposite the space between the dorsals, and the other four opposite the laterals. Mandibles black. Siphon small, hardly projecting beyond the mantle. Fins dorsal, triangular, terminal, half as long as the body, outer angle rounded. Internal plate long, very slender, widest in the middle, tapering both ways, median ridge as high as the lateral plate, conical portion at the base, minute, laterally compressed, tip curved.

Color, light yellowish-brown, on the under surface and inside of the arms; back purplish-brown, nearly black on the median line and the posterior portion of the head, caused as in the preceding species, by the peculiar arrangement of dark spots. On the back of the fins these spots are of two sizes—large ones surrounded by an uncolored space, and small ones of a lighter color, interspersed.

Length of horny plate, 3.2 inches; width, .15 inch; length of terminal cone, .15 inch; circumference of body, 2 inches; length of fin, 1.6 inches; breadth of fins, 2.1 inches; length of longest sessile arm, 1.5 inches; length of shortest, .9 inch; length of tentacle, 2.1 inches.

Said to have been caught off Cape Horn.

[From Proceedings Academy Natural Science, Philadelphia, vol. XIV, 1862, p. 483.]

DESCRIPTION OF A NEW SPECIES OF CEPHALOPOD FROM THE COAST OF CALIFORNIA.

By W. M. GABB.

Ommastrephes Tryonii.—Body large, subcylindrical for about two-thirds of its length, posterior third tapering, acute at the extremity. Fins between one-third and one-fourth the length of the body, nearly twice as broad as long, rhomboidal; angles rounded. Anterior of the body truncated at a right angle to the length and with a slight angle on the dorsal median line. Siphon short, broad, head small, not wider than the body, flattened above (and at the sides?). Eyes small. Sessile arms robust, short, compressed: comparative length, 4, 2, 1, 3, the dorsal being the shortest, although they are all of nearly equal length. The second and third pair are so compressed that the cups appear to be arranged in a single line. The lower half or two-thirds of the outer side of the dorsal and the whole of the same portion of the other arms are fringed with a narrow membrane. The inner side of the third pair is also fringed on each side of the cupules.

The cupules are all small, but the bordering rows of teeth are well marked. Tentacular arms compressed, very little longer than the longest pair of sessile arms. Cupules arranged on the distal two-fifths, largest in the middle, becoming very small towards each end. Mouth small, the surrounding membrane without cupules, with a bifurcating process between the dorsal pair of arms and one extending to each of the other sessile arms. Surface flesh colored, covered with small dots, sparsely placed on the lower side and pinkish; on the back these dots are nearly black and placed close together so as to produce a mottled appearance. Between the back and sides there is a well-marked lighter band extending from the edge of the fins to the anterior end of the body.

Shell narrow, pointed in front, and tapering backwards regularly, except the last half inch which is dilated into the usual slipper-like process.

Length of body, 5.5 in.; circumference, 3 in.; length of fin, 1.8 in.; width of fin, 3.4 in.; length of head, .8 in.; breadth (about), .9 in.; length of longest sessile arm, 2.1 in.; length of shortest, 1.5 in; length of tentacular arm, 2.5 in.; length of siphon (about), .5 in.

Locality.—Coast of California?

The specimen was presented to me by Dr. W. O. Ayers, of San Francisco, and was found in a lot of salt, most probably from near Point Conception. The colors are well-preserved, but the specimen is so soft after relaxation that the exact form of the head can not be determined.

It resembles *O. sagittata, d'Orb.*, in both external form and the shape of the shell. It differs from that species, however, in the much shorter tentacular arms and the broader fin. The shell, which is pointed in nearly the same manner anteriorly, tapers regularly, while in d'Orbigny's species it is suddenly constricted.

[From Zoe, vol. III, 1892, p. 51–52.]

NOTE ON A CALIFORNIAN LOLIGO.

By Henry Hemphill.

In the July (1891) number of the Nautilus, in an article under the heading "Edible Shell Notes," Mr. R. E. C. Stearns mentions a "Ten-armed Cephalopod" which he had seen offered as an article of food in the San Francisco markets. Recently, while passing through the San Francisco and Oakland markets, I found a form of a loligo lying on the stalls of the fish dealers, which they offered at 25 cents per pound, and which I think is the "Ten-armed cephalopod" referred to by Mr. Stearns. Doctor Cooper informs me that he had observed a shoal of loligo at Monterey, some years ago, but having no net he was unable to secure a specimen. These that we find here in the markets now are said, by the fish dealers, to be taken in nets outside the Heads by the Chinese fishermen.

The body and arms of my largest specimen measures about 10 inches, the two longest arms being about three inches longer. The arms are not webbed, but each of the eight short ones have two rows of suckers their entire length, while the two other arms have a small patch of small suckers toward their tips. It took nine individuals of those I purchased from the fish dealer to weigh a pound, so we may say they weigh about two ounces each. In cleaning for cooking they will lose about half their weight, and each one will then furnish about one ounce of flesh.

In preparing them for cooking, after having removed the outer skin, pen, head, arms and entrails, they should be carefully washed, and fried in plenty of hot butter or fat, and seasoned to the taste.

Those which I had prepared and cooked were a little tough, though quite palatable, being nicely flavored, but they never will take the place of the delicious oysters and clams that have inspired poets to sing their praises.

In the form of its body and the coloring, as well as in the form of the pen, it closely resembles *Loligo Gahi* D'Orbigny, but as I have no other material with which to compare it, and no description of that form, I can not say definitely whether it is that species or not. This form makes an interesting addition to our west coast Cephalopods, and if upon further study I should conclude it to be new I propose to call it *Loligo Stearnsii*.

The following is a list of all the Cephalopods known to our coast, from San Diego to Alaska:

Argonauta argo L.
Octopus punctatus Gabb.
Ammostrephes ayresii Gabb.
Ammostrephes giganteus Gabb.
Onychoteuthis fusiformis Gabb.

EXPLANATION OF PLATES.

Except where otherwise stated in the context, all the drawings in the following plates were prepared by Miss Lora Woodhead, of Stanford University. The photographs, except that reproduced on plate XLVIII, are by Mr. J. H. Paine.

Numbers in brackets refer to specimen number in author's register.

PLATE XXXII.

Fig. 1. *Cirroteuthis macrope*, ventral view of entire animal (type specimen); ×1¼; arms and web partially restored. [120.]

Fig. 2. *Cirroteuthis macrope*, odontophore of young individual; greatly enlarged camera drawing from mount in balsam. [120.]

Fig. 3. *Cirroteuthis macrope*, view of interior of funnel of type specimen showing the funnel organ, ×1½. [120.]

Fig. 4. *Eledonella heathi*, inner aspect of right third arm of type, enlarged to about 2 diameters. [118.]

PLATE XXXIII.

Fig. 1. *Stauroteuthis* (?) sp., ventral view of young animal, ×2. [119.] Drawn by R. L. Hudson.

Fig. 2. *Eledonella heathi*, ventral view of type specimen, ×1⅓. [118.] Drawn by R. L. Hudson.

Fig. 3. *Eledonella heathi*, sixth sucker of right third arm of type, dorsal aspect; much enlarged. [118.]

Fig. 4. *Eledonella heathi*, interior of funnel showing the funnel organ. [118.]

PLATE XXXIV.

Fig. 1. *Polypus bimaculatus*, dorsal view of a young specimen from San Diego, California, rugose stage, ×2½. [124.]

Fig. 2. *Polypus bimaculatus*, dorsal view of a slightly larger individual with relatively smooth surface from La Jolla, California, slightly enlarged. [104.]

PLATE XXXV.

Fig. 1. *Polypus leioderma*, lateral view of type specimen, a female from Shelikof Strait, Alaska, natural size. [127.]

Fig. 2. *Polypus bimaculatus*, hectocotylized portion of right third arm of a male specimen from La Jolla, California; inner aspect, ×10. [104.]

Fig. 3. *Polypus hongkongensis*, detail of surface papillation on medio-dorsal region of body of a very rugose specimen, ×4. [142.]

Fig. 4. *Polypus gilbertianus*, detail of surface papillation on medio-dorsal region of body, same scale as fig. 3. [139.]

Fig. 5. *Polypus gilbertianus*, hectocotylized portion of right third arm of a male specimen (type) from Behm Canal, Alaska; inner aspect, ×5. [139.]

Fig. 6. *Polypus californicus*, detail of surface papillation of type specimen in medio-dorsal region of head, ×4. [131.]

Fig. 7. *Polypus californicus*, detail of surface papillation of same specimen in medio-dorsal region of body, same scale as fig. 6. [131.]

PLATE XXXVI.

Fig. 1. *Polypus hongkongensis*, lateral view of a male specimen from Uyak Bay, Alaska (type of *P. apollyon*), ×⅔. [142.] Photograph by J. H. Paine.

Fig. 2. *Polypus gilbertianus*, dorsal view of a male specimen (type) from Behm Canal, Alaska, ×1½. [129.] Photograph by J. H. Paine.

PLATE XXXVII.

Polypus gilbertianus, drawing of specimen shown in fig. 2 of preceding plate, ×⅔. [129.]

PLATE XXXVIII.

Fig. 1. *Polypus californicus*, ventral aspect of large male from off San Diego, California, ×½. [132.] Photograph by J. H. Paine.

Fig. 2. *Polypus californicus*, dorsal aspect of type specimen (male), ×⅔. [131.] Photograph by J. H. Paine.

PLATE XXXIX.

Fig. 1. *Polypus californicus*, hectocotylized portion of right third arm of specimen shown in pl. VII, fig. 1, ×1¾. [132.]

Fig. 2. *Polypus californicus*, inner aspect of portion of left ventral arm of same specimen just below the margin of the umbrella, ×1¾. [132.]

Fig. 3. *Polypus hongkongensis*, inner aspect of portion of right dorsal arm of young male near the umbrella margin, showing sucker enlargement, ×3½. [134.]

Fig. 4. *Polypus hongkongensis*, hectocotylized portion of right third arm of a male specimen from Uyak Bay, Alaska, ×6. [142.]

Fig. 5. *Polypus bimaculatus*, beak of a ♂ individual from the vicinity of San Diego, California, much enlarged. [103.]

PLATE XL.

Fig. 1. *Polypus hongkongensis*, ventral aspect of a young male from Pacific Grove, California, ×2. [164.] Photograph by J. H. Paine.

Fig. 2. *Polypus californicus*, lateral view of an immature specimen from off Santa Catalina Island, California, ×1¼. [130.] Photograph by J. H. Paine.

Fig. 3. *Polypus californicus*, dorsal view of a still smaller specimen from off San Diego, California, ×1½. [128.] Photograph by J. H. Paine.

Fig. 4. *Polypus leioderma*, dorsal view of a female (type), ×1½. [137.] Photograph by J. H. Paine.

Fig. 5. *Polypus leioderma*, ventral view of very young specimen from Monterey Bay, California, ×1½. [138.] Photograph by J. H. Paine.

PLATE XLI.

All figures on this plate are from photographs by J. H. Paine, and are approximately natural size.

Fig. 1. *Rossia pacifica*, dorsal view of a male from Behm Canal, Alaska. [21.]

Fig. 2. *Rossia pacifica*, dorsal view of a female from Behm Canal, Alaska. [21.]

Fig. 3. *Rossia pacifica*, dorsal view of another female from the same lot. [21.]

Fig. 4. *Rossia pacifica*, ventral view of specimen shown in fig. 3. [21.]

Fig. 5. *Rossia pacifica*, dorsal view of a large female from Chignik Bay, Alaska. [26.]

Fig. 6. *Rossia pacifica*, dorsal view of a male from Monterey Bay, California. [24.]

PLATE XLII.

All figures on this plate are from photographs by J. H. Paine, and are approximately natural size.

Fig. 1. *Rossia pacifica*, ventral view of specimen shown in figure 6 of preceding plate. [24.]

Fig. 2. *Rossia pacifica diegensis*, dorsal view of a female from off San Diego, California. [19.]

Fig. 3. *Rossia pacifica diegensis*, ventral view of same specimen. [19.]

Fig. 4. *Rossia pacifica diegensis*, dorsal view of another female from the same lot. [19.]

Fig. 5. *Rossia pacifica diegensis*, dorsal aspect of a very young specimen from the same lot. [19.]

Fig. 6. *Rossia pacifica diegensis*, dorsal view of a variant male from off San Diego, California. [20.]

PLATE XLIII.

Fig. 1. *Rossia pacifica diegensis*, inner aspect of left third arm of male from off San Diego, California, ×2½. [20.]

Fig. 2. *Rossia pacifica*, inner aspect of arms of entire right side of a male from Behm Canal, Alaska, ×2. [21.]

Fig. 3. *Rossia pacifica*, outer lateral view of left dorsal arm of same specimen, ×2. [21.]

Fig. 4. *Rossia pacifica*, right tentacle club of same specimen, ×4. [21.]

Fig. 5. *Loligo opalescens*, ventral view of an embryo of 3.5 mm., ×20. [163.] *br*, gill; *c*, chromatophores; *e*, eye; *g*, gonad; *i*, ink-sac; *l*, lens; *y*, yolk-sac.

Fig. 6. *Loligo opalescens*, buccal membrane of type, ×3. [101.]

Fig. 7. *Loligo opalescens*, distal portion of left ventral arm of an adult male from Monterey Bay, California, showing hectocotylization, ×2½. [59.] Drawn by H. V. Poor.

Fig. 8. *Loligo opalescens*, part camera drawing of sucker from third arm of male oral aspect. [101.] From a mount in balsam.

PLATE XLIV.

Fig. 1. *Rossia pacifica*, ventral view of an adult male from Admiralty Inlet, Alaska, ×2. [5.] Drawn by R. L. Hudson.

Fig. 2. *Loligo opalescens*, ventral view of young animal from Monterey Bay, California, ×1½. [62.] Drawn by R. L. Hudson.

Fig. 3. *Loligo opalescens*, locking cartilage from left side of funnel of a male from Monterey Bay, California, × 2¼. [69.]

Fig. 4. *Loligo opalescens*, nuchal locking cartilage of same individual, ×2¼. [69.]

Fig. 5. *Rossia pacifica*, interior of funnel of a female from Monterey Bay, California, laid open from below to show the funnel organ, ×2½. [7.] The posterior outlines of the median organ are not shown.

PLATE XLV.

Fig. 1. *Loligo opalescens*, dorsal view of type specimen (male) from Puget Sound, natural size. [101.]

Fig. 2. *Loligo opalescens*, ventral view of same, natural size. [101.]

PLATE XLVI.

Fig. 1. *Galiteuthis phyllura*, right third arm of type, inner aspect, ×3. [113.]

Fig. 2. *Galiteuthis phyllura*, right tentacle club of type, inner aspect, ×5½. [113.]

Fig. 3. *Galiteuthis phyllura*, inner aspect of left tentacle of type near the base showing fixing pads and suckers, ×6. [113.]

Fig. 4. *Loligo opalescens*, inner aspect of median portion of right third arm of type, showing suckers and marginal web, much enlarged, ×5. [101.]

Fig. 5. *Loligo opalescens*, right third arm of type, inner aspect, × 2. [101.]

PLATE XLVII.

Fig. 1. *Sthenoteuthis bartramii*, oblique lateral view of right third arm of specimen from Bering Sea, ×1½. [114.]

Fig. 2. *Sthenoteuthis bartramii*, nuchal locking cartilage of same specimen, ×2½. [114.]

Fig. 3. *Sthenoteuthis bartramii*, locking cartilage of right side of funnel, ×2½. [114.]

Fig. 4. *Sthenoteuthis bartramii*, ventral view of same specimen, reduced nearly ½. [114.] Drawn by R. L. Hudson.

PLATE XLVIII.

Dosidicus gigas, photograph of ventral aspect of specimen from Monterey Bay, California, ×1/6. [72.]

PLATE XLIX.

Fig. 2. *Dosidicus gigas*, inner aspect of carpal portion of right tentacle, natural size. [72.]

Fig. 3. *Dosidicus gigas*, inner aspect of portion of left third arm near the base of the wide web, greatly enlarged. [72.]

Fig. 4. *Dosidicus gigas*, inner aspect of portion of right third arm near the extremity, greatly enlarged. [72.]

Fig. 5. *Dosidicus gigas*, lateral view of sixth ventral sucker from basal portion of right second arm, greatly enlarged. [72.]

Fig. 6. *Dosidicus gigas*, lateral view of small sucker from extreme distal portion of second arm, greatly enlarged. [72.]

PLATE L.

Fig. 1. *Meleagroteuthis hoylei*, dorsal view of specimen from off Santa Barbara Island, California, nearly natural size. [108.] Drawn by R. L. Hudson.

Fig. 2. *Meleagroteuthis hoylei*, ventral view of same specimen, same scale as preceeding. [108.] Drawn by R. L. Hudson.

(This and the preceding drawing err in representing a condition of complete bilateral symmetry. A further sketch by Miss Woodhead has been added as giving a better idea of the true proportions; pl. LI, fig. 1.)

Fig. 3. *Meleagroteuthis hoylei*, buccal region of same specimen, same scale as preceeding. [108.] Drawn by R. L. Hudson.

Fig. 4. *Sthenoteuthis bartramii*, sucker from right third arm, ×5. [114.]

Fig. 5. *Sthenoteuthis bartramii*, carpal region of left tentacle of specimen from Bering Sea, ×2. [114.]

PLATE LI.

Fig. 1. *Meleagroteuthis hoylei*, dorsal view of specimen from Monterey Bay, California, ×2/3. [110.]

Fig. 2. *Meleagroteuthis hoylei*, right third arm of specimen shown in fig. 1-3 of preceding plate, inner aspect, ×1 1/3. [108.]

Fig. 3. *Meleagroteuthis hoylei*, distal portion of right tentacle of same specimen, inner aspect, showing fixing apparatus, ×2. [108.]

Fig. 4. *Meleagroteuthis hoylei*, funnel of specimen from Monterey Bay, California, laid open ventrally to expose the funnel organ, ×2. [109.]

Fig. 5. *Meleagroteuthis hoylei*, funnel region of same specimen with mantle laid open ventrally to expose the locking apparatus, ×1 1/2. [109.]

PLATE LII.

Fig. 1. *Gonatus fabricii* (?), inner aspect of right tentacle club of specimen shown on pl. LIII, fig. 1, ×1 1/2. [88.]

Fig. 2. *Gonatus fabricii* (?), outer aspect of same, drawn to same scale. [88.]

Fig. 3. *Gonatus fabricii*, distal portion of left tentacle of young specimen from Monterey Bay, California, ×7. [98.]

Fig. 4. *Gonatus fabricii*, basal portion of right tentacle club of another individual from Monterey Bay, California, ×10. [100.]

Fig. 5. *Meleagroteuthis hoylei*, oral aspect of sucker from third arm of specimen from Monterey Bay, California, ×40. [109.] Drawn from mount in balsam.

Fig. 6. *Meleagroteuthis hoylei*, left eye with surrounding integument from same specimen, ×2. [109.]

Fig. 7. *Meleagroteuthis hoylei*, right eye of same individual, same scale as fig. 6. [109.]

PLATE LIII.

Fig. 1. *Gonatus fabricii* (?), ventral view of adult specimen from Puget Sound, ×½. [88.] Photograph by J. H. Paine.

Fig. 2. *Gonatus fabricii* (?), ventral view of specimen taken near Victoria, B. C.; mantle laid open along medio-ventral line to expose interior of mantle cavity, ×½. [90.] Photograph by J. H. Paine.

PLATE LIV.

Fig. 1. *Gonatus fabricii* (?), dorsal aspect of specimen shown in fig. 1 of preceding plate, ×⅔. [88.]

Fig. 2. *Gonatus fabricii* (?), oral aspect of sucker from median portion of tentacle club of same specimen, × 40. [88.] Drawn from a mount in balsam.

Fig. 3. *Gonatus fabricii* (?), oral aspect of sucker from third arm, ×25. [88.] Drawn from a mount in balsam.

Fig. 4. *Gonatus fabricii* (?), interior of funnel viewed from below, showing funnel organ, slightly enlarged. [90.]

Fig. 5. *Galiteuthis phyllura*, funnel laid open along medio-ventral line to expose the funnel organ, ×2. [112.]

Fig. 6. *Galiteuthis phyllura*, right lateral pad of the funnel organ shown in isolation, same scale as fig. 5. [112.]

PLATE LV.

Fig. 1. *Gonatus fabricii* (?), basal portion of right third arm of specimen shown in pl. LIII, fig. 1, ×3. [88.]

Fig. 2. *Gonatus fabricii*, ventral view of young specimen from Monterey Bay, California, ×3. [98.] Drawn by R. L. Hudson.

Fig. 3. *Gonatus fabricii* (?), hook from near tip of third arm shown in fig. 1, greatly enlarged. [88.] Drawn by reflected light from mount in balsam.

Fig. 4. *Gonatus fabricii* (?), hook from near middle of same arm, ×4. [88.]

Fig. 5. *Gonatus fabricii* (?), locking cartilage from left side of funnel of specimen taken near Victoria, B. C., ×1½. [90.]

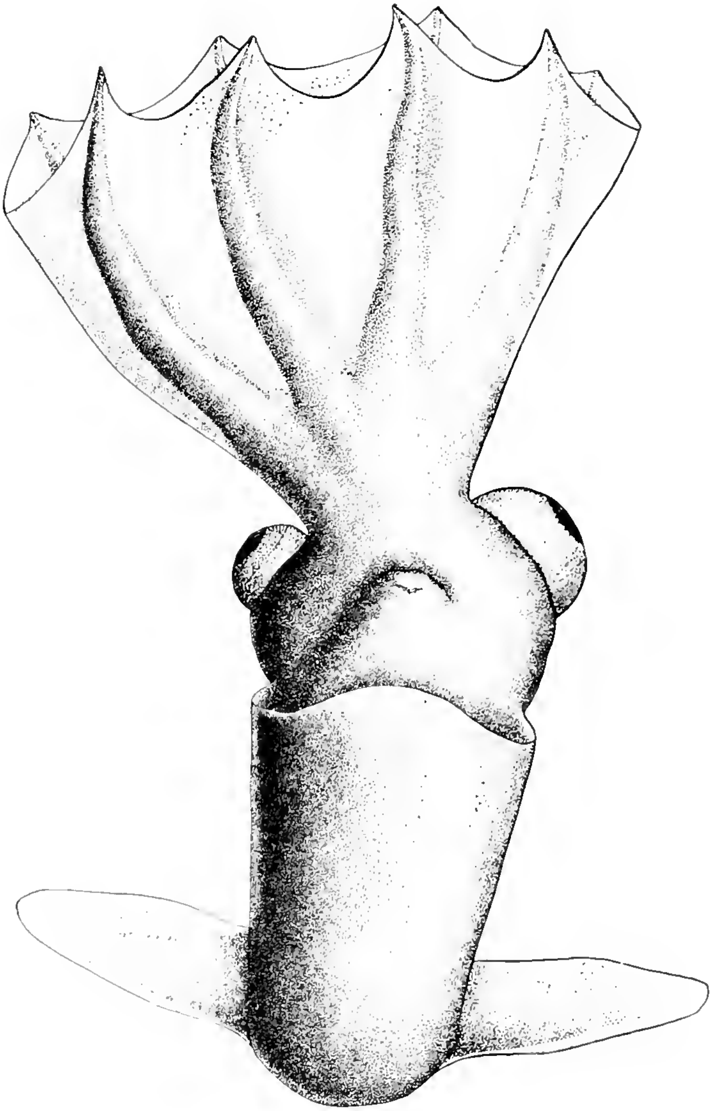
Fig. 6. *Gonatus fabricii* (?), ridge on inner surface of mantle of same specimen corresponding to cartilage shown in fig. 5, same scale. [90.]

Fig. 7. *Gonatus fabricii* (?), recurved dorsal margin of right tentacle club, showing distal portion of fixing apparatus, ×4. [88.]

PLATE LVI.

Fig. 1. *Galiteuthis phyllura*, dorsal view of entire animal (type), nearly natural size. [113.]

Fig. 2. *Galiteuthis phyllura*, ventral view of same, same scale. [113.] Drawn by R. L. Hudson.



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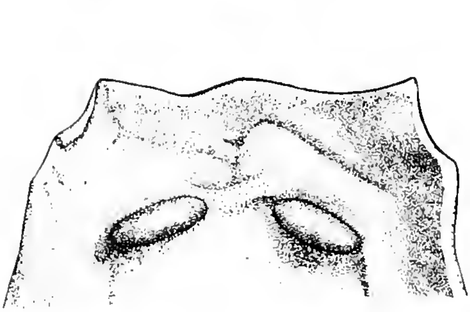

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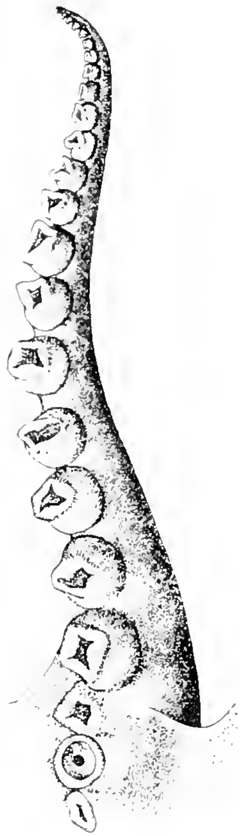

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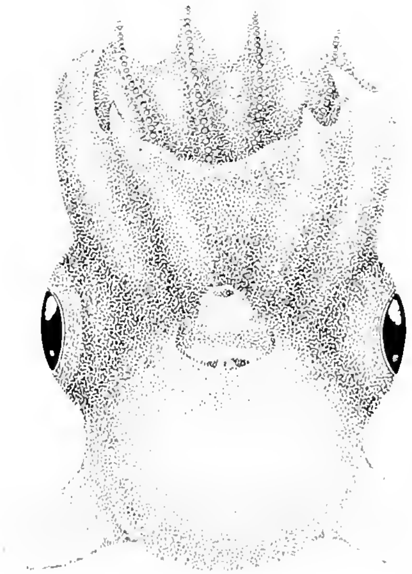

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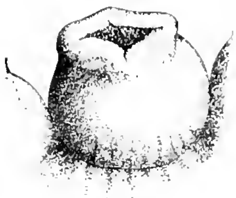

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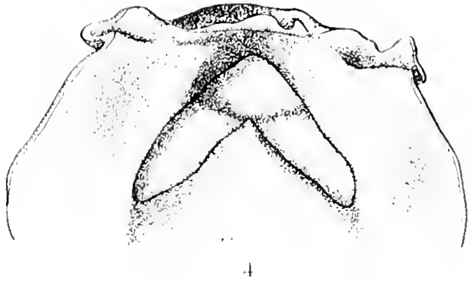

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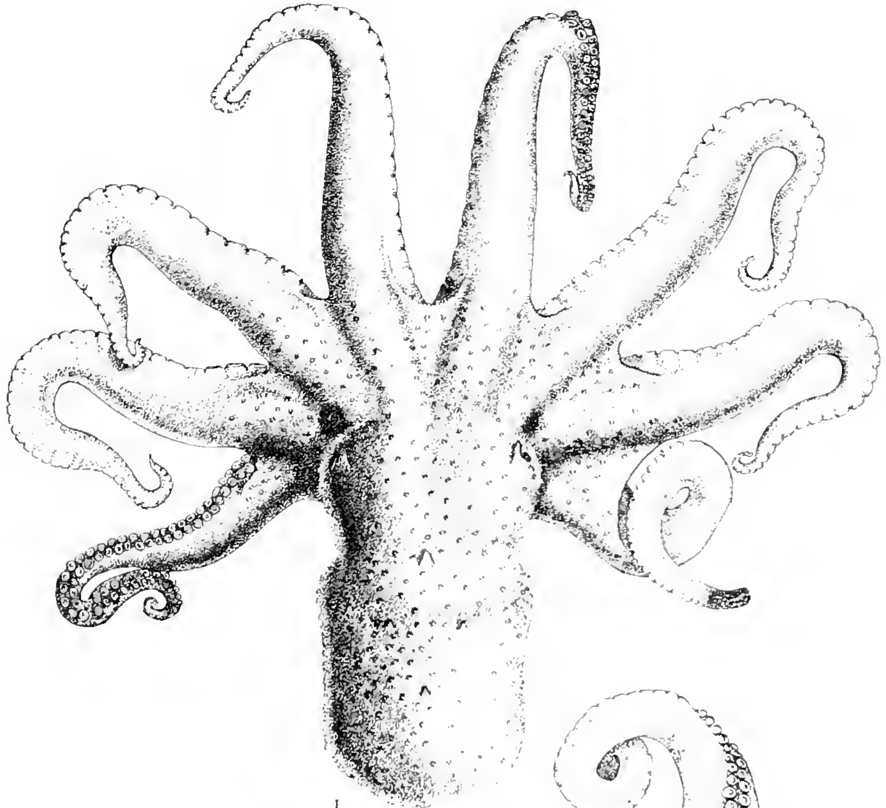

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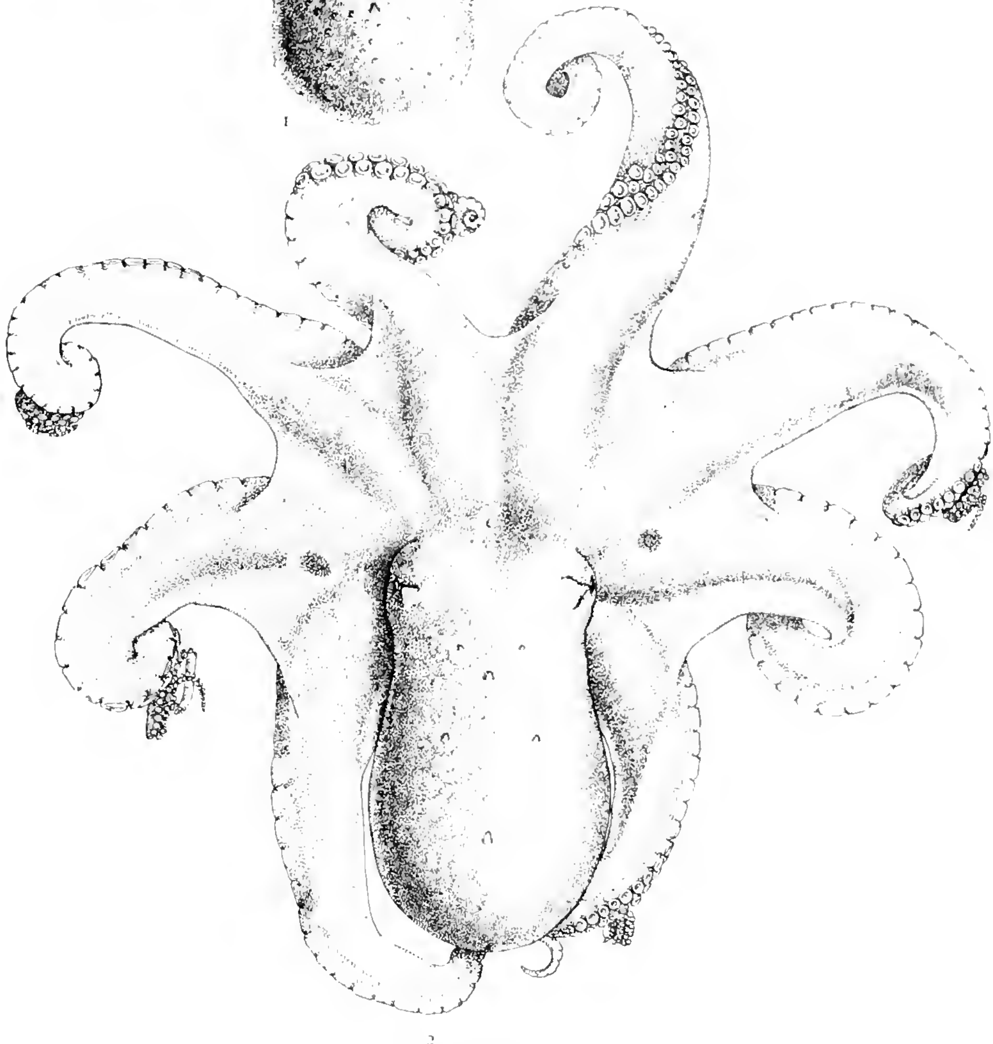

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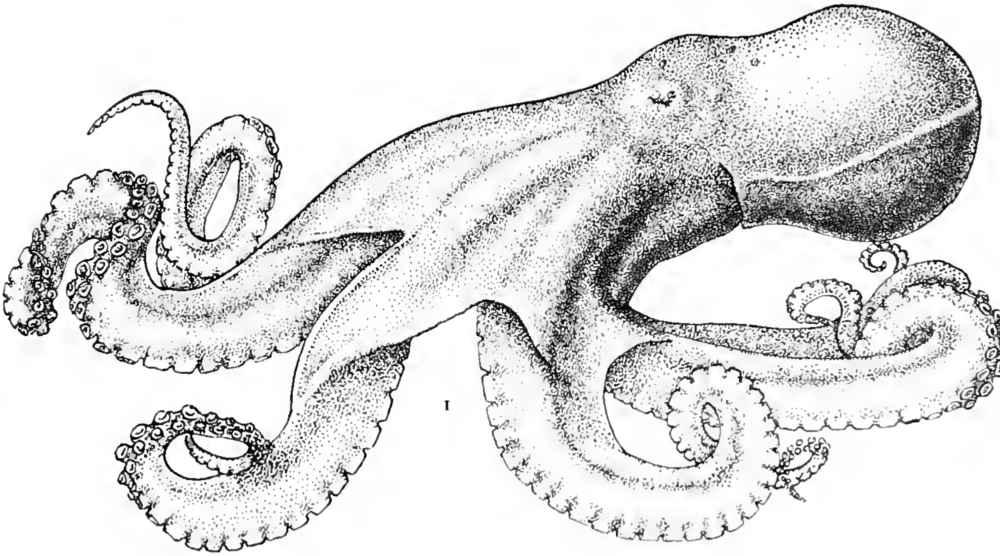

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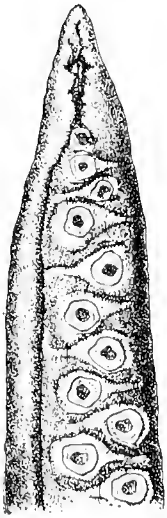

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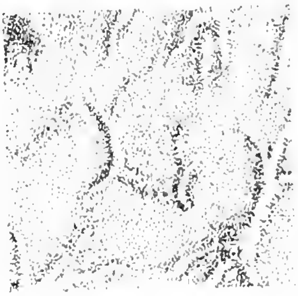

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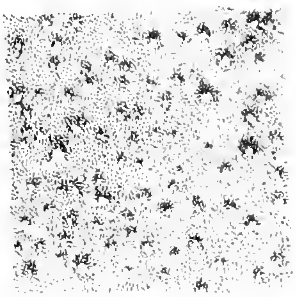

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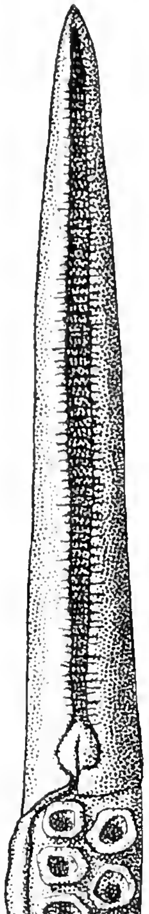

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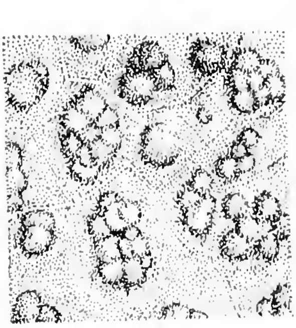

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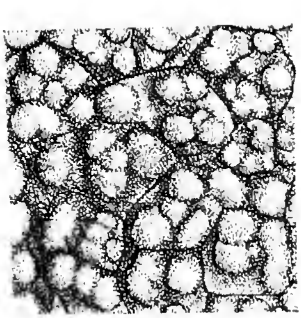

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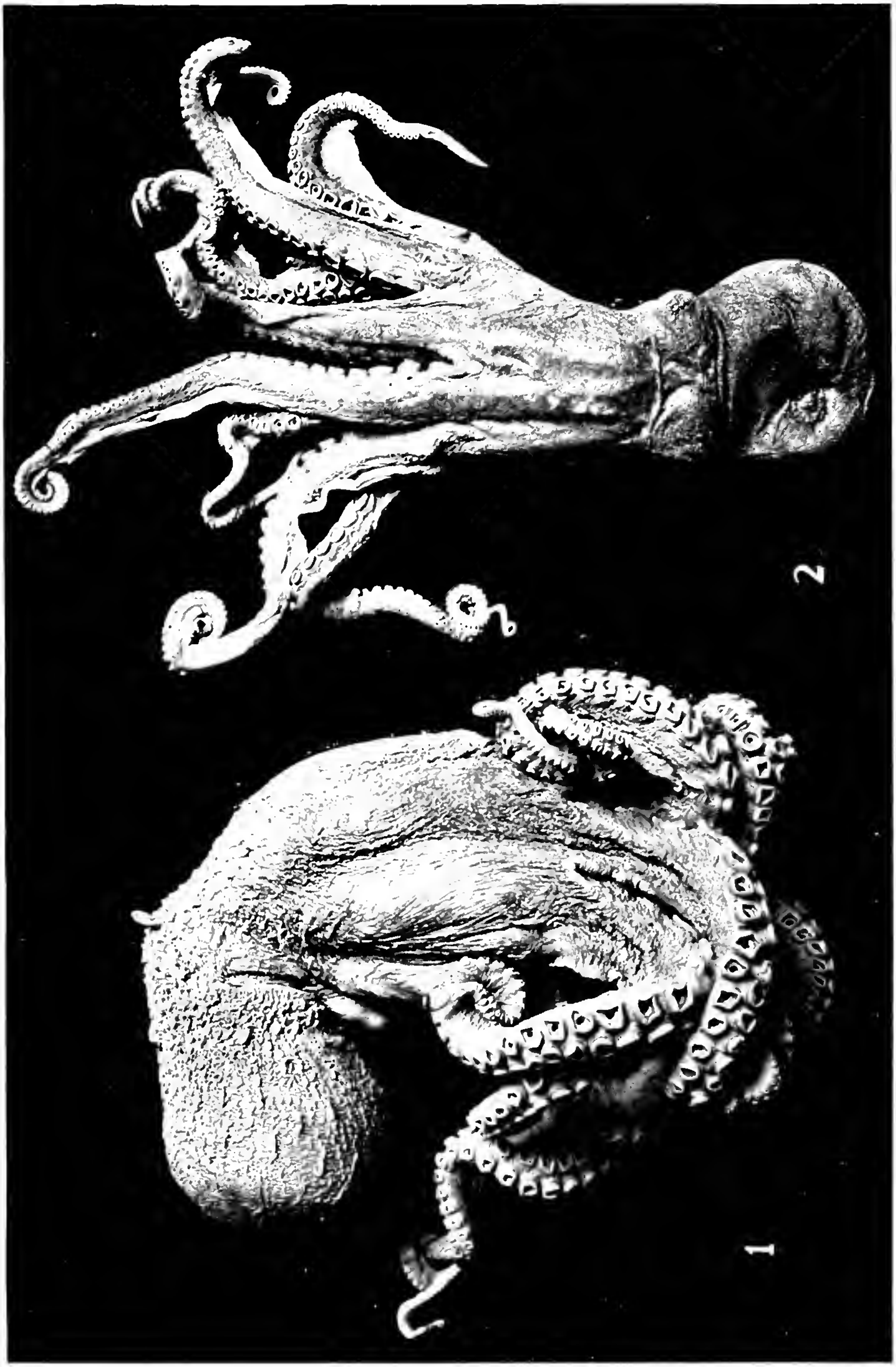

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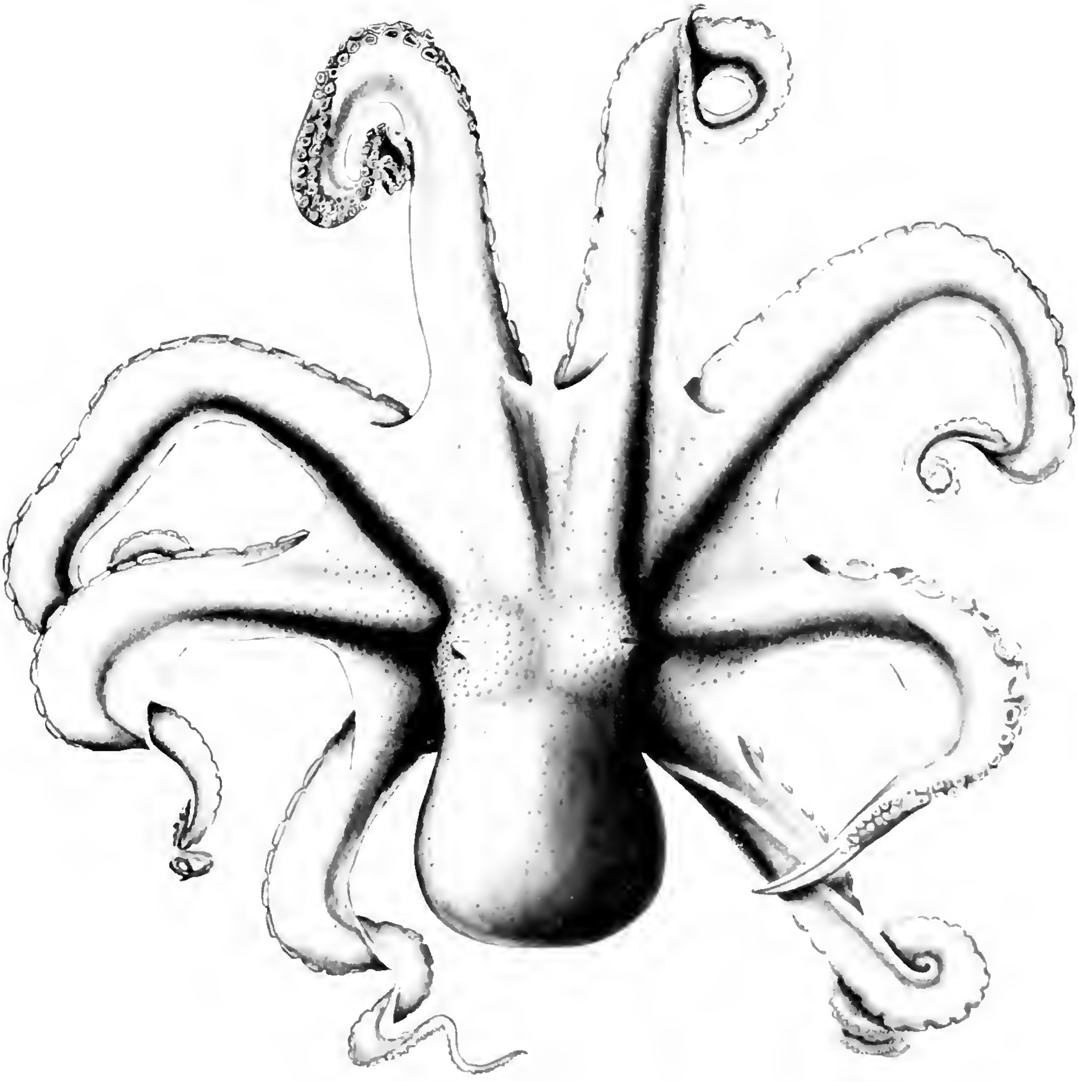

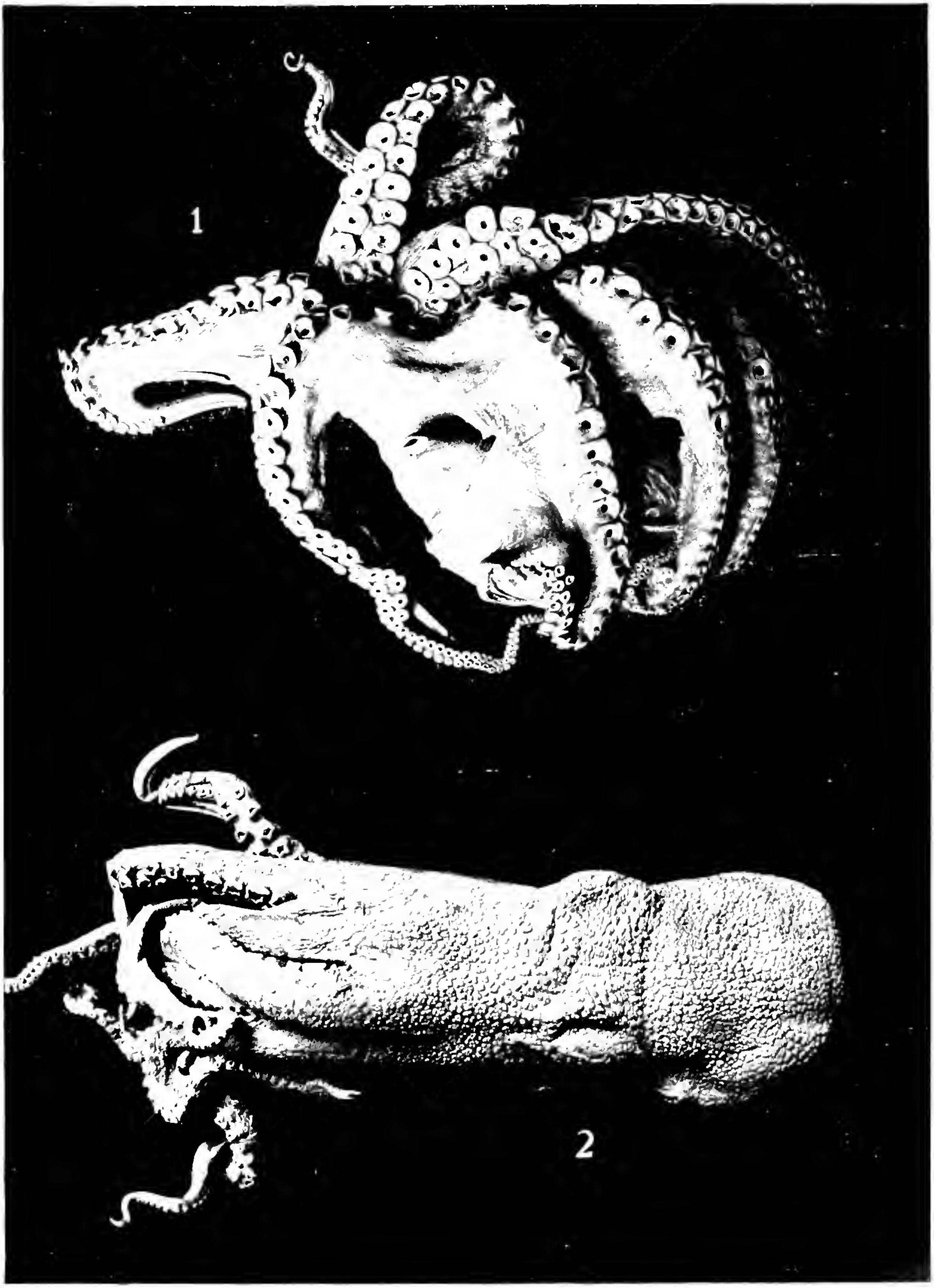
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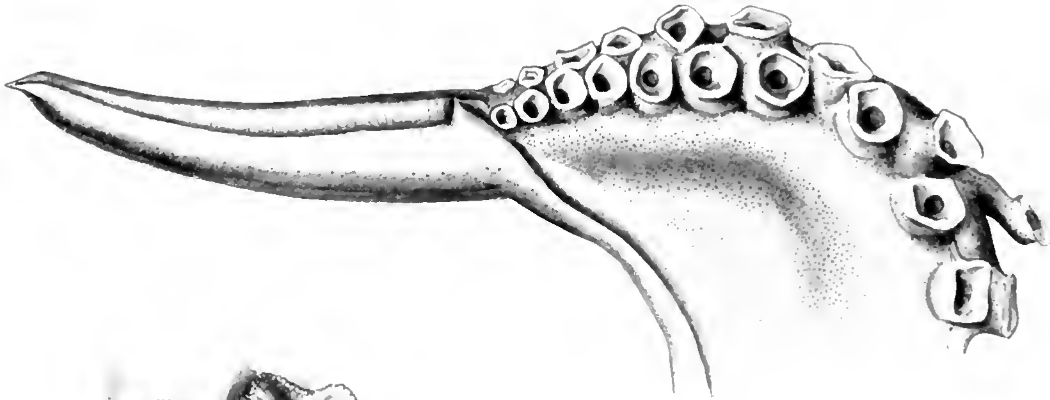

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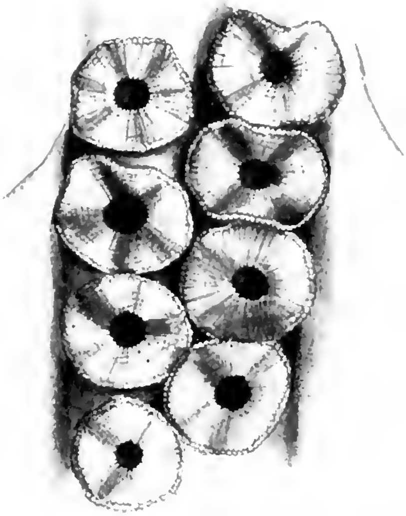

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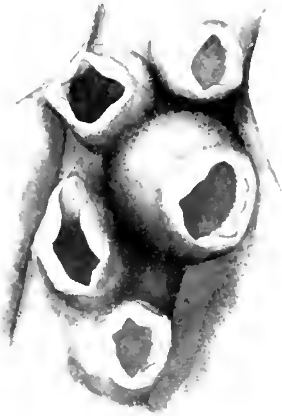

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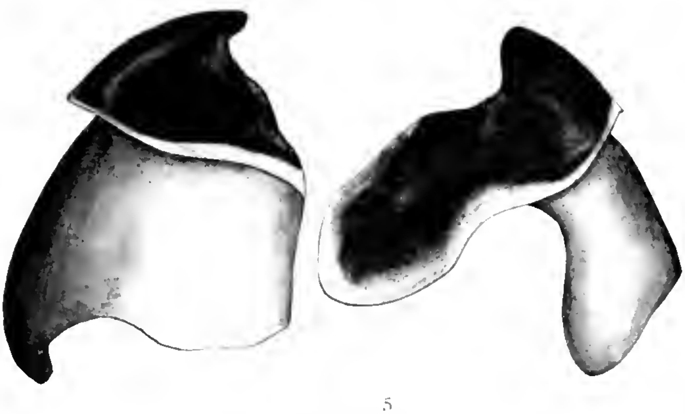

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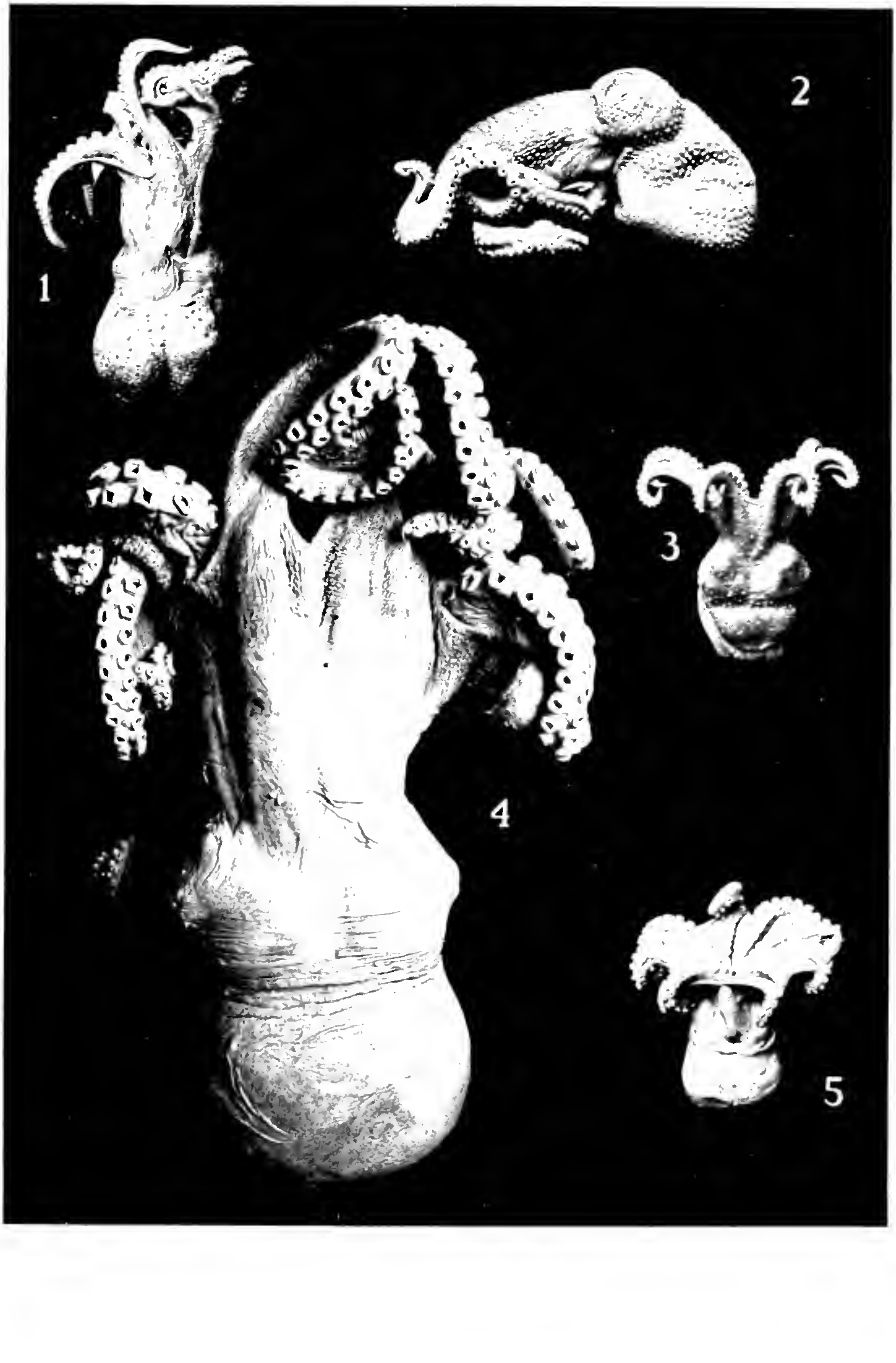
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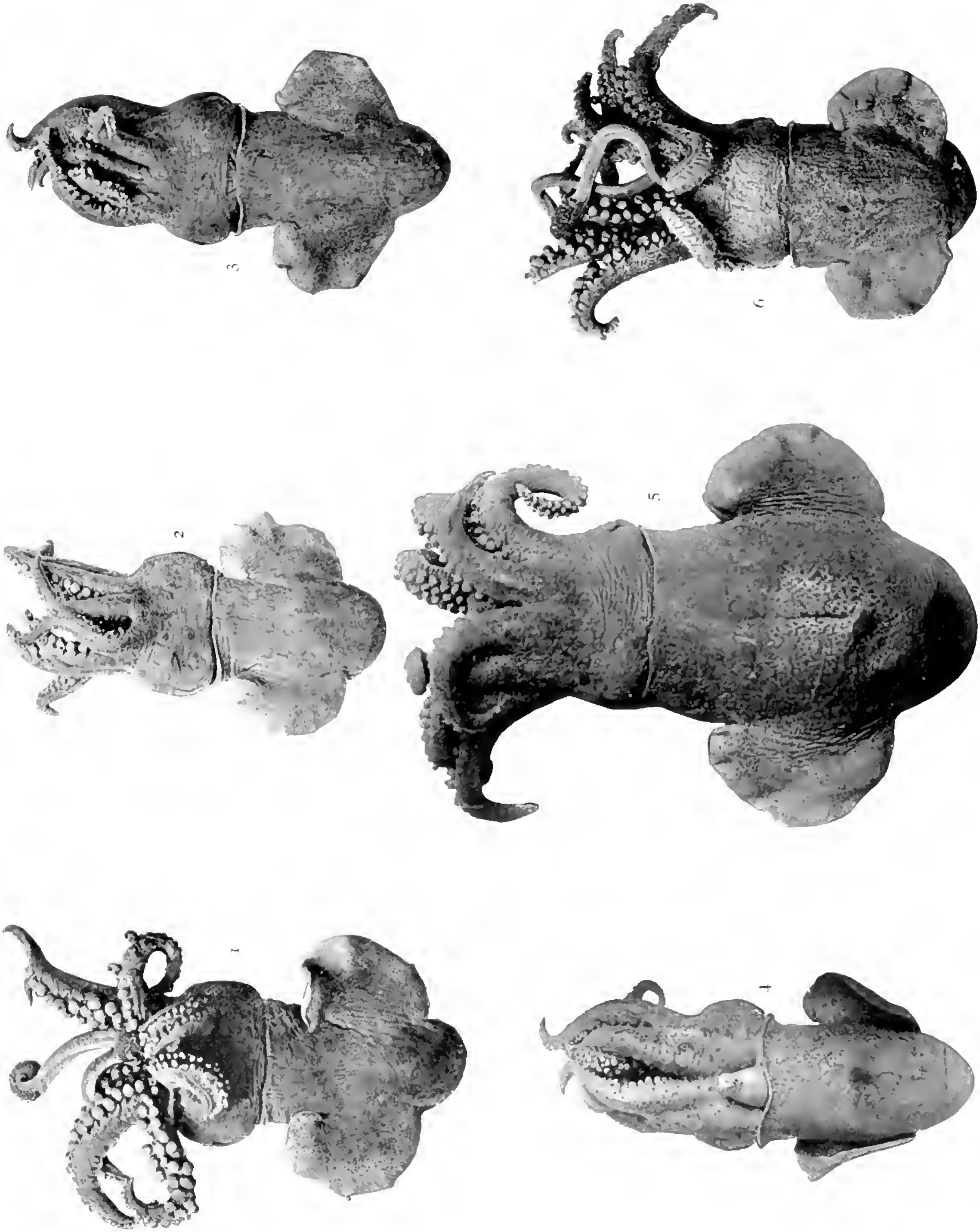

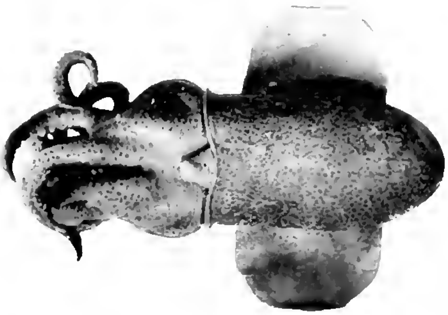

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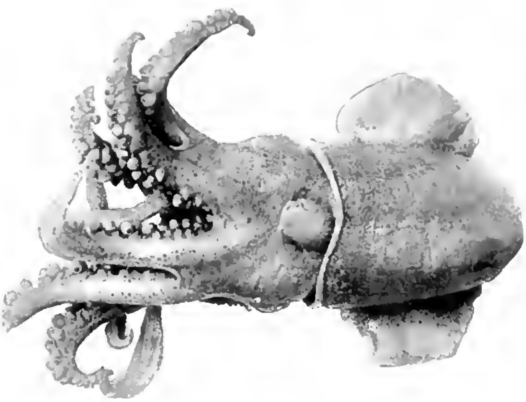

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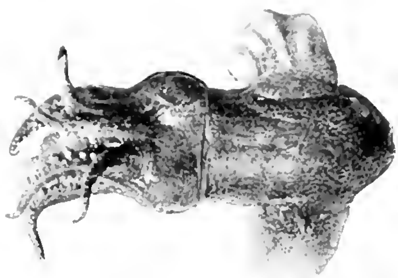

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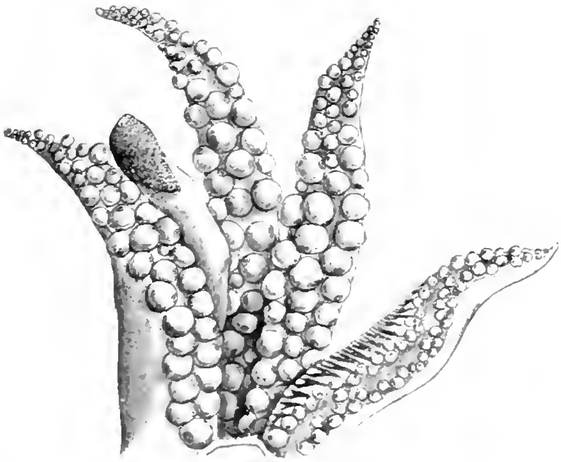

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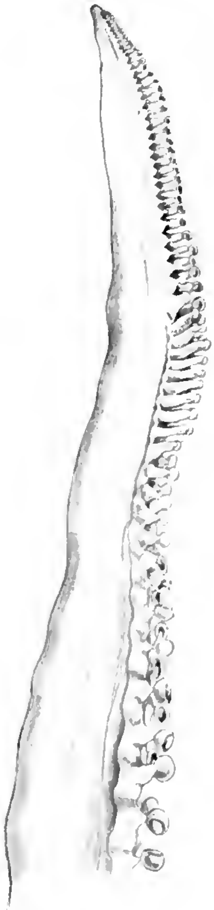

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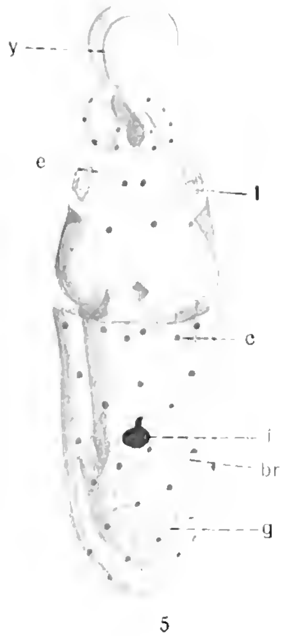

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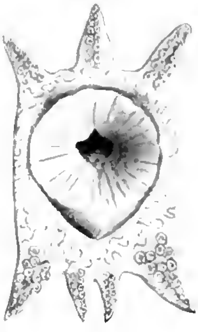

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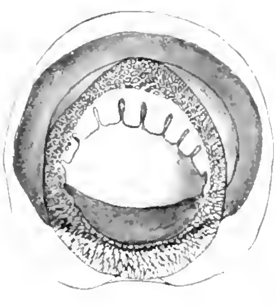

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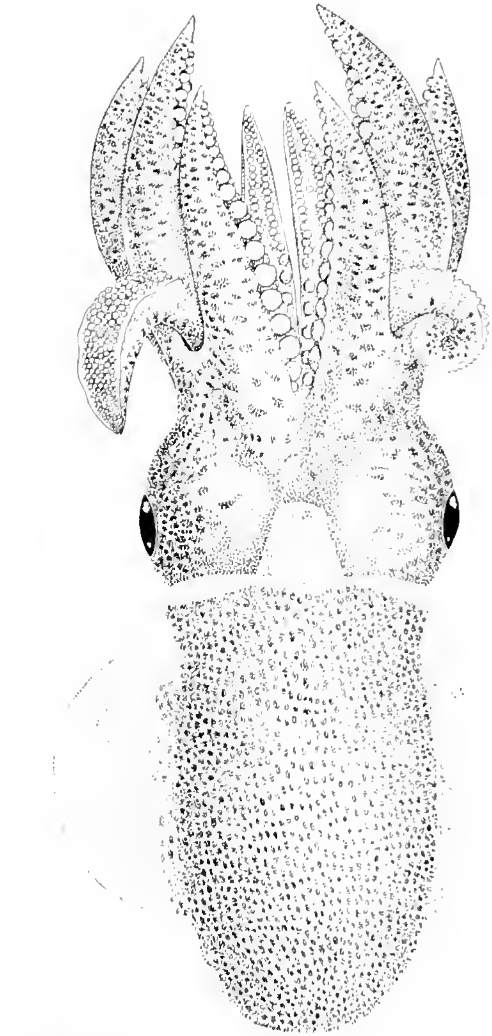

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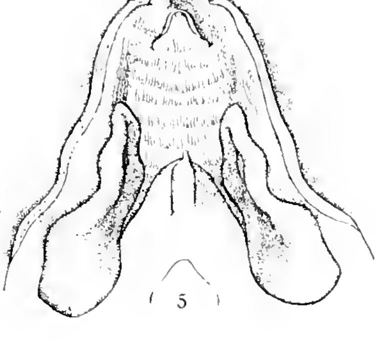

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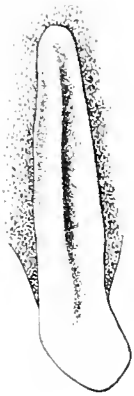

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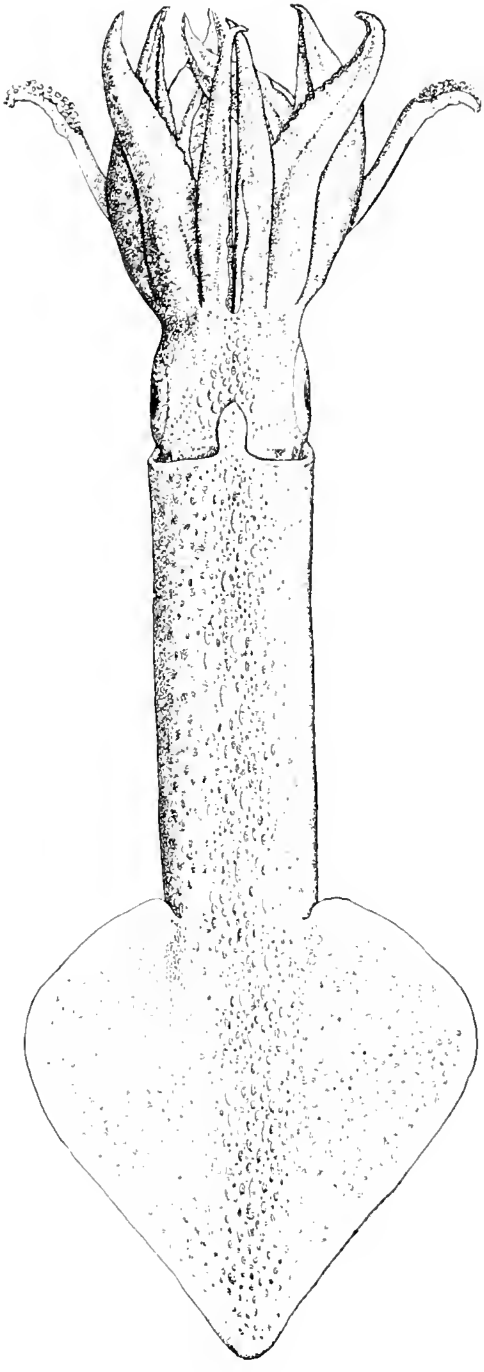

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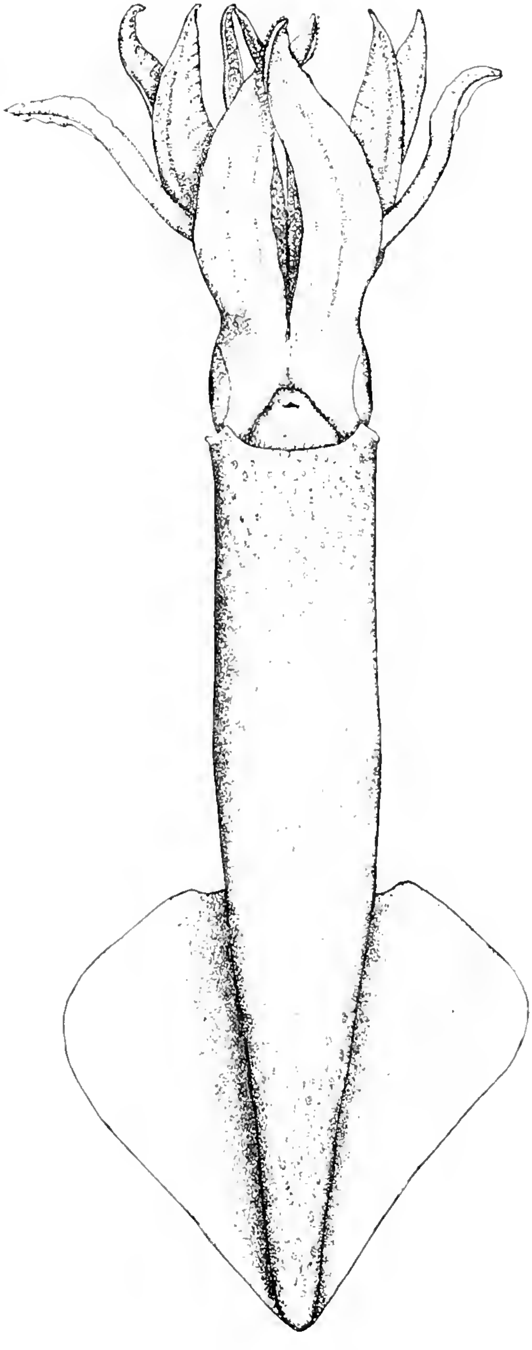

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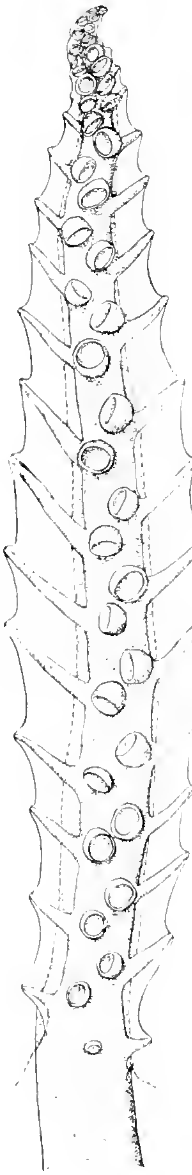

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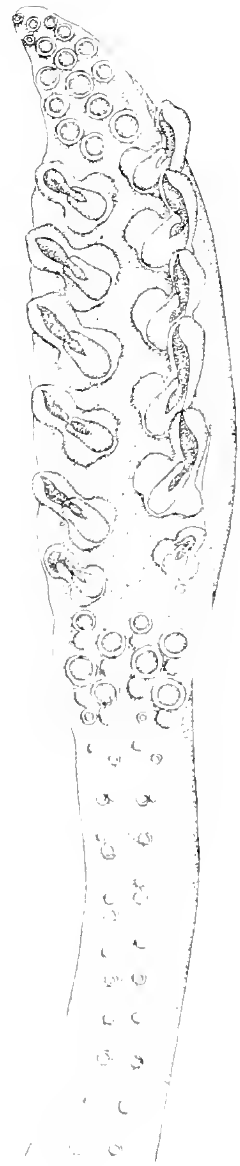

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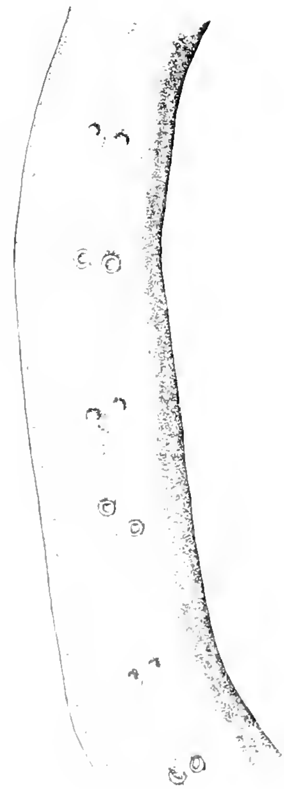

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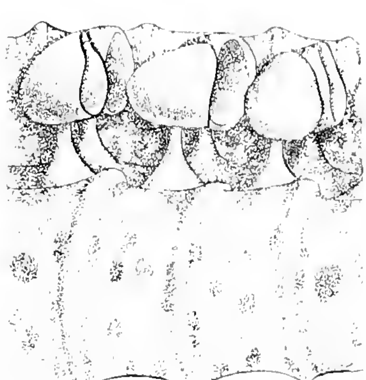

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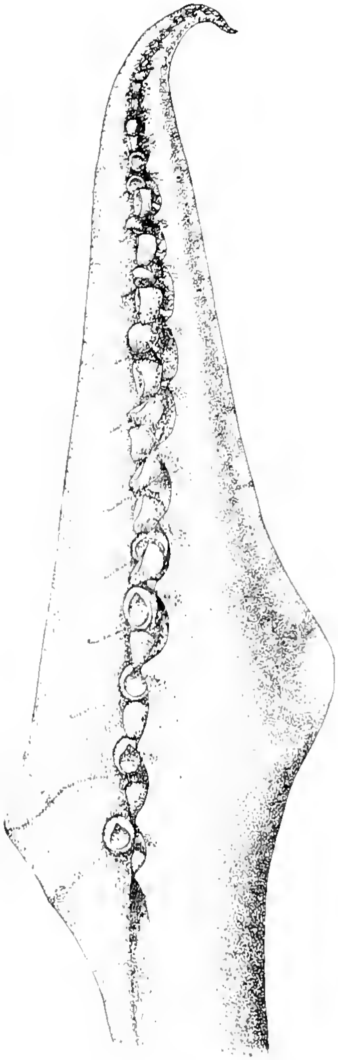

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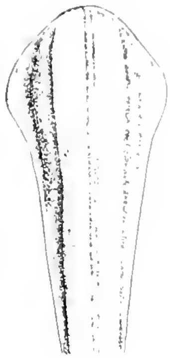

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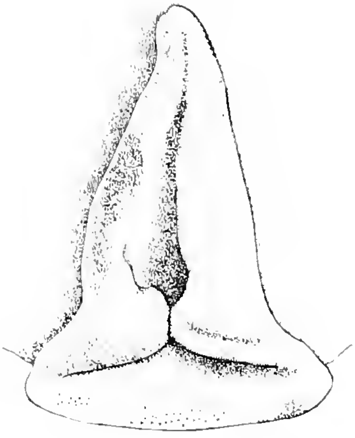

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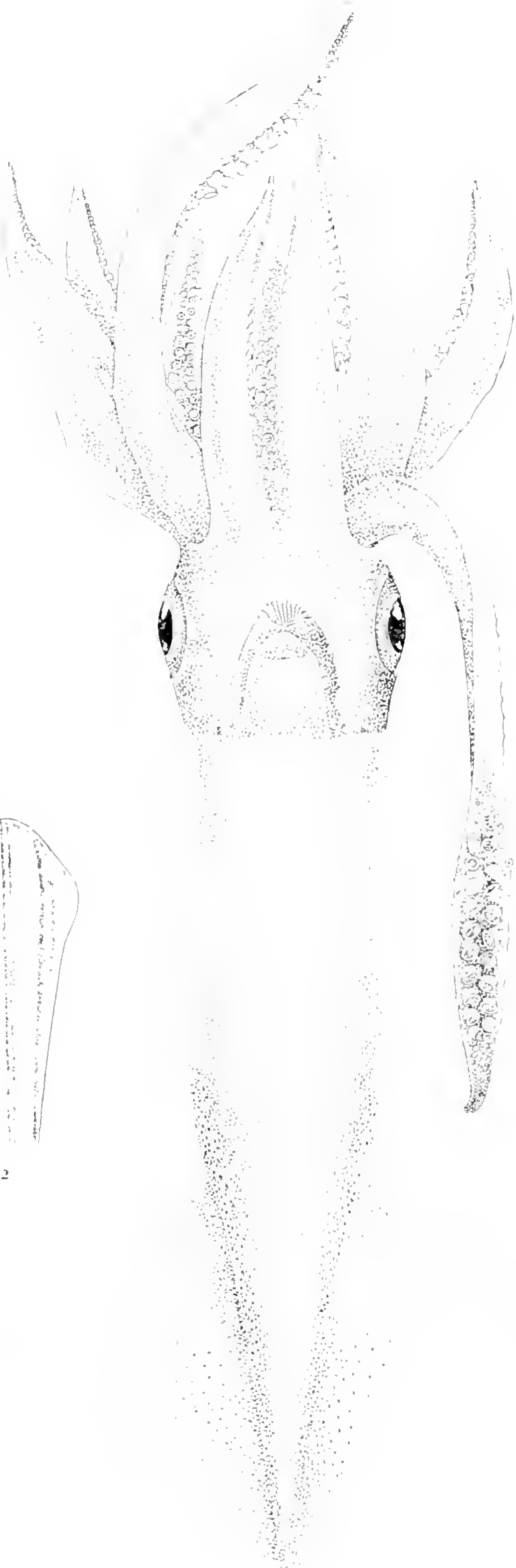

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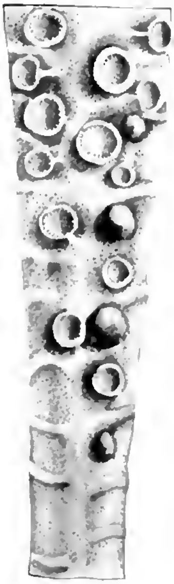

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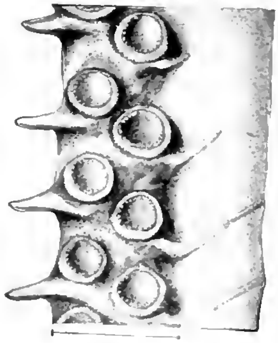

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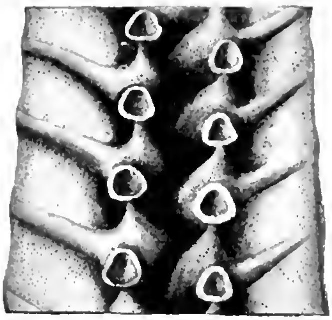

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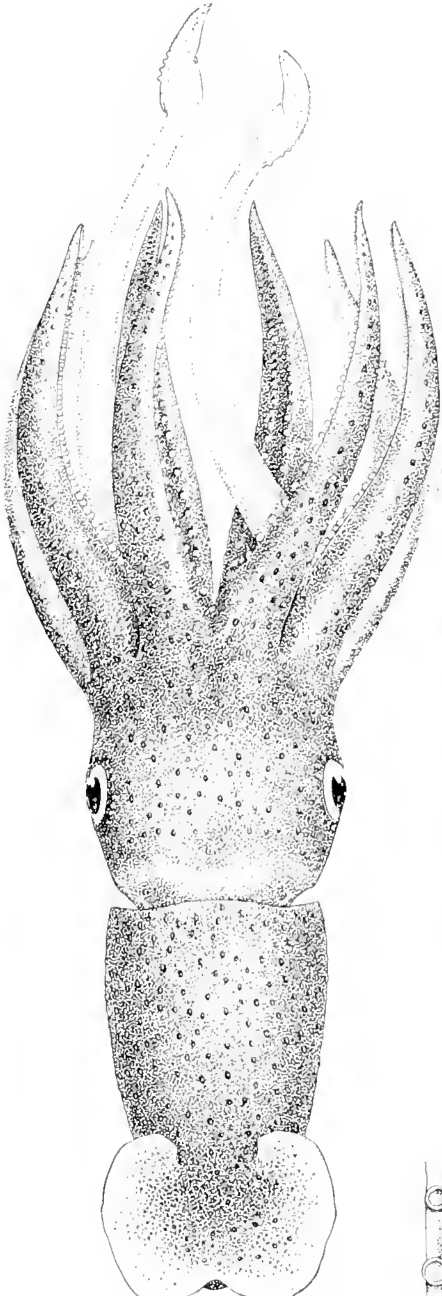

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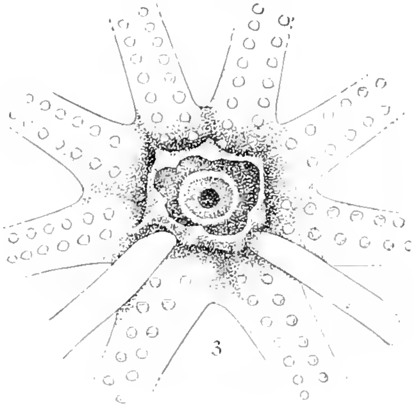

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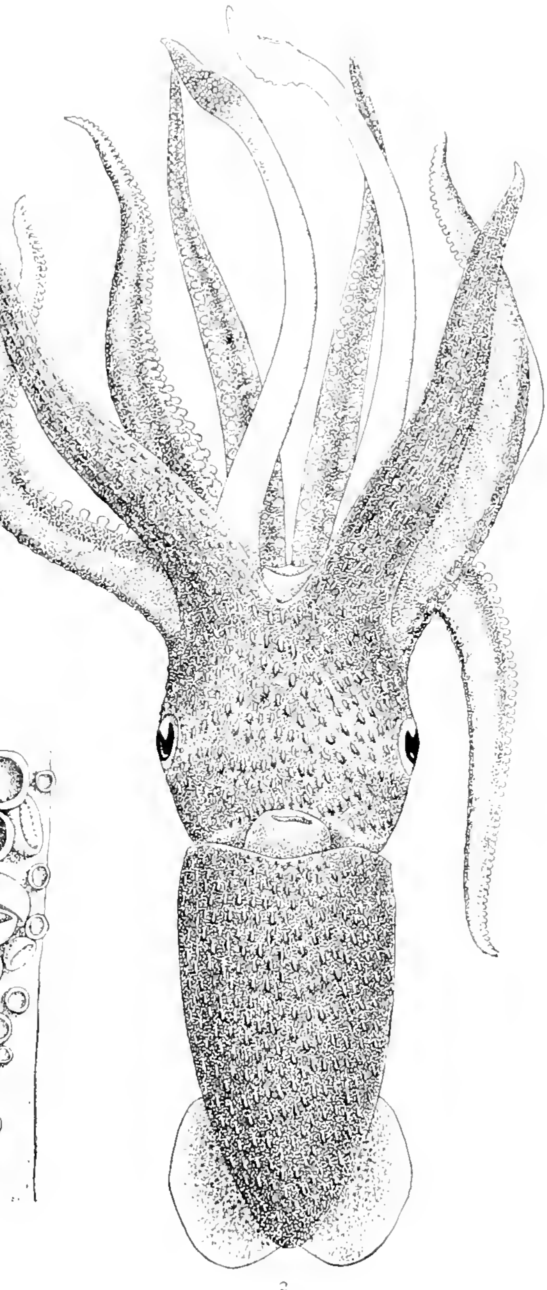

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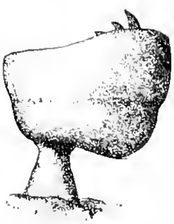

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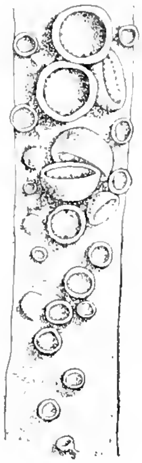

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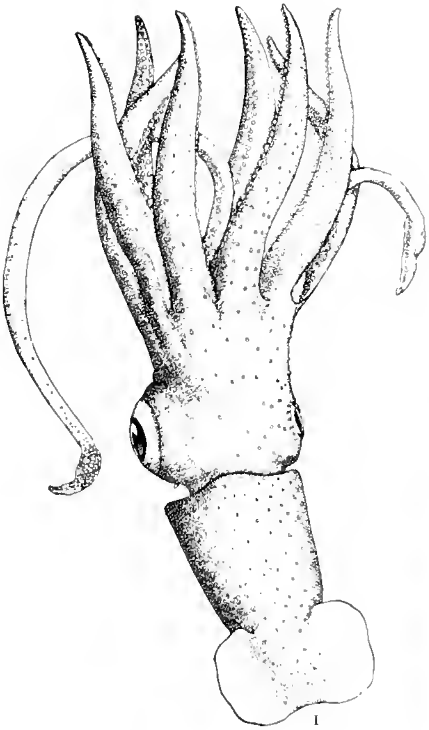

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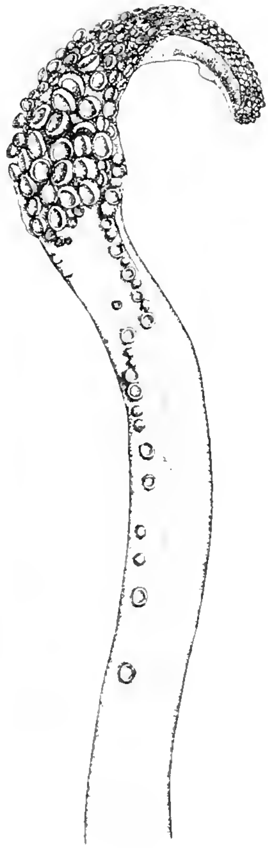

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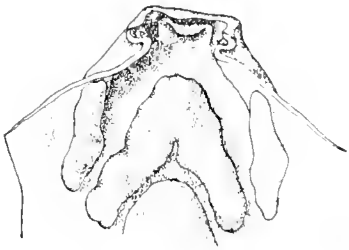

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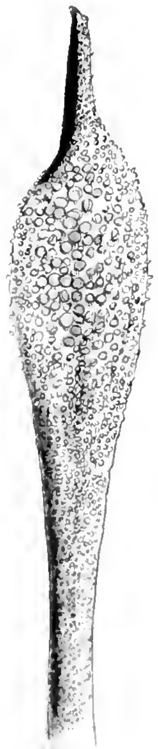

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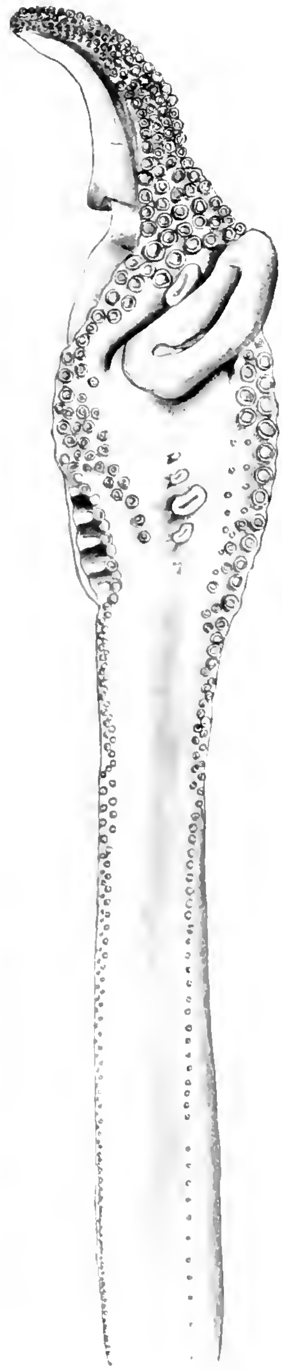

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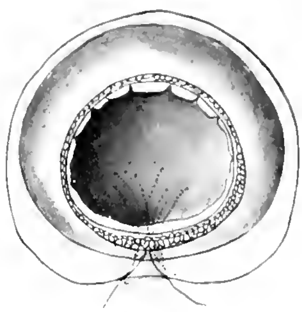

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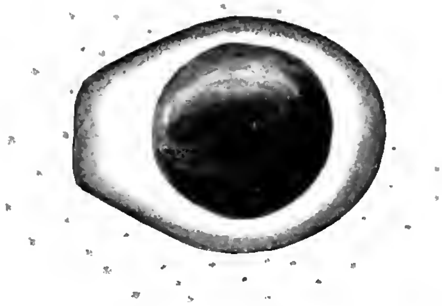

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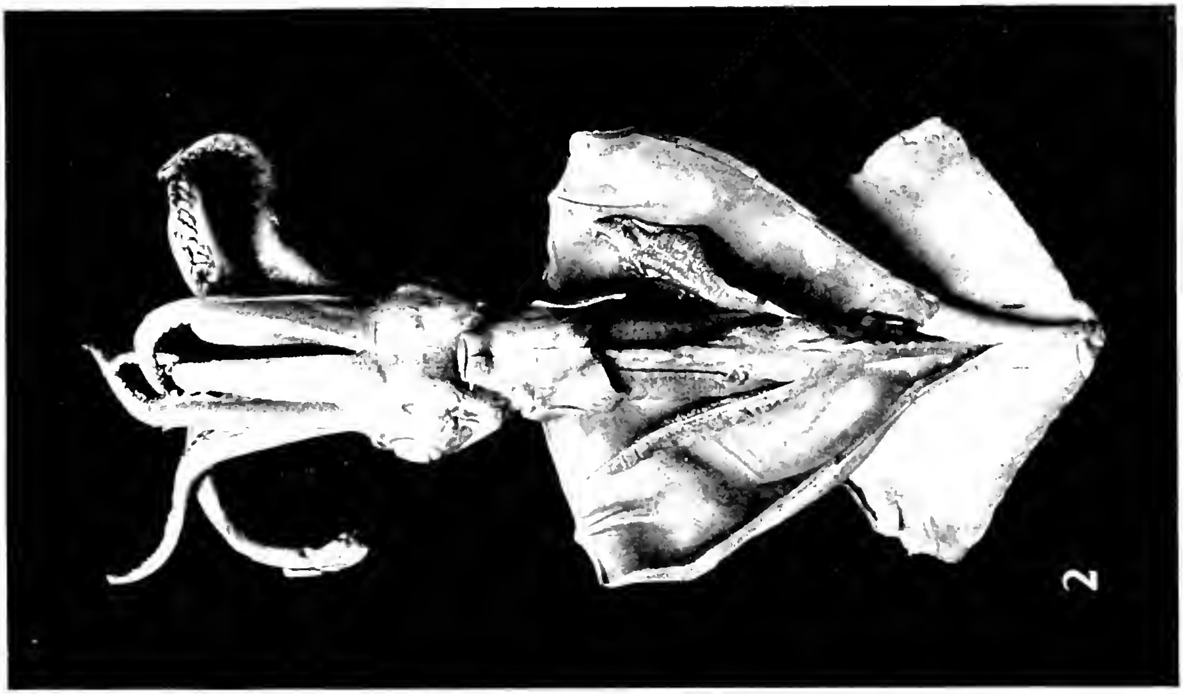

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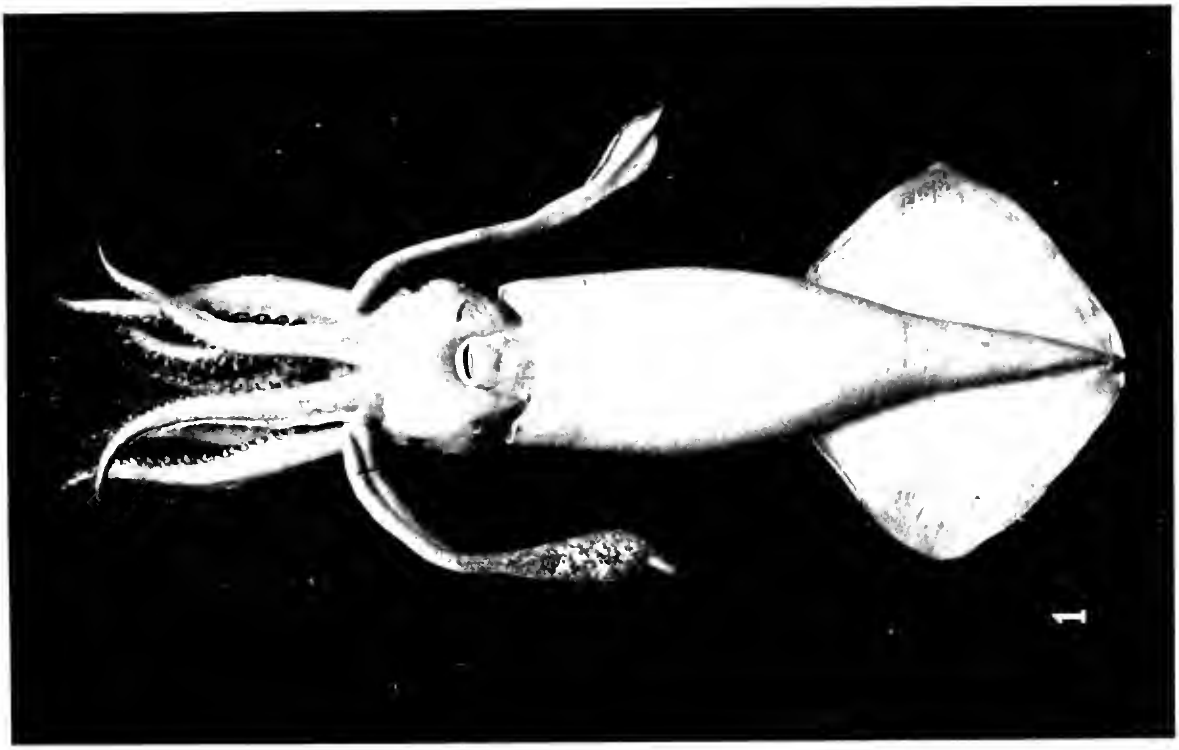

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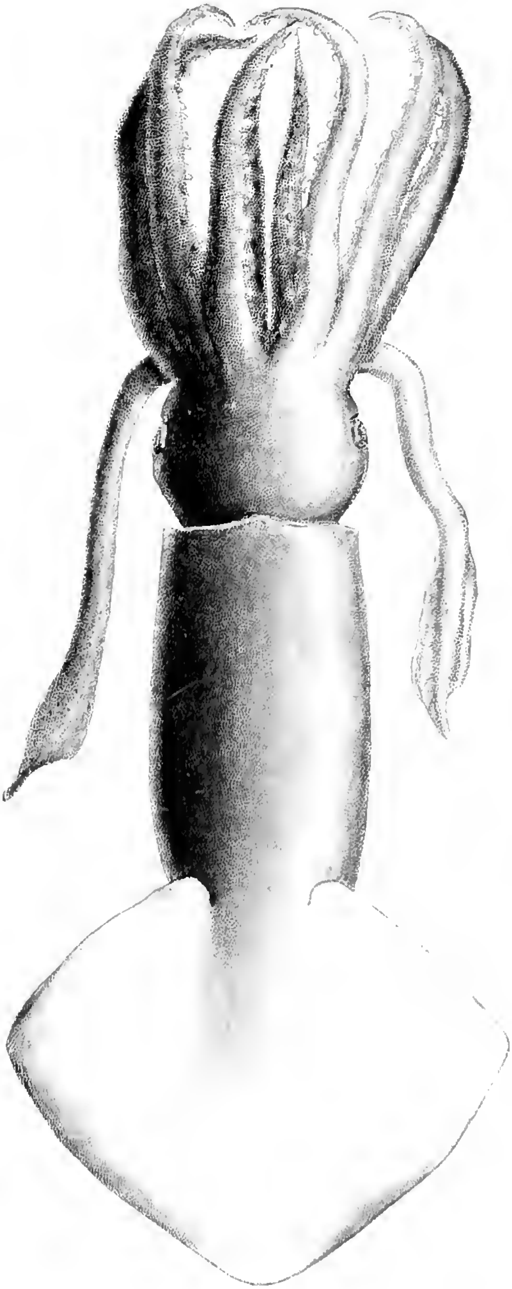

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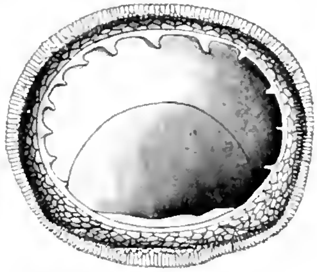

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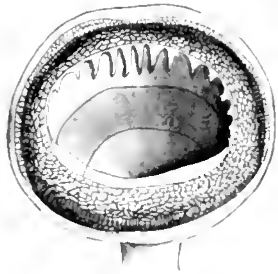

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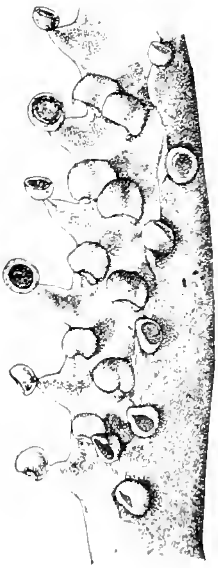

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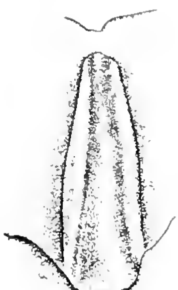

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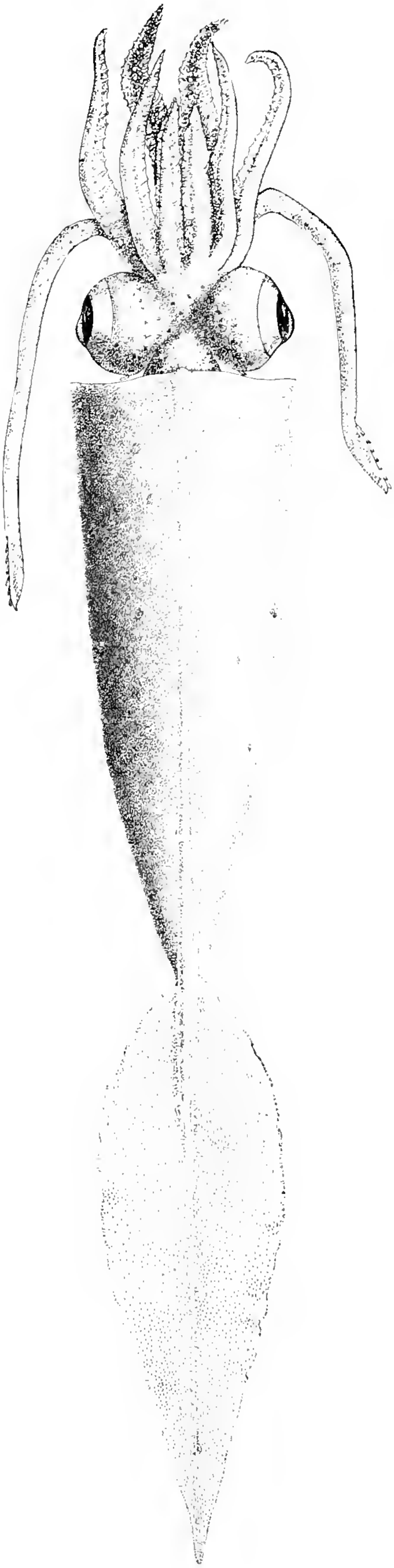

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SOME HYDROIDS OF BEAUFORT, NORTH CAROLINA

By C. McLean Fraser, Ph. D.

University of Iowa

SOME HYDROIDS OF BEAUFORT, NORTH CAROLINA.

By C. McLEAN FRASER, Ph. D.
University of Iowa.

INTRODUCTION.

During the two weeks from August 31 to September 12, 1911, at the United States Bureau of Fisheries Laboratory at Beaufort, N. C., the facilities for collecting were put at my disposal to such an extent that, although the time was so limited, I was enabled to make a very interesting collection of hydroids. Since very little systematic work has been done on the Beaufort forms, and as the material seemed promising, it was suggested by Prof. H. V. Wilson that a key be made out for the use of others who might wish to study the hydroids of that region. When the material was examined, 51 species were found and seemed to make such work worth while. It is fully recognized that with such a scant survey as the limited time made necessary, this key must be very far from complete, but such as it is it may be useful until somebody has opportunity to make a more careful survey of the whole region.

In writing this paper an endeavor has been made to have the account of each species as explicit as possible, with illustrations to indicate all special points, so that the casual student of hydroids may be able to make a diagnosis of any specimen of species herein described. For those who wish to go into the matter more deeply, a synonymy reference list has been given, not complete by any means, but including a reference to the original description and to well-known papers or those mentioned in the context.

To make the paper especially applicable to Beaufort, all the descriptions are made from the Beaufort specimens, except that in some cases others were used in comparison. All trophosome drawings, unless for comparison, were made from Beaufort specimens and all gonosome drawings also, when the gonosome was found. The drawings are all made to the same scale (a magnification of 20 diameters) except where enlarged drawings were needed for detail, in which case this enlargement is indicated in the explanation of the figure.

Of the 51 species obtained but one is new, though several are new to this part of the coast and four gonosome descriptions are new. Much of the material was in such good condition and contained so many good specimens, that many interesting points were made out. The discussion of these points has been introduced with the regular description of the species, so that the paper, besides being a key, introduces a large amount of new matter which may prove of interest.

The material was obtained from four different sources:

(1) From the piles and rocks at low water. This included the piles of the United States Bureau of Fisheries Wharf, of the Beaufort wharves, of the railroad bridge, all the way from Beaufort to Morehead City, of the boathouse of the life-saving station at Cape Lookout, and of the wharves of Marshallberg and the rocks that form the jetties at Bogue and Shackleford Banks. Some specimens obtained from the sea buoy might be mentioned here, but as this had been changed a short time before, there were not many to be found.

(2) By dredging. This was done to the greatest extent in Bogue Sound, nearly opposite Morehead City, in 10 or 12 feet of water, but dredgings were also made in the North River and at various points along the straits, from the west end nearly to the east end, and in the harbor near Shackleford, all at a depth of from 8 to 15 feet; near Cape Lookout in 15 to 20 feet, with little success, and near the sea buoy in 6 or 7 fathoms. These forms, in general, were little different from the shore forms as the water was so shallow. The bottom is nearly all sandy, but shells are plentiful to give a means of attachment for hydroids and other forms on which hydroids grow.

(3) From floating gulfweed. This provided a large number of the best specimens. A severe southwest storm, a few days previous, had torn loose a large amount of this gulfweed, and in consequence it was drifting in during the whole of my stay. The greater portion of it belonged to the genus *Sargassum* but some *Turbinaria* was also present. The most suitable place to collect it was on the seaward side of Bogue Bank, where it could easily be obtained before it reached the shore, and while it was still alive. An hour in or on the hot sand on the beach was enough to destroy many of the more delicate specimens. Much of the gulfweed drifted right into the harbor and up into Bogue Sound, so that it was available at any time. Sometimes the local seaweed was found floating, but the forms on it usually corresponded with the shore forms.

(4) From material dredged by the Fish Hawk. On May 14 and 15, 1907, the United States Fisheries steamer Fish Hawk was used for dredging at a point 20½ miles SSW. ¼ W. from the sea buoy at the entrance to Beaufort Harbor, or about 23 miles from the United States Fisheries Station at Beaufort. The dredging, which was done in 13 or 14 fathoms of water, was done largely to obtain seaweed from the coral bottom, but some other material was obtained. The seaweed was taken away for examination but some sponges and crabs were stored at the Beaufort station. The Bureau kindly allowed me to look over this material for hydroids, and several interesting specimens were found.[a]

According to general opinion, large collections of hydroids from Beaufort could not be expected, but I am doubtful whether in such a limited time, within such a limited area, so much interesting material could be collected at many other localities along the coast.

[a] I wish to express my obligation to Prof. C. C. Nutting, of the State University of Iowa, who, besides giving invaluable advice, placed his fine collection of hydroid material, his extensive literature, and even his manuscript, at my disposal. To my wife I am indebted for the drawings of the numerous illustrations in the paper. These were taken from pencil drawings made with the camera-lucida.

GEOGRAPHICAL DISTRIBUTION.

A lengthy discussion on geographical distribution would be out of place in connection with so limited a number of species, but a few general remarks may be appropriate. The locality is of very great interest because it is less than 100 miles from Cape Hatteras, which has been considered somewhat a rival of Cape Cod as a divisional point for different groups of marine forms. A study of the distribution of these few species is illuminating, though what may be true of hydroids is not necessarily true of other forms and in some cases might seem to be necessarily untrue of them.

Of the 51 species described in this paper, only one, *Hydractinia carolinæ*, is new, and only four others are new to the east coast of North America, namely, *Scandia mutabilis*, *Aglaophenia acacia*, *Plumularia setaceoides*, and *Halecium repens*, this last not being diagnosed with certainty. Two more, *Halecium bermudense* and *Halecium nanum*, have not been reported near the mainland, the former only by Congdon from the Bermudas, and the latter by the same investigator and also by Billard from the Antilles. *Thuiaria fabricii* and *Filellum expansum* have not been reported south of Greenland. Thirty-one species have been reported north of Beaufort, along the Atlantic coast of North America, and 24 south (this does not include the Bermuda forms), while 10 species have been reported both north and south. Of these 10 latter, 4 are usually considered northern forms and 6 are forms usually found in tropical or subtropical waters which have been carried northward largely with the sargassum in the Gulf Stream. Of the 19 species described by Congdon from the Bermudas, 11 were found at Beaufort. With the exception of two that are northern or have a general range, all of these are tropical or subtropical forms. Fifteen species have been reported from the west coast of North America and 18 from Europe, while 12 are common to the west coast of North America and to Europe. Seventeen species have been reported from the west coast of Africa, only 7 of which are warm-water forms. Ten species have been reported from Australia, 5 of which are cosmopolitan and the other 5 warm-water forms. Six species are reported by Hartlaub from the Strait of Magellan and the Chile coast, but they are all cosmopolitan forms.

From these few comparisons some generalizations may be made. In the first place, when 31 species out of a total of 51 have been reported from the east coast of North America farther north, there is no evidence, as far as hydroids are concerned, that Cape Hatteras with its storms is any decisive barrier. When there is such a large percentage of shore and shallow water forms common to the north and the south, one should readily suppose that if the forms of the deeper water were studied, the similarity would be still more marked. As it is, there is no more difference than would be found in the same distance on almost any coast, due to the dropping out of certain forms and the appearance of others in natural succession. It is true that only 10 of these 31 forms have been reported still farther southward, but that is not surprising when it is taken into consideration that, with the exception of the species described by McCrady more than half a century ago, there has been practically no work done on shore and shallow water forms in the region to the south of Beaufort. Of the species reported farther south the great majority are floating forms.

In the second place, what little evidence there is goes to sustain the conclusion that many of the hydroids have been distributed from a circumpolar area, southward along meridional lines. When out of 51 species collected as far southward as Beaufort there are included as many as 12 species that have been found on the west coast of Europe and also on the west coast of North America, it seems scarcely possible to come to any other conclusion. It might be said that the 17 species reported from Africa would indicate a transference to North America by the Equatorial Current, and that certainly must have a great influence, but when it is noted that 10 out of the 17 are European forms as well, it may readily be, and probably is, the case that these 10 were carried southward in both cases and have direct connection only through the Arctic Regions, while the other 7, being tropical forms, were carried across the ocean by the Equatorial Current, and carried northward with the Gulf Stream. It would seem that the Equatorial Current and its related currents must account for a connection with far-off Australia, as 5 out of the 10 forms are tropical or subtropical floating forms that have been reported along the paths of these currents. On the other hand, the 6 species reported by Hartlaub from the South American coast include none of these forms. None would likely be carried either way across the Equator against the currents, and none could go otherwise unless the Equatorial Current should distribute them both to the north and to the south.

In the third place, there is a further indication as to the way in which the Bermudas are populated. The Gulf Stream flows northward between Beaufort and the Bermudas. Of the 11 species common to the two places, only 2 are of general distribution. The other 9 are all forms that would likely be carried on the sargassum with the Gulf Stream. As only 19 species were reported by Congdon, evidently nearly 50 per cent have been carried there from the south by the Gulf Stream. A more detailed survey of each field would naturally indicate a much higher percentage. On the other hand, there is little evidence to show that any of them have been carried directly across, in either direction.

Finally, it adds to the evidence, if further evidence was needed, that there is no limit to the distribution of hydroid forms. When, by hydroid distribution, Beaufort, in low latitude, is connected with such distant places as Australia, Chile, Bering Sea, and the White Sea, all in high latitudes, not by one but by several species, nothing further need be said.

The accompanying table puts these comparisons in a more concrete form, especially for the individual species. It is not intended to be exhaustive by any means. It is merely a specific way of stating the comparisons made above.

TABLE OF GEOGRAPHICAL DISTRIBUTION OF HYDROIDS FOUND AT BEAUFORT.

Species.	Beaufort.	East coast of North America north of Beaufort.	East coast of North America south of Beaufort.	Bermudas.	West coast of North America.	European.	West Africa.	Strait of Magellan and Chile.	Australian.
Turritopsis nutricula	×		×						
Gemmaria costata	×		×						
Syncoryne mirabilis	×	×			×			×	
Bougainvillia rugosa	×	×							
Eudendrium album	×	×				×			
Eudendrium capillare	×	×			×	×			
Eudendrium carneum	×	×							
Eudendrium ramosum	×	×	×	×	×	×	×		
Hydractinia carolinæ	×								
Hydractinia echinata	×	×				×			
Pennaria tiarella	×	×		×					
Campanularia integra	×	×				×			×
Campanularia raridentata	×	×				×	×		
Clytia coronata	×		×						
Clytia cylindrica	×	×							
Clytia johnstoni	×	×			×	×	×		
Clytia longicyatha	×		×				×		
Clytia noliformis	×	×	×	×					
Gonothyræa gracilis	×	×					×	×	
Obelia bicuspidata	×	×						×	×
Obelia dichotoma	×	×			×	×	×		
Obelia geniculata	×	×			×	×		×	×
Obelia hyalina	×	×		×					
Cuspidella humilis	×	×			×		×		
Lovenella clausa	×	×							
Halecium beani	×	×					×	×	×
Halecium bermudense	×			×					
Halecium nanum	×		×	×					
Halecium repens	×					×			
Halecium tenellum	×	×	×		×	×		×	×
Filellum expansum	×	×			×	×			
Filellum serpens	×	×			×	×		×	
Hebella calcarata	×	×		×			×		×
Scandia mutabilis	×								
Pasythea quadridentata	×	×	×						×
Sertularella conica	×				×				
Sertularia cornicina	×	×	×		×				×
Sertularia stookeyi	×		×						
Sertularia versluysi	×	×	×	×			×		
Thuiaria fabricii	×	×			×				
Aglaophenia acacia	×						×		
Aglaophenia minuta	×		×	×					
Aglaophenia rigida	×		×						
Lytocarpus philippinus	×		×	×					
Monostæchas quadridens	×	×	×				×		
Monotheca margaretta	×								
Plumularia alternata	×		×	×					
Plumularia floridana	×		×						
Plumularia inermis	×		×						
Plumularia setaceoides	×								×
Schizotricha tenella	×	×	×						

SYSTEMATIC DISCUSSION.

The method of classification and the nomenclature followed in this paper correspond to that used by me in the paper entitled "Hydroids of the west coast of North America," with the papers by Nutting, Allman, and Hincks as a basis. One family name appears that has not been used previously in any published paper, but it is used by Prof. Nutting in his manuscript, not yet complete, to be published as another volume of his monograph on American Hydroids. This family is the Hebellidæ. The reasons for adopting the name are given in the text where the family appears in the regular course of the paper. In the synonymy, reference to the original description is always given, together with references to some of the well-known papers in which a description of the species appears. In no case is the author's name given with the family or genus, but the characteristics of each, as significant of what it means in this paper, is always given.

KEY TO THE HYDROID FAMILIES FOUND IN THE BEAUFORT REGION.

A. GYMNOBLASTEA.
- *a*. Hydranths with scattered filiform tentacles.............................Turridæ.
- *b*. Hydranths with one whorl (or two whorls closely approximated) of filiform tentacles around the base of the proboscis.
  - I. Proboscis conical or clavate.
    - 1. Colony regularly branched....................................Bougainvillidæ.
    - 2. Colony not branched, with basal encrusting cœnosarc...........Hydractinidæ.
  - II. Proboscis trumpet-shaped or hemispherical..........................Eudendridæ.
- *c*. Hydranths with scattered capitate tentacles but no filiform tentacles.......Syncorynidæ.
- *d*. Hydranths with a single row of filiform tentacles around the base and capitate tentacles scattered over the proboscis.......................Pennaridæ.

B. CALYPTOBLASTEA:
- *a*. Hydranths with trumpet-shaped proboscis and campanulate hydrothecæ....Campanularidæ.
- *b*. Hydranths with conical proboscis and tubular or turbinate hydrothecæ.
  - I. Hydrothecæ with operculum of converging segments..................Campanulinidæ.
  - II. Hydrothecæ without operculum.
    - 1. Stem fascicled, gonosome a Coppinia mass......................Lafœidæ.
    - 2. Stem simple, gonangia not collected into a mass..................Hebellidæ.
- *c*. Hydrothecæ reduced to saucer-shaped hydrophores.........................Halecidæ.
- *d*. Hydrothecæ sessile, adnate to main stem or branches.
  - I. Hydrothecæ arranged on both sides of branches.......................Sertularidæ.
  - II. Hydrothecæ on one side only of the branches.......................Plumularidæ.

Suborder GYMNOBLASTEA.

Hydroids with hydranths unprotected by hydrothecæ and gonophores unprotected by gonangia.

Family TURRIDÆ.

Trophosome.—Hydranths with scattered filiform tentacles. Colony simple or branched.

Gonosome.—Gonophores give rise to free medusæ with simple radiating canals and simple marginal tentacles.

Genus TURRITOPSIS.

Trophosome.—Small colonies with few branches from a much branched stolon. Perisarc reaching to the base of the hydranth.

Gonosome.—Gonophores give rise to medusæ with four radial canals and several simple marginal tentacles.

Turritopsis nutricula McCrady.

Oceania nutricula McCrady, Proc. Elliott Soc., 1856, p. 1–59.
Turritopsis nutricula McCrady, Gymnoph. Charleston Har., 1857, p. 25. Brooks, Mem. Boston Soc. Nat. Hist., 1886, p. 388. Mayer, Hydromedusæ, vol. 1, 1910, p. 143.

Trophosome.—Mature colony slightly branched, each branch bearing a single hydranth. Perisarc thick, ending abruptly immediately below the hydranth. Proboscis clavate, elongated. Tentacles arranged in a series of somewhat regular rows.

Gonosome.—Gonophores, each giving rise to a single medusa, appear on short pedicels at the base of the hydranth. Each medusa bud is invested with perisarc. At the time of liberation the medusa has eight tentacles, but the number is greatly increased later. The mature medusa has a quadrate stomach and a four-lipped mouth.

Color.—Pale yellowish red.

Distribution.—At low water on piles of the Norfolk Southern railway bridge at different points between Morehead City and Beaufort; in Bogue Sound 10 feet; on piles for the boathouse for the life saving station at Cape Lookout.

Dr. W. K. Brooks made an exhaustive study of this species while pursuing investigations in this locality. He found the medusæ in large numbers but was not so successful with the hydroids, as he found them at one point only, viz, the steamboat wharf at Morehead City. The specimens obtained in this collection were by no means numerous, although they were obtained from several different points. At all these points, however, the conditions were much similar to those at Morehead City wharf. Many of the specimens were unbranched and hence were probably young colonies, at which time they resemble the figures given by Hincks of *Turris neglecta* Lesson. Very few of them had developing medusæ present. Those specimens found at Cape Lookout had a peculiar appearance. Either they were growing through a sponge so that little more than the hydranths were showing outside, or, as is more likely, the sponge was growing up around the hydroid colony as far as the perisarc reached, because the hydroid colony had begun to grow on the living sponge. The sponge was semitransparent so that the colony could readily be traced as it appeared within.

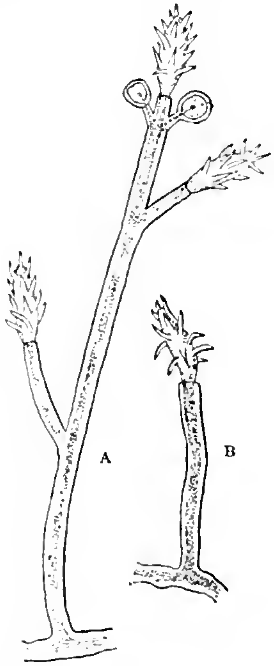

FIG. 1.—*Turritopsis nutricula* McCrady. A, mature colony with gonosome; B, young colony.

Though no special medusa collecting was attempted, on September 4 I was fortunate enough to get a large number of mature medusæ of this species in the large chamber of the crab float at the United States Bureau of Fisheries wharf. At other times I saw an occasional one at the same place but at no other time did they appear so plentiful.

Brooks, and later Mayer, in describing the hydroid of this species, speaks of it as being a *Dendroclava* much similar to the species described by Weismann as *Dendroclava dohrnii*.[a] Weismann, in giving the original description of this genus, mentions the fact that it differs from the *Clavidæ* in general, in having gonophores that produce free medusæ. I prefer to follow Allman in making that a family difference. For that reason I have retained the generic name *Turritopsis* which has been applied to the medusa and have placed the genus in the family Turridæ.

Family SYNCORYNIDÆ.

Trophosome.—Hydranths with no filiform tentacles; capitate tentacles numerous with little regularity of arrangement.

Gonosome.—Gonophores borne on the hydranth among or near the proximal tentacles, give rise to free medusæ with four radial canals and four tentacles, some or all of which may be rudimentary.

[a] Enstehung Sexualzellen bei Hydromedusen, 1888, p. 26, 215.

KEY TO GENERA OF THE SYNCORYNIDÆ FOUND IN THE BEAUFORT REGION.

A. Chitinous perisarc absent or slightly developed. Hydranths elongated with the stem shorter than the hydranth or absent. . . . . *Gemmaria*.
B. Chitinous perisarc well developed. Hydranth body shorter than the stem. . . . . *Syncoryne*.

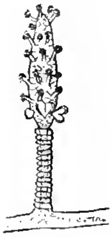

FIG. 2.—*Gemmaria costata* (Gegenbaur).

Genus GEMMARIA.

Trophosome.—Perisarc absent or slightly developed; colony consists of a single elongated hydranth growing from a stolon; short capitate tentacles scattered over the whole body of the hydranth.

Gonosome.—Gonophores producing medusæ with two of the tentacles rudimentary, the other two well developed and supplied with stalked bodies especially well provided with nematocysts.

? Gemmaria costata (Gegenbaur).

Zanclea costata Gegenbaur, Zeit. für Wissen. Zool, bd. VIII, 1856, p. 229.
Gemmaria gemmosa Mayer, Bull. Mus. Comp. Zool., Harvard, 1900, p. 35.
Gemmaria costata Mayer, The Hydromedusæ, vol. I, 1910, p. 87.

Trophosome.—Hydranth elongated, supported by a short pedicel provided with an annulated perisarc. The perisarc of the stolon is not annulated. Tentacles are arranged in numerous fairly definite whorls.

Gonosome.—Gonophores growing from the hydranth body near the proximal tentacles.

Color.—Perisarc opaque yellow, hydranths pale red.

Distribution.—On sargassum collected on the seaward side of Bogue Bank.

There has been much discussion regarding *Gemmaria* as to whether it is a genus distinct from *Zanclea*, but all such discussion has been from the medusa standpoint. As all the hydroids so far described have been called *Gemmaria* I have used that name. Mayer, who first described and figured this hydroid, confused it, at that time, with *Gemmaria gemmosa* McCrady, but later recognized the difference. This latter species has also given rise to much confusion, being described by various authors as *Corynitis agassizii* and *Halocharis spiralis*. Hargitt finally cleared up the matter by showing it to be the same species as *Halocharis spiralis* Agassiz and entirely different from *Corynitis agassizii* McCrady.[a]

Gemmaria costata resembles *G. gemmosa* very much, but can readily be distinguished from it by the short stalk of the hydranth that is supported by the strongly annulated perisarc. *G. gemmosa* has no pedicel and hence no perisarc except on the stolon. I have made this note because, though I did not find *G. gemmosa*, it is quite possible that it grows in the vicinity, since it is plentiful at Woods Hole and was found as far south as Charleston by McCrady, who first described it.

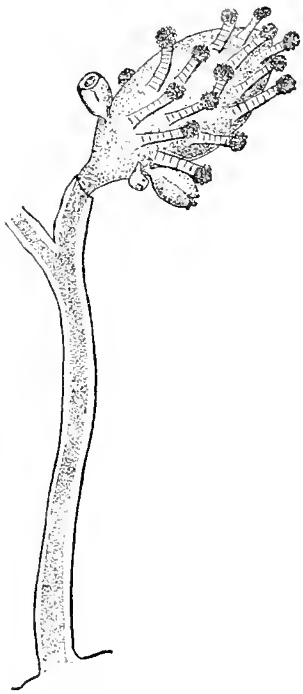

FIG. 3.—*Syncoryne mirabilis* (Agassiz).

Genus SYNCORYNE.

Trophosome.—Colony simple or slightly branched; perisarc well developed; tentacles stout, very strongly capitate.

Gonosome.—Gonophores usually few in number; medusæ with four rudimentary tentacles.

[a] Biological Bulletin, 1908, p. 100.

Syncoryne mirabilis (Agassiz).

Coryne mirabilis Agassiz, Cont. Nat. Hist. U. S., IV, 1862, p. 185.
Syncoryne mirabilis Nutting, Hydroids of the Woods Hole Region, 1901, p. 328. Hargitt, Am. Nat., 1901, p. 306.

Trophosome.—Colony unbranched or slightly and irregularly branched; hydranth body large, very stout for its length; perisarc smooth, reaching to the base of the hydranth.

Gonosome.—Gonophores borne below the proximal tentacles; medusæ become sexually mature before being liberated.

Color.—Hydranth rose red.

Distribution.—On floating sargassum from the seaward side of Bogue Bank.

Family BOUGAINVILLIDÆ.

Trophosome.—Colony usually branching; hydranths that may change from conical to a low dome shape; tentacles filiform but rather short and rigid, arranged in one whorl around the base of the hydranth body.

Gonosome.—Gonophores producing free medusæ borne on the hydrocaulus below the hydranth body; the marginal tentacles may be in clusters.

Genus BOUGAINVILLIA.

Trophosome.—Perisarc well developed on the branches as well as on the main stem.

Gonosome.—Gonophores supported on short pedicels, medusæ with four radial canals and four clusters of tentacles.

Bougainvillia rugosa Clarke.

Bougainvillia rugosa Clarke, New Hydroids from Chesapeake Bay, 1881, p. 140. Mayer, The Hydromedusæ, vol. 1, 1910, p. 171.

Trophosome.—Stem growing from a stolon, fascicled at the base, reaching a height of about 3 inches; branching irregular. None of the branches are so large as the main stem. Commonly these branches remain unbranched, but each gives rise to three or four pedicels for the hydranths. The perisarc extends well up on the hydranth body, and the portion thus extended is much corrugated with ridges that pass around the hydranth parallel to one another. The proboscis is ordinarily conical, but may be much flattened. The tentacles are few in number, 8 to 10, and short.

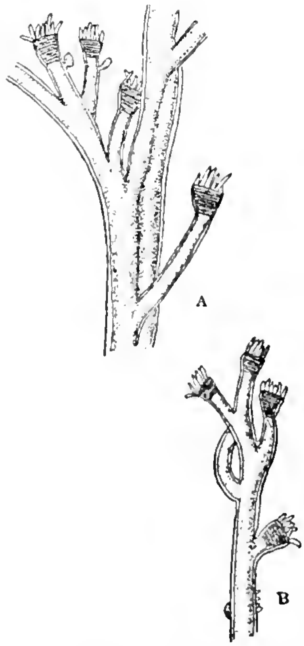

Fig. 4.—*Bougainvillia rugosa* Clarke. A, a fascicled portion of the stem; B, a portion of a branch

Gonosome.—Gonophores produced from the hydrocaulus below the hydranth body, covered with perisarc. In the free medusa there are four oral tentacles and four groups of three marginal tentacles.

Color.—Light brown.

Distribution.—Dredged in Bogue Sound at a depth of 10 or 12 feet; on piles of the wharf at Marshallberg, near low-water mark.

Family EUDENDRIDÆ.

Trophosome.—Colony branching; perisarc well developed; proboscis trumpet-shaped, but with much freedom of movement; tentacles all filiform, in a single whorl.

Gonosome.—Male and female gonophores bear little resemblance to each other. Male gonophores are usually in whorls, female gonophores usually in clusters. Free medusæ are not produced.

Genus EUDENDRIUM.

This is the only genus of the family Eudendridæ.

KEY TO THE SPECIES OF EUDENDRIUM FOUND IN THE BEAUFORT REGION.

A. Main stem simple, colony minute.
  a. Hydranths which bear gonophores showing little or no abortion .... *E. album*.
  b. Hydranths which bear gonophores much aborted .... *E. capillare*.
B. Main stem fascicled, colony large.
  a. Hydranths which bear gonophores with little or no abortion .... *E. ramosum*.
  b. Hydranths which bear gonophores much aborted .... *E. carneum*.

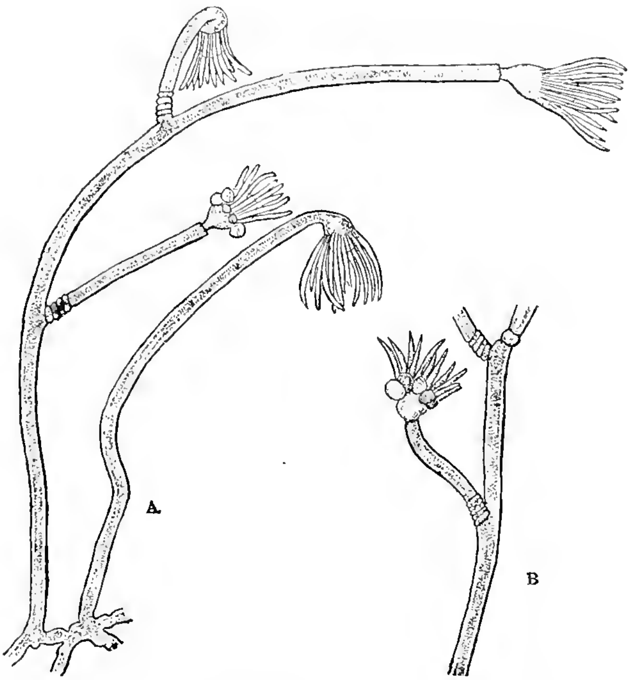

FIG. 5.—*Eudendrium album* Nutting. A, male colony with gonophores; B, hydranth with female gonophores.

Eudendrium album Nutting.

Eudendrium album Nutting, Ann. and Mag. Nat. Hist., 1898, p. 362. Nutting, Hydroids of the Woods Hole Region, 1901, p. 334. Hargitt, Biol. Bull., 1908, p. 97.

Trophosome.—Colony minute, seldom more than one-quarter of an inch in height; stem unbranched or with a few straggling branches, very slender. Annulations may be present, but not in any very definite arrangement.

Gonosome.—Gonophores borne on the hydranth body immediately below the tentacles. The hydranth may be smaller and the tentacles may be reduced in number, but the abortion is never complete. Male gonophores two or three chambered, few on a hydranth; female gonophores similar to the type for the genus, but small and few in number.

Color.—Hydranths and female gonophores white, male gonophores pale yellow, hydrocaulus nearly transparent.

Distribution.—On shells, Bogue Sound, 10 feet; on sponge, North River, 6 to 10 feet; on piles at Marshallberg, near low water.

Eudendrium capillare Alder.

Eudendrium capillare Alder, Cat. Zooph. Northumberland and Durham, 1857, p. 15. Nutting, Hydroids of Woods Hole Region, 1901, p. 334.

Trophosome.—Colony small, not more than one-half inch in height, usually branched; annulations at the base of the branches and pedicels.

Gonosome.—Female gonophores borne on aborted hydranths which may spring from a branch or directly from a hydrorhiza. They form a very noticeable cluster. Male gonophores with an arrangement similar to the female gonophores, and like them found on pedicels arising from a branch or the hydrorhiza. They are two or three chambered.

Color.—Hydranths and male gonophores light green, female gonophores reddish orange.

Distribution.—On shells in Bogue Sound, 10 feet.

Only a few specimens of this species were obtained and among them there were no male colonies. On that account I have copied Allman's figures and made use of his description.

Eudendrium carneum Clarke

Eudendrium carneum Clarke, Hydroids of Chesapeake Bay, 1882, p. 137. Nutting, Hydroids of Woods Hole Region, 1901, p. 333.

Trophosome.—Colony much branched, attaining a height of 4 or 5 inches; stem fascicled; annulations at the base of the branches and pedicels.

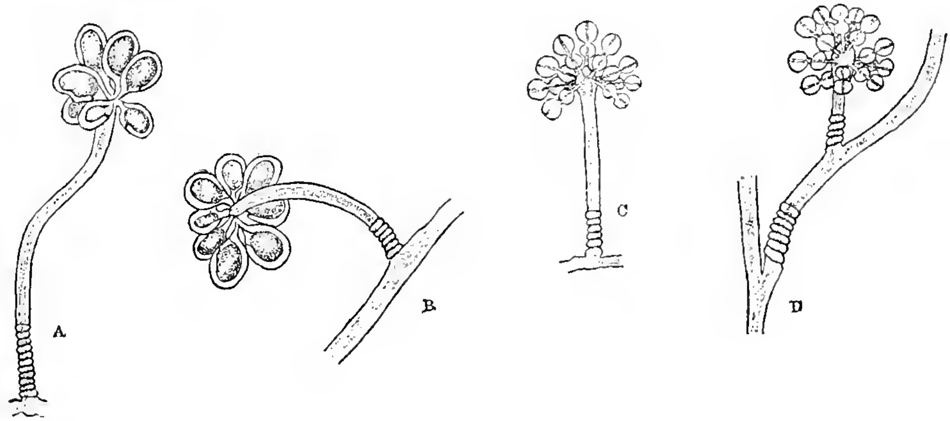

FIG. 6.—*Eudendrium capillare* Alder. A, cluster of female gonophores growing from the hydrorhiza; B, cluster of female gonophores growing from the stem; C, cluster of male gonophores growing from the hydrorhiza (after Allman); D, cluster of male gonophores growing from the stem (after Allman).

Gonosome.—Female gonophores borne on aborted hydranths, commonly with a zigzag arrangement from the end of the pedicel, this pedicel being more or less annulated throughout; often a series of pedicels appear in succession from a single branch. They may be close enough together so that the series of gonophore clusters may look like a single cluster. Over a large portion of the surface of each gonophore the perisarc is very much thickened. Male gonophores are clustered about an aborted hydranth. The cluster is much larger than in any other species found in this locality, five chambers being common. The reproductive hydranth is attached to the pedicel of an ordinary hydranth a short distance from where the latter is attached to the branch.

Color.—Hydranths and gonophores red.

Distribution.—Common on piles of United States Bureau of Fisheries wharf and on piles of the Norfolk Southern Railroad bridge from Morehead City to Beaufort; dredged near Shackleford, 12 feet.

Eudendrium ramosum (Linnæus).

Tubularia ramosa Linnæus, Systema Naturæ, 1767, p. 1302.

Eudendrium ramosum Hargitt, American Naturalist, 1901, p. 309. Nutting, Hydroids of the Woods Hole Region, 1901, p. 332.

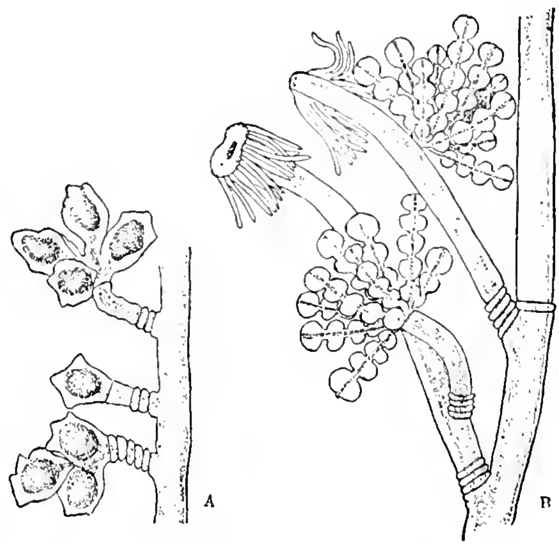

FIG. 7.—*Eudendrium carneum* Clarke. A, portion of female colony; B, portion of male colony.

Trophosome.—Colony much branched, reaching a height of 5 or 6 inches; stem fascicled; annulations at the base of the pedicels and branches and sometimes at the base of the internodes.

Gonosome.—Female gonophores borne on hydranths that are scarcely aborted, though they may be smaller than the ordinary hydranths. They are rather below the hydranth body than on it, and even may be found straggling down the pedicel for some distance. The pedicels are sometimes annulated throughout, but are not always so. Male gonophores are borne at the base of the body of the hydranths, which show much variation in the extent of the abortion; some of them are scarcely aborted, some are more so, and some have the tentacles reduced to mere buds. Gonophores are few in number, commonly three, with three chambers, or only two. They stand out very conspicuously almost at right angles to the axis of the hydranth.

Color.—Hydranths and male gonophores vermilion or pink; female gonophores bright orange-red.

Distribution.—On the piles of the United States Bureau of Fisheries wharf and of the railroad bridge from Morehead City to Beaufort, usually growing on large tunicates; on shells in Bogue Sound, 10 feet.

Congdon reports specimens from Bermudas in which the hydranths bearing the gonophores are entirely aborted, but I have found no specimens of such a nature in this region.

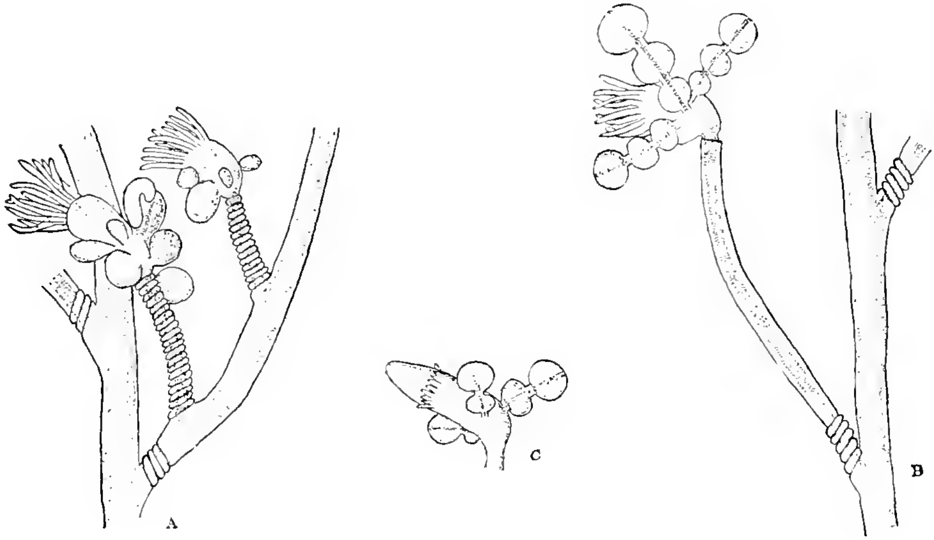

FIG. 8.—*Eudendrium ramosum* (Linnæus). A, portion of a female colony; B, portion of a male colony; C, a male hydranth much aborted.

Some difficulty may be experienced in distinguishing the different species of *Eudendrium*. It may be impossible to do so from the trophosome alone, because the general appearance is so much the same in each case. We speak of a difference of size, but that is very little to depend on, as, in the case of *E. ramosum* in particular, there is very wide variation. Though this hydroid may attain a height greater than any of the others, and usually is large when it is found near tide mark, in deeper water the forms dredged may be mature before the height of an inch is reached, at which time this species bears much resemblance to *E. capillare*, which, on the other hand, never reaches a great height. Mode of branching is a poor criterion upon which to depend, because there is not a definite method in any species, with the possible exception of *E. album*. The amount of annulation will not answer the purpose, because this is not constant, and, in any event, agrees fairly well in the four species under discussion. If the male and the female gonophores can be found in good condition the difficulty disappears. For that reason I have laid special stress on the gonophores in each species. Those of *E. ramosum* and *E. album* have the greatest resemblance to each other, but those of *E. album* are much smaller, corresponding to the minuteness of the species. Besides this, the male gonophores do not stand out at right angles as they do in *E. ramosum*. I have never found any female gonophores arising from the hydrocaulus, as they often occur in *E. ramosum*. *E. ramosum* and *E. carneum* are found growing side by side in so many localities and have the general appearance so much alike that care must be taken to avoid confusion between the two.

Family HYDRACTINIDÆ.

Trophosome.—Colony formed of distinct nutritive and generative zooids growing from a common basal cœnosarc, which ordinarily is beset with jagged spines. Other kinds of zooids may also be present. Hydranths with a single row of filiform tentacles; proboscis conical.

Gonosome.—Gonophores in the form of fixed sporosacs on special generative zooids.

Genus HYDRACTINIA.

This is the only genus of the family.

KEY TO SPECIES OF HYDRACTINIA FOUND IN THE BEAUFORT REGION.

A. Generative zooids without tentacles, cœnosarc beset with jagged spines. . . . . *H. echinata.*
B. Generative zooids possessing tentacles, jagged spines not present in the cœnosarc . . . . *H. carolinæ.*

Hydractinia carolinæ new species.

Trophosome.—Colony composed of persons less crowded than in *H. echinata*, arising from an encrusting mass which does not have the strongly jagged spines, these being so much reduced as to be scarcely noticeable as little nodules on the surface; hydranths much similar to those of *H. echinata*. There were no dactylozooids present nor could any of the long, slender, sensitive zooids be seen.

Gonosome.—Gonophores borne on generative persons not very much unlike the nutritive persons, except that they are smaller and the tentacles are somewhat less numerous. No batteries of nematocysts except those ordinarily found on tentacles are present. In no case were there more than two gonophores attached to one person. Six ova could be made out in the majority of the sporosacs.

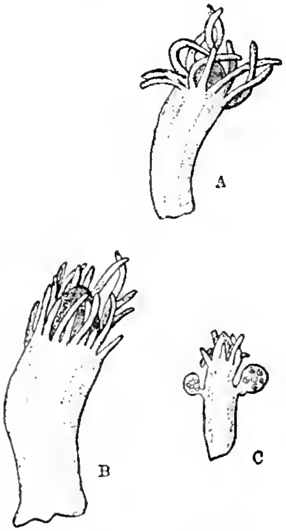

FIG. 9.—*Hydractinia carolinæ*, new species. A and B, nutritive zooids; C, generative zooid.

Color.—As the specimens had been in alcohol for a long time, naturally no very definite color could be made out.

Distribution.—Found growing on the legs of a crab dredged by the United States Fisheries steamer Fish Hawk about 23 miles southwest of Beaufort, in 13 or 14 fathoms of water.

This species differs from other species of *Hydractinia* in the nature of the gonosome, in the absence of other than the nutritive and generative zooids, and in the absence of pronounced spines on the basal expansion.

As all the specimens obtained were from the legs of an individual crab, the zooids were all of one sex, female. The presence of several tentacles and the absence of special batteries of nematocysts readily distinguish it from almost all other species. The number and arrangement of the gonophores are distinctive, but these vary with different species. The absence of the dactylozooids and of the basal spines may be due to the same cause. There is not much necessity of these, as the surface of the crab's legs is well protected, in the first place, by large, sharp spines, and, in the second, in some places at least, with a regular thicket of stiff bristles. These must offer as good protection as is afforded in other species by the special protective persons.

The fact that the long, slender, sensitive persons were not observed does not necessarily indicate their absence, as it is seldom that they can be observed, except when they are in the active state in live colonies, and even then they are not very numerous.

This species resembles *Hydractinia verdi* Ritchie,[a] but he found three or four sporosacs on each generative zooid and only three eggs in each. The spines in his species are better developed also.

Hydractinia echinata (Fleming).

Alcyonium echinatum Fleming, British Animals, 1828, p. 517.
Hydractinia echinata Hincks, British Hydroid Zoophytes, 1868, p. 23. Allman, Ray Society, 1871, p. 345.
Hydractinia polyclina Agassiz, Cont. Nat. Hist. U. S., 1862, p. 227.
Hydractinia echinata Hargitt, American Naturalist, 1901, p. 310.
Hydractinia polyclina Nutting, Hydroids of the Woods Hole Region, 1901, p. 335.

Trophosome.—Colony arising from a basal cœnosarc which overlies a chitinous, encrusting plate. Hydranths with great power of contractility and extensibility. Thus they may appear long and slender or short and stout. They are generally contracted in the preserved specimens. Tentacles vary much in number. The whorl may appear very definite or may be so irregular as to appear as though there were several approximated whorls.

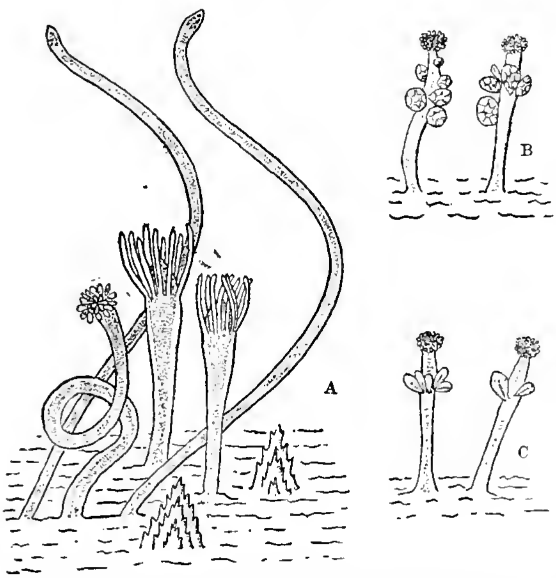

FIG. 10.—*Hydractinia echinata* (Fleming). A, portion of colony, showing nutritive zooids, defensive zooids, and sensory zooids, as well as the basal spines; B, female generative zooids; C, male generative zooids.

Gonosome.—The sporosacs, male and female, in different colonies, are found on special generative zooids which are devoid of tentacles but instead have extensive batteries of nematocysts. They are usually noticeably smaller than the nutritive zooids.

Other zooids.—At intervals among the nutritive and generative zooids there are zooids which look much like the generative zooids, except that they are much longer and more slender and are devoid of sporosacs. They are even more mobile than the nutritive zooids and may even double on themselves to form spirals. They probably serve for the defense of the colony.

Near the outer margin of the colony still other zooids may be found. They are even longer than the spiral zooids, but they do not possess the nematocyst batteries. They appear specially sensitive, and probably serve for the sense of touch for the colony. They are few in number and are likely to escape notice, even in the living colony, unless they are in active movement. Unless preserved specimens have been specially fixed they seldom show these zooids.

Color.—Whitish to reddish. Female gonophores orange red or bright red.

Distribution.—Bogue Sound, on shells, 10 to 12 feet.

Since the time when Agassiz, in his Contributions to the Natural History of the United States, described a species of *Hydractinia* and called it *H. polyclina*, there has been much discussion as to whether this species is identical with the British species *H. echinata* Fleming. Hincks placed the American species with the British, but Allman separated them, accepting Agassiz's opinion, though, at the same time, expressing grave doubts as to the propriety of doing so. Among American naturalists Hargitt has followed Hincks, while Nutting has taken the opposite view. With the exception of Nutting, none of these ever had specimens from both sides of the Atlantic to compare, and it would seem, therefore, that his opinion should have the soundest basis.

[a] Hydroids from Cape Verde Islands, 1907, p. 498.

During the past summer I obtained specimens of *Hydractinia* from South Harpswell, Me., from different localities near Woods Hole, Mass., and from Beaufort, N. C. In working up the Beaufort hydroids it was necessary to come to a decision as to this species. With that end in view comparison was made, not only of the specimens referred to, but also specimens that had been used by Prof. Nutting from Woods Hole, Mass., Grand Manan, New Brunswick, and from Plymouth, England, as well as some specimens collected some years ago at Canso, Nova Scotia.

In comparing Prof. Nutting's specimens from Woods Hole and from Plymouth it was an easy matter to see the difference in size of hydranth and number of tentacles that he mentions, but in comparing the Plymouth specimens with some of the specimens obtained during the past summer, the same dif-

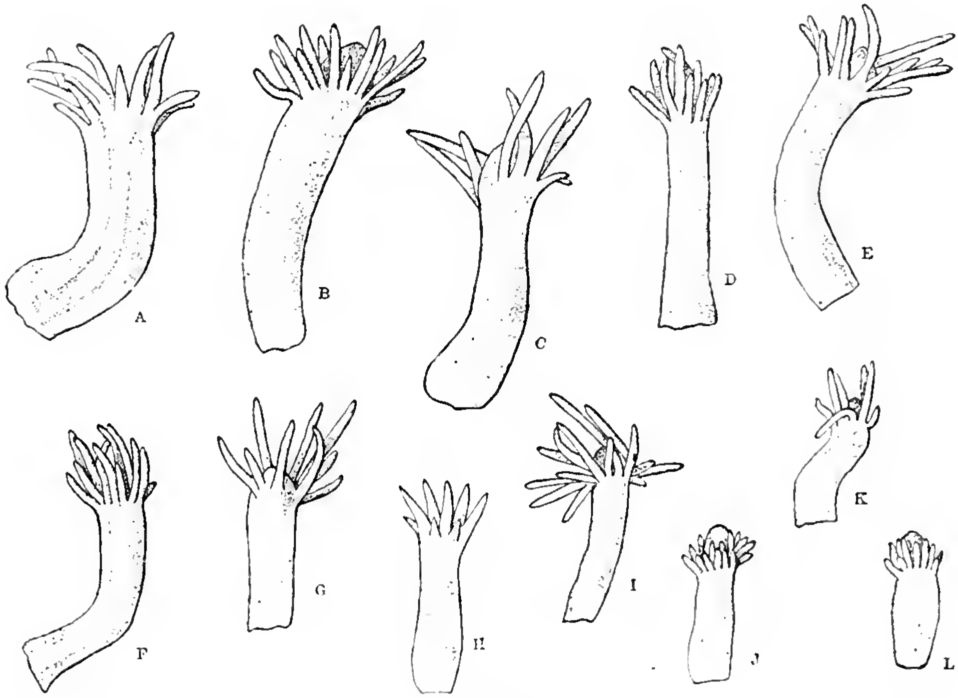

FIG. 11.—*Hydractinia echinata* (Fleming). A to L, nutritive zooids from various localities to show variation in size and number of tentacles

ference could not be observed. The individuals of several colonies from Vineyard Haven (near Woods Hole), from Canso, and from South Harpswell were larger than any of the Plymouth individuals and many of them had even fewer tentacles. On the other hand, some from Tarpaulin Cove (near Woods Hole) were as small as Prof. Nutting's specimens from Woods Hole, and those from Beaufort were still smaller. That the difference may be appreciated several drawings have been made (fig. 11), in all cases from among the largest individuals of mature colonies. A, C, and G are Vineyard Haven specimens, B from Canso, D from South Harpswell, E, F, and I from Plymouth, H from Grand Manan, J from Woods Hole, K from Tarpaulin Cove, and L from Beaufort. They are made from preserved specimens and hence show the individuals in the state of contraction.

With such a gradation shown, I do not see how it is possible to consider that there are two distinct species, for certainly one who did not know the specimens or drawings could not pick the three British specimens out of the lot. The difference in size could not be influenced particularly by the bases for attachment as there was much variation in these. The Plymouth specimens were attached to gastropod shells, the Canso specimens to shells and stones, the Grand Manan specimens to seaweed, the South Harpswell specimens to shells and to rock, the Vineyard Haven specimens to piles of a bridge, the Tarpaulin Cove specimens to shells, and the Beaufort specimens to shells.

It is possible that the general habitat has something to do with size. At Vineyard Haven, where the largest specimens were obtained, the colonies form encrusting masses completely covering the piles from low-water point to a depth of several feet. That there is only one colony on each pile is indicated by the fact that all the individuals on one pile are of the same sex. This bridge spans the narrow entrance to a large body of water known as Lagoon Pond. With every turn of the tide a strong current is produced, a condition which is notably suitable for hydroid life, as an abundant food supply is assured. If any other evidence were necessary it might be stated that a dozen species of hydroids were obtained from these piles in less than half an hour.

At South Harpswell the conditions were similar. The specimens were obtained at the site of an old tide mill, where the current was strong enough to turn the mill wheel 8 hours out of 12. Large surfaces of rock were covered with the colonies in much the same way that the piles were at Vineyard Haven, though gastropod shells inhabited by hermit crabs were numerous also to provide a basis of attachment.

At Canso, the colonies were found along the shore at low water or on the bottom a short distance below low water. As the Canso Peninsula projects so far into the Atlantic Ocean a tide current is running almost continually either into or out of Chedabucto Bay, past this point. Furthermore, as there is a fringe of rocky islands and reefs surrounding the peninsula at a short distance out from shore, this tide current is broken up into innumerable small currents, some of which attain to a much greater velocity as they move through the narrow passages. Here also an abundant food supply is assured. I do not know the exact conditions at Grand Manan, but no place in the Bay of Fundy is likely to be without a good supply of current. It seems as though in all these cases the food supply was abundant, and large specimens as well as large colonies were the result.

In contradistinction to this, the small colonies were all found in quiet water. At Tarpaulin Cove the colonies came up on the tangles used for collecting sea urchins or were obtained along the shore at low tide. The cove serves as a good anchorage because of its sheltered waters. If the movement of the water is slight the food supply of the hydroids can not be abundant. At Beaufort the specimens were obtained where the conditions were much similar to those at Tarpaulin Cove, at a depth of 10 or 12 feet in Bogue Sound, on sea-urchin ground, where the bottom is sandy with here and there lamellibranch and other mollusk shells. There are 3 or 4 miles of shallow water before the open ocean is reached and even the ocean is shallow for a long distance out. It is not surprising then that the colonies and the individuals are even smaller here than at Tarpaulin Cove, for the latter is at least close to the deep weter of Vineyard Sound.

In many cases temperature appears to have much to do with the distribution of hydroids, and one might suppose that the influence of temperature might account for the difference of size in this species, since the larger specimens, in general, as far as this collection is concerned, are confined to the colder waters and the smaller specimens the warmer. There is one difficulty in the way of accepting such a conclusion. The large specimens from Vineyard Haven were obtained but 7 or 8 miles from the very small specimens at Tarpaulin Cove, and as there is direct water connection between the two places there can be little difference in temperature.

The variation in depth in the whole series is not enough to make any material difference in growth, and it is hard to conceive of any other influence that might do so besides those mentioned.

Difference in the food supply must be an important factor in producing this difference of growth and it would seem, if one can judge from the specimens considered in this discussion, that it is the most prominent factor.

Family PENNARIDÆ.

Trophosome.—Colony branched; hydranths with a proximal whorl of long filiform tentacles around the body of the hydranth and several capitate tentacles on the proboscis, these usually in a series of whorls.

Gonosome.—Gonophores producing free medusæ with four radial canals and four rudimentary tentacles.

Genus PENNARIA.

Trophosome.—Colony large, much branched, often with a distinct pinnate or twice pinnate arrangement; hydranth with a large proboscis, very noticeable when extended, well supplied with whorls of capitate tentacles.

Gonosome.—Gonophores borne on the hydranth body just distal to the proximal whorl of tentacles; medusæ very large, often mature, when liberated. They may even liberate the sex products before being set free from the hydranth.

Pennaria tiarella McCrady.

Pennaria tiarella McCrady, Gymnoph. of Charleston Har., 1857, p. 51. Hargitt, American Naturalist, 1900, p. 387. Hargitt, American Naturalist, 1901, p. 311. Nutting, Hydroids of the Woods Hole Region, 1901, p. 337.

Trophosome.—Colony large, sometimes reaching the height of 6 inches; branching twice pinnate. A varying number of annulations, never very many, occur on the main stem above the origin of the branch and on the branches above their origin. The hydranths are large, narrowing distinctly to form the proboscis. There are 10 or 12 filiform tentacles and a varying number of capitate tentacles which are usually arranged in four or five quite regular whorls in the fully developed hydranth. Often a hydranth bud appears growing directly from the wall of the main stem or branch.

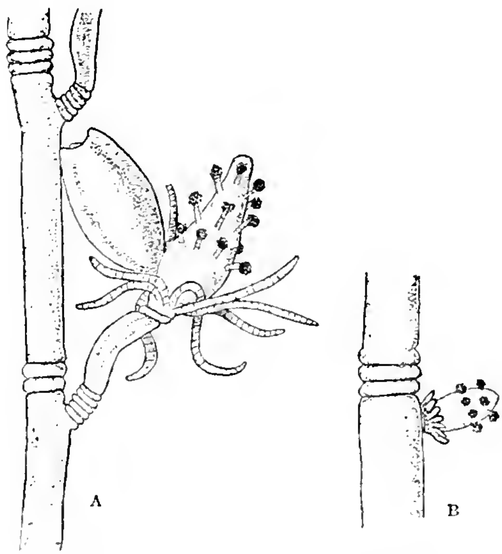

Fig. 12.—*Pennaria tiarella* McCrady. A, hydranth and gonosome; B, bud growing directly from the branch.

Gonosome.—Gonophores few in number; when there are more than one on a hydranth at the same time they seldom are at the same stage of development. The medusæ are oval or ovate; rudimentary tentacles, radial canals, and the manubrium with its gonads are all well developed, and the sexual products may be dehisced before the medusæ are set free.

Color.—Stem and main branches of dark horn color; hydranths and medusa markings similar to each other in color; they may be a vermilion or pink or they may be a light gray, almost a white; tentacles white.

Distribution.—On the crab float and the piles of the United States Bureau of Fisheries wharf, on the piles of the railway bridge at all points from Morehead City to Beaufort, on stones and shells in shallow water in many near-by localities.

Hargitt, in his 1900 paper, speaks of two varieties of this species as it is found at Woods Hole: The one occurring early in the season, a deeper form with little tendency to bilateralism, with little coloration in hydroid or medusa, the medusa being inactive or never becoming free; and a shallow water or surface form, occurring later, which is distinctly bilateral, with higher coloration in hydranth and medusa, the medusa being active, the whole colony having a more rapid growth than the former. He suggests that the bilateralism and higher coloration in the latter is due to exposure at the surface while it is floating, and that this might account for its rapid development as well.

Whatever bearing that may have on the Woods Hole *Pennaria*, it does not seem to apply to the Beaufort forms. At Woods Hole the eelgrass variety had become common early in August. The Beaufort specimens were examined a month later, and therefore, as far as time is concerned, should agree with the later eelgrass variety. Growing side by side on the crab float, and therefore always at the surface, were found colonies as close as it is possible for colonies to grow—the one with the hydranths and medusa markings pink or vermilion and the other grayish or milky white. Both exhibited marked bilateralism and both appeared to retain the medusæ at least until the sex products were mature. In the specimens obtained from the piles of the railroad bridge under nearly the same conditions, the two varieties were found similarly. As far as I can make out, there are no structural differences. I had no time to make any investigations, and consequently have no explanation or even suggestion to account for the differences, but I can not see that Hargitt's suggestion will in any way apply to the Beaufort specimens, except that regarding bilateralism, which, I think, may hold good.

Suborder CALYPTOBLASTEA.

Hydranths protected by hydrothecæ and gonophores by gonangia.

Family CAMPANULARIDÆ.

Trophosome.—Hydrothecæ campanulate, never sessile, never adnate to or immersed in the stem or branches; no operculum; diaphragm always present; hydranth with trumpet-shaped proboscis.

Gonosome.—Gonophores producing sporosacs or free medusæ. These medusæ usually have otocysts and have the ovaries along the course of the radial canals.

Key to the Genera of the Campanularidæ Found in the Beaufort Region.

A. Gonophores do not produce free medusæ.
- *a.* Reproduction by sporosacs which remain in the gonangium; these give rise to planulæ. *Campanularia.*
- *b.* Reproduction by sporosacs which are extruded into a sac at the summit of the gonangium, in which sac the planulæ are produced ...... *Gonothyræa*

B. Gonophores produce free medusæ.
- *a.* Medusæ, with 4 tentacles at time of liberation ...... *Clytia.*
- *b.* Medusæ, with 16 or more tentacles at liberation ...... *Obelia.*

There are few distinguishing differences in the trophosomes of these genera.

Genus CAMPANULARIA.

Trophosome.—As in the family.

Gonosome.—Gonophores producing sporosacs from which planulæ develop within the gonangia.

Key to Species of Campanularia Found in the Beaufort Region.

A. Hydrotheca, with entire margin ...... *C. integra.*
B. Hydrotheca, with margin toothed ...... *C. raridentata.*

Campanularia integra MacGillivray.

Campanularia integra MacGillivray, Ann. and Mag. Nat. Hist., 2d ser., 9, 1842, p. 465. Hincks, Br. Hydroid Zoophytes, 1868, p. 163. Fraser, West Coast Hydroids, 1911, p. 31.

Trophosome.—Colony usually unbranched, arising from a stoloniferous network; pedicels long and slender, varying much in the amount of annulation, some being almost smooth and some being annulated throughout. There are always two or three annulations below the hydrotheca. Hydrotheca with entire margin tapering very gradually from rim to base.

Gonosome.—Gonangium very large, deeply corrugated, the corrugations having a distinct keel; attached by a short annulated pedicel to the stolon.

Distribution.—On a piece of board found floating on the open ocean near Cape Lookout.

No gonosome was found on these specimens. The drawing was made from a Puget Sound specimen.

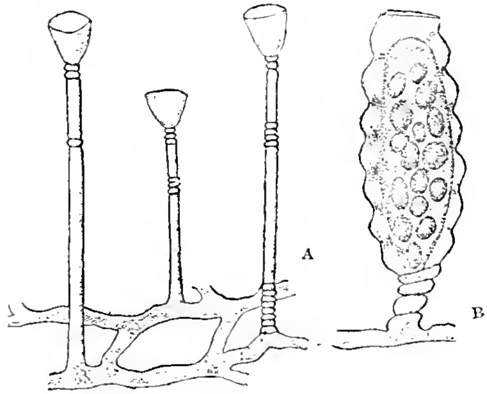

FIG. 13.—*Campanularia integra* MacGillivray. A, trophosome; B, gonosome.

? Campanularia raridentata Alder.

Campanularia raridentata Alder, Ann. and Mag. Nat. Hist., 3d ser., IX, 1862, p. 315. Hincks, Br. Hydroid Zoophytes, 1868, p. 176. Fraser, West Coast Hydroids, 1911, p. 32.

Trophosome.—Colony unbranched, arising from a stolon which at this point has a distinct elevation somewhat bulbous in appearance; pedicel annulated at the base and below the hydrotheca, sometimes throughout almost the whole length; hydrothecæ long and narrow, tapering but slightly from margin to base; teeth usually five in number, deep and rounded at the tip.

Gonosome.—Unknown.

Distribution.—Dredged near the sea buoy in 6 or 7 fathoms of water.

Since the gonosome has not been observed, this species can be put in the genus *Campanularia* only provisionally.

There has been much confusion of this species with *Thaumantias inconspicua* Forbes, though when the two are compared the resemblance is not marked. The matter has been discussed in my West Coast paper.

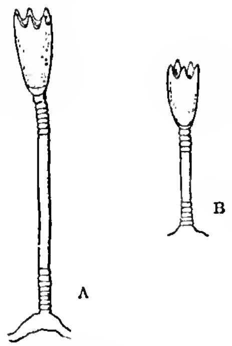

FIG. 14.—*Campanularia raridentata* Alder. A and B, single colonies.

Genus CLYTIA.

Trophosome.—Colony unbranched or irregularly branched.

Gonosome.—Gonophores produce medusæ with 4 radial canals and 4 marginal tentacles when liberated, 8 lithocysts between the bases of the tentacles.

KEY TO SPECIES OF CLYTIA IN THE BEAUFORT REGION.

A. Hydrothecæ deeply campanulate, with few teeth............*C. coronata.*
B. Hydrothecæ cylindrical, with sharp teeth..................*C. cylindrica.*
C. Hydrothecæ broadly campanulate, with sharp teeth.......*C. johnstoni.*
D. Hydrothecæ large, cylindrical, with deeply cut teeth.....*C. longicyatha.*
E. Hydrothecæ broadly campanulate, with rounded teeth.....*C. noliformis.*

? Clytia coronata (Clarke).

Campanularia coronata Clarke, Bull. Mus. Comp. Zool., Harvard, 1870, p. 242.

Trophosome.—Colony unbranched or with a few irregular branches which take an abrupt bend near their origin and pass out parallel and close to the main stem. When the colony is unbranched the pedicel is strongly annulated proximally and distally and may be annulated throughout. This also applies to the individual pedicels in the branched forms, but besides this the main stem is annulated above the origin of the branch or pedicel. The hydrothecæ are rather long, tapering gradually from below the margin to the base. There are eight or nine distinctly cut teeth that are not especially acute.

Gonosome—Gonophores appear both on the stolon and on the stem borne on short annulated pedicels. The gonangia are oblong-oval in shape with the opening occupying the greater part of the upper surface.

Distribution.—On seaweed floating in Beaufort Harbor.

The gonosome has not been described hitherto. Many gonangia were present on this material but almost all were empty. Some of them had two or three medusæ but they were not in a good state of preservation. They were certainly not *Obelia* medusæ and probably not *Thaumantias*. They had the shape of *Clytia* medusæ and I have little doubt that they belong to that genus.

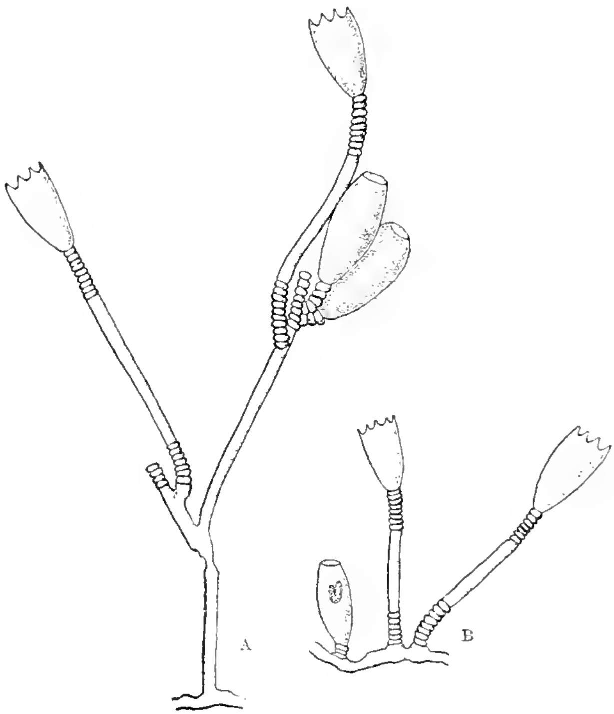

FIG. 15.—*Clytia coronata* (Clarke). A, branched colony; B, unbranched colonies.

Clytia cylindrica Agassiz.

Clytia cylindrica Agassiz, Cont. Nat. Hist. U. S., IV, 1862, p. 306. Hargitt, American Naturalist, 1901, p. 381. Nutting, Hydroids of Woods Hole, 1901, p. 342.

Trophosome.—Stem unbranched with slender pedicel, annulated proximally and distally; hydrothecæ cylindrical, more than twice as deep as wide, suddenly constricted at the base at the point where the diaphragm appears inside, the part below the diaphragm being little larger than the end of the pedicel; teeth 10 to 12, sharp-pointed and deeply cut.

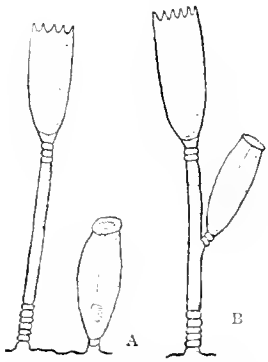

FIG. 16.—*Clytia cylindrica* Agassiz. A, hydrotheca and gonangium growing from the stolon; B, gonangium growing from the pedicel.

Gonosome.—Gonophores arising either from the hydrorhiza or from the pedicel by means of short pedicels with one or two annulations; gonangium smooth, oblong, slightly narrowed just below the rim.

Distribution.—Very common, growing on *Pennaria*, *Eudendrium*, alcyonarians and many other forms, on the piles of the railroad bridge, on floating sargassum, on the piles at Marshallberg; dredged in 6 to 12 feet of water in Bogue Sound, North River, and the Straits.

Clytia johnstoni Alder.

Campanularia johnstoni Alder, Ann. and Mag., 2nd ser., XVIII, 1856, p. 359.

Clytia johnstoni Hincks, Br. Hydroid Zoophytes, 1868, p. 143.

Clytia bicophora Agassiz, Cont. Nat. Hist. U. S., IV, 1862, p. 304. Hargitt, American Naturalist, 1901, p. 381. Nutting, Hydroids of Woods Hole, 1901, p. 343.

Trophosome.—Stem unbranched or sometimes with a single branch; pedicels long and slender, annulated proximally and distally; hydrothecæ broadly campanulate, not much deeper than wide, with 12 to 14 sharply pointed, rather shallow but distinctly cut teeth.

Gonosome.—Gonophores growing either from the stem or the hydrorhiza attached by short annulated pedicels; gonangia strongly corrugated, each corrugation with a distinct keel; oval, truncate at the distal end.

Distribution.—On floating sargassum from the seaward side of Bogue Bank.

I can see no good reason for separating *Clytia bicophora* Agassiz from *Clytia johnstoni* (Alder). They seem to agree in every particular.

Clytia longicyatha (Allman).

Obelia longicyatha Allman, Mem. Mus. Comp. Zool., Harvard, 1877, p. 10.
Clytia longicyatha Pictet, Revue Suisse de Zoologie, 1893, p. 28.

Trophosome.—"Hydrocaulus attaining the height of nearly an inch, fascicled below, alternately branched; main stem annulated for a short distance above each ramulus; ramuli annulated at their origin; hydrothecal peduncles of moderate length, more or less annulated. Hydrothecæ narrow, deep, nearly cylindrical above and then tapering toward the base; the orifice cut into about 20 acute, deep, narrow teeth." (Allman.)

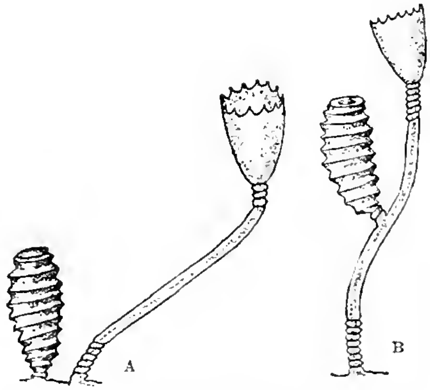

Fig. 17.—*Clytia johnstoni* (Alder) A, hydrotheca and gonangium growing from the stolon; B, gonangium growing from the pedicel.

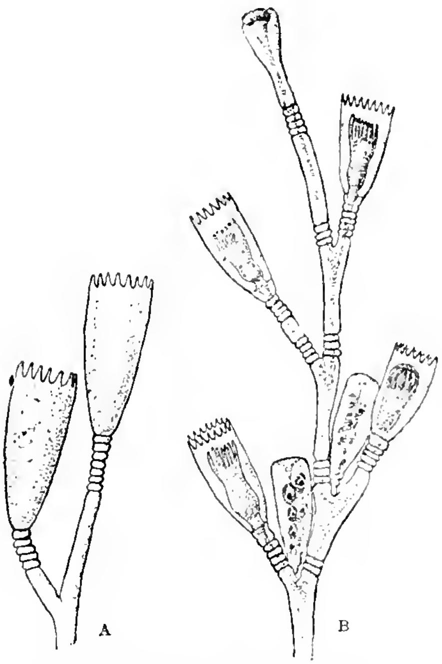

Fig. 18.—*Clytia longicyatha* (Allman). A, two hydrothecæ; B, portion of colony to show gonosomes. (After Pictet.)

Gonosome.—Gonangia with smooth walls, borne on the hydrorhiza or the stem, inclosing the deep bell-shaped medusa buds, arranged on the blastostyle in pairs, the one opposite the other. Length of gonangium 1 to 1.1 mm., diameter 0.4 mm. (From Pictet.)

Distribution.—On floating sargassum off Bogue Bank; on sponge dredged by Fish Hawk.

Allman described this species from Florida without finding the gonosome and judged it to be *Obelia*. Later Pictet found what he considered to be the same species from the Bay of Amboine, with the gonosome present. This showed it to be a *Clytia* instead of an *Obelia*. There seems little doubt that this is Allman's species, although the depth of the hydrotheca is not so great as in Allman's specimens or in those I have obtained. I obtained only a fragment of a colony with two perfect hydrothecæ and another with but one. Consequently, I have copied Allman's description of the trophosome and have translated Pictet's description of the gonosome. The figure of the gonosome is from Pictet.

Clytia noliformis (McCrady).

Campanularia noliformis McCrady, Proc. Elliott Soc., 1857, p. 92.
Clytia noliformis Nutting, Hydroids of Woods Hole, 1901, p. 343.

Trophosome.—Stem unbranched; pedicels short, stout, extensively annulated, sometimes throughout the whole length; hydrothecæ broadly campanulate, sometimes broader than deep but usually with length and breadth about equal; teeth 10 to 12, rounded at the tip.

Gonosome.—Gonophores growing from the hydrorhiza, almost sessile; gonangia broadly oval in general shape but narrowing distinctly just below the rim, which is expanded, so that it appears to have a distinct but very short neck.

Distribution.—Very common on the sargassum that drifted in to Bogue Bank and even into Beaufort Harbor.

The gonosome has not been described for this species under this name but it seems probable that this is the species that Congdon has described as *C. simplex*,[a] the gonosome being figured and described and also the species that Hargitt has described as *C. volubilis*.[b] The fact that in both cases the specimens were found on the sargassum makes it even more probable.

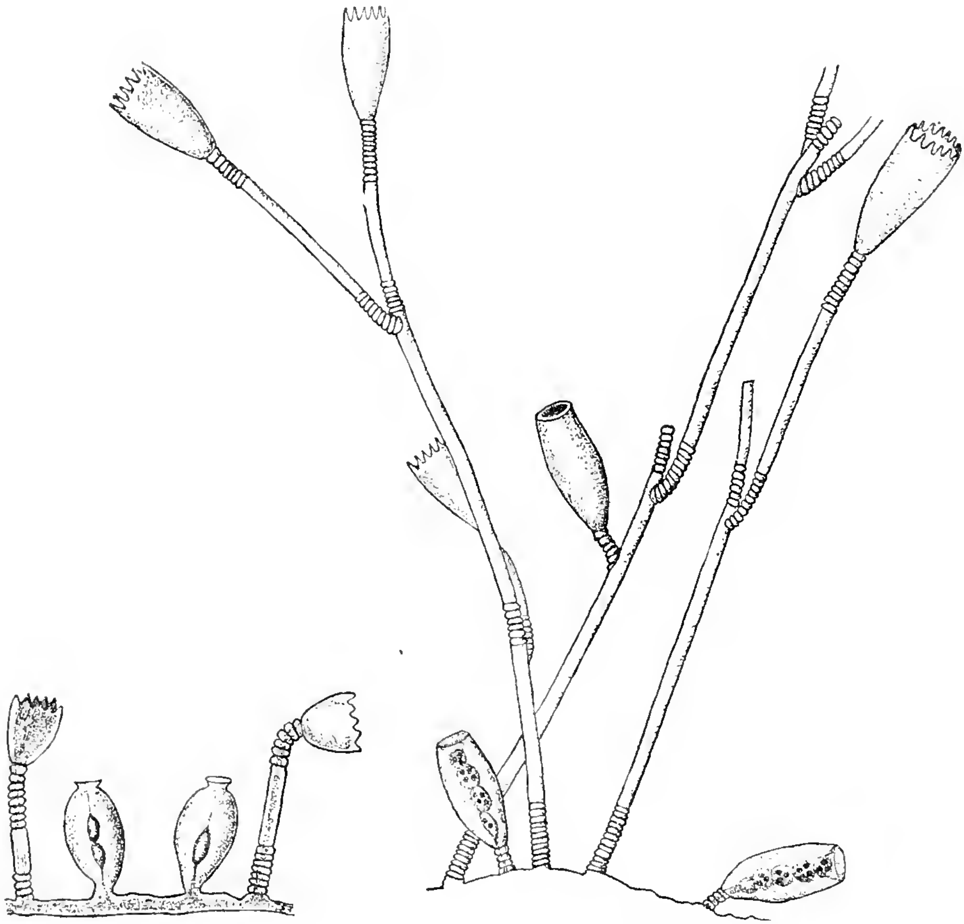

FIG. 19.—*Clytia noliformis* (McCrady).

FIG. 20.—*Gonothyræa gracilis* (Sars).

Genus GONOTHYRÆA.

Trophosome.—As in the family.

Gonosome.—Gonophores giving rise to sporosacs which are provided with short filiform tentacles. Before maturity these sporosacs pass out of the gonangia but remain attached to the top until the planulæ are liberated.

Gonothyræa gracilis (Sars).

Laomedea gracilis Sars, Beretning om en zoologisk Reise i Lofoten og Finmarken, 1851, p. 18.
Gonothyræa gracilis Allman, Ann. and Mag. N. H., 3d ser., XIII, 1864, p. 374. Hincks, Br. Hydroid Zoophytes, 1868, p. 183.

Trophosome.—Colony irregularly branched; stem, branches, and pedicels long and slender; branches and pedicels bend abruptly near the origin and pass upward in the same direction as the main stem; stem with several annulations at the base and above the origin of each branch and pedicel; each pedicel with several annulations at the base and below the hydrotheca; hydrotheca long for its width, cylindrical for the upper half or two thirds and gradually tapering to the base; teeth 10 to 14, deeply cut and rather sharp.

Gonosome.—Gonophores borne on the hydrorhiza and on the stem, with distinct, annulated pedicels; gonangia oblong-oval in shape, flaring a little at the rim. Each gonophore bears four or five sporosacs.

Distribution.—On *Pennaria* growing on the piles of the railroad bridge near Beaufort and on gulf-weed collected on the seaward side of Bogue Bank. This species bears much resemblance to *Clytia edwardsi* (Nutting) in its general appearance, particularly in the mode of branching and in the shape of the hydrotheca, but the gonosome is entirely different.

Genus OBELIA.

Trophosome.—As in the family.

Gonosome.—Gonophores producing medusæ, which when set free have 4 radial canals, more than 8 marginal tentacles and 8 lithocysts borne on the base of the tentacles; umbrella disk-shaped.

Key to the Species of Obelia Found in the Beaufort Region.

A. Hydrothecæ with toothed margin.
  Each tooth is provided with two sharp points. . . . . *O. bicuspidata.*
B. Hydrothecæ with entire margin.
  a. Hydrothecæ with straight sides. . . . . *O. dichotoma.*
  b. Hydrothecæ nearly bell-shaped, coming off alternately from a geniculate stem which supplies a shoulder for each. . . . . *O. geniculata.*
  c. Hydrothecæ bell-shaped with a tendency to a flaring rim. Stem and pedicels much annulated. *O. hyalina.*

Obelia bicuspidata Clarke.

Obelia bicuspidata Clarke, Trans. Conn. Acad. Sc., vol. III, 1876, p. 58.
Obelia bidentata Clarke, Trans. Conn. Acad. Sc., vol. III, 1876, p. 58.
Obelia bicuspidata Nutting, Hydroids of Woods Hole, 1901, p. 351.
Obelia bidentata Nutting, Hydroids of Woods Hole, 1901, p. 351.

Trophosome.—Colony small, not much branched; main stem geniculate, annulated at the base and above each branch or pedicel; hydrothecæ on short pedicels, except the terminal one, annulated throughout, standing well out from the stem; long and slender, tubular but tapering slightly to the base; margin toothed, each tooth provided with two sharp points; lines are usually found running from the base of the indentations, lengthwise of the hydrothecæ.

Gonosome.—Gonophores very small, borne in the axils of the hydrotheeal pedicels, supported on short, annulated pedicels; gonangia ovate or oval, with the top truncated or, in some cases, slightly inverted at the center; some of them are shorter than the hydrothecæ.

[a] Hydroids of the Bermudas, 1907, p. 472.
[b] Biological Bulletin, 1909, p. 373.

Distribution.—On *Pennaria*, *Eudendrium* and gorgonian stems, common; on piles of the United States Bureau of Fisheries wharf, on the piles of the railroad bridge, Bogue Sound 10 feet, North River 8 to 10 feet.

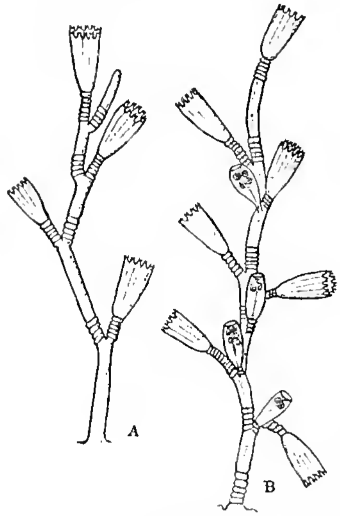

FIG. 21.—*Obelia bicuspidata* Clarke. A, small colony; B, colony showing gonosome.

In the colonies found on the *Pennaria* stems it is possible to find enough variation to cover all the points given as differences between *O. bicuspidata* and *O. bidentata*, in Clarke's descriptions, so that it is hardly possible that there are the two distinct species. The gonosome has not been described hitherto

Obelia dichotoma (Linnæus).

Sertularia dichotoma Linnæus, Systema Naturæ, 1767, p. 1312.
Obelia dichotoma Hargitt, American Naturalist, 1901, p.382. Nutting, Hydroids of Woods Hole, 1901, p. 350.

Trophosome.—Colony branching, usually in a dichotomous manner, though in the branches this may be quite irregular; two or three annulations on the main stem and branches above each branch and pedicel; pedicels short, annulated throughout or at each end only; hydrothecæ much deeper than wide, with straight sides; margin entire, though in some cases it appears slightly wavy or crenulated.

Gonosome.—Gonophores usually borne in the axils of the pedicels, obovate with a distinct collar which narrows from base to tip, somewhat rounded at the end, making a collar quite characteristic; pedicels distinct, with 3 to 6 annulations.

Distribution.—On barnacles found growing on the sea buoy.

The hydrothecæ are smaller in these specimens than in those found farther north.

Obelia geniculata (Linnæus).

Sertularia geniculata Linnæus, Systema Naturæ, 1767, p. 1312.
Obelia geniculata Hargitt, American Naturalist, 1901, p. 382. Nutting, Hydroids of Woods Hole, 1901, p. 351.

Trophosome.—Colony usually consisting of a single geniculate stem, an inch or less high, bearing alternate pedicels on shoulder processes; pedicels short, curved so that their hydrothecæ often lie with their long axes horizontal; annulated throughout or with the central portion smooth; hydrothecæ broadly campanulate, depth and width being nearly equal; margin entire.

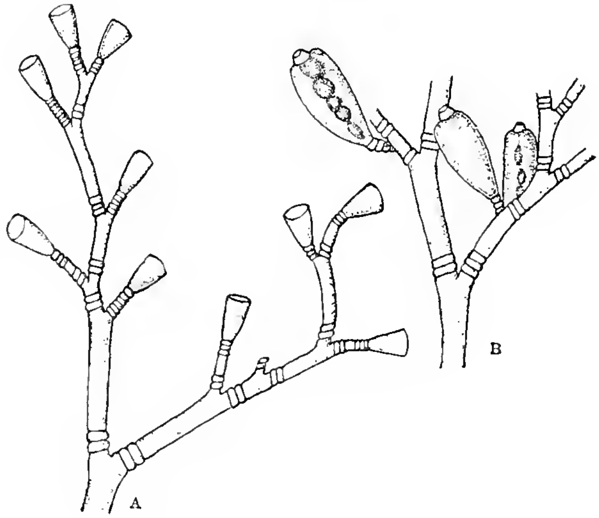

FIG. 22.—*Obelia dichotoma* (Linnæus). A, part of colony to show mode of branching; B, gonosome.

Gonosome.—Gonophores borne in the axils of the pedicels; gonangia nearly oval but tapering slightly to the base, distally provided with a distinct collar that is the same size throughout.

Distribution.—On the crab float at the United States Bureau of Fisheries wharf.

Obelia hyalina Clarke.

Obelia hyalina Clarke, Bull. Mus. Comp. Zool., Harvard, 1879, p. 241.

Trophosome.—Colony small usually from 15 to 20 mm. in height; some colonies scarcely branched, others of about the same height with several branches; stem distinctly geniculate with several annulations above the origin of each branch and pedicel; branches sometimes coming from the axil of a pedicel and sometimes taking the place of pedicels; pedicels either short and annulated throughout or longer and annulated at each extremity; hydrothecæ campanulate, depth and width nearly equal; sometimes there is a tendency to flaring of the margin; margin entire.

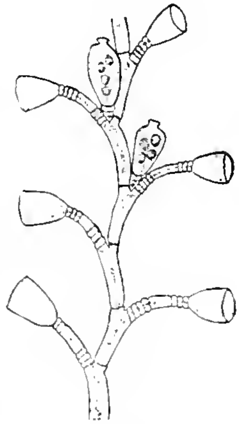

Fig. 23.—*Obelia geniculata* (Linnæus).

Gonosome.—Gonophores borne in the axils of the pedicels; gonangia oval but slightly tapering at the base; distal end either rounded or provided with a distinct collar; length of the gonangium from two to four times the length of the hydrotheca.

Distribution.—Common on sargassum collected off Bogue Bank, but found also growing on tunicates, growing on the piles at Marshallberg and on sponge dredged by the Fish Hawk.

Congdon found some specimens in the Bermudas which he considered to be *Obelia hyalina* Clarke.[a] Hargitt later found specimens on floating sargassum at Woods Hole which he considered to be the same species as Congdon's specimens, but he did not agree with Congdon that it was *O. hyalina*.[b] He called his species *O. congdoni*. Clarke says that in *O. hyalina* "the gonangia are small, about twice the length of the hydrothecæ, rounded off at the distal end, with a simple, spherical, terminal opening which stretches across the distal end," and that the "colony is about 12 mm. in height and but little branched," while in Hargitt's specimens "the gonangia are large, about four times the length of the hydrothecæ, and the opening is not simple, but there is a terminal neck with an everted rim," while "the colony is from 20 to 30 mm. in height and much branched."

In the Beaufort material there were many colonies branched and many unbranched. Those that were branched had the branches coming out either at the axil of the pedicel or taking the place of pedicels. Gonangia with rounded distal ends were found in the same colony as those with distinct collars. There was much variation in size, and though I found few in my own material bearing a ratio of 4 to 1, as compared with the length of the hydrothecæ in the same colony, there were plenty of them with an absolute measurement as high as 7 mm., which is evidently as large as that figured by Congdon. This shows that the size of the ratio is increased by the smaller size of the hydrothecæ, rather than by the larger size of the gonangia, as I found to be the case in the few specimens where I found the ratio as high as 4 to 1. Moreover, in the specimens obtained on the Bahama expedition by Prof. Nutting and diagnosed by him as *Obelia hyalina* Clarke[c] (in this diagnosis he had the use of Prof. Clarke's specimens for comparison), the gonangia show a 4 to 1 ratio.

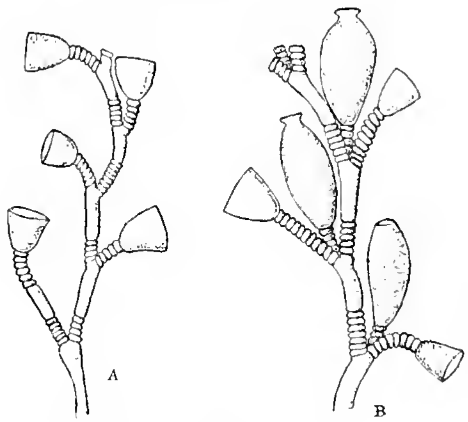

Fig. 24.—*Obelia hyalina* Clarke. A, portion of colony; B, gonangia.

I did not find any colonies as much as 30 mm. high, but that is scarcely a criterion to base a difference of species upon, at any rate, in a branched form. Without being able to compare the specimens visually it is impossible to say with certainty that the specimens all belong to the same species, but from the facts above stated I can not think otherwise than that they do.

[a] Hydroids of the Bermudas, 1907, p. 468.
[b] Biol. Bulletin, 1909, p. 375.
[c] Narrative of the Bahama Expedition, 1895, p. 89, fig. 3.

Family CAMPANULINIDÆ.

Trophosome.—Colonies usually small, often unbranched; hydrothecæ not always pedicellate, tubular, provided with an operculum of converging segments; diaphragm present; hydranths with conical proboscis.

Gonosome.—Gonophores producing sporosacs or free medusæ.

KEY TO THE GENERA OF CAMPANULINIDÆ FOUND IN THE BEAUFORT REGION.

A. Colony unbranched, hydrothecæ sessile, tubular . . . . *Cuspidella.*
B. Colony branched or unbranched, hydrothecæ turbinate . . . . *Lovenella.*

Genus CUSPIDELLA.

Trophosome.—Colony unbranched; hydrothecæ sessile, tubular, with conical operculum which is not distinctly marked off from the remainder of the hydrotheca.

Gonosome.—Unknown.

Cuspidella humilis (Alder).

Campanularia humilis Alder, Trans. Tyne. F. C., V, 1862, p. 239.
Cuspidella humilis Hincks, British Hydroid Zoophytes, 1868, p. 209.

Trophosome.—Sessile, tubular hydrothecæ arise from a creeping stolon; very small, 0.2 mm. in height; operculum of 10 to 12 converging segments.

Gonosome.—Unknown.

Distribution.—Growing on a branching bryozoan on the piles of the railroad bridge, near Beaufort.

FIG. 25.—*Cuspidella humilis* (Alder). A, portion of stolon with three hydrothecæ; B, hydrotheca more highly magnified

Genus LOVENELLA.

Trophosome.—Colony usually branched; hydrothecæ turbinate; operculum sharply defined by a sinuous margin on the tube of the hydrotheca.

Gonosome.—"Gonangia borne on the stems, producing free, bell-shaped medusæ with eight tentacles in two sets, and four lithocysts." (Nutting.)

Lovenella clausa (Loven).

Campanularia clausa Loven, Bidrag till Kannedomen om Släktena Campanularia och Syncoryna, 1836, p. 262.
Lovenella clausa Hincks, Br. Hydroid Zoophytes, 1868, p. 177. Hincks, Ann. and Mag. N. H., 4th ser. 8, 1871, p. 79.
Lovenella gracilis Clarke, Hydroids of Chesapeake Bay, 1882, p. 139.
Lovenella clausa Hartlaub, Die Hydromedusen Helgolands, 1897, p. 501.

Trophosome.—Colony unbranched or slightly branched. In the unbranched forms the pedicels are long and slender, varying much in the extent of their annulation. The stem in the branched forms may be annulated more or less, or wavy in outline. Hydrothecæ are long, turbinate, with much space between the diaphragm and the base; operculum formed of eight wedge-shaped segments, each with a distinct, rounded base, showing plainly the margin of the hydrotheca.

Gonosome.—Gonophores appearing on the stem in much the same way as the hydrothecæ but with short pedicels; gonangia much elongated, about twice the length of the hydrothecæ, somewhat tubular but wider at the distal end or near it and tapering very gradually to the base; distal end truncated. Each gonangium contains about five medusæ, which, when liberated, are globose, have four radial canals and eight tentacles, two of which are rudimentary. Two are large and bulbous at the base; these are opposite two of the radial canals; at the end of the other two canals are the two rudiments; the other four are smaller and are not bulbous at the base. Four lithocysts are present.

Distribution.—Dredged in Bogue Sound, 10 feet.

When Hincks described this species in 1868, he had not seen the gonosome, but later, on finding it, he described and figured it. When Clarke described his species from Chesapeake Bay, he evidently looked up Hincks' first paper but not the second. He obtained specimens of *Lovenella clausa* with the gonosome, and as he considered that the gonosome had not been described, he hesitated to put the specimens in that species, but named them instead *Lovenella gracilis*, though he states that the trophosomes appear to be identical. To quote the descriptions of the gonosome given by these two investigators is sufficient to show that there is strong evidence of the identity of the species.

Hincks' description is as follows:

"Gonothecæ borne on the stems and producing free medusiform zooids.

"Gonozooid.—Umbrella (at the time of liberation) globose; manubrium short, with a simple orifice; radiating canals 4; marginal tentacles of two kinds—4 in connection with the radiating canals, of which 2 only are fully developed at the time of birth, springing from nonocellated, bulbous bases, 4 intermediate, of small size, without bulbs, slightly clavate, with thread-cells only toward the extremity (?); lithocysts 4, one of which is placed halfway between each pair of the larger tentacles and close to one of the smaller.

"The gonotheca of *Lovenella clausa* is borne on a rather long-ringed pedicel, which rises from the stem a short distance below the calycle. It is elongated in form, tapering off from the truncate top

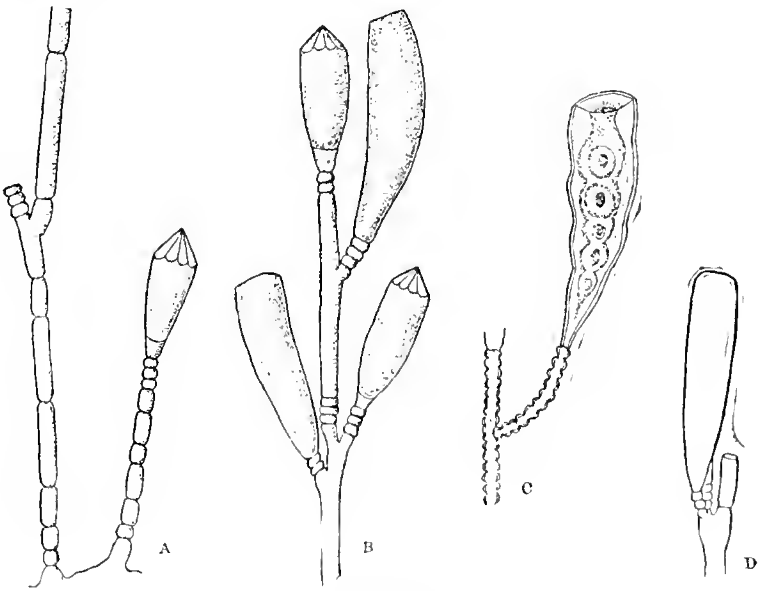

FIG. 26.—*Lovenella clausa* (Loven). A, trophosome; B, gonangia (after Hartlaub); C, gonangium (after Hincks); D, gonangium (after Clarke).

to the base, the sides present a slightly sinuated outline. It contains many gonophores, from each of which a medusiform zooid is liberated."

Clarke says:

"Gonosome.—Gonangia developed from the base of the hydrothecal peduncles, very long and slender, largest at the distal end and tapering toward the base, supported on short pedicels consisting of one to three annulations; from three to five planoblasts developed in each gonangium, aperture terminal.

"Planoblasts 24 hours after liberation round and somewhat flattened in outline, microscopic in size; radial canals four, connected by a circumferential canal at the periphery; marginal tentacles six, of which two are very large, separated at the peripheral extremities by two opposite chymiferous tubes, the four smaller tentacles disposed one on either side of each of the large ones; at the points of the margin of the bell where the two other chymiferous tubes join the peripheral canal there are rounded processes which have the appearance of rudimentary tentacles, as yet undeveloped; lithocysts four in number are located midway between the points where each of the adjoining chymiferous tubes connect with the circumferential tube; the tentacles and the entire surface of the bell are well supplied with nematocysts."

Still later, in 1897, Hartlaub concluded that he was the first to discover the gonosome of the species. It is not necessary to go over his description as his species would naturally agree with Hincks's. This point might be mentioned, however: The length of the gonothecal pedicel described and drawn by Hartlaub more nearly agrees with Clarke's than with Hincks's.

The specimens obtained in this material resemble those of Clarke's in that the annulations of the stem are single and some distance apart, giving the stem a segmented appearance, like the stem of a coralline.

No gonosome was present. In the figure, the gonophores, as drawn by Hincks, Clarke, and Hartlaub, are shown for comparison.

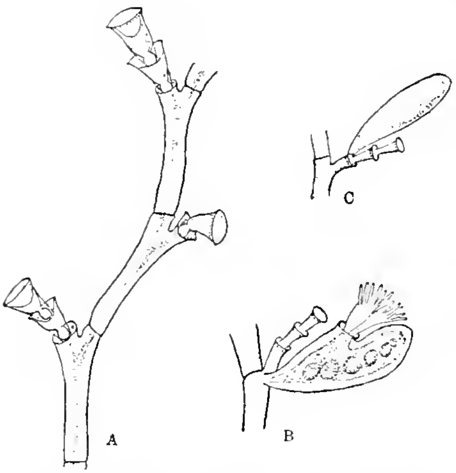

FIG. 27.—*Halecium beani* (Johnston). A, portion of colony; B, female gonosome (after Hincks); C, male gonosome (after Hincks).

Family HALECIDÆ.

Trophosome.—Hydrothecæ reduced to saucer-shaped hydrophores, which usually pass without constriction, into the broad tubular pedicels; they are too small to lodge the contracted hydranth; margin entire, often flaring; reduplication common; hydrophore with a circle of bright dots just below the rim; hydranth with conical proboscis.

Gonosome.—Gonophores produce sporosacs, usually different in the two sexes.

Genus HALECIUM.

Characters as in the family.

KEY TO SPECIES OF HALECIUM FOUND IN THE BEAUFORT REGION.

A. Female gonangia surmounted by hydranths.
  a. Colony large, stem fascicled .... *H. beani.*
  b. Colony minute, branches not all in the same plane .... *H. nanum.*
  c. Colony minute, creeping .... *H. repens.*
B. Female gonangia not surmounted by hydranths.
  a. Stem fascicled .... *H. bermudense.*
  b. Stem minute, simple .... *H. tenellum.*

Halecium beani (Johnston).

Thoa beanii Johnston, British Zoophytes, 1847, p. 120.
Halecium beanii Hincks, Br. Hydroid Zoophytes, 1868, p. 224. Hargitt, American Naturalist, 1901, p. 388.
Halecium beani Nutting, Hydroids of Woods Hole, 1901, p. 358.

Trophosome.—Colony consisting of a fascicled stem which gives off branches at irregular intervals, the largest of these may also be fascicled; these branches may branch again in such a way as to give a zigzag appearance; the branches are divided into internodes by oblique nodes. The hydrophores are given off immediately below the nodes; not flaring very much; margin often reduplicated.

Gonosome.—Gonangia borne at the base of the hydrophore; male, regular, oblong-oval; female mitten-shaped, with the aperture at the end of the portion corresponding to the thumb; two hydranths arise from the aperture.

Distribution.—On red algæ floating on the surface, off Bogue Bank.

The drawing of the gonosome was taken from Hincks as there was no gonosome on the Beaufort material.

? Halecium bermudense Congdon.

Halecium bermudense Congdon, Hydroids of Bermuda, 1907, p. 473.

Trophosome.—Colony not very large, sometimes reaching a height of 35 mm.; main stem fascicled; branches may be slightly geniculate, divided into regular internodes by transverse nodes. Hydrophores alternate, shallow, often reduplicated; when reduplication does take place the succeeding rims are very close together.

Gonosome.—"Colonies diœcious. Gonothecæ sessile at the axils of hydrophores, sometimes found arising from hydrophores. Female gonothecæ ovoid, flattened, with a short pedicel-like base, one side open for two-thirds of its length, the edges of the opening forming two similar compound curves. The blastostyle extends up around the opposite side, curving toward the opening. The development of the eggs is accompanied by the breaking down of the tissue between them and the opening. Male gonotheca cylindrical and usually slender, truncate, and tapering toward base, often marked by an irregular encircling groove somewhat wavy in outline one-third of the way from the base." (Congdon.)

Distribution.—On sponge dredged by the Fish Hawk.

The trophosome, which was all that was found in this case, resembles the trophosome described and figured by Congdon, but without the gonosome it is impossible to be sure of the identification. Congdon's description and figures are given.

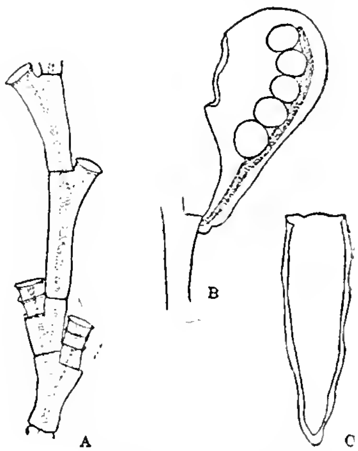

FIG. 28.—*Halecium bermudense* Congdon. A, portion of colony; B, female gonosome (after Congdon); C, male gonosome (after Congdon.)

Halecium nanum Alder.

Halecium nanum Alder, Ann. and Mag. N. H., 3d ser. 3, 1859, p. 355.
Halecium marki Congdon, Hydroids of Bermuda, 1907, p. 474.

Trophosome.—Colony minute, 1.5 to 2 mm. high (Congdon reports them as high as 3 mm.), arising from a much branched stolon, which seems to have more free ends than usual. On one small piece of sargassum may be found colonies in several stages of growth, from those with a single hydrophore only, supported on a tubular pedicel, to those that have attained adult growth. The mode of branching is irregular and characteristic. Usually the main stem consists of the original hydrophore and its pedicel, though that may be extended by reduplication. Just below the hydrophore another pedicel may be given off, which may reduplicate or give off one or two branches and this may be repeated. Branches

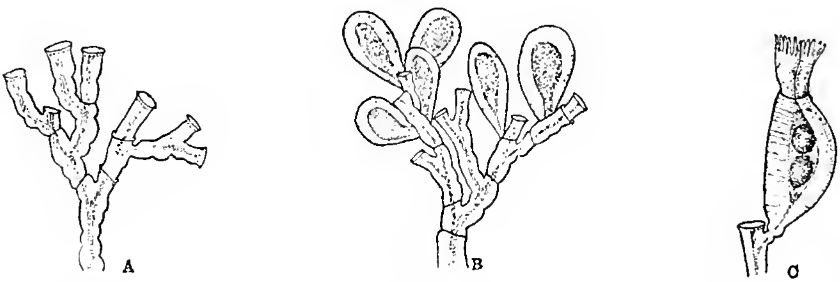

FIG. 29.—*Halecium nanum* Alder. A, portion of colony; B, portion of colony to show male gonosome; C, female gonosome.

may be given off at both sides to make a rather regular bilateral arrangement or they may be almost all on the one side. Frequently they are not all given off in the same plane, though they can scarcely be said to be given off on all sides. The hydrophores are longer than usual among the *Halecidæ*.

Gonosome.—Gonangia given off similar in position to the lateral hydrophores or branches; male ovate or obovate, with a narrow attachment but broadly rounded at the distal end; female larger, with a straight annulated support passing up the one side and the other side forming the segment of a circle; the two unite distally to form a hydrophore for the two hydranths that are given off. In each gonangium there are usually two large ova, the one above the other.

Distribution.—Common on the floating sargassum, collected on the seaward side of Bogue Bank.

There can be little doubt that this species, which is the same that Congdon described from Bermuda as new, is the same that Alder obtained on sargassum from the Azores. Figures and description agree perfectly. Since Alder described it, it was found by Jäderholm [a] in material obtained from the Antilles and by Billard [b] in the Sargasso Sea, consequently its distribution agrees with several other sargassum forms.

? Halecium repens Jäderholm.

Halecium repens Jäderholm, Zool. Anzeiger, bd. XXXII, 1907, p. 373; Northern and Arctic Invert., IV, 1909, p. 54.

Trophosome.—Colony minute, 2 to 5 mm. high, growing from a stolon that creeps over the surface of other hydroids, without giving off any very regular branches. The whole colony may consist of a single hydrophore growing from the stolon, either simple or reduplicated. In other cases a branch is given off from the pedicel just below the hydrophore and this may be repeated to form a secondary

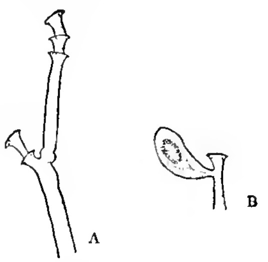

FIG. 30.—*Halecium repens* Jäderholm. A and B, colonies growing from stolon; C, female gonosome (after Jäderholm).

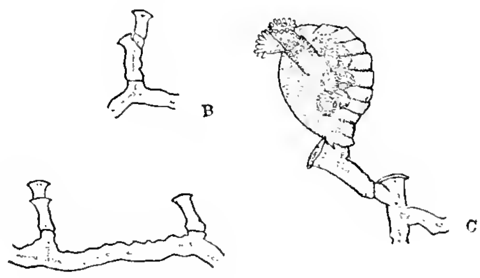

FIG. 31.—*Halecium tenellum* Hincks. A, portion of colony; B, gonosome (after Hincks).

branch, but each branch consists of a single hydrophore and its pedicel, single or reduplicated. Near the proximal end of the pedicel there is an annulation that appears like a wrinkle formed by shoving down the distal end. The perisarc is evidently weak at this point, as many of the colonies are broken off here, leaving a basal stump. Besides this wrinkle, which seems to be always present, there may be other annulations or parts of annulations much less distinct. The hydrophore has a widely flaring rim and the usual circle of dots.

Gonosome.—Female gonangia pear-shaped, somewhat laterally compressed, with the aperture in the side in a distinct collar. From the base of the collar flutings radiate to form incomplete rings around the gonangia. Two hydranths pass out through the aperture.

Distribution.—Found creeping over a colony of *Pasythea quadridentata*, dredged by the *Fish Hawk*.

There were no gonangia on the specimens, and in the genus that is almost necessary to insure identification. The trophosome answers to Jäderholm's description and figure, though I found no colonies as large as those he reports. Some of the features, notably the wrinkling of the pedicel and the creeping nature, seem to be quite distinctive.

One hesitates to place a specimen found at Beaufort with one that has been reported from northern Europe only, but since this is such a minute species it might be readily overlooked, and many other species, among them some described in this paper, have as wide and as varied a range.

I have depended on Jäderholm's description and figure for the characters of the gonosome and evidently he found only female colonies.

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[a] Aussereuropean Hydroiden, 1903, p. 267. [b] Exped. Sc. du Travailleur et du Talisman, 1907, p. 164.

Halecium tenellum Hincks.

Halecium tenellum Hincks, Ann. and Mag. N. H., 3d ser., 8, 1861, p. 252. Hincks, Br. Hydroid Zoophytes, 1868, p. 226. Nutting, Hydroids of Woods Hole, 1901, p. 354.

Trophosome.—Colony small, not over one-half inch in height; stem delicate, sometimes annulated or wavy, irregularly branched; branches given off below the hydrophores, making almost a right angle with the stem; hydrophores strongly flaring, usually reduplicated.

Gonosome.—Gonangia oval or ovate, smooth, borne at the base of the branches or below the hydrophores.

Distribution.—On sponge dredged by the Fish Hawk, on which were specimens of *Aglaophenia rigida*.

There was no gonosome; the figure is taken from Hincks.

Family LAFŒIDÆ.

Trophosome.—Hydrothecæ tubular, margin entire, operculum absent, no diaphragm; hydranth, with conical proboscis.

Gonosome.—Gonangia forming a Coppinia mass.

The genus *Filellum* is the only genus of this family represented in this material.

Genus FILELLUM.

Trophosome.—Stem a slender stolon, parasitic on other hydroids; hydrothecæ, partly adherent, curved outward from the support at the point of separation.

Gonosome.—A Coppinia mass.

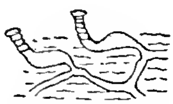

FIG. 32.—*Filellum expansum* Levinsen.

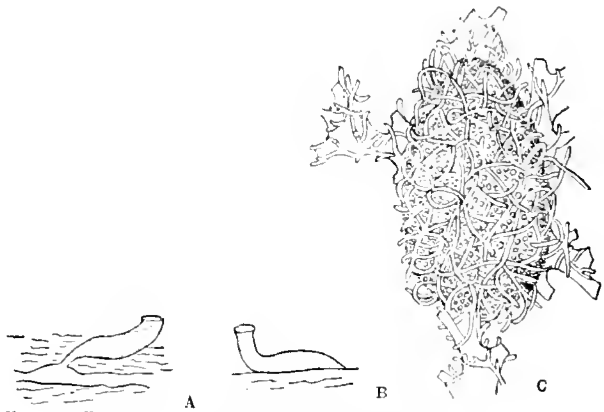

FIG. 33.—*Filellum serpens* (Hassall). A and B, hydrothecæ; C, Coppinia mass (after Bonnevie).

Filellum expansum Levinsen.

Filellum expansum Levinsen, Hydroider fra Grönlands Vestkyst, 1893, p. 30. Fraser, West Coast Hydroids, 1911, p. 50.

Trophosome.—Stolon creeping over other hydroids, Bryozoa, etc.; hydrotheca minute, adherent for about half of its length, to the surface over which the stolon creeps, then abruptly turned away. The free portion is provided with three or more annulations, in the form of ridges, that may be either transverse or oblique. The free portion is more slender than the adherent portion. The margin is flaring.

Gonosome.—Unknown.

Distribution.—On sponge dredged by the Fish Hawk.

Filellum serpens (Hassall).

Campanularia serpens Hassall, Trans. Micro. Soc., III, 1852, p. 163.
Filellum serpens Hincks, Br. Hydroid Zoophytes, 1868, p. 214.
Lafœa serpens Bonnevie, Norske Nordhavs, Ex., 1899, p. 63.

Trophosome.—Stolon usually creeping over other hydroids; hydrothecæ larger than in *F. expansum*, adherent for about two-thirds of the length; not annulated but sometimes striated transversely just below the rim; margin not flaring.

Gonosome.—"Coppinia with thin soft tubes, lying close to the gonangia; irregularly curved." (Bonnevie.)

The gonosome was not found. The description given by Bonnevie is the only one I have seen.

Family HEBELLIDÆ.

(Used by Nutting in MSS.)

Trophosome.—Colony simple, creeping; hydranth with conical or dome-shaped proboscis; hydrothecæ tubular, diaphragm present, no operculum.

Gonosome.—Gonangia separate, not collected in a mass.

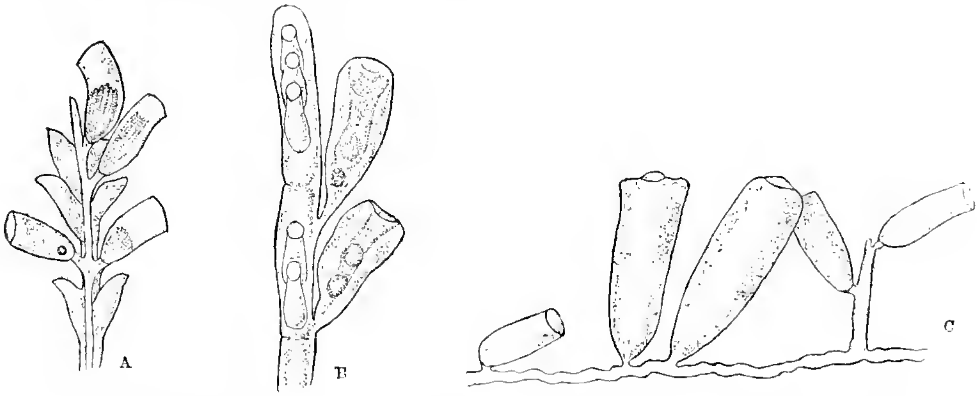

FIG. 34.—*Hebella calcarata* (A. Agassiz). A, colony growing over *Pasythea quadridentata;* B, gonosome from stolon growing over the same hydroid; C, stolon growing on the surface of gulfweed, with hydrothecæ and gonangia.

As indicated in my paper on "West Coast Hydroids," I have felt that there was no proper place for the genus *Hebella* among the Calyptoblastic families that up to the present have been established. To this difficulty another was added, when I came to the study of the Beaufort material, as I found a species that agreed with the genus *Hebella* in every respect except that the gonophores produced sporosacs instead of free medusæ. This was not a new species, as it was described by Ritchie under the name, *Campanularia mutabilis*[a] and by Warren, under the name *Lafœa magna*.[b] It can not belong to the genus *Campanularia*, as it has a tubular hydrotheca and a dome-shaped or conical proboscis, nor to the genus *Lafœa*, as there is a diaphragm present in the hydrotheca and the gonangia are not collected into a Coppinia mass.

In discussing the matter with Prof. Nutting I found that in his manuscript dealing with the *Lafœa* group, a portion of his Monograph of American Hydroids not yet published, he had instituted a new family, the Hebellidæ, to include the genus *Hebella*, the absence of the Coppinia mass and the presence of a diaphragm at the base of the hydrotheca distinguishing it from the Lafœidæ and the conical proboscis separating it from the Campanularidæ. This seemed a satisfactory solution to the difficulty, as it would not only supply a home for the genus *Hebella*, but would also include the other species to which reference has been made. To accommodate this species a new genus must be estab-

[a] The Marine Fauna of Cape Verde Islands, 1907, p. 504. [b] Natal Hydroids, 1908, p. 342.

lished, since the gonophores do not produce free medusæ. To that genus I have given the name *Scandia*. The specific name "*mutabilis*" has priority and has therefore been retained.

Prof. Nutting has kindly given me permission to use the family name, Hebellidæ, in this paper. It thus appears containing the two genera *Hebella* and *Scandia*.

KEY TO THE GENERA OF THE HEBELLIDÆ FOUND IN THE BEAUFORT REGION.

A. Gonophores producing free medusæ . . . . *Hebella.*
B. Gonophores producing sporosacs . . . . *Scandia.*

Genus HEBELLA.

Trophosome.—Colonies consisting of single hydranths attached by short pedicels to a stolon, which usually creeps over other hydroids. A distinct diaphragm is present in the hydrotheca.

Gonosome.—Gonophores producing free medusæ.

Hebella calcarata (A. Agassiz).

Lafœa calcarata A. Agassiz, North American Acalephæ, 1865, p. 122. Hargitt, American Naturalist, 1901, p. 387.
Hebella calcarata Nutting, Hydroids of the Woods Hole Region, 1901, p. 353.

Trophosome.—Colony commonly creeping on other hydroids, especially sertularians, in which case the stolon may creep along the axis of the sertularian and give off its hydrothecæ more or less regularly

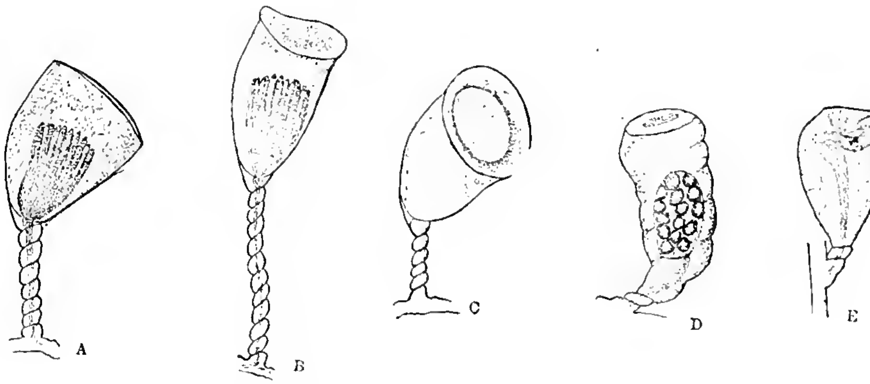

FIG. 35.—*Scandia mutabilis* (Ritchie). A, B and C, different forms of hydrothecæ; D, female gonosome; E, male gonosome.

and symmetrically, so that at first glance it looks like part of the sertularian colony. Occasionally a small portion may become erect without support. When the stolon creeps over an erect hydroid, the hydrothecæ may be given off in pairs, but this is not always the case. When a stolon creeps over a horizontal surface, the hydrothecæ are given off singly. They are tubular, about three times as long as broad, with a smooth surface, attached by means of a very short pedicel; they may be bent so that the sides may form a very distinct curve.

Gonosome.—Gonangia quite large, from one and a half to two times the length of the hydrothecæ, attached to the stolon by short pedicels; they are broad at the distal end and taper gradually to the proximal; the opening does not occupy the whole of the distal end.

Distribution.—Found most commonly growing over *Pasythea quadridentata*, but occasionally on other hydroids and quite often directly on the surface of the gulfweed to which these hydroid hosts were attached.

Genus SCANDIA, new genus.

Trophosome.—Colony simple, creeping, giving off single individuals at intervals along the stolon; hydrothecæ tubular, with narrow diaphragm and entire margin; proboscis dome-shaped.

Gonosome.—Gonophores producing sporosacs.

Scandia mutabilis (Ritchie).

Campanularia mutabilis Ritchie, Hydroids from Cape Verde Islands, 1907, p. 504.
Lafœa magna Warren, Natal Hydroids, 1908, p. 342.

Trophosome.—Colony creeping, giving off single individuals at fairly regular intervals; pedicels short but varying somewhat in length, strongly annulated, the annulations having a spiral arrangement; hydrothecæ large, with flaring rim, often placed obliquely and sometimes reduplicated; shallow corrugations sometimes present; diaphragm narrow but readily distinguishable; proboscis dome-shaped.

Gonosome.—Gonangia borne on the stolon, with shorter pedicels than are usually found for the hydrothecæ, oval in shape; the male much the same shape and size as the hydrothecæ, the female longer and more slender, more or less corrugated; truncate, with the opening much smaller than the whole upper surface.

The gonosome has not been described hitherto.

Distribution.—On *Aglaophenia rigida* and *Aglaophenia minuta* and occasionally directly on the sargassum to which these plumularians were attached; on the seaward side of Bogue Bank.

Family SERTULARIDÆ.

Trophosome.—Hydrothecæ sessile, arranged on both sides of the stem and branches and more or less adnate to them; hydranths with conical proboscis.

Gonosome.—Gonophores producing sporosacs, never free medusæ.

Key to the Genera of Sertularidæ Found in the Beaufort Region.

A. Hydrothecæ in opposite pairs.
- *a.* One pair of hydrothecæ to each internode .... *Sertularia.*
- *b.* Hydrothecæ arranged in groups of pairs .... *Pasythea.*

B. Hydrothecæ alternate.
- *a.* Operculum with one abcauline flap or two flaps .... *Thuiaria.*
- *b.* Operculum with three or four flaps .... *Sertularella.*

Genus PASYTHEA.

Trophosome.—Hydrothecæ opposite, arranged in groups of two or more pairs, the different pairs of each group being unequal in size; margin with two or three teeth; operculum usually with two flaps.

Gonosome.—Gonangia oval with large aperture.

Pasythea quadridentata (Ellis and Solander).

Sertularia quadridentata E. & S., Nat. Hist. Zooph., 1786, p. 57.
Pasythea quadridentata Bale, Australian Hydroid Zoophytes, 1884, p. 112. Bale, Proc. Linn. Soc. N. S. W., 2d ser., III, 1888, p. 770. Nutting, American Hydroids, pt. II, 1904, p. 75.
Pasythea nodosa Hargitt, Biological Bulletin, 1908, p. 114.

Trophosome.—Colony usually from 3 to 8 mm. in height, but sometimes reaching 20 mm.; stem unbranched or slightly branched, arising from a creeping stolon, divided into quite regular nodes, bearing from one to five pairs of hydrothecæ; nodes running obliquely from front to back. Commonly, the first internode has one pair of hydrothecæ and all the others have more than one pair; three pairs are the commonest in the Beaufort specimens. The hydrothecæ of the lowest pair are bent out nearly at right angles, the next pair less so, and the distal pair adhere for the greater part of their length. The members of each pair are united in front, but are some distance apart behind. Most of the colonies have but two, three, or four internodes, but one specimen with as many as 13 was obtained. The margin of the hydrotheca has two or three teeth.

Gonosome.—A single gonophore is borne on the front of the stem just at the base. The gonangium is large, nearly oval, but broader at the distal end than at the proximal, provided with five or six broad corrugations; aperture large, circular, occupying all, or nearly all, of the distal end. An operculum is stretched tightly across the aperture.

Distribution.—Found abundantly on floating sargassum, off Bogue Bank.

In his paper mentioned in the synonymy, Hargitt gives a full description of a species of *Pasythea* which he calls *P. nodosa*, under the impression that it is different from *P. quadridentata*. My specimens would answer his description exactly, but I believe they belong to the species *P. quadridentata*. I have found numerous gonangia and they agree exactly with those of that species. This resemblance is really the determining factor, and I think if Hargitt had found gonangia on his specimens he would have come to the same conclusion. I have compared my specimens with Nutting's types, and I find that the stem supporting the groups of hydrothecæ is much shorter and stouter in mine than in his, but the gonosome is exactly similar. Furthermore, I find that mine agrees perfectly with the figures given by Bale, in both of his papers, and he found his gonangia agreeing with those of *P. quadridentata*.

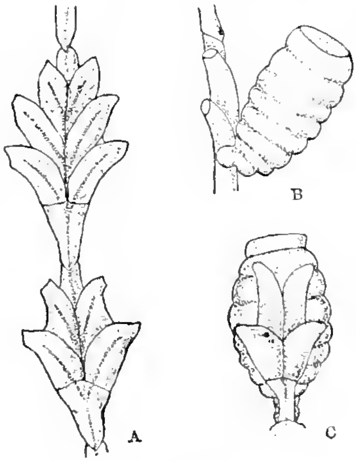

FIG. 36.—*Pasythea quadridentata* (Ellis and Solander). A, portion of colony; B and C, gonangia.

Genus SERTULARELLA.

Trophosome.—Stems and branches usually divided into distinct internodes; hydrothecæ alternate; margin commonly with three or four teeth; operculum with three or four flaps.

Gonosome.—Gonangia large, often annulated.

Sertularella conica Allman.

Sertularella conica Allman, Hydroids of the Gulf Stream, 1877, p. 21. Clarke, Bull. Mus. Comp. Zool., 1879, p. 246. Nutting, American Hydroids, pt. II, 1904, p. 79. Fraser, West Coast Hydroids, 1911, p. 68.

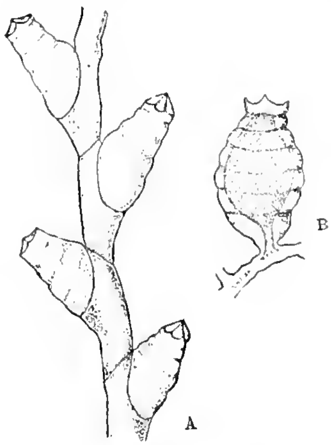

FIG. 37.—*Sertularella conica* Allman. A, portion of colony; B, gonosome.

Trophosome.—Colony attaining a height of 20 mm. in Beaufort specimens, but reported elsewhere as high as 45 mm.; unbranched, or sparsely or irregularly branched; stem divided into regular internodes by oblique nodes, slanting upward to the one side and to the other alternately; hydrothecæ free for about two-thirds of their length, swollen proximally and narrowing distally; shallow corrugations present; margin provided with four rather acute teeth and a four-flapped operculum, the four flaps meeting to form a cone-shaped extremity for the hydrotheca.

Gonosome.—Gonangia on very short pedicels grow directly from the hydrorhiza, oval, corrugated; collar distinct, but little smaller than the part of the hydrotheca on which it rests; margin with four distinct teeth, less acute than those on the margin of the hydrotheca. Apparently the gonophores are produced while the colony is still young, as in the same specimens in which they were present there were stems with only one hydrotheca, some with two and none with more than three or four.

Distribution.—On sponge dredged by the Fish Hawk.

No gonosome was found in these specimens. The description and the drawing have been made from specimens obtained from Vancouver Island and reported in the paper referred to in the synonymy.

Genus SERTULARIA.

Trophosome.—Stem and branches divided into regular internodes, each of which bears a pair of opposite hydrothecæ; operculum of two flaps.

Gonosome.—Gonangia oval or ovate.

KEY TO THE SPECIES OF SERTULARIA FOUND IN THE BEAUFORT REGION.

A. Colony with alternate branches.

Hydrothecæ with free portions almost at right angles to adnate portions...*S. versluysi.*

B. Colony unbranched.

a. Hydrothecæ adnate for two-thirds of their length...*S. cornicina.*

b. Hydrothecæ small, adnate for less than one-half their length, *S. stookeyi.*

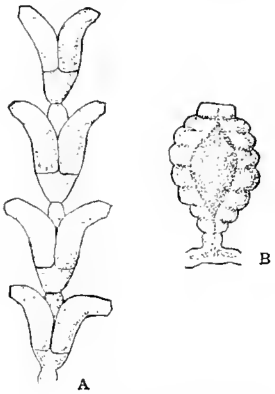

FIG. 38.—*Sertularia cornicina* (McCrady). A, portion of colony; B, gonosome.

Sertularia cornicina (McCrady).

Dynamena cornicina McCrady, Gymn. Charleston Harbor, 1858, p. 204.
Sertularia cornicina Nutting, Hydroids of Woods Hole, 1901, p. 359. Hargitt, American Naturalist, 1901, p. 390. Nutting, American Hydroids, pt. II, 1904, p. 58.

Trophosome.—Colony in the form of an erect stem, usually less than one-half an inch high, without branches; stem divided into regular internodes, each of which bears a pair of opposite hydrothecæ; hydrothecæ tubular, adnate in front for about two-thirds of their length and then turned rather abruptly outwards; margin with two teeth and a two-parted operculum.

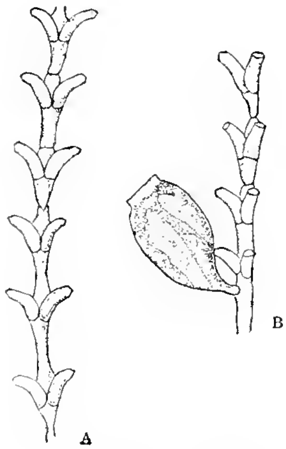

FIG. 39.—*Sertularia stookeyi* Nutting. A, portion of colony; B, gonosome.

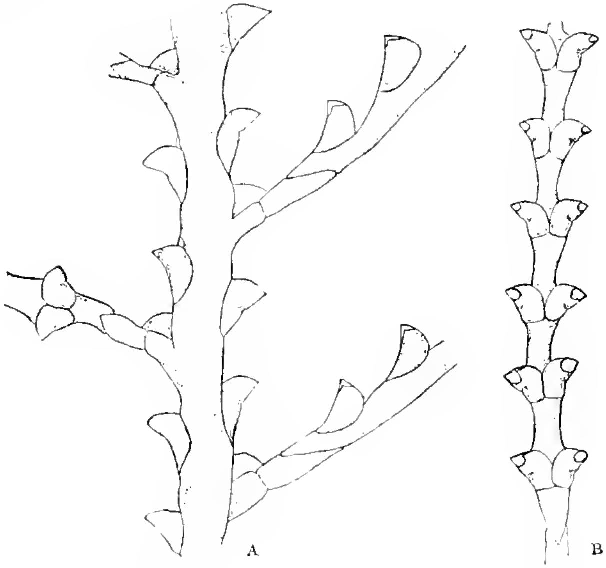

FIG. 40.—*Sertularia versluysi* Nutting. A, portion of main stem; B, portion of branch.

Gonosome.—Gonangia borne on the stolon, oval with a distinct but rather short collar; regularly annulated.

Distribution.—On floating seaweed and gulfweed in Bogue Sound; in North River and the Straits at a depth of about 10 feet; on sponge dredged by Fish Hawk.

In some cases *Hebella calcarata* was found associated with this species, but not so commonly as has been reported from other localities.

Sertularia stookeyi Nutting.

Sertularia stookeyi Nutting, American Hydroids, pt. II, 1904, p. 59.

Trophosome.—Colony an unbranched stem which may reach a height of one-half inch, very slender. The proximal part of the stem is not divided into distinct internodes, but the remainder is divided into long, slender internodes, each of which bears a pair of opposite hydrothecæ. In conformity with the slenderness of the stem, the hydrothecæ are smaller than are usually found in this genus. The two on one internode are adnate in front of the stem for not more than the proximal third of their length, after which they gradually diverge, so that the distal third is free from the stem. In some colonies, probably old ones, these portions were much prolonged. The margin has two teeth and a two-parted operculum.

Gonosome.—Gonangia borne on the front of the stem, immediately below the proximal pair of hydrothecæ, oval with a distinct collar and operculum; no annulations on the surface; pedicel short and curved.

Distribution.—Common. Often accompanying *S. cornicina* on floating seaweed and gulfweed; dredged in Bogue Sound, North River and the Straits in 10 feet; on sponge dredged by the Fish Hawk.

Sertularia versluysi Nutting.

Desmoscyphus gracilis Allman, Challenger Report, Hydroids, 1888, p. 71.
Sertularia versluysi Nutting, American Hydroids, pt. II, 1904, p. 53.

Trophosome.—Colony branched, varying much in height, but not reaching higher than 2 inches. Sometimes the stem is divided into regular internodes, with a branch and two hydrothecæ on one side and one hydrotheca on the other, but at other times the nodes are indistinct or absent. Branches are given off alternately and regularly. The main stem may be straight, in which case the branching gives it a regular appearance, or it may be more or less geniculate with the branches given off at the bends, so that it seems almost dichotomous. Each branch has a transverse node followed by an oblique node before the proximal hydrothecæ are given off. As in the case of the stem, the nodes may be indistinct, absent, or distinct and regular. The hydrothecæ are arranged alternately on the stem, but are strictly opposite on the branches, the pairs being rather distant. The hydrothecæ are short and stout, the proximal portion being very turgid, those of the pair being adnate. The distal portions are bent so abruptly as to produce a wrinkle on the concave side. The margin has two teeth and an operculum of two flaps.

Gonosome.—Unknown.

Distribution.—On *Sargassum* collected on the seaward side of Bogue Bank.

Genus THUIARIA.

Trophosome.—Stem divided into irregular internodes with more than one hydrotheca to each internode, or undivided; hydrothecæ alternate; margin entire or with one or two teeth; operculum with one abcauline flap or two flaps.

Gonosome.—Gonangia oval or obovate, often supplied with spines on the shoulder.

Thuiaria fabricii (Levinsen).

Sertularia fastigiata Fabricius, Fauna Grœnlandica, 1780, p. 458.
Sertularia fabricii Levinsen, Vid. Middel. Naturh. Foren., 1892, p. 48.
Thuiaria fabricii Nutting, Hydroids of the Harriman Ex., 1901, p. 185. Nutting, American Hydroids, pt. II, 1904, p. 71.

Trophosome.—Colony reaching a height of 2 inches; main stem straight, divided into irregular internodes, the distal ones each giving rise to one or more branches, which come off on all sides to give a bushy appearance; branches divided dichotomously; irregular internodes give rise to a varying number of hydrothecæ, five to seven being common; hydrothecæ slightly flask-shaped but slightly outcurved, distal portion free; margin with two blunt teeth; operculum with a large adcauline flap and a smaller abcauline flap.

Gonosome.—Gonangia borne on the upper sides of branches and branchlets, often forming a row; oblong-obovate in shape, with a tapering collar and circular opening; two small spines may be present on the shoulder.

Distribution.—Found in the Fish Hawk material, some specimens attached to a crab and some growing on *Aglaophenia rigida*.

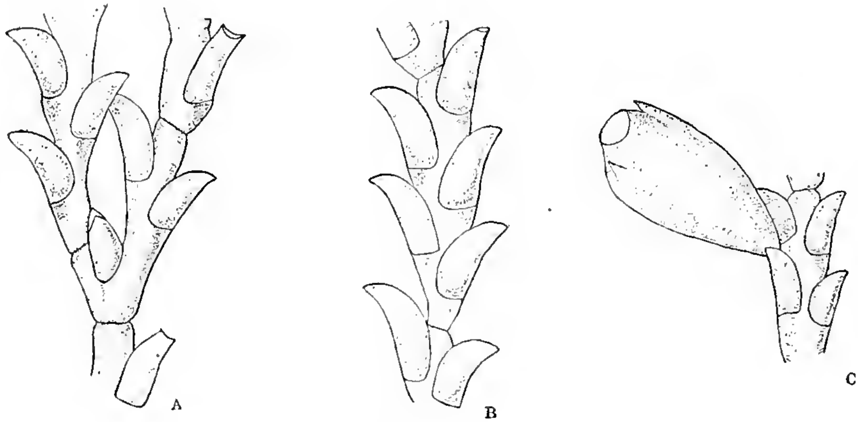

FIG. 41.—*Thuiaria fabricii* (Levinsen). A and B, portions of colony; C, gonosome.

There was no gonosome present in the material obtained. The drawing and description were made from a specimen of Prof. Nutting's, obtained at Orca, Alaska, during the Harriman Alaska expedition.

Family PLUMULARIDÆ.

Trophosome.—Hydrothecæ sessile, usually adnate by one side, arranged on the upper side of the hydrocladia; nematophores always present.

Gonosome.—Gonophores producing sporosacs, which are often protected by corbulæ.

KEY TO THE GENERA OF PLUMULARIDÆ FOUND IN THE BEAUFORT REGION.

A. Statoplean forms, i. e., those with fixed nematophores which are usually monothalamic.
- *a*. Gonosome protected by corbulæ, each of which is a modified hydrocladium.... *Aglaophenia*.
- *b*. Gonosome provided with protective branchlets, each of which is a modified hydrocladium *Lytocarpus*.

B. Eleutheroplean forms, i. e., those with moveable nematophores which are usually bithalamic.
- *a*. Gonangia not especially protected.
  - I. Hydrocladia pinnately arranged.
    - 1. Each hydrocladium bears more than one hydrotheca .... *Plumularia*.
    - 2. Each hydrocladium bears a single hydrotheca....................... ..*Monotheca*.
  - II. Hydrocladia all springing from upper side of branches .... *Monostæchas*.
- *b*. Gonangia protected by a forking of the hydrocladia.......................... *Schizotricha*.

Genus AGLAOPHENIA.

Trophosome.—Hydrothecal margin provided with sharp teeth; posterior intrathecal ridge present; one mesial and two supracalycine nematophores for each hydrotheca always present.

Gonosome.—Gonangia inclosed in true corbulæ, formed of modified pinnæ. There are no hydrothecæ at the bases of the gonangial leaves.

KEY TO THE SPECIES OF AGLAOPHENIA FOUND IN THE BEAUFORT REGION.

A. Colonies branched.
- *a.* Branching regularly pinnate or twice-pinnate .... *A. acacia.*
- *b.* Branching irregular, branches coming off singly or in pairs from the anterior of the stem. *A. rigida.*

B. Colonies unbranched .... *A. minuta.*

Aglaophenia acacia Allman.

Aglaophenia acacia Allman, Challenger Report, pt. xx, Hydroida, 1883, p. 38.

Trophosome.—Colony reaching a height of 6 inches. There are no branches on the proximal portion of the stem, but distally they are given off regularly, in opposite or subopposite pairs. These branches

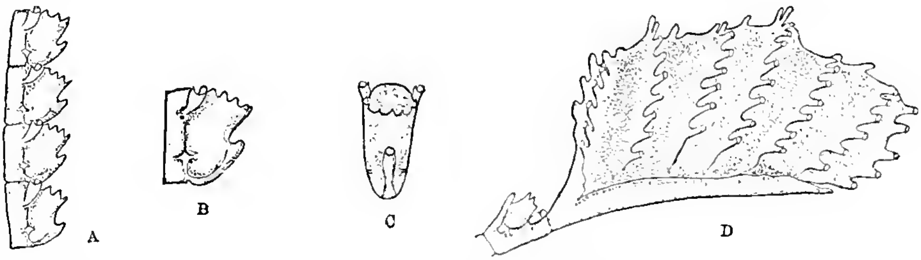

FIG. 42.—*Aglaophenia acacia* Allman. A, portion of hydrocladium; B, hydrotheca, side view, more highly magnified; C, hydrotheca, front view, more highly magnified; D, corbula (after Allman).

may also give off branches in pairs to form a twice-pinnate arrangement. The whole colony has a much more spreading appearance and is much more graceful than *A. rigida.* The internodes of the main stem are not distinctly marked off, or at any rate not so distinctly as some other species; the hydrocladial shoulder is near the middle of each internode. Each internode has two nematophores, one above and one below the shoulder. The hydrocladia are very regularly arranged, are all nearly the same length, from 5 to 8 mm., throughout the larger portion of the branch or branchlet, but gradually shorten toward the distal end to produce a gracefully rounded effect. The hydrocladia are divided into regular internodes, each of which has an internal ridge at the base of the supracalycine nematophore and one opposite the intrathecal ridge. The hydrothecæ are rather deep in comparison with their width. The margin has about nine teeth, rather sharp and deeply cut. The intrathecal ridge is short but very distinct. The supracalycine nematophores are stout, reaching to about the margin of the hydrotheca or a little above it. The mesial nematophore reaches more than half way up the anterior wall of the hydrotheca; the distal portion is free.

Gonosome.—"Corbulæ rather short and deep, with about six pairs of closely adnate costæ."—Allman.

Distribution.—From fishing grounds outside of Beaufort Harbor.

As there was no gonosome present, the description and the figure are taken from Allman's paper.

Aglaophenia minuta Fewkes.

Aglaophenia minuta Fewkes, Bull. Mus. Comp. Zool., 1881, p. 132. Nutting, American Hydroids, pt. 1, 1900, p. 96.

Trophosome.—Colony unbranched, usually from 10 to 15 mm. high, but reaching as high as 20 mm.: the stolon is regularly annulated; stem with one or two oblique nodes near the base and the remainder divided by transverse nodes into regular internodes each of which gives off a hydrocladium near its distal end; hydrocladia divided into regular internodes, each of which has two internal ridges, the one at the base of the supracalycine nematophore and the other opposite the intrathecal ridge; hydrothecæ short and stout, turned well outward at the distal end; margin with sharp teeth; intrathecal ridge extending well across; a broad keel present which passes up the anterior surface to the top of the

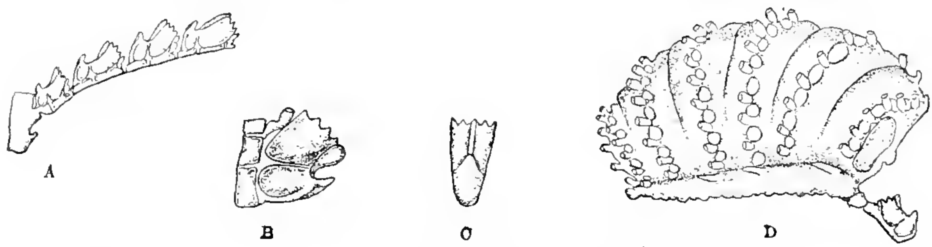

FIG. 43.—*Aglaophenia minuta* Fewkes. A, portion of hydrocladium; B, hydrotheca, side view, more highly magnified; C, hydrotheca, front view, more highly magnified; D, corbula.

hydrotheca; supracalycine nematophores small, geniculate, not reaching so high as the margin of the hydrotheca; mesial nematophore short, with distal end free, the free portion being partially separated from the remainder by a deep constriction.

Gonosome.—Corbulæ large, borne on a modified hydrocladium, which is usually the one nearest the base; corbulæ short, stout, rounded, composed of 7 or 8 pairs of leaves, which meet only at the base of the nematophores, thus leaving a pair of perforations for each row. Each leaf has a row of nematophores and a large spine at the base.

Distribution.—Found plentifully on the *Sargassum* that floated in to the seaward side of Bogue Bank.

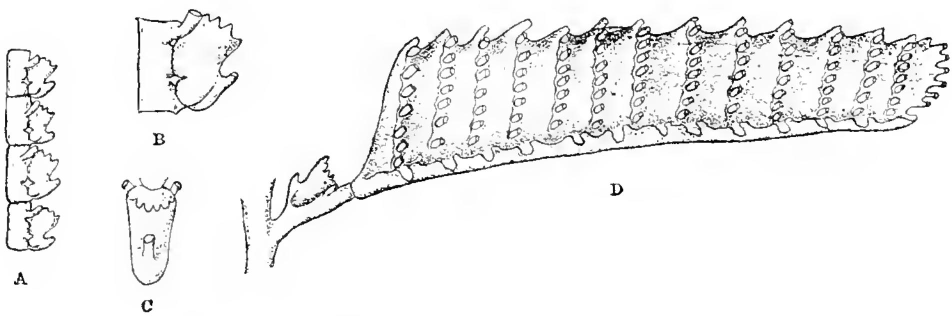

FIG. 44.—*Aglaophenia rigida* Allman. A, portion of hydrocladium; B, hydrotheca, side view, more highly magnified; C, hydrotheca, front view, more highly magnified; D, corbula (after Nutting).

Aglaophenia rigida Allman.

Aglaophenia rigida Allman, Mem. Mus. Comp. Zool., 1877, p. 43. Nutting, American Hydroids, pt. 1, 1900, p. 91.

Trophosome.—Colonies reaching a height of 8 inches in specimens obtained but reported as high as 24 inches; stem simple, slender and wiry, divided into regular internodes, each of which gives rise to a hydrocladium; branches few in number, often absent, usually given off in pairs from the front of the stem. Hydrocladia up to 10 mm. in length, divided into regular internodes; two internal ridges present in the usual position. The hydrotheca occupies almost the whole length of the internode, so that there is little space between any two in succession; it is stout as compared with its depth and is provided with eight deeply cut marginal teeth; supracalycine nematophores reach about to the level of the margin of the hydrotheca and the mesial nematophore is about half the height of the hydrotheca: a small portion of its distal end is free.

Gonosome.—"Corbulæ long, cylindrical, with 12 to 14 pairs of leaves when mature; leaves closed, each with a row of nematophores along its distal edge, and a short, stout spur at its base."—Nutting.

Distribution.—On floating *Sargassum* and on sponge dredged by the Fish Hawk.

Many specimens of this species were obtained but there was no gonosome present. The description and the figure were taken from Prof. Nutting's monograph.

Genus LYTOCARPUS.

Trophosome.—Stem fascicled, with large, triangular nematophores and a perforated process at the base of each hydrocladium; both the supracalycine and the mesial nematophores may have two openings.

Gonosome.—"Gonangia borne on hydrocladia which are modified to form protective branchlets often aggregated into a pseudo-corbula, which differs from a real corbula in the fact that its leaves are formed by modified hydrocladia instead of appendages to hydrocladia, as in the genus *Aglaophenia*. The gonangia take the place of hydrothecæ in the species which I have examined, and there is a hydrotheca on the proximal part of each protective branch."—Nutting.

Lytocarpus philippinus (Kirchenpauer).

Aglaophenia philippina Kirchenpauer, Ueber die Hydroidenfamilie, Plumularidæ, pt. 1, 1872, p. 45.

Lytocarpus philippinus Nutting, American Hydroids, pt. 1, 1900, p. 122.

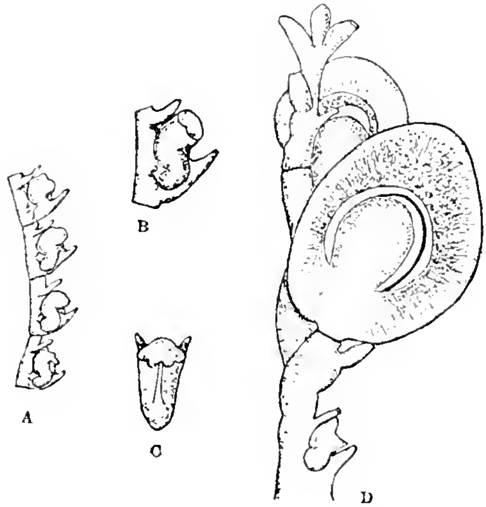

Fig. 45.—*Lytocarpus philippinus* (Kirchenpauer). A, portion of hydrocladium; B, hydrotheca, side view, more highly magnified; C, hydrotheca, front view, more highly magnified; D, gonosome with phylactocarp (after Nutting).

Trophosome.—Colony twice pinnately branched, the secondary branches bearing the hydrocladia; no complete specimens were obtained, but a height of 8 inches has been reported; stem, primary and secondary branches fascicled; hydrocladia alternate, divided into regular internodes, the nodes not very distant; each internode with two internal ridges; hydrotheca with a deep constriction in front, around which the hydrotheca seems to bend, so that the margin is nearly parallel with the axis of the hydrocladium; margin wavy but not very definitely toothed; intrathecal ridge distinct but not very long; supracalycine nematophore long, tubular, extending past the margin of the hydrotheca; mesial nematophore long, tubular, reaching (in these specimens) beyond the margin of the hydrotheca. Supracalycine and mesial nematophores have two openings each.

Gonosome.—"Gonangia flattened, ovoid, borne on modified hydrocladia, each with a hydrotheca on its proximal end; the next hydrotheca is replaced by a gonangium, and there is usually a second gonangia above the first, the remaining portion of each phylactocarp is straight and armed with nematophores."—Nutting.

Distribution.—Dredged in Bogue Sound, 10 feet; on seaweed growing in shallow water off Shackleford.

These specimens agree with those referred to by Congdon[a] in having the mesial nematophore long, and not ending below the level of the margin of the hydrothecæ as Nutting describes. No gonosome was obtained. The description and the drawing for this was taken from Prof. Nutting's monograph.

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[a] Hydroids of Bermuda, 1907, p. 484.

Genus MONOSTÆCHAS.

Trophosome.—Colony dichotomously branched; hydrocladia all springing from the upper side of the branches; cauline nematophores absent.

Gonosome.—Gonangia without special protection; oval or ovate.

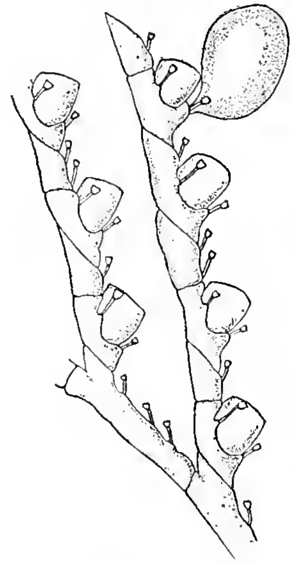

FIG. 46.—*Monostæchas quadridens* (McCrady).

Monostæchas quadridens (McCrady).

Plumularia quadridens McCrady, Proc. Elliott Soc., 1857, p. 97.
Monostæchas quadridens, Nutting, American Hydroids, pt. 1, 1900, p. 75.

Trophosome.—Colony attaining a height of 6 inches, dichotomously branched; branches coming off from the main stem at irregular intervals; branches divided into long internodes, each internode giving rise to a hydrocladium from its upper side and distal end; several long, slender nematophores are present on the upper side of each internode. The hydrocladia are given off at such an angle that they all pass up in the same general direction as the main stem and hence run parallel to one another. Each hydrocladium is divided into alternate hydrotheecate and intermediate internodes, the proximal one being hydrotheecate. Each hydrotheecate internode is oblique proximally and straight distally, each intermediate, straight proximally and oblique distally. Hydrothecæ large, campanulate; supracalycine nematophores, borne on distinct internodal processes, reach to or above the margin of the hydrothecæ; mesial nematophore present; one or two nematophores to each intermediate internode.

Gonosome.—Gonangia oval to spherical, borne on a process immediately below the hydrotheca, often occurring in series, one for each hydrotheca for some distance along the hydrocladium. Each gonangium is provided with a pair of nematophores at the base.

Distribution.—On sponge dredged by the Fish Hawk.

Genus MONOTHECA.

Trophosome.—Stem usually unbranched; hydrocladium consisting of a proximal nonhydrotheecate and a distal hydrotheecate internode. The latter is terminated by a pair of nematophores.

Gonosome.—"Gonangia borne on the stem, usually on the proximal portion, ovate or sac-shaped and without protective appendages."—Nutting.

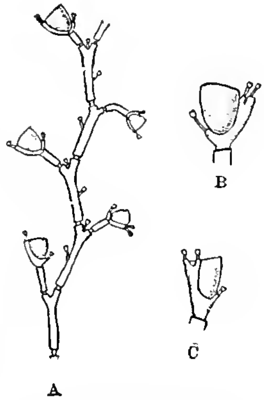

FIG. 47.—*Monotheca margaretta* Nutting. A, portion of colony; B and C, hydrothecæ.

Monotheca margaretta Nutting.

Monotheca margaretta Nutting, American Hydroids, pt. 1, 1900, p. 72.

Trophosome.—Colony reaching a height of nearly half an inch, usually unbranched; stem divided into regular internodes by a double annulation, the portion between the rings being of less diameter than the remainder of the stem, regularly geniculate so that it looks like *Obelia geniculata* in miniature. A hydrocladium is given off at the distal end of each internode. The proximal internode of each hydrocladium, which is nonhydrotheecate, is connected with the stem by a joint, similar to those on the stem. The distal internode (there are but two) is curved to support the hydrotheca and is bifid at the extremity, each portion of the fork having a nematophore; these would correspond to the regular supracalycine nematophores of the genus *Plumularia*. A mesial nematophore is present, situated on a process below the hydrotheca. The hydrotheca is deeply campanulate. A single nematophore is found on each stem internode and one or two in each of the axils.

Gonosome.—Unknown.

Distribution.—On floating *Sargassum* off Bogue Bank.

Genus PLUMULARIA.

Trophosome.—Hydrocladium unbranched, pinnately arranged, each having more than one hydrotheca; hydrothecæ with entire margins; all nematophores movable.

Gonosome.—Gonangia without extra protection.

KEY TO THE SPECIES OF PLUMULARIA FOUND IN THE BEAUFORT REGION.

A. Hydrocladia arising from alternate internodes only . *P. alternata*.
B. Hydrothecæ cylindrical, but slightly adnate ...... *P. floridana*.
C. Hydrocladia usually without intermediate internodes . *P. inermis*.
D. Hydrocladial internodes with numerous internal ridges, *P. setaceoides*.

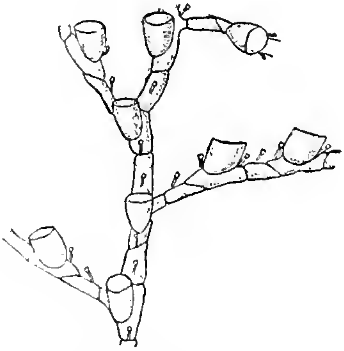

FIG. 48.—*Plumularia alternata* Nutting.

Plumularia alternata Nutting.

Plumularia alternata Nutting, American Hydroids, pt. 1, 1900, p. 62.

Trophosome.—Colony attaining a height of about half an inch, simple, unbranched; stem geniculate, divided into internodes, of which every alternate one bears a hydrotheca and a hydrocladium. This makes the hydrothecæ more distant than usual. Hydrocladia divided into regular internodes, hydrothecate and nonhydrothecate alternating; hydrothecate internodes bounded by oblique nodes proximally and transverse nodes distally; hydrothecæ deeply campanulate with about one-third of the distal end free; supracalycine and mesial nematophores present. There is one nematophore on each internode, one at the axil of the hydrocladium and one on each internode of the stem.

Gonosome.—Unknown.

Distribution.—Found in abundance on floating *Sargassum* and *Turbinaria*.

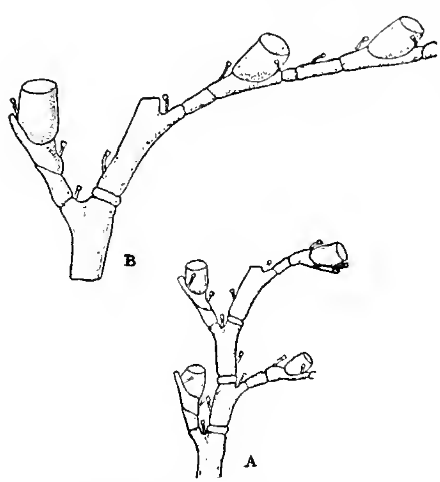

FIG. 49.—*Plumularia floridana* Nutting. A, portion of colony showing part of main stem; B, portion of colony, more highly magnified.

Plumularia floridana Nutting.

Plumularia floridana Nutting, American Hydroids, pt. 1, 1900, p. 59.

Trophosome.—Colony attaining a height of about half an inch, simple, unbranched; stem divided into regular internodes, each of which gives rise to a hydrocladium from a process at its distal end. There may be two or three annulations at each node. Hydrocladia divided into alternate hydrothecate and nonhydrothecate internodes, the proximal being nonhydrothecate. Sometimes the intermediate internodes may be again divided. Hydrothecæ large, when the small size of the hydrocladia is considered, nearly cylindrical, with sometimes more than the distal half free; nematophores small, supracalycine and mesial nematophores present, one on each of the intermediate but none on the proximal internode, one in the axil of each hydrocladium and one on each internode of the stem.

Gonosome.—Unknown.

Distribution.—On floating *Sargassum* off Bogue Bank, rare.

Plumularia inermis Nutting.

Plumularia inermis Nutting, American Hydroids, pt. 1, 1900, p. 62.

Trophosome.—Colony simple, unbranched, reaching the height of about half an inch; divided into regular, long, slender internodes, each of which bears a hydrocladium from a process at its distal end. The hydrocladia are divided into regular internodes, all of which, including the proximal, bear hydrothecæ, except very occasionally when there may be an intermediate internode. These internodes are long and slender, so that there is a long interval between two successive hydrothecæ. Hydrothecæ shallow campanulate; supracalycine nematophores are absent. There is a nematophore above and one below the hydrotheca and one at the axil of each hydrocladium; hydranths too large to be entirely retracted into the hydrothecæ.

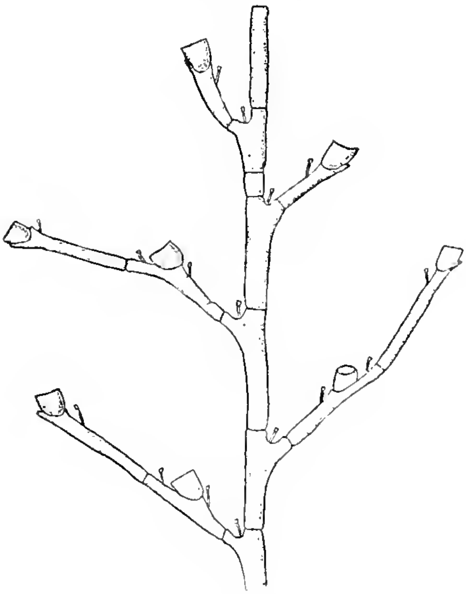

FIG. 50.—*Plumularia inermis* Nutting.

Gonosome.—Unknown.

Distribution.—On *Turbinaria* off Bogue Bank.

Plumularia setaceoides Bale.

Plumularia setaceoides Bale, Hydroida of Southeastern Australia, 1881, p. 28.

Trophosome.—Colony, in Beaufort specimens, not more than 1 inch in height, but Bale reports them up to 3 inches; simple, unbranched, divided into regular internodes, each giving off a hydrocladium from a process near the distal end; two or even three or four annulations at each node; hydrocladia slender, recurved, with alternating nonhydrothecate and hydrothecate internodes, the proximal being nonhydrothecate. This and all the intermediate internodes have two internal ridges. The hydrothecate internodes have one or two ridges proximal to the hydrotheca and one opposite the base of the hydrotheca. Hydrothecæ cup-shaped, with about one-third of the distal end free; supracalycine nematophores present, one nematophore below the hydrotheca, one on each intermediate internode but none on the proximal, one in the axil of each hydrocladium and one on each internode of the stem.

Gonosome.—Gonangia very large for such a slender colony, borne on the face of the stem, at the base of the hydrocladium. Bale reports them as sometimes forming two rows reaching halfway up the stem, but I found them singly only. They are oblong in shape but are curved so that the convex lower surface is much longer than the concave upper surface, and the whole gonangium projects outward almost at right angles to the stem. Proximally it tapers gradually to the point of attachment, distally it is truncate. There are several distinct, though not very deep corrugations.

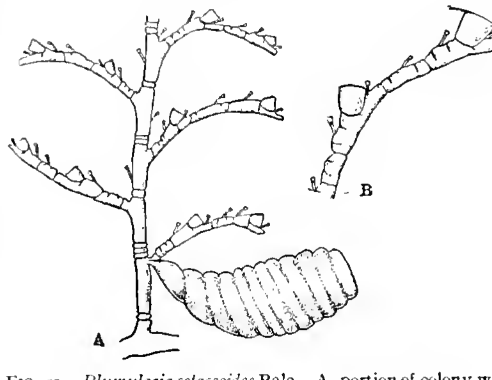

FIG. 51.—*Plumularia setaceoides* Bale. A, portion of colony with gonangium; B, hydrocladium, more highly magnified.

Distribution.—On floating *Sargassum* and *Turbinaria* off Bogue Bank.

Genus SCHIZOTRICHA.

Trophosome.—Colony simple, branched, with hydrocladia pinnately arranged.

Gonosome.—Gonangia springing from the stem, branch or hydrocladium, not directly protected.

Schizotricha tenella (Verrill).

Plumularia tenella Verrill, Invert. An. Vineyard Sound, 1874, p. 731.

Schizotricha tenella Nutting, American Hydroids, pt. 1, 1900, p. 80.

Trophosome.—Colonies usually growing in clusters, reaching a height of 2 inches but usually much less than that in the Beaufort specimens; stems dichotomously branched; divided into internodes, each alternate one bearing a hydrocladium and a hydrotheca; hydrocladia slender, often branched, divided into three kinds of internodes, the one following the other in regular succession, the first a short internode without any nematophore and with a transverse node at its distal end, the second somewhat longer, with one or two nematophores and with an oblique node at its distal end, the third about the same length as the second or longer, bearing a hydrotheca, with two supracalycine nematophores and a nematophore below the hydrotheca; hydrotheca cup-shaped to cylindrical, with about one-half of the distal end free. There are two or more nematophores on each of the stem internodes.

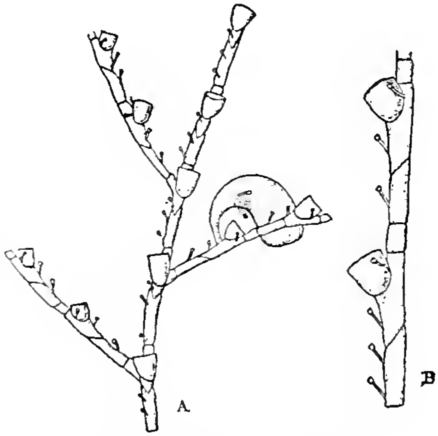

FIG. 52.—*Schizotricha tenella* (Verrill). A, portion of colony showing gonangium; B, portion of hydrocladium, more highly magnified

Gonosome.—Gonangia appearing at the base of the hydrothecæ, curved-cornucopia-shaped, with three or four nematophores not far from the base.

Distribution.—Rather common in water about 10 feet deep in Bogue Sound and North River; found also on the piles at Marshallberg.

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NOTES ON A NEW SPECIES OF FLATFISH FROM OFF THE COAST OF NEW ENGLAND

By William C. Kendall
Assistant, Bureau of Fisheries

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About April 18, 1912, the Bureau of Fisheries received from Mr. John R. Neal, of Boston, three specimens of flounders taken in an otter trawl on one of the offshore banks of New England. An examination of these specimens and comparison with known American and European flatfish indicated that they were a hitherto undescribed species.

On May 22, 11 additional specimens were received from Mr. Neal, by request, and examination supported the view that they were new to science.

Something over 15 years ago the writer was told by a Georges Banks fisherman that occasionally flounders were taken on Georges Banks that were known to the fishermen as "lemon sole," owing to their prevailing yellow coloration. The identity of this fish was never definitely determined, but it was thought that it was probably the "rusty dab" (*Limanda ferruginea*). Mr. B. A. Bean, Assistant Curator of Fishes, United States National Museum, recently informed the writer that a number of years ago the Museum received from Mr. Eugene Blackford, of Fulton Market, New York, a number of large flounders taken in deep water off the New England coast which were then decided to be a deep-water form of *Pseudopleuronectes americanus.*

While the differences between this form and *P. americanus* are not very great, they appear to be collectively constant, although many of the characters individually approach *P. americanus* very closely. In fact, some of them, especially those exhibited by single specimens of each form examined, may disappear in an examination of larger series, particularly of fish of similar sizes, as the gillrakers and teeth of most fishes vary in number and character with the age of the fish. All of the differences, even, may be found to intergrade, but on the principle that a binomial name should represent what is known rather than what is not, it is believed that what is shown in the following descriptions and tables entitles this fish to be considered a distinct species until complete intergradation shall have been proved. Should such an intergradation be discovered, the name will only be lengthened to a trinomial and will still bear the terminal attributive signifying "worthy."

The most conspicuous differential characteristics of this species consist of a somewhat shorter head, a larger number of vertical fin rays, the coloration, and the large size attained; which, taken with its deep-water habitat and different spawning season from that of *P. americanus*, seem sufficiently distinctive.

Pseudopleuronectes dignabilis Kendall, new species.

Head, 4.5 in length without caudal; depth, 2.2; eye, 6.5; snout, 5.4 in head; dorsal, 68; anal, 50; scales, 85.

Body broadly elliptical, dextral, its greatest depth about in a line between the twenty-seventh dorsal and eleventh anal rays; lateral line nearly straight; distance from the posterior end of the dorsal to base of upper caudal ray equal to distance from posterior end of anal to base of lower caudal ray, about 2.66 in head and less than the width of the narrowest part of the caudal peduncle, immediately back of the vertical fins, which is about 1.75 in head; scales on right side strongly ctenoid but entirely smooth on left; scales extending nearly to tips of most of the rays of all of the fins on right side; first 15 and last 6 dorsal, and first 5 and last 6 anal rays without scales; fortieth dorsal ray about equaling twenty-sixth anal ray in length, the longest ray in each fin about 1.9 in head; pectoral moderate, 1.60 in head; ventral short, about 2.60 in head; head comparatively short, almost entirely scaled on right side and wholly naked on left; mouth small, lips thick, the lower with a sort of thick triangular projection at its symphysis, turned somewhat to the right; close set incisor teeth in both jaws, mostly on the blind side; gape much less than the length of upper jaw (maxillary and premaxillary); upper jaw 4, mandible about 2.70, in head; preorbital in widest part about 7.40, snout (consisting of preorbital and premaxillary widths) about 4.20 in head; eye moderate and prominent; interorbital almost flat and scaly, more than ½ eye, about 10.20 in head.

Color: generally light yellowish-brown with irregular wash of lemon yellow; center of each scale bluish-gray, the brown forming a broad margin; some variously sized blotches of darker brown, the brown covering the scales, but their margins still darker; faint whitish blotches, with an approach to regularity of arrangement, appearing on margins of body dorsally and ventrally near bases of the vertical fins, one on each side of the caudal peduncle, and some somewhat alternately along each side of lateral line; margins of preopercle and opercle, also branchiostegals and some of the fin-rays, lemon yellow.

Type, a female 22 inches long (no. 73918, U. S. National Museum) from Georges Bank. (*Dignabilis*, worthy.)

TABLE OF RANGES AND AVERAGES OF PROPORTIONAL MEASUREMENTS AND COUNTS OF 8 COTYPES.

	Range.	Average.
Total length	14¾ to 23½ inches.	A little over 20 inches.
	In length without caudal:	*In length without caudal:*
Head	4.87 to 4.26	About 4.50.
Depth	2.30 to 2.08	2.20.
	In head:	*In head:*
Eye	6.58 to 5.70	About 6.10.
Snout	5.00 to 4.86	4.90.
Maxillary	4.48 to 3.81	4.20.
Mandible	3.14 to 2.63	2.80.
Gape	7.64 to 6.60	7.00.
Interorbital	11.50 to 9.00	10.00.
Preorbital	10.45 to 7.22	8.10.
Longest dorsal ray	2.00 to 1.71	1.90.
Longest anal ray	2.00 to 1.71	1.90.
Pectoral	1.94 to 1.60	1.80.
Ventral	2.90 to 2.40	2.70.
Distance from dorsal to caudal	3.31 to 2.45	2.90.
Distance from anal to caudal	3.31 to 2.45	2.90.
Width caudal peduncle	2.10 to 1.71	1.90.
	Number:	*Number:*
Scales	....	About 85 in series above lateral line.
Dorsal rays	68 to 73	71.
Anal rays	51 to 54	52.

TABLE OF RANGES AND AVERAGES OF PROPORTIONAL MEASUREMENTS OF 3 SPECIMENS FIRST RECEIVED.

	Range.	Average.
Total length....	16 to 21 inches.	About 19.70 inches.
	In length without caudal:	*In length without caudal:*
Head....	4.99 to 4.65	About 4.81.
	In head:	*In head without caudal:*
Depth	2.25 to 2.09	About 2.19.
Eye....	6.00 to 5.80	6.18.
Snout....	5.43 to 5.00	5.21.
Maxillary.....	4.80 to 4.13	4.45.
Mandible....	2.56 to 2.42	2.48.
Gape	7.30 to 6.60	6.97.
Interorbital.....	10.42 to 10.00	10.21.
		In head:
Preorbital	7.25 to 6.25	About 6.61.
Longest dorsal ray...	1.77 to 1.52	1.65.
Longest anal ray...	1.77 to 1.52	1.65.
Pectoral.	1.61 to 1.43	1.54.
Ventral.........	2.50 to 2.14	2.30.
Distance dorsal to caudal	3.44 to 1.92	2.59.
Distance anal to caudal ..	3.44 to 1.92	2.59.
Width caudal peduncle...	1.81 to 1.65	1.70.
	Number:	*Number:*
Scales......	....	About 85.
Dorsal rays..	....	72.
Anal rays.....	52 to 54	53.

The ranges and averages of dorsal and anal fin rays of 11 specimens of *Pseudopleuronectes dignabilis* compared with 11 specimens of *P. americanus* appear as follows, the specimens of *dignabilis* being the type and cotypes previously tabulated and those of *americanus*, representing localities from Cape Cod to Chesapeake Bay, being selected for their size:

Name.	Dorsal rays.		Anal rays.	
	Range.	Average.	Range.	Average.
P. dignabilis	68 to 73	70.6	50 to 54	52.3
P. americanus	61 to 67	64.7	46 to 50	48

The gillrakers of one specimen of *P. dignabilis* were 4+8 and of one *P. americanus* 3+7, the latter the smaller specimen.

The teeth in the upper jaw of *P. dignabilis* consisted of 2 on the right side separated by a short gap from an irregular row of 17 on the left side. In a smaller *P. americanus* there was only 1 on the right side and 19 in a regular row on the left. The lower jaw of *P. dignabilis* had no teeth on the right side and 17 on the left. *P. americanus* had 2 on the right side and 17 on the left. The upper pharyngeals of each species have 3 rows of teeth each. In *P. dignabilis* the row next the mouth consists of 7 short, blunt teeth, the middle row of 5 somewhat hooked and sharper teeth and the inner row of 7 still sharper and more strongly hooked teeth. *P. americanus* has 7 teeth in the row next to the mouth and 6 in each of the other rows and all are equally strongly hooked, longer and sharper than in the other species. In both species there are 2 irregular rows of teeth in the lower pharyngeals, short and blunt in *P. dignabilis* and somewhat longer and sharper in *P. americanus*.

The lateral line in *P. dignabilis* as in *P. americanus* sometimes has a small curve above the pectoral fin.

The first 3 specimens received consisted of 2 males and 1 female, the latter being the largest. Of the 11 specimens of the second lot, only the smallest two were males. Thus the males seem to run considerably smaller than the females. All of the males have the scales of the left as well as of the right side ctenoid. One female, however, was found to have some strongly ctenoid scales on the left side.

Individuals vary considerably in color, the males usually being darker and the colors more strongly pronounced than in the females. The spots and blotches show, as a rule, but faintly in fresh specimens, but appear more distinctly after preservation, especially if formalin is first used. The color of the 21¼-inch female of the first lot when first received was light, irregular yellowish-brown generally, the brown extending on some of the vertical fin rays; centers of scales bluish gray with brown margins; faint blotches of darker brown, covering the scales in the blotch but still most intense on the edge of each scale; yellowish tinge in large poorly defined blotches; dorsal fin rays pink with orange posterior edge, this color extending on membrane, but the tips of the rays white; on the 26th ray the scales begin to be brown, becoming more intense posteriorly with the orange yellow more defined on base of fin at the posterior third; last 8 rays pink and very little yellowish; anal colored as dorsal; scales on caudal brown margined, membranes and rays somewhat tinged with yellow except near terminal margin, where it is bluish translucent and tips of rays white; pectoral membrane bluish translucent; scales of rays brown-edged and few at base tinged with yellowish; ventral membrane pink with light-brown-edged scales on rays; jaws pink, tinged with yellowish brown; preopercle and opercle same as on body; chin and gular region pink; branchiostegals orange, as is margin of opercle, the upper one the most intensely colored; iris golden and upper occular membrane bluish gray, tinged or dappled irregularly with yellowish brown; under or left side of head, jaws and all except cheek (which is white) pink; fins all pink; body white; belly pink.

The 21¼-inch male was generally colored much as in the female but somewhat darker and not so pink underneath, with orange and ferruginous blotches smaller and more distinct; belly orange; fins all dark; outer terminal half of caudal slatey; ventral of right side light rusty yellowish; left side white; a number of light gray-white blotches on head and body, made up of groups of scales, but each scale having a narrow brown margin; these blotches mostly more definitely spot-like than the darker ones, arranged along body irregularly, but most numerous and approaching alternate regularity on opposite side of the lateral line; large whitish blotch-like area under pectoral; another on side of abdomen and others regularly arranged as follows: 5 along dorsal margin of body, 1 opposite base of seventeenth, twenty-fifth, thirty-fifth, forty-sixth, and sixtieth dorsal ray, respectively; 4 along ventral margin of body, 1 opposite ninth, seventeenth, twenty-ninth, and forty-fifth ray, respectively; 1 on each side of caudal peduncle, and 1 each at bases of fifth and sixth rays from upper and lower margin of caudal, respectively.

The first 3 fish received were nearly ripe; the others, excepting the 2 small males, which appeared to be immature, were spent, thus indicating that the spawning season is between April 15 and May 15. The height of the spawning season of *P. americanus* at Woods Hole is in February, and is earlier farther north.

The stomachs of the fish were gorged with hydroids, among which were a few small crabs and other invertebrates.

The locality from which the first lot was obtained was not definitely known. Regarding this lot Mr. Neal wrote:

"Referring to the flatfish, a sample of which we sent you, our trawlers have taken these fish on all parts of Georges Bank and on grounds east of Nantucket, the latter much smaller and less plentiful than on Georges.

"Fishing on Georges in water from 20 to 25 fathoms we have landed up to 15,000 pounds, or about 30 per cent of the total catch per trip.

"In water from 40 to 70 fathoms the percentage drops to about 5.

"We give the actual fishing of the steamer *Spray*, May 1, 1911, to April 29, 1912, total catch 3,292,744 pounds, out of which were 120,000 pounds of these flatfish.

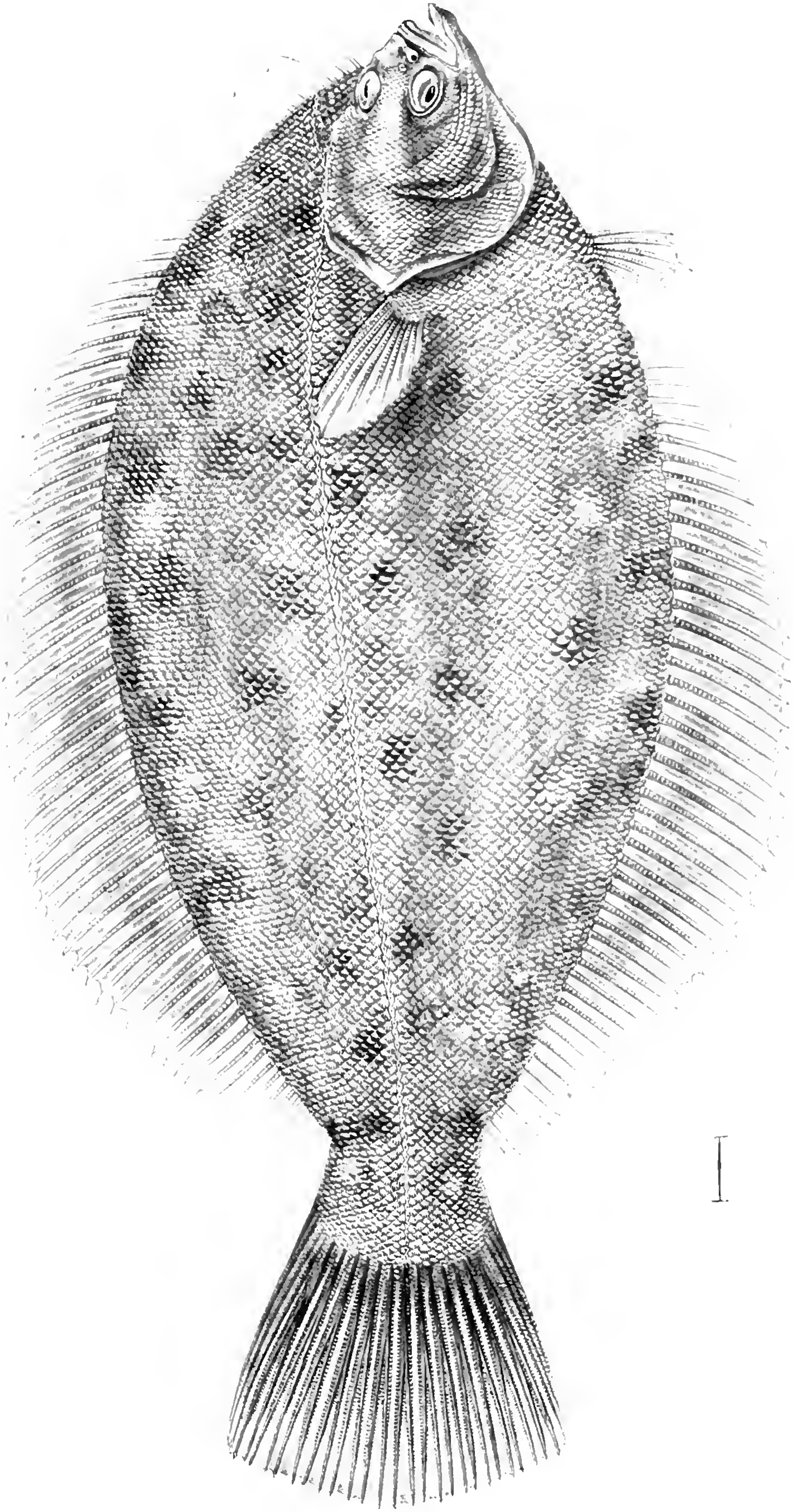
"These fish appear to be on the grounds as above stated at all seasons of the year in about the same quantities."

Regarding the second lot Mr. Neal wrote:

"These fish were caught on Georges Bank in latitude from 41° 15′ to 42° north and longitude 67° to 68° 30′ west, from 15 to 35 fathoms of water, most plentiful in 20 fathoms. These fish were caught by the steamer *Ripple*, which had about 10,000 pounds, or about 25 per cent of the total catch for this trip."

The fish is thick and firm meated, and the flesh is flaky and, when cooked, moist and of delicious flavor.

In size attained, numbers caught, and delectability, considered economically and gastronomically it is surely a "worthy" fish.



Lemon flounder. *Pseudopleuronectes dignabilis* Kendall

GENERAL INDEX.