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

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ERRATA.

Since the publication of paper No. 1772, on September 23, 1910, the author has submitted the following alterations:

Page 2, line 6, read "six segments" instead of "seven segments."

Page 17, seven lines from the bottom, delete "Angra Pequena." The species which occurs here has recently been shown by the author to be *A. assimilis* var. *affinis*.

Page 21, lines 19-28. Since these lines were printed the author has received specimens of *A. assimilis* var. *affinis* from Angra Pequena and Table Bay. The statements in lines 19 to 28 therefore no longer hold.

THE ANNELIDS OF THE FAMILY ARENICOLIDÆ OF NORTH
AND SOUTH AMERICA, INCLUDING AN ACCOUNT OF
ARENICOLA GLACIALIS MURDOCH.

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INTRODUCTION.

The account of the Arenicolidæ which is given in the following pages is based chiefly on material in the U. S. National Museum, to the authorities of which institution I am greatly indebted for their kindness in sending to me for examination the whole collection of specimens belonging to this family of Polychæta. My thanks are also tendered to many others who have helped me with the gift or loan of specimens, and I would mention especially Prof. H. C. Bumpus, Dr. H. P. Johnson, Dr. W. McM. Woodworth, Prof. A. D. Howard, Prof. C. A. Kofoid, Dr. R. S. Lillie, Prof. H. Heath, and Prof. A. L. Treadwell.

In addition to the material received directly from the United States, I have also examined a considerable number of specimens from American sources now deposited in various museums in Europe. I hoped to obtain sufficient material to enable me to give a moderately complete account of the distribution of the American species of *Arenicola*, but, up to the present, the only regions from which material, adequate enough for this purpose, has been obtained are the eastern coast of North America and the extreme south of South America. The stations from which specimens have been taken on the west coast of North and South America are so few that the limits of distribution of the two or three species concerned must be left quite indeterminable, and there are no specimens recorded from the east coast of South America, nor have I been able to obtain any although I have made inquiries for them from several likely sources. It is to be hoped that collections from the west coast of North America and from the seaboard of South America may soon be forthcoming, which will provide the material necessary for the determination of the range of the various species.

DESCRIPTIONS OF GENUS AND SPECIES.

Genus *ARENICOLA* Lamarck.

The characters of this genus may be stated thus: Polychæta, usually found burrowing in sand or gravel, of elongate cylindrical form, provided with pairs of dorsally-borne branched gills which, however, are not present on the first seven segments. Prostomium small, bounded posteriorly by the nuchal groove, without tentacles and palps. Peristomium without cirri. Each chætigerous segment, except the first three or four, is subdivided into five annuli; the annulus which bears the parapodia is larger than the others. Each parapodium consists of a conical notopodium, bearing capillary setæ, and a neuropodium, in the form of a muscular pad or ridge on the lateral or ventro-lateral region of the chætigerous annulus, traversed by a deep groove in which a row of crotchets is situated. The pharynx has no armature except a series of papillæ the tips of which may be capped with chitin. One or more pairs of glandular cœca are present on the posterior part of the œsophagus; a short distance posterior to these is a pair of hearts. The number of nephridia varies in different species, five, six, or thirteen pairs being present; the first nephridium opens on the fourth or fifth segment. Cœlomic septa have disappeared in the region of the body in which the stomach is situated, but septa are constantly present at the anterior border of the first, third, and fourth chætigerous segments and also in a greater or less extent of the intestinal region of the worm. In all the known species, except *A. claparedii* Levinsen, there is a pair of statocysts (otocysts) in the peristomium.

The genus *Arenicola* is divisible into two sections, one, the caudate section, containing those species in which a posterior region or "tail" is present upon which neither parapodia nor gills are borne, the other, the ecaudate section, comprising those species in which the parapodia, and generally also the gills, extend to the posterior end of the animal.

Up to the present no specimen belonging to the ecaudate section of the genus has been recorded from America. The two species, *A. ecaudata* Johnston and *A. grubii* Claparède, which comprise this section, therefore, claim little attention in this communication. It may be stated for the guidance of workers on the American littoral fauna that these two species have hitherto been found, for instance, in Great Britain and France, near low-tide mark and chiefly in coarse gravelly sand, among stones or in débris at the base of rocks formed by the breaking down of the latter. The burrows of these worms are oblique or sinuous cavities in the gravel or between the rocks and the castings of the worms are composed of coarse material, having little coherence, and therefore soon falling to pieces. The well-

known signs, the sand-rope-like castings and the mouth of the burrow, which indicate the presence of *A. marina* on a sandy beach, have no good counterparts in the case of the ecaudate species, in which both the castings and the mouth of the burrow are inconspicuous among their surroundings. Whether these species are present in any given area is therefore not obvious from a superficial examination, as is often the case where *A. marina* is concerned; their presence can only be ascertained after careful, and sometimes prolonged, search in likely places, such as those above suggested.

Four caudate species of *Arenicola* and a variety of one of them are now moderately well known, namely, *A. marina* (Linnaeus), *A. claparedii* Levinsen, *A. assimilis* Ehlers, *A. assimilis*, var. *affinis* Ashworth, and *A. cristata* Stimpson, all of which have been recorded from the shores of North or South America. *A. glacialis* Murdoch, *A. pusilla* Quatrefages, and *A. natalis* Girard, species concerning which comparatively little is known, have been found near Point Barrow (Alaska), Coquimbo (Chile), and Chelsea, Massachusetts, respectively. *A. natalis* is not a valid species; it is now merged with *A. marina* (see p. 6). I have recently shown that *A. pusilla* does not exhibit any characters which entitle it to retain individuality as a species and that it should be merged with *A. claparedii* (see p. 14). *A. glacialis* is shown in this memoir to be a distinct and valid species, although the characters given in the original diagnosis are insufficient to firmly establish it as such. I have investigated the original specimens on which Murdoch founded the species, and give below (see p. 24) a description of them in as much detail as is possible, having regard to their condition and their value as unique examples.

The external characters upon which reliance is placed in differentiating the caudate species of *Arenicola* are:

1. The number of chætigerous segments and the number of segments provided with gills.

2. The mode of branching of the gill axes. There are two principal modes of branching; in the first type, each of the axes of which the gill is composed bears lateral branches closely set or irregularly placed so that the gill has a bushy appearance: in the second type the lateral branches on each gill axis are more numerous and are placed at almost regular intervals, producing a pinnate appearance.

3. The relative size of the median and lateral lobes of the prostomium.^a

4. The presence or absence of apertures of statocysts.^a

5. The segments on which the apertures of the nephridia are situated.^a

^a For the examination of the apertures of the statocysts and nephridia, the shape of the prostomial lobes and other minute features, a binocular dissecting microscope is almost indispensable.

6. The degree of development of the neuropodia, especially those of the first three or four, and of the last few chætigerous segments.

The setæ of several of the species of *Arenicola* present such close resemblance to each other that these structures are of comparatively little service in specific work and are not employed in diagnosis in the present paper; more reliable and more practicable characters are available.

It may be readily understood that in a considerable number of the specimens which have been collected and preserved some, at least, of the above-mentioned external characters are not available for reference. For instance, some features may have been damaged or destroyed at the time of capture or can no longer be seen, owing to the unsuitable mode of preservation adopted, or to the defective condition of the specimen brought about by its having been long kept in a medium which has partially lost its conserving powers. In specimens which have died contracted, owing to having been at once plunged into strong alcohol, the apertures of the nephridia and of the statocysts (if the latter pores are present) are invisible, the prostomium is so much withdrawn into the nuchal organ that the relative size of its lobes can not be ascertained, and the gills may be so fully contracted that the nature of the branching of their axes is indeterminable. In such cases the number of segments and the number of pairs of gills present are the only characters which can be seen, and they are insufficient to provide the basis for a reliable diagnosis. Even in some cases in which the external characters are moderately preserved the specific differences presented by these features are so small that great care is requisite if a safe diagnosis is to be reached. In all these cases it is necessary to have recourse to an examination of the internal organs before a definite determination of the species to which the specimen belongs can be made. If specimens from a new region are concerned it is particularly advisable not to depend upon the external characters alone, but to make an incision along the mid-dorsal line of the worm, extending from about the eleventh segment forward nearly to the prostomium, so as to permit an examination of all the important internal organs to be made. The making of such an incision and examination does not destroy any external feature or impair the value of the specimen for future study. The neglect of the examination of the internal organs has been responsible for many errors of diagnosis, some of which could scarcely have been made had these organs been even casually inspected.

The internal organs most useful in aiding specific determinations are:

1. The œsophageal glands or cœca, their number and comparative size.

2. The muscular pouches, a pair of which is present in several species, projecting backward from the ventral region of the first septum. The grade of development of these organs should be noted.

3. The nephridia, their number, the segments on which they open, and, in some cases, the character of the lips of the funnel.

4. The statocysts, when present, whether they are open or closed, and the number and nature of the statoliths which they contain.

ARENICOLA MARINA (Linnæus).

= *Arenicola piscatorum* LAMARCK.

Nineteen chætigerous segments; thirteen pairs of gills, the first, which is on the seventh segment^a, may be small or absent; gills are usually bushy, but in some cases they approximate to the pinnate type; the three lobes of the prostomium are nearly equal in size; at any rate, the lateral lobes are seldom much larger than the median one; neuropodia are clearly visible in each segment, in the posterior branchial region they form long muscular ridges, and their grooves reach nearly to the mid-ventral line; six pairs of nephridia, which open on the fourth to the ninth segments;^b one pair of œsophageal glands, conical or club-shaped; one pair of small globular, conical, or flask-shaped muscular pouches projecting backward from the ventral region of the first septum; a pair of statocysts in the peristomium, which open to the exterior (the apertures, which are often minute, are situated close to the points where each metastomial groove crosses the first interannular groove), the numerous statoliths are composed of sand grains, which may be enveloped to a greater or less extent with material secreted by the walls of the statocyst.

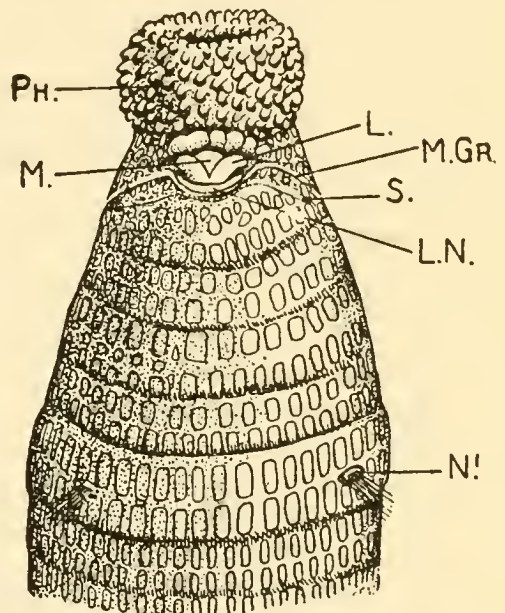


FIG. 1.—A. MARINA, ANTERIOR END, DORSAL ASPECT, TO SHOW THE PROSTOMIUM; L, LATERAL LOBE OF PROSTOMIUM; L. N., LIP OF NUCHAL ORGAN; M, MEDIAN LOBE OF PROSTOMIUM; M. GR., METASTOMIAL GROOVE; N¹, FIRST NOTOPODIUM; PH, PHARYNX; S, APERTURE OF STATOCYST. X4.

^a That is the seventh chætigerous segment. The word "segment" throughout the following pages means "chætigerous segment." The region anterior to the first chætigerous segment probably represents the peristomium and an achætous body segment, so that the first chætigerous is really the third true segment. See the author's memoir on *Arenicola*. Liverpool Marine Biology Committee, Memoirs, XI, 1904, p. 9.

^b The first nephridium is not uncommonly reduced or even absent.

The previous records of this species from American stations are:

1. On the East coast—

- A. marina*, Labrador. J. H. ASHWORTH, Mitth. Kongl. Zool. Mus. Berlin, vol. 4, 1910, p. 349.
- A. piscatorum*, Belles Amours (Strait of Belle Isle). A. S. PACKARD, Mem. Boston Soc. Nat. Hist., vol. 1, 1867, p. 293.
- A. marina*, St. Lawrence. P. TAUBER, Annulata Danica, 1879, p. 110, Kjöbenhavn.
- A. piscatorum*, Grand Manan. W. STIMPSON, Smiths. Contr. Knowl., vol. 6, 1854, art. 5, p. 31.
- A. marina*, Grand Manan. F. W. GAMBLE and J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 422.
- A. marina*, New England. A. E. VERRILL, Trans. Conn. Acad. Arts and Sci., vol. 4. New Haven, 1881. (New England Annelida, annotated lists of species hitherto recorded.)
- A. marina*, Eastport, Maine. H. E. WEBSTER and J. E. BENEDICT, U. S. Fish Comm. Part 13, Rep. for 1885, p. 727. Washington, 1887.
- A. piscatorum*, Eastport, Maine. A. E. VERRILL, Bull. Essex Inst., vol. 3, 1872, p. 6, Salem, Massachusetts.
- A. marina*, Nahant, Massachusetts. F. W. GAMBLE and J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 423.
- A. natalis*, Chelsea, Massachusetts. C. GIRARD, Proc. Boston Soc. Nat. Hist., vol. 5, 1856, p. 88.
- A. piscatorum*, Massachusetts Bay. W. STIMPSON, Proc. Boston Soc. Nat. Hist., vol. 5, 1856, p. 114.
- A. marina*, Race Run, Massachusetts. H. E. WEBSTER and J. E. BENEDICT, U. S. Comm. Fish and Fisheries. Part 9, Rep. Commissioner for 1881, p. 725. Washington, 1884.
- A. marina*, Noank, Connecticut. A. E. VERRILL, Amer. Journ. Sci., ser. 3, vol. 10, 1875, p. 39.

2. On the West coast—

- A. marina*^a, Vancouver Island. E. VON MARENZELLER, Zool. Jahrb. Abth. Syst., vol. 3, 1888, p. 12.
- A. marina*^a, Puget Sound. C. M. CHILD, Trans. N. Y. Acad. Sci., vol. 16, 1898, p. 387.
- A. piscatorum*^b, Bay of Paita. L. K. SCHMARDA, Neue wirbellose Thiere, vol. 1, pt. 2, p. 52, Leipzig, 1861.
- A. piscatorum*^c, Callao. E. GRUBE, Vid. Medd. naturh. For. Kjöbenhavn for Aaret 1858, p. 120. Kjöbenhavn, 1859.
- A. marina*^a, Puerto Montt, Chile. E. EHLERS, Festschr. K. Ges. Wiss. Göttingen, 1901, p. 176.

Rathbun^d and Tauber^e also mention the occurrence of this species on the shores of the United States.

Remarks on the foregoing records.—The specimens on which the species *A. natalis* Girard was founded are very shortly and insufficiently

^a *A. claparedii*, see pp. 7, 8, 9.

^b Probably *A. claparedii*, see p. 8.

^c See p. 9.

^d R. Rathbun. The Worms in: The Fisheries and Fishery Industries of the United States. Section 1. Washington, 1884, p. 833.

^e Annulata Danica, p. 110.

described; no single character is mentioned by means of which the species with which Girard was dealing can be absolutely fixed. Nevertheless, it is, I consider, practically certain that the specimens in question were ordinary examples of *A. marina*. It is evident from the description that Girard mistook the ventral for the dorsal surface, for he speaks of the dorsal region as being marked by a conspicuous smooth line, which, upon the cephalic region, subdivides into right and left branches, which unite again anteriorly; this dorsal line is given as one of the principal specific features. This smooth band or line is, however, really ventral in position, and is seen in nearly all specimens of *A. marina* (and, indeed, in other caudate Arenicolidæ); it marks the position of the ventral nerve cord, and in front it is continuous with the metastomial grooves, which mark the course of the œsophageal connectives. I have endeavored to procure the type-specimen of this species, but without success; the curator of the museum of the Boston Society of Natural History informs me (letter dated, November 4, 1908) that he has not been able to locate the type and that there is no record of its having been given to the Society. There can be little doubt that the specimens were examples of *A. marina*, which species, as may be seen from the list of records given above, has been found at other stations in the immediate neighborhood of Chelsea.

There are two specimens in the Museum of Comparative Zoology, Cambridge, Massachusetts, which were collected at Grand Manan and bear the label "*Arenicola natalis* Girard." (Mus. No. 87.) I have re-examined these and have no hesitation in referring them to the species *A. marina*, with which they agree in every respect, both in regard to external characters and internal organs.

The records from Vancouver Island, Puget Sound, the Bay of Paita, Callao, and Puerto Montt can not be passed without emendation.

Von Marenzeller^a states that he examined examples of *A. marina* from Vancouver Island. As his diagnosis was reached from a consideration of the external characters only it seemed to me that a re-examination, which should include the internal organs, was desirable. Professor von Marenzeller kindly lent me a specimen for this purpose. The specimen is about 70 mm. long and looks at first sight like a small example of *A. marina*, except that the lateral lobes of its prostomium are proportionately larger than those of *A. marina*. Although I had a suspicion that it should not be referred to this species, it was impossible to finally determine this point by an examination of the external features only. Accordingly, an incision was made along the greater part of the worm and the flaps of the body wall turned aside. It was then seen that instead of a single pair of

^a Zool. Jahrb. Abth. Syst., vol. 3, 1888, p. 12.

œsophageal glands, as in *A. marina*, this specimen has five pairs, the first being 9 to 10 mm. long and the others 1.5 to 3.5 mm. long. There are no muscular pouches on the first diaphragm (these structures are present in *A. marina*), and statocysts could not be found after careful search.^a Five pairs of nephridia are present, opening on the fifth to the ninth segments. These internal characters and the nature of the prostomium indicate that the worm is to be referred to the species *A. claparedii* Levinsen. Child's record of *A. marina* from Puget Sound is founded on a misapprehension. He was concerned with the cytology of the ova and probably did not make any examination of the systematic characters of the worms. Johnson^b states that the specimens examined and recorded by him as *A. claparedii* were given to him by Child; moreover, subsequent records of specimens from Puget Sound and all the specimens from that area which I have myself examined belong to the species *A. claparedii*. We need therefore have no hesitation in transferring Child's record from *A. marina* to *A. claparedii*.

Schmarda records *A. piscatorum* from the Bay of Paita, but a statement in his description shows that he was not dealing with this species, for he mentions the presence of twenty glandular sacs just anterior to the stomach, that is, the specimen had twenty œsophageal glands, whereas *A. marina* has only two. I have tried to find Schmarda's specimens, but have failed to do so. Prof. Dr. K. Grobben has been good enough to look through the catalogue of the collection in the Zoological Institute of Vienna, where I thought the specimens might possibly be, but there is no example of *Arenicola* in that collection from the Bay of Paita and no specimen of this genus collected by Schmarda. His specimens from Paita were examples either of *A. claparedii* or *A. assimilis*, probably the former, judging from the distribution of these species (see p. 17 and p. 20). At any rate they can not be examples of *A. marina*, as is definitely shown by the number of their œsophageal glands, and we may provisionally regard them as belonging to the species *A. claparedii*.^c

^aIn order to definitely establish the absence of statocysts, it would be necessary to cut serial sections of the anterior end of the worm, but this was impossible in the present instance.

^bH. P. Johnson, Proc. Boston Soc. Nat. Hist., vol. 29, 1901, p. 422.

^cIt should be borne in mind that, at the period when the records by Schmarda (1861) and Grube (1859) were published, *A. marina*, or, as it was then almost universally called, *A. piscatorum*, was the only known caudate species of *Arenicola* with nineteen segments and thirteen pairs of gills. It was not until 1883 that Levinsen pointed out the characters which distinguish *A. claparedii* from *A. marina*. It is easy to understand that up to that time all specimens of *Arenicola* with nineteen segments and thirteen pairs of gills would be at once referred to the species *A. marina*, a practice which prevailed, with one or two exceptions, until little over ten years ago.

Grube's record of "*Arenicola piscatorum* Cuv." from Callao is a mere mention of the name without any comment whatever. In the hope of finding this specimen I wrote to Professor Levinsen, of the Museum of Copenhagen (in the publications of which museum the record was published), but he informs me that he can not find any corresponding specimen in the museum collection. I have therefore no means of verifying or amending this record by reference to the actual specimen, but I consider that, as a record of *A. marina*, it should be only provisionally given. It is equally, if not more, probable that Grube was dealing with one of the species externally closely similar to *A. marina*, for instance, *A. claparedii*.^a

Ehlers records *A. marina* from Puerto Montt, Chile. Fortunately, the two specimens on which the record is based have been kept. I am indebted to Professor Ehlers and to Doctor Michaelsen of the Naturhistorisches Museum, Hamburg, to which institution the specimens belong, for the opportunity and permission to examine them. The worms are both dark colored, nearly black and badly preserved, 123 and 110 mm. long, respectively; the longer one is apparently incomplete, the posterior end of the tail being absent. In the number of their segments and the number and position of their gills, almost the only external characters available for reference, these specimens agree with *A. marina*, but on examining the internal organs of one of them which had already been partially dissected, it was evident that the specimen could no longer be referred to this species. Ten œsophageal glands are present on each side; there are no pouches on the first septum, and statocysts could not be found in spite of most careful search. The internal organs of the other specimen were also examined; seventeen œsophageal glands are present, but no septal pouches and no statocysts. The anterior region of one of the specimens was cut into serial sections, but statocysts could not be found. Had these vesicles been present in the living animal they would have been recognizable even though the tissue was so badly preserved. We may conclude that these specimens do not possess statocysts and that they belong to the species *A. claparedii*, the only species in which statocysts are absent. The gills, though not in a good state of preservation, are of the pinnate type and the neuropodia of the posterior branchial region are broad cushions not nearly reaching the mid-ventral line; both these characters confirm the diagnosis previously reached. The lobes of the prostomium are not sufficiently well preserved to be of service in diagnosis. Both these specimens are remarkable in that they possess six pairs of nephridia, while typical specimens of *A. claparedii* have only five pairs. Each of the first

^a See footnote c on page 8.

nephridia, in both specimens, is in contact at its anterior end with the third septum, but in none of them could a nephridial funnel be seen on the anterior face of this septum. Possibly these nephridia were, in life, not provided with funnels, i. e., they were incomplete or reduced, as not uncommonly happens in the case of the corresponding first nephridium in *A. marina*, but the very defective preservation of the specimens does not permit me to determine this point decisively. The vesicles of some of the other nephridia are strongly dilated; a similar condition has been observed in the nephridial vesicles of other species of *Arenicola* in the breeding season. The condition of the nephridial vesicles suggests that the specimens were sexually mature. They were collected on June 17, 1900.

The records of *A. marina* from Vancouver Island, Puget Sound, and Puerto Montt are shown above to be invalid; the specimens on which the records were founded have been re-examined and shown to belong to the species *A. claparedii*, under which they are now to be recorded. (See p. 12, footnote *b*, and p. 14.) Schmarda's record of *A. piscatorum* from the Bay of Paita should also no longer be credited to this species, but probably to *A. claparedii*, and Grube's record of *A. piscatorum* from Callao should be accepted with reserve. There is therefore no certain record of the occurrence of *A. marina* on the west coast of North or South America.

I have examined specimens of *A. marina* from the following stations on the eastern coast of North America:

- Rigolet, Labrador. [83.]
- Cape Breton, Nova Scotia. [23662.]
- Halifax, Nova Scotia. [8931.]
- Eastport, Maine. [546, 587.]
- Gloucester, Massachusetts. [9365, 9368.]
- Provincetown, Massachusetts. [219.]^a
- Barnstable, Massachusetts. [No number.]
- Woods Hole, Massachusetts.
- Buzzard's Bay, Massachusetts. [9367.]

All the specimens, except those from Woods Hole, are in the collection of the U. S. National Museum. The numbers in brackets are the registration numbers.

Before leaving the consideration of this species of *Arenicola*, I wish to refer briefly to a specimen in the collection of the Zoological Insti-

^a Webster and Benedict (U. S. Comm. Fish and Fisheries, part 9, Rept. Commissioner for 1881, p. 725, Washington, 1884) state that *A. marina* was not found at Provincetown or at Wellfleet although it was carefully looked for, but the former author evidently made a further and successful search, for the bottle No. 219, which contains nineteen specimens, bears the note "From H. E. Webster."

tute of the University of Vienna, for the opportunity of examining which I am indebted to the kindness of Prof. Dr. K. Grobben. This is a single specimen labeled, "*A. piscatorum*, Chile, No. 253," and added in pencil are the words "var. *carbonaria*." The specimen is not in a good state of preservation, its muscles are very relaxed, and the tail region is broken into two pieces. Its total length is 300 mm., of which the tail, only a portion of which is present, represents 50 mm. The external characters and internal organs of this specimen agree absolutely with those of *A. marina*; it certainly belongs to this species. There is unfortunately no information available either as to the history or the exact place of capture of this worm. If it be really from Chile, it is, so far as I am aware, the only known specimen of *Arenicola marina* from the west coast of America.

Summary of the distribution of Arenicola marina on American shores.—*Arenicola marina* has been recorded from a considerable number of stations on the eastern coast of North America, from Rigolet, Labrador, in the north to Noank, Connecticut, in the south. Although there have been a few records of *A. marina* from the west coast of North and South America, a re-examination of all the recorded specimens still in existence has shown that they are examples of *A. claparedii*. The only specimen of *A. marina* which I have seen from the west coast of America is one in the Museum of the Zoological Institute of Vienna, said to be from Chile, but no information regarding the history of the specimen or the exact station where it was captured is available.

Further distribution of A. marina.—The shores of the White Sea, Siberia, Norway, Sweden, Denmark, Germany, Holland, Belgium, the British Isles, France, Portugal, the Mediterranean (a few stations only, for instance, Trieste), the Faroe Islands, Iceland, Greenland, the Marquesas and Kingsmill (Gilbert) Islands.

ARENICOLA CLAPAREDII Levinsen.

Nineteen chætigerous segments; thirteen pairs of gills, the first, which is on the seventh segment, may be small or absent; gills usually of the pinnate type but may be bushy; lateral lobes of the prostomium very large, much larger than the median lobe, and often folded in their anterior portion (fig. 2); neuropodia clearly visible in each segment, those of the posterior branchial region are wide antero-posteriorly, forming cushion-like pads, but are not so long as those of *A. marina*, so that neither the muscular ridge nor the groove which contains the crotchets, approaches the mid-ventral line; five

pairs of nephridia which open on the fifth to the ninth segments^a; several (four to sixteen) pairs of œsophageal glands, the anterior pair long and slender, the others shorter and more or less pear-shaped; no pouches on the first septum; statocysts absent. This last is a most noteworthy feature, and is diagnostic of the species, for all other known species of *Arenicola* possess statocysts.

This species has been hitherto recorded from only three stations on the American coast, namely:

A. claparedii, Crescent City, California. F. W. GAMBLE, and J. H. ASHWORTH. Quart. Journ. Micr. Sci., vol. 43, 1900, p. 423.

A. claparedii, Crescent City, California. J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 46, 1903, pp. 773-774.

A. claparedii, Puget Sound,^b Washington. H. P. JOHNSON, Proc. Boston. Soc. Nat. Hist., vol. 29, p. 421, 1901.

A. claparedii, Puget Sound, Washington. J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 46, 1903, p. 774.

A. claparedii,^c Falkland Islands. E. M. PRATT, Mem. Proc. Manchester Lit. Philos. Soc., vol. 45, no. 13, p. 12; no. 14, p. 15, 1901.

A. claparedii,^c Falkland Islands. R. VALLENTIN, Mem. Proc. Manchester Lit. Philos. Soc., vol. 48, no. 23, p. 9, 1904.

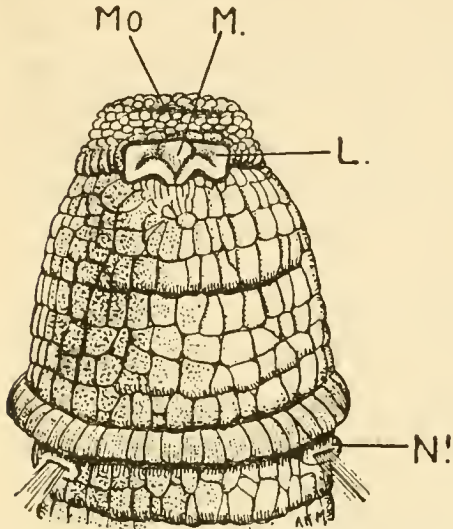


FIG. 2.—*A. CLAPAREDII*, ANTERIOR END, DORSAL ASPECT OF SPECIMEN FROM CRESCENT CITY, CALIFORNIA, TO SHOW THE PROSTOMIUM. L, LATERAL LOBE OF PROSTOMIUM; M, MEDIAN LOBE; Mo, MOUTH; N¹, FIRST NOTOPODIUM. $\times 6$.

The records from Crescent City and Puget Sound hold good, but those from the Falkland Islands must be transferred to the species *A. assimilis*. Miss Pratt's record is founded on certain post-larval specimens of *Arenicola* taken by Mr. Vallentin in Stanley Harbor. These post-larval specimens were subsequently re-examined, two of them were sectioned, with the result that they were conclusively shown to be young stages of *A. assimilis*, var. *affinis*.^d Mr. Vallentin's record is undoubtedly based on Miss Pratt's. All the specimens of *Arenicola* which he collected in the Falkland Islands were examined by me and it was from them that I described the new variety *affinis* of *A. assimilis* in the paper cited^d (pp. 768-772). All the specimens belong to this variety; there is no example of *A. claparedii* among them.

The specimens, five in number, from Crescent City, are in the Museum of Comparative Zoology, Cambridge, Massachusetts (register

^a Out of 100 specimens examined I have seen only three which depart from this condition; in each of these there was also a nephridium opening on the fourth segment. These three specimens were from the west coast of South America, namely, from Coquimbo ("*A. pusilla*" Quatrefages) and from Puerto Montt, Chile. See also p. 16.

^b This species was also obtained in Puget Sound by C. M. Child, but was erroneously stated to be *A. marina*. (Trans. N. Y. Acad. Sci., vol. 16, 1898, p. 387.) See p. 8.

^c *A. assimilis*, var. *affinis*. See the lower part of this page.

^d J. H. Ashworth, Quart. Journ. Micr. Sci., vol. 46, 1903, pp. 764-768.

number 91); there is another, doubtless from the same batch, in the Museum of the Zoological Institute, Göttingen (no. 27a). In four of those in the Harvard collection and in the Göttingen example the seventh segment is abbranchiate, the first gill being borne on the eighth segment; the fifth Harvard specimen has a pair of very small gills on the seventh segment. These specimens vary in length from 105 mm. (of which the tail forms 13 mm.) to 207 mm. The tail of the latter specimen reaches the extraordinary proportion of 117 mm.

A specimen from Puget Sound, from the collection of H. P. Johnson, is preserved in the Harvard Museum (no. 956) and another is in the Department of Biology, University of California (no. 1066). The former is 94 mm. and the latter 60 mm. long, of which in each case the tail forms 13 to 14 mm., but the posterior end is apparently incomplete in both cases. In both these and in two other specimens from the same collection, given to me by Doctor Johnson, the first gill is borne by the seventh segment, but in one specimen there is a gill only on the right side of that segment, the corresponding gill of the left side being absent.

There are examples of this species in the Smithsonian Collection from Constantine Harbor, Amchitka Island, Aleutian Islands (1047); Atka Island, Aleutian Islands (no number); Sand Point, Humboldt Bay, California (no number).

The single specimen from Humboldt Bay, the one from Amchitka Island, and one of the four from Atka Island were opened in order to see the internal organs. All are typical examples of the species in regard to both their external and internal features, prostomium, neuropodia, nephridia, œsophageal glands, absence of septal pouches; statocysts could not be found on dissection of the anterior region of these specimens. In the case of the dissected specimen from Atka Island, the region in which the right statocyst is situated in those species which possess these organs, was excised and cut into serial sections, an examination of which proves that a statocyst is not present in this worm.

I have recently examined seven specimens from Dutch Harbor, Unalaska (Harriman Expedition), and a dozen specimens collected at San Juan Island, in the Strait of Juan de Fuca. All are typical examples of *A. claparedii*, and in all the first true gill is present. The absence of statocysts was determined in a large specimen from Unalaska by dissection, and in the case of those from San Juan by examination of serial sections of the anterior end of one of the worms.

The specimens from Unalaska are the largest examples of this species I have seen. Their length, 132 to 160 mm., is not specially remarkable, but they are of massive build, the four largest specimens have a girth (measured at the fifth segment) of 50 to 60 mm.

Arenicola claparedii has been taken at three other points on the western seaboard of America, but was recorded under other names. To the records given above the following should therefore be added:

A. marina, Vancouver Island. E. VON MARENZELLER, Zool. Jahrb. Abth. Syst., vol. 3, 1888, p. 12.

A. pusilla, Coquimbo, Chile. A. DE QUATREFAGES, Histoire naturelle des Annelés, p. 266, Paris, 1865.

A. marina, Puerto Montt, Chile. E. EHLERS, Festschr K. Ges. Wiss. Göttingen, 1901, p. 176.

I have shown above that a re-examination of one of von Marenzeller's specimens from Vancouver Island (see p. 7) and of the two

specimens recorded by Ehlers from Puerto Montt (see p. 9) clearly proves that they do not belong to the species *A. marina*, but to *A. claparedii*.

The specimen from Coquimbo is the type-specimen of *A. pusilla*, de Quatrefages, the characters of which were thus defined: "Annuli ebranchiati 9. Branchiæ magnæ ramosissimæ." These diagnostic features are so inadequate that the position of this species with regard to other species of *Arenicola* has been quite indeterminable, and indeed it has been impossible to decide whether or not this species is a valid one. I have recently made an exhaustive examination of this

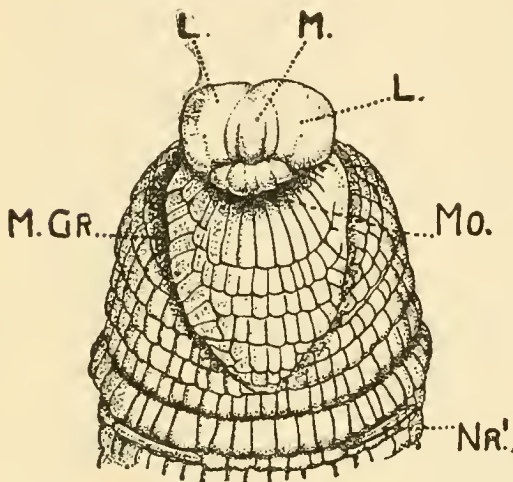


FIG. 3.—ANTERO-VENTRAL VIEW OF THE ANTERIOR PORTION OF "A. PUSILLA" QUATREFAGES. IN THIS VIEW ALL THE PARTS, EXCEPT THE PROSTOMIUM, ARE SEEN SOMEWHAT FORESHORTENED. $\times 8$. L, LATERAL LOBES OF PROSTOMIUM; M, MEDIAN LOBE; M. GR, METASTOMIAL GROOVE; Mo, MOUTH; Nr¹, FIRST NEUROPODIUM.

specimen as far as is possible without damaging its diagnostic features. It is small, slender, and incomplete, only the anterior region, as far back as the eleventh chætigerous annulus, being preserved. It is about 35 mm. long and 3 to 3.5 mm. in diameter. The first gill is borne on the eighth segment (not the tenth, as stated by de Quatrefages), but is small. The other gills are larger and tend toward the pinnate type. The first seven neuropodia are feebly developed, those of the succeeding segments are larger, and those of the tenth and eleventh segments form well-developed cushion-like ridges. The setæ are very similar to those of Californian examples of *A. claparedii*. The prostomium is very fully everted, carried forward, and, as it were, displayed over the anterior end of the worm so that, in order to obtain a view of its lobes, an antero-ventral view is necessary (fig. 3). The lateral lobes of the prostomium are in the form of two flattened disks, the edges only of which are visible in a

dorsal view of the worm; their flat faces are well seen on looking at the worm from the anterior aspect. The lateral lobes envelop the smaller median lobe posteriorly and laterally. As seen from the dorsal aspect (fig. 4) the lateral lobes of the prostomium are widely divaricated, and immediately behind their point of union there is a small median structure (P) which lies in the nuchal groove, its posterior and slightly narrower end being hidden in the median portion of the nuchal organ. This little structure seems to have been regarded by Fauvel, who examined the external characters of the specimen about eleven years ago, as the median lobe of the prostomium,^a but, as we have already seen, the true median lobe is anterior to the point of union of the lateral lobes (as it is in other species of *Arenicola*) while the lobe under discussion is posterior to this junction. This structure is the most posterior portion of the prostomium, only a very small portion, or none, of which is usually visible, because it is generally almost or entirely hidden in the nuchal organ; the extreme protrusion of the prostomium in this specimen has brought this posterior median portion into view. The examination of the internal organs of this worm showed that there are six pairs of nephridia opening on the fourth to the ninth segments, twelve œsophageal glands (six on each side), and that septal pouches are not present. Most careful examination of the region in which statocysts should be looked for failed to reveal their presence; to definitely establish their absence it would be necessary to make serial sections of a portion of the anterior end of the worm, but that is, of course, precluded in this case. I can only say, therefore, that, having very carefully searched for the statocysts, as far as was possible in such a valuable specimen, I believe them to be absent.

We have now the information at our disposal to enable us to determine whether *A. pusilla* de Quatrefages is henceforward to be regarded as a valid species or whether it should be merged with one of the better-known species. It is clear that the diagnosis given by de Quatrefages is erroneous, for gills are borne on the eighth and ninth segments. The comparatively high grade of development of the gills mentioned by de Quatrefages is not a definite character on which to found a

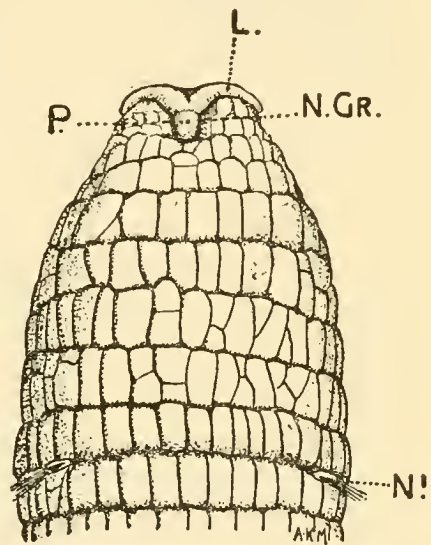


FIG. 4.—DORSAL VIEW OF THE ANTERIOR END OF “*A. PUSILLA*” QUATREFAGES SHOWING THE WIDELY DIVARICATED LATERAL LOBES (L) AND THE MEDIAN POSTERIOR PORTION (P) OF THE PROSTOMIUM (N¹) FIRST NOTOPODIUM; (N.GR) NUCHAL GROOVE. X8.

^a “Petit lobe médian triangulaire.” Mem. Soc. Nation. Sci. Nat. Math. Cherbourg, vol. 31, 1899, p. 177.

species; at least two other externally similar species of *Arenicola* have gills as highly developed as those of *A. pusilla*. The characters given in the original diagnosis of the species *A. pusilla*, one of them erroneous, the other insufficient, can not be held to establish it as a valid species, nor is there any feature of the internal anatomy which marks this specimen as unique.

The most striking of the external features of *A. pusilla* is undoubtedly its prostomium, the high grade of development of the lateral

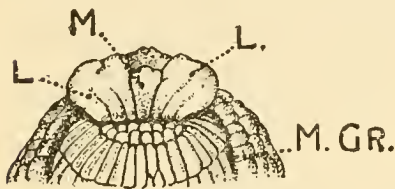


FIG. 5.—ANTERO-VENTRAL VIEW OF THE ANTERIOR END OF A SPECIMEN OF *A. CLAPAREDII* FROM CRESCENT CITY, CALIFORNIA. $\times 6$. FOR LETTERING SEE FIG. 3.

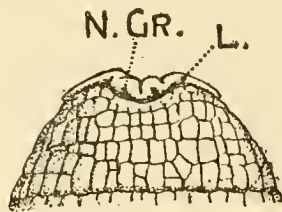


FIG. 6.—DORSAL VIEW OF THE ANTERIOR END OF THE SAME SPECIMEN. $\times 6$. FOR LETTERING SEE FIG. 4.

lobes of which is paralleled, among known species, only in *A. claparedii*. Figs. 5 and 6 represent the anterior end of a specimen of *A. claparedii* from Crescent City, California (Harvard Collection), which has a

prostomium of the same type as that of *A. pusilla*, although owing to contraction in the oral region at the time of preservation the ventral portions of the lateral lobes of the Californian specimen have been brought nearer together and have unduly compressed the median lobe. Nevertheless it is obvious that the Californian specimen and *A. pusilla* have prostomia of an identical type, and that the latter specimen, judged by its prostomium, is to be referred to the species *A. claparedii*. This diagnosis is confirmed by the examination of the internal organs, the results of which are given above (p. 15), particularly by the absence of statocysts, which is a feature of special significance. The only point of difference in regard to the internal organs between *A. pusilla* and *A. claparedii* is that in the former there are six pairs of nephridia and in the latter typically only five pairs, there being usually no nephridium opening on the fourth segment. But this sole difference is not important; certainly it is not one which would justify the separation of two otherwise identical forms. The two examples of *A. claparedii* from Puerto Montt (see p. 10) have also six pairs of nephridia; this may be a character of the Chilean race of the species. We may conclude that the specimen of *A. pusilla* de Quatrefages is a fragment of a small example of *A. claparedii* Levinsen; had it been complete it would probably have been about 80 to 90 mm. in length. A more detailed account of "*A. pusilla*" and discussion of its affinities will be found in a forthcoming paper, by the present writer, in *Annales des Sciences Naturelles, Zoologie*, ser. 9, vol. 10, Paris, 1910.

In his account of the specimens of *A. claparedii* from Puget Sound Johnson^a states that "the only notable points of difference between

^a Proc. Boston Soc. Nat. Hist., vol. 29, p. 1901, p. 421.

the Puget Sound specimens and those from Naples are the vastly greater size—at least eight times as great—of the former and the smaller number of œsophageal cœca or pouches in the latter.” The difference in regard to the number of œsophageal cœca in specimens from Naples and the western seaboard of America seems to be a clear one, and is sometimes even striking. Neapolitan specimens seldom have more than four pairs of cœca, but I have seen only one American example with as few as five pairs; the others had six, eight, nine, and ten pairs, and Johnson records specimens with fifteen and sixteen pairs, and one with sixteen cœca on the right and eighteen on the left side. Johnson’s remark regarding the comparative size of Neapolitan and American specimens is not in agreement with my experience; possibly he had been supplied with very small Neapolitan examples. There is not so great a difference in the length of specimens from the two regions. I have seen sixteen specimens from Puget Sound, including four from Johnson’s collection, the largest of which is 103 mm. long (of which the tail forms 28 mm.), and 11 of them are less than 50 mm. long. I have recently had a Neapolitan example 97 mm. long (of which the tail forms 20 mm.), and the average length of nine specimens which have just passed through my hands is 80 mm. (of which the tail forms 17 mm.). Lo Bianco states that examples of this species from the Bay of Naples attain a length of 150 mm.^a The longest American specimen of *A. claparedii* I have seen is one from Crescent City, California, in the Harvard collection, which is 207 mm. long, but this great length is largely accounted for by the unusual extent of the tail, which measures no less than 117 mm. American specimens have generally a thicker body wall than Neapolitan ones, and are stouter; among the scores of living and preserved Neapolitan examples of this species which I have examined I never saw any whose girth approached that of the massive specimens from Unalaska. (See p. 13.)

Summary of the distribution of Arenicola claparedii on American shores.—*Arenicola claparedii* is now known from several stations on the western seaboard of America, namely, the Aleutian Islands (Amchitka, Atka, Unalaska), Vancouver Island, San Juan Island, Puget Sound, Crescent City and Humboldt Bay, California; Coquimbo and Puerto Montt (Chile).

Further distribution.—Naples, Ossero (Adriatic), Angra Pequena (southwest Africa), and North Japan.

ARENICOLA ASSIMILIS Ehlers.

Twenty chætigerous segments; thirteen pairs of gills, the first, which is on the eighth segment, may be small or absent; the gills may be bushy or may tend toward the pinnate type, but are seldom clearly and typically pinnate; median lobe of the prostomium

^a Atti R. Accad. Sc. fis. mat., Napoli, vol. 5, ser. 2, 1893, no. 11, p. 9.

large or moderately large, lateral lobes in the form of a V, the limbs of uniform width, not dilated anteriorly, though they may be bent (figs. 7, 8); neuropodia similar to those of *A. claparedii*; six pairs of nephridia, which open on the fourth to the ninth segments; several (6 to 15) pairs of œsophageal glands, the anterior pair long and slender, the others smaller and more or less pear-shaped; no pouches on the first septum; a pair of large statocysts in the peristomium, which open to the exterior; statoliths numerous, spherical or rounded secreted chitinoid bodies.

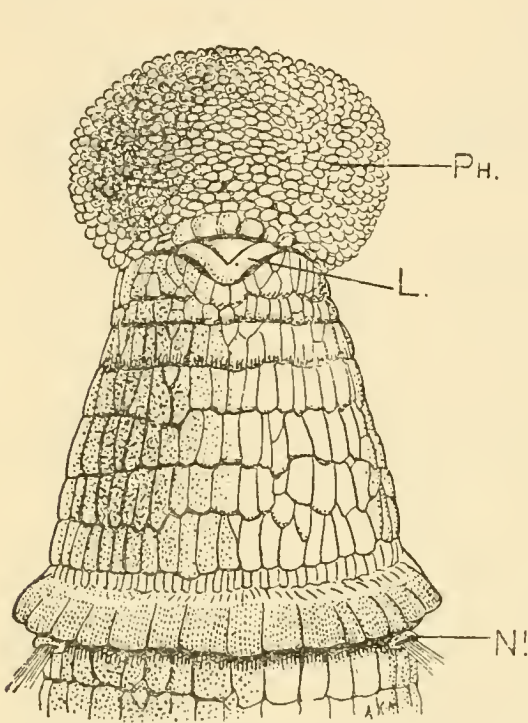


FIG. 7.—*A. ASSIMILIS*, ANTERIOR END, DORSAL ASPECT, OF SPECIMEN FROM USCHUAIA. THE PROSTOMIUM IS IN A STATE OF NORMAL EXTENSION. FOR LETTERING SEE FIG. 8. $\times 6$.

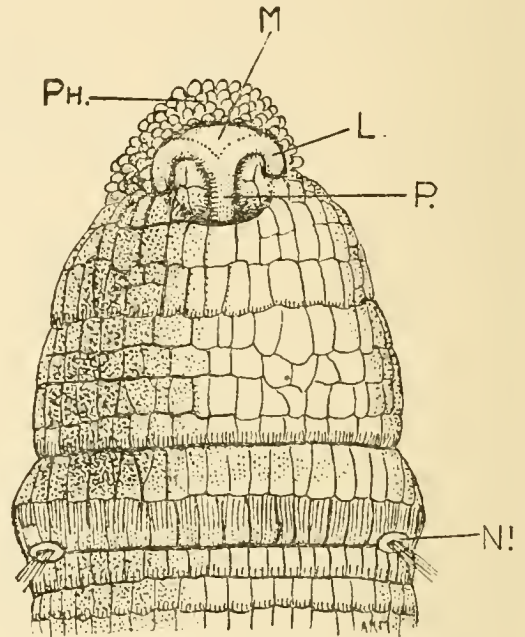


FIG. 8.—*A. ASSIMILIS*, VAR. *AFFINIS*, ANTERIOR END, DORSAL ASPECT, OF SPECIMEN FROM THE FALKLAND ISLANDS. THE PROSTOMIUM IS PROTRUDED TO ITS FULLEST EXTENT. $\times 6$. *L*, LATERAL LOBE OF PROSTOMIUM; *M*, MEDIAN LOBE; *N*¹, FIRST NOTOPODIUM; *P*, MEDIAN POSTERIOR PORTION OF PROSTOMIUM; *PH*, PHARYNX.

ARENICOLA ASSIMILIS, var. *AFFINIS* Ashworth.

Nineteen chætigerous segments; thirteen pairs of gills, the first, which is liable to reduction, on the seventh segment. Statoliths numerous, consisting of either foreign bodies, such as quartz grains, or of rounded secreted chitinoid bodies. Other characters as given above for *A. assimilis* Ehlers.

A. assimilis has been recorded from—

California.^a E. EHLERS, Polychaeten, p. 104, in Hamburger Magalhaensische Sammelreise, Hamburg, 1897.

Punta Arenas (Strait of Magellan), Lapataia Nueva (Beagle Channel) and Uschuaia (Tierra del Fuego). E. EHLERS, Polychaeten, p. 104, in Hamburger Magalhaensische Sammelreise, Hamburg, 1897; also Festschr. K. Ges. Wiss. Göttingen, 1901, p. 178.

Susanna Cove (Strait of Magellan).^b E. EHLERS, Polychaeten, p. 104, in Hamburger Magalhaensische Sammelreise, Hamburg, 1901; also Zool. Jahrb., Suppl. 5, Fauna Chilensis, vol. 2, pp. 265, 269, 1901.

South Georgia. E. EHLERS, Polychaeten, p. 104, in Hamburger Magalhaensische Sammelreise, Hamburg, 1897; also Festschr. K. Ges. Wiss. Göttingen, 1901, p. 178.

^a Transfer to *A. claparedii*, see p. 19.

^b Transfer to var. *affinis*, see p. 19.

Schmarda's record of *A. piscatorum* from the Bay of Paita (see p. 8) is included by Ehlers under the species *A. assimilis* (Festschr. Göttingen, p. 178).

The variety *affinis* of *A. assimilis* is recorded from the following stations on or near the American coast:

Falkland Islands. J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 46, 1903, pp. 764-772.

Susanna Cove (Strait of Magellan). J. H. ASHWORTH, Mitth. Kongl. Zool. Mus. Berlin, vol. 4, 1910, p. 352.

The specimen on which the record of *A. assimilis* from California is based is in the Göttingen Museum and, by the courtesy of Professor Ehlers, I have been permitted to examine it. Professor Ehlers informed me that this is a duplicate from Professor Agassiz's collection, which was sent to Göttingen to be examined. The remaining specimens were returned to Professor Agassiz and are doubtless those which I have at present in my hands from the Harvard collection (bottle No. 91). I have compared the Göttingen specimen with the Harvard examples and find that they agree in every respect. In the former there are nineteen chætigerous segments, the first of the twelve pairs of gills is on the eighth segment; there are five pairs of nephridia which open on the fifth to the ninth segments; there is no nephridiopore on the fourth segment; the lateral lobes of the prostomium are well developed, and in pigmentation and general appearance this specimen agrees absolutely with the Harvard specimens of *A. claparedii* from California (see p. 12). I have no hesitation, after making this direct comparison, in confirming the opinion which I expressed in 1903^a that Ehlers is in error in recording *A. assimilis* from California; the record should be transferred to *A. claparedii*.

It is very probable that Schmarda's specimen, regarded by Ehlers as *A. assimilis*, was really *A. claparedii*; the point at which the specimen was obtained (the Bay of Paita) is within the known range of *A. claparedii*, but is over 3,000 miles north of the nearest station from which *A. assimilis* has been recorded.

Through the kindness of Doctor Michaelsen, of the Hamburg Museum, I have been enabled to examine specimens of *A. assimilis* from Punta Arenas, Lapataia Nueva, Uschuaia, and South Georgia, and the specimens from Susanna Cove, now in the Königlische Zoologisches Museum, Berlin, were recently entrusted to me for examination by Director Brauer. The examples from Punta Arenas, Uschuaia, and South Georgia have twenty chætigerous segments and are typical specimens of *A. assimilis*, but those from Lapataia Nueva and Susanna Cove—the original examples determined by Ehlers, as the accompanying labels testify—have only nineteen segments and are referable to the variety *affinis*.

^a Quart. Journ. Micr. Sci. vol. 46, 1903, p. 774.

A post-larval specimen with nineteen segments and therefore referable to the variety *affinis*, was recorded by Ehlers from Uschuaia among the "roots" of *Fucus*.

Summary of the distribution of Arenicola assimilis on American shores.—Typical examples of *A. assimilis* have been found at Punta Arenas (Strait of Magellan), Uschuaia (Beagle Channel), and South Georgia.

Examples referable to the variety *affinis* are known from Uschuaia (a gill-less post-larval specimen), Lapataia Nueva (Beagle Channel), Susanna Cove (Strait of Magellan), and the Falkland Islands.

Further distribution.—Typical examples of *A. assimilis* have not yet been recorded from any other stations than those mentioned above. The variety *affinis* is, however, found also at Otago Harbor, New Zealand, and Stewart Island,^a and at Kerguelen.^b

Remarks on Arenicola assimilis.—The three caudate species of *Arenicola*—*marina*, *claparedii*, and *cristata*, present a remarkable constancy in the number of their chætigerous segments and in the segments on which gills are borne. Only in rare cases is an additional chætigerous segment found at the posterior end of the branchial region, and very rarely does this segment bear gills. Among the thousands of specimens of *A. marina* which have passed through my hands during the last few years I have seen only three with a complete chætigerous and branchiate twentieth segment.

Ehlers separated *A. assimilis* from *A. marina* because in the former the first gill was not on the seventh but on the eighth or ninth segment. But the number of chætigerous segments is a still more striking character, and, in view of the constancy in the number of these segments in the other caudate species, it seemed to me that the occurrence of examples of *A. assimilis* with twenty and others with nineteen chætigerous segments called for recognition. It was on these grounds that, in 1903, I established the variety *affinis* for those examples of *A. assimilis* with only nineteen chætigerous segments. The varietal and typical specimens are, however, very closely related; the only differences between them are in regard to the number of segments and the position of the first gill.

A. assimilis (in the wider sense, that is, including the variety) is clearly the characteristic species of the southern regions. It extends from Tierra del Fuego, by way of the Falkland Islands, South Georgia, and Kerguelen, to New Zealand. The most northerly station from which it has been recorded is Otago Harbor, about 46 degrees south.

^a Unpublished record, from the manuscript of the present writer.

^b This specimen from Kerguelen, recorded by Grube (Monatsb. K. Preuss. Akad. Wiss. Berlin, aus dem Jahre 1877, 1878, p. 511) as *A. piscatorum* Cuvier var., is now in the Königlische Zoologisches Museum, Berlin. I have recently examined it, and conclude that it is to be referred to the species *A. assimilis* var. *affinis*.

The distribution of this species presents a remarkable parallel to that of certain Oligochætes. Beddard^a has pointed out that the characteristic earthworms of New Zealand are Acanthodrilidæ, and that the same family is equally characteristic of Patagonia. This close resemblance, in regard to their earthworms, between Patagonia and New Zealand is accentuated by the fact that the only earthworms known from the intervening localities, the Falklands, South Georgia, Marion, and Kerguelen islands, belong to the genus *Acanthodrilus*. Beddard regards these facts as evidence in favor of a former greater extension northward of the circumpolar antarctic continent, and he is inclined to believe that this region did not include the Cape of Good Hope. The evidence afforded by the distribution of the earthworms points to a more recent communication between Patagonia and New Zealand than between either of these countries and the Cape of Good Hope.

The occurrence of *Arenicola assimilis* in the southern extremity of South America, the Falklands, South Georgia, Kerguelen, and the southern portion of New Zealand supports the view that there was formerly a more extensive antarctic continent. It is noteworthy that the only species of *Arenicola* known from South Africa is *A. loveni* Kinberg,^b which is widely different from *A. assimilis* in almost every character, a fact which suggests that the antarctic continent was not continuous with the Cape of Good Hope, to which conclusion, as we have already seen, Beddard was inclined to come from a study of the earthworms.

ARENICOLA CRISTATA Stimpson.

Arenicola antillensis LÜTKEN.

Seventeen chætigerous segments; eleven pairs of gills, the first situated on the seventh segment; gills large, pinnate, their axes generally joined basally by a web-like membrane; the median lobe of the prostomium (fig. 9)

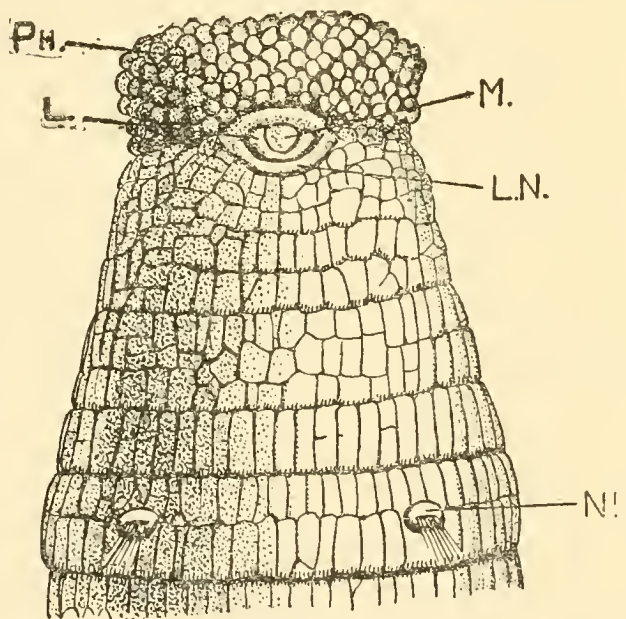


FIG. 9.—*A. CRISTATA*, ANTERIOR END, DORSAL ASPECT, OF A SPECIMEN FROM FLORIDA. $\times 4$. *L*, LATERAL LOBE OF PROSTOMIUM; *L. N.*, LIP OF NUCHAL ORGAN; *M*, MEDIAN LOBE OF PROSTOMIUM; *N*¹, FIRST NOTOPODIUM; *PH*, PHARYNX.

^a F. E. Beddard. A Monograph of the Order of Oligochæta. Oxford, 1895, p. 154. See also, by the same author, A Text-book of Zoogeography. Cambridge, 1895, pp. 60, 170.

^b This species, the anatomy and characters of which have not been described, is at present under investigation by the writer.

larger than the lateral ones; the neuropodia of the first few segments are very small, in fact, it is often impossible to see them on the first three segments and that of the fourth segment is a very short slit, the neuropodia of the posterior branchial region are long dorso-ventrally, they and their grooves reach almost to the mid-ventral line; six pairs of nephridia which open on the fifth to the tenth segments; one pair of œsophageal glands, conical, cylindrical, or clavate and comparatively short; a pair of well-developed, muscular finger-shaped pouches projecting backward from the first septum; a pair of statocysts, closed, spherical or ovoid sacs, each containing a single, large, secreted, statolith.

This species has been recorded from the following stations on the American coast:

A. cristata, Woods Hole, Massachusetts. C. M. CHILD, Arch. Entwicklungsmech, vol. 9, 1900, p. 587.

A. cristata, Woods Hole, Massachusetts. R. S. LILLIE, Mitth. Zool. Stat. Neapel, vol. 17, 1905, p. 344.

A. cristata, North Falmouth, Massachusetts. C. M. CHILD, Arch. Entwicklungsmech, vol. 9, 1900, p. 587.

A. cristata, New Jersey. H. E. WEBSTER, 32d Ann. Rept. New York State Museum, p. 117, Albany, 1879.

A. cristata, Anglesea, New Jersey. J. E. IVES, Proc. Acad. Nat. Sci. Phila. for 1890, p. 73, Philadelphia, 1891.

A. cristata, Beaufort, North Carolina. E. A. ANDREWS, Proc. U. S. Nat. Mus., vol 14, p. 289, Washington, 1892.

A. cristata, Charleston Harbor, South Carolina. W. STIMPSON, Proc. Boston Soc. Nat. Hist., vol. 5, 1856, p. 114.

A. antillensis, Florida, Captiva Key, Florida. E. EHLERS, Mem. Mus. Comp. Zoöl. Harvard, vol. 15, 1887, p. 173.

A. cristata, Captiva Key, Florida. F. W. GAMBLE and J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 423.

A. cristata, Manatee River, Florida. J. E. IVES, Proc. Acad. Nat. Sci., Phila. for 1890, p. 74, Philadelphia, 1891.

A. cristata, Bermuda. H. E. WEBSTER, Bull. U. S. Nat. Mus., No. 25, p. 523, Washington, 1884.

A. cristata Bermuda. A. E. VERRILL, Trans. Conn. Acad. Arts and Sci., vol. 10, pt. 2, 1900, p. 599; vol. 11, 1902, p. 39; vol. 12, 1907, p. 147.

A. cristata, Bluefields, Jamaica. F. W. GAMBLE and J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 423.

A. antillensis, St. Croix (Santa Cruz). C. LÜTKEN, Vid. Medd. Naturh. For. Kjöbenhavn, Aaret 1864, 1865, p. 121.

This is one of the most readily recognized species of *Arenicola* by reason of its seventeen chætigerous segments, eleven pairs of large gills, and the beautifully pinnate character of the gills which is so marked a feature of most of the specimens. The character of the gills of Lütken's specimens was so striking that he held it to be a sufficient basis for the delimitation of a new subgenus for which he proposed the name *Pteroscolex*.

I have recently examined specimens from the stations given below; to those in the Smithsonian collection the register numbers are affixed:

Beaufort, North Carolina. [149, 4861, 42896.]

Florida. [211.]

Key West, Florida. [4531.]

Pensacola, Florida. [27229.]

Bermuda. [34478.]

Curaçao. [3798.]

San Pedro, California.

Monterey Bay, California.

The specimen recorded from Pensacola, Florida, extends the distribution of this species westward along the coast of Florida to its extreme western limit. The one from Curaçao is the first example to be recorded from the coast of South America. Of special interest is the finding of this species on the western seaboard of America, which greatly extends its known range, for this species has hitherto been found only at Naples, on the eastern coast of the United States from Woods Hole southward, in Bermuda, and in the West Indies. In one of the specimens from San Pedro there is a small gill on the right side of the sixth segment. This is the only specimen of *Arenicola*, out of thousands examined, in which I have seen a gill on the sixth segment.

Arenicola cristata is a giant among Polychæta. One of the examples from Beaufort has a length of 385 mm. (of which the tail forms 115 mm.) and the specimen from Pensacola reaches a length of 460 mm. (of which the incomplete tail forms 80 mm.) and its girth at the sixth segment is about 60 mm. The largest example of this species which I have had is one from Woods Hole, which attains the great length of 515 mm. (of which the tail is 190 mm.) and a girth of 75 mm.

In this, as in other caudate species of *Arenicola*, the tail is obscurely segmented, at segmental intervals there is a larger annulus and upon this, in most American examples, there are, on the ventro-lateral or lateral region, hollow outgrowths of the body wall usually in the form of thumb-shaped processes. The processes at the base of the tail, i. e., in the first tail segment, are usually the largest, and occasionally one of them, generally the most dorsal one, is branched at its distal end, resembling a small gill; this branched process corresponds in position, and seems to be serially homologous, with the gills on the preceding segments. Neapolitan examples of this species do not possess these long caudal processes; slightly larger epidermal papillæ are present on the larger annulus of each tail segment, but they are of the same order as the papillæ of the other annuli.

The type-specimen of *A. cristata* Stimpson is apparently no longer in existence. I have made inquiry for it from the curator of the museum of the Boston Society of Natural History, but I am informed that it is not in that museum; that it was probably in Stimpson's own collection, and, if so, was probably destroyed when the Chicago Academy of Sciences was burned in the great Chicago fire. The specimens on which Lütken based his new species *A. antillensis* are preserved in the Universitets Zoologiske Museum, Kjöbenhavn. I have recently examined two of them. They are typical American specimens of *A. cristata*.

Summary of the distribution of Arenicola cristata on American shores.—*A. cristata* is found on the eastern coast of the United States, from Woods Hole, Massachusetts, southward. It extends along the western coast of Florida to Pensacola; it is also recorded from Bermuda, Jamaica, Santa Cruz, and Curaçao, and from two stations, San Pedro and Monterey Bay, on the Californian coast.

Further distribution.—Naples, Suez,^a Barrow Island (northwest Australia),^a Misaki (Japan).^a

ARENICOLA GLACIALIS Murdoch.

This species was founded to contain specimens of *Arenicola* taken on the International Polar Expedition to Point Barrow, Alaska. Murdoch^b remarked that the worms in question are closely allied to *A. marina*, but that they have only six setigerous segments anterior to the gills and eleven branchiferous segments, instead of seven and thirteen, respectively, as in *A. marina*. (He should have said six and thirteen, for there are normally six anterior abbranchiate setigerous segments in *A. marina*.) He described each gill as a cluster of about fifteen simple cirri and noted that the tail of each worm, which forms about a third of the length, is without tubercles or other appendages. Five specimens were picked up on the beach on September 12 and 13, 1882, after a fresh westerly gale, and two mutilated ones were obtained from the gullet of an eider duck which had been diving on one of the sandy patches, in about 3 fathoms, just above the station.

There are no figures of this species, and the above constitutes the whole of the information regarding it. Consequently the systematic position of *A. glacialis* with regard to other species is in doubt, and indeed its validity as a species has been questioned. In the number of its anterior abbranchiate segments and of its branchiferous segments this species agrees with *A. cristata*, and on this ground some

^a Unpublished records from the manuscript of the present writer.

^b Report Intern. Polar Exped. to Point Barrow, Alaska, p. 155, Washington, 1885; also in Proc. U. S. Nat. Mus., vol. 7, p. 522, Washington, 1885.

writers^a have considered *A. glacialis* to be a synonym of *A. cristata*. Von Marenzeller,^b however, places it under *A. marina*.

The specimens, which are in the collection of the Smithsonian Institution, are now in a very fragile condition; only one of them is complete, another is in two parts, held together by a strand of muscle, and the other three are fragmentary. I have made as complete an examination of these worms as is possible in their present condition, and having regard to their value as types. The inspection of the internal organs was made on one of the imperfect examples (No. 3 in the list below), which consists of the anterior end as far back as the seventh chætigerous annulus and was almost dropping to pieces.

The examination of the specimens shows that *A. glacialis* is a distinct and valid species. As Murdoch's description is totally inadequate, I propose to give an account of the species as far as I have been able to investigate it on the material at my disposal.

The material consists of:

1. A complete specimen 90 mm. long, of which the tail, which is strongly contracted, forms 11 mm.
2. A specimen 105 mm. long, of which the tail forms 45 mm. This specimen is broken, about the ninth segment, into two pieces, held together by a strand of muscle.
3. A portion of an anterior region, 26 mm. long, as far back as the seventh chætigerous annulus.
4. A portion of an anterior region, 14 mm. long, as far back as the third chætigerous annulus.
5. A fragment similar to No. 4, 12 mm. long.
6. A posterior region, consisting of eleven segments and tail, belonging to either No. 4 or No. 5.
7. A posterior region, consisting of eight segments and tail.
8. A branchial region.
9. A portion of a tail.

All the specimens are dark brown to nearly black in color.

Each of the specimens, No. 1 and No. 2, possesses seventeen chætigerous segments, the last eleven of which are provided with gills. It is evident, from an examination of all the specimens, that the gills of this species are small. The axes of the largest gills are not more than 2 mm. in length, measured from their origins to the tips of their terminal gill filaments. The first gill may be very small, as in specimen No. 2, and the last gill is smaller than the preceding ones.

^a P. Fauvel, Mem. Soc. Nation. Sci. Nat. Math. Cherbourg, vol. 31, 1899, pp. 169, 171. F. W. Gamble and J. H. Ashworth, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 428.

^b Zool. Jahrb. Abth. Syst., vol. 3, 1888, p. 15.

The gills are best studied in No. 8. The most fully expanded gill of this specimen is shown in fig. 10. It consists of nine or ten axes, which arise from a short, curved, common basal structure situated immediately posterior to the notopodium. The largest axis (see fig. 10, C) bears five branches, each of which divides once, i. e., forks. The longest of the resultant gill filaments are thumb or finger shaped

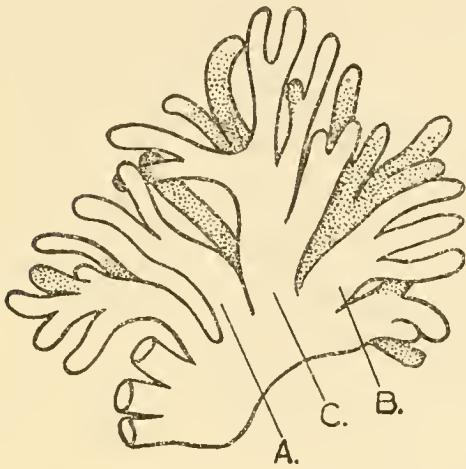


FIG. 10.—A. *GLACIALIS*, NINTH GILL OF NO. 8. THREE OF THE AXES ARE CUT OFF. $\times 15$.

structures, not more than about 0.7 mm. in length, and the shortest are mere tubercles. This axis, measured from its origin to the tip of the filaments, is 2 mm. in length. The smaller axes of this gill bear fewer branches, only two or three, and these may be simple, i. e., undivided, distally (see fig. 10, A, B). Another gill, from fragment No. 6, and one of the most fully expanded gills present in the whole of the specimens, is shown in fig. 11. This gill is smaller than the one just described. It is composed of seven axes, the longest and largest

of which (A) bears three branches, each of which bifurcates, and one of the two so formed again divides, but the other does not. In this way three groups, each of three gill filaments, are clustered at the end of the axis. From the base of this axis to the tip of its filaments is a distance of about 1 mm. In all the gills examined the branches of the gill axis are not given off right and left, but are clustered at the end of the axis, so that each axis and its branches look almost like a hand and fingers (see, for instance, figs. 10, 11, B). This character distinguishes the gills of *A. glacialis* from those of any other species, and especially from those of *A. cristata*, the only other species in which there are

eleven pairs of gills, for in *A. cristata* the branches borne on the gill axes are much more numerous and are regularly arranged along the sides of each axis, forming a typically pinnate gill. The gills of *A. glacialis* are also much smaller than those of *A. cristata*. The gill axes of a specimen of the latter 110 mm. long are from 4 to 5 mm. in length, compared with 1 to 2 mm. in examples of *A. glacialis* of about the same size.

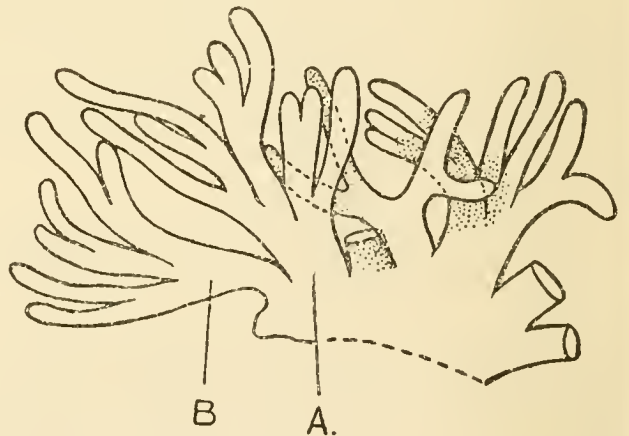


FIG. 11.—A. *GLACIALIS*, THIRD GILL OF NO. 6. THREE OF THE AXES ARE CUT OFF. $\times 35$.

eleven pairs of gills, for in *A. cristata* the branches borne on the gill axes are much more numerous and are regularly arranged along the sides of each axis, forming a typically pinnate gill. The gills of *A. glacialis* are also much smaller than those of *A. cristata*. The gill axes of a specimen of the latter 110 mm. long are from 4 to 5 mm. in length, compared with 1 to 2 mm. in examples of *A. glacialis* of about the same size.

The prostomium is well seen in only two of the specimens. It consists (see fig. 12) of two large lateral lobes of almost uniform width (i. e., they are not markedly dilated anteriorly), which unite posteriorly to form a wide median portion of the prostomium. Between the lateral lobes is situated the median one, which is small. Its transverse diameter is less than one-third that of the whole prostomium and its antero-posterior diameter is also short (about .5 mm.). The nuchal organ exhibits the usual relations to the prostomium. In the specimen figured (from No. 5) the lip (L. N.) of the nuchal organ is well everted.

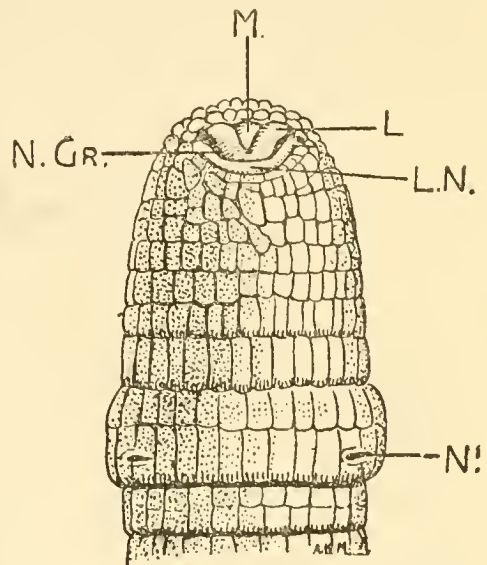


FIG. 12.—A. GLACIALIS, ANTERIOR END, DORSAL ASPECT. $\times 6$. L, LATERAL LOBE OF PROSTOMIUM; L. N., LIP OF NUCHAL ORGAN SLIGHTLY EVERTED; M, MEDIAN LOBE OF PROSTOMIUM; N¹, FIRST NOTOPODIUM (THE NOTOPODIUM IS RETRACTED, LEAVING A SLIT ON THE SURFACE); N. Gr., NUCHAL GROOVE.

The annulation of the anterior region is represented in the annexed diagram (fig. 13), which

is drawn from specimens Nos. 1 and 2. Each segment behind the third is divided into five rings, the largest of which is the chætigerous one.

Neuropodia are clearly visible on each segment, even on the first one. (Compare *A. cristata*.) The groove of the first neuropodium is 0.3 to 0.5 mm. long and five or six erotchetes may be seen in it. The neuropodia gradually increase in length in successive segments; that of the sixth segment is 2.5 mm. in length (in No. 1), and in the branchial region the long muscular ridges of the neuropodia become more obvious. Those of the posterior segments extend from a point just below the notopodium almost to the mid-ventral line and their grooves are about 4.5 mm.

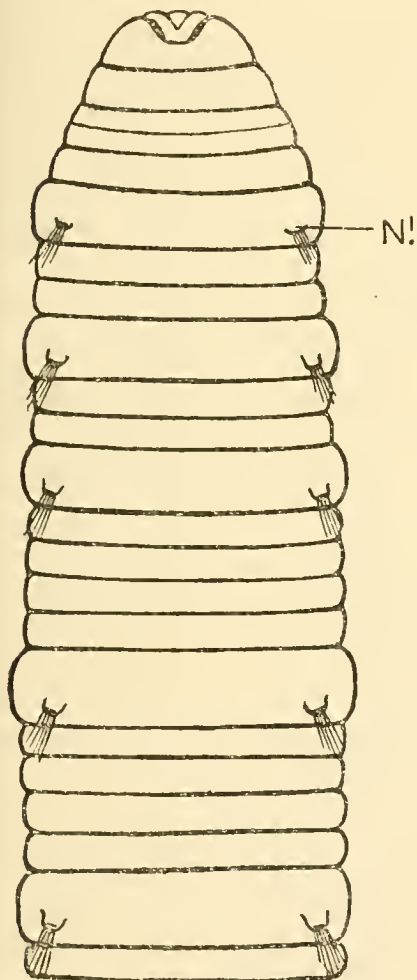


FIG. 13.—A. GLACIALIS, DIAGRAM REPRESENTING THE ANNULATION OF THE ANTERIOR END. $\times 4$. N¹, FIRST NOTOPODIUM.

long. These posterior neuropodia are of the elongate type, seen also in *A. marina* and *A. cristata*, and differ from those of *A. claparèdii* and *A. assimilis*, which are shorter and more or less oval cushion-like pads.

The notopodia are simple conical elevations which call for no comment, except that in some of the segments they are retracted, in which case the setæ appear to issue from a slit on the body wall. (See fig. 12, N.¹)

Specimen No. 1 presents an interesting abnormality. There is, on both sides, an eighteenth neuropodium, about the same size as the seventeenth, but there is no corresponding notopodium or gill. I have met with a similar abnormality in several other species of *Arenicola*, but it is by no means frequent.

The tail, in those specimens in which it is preserved extended, is encircled by pale grooves, which are more strongly marked at segmental intervals. In No. 2 about 22 segments are so indicated; in No. 6, 14 segments; and in No. 7, 21 segments. In No. 1 the tail is contracted and its markings are not clear. The papillæ on the tail are feebly developed and there are no longer processes present such as are found in the tail of *A. cristata*.

Setæ.—Most of the notopodial setæ are imperfect, their tips having been broken off, but two or three perfect ones have been examined. These are of the same type as those of *A. marina*; they are about 3.3 mm. long and taper to a fine point and their terminal third bears numerous minute pointed processes closely appressed to the shaft of the seta. No setæ bearing a laminate margin were observed.

Three series of neuropodial crotchets from different specimens (Nos. 3, 6, and 7) have been examined. Most of these crotchets are similar to those of examples of *A. marina* about 70 to 100 mm. in length. The shaft of the crotchet is curved, but not strongly so, and it presents only a slight dilatation near the middle of its length. The distal portion forms a beak-like structure, the "rostrum," bent at an angle of about 130° to the shaft. Immediately proximal to the rostrum, on the convex side of the crotchet, there is occasionally a minute tooth, or sometimes two, to be seen, but in most cases teeth are wanting. Only a few of the crotchets examined have a sub-rostral tooth and when present it is very minute. In most of the crotchets the rostrum is a bluntly conical beak, but in one of the series, which contains the longest crotchets, the rostrum is longer, curved and almost scythe-like in shape (fig. 14, D). This difference is probably attributable to the greater age of these crotchets. The most interesting point observed during the examination of the neuropodial crotchets was in the series from No. 6. At the base of the crotchets in use (fig. 14, B), which are about 0.2 to 0.25 mm. long, there are two much smaller, more strongly curved and only about 0.13 mm. long, so that their tips would not project beyond the lips of the neuropodial groove (fig. 14, A). These small crotchets have a comparatively larger distal region and well-marked teeth are present behind the rostrum. The

characters of crotchets from examples of different ages have been adequately studied only in one species of *Arenicola*, namely, *A. marina*. Judging from the characters of the crotchets from specimens of *A. marina* of different sizes, the two small crotchets above described are such as one would expect to find in a young worm not more than about 20 mm. long. Most of the crotchets of this worm would, after becoming worn, be gradually cast out and replaced by others of a slightly larger size, and this process has no doubt been repeated several times, but for some reason these two crotchets have escaped being cast out and remain among the bases of the crotchets formed at a much later period than they were, for the worm must have been, at the time of capture, about 70 mm. long.

Nephridiopores are visible on the fourth to the ninth segments, inclusive, in specimens Nos. 1 and 2. These apertures have the usual position on the segment, i. e., near the upper end of the neuropodium.

Ova were found escaping through a rupture in the body wall of specimen No. 1. The diameter of these ova is nearly 0.2 mm.

In two specimens the pharynx ("proboscis") is protruded; it is covered with papillæ. Those of the region first everted are conical in form. Those of the portion everted later are much smaller and rounded at their tip.

The internal organs of fragment No. 3 have been examined, but they are very badly preserved, and therefore only a general description of them can be given.

The alimentary canal presents the usual regions—pharynx, œsophagus, and stomach. There is a single pair of œsophageal glands; each gland is somewhat conical in form and about 5.5 mm. long.

Projecting backwards from the first septum, ventro-lateral to the point at which the œsophagus pierces it, there are two thumb-shaped pouches, 2.0 and 2.5 mm. long, respectively.

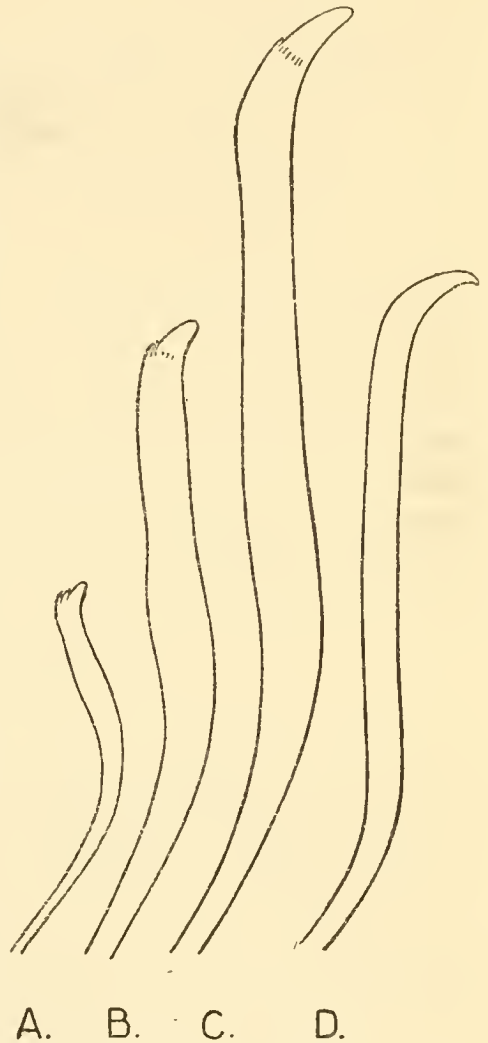


FIG. 14.—A. GLACIALIS, NEUROPODIAL CROTCHETS. A AND B WERE FOUND TOGETHER, THE CROCKET B WAS IN USE, A IS ONE OF THE TWO SMALL CROTCHETS FOUND IN THIS NEUROPODIUM. FOR FURTHER REMARKS ON THESE, SEE TEXT. A AND B ARE FROM NO. 6, $\times 300$, C FROM NO. 7, $\times 300$, D FROM NO. 3, $\times 150$.

The nephridia are apparently of the same type as those of *A. marina*. The dorsal lip of the second one bears eight flattened processes, rounded at their margins.

A brain and nerve cord are apparently similar to those of *A. marina*, but a detailed examination of them is precluded. Sections of the nerve cord demonstrate the presence of giant nerve cells and giant nerve fibers, such as are found in the cord of all species of *Arenicola* except *A. claparedii*.

Statocysts are present. A small piece of the wall of the peristomium and the statocyst situated upon it were cut into serial sections, the examination of which shows that the statocyst is a pear-shaped vesicle opening to the exterior by a very narrow tube situated in a position corresponding to that of the stalk of the pear. The three diameters of the lumen of the statocyst are 0.144, 0.084, and 0.084 mm., respectively. Its wall is 0.04 to 0.08 mm. in thickness. The statoliths are numerous yellow or colorless sand grains, the largest of which is about 25μ in diameter. As seen in transverse section, the lumen of the tube, which connects the statocyst to the exterior, is a narrow oval slit, the diameters of which are 4μ by 20 to 25μ . The statocyst and statoliths are similar to those of *A. marina*, and differ entirely from those of *A. cristata*, which has a closed statocyst containing a single large secreted statolith.

We may now proceed to state the diagnostic characters of

ARENICOLA GLACIALIS Murdoch.

Seventeen chætigerous segments; eleven pairs of small gills, the first on the seventh segment; the gill axes are short and their branches are not given off right and left but at or near the distal end of the axis, each branch divides dichotomously once or twice, the resultant finger or thumb shaped gill filaments form clusters at the end of each axis; the median lobe of the prostomium is small, the lateral ones are well developed but are not markedly dilated or lobate at their anterior ends; neuropodia are clearly visible in each segment, those of the posterior branchial segments are long dorso-ventrally and almost reach the mid-ventral line; six pairs of nephridia which open on the fourth to the ninth segments; one pair of conical œsophageal glands; a pair of small pouches projecting backward from the ventral region of the first septum; a pair of statocysts in the peristomium, which open to the exterior; statoliths, numerous, composed of sand grains. Types, the only specimens known, in the Smithsonian Institution, from the beach, Cape Smyth, Alaska, September 12, 1882. [Bottle No. 851.]

Affinities of Arenicola glacialis.—The affinities of this species with other caudate species of *Arenicola* may now be determined. There are really no points of agreement between this species and *A. claparedii*. Only two features are common to *A. glacialis* and *A. assimilis*, namely, the number of nephridia and the open statocysts, but these are greatly overbalanced by weighty differences in the number of segments, the number of segments bearing gills, the nature of the

gills, of the neuropodia and especially of the œsophageal glands; we may therefore conclude that the Alaskan species has little affinity with the antarctic one. *A. glacialis* agrees with *A. marina* in the number of its nephridia, its neuropodia, œsophageal glands, septal pouches, statocysts, and statoliths, but differences are noticeable in regard to the number of chætigerous segments and pairs of gills and in the character of the gills, though the gills of *A. glacialis* may almost be regarded as an extreme form of the bushy type of gill seen in many specimens of *A. marina*. *A. glacialis* and *A. cristata* agree in the number of their segments and pairs of gills and in the character of the neuropodia in their branchial region, but they differ in respect of the size and type of their gills, the number and situation of their nephridia, the nature of their septal pouches, statocysts, and statoliths. The systematic position of the species may be stated thus: *A. glacialis* presents no affinity with *A. claparedii* and is so slightly related to *A. assimilis* that the relationship may be neglected; it presents externally some resemblance to *A. cristata*, having the same number of segments and gills, but its internal organs are very like those of *A. marina* and in the form of its prostomium and the character of its gills it is more like *A. marina* than any other species. *A. glacialis* is related to *A. cristata* and *A. marina*, but much more closely to the latter than to the former.

THE DIFFERENT REGIONS OF THE AMERICAN SEABOARD AND THEIR SPECIES OF ARENICOLA.

1. East coast of North America:

Arenicola marina has been taken at numerous stations on this coast from Rigolet, Labrador, to Noank, Connecticut. The southern limit of this species is probably about 40° N.

Arenicola cristata extends from Woods Hole southward to Florida, and is also known from Bermuda.

2. Gulf of Mexico, West Indies, Carribbean Sea:

Arenicola cristata is the only species known from this region; it is recorded from Florida, Jamaica, Santa Cruz, and Curaçao.

3. East coast of South America as far south as lat. 51° S.:

There are no records whatever from this portion of the coast.

4. North coast of North America:

Arenicola glacialis is recorded from Port Barrow, Alaska. This is the only record of *Arenicola* from the arctic shores of America.^a

5. West coast of North and South America as far south as lat. 51° S.:

Arenicola claparedii is recorded from several stations on this coast, namely, the Aleutian Islands (Amchitka, Atka, Unalaska), Vancouver Island, San Juan Island, Puget Sound, California, Coquimbo, and Puerto Montt (Chile).

Arenicola cristata is now recorded from two stations on the Californian coast, namely, Monterey Bay and San Pedro.

6. Southern extremity of South America, south of lat. 51° S.:

Arenicola assimilis and the variety *affinis* are the only forms known from this region. *A. assimilis* is known from the Strait of Magellan, the Beagle Channel, and South Georgia. The variety *affinis* is recorded from the Strait of Magellan, the Beagle Channel, and the Falkland Islands.

^a*Arenicola* is recorded from Greenland, which I have not included as American. All the known specimens from Greenland are *A. marina*.

KEY TO THE AMERICAN SPECIES OF ARENICOLA.

1. Seventeen chætigerous segments, 11 pairs of gills 2
Nineteen or twenty chætigerous segments, 13 (or 12) pairs of gills 3
2. Gills large, pinnate; nephridia open on fifth to tenth segments; septal pouches large; statocysts closed, each containing one large statolith.....*cristata*.
Gills small, bushy; nephridia open on fourth to ninth segments; septal pouches small; statocysts open, each containing numerous statoliths (sand grains).*glacialis*.
3. Neuropodia of posterior branchial region long, their grooves extending almost to the mid-ventral line; one pair of œsophageal glands; a pair of small septal pouches; statocysts open, each containing numerous statoliths (sand grains)*marina*.
Neuropodia of posterior branchial region short, forming pads on the sides of the segments, their grooves not nearly reaching to the mid-ventral line; several pairs of œsophageal glands; no septal pouches 4
4. Twenty chætigerous segments; nephridia open on fourth to ninth segments; large open statocysts each containing numerous statoliths.....*assimilis*.
Nineteen chætigerous segments 5
5. Lateral lobes of prostomium of moderate size, not folded anteriorly; nephridia open on fourth to ninth segments; open statocysts each containing numerous statoliths.....*assimilis*, var. *affinis*.
Lateral lobes of prostomium very large, generally folded at their anterior end, nephridia open on fifth to ninth ^a segments, no statocysts.....*claparedii*.

In drawing up this key the character of the prostomium has been used as little as possible, because in many preserved specimens the prostomium is either retracted or its lobes have undergone alteration of shape, owing to their having been in contact with the walls of the vessel in which the specimens have been kept.

Considerable care is necessary in discriminating between *A. claparedii* and *A. assimilis*, var. *affinis* (section 5 of the key). If the prostomial lobes of the specimen under observation are not well preserved, the only features by means of which the species can be determined are the number of nephridia and the presence or absence of statocysts. Rarely specimens of *A. claparedii* have an extra nephridium opening on the fourth segment, only three such cases have been seen out of about a hundred examined, so that the number of nephridia is not an absolutely reliable character for diagnostic purposes. The only way ^b of deciding the species in these cases is therefore to examine, in the dissection which will have been already made to ascertain the number of œsophageal glands and the absence of septal pouches (section 3 of the key), the inner wall of the peristomium along the first part of the course of the œsophageal connectives; if statocysts are visible the specimen is one of *A. assimilis*, var. *affinis*. Occasionally the statocysts are well imbedded in the musculature, and owing to this and to their small size may escape detection. To definitely prove their absence it is necessary to make serial sections of the anterior end of the specimen, or of that region of the peristomial wall in which one of the statocysts would, if present, be situated. Fortunately, recourse to sections is comparatively seldom necessary for diagnostic purposes.

^a Rarely on fourth to ninth.

^b Since writing this I have found that the form of the neuropodial crotchets usually affords help in distinguishing these two species.

A NEW GENUS AND SPECIES OF LIZARD FROM FLORIDA.

By LEONHARD STEJNEGER,

Curator, Division of Reptiles and Batrachians, U. S. National Museum.

The North American fauna is not rich in skinks compared with the rest of the world. The late Prof. E. D. Cope recognized no less than 79 genera in the family Scincidæ, of which only four are represented on the continent north of Panama and only two within the confines of the United States, namely, *Leiolopisma* and *Eumeces*. Hitherto not a single form was known from North America corresponding to the many degraded types so frequent in the Old World, in which the limbs have been reduced to mere stumps with a greatly diminished number of digits.

The discovery of such a form in Florida is therefore highly interesting and significant. The fact that this small worm-like creature has been overlooked so long may be due partly to its burrowing habits, but it can scarcely be doubted that the animal is very rare. Mr. A. G. Reynolds, who has generously donated the unique specimen to the National Museum, and for whom the species has been named, states expressly that a search for others was made in the same locality without results.

NEOSEPS, new genus.

Diagnosis.—Nostril between two nasals; supranasals present; palatine bones separated on the median line of the palate; no frontoparietals; eyelids movable; lower eyelid with a large transparent disk; ear hidden; fore feet with one, hind feet with two toes.

Type.—*Neoseps reynoldsi*.

This genus is probably nearest related to *Sphenoscincus*, which occurs in eastern Persia, Afganistan, and the northwestern corner of India. *Sphenoscincus tridactylus* has three toes on all feet and differs in many other respects, but it bears a certain strong outward resemblance to the Florida species here described. The true relationship of the latter, however, must remain undecided until the acquisition of more material shall allow a closer anatomical examination to be made.

NEOSEPS REYNOLDSI, new species.

Diagnosis.—Snout wedge-shaped with angular labial edge; five supralabials; one large temporal; three supraoculars; 16 scale rows around the body.

Habitat.—Florida.

Type-specimen.—Cat. No. 42147, U.S.N.M.; near Spring Lake, Fruitland Park, Lake County, Florida; A. G. Reynolds, collector.

Description of type specimen (figs. 1–6).—Snout wedge-shaped, with angular projecting labial edge; mouth inferior; nostril between two small nasals, the anterior crescent-shaped, the posterior triangular, both situated between rostral, supranasal, and first supralabial; rostral large; supranasals large, broadly in contact behind the rostral and with the first supralabial, separating the posterior nasal from the loreal; fronto-nasal large, broadly in contact with loreal and anterior supraocular; frontal large, slightly longer than broad, anterior and posterior margins convex forward, lateral margins concave, in contact with all the supraoculars; three small, nearly subequal supra-

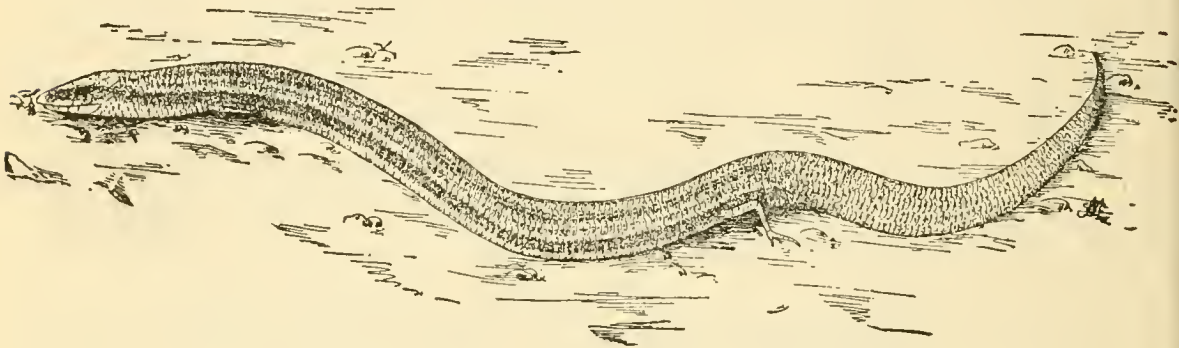
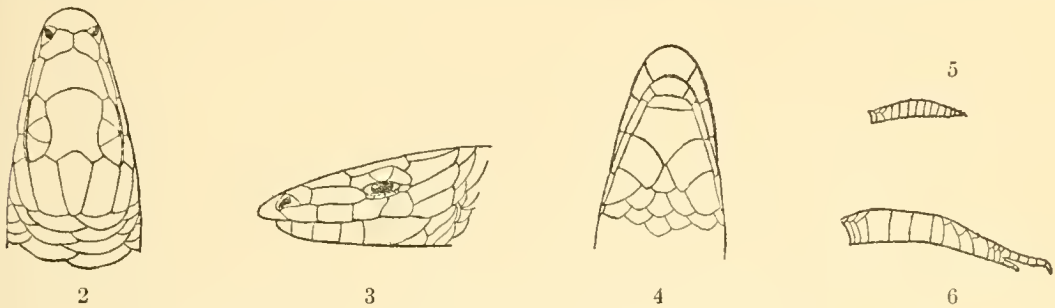


FIG. 1.—NEOSEPS REYNOLDSI. $1\frac{1}{3} \times$ NAT. SIZE. NO. 42147, U. S. N. M.

oculars, the median one triangular, its outer angle just reaching the superciliary border; no superciliaries; no fronto-parietals; parietals nearly as long as frontal, well-developed, with parallel sides, and entirely separated by the interparietal, which equals them in width anteriorly, narrowing to a blunt point posteriorly; one pair of nuchals, not much larger than nearest dorsals; loreal single, three times as long as high, anteriorly widely separated from posterior nasal by supranasal, posteriorly entering eye; lower eyelid with a large transparent disk; eye separated from supralabials by a row of about four small scales; a small postocular; a single, very large temporal shield between the last supralabial and the parietal, bordering the entire lateral margin of the latter; five large supralabials of subequal length, third and fourth under eye, first, second, and third in contact with loreal; four lower labials increasing in size posteriorly; two unpaired postmentals, the second very large; behind these on either side two large shields in contact with the lower labials; 16 rows of smooth scales around the body, the two median series wider than the others,

considerably so anteriorly; two large preanal shields; fore leg rudimentary, consisting of a short, slender style ending in a small claw; distance between axilla and groin twenty times the length of the fore leg; hind leg diminutive, slender, ending in two short, clawed toes; median series of scales on underside of tail (reproduced) slightly widened. Color (in alcohol) above pale purplish drab, each scale with a dark brown median spot, so as to form four series of beady dark lines, separated by pale stripes, the median ones being wider than the others; sides similarly colored, but darker, so as to form a continuous broad, dark band from nostril through eye, above legs to side of tail;



FIGS. 2-6.—NEOSEPS REYNOLDSI. $3 \times$ NAT. SIZE. 2, TOP OF HEAD; 3, SIDE OF HEAD; 4, UNDERSIDE OF HEAD; 5, FORE LEG; 6, HIND LEG. NO. 42147, U. S. N. M.

the reproduced part of latter paler drab, evenly dusted over with small, black spots; head above uniform dark drab; underside uniform pale.

Dimensions.

	<i>mm.</i>
Total length.....	85
Tip of snout to vent.....	58
Vent to tip of tail (reproduced).....	27
Width of head.....	4.5
Tip of snout to fore leg.....	14
Axilla to groin.....	40
Fore leg.....	2
Hind leg.....	6
Longest toe with claw.....	1.5

THE THORAX OF THE HYMENOPTERA.

By ROBERT EVANS SNODGRASS,

Of the Bureau of Entomology, United States Department of Agriculture.

1. INTRODUCTION.

There are always two classes of workers concerned in the scientific study of any group of animals who think that the work of the other class is properly but secondary to their own. These are the systematists and the morphologists. In the field of entomology, however, there is now a very large third class of workers who pick out as important only those phases of the subject that have some direct connection with the welfare of mankind. We need not discuss the relative merits of the three, however, because the present paper is a sufficient demonstration of the interdependence of all these branches of entomological research. To wit, the gypsy moth and the brown-tail moth have been for a number of years greatly infringing on human interests and pleasure in certain parts of New England. A most promising means of combating them is the importation and rearing of destructive Hymenopteran parasites. Students of these parasites discover that the thorax presents valuable characters for the determination and classification of species, but they are handicapped in the use of such characters by the lack of reliable studies on the structure of the thorax among parasitic Hymenoptera in general. When, furthermore, the present writer undertook a study of the latter subject, he soon found himself necessarily involved in a general investigation of the Hymenopteran thorax, and especially of that of the lower members—the Tenthredinoidea and Siricoidea. These in turn had to be compared with the more generalized orders of insects to make sure of correct interpretations. Hence, while an unscientific person may be inclined to ask what the study of a cockroach's thorax has to do with the extermination of the gypsy moth in Massachusetts, experience shows that no special branch of entomology can be developed properly unless based on a knowledge of the fundamental structure of insects in general.

The study of the Hymenopteran thorax here presented is a contribution from the United States Bureau of Entomology, prepared under the direction of its chief, Dr. L. O. Howard. The work by the writer has been in the nature of a collaboration with Mr. J. C. Crawford of the United States National Museum and with Mr. H. L. Viereck and Mr. S. A. Rohwer of the bureau, who, as specialists in various groups of the Hymenoptera, have furnished not only the identified specimens from which the dissections and drawings were made, but also the taxinomic plan followed in treating the various species.

The most irreconcilable subject of contention between systematists and morphologists is in the field of terminology. The morphologists, of course, insist that the same anatomical parts should be given the same names in all the orders. The systematists, on the other hand, inheriting from their forerunners in taxinomy a different set of terms in each order, hold that these names should be retained for the sake of convenience, since every new student has to learn them anyway. They think it well enough to let such names remain as they are with the understanding that they are merely handles to the different parts used in description and that they are not supposed to have any morphological significance. Furthermore, the morphologists often make up such cumbrous terms, that, however significant from an anatomical standpoint, they are far too unwieldy for using as the names of organs or parts in specific descriptions. Hence, perhaps complete uniformity will never exist in entomological nomenclature. In the preparation of the present paper, however, no such conflict has arisen, and this for two reasons: First, the lateral and ventral parts of the Hymenopteran thorax have been so little used in specific descriptions that no system of names has yet been given to them; and secondly, the names commonly applied to the back plates are in some cases so glaringly misplaced that even systematists themselves are glad to have their nomenclature revised.

At first sight the thorax of most of the Hymenoptera appears very different from that of all other insects. Not only does it seem impossible to make out the ordinary parts of each segment, but the limits of the segments themselves are obscure. For a true solution of the subject the student must begin with a study of the Tenthredinoidea and Siricoidea and compare their structure with that of the more generalized orders of insects. While some entomologists have separated these two groups as a distinct order from the rest of the Hymenoptera, there can be no doubt that in their thoracic characters they are truly Hymenopteran. Yet, on the other hand, their thorax is so generalized that one can not possibly mistake its morphology in a comparison with the thorax of a grasshopper or stonefly. Hence, if the *Phytophaga*, so called, had become extinct, the Hymenopteran tree would have been cut off just so much higher above its

base, and the thoracic structure of its various branches would have been much more difficult to decipher.

The Hymenoptera are usually given the highest place in the scale of specialization, yet in almost every feature, members of some other order might be placed ahead of them. The mouth parts of the Hemiptera, the thorax and wings of the Diptera, and the internal organs of many other forms are more specialized than the corresponding parts of the Hymenoptera, while the Tenthredinoidea are certainly more generalized in their adult characters than the lowest members of the Hemiptera, Lepidoptera, or Diptera. These other orders, however, have picked out some one character or group of characters for extreme specialization. The Hymenoptera, on the contrary, have carried nearly *all* their organs to a high state of perfection and specialization. The mouth parts, the thorax, the legs, the wings, the ovipositor or sting, the alimentary canal, the tracheal system—all constitute a group of specialized organs unparalleled in any other order. Added to this is the high development of their instincts and the great diversity of their habits. Hence, there can be no doubt that the order amply merits the place of honor assigned to it.

2. GENERAL STRUCTURE OF THE INSECT THORAX.

It may still be confidently asserted that the thorax of insects consists of three segments, the attempts of various entomologists to make out a contrary case notwithstanding. Those who would elaborate this region of the body into a composite structure of many original segments may be grouped into two classes. The first includes those who look upon each apparent segment as a compound of two or four primitive segments. The second includes those who believe that all but three of the original segments have disappeared, except in some of the lowest insects where their rudiments persist as the intersegmentalia or little sclerites situated between the normal segments. The theory of the first class of speculators derives the consecutive parts of each definitive segment from a series of coalesced primitive segments; that of the second class leaves each modern segment a unit, and only assumes that there were once a great many more such units present. In the study of insects alone neither of these theories seems to be demanded. There is no necessity for supposing that the parts of any segment are anything more than secondary differentiations, or that the intersegmentalia are anything more than secondary products of the principal segments. Embryologists have never discovered more than three metameres in the true thoracic region of any insect.

In this connection it is interesting to note that both of these theories have been urged principally by myriopodists, or by entomologists who have included the Myriopoda largely in their studies. In fact, both theories are really based on the idea that insects are lineal

descendants of the centipedes. The myriopodists find that the different forms of the Chilopoda may be arranged in a series indicating a progressive reduction and disappearance of alternating segments. If this process should be continued far enough and accompanied by the disappearance of most of the legs, together with a few other changes, there would undoubtedly be produced an insect-like creature. Or, again, the same result might be obtained if the reduction in the number of segments were brought about by a combination of the chilopod segments instead of by an obliteration of the supernumerary ones. Hence, the evolution of insects from centipedes may be explained in two ways, but it would seem that the myriopodists simply assume the fact of this evolution which they would so amply explain. While probably few entomologists disclaim a common origin for the Chilopoda and Hexapoda, yet probably few of them admit that a study of insects alone affords any evidence of a lineal descent of the latter from centipedes. While it may be true, then, that the myriopods appear to be evolving into insects, it is not true that insects appear to have descended lineally from centipedes. The alleged relationship seems to be a case of a myriopodan claimant.

The theory that an insect is a centipede which has lost most of its segments by reduction has been elaborated chiefly by Verhoeff, but that author's ideas have been so widely criticised, especially by European entomologists, that the writer will not reiterate the subject here.^a The bulk of opinion favors the notion that the intersegmental plates are secondary sclerites cut off from the front parts of the thoracic segments. Crampton (1909) has given the general term of *intersegmentalia* to all the sclerites that occur between any two segments, while Enderlein (1907) designated the special group apparently derived from the front of any segment as the *apotom* of that

^a The writer has heretofore overlooked the theory of Hagen (1889) that each thoracic segment of modern insects is a composite of *three* primitive segments, the first of which carried the wings, the second the legs, and the third the spiracle. Hagen's reasoning is a good example of the exasperating style of logic such writers always use for closing their argument at both ends. For example, after stating his proposition, he expects the reader to accept its truth simply because it explains the structure of the thorax so nicely, as if this in itself were sufficient evidence. In the first place, the author assumes that there is something to explain, and, in the second place, he gives no reason why the parts have not been produced secondarily from *one* primitive segment, as they so evidently appear to be formed to students of development. The negative argument, that embryos of insects do not indicate any such thoracic composition, is set aside, after the manner of all such writers, by the statement that the condensation of the three segments into one took place so far back in phylogenetic history that even the embryo shows no longer any trace of it. ("Ich meine also, dass diese Cumulation von je drei Segmenten einen so alt erworbenen Zustand darstelle, dass selbst im Embryo der Nachweiss nicht mehr vorhanden ist.") This argument must give a feeling of profound peace to all who seek its blissful security. Who enters here leaves all doubt behind and shuts out all pursuit. In this garden of Eden anybody can have all creatures created according to his own private formulas.

segment, those of the thorax corresponding with the "mikrothorax," "stenothorax," and "cryptothorax," of Verhoeff.

It is only in the neck region that a sufficient structure is found to warrant the idea of an extra segment. Many entomologists as well as myriopodists have believed, as first suggested by Huxley, that the sclerites in the walls of the neck, often highly developed in the lower orders, are the rudiments of a fourth thoracic segment. This supposed segment was named by Verhoeff the "*mikrothorax*." But yet, no actual proof has been adduced of the segmental nature of this group of sclerites. Some students of the subject think that the plates in question are derived from the labial segment of the head, others from the front of the prothorax, while still others claim that they arise from both of these sources. No one has discovered a separate neck segment. If the neck sclerites belong to the labial segment, then this segment must carry the name "microthorax" if the term be used at all. To the writer it now seems preferable to dispense with this appellation altogether, and to substitute the term *cervicum*, as used by Crampton (1909), to designate the neck and its plates; distinguishing the latter as the *cervical sclerites*. This involves no theory concerning the nature of these parts. The writer thus retracts whatever doubtful notions on the "microthorax" he may have expressed in former papers (1909, 1910).

The terms used in this paper to designate the principal parts of the body and of each thoracic segment are classified in the following tables. The phragmas, as will be shown later (pp. 57 to 64), are really intersegmental structures, or at least are developed intersegmentally, and hence, should be classed as such, though in adults they become associated with either the segment before or behind them. Since the first segment of the thorax is often so very different from the other two, on account of the reduction of its parts, a wing-bearing segment is given as a complete example of a thoracic segment.

PRINCIPAL PARTS OF AN ADULT INSECT.

Head.—Composed of seven consolidated segments.

Cervicum.—The neck region, including the cervical sclerites, derived perhaps from both the head and the prothorax.

Thorax.—Composed of three segments.

Prothorax.

Anterior phragma.

Mesothorax, including the mesothoracic apotomal plates when present.

Middle phragma.

Metathorax, including the metathoracic apotomal plates when present.

Posterior phragma.

Abdomen.—Composed of ten or more segments, except in Hymenoptera, where the first is transferred to the thorax.

PRINCIPAL PARTS OF A WING-BEARING SEGMENT.

*Dorsum.**Tergum (T).**Notum (N).**Prescutum (Psc).**Scutum (Sct).**Scutellum (Scl).**Postnotum, postscutellum (PN).**Latus.**Pleurum (Pl).**Preepisternum (Peps).**Episternum (Eps) and episternal paraptera (1P, 2P).**Epimerum (Epm) and epimeral paraptera (3P, 4P).**Trochantin (Tn).**Venter.**Sternum (S).**Presternum (Ps).**Eusternum (Es).**Sternellum (Sl).**Poststernellum (Psl).**Wing (W).**Wing membrane, including the axillary membrane (AxM).**Wing veins—costa (C), subcosta (Sc), radius (R), media (M), cubitus (Cu), anals (A).**Axillaries (Ax), first (1Ax), second (2Ax), third (3Ax), and fourth (4Ax).**Leg (L).**Coxa (Cx).**Trochanter (Tr).**Femur (F), with sometimes second trochanter.**Tibia (Tb).**Tarsus (Tar), including claws (Cla), pulvilli (Pv), and empodium (Emp).*

In selecting and inventing names for the parts the writer has used those most in harmony with the system established by Audouin (1824), and, in fact, has retained Audouin's names wherever possible. The prefixes *pro*, *mesa*, and *meta* are reserved exclusively for designating the three thoracic segments or their respective parts, while corresponding anterior and posterior parts of any one segment are distinguished by the prefixes *pre* and *post*. Thus, "proscutum" means the scutum of the prothorax, but "prescutum" is the notal subdivision in front of the scutum in any segment. This system leads to a number of hybrid combinations of Latin and Greek terms, but, to avoid them, confuses the significance of the words. Berlese

(1906) distinguishes the four parts of the tergum by the names "acrotergite," "protergite," "mesotergite," and "metatergite," which offend in both respects at once. The writer believes that it is better to use a mixed term like "postnotum" to designate the plate lying behind the notum in any segment than to create confusion by calling it the "metanotum," by which term most anyone would understand the notum of the metathorax.

The following are definitions of the terms given in the above tables, together with descriptions of the secondary parts pertaining to each. A special discussion of the morphology of the postnotum and the phragmas is given on pages 53 to 64.

Dorsum.—The back or dorsal surface of any segment, of any part, or of the entire body.

Tergum.—The chitinous plate or plates of the dorsum of any seg-

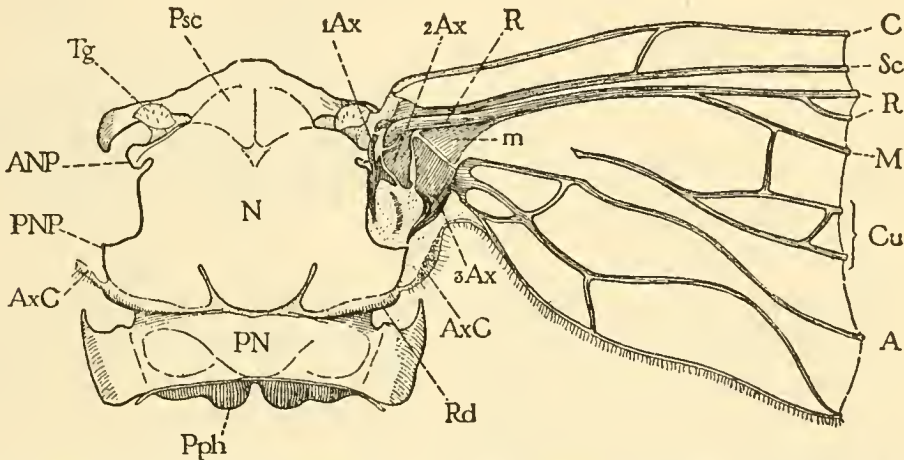


FIG. 1.—MESOTERGUM AND BASE OF RIGHT WING OF *TÆNIOPTERYX FRIGIDA* (STONEFLY), SHOWING THE WING-BEARING NOTUM (*N*) AND THE POSTNOTUM (*PN*): *A*, ANAL VEIN; *ANP*, ANTERIOR NOTAL WING PROCESS; *1Ax*, FIRST AXILLARY; *2Ax*, SECOND AXILLARY; *3Ax*, THIRD AXILLARY; *AxC*, AXILLARY CORD; *C*, COSTA; *Cu*, CUBITUS; *M*, MEDIA; *m*, MEDIAN PLATE OF WING BASE; *N*, NOTUM; *PN*, POSTNOTUM; *PNP*, POSTERIOR NOTAL WING PROCESS; *Pph*, POSTPHRAGMA; *Psc*, PRECUTAL DIFFERENTIATION OF NOTUM; *R*, RADIUS; *Rd*, POSTERIOR MARGINAL REDUPLICATION OF NOTUM; *Sc*, SUBCOSTA; *Tg*, TEGULA.

ment, typically confined to the back, but often extending downward on the sides or even upon the ventral surface. In adult winged insects the tergum of the mesothorax and of the metathorax very commonly consists of an anterior wing-bearing plate, and of a posterior plate having no connection with the wings. These are distinguished as the *notum* and the *postnotum* (fig. 1, *N* and *PN*).

Notum.—The primitive tergal plate, being the entire tergum of any segment in nymphal forms, as well as of the prothorax and of the abdominal segments in all adults. In the mesothorax and metathorax of adults, when there are two tergal plates present in each segment, the notum is the anterior or wing-bearing one (figs. 1 and 8, *N*). The words "tergum" and "notum," as used by the writer, are, therefore, synonymous except where there is present in the wing-bearing segments a secondary postalar tergal plate. Since "tergum" has

priority over "notum" as a general term, the writer has used the latter in the more restricted sense, and has named the posterior secondary sclerite of the tergum, when present, the "postnotum."

The lateral margins of each wing-bearing notum are produced into the *anterior* and *posterior notal wing processes* (figs. 1, 2, and 4, *ANP* and *PNP*) for the articulation of the wings. The ventral surface very commonly presents three ridges—an *anterior notal ridge* (fig. 3, *ANR*), a *posterior notal ridge* (*PNR*), and a median *V-shaped notal ridge* (*VNR*)—the "entodorsum," having its apex forward. These three ridges form three transverse lines (fig. 2, *anr*, *vnr*, and *pnr*) on the surface of the notum. The first is slightly submarginal on account of the reflexed anterior edge of the notum, while the third is nearly always some distance in front of the posterior edge of the notum,

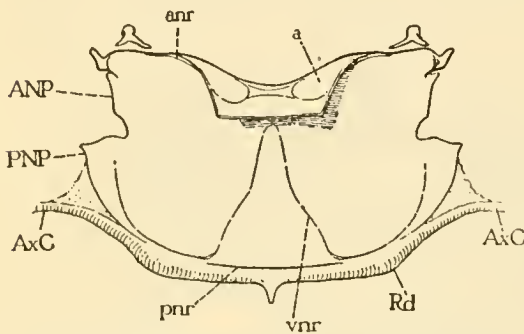


FIG. 2.—MESOTERGUM OF *BLATELLA GERMANICA* (COCKROACH), DORSAL VIEW, ILLUSTRATING A TERGUM CONSISTING OF A NOTAL PLATE ALONE: *a*, CHITINOUS FOLD REFLECTED UPON POSTERIOR EDGE OF PROTERGUM; *ANP*, ANTERIOR NOTAL WING PROCESS; *anr*, LINE FORMED BY ANTERIOR VENTRAL NOTAL RIDGE; *AxC*, AXILLARY CORD; *PNP*, POSTERIOR NOTAL WING PROCESS; *pnr*, LINE FORMED BY POSTERIOR VENTRAL NOTAL RIDGE; *Rd*, POSTERIOR REDUPLICATION OF THE NOTUM; *vnr*, LINE FORMED BY MEDIAN VENTRAL V-SHAPED NOTAL RIDGE.

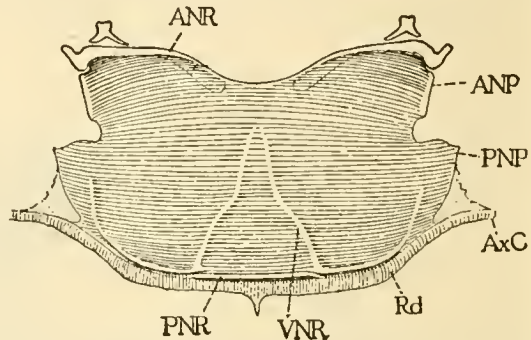


FIG. 3.—VENTRAL VIEW OF MESOTERGUM OF *BLATELLA GERMANICA*: *ANR*, ANTERIOR NOTAL RIDGE; *PNR*, POSTERIOR NOTAL RIDGE; *VNR*, MEDIAN V-SHAPED NOTAL RIDGE, THE "ENTODORSUM;" OTHER LETTERING AS IN FIG. 2.

which forms a conspicuous posterior reduplication of varying width (figs. 1, 2, and 3, *Rd*) overlapping the part behind.

Finally, the notum is commonly more or less divided into three regions by topographical differentiation or by transverse lines or sutures, independent of those formed by the ventral ridges. The first subdivision is the *prescutum*, the second the *scutum*, and the third the *scutellum*. These are best marked in the higher forms, as illustrated by the mesotergum of a crane-fly (fig. 4, *Psc*, *Sct*, *Scl*), and are clearly not homologous in all the orders, because they do not always bear the same relation to the more fixed characters of the notum. In the Hymenoptera the notum is actually cut into two separate pieces by a suture crossing it in front of the apex of the V-shaped ridge (pl. 10, fig. 46, *k*). In the lower orders the differentiations of the notum are largely topographical. In the cockroach (fig. 2) there are no divisions corresponding with those of the crane-fly (fig. 4),

though in the stonefly (fig. 1) a prescutal region (*Psc*) is distinctly marked off from the rest. The cord-like thickenings of the basal membranes of the wings (figs. 1, 2, 3, and 4, *AxC*) arise from the posterior angles of the notum, at the ends of the posterior reduplication.

Postnotum (*PN*).—The posterior transverse postalar sclerite of the mesotergum and metatergum (figs. 1, 4, and 5, *PN*), developed best in those segments that have the wings best developed as organs of flight, though not present in either segment of the Isoptera. It is absent in the mesothorax of Orthoptera, Euplexoptera, and Coleoptera, and is greatly reduced or absent in the metathorax of species having the hind wings reduced. That of the metathorax is generally fused with the first abdominal tergum in Orthoptera, Euplexoptera, and Hymenoptera.

The postnotum is ordinarily called the "postscutellum," since it lies immediately behind the scutellum of the notum. However, it is not one of the divisions of the notum, since it is formed independently as a secondary tergal chitinization in the dorsal membrane behind the notum. Laterally it is connected with the epimera of the same segment (fig. 5, *PN* and *Epm*), while posteriorly it carries the succeeding phragma, which thus becomes a post-phragma (figs. 1 and 4, *Pph*) of the segment. (See special discussion of the postnotum and the phragmas, pp. 53 to 64.)

Phragmas (*Ph*).—The internal, vertical, transverse plates developed from the intersegmental folds between the terga (figs. 15 and 16, *2Ph*, *3Ph*). There are commonly three phragmas present, the anterior, the middle, and posterior, originating between the prothorax and the mesothorax, between the mesothorax and metathorax, and between the metathorax and the first abdominal segment respectively. In the adult stage the phragmas are not independently intersegmental, each being connected with either the tergum behind it or the one in front of it. The first, when present, is always fused with the front edge of the mesonotum. The second is likewise fused with the front of the metanotum in Orthoptera, Euplexoptera, and Coleoptera, but when present in the other orders it is connected with the postnotum of the mesotergum. The third is always connected with the meta-postnotum even when this plate is fused with the first abdominal tergum. If the postnotum is absent there is likewise no phragma.

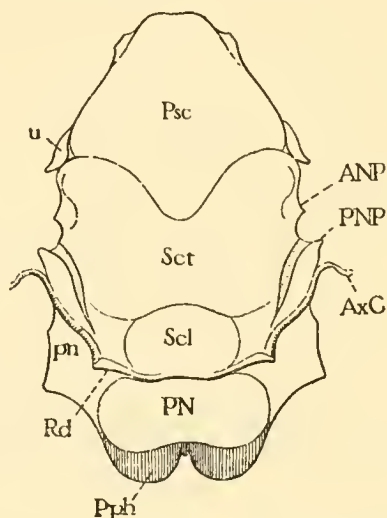


FIG. 4.—MESOTERGUM OF *HOLORUSIA GRANDIS* (CRANEFLY), SHOWING DIVISION OF NOTUM INTO THREE PARTS (*Psc*, *Sct*, AND *Scl*), BACK OF WHICH IS POSTNOTUM (*PN*): *AxC*, AXILLARY CORD; *ANP*, ANTERIOR NOTAL WING PROCESS; *PN*, *pn*, POSTNOTUM; *PNP*, POSTERIOR NOTAL WING PROCESS; *Pph*, POSTPHRAGMA; *Psc*, PRESCUTUM; *Rd*, POSTERIOR REDUPLICATION OF NOTUM; *Scl*, SCUTELLUM; *Sct*, SCUTUM; *u*, LOBE OF PRESCUTUM BEFORE BASE OF WING.

Thus, in adults, any phragma may be spoken of either as a *prephragma* (*Aph*) or as a *postphragma* (*Pph*) of the segment to which it is attached. In those orders having a postnotum in the mesothorax the tergum of this segment carries both a prephragma and a postphragma, while the metatergum has only a postphragma. In the other orders the metatergum bears two phragmas while the mesotergum has only a phrephagma.

Latus.—The side of any segment, of any part, or of the entire body—the lateral area between the dorsum and the venter. The writer introduced this term, in the sense here defined, in a former paper (1910), because, if the term “pleurum” is used to designate the chitinous parts of the side of any segment, it is evident that another is needed to refer to the side of the segment itself, which should include both the membranous and

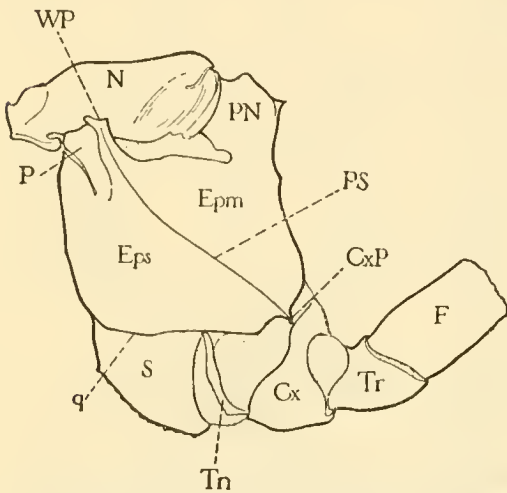


FIG. 5.—METATHORAX OF TÆNIPTERYX FRIGIDA (STONEFLY), LEFT SIDE, WINGS REMOVED: *Cx*, COXA; *CxP*, PLEURAL COXAL PROCESS; *Epm*, EPI-MERUM; *Eps*, EPISTERNUM; *F*, BASE OF FEMUR; *N*, NOTUM; *P*, EPISTERNAL PARAPTERUM; *PN*, POSTNOTUM; *PS*, PLEURAL SUTURE; *q*, STERNO-PLURAL SUTURE; *S*, STERNUM; *Tn*, TROCHAN-TIN; *Tr*, TROCHANTER; *WP*, PLEURAL WING PROCESS.

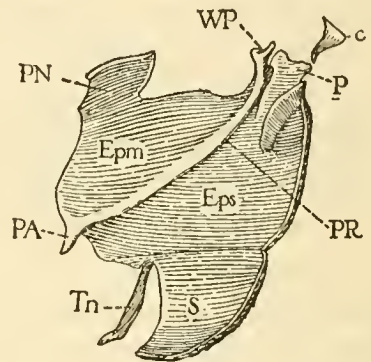


FIG. 6.—LEFT METAPLEURUM OF TÆNIPTERYX FRIGIDA (STONEFLY), INTERNAL: *c*, SCLERITE CON-NECTING PARAPTERUM (*P*) WITH HEAD OF COSTAL VEIN OF WING; *Epm*, EPI-MERUM; *Eps*, EPISTERNUM; *P*, EPISTERNAL PARAPTERUM; *PA*, PLEURAL ARM; *PN*, LATERAL PART OF POSTNOTUM, CONTI-NUOUS WITH EPI-MERUM; *PR*, PLEURAL RIDGE; *S*, STERNUM; *Tn*, TROCHANTIN; *WP*, PLEURAL WING PROCESS

the chitinous parts. The adjective “lateral” follows from “latus,” just as does “dorsal” from “dorsum” and “ventral” from “venter.”

Pleurum (*Pl*).—The chitinous plate or plates of the latus of any segment, often partially crowded out by lateral encroachments of the tergum or sternum, especially in the prothorax. A typical adult pleurum of the mesothorax or metathorax covers most of the latus and presents externally a vertical or oblique *pleural suture* (fig. 5, *PS*) extending from the base of the *wing process* (*WP*) above to the *coxal process* (*CxP*) below. This divides the pleurum into an anterior or ventral *episternum* (*Eps*) and a posterior or dorsal *epimerum* (*Epm*). Internally there is a heavy *pleural ridge* (fig. 6, *PR*) along the line of the pleural suture, which gives off a *pleural arm* (*PA*) at or near its lower end. At the upper end of the epi-

sternum are one or two *episternal paraptera*, small plates connected with the head of the wing and giving insertion to the extensor and pronator muscle of the wing. At the upper end of the epimerum there is likewise frequently one and very rarely two *epimeral paraptera*. The metapleurum of the stonefly, shown in figure 5, has only one parapteral plate (*P*), situated just in front of the wing process and not entirely disconnected from the episternum.

Audouin (1824) first described the "paraptère" as a little plate of the pleurum situated in front of the wing base. The present writer, in a former paper (1909), applied the term in the plural to the series of little subalar pleural plates both before and behind the wing process, as defined here. Some authors have supposed that Audouin referred to the tegula in describing the "paraptère," but his description shows clearly what he meant. (The present writer has fully discussed this subject in a former paper, 1910, footnote *a*, pp. 20 and 21.)

Ventrally to the episternum and in front of the coxa is a variable plate called the *trochantin* (fig. 5, *Tn*). It is best developed in the lower orders, where it articulates by its lower end with the ventral rim of the coxa; but it is often rudimentary or is fused with the lateral precoxal part of the sternum. In cases where the coxa appears to articulate ventrally with the sternum, it may be that the articulation is really with the absorbed trochantin.

In the Orthoptera and Euplexoptera there is very often present a plate lying before the episternum which the writer (1909) has termed the preepisternum (fig. 7, *Peps*). In a few cases it forms a continuous band from the front of the episternum to the front of the sternum (presternum). It was described by Verhoeff (1903) as the "katopleure." When the preepisternum does not reach the sternum, there is very frequently a plate lying between it and the sternum (fig. 7, *x*). In a former paper on the thorax the writer (1909) followed the prevalent custom, especially among German entomologists, of regarding these plates as separated presternal sclerites (the "Vorplatten" of the Germans). Crampton (1909), however, has elaborated the following theory based principally on a study of the Blattidæ and Euplexoptera. He supposes that in a primitive form the chitin was continuous across the ventral surface

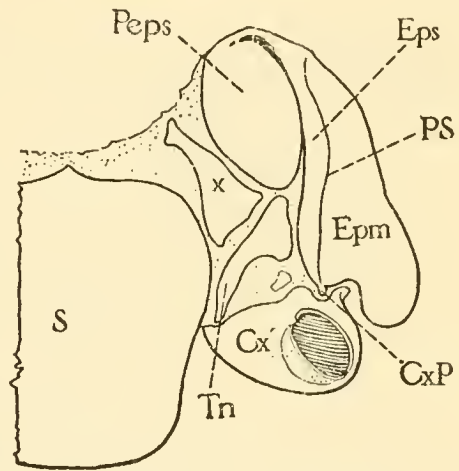


FIG. 7.—RIGHT HALF OF MESOPECTUS OF SPONGIPHORA APICIDENTATA (EARWIG); *Cx*, COXA; *CxP*, PLEURAL COXAL PROCESS; *Epm*, EPIMERUM; *Eps*, EPISTERNUM; *Peps*, PREEPISTERNUM; *PS*, PLEURAL SUTURE; *S*, STERNUM; *Tn*, TROCHANTIN; *x*, PLATE BETWEEN THE STERNUM AND PREEPISTERNUM.

of the segment from one pleural suture to the other. This was then divided by sutures into a sternal sclerite, an episternal sclerite, a trochantin, and a large plate lying between the sternum and the episternum, which Crampton calls the "laterale." Finally, this is supposed to have differentiated into an "episternal laterale" adjoining the episternum (fig. 7, *Peps*) and into a "sternal laterale" (*x*) adjoining the sternum. A study of adult insects furnishes plenty of facts for illustrating such a theory, and it certainly looks reasonable, but the writer would not urge it without knowing whether there are any facts of development that would contradict it. Since neither of the plates in question (*Peps* and *x*) occur in the Hymenoptera, however, a decision on their nature or origin is immaterial to the present paper.

Venter.—The under surface of any segment, of any part, or of the entire body.

Sternum (*S*).—The chitinous parts of the venter of any segment, which, however, may extend upward in the latera, thereby encroaching upon the territory of the pleura.

The determination of the homologies of the sternites—that is, the sclerites of each sternum—is the most unsatisfactory subject connected with a study of the thorax. In the higher orders the sternum very commonly consists of a single ventral sclerite often continuously fused with the pleura. But in many of the lower orders there is a multiplicity of sternal sclerites, and it is often a difficult matter to determine corresponding parts in different forms. MacLeay (1830) first surmised that there are four sternites corresponding with the four parts of the tergum, and he named them the "præsternum," "sternum," "sternellum," and "poststernellum." Comstock and Kochi (1902) adopted the same nomenclature. Crampton (1909), however, has made a more careful study of the sternal anatomy, and, while he discovers four transverse parts, he names them the "præsternum," "basisternum," "furcisternum," and "spinisternum," because, as he says, only the first coincides with the divisions recognized under the earlier set of names. Crampton's system eliminates the inconvenience of calling both the entire ventral chitinization and its principal subdivision the "sternum." The writer, however, would prefer to substitute the word *eusternum* for the second subdivision (as given in the table, page 42) so as to retain the original names even though with an altered significance as to the limits of the sclerites to which they are applied.

Each thoracic sternum almost invariably has a forked apodeme projecting upward from its inner surface. This is commonly known as the *furca* or "entosternum." The *furca*, according to Crampton, is carried by the third sternite, the "furcisternum" of his nomenclature.

The posterior part of the prosternum frequently bears a long internal spine projecting posteriorly, hence the name "spinisternum" of Crampton.

Wings.—In immature stages the wings appear to be hollow expansions of the back plates of the mesothorax and metathorax. In adults the upper surface of each is continuous by membrane with the edge of the notum and the lower surface with that of the pleurum. Each is more firmly hinged to the wing processes of the notum by two small axillary sclerites, and is pivoted upon the wing process of the pleurum by another.

Wing membrane.—The appressed dorsal and ventral walls of the original wing sac, forming the *cells* between the chitinous veins and the thin *axillary membrane* between the axillaries. The second is

nearly always bordered posteriorly by a conspicuous ligament-like thickening, the *axillary cord* (figs. 1, 8, and 10, *AxC*) arising typically from the posterior angles of the notum at the outer ends of the posterior reduplication (figs. 1, 2, and 3, *AxC* and *Rd*). Sometimes the axillary membrane forms a large lobe or a pair of lobes, called the *alula*, at the posterior angle of the wing base. On its anterior edge is a

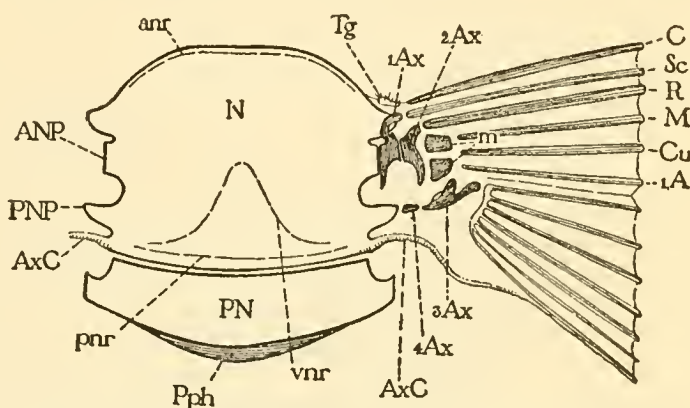


FIG. 8.—THEORETICAL DIAGRAM OF A WING-BEARING TERGUM AND BASE OF WING: 1A, FIRST ANAL VEIN; ANP, ANTERIOR NOTAL WING PROCESS; anr, LINE OF ANTERIOR VENTRAL NOTAL RIDGE; 1Ax, 2Ax, 3Ax, 4Ax, FIRST, SECOND, THIRD, AND FOURTH AXILLARIES OF WING BASE; AxC, AXILLARY CORD; C, COSTA; Cu, CUBITUS; M, MEDIA; m, MEDIAN PLATES OF WING BASE; N, NOTUM; PN, POSTNOTUM; PNP, POSTERIOR NOTAL WING PROCESS; pnr, LINE OF POSTERIOR VENTRAL NOTAL RIDGE; Pph, POSTPHRAGMA; R, RADIUS; Sc, SUBCOSTA; Tg, TEGULA; vnr, LINE OF MEDIAN VENTRAL V-SHAPED NOTAL RIDGE.

hairy pad, the *tegula* (*Tg*), which, in the front wing, is sometimes developed into a large scale overlapping the root of the wing.

Wing veins.—The writer adopts the Comstock-Needham (1898) system of wing venation and nomenclature for morphological purposes, but he does not advocate its use by systematists for descriptive purposes. A vein that is evidently a compound of several original veins must, according to this system, be named as the sum of all its components. Thus results such appellations as $Sc + R + M$, or $Cu_1 + Cu_2 + M_4 + 1stA + 2dA + 3dA$ for names of veins in the Hymenopteran wing. Combinations of this sort are certainly too cumbrous to be practical—a systematist should not be required to use such complex terms when he wants to mention a particular vein of the wing. Hence, while this system may be used to show the morphology of

any vein, taxinomists, especially in the Hymenoptera, will probably continue the use of more convenient, though less significant, individual names for the veins. An unfortunate thing in this connection is that systematists in different orders have, in many cases, used the same names for entirely different veins.

Axillaries (*Ax*).—The little sclerites at the base of the wing which hinge the latter to the notum and pleurum. Many individual names have been given to these sclerites by different students, but the writer has selected the general term of *axillaries* proposed by Strauss-Dürckheim (1828) for those of the hind wing of *Melolontha*, distinguishing the individual plates as the *first*, *second*, *third*, and *fourth*. The fourth is usually absent except in Orthoptera and Hymenoptera, but the other three are of almost universal occurrence in all the winged orders except the mayflies and dragonflies.

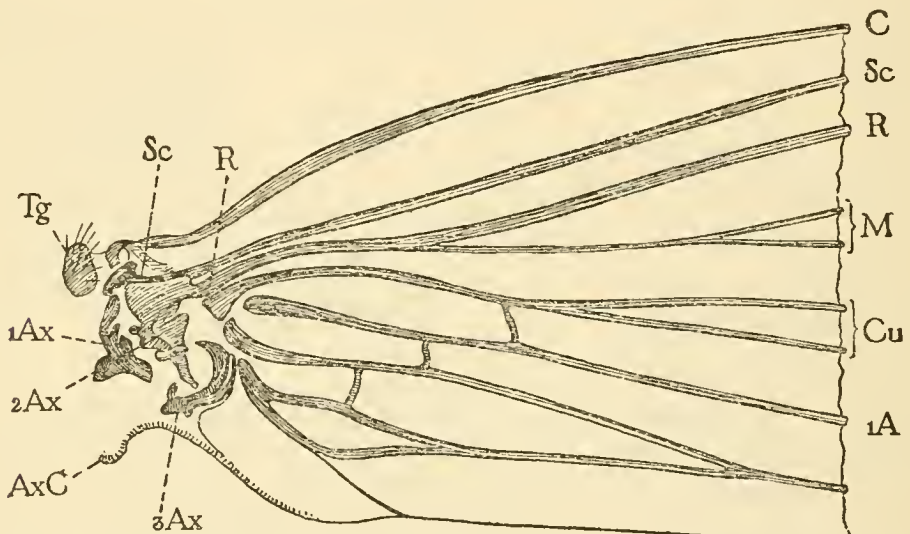


FIG. 9.—BASE OF FRONT WING OF *ASYNARCHUS PUNCTATISSIMUS* (CADDICEFLY): *1A*, FIRST ANAL VEIN; *1Ax*, *2Ax*, *3Ax*, FIRST, SECOND, AND THIRD AXILLARIES; *Ax C*, AXILLARY CORD; *C*, COSTA; *Cu*, CUBITUS; *M*, MEDIA; *R*, RADIUS; *Sc*, SUBCOSTA; *Tg*, TEGULA.

The axillaries, their relations to the back and to the base of the wing, are shown diagrammatically by figure 8. The first (*1Ax*) nearly always has a curved anterior neck which rests upon the anterior notal wing process (*ANP*), while its body is hinged to the edge of the notum back of the latter. Its anterior end is associated with the base of the subcosta (*Sc*). The second (*2Ax*) is the pivotal sclerite of the wing base, since it rests and turns upon the wing process of the pleurum. Its anterior end is associated with the base of the radius (*R*). The third axillary (*3Ax*) is associated with the bases of the anal veins, except with the first (*1A*) when this vein is separated from the others, as it is in the Orthoptera. The *flexor muscle* is attached to this sclerite, which serves also to plicate the wing of those forms that fold the anal region. When the fourth axillary (*4Ax*) is present it articulates with the posterior wing process of the notum (*PNP*), and intervenes between the latter and the third axillary. When it is absent

the third articulates more or less directly with the posterior process. Distad to the second axillary, and associated with the bases of the media (*M*), the cubitus (*Cu*) and the first anal (*1A*), when these veins are distinct at their bases, are one or two small *median plates* (*m*) which are not of constant occurrence, and which vary much in different forms when they are present. It will be observed that the base of the costa is not associated with any of the axillaries. The membrane of the wing base directly connects this vein with one or both of the episternal paraptera, upon which is inserted the *extensor muscle* of the wing, called also the "pronator" because, while it turns the wing forward, it at the same time depresses the anterior edge.

The diagram, figure 8, is constructed from a study of all the orders, for no one form shows all the parts of the wing so generalized. Many, however, approximate it. The stonefly shown in figure 1 is very simple. In it the subcosta (*Sc*) articulates with the first axillary (*1Ax*), the radius (*R*) is continuous with the second (*2Ax*). The media (*M*) fuses basally with the radius, but a distinct median basal plate (*m*) is present. The cubitus (*Cu*) does not reach the wing base, and there is no separate first anal. The other anals (*A*) are connected with the third axillary (*3Ax*), which is articulated directly to the posterior wing process (*PNP*), the fourth axillary being absent. The wing of the caddicefly, shown in figure 9, is likewise very generalized, though it not only lacks a fourth axillary, but has also no median plates. The media (*M*) is here, again, fused with the base of the radius (*R*), which is continuous with the second axillary (*2Ax*). The subcosta (*Sc*) articulates, by a prominent basal knob, with the first axillary (*1Ax*). The cubitus (*Cu*) and the first anal (*1A*) reach the base of the wing as separate veins, while the other anals are associated with the third axillary (*3Ax*).

The first, third, and fourth axillaries are developed in the dorsal wall of the wing sac. The second is formed from united dorsal and ventral elements. The latter is clearly shown as a separate piece in the wing of *Tæniopteryx frigida* (fig. 10, *2Ax*), and has attached to its posterior end the large internal chitinous *axillary disc* (*AxD*). The ventral part articulates with the pleural wing process, while the dorsal part (fig. 1, *2Ax*) carries the radius (*R*), which is but weakly developed below. The axillary disc (fig. 10, *AxD*) is of very general occurrence and bears the dorsal insertion of the *coxo-axillary muscle*, whose lower end is attached to the rim of the coxa of the same segment. The disk is very commonly attached to the second

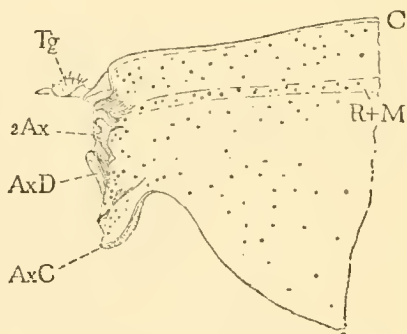


FIG. 10.—VENTRAL SURFACE OF BASE OF FRONT WING OF *TÆNIOPTERYX FRIGIDA* (SEE FIG. 1): *2Ax*, VENTRAL ELEMENT OF SECOND AXILLARY; *AxC*, AXILLARY CORD; *AxD*, AXILLARY DISK; *C*, COSTA; *R+M*, BASAL TRUNK OF RADIUS AND MEDIA; *Tg*, TEGULA.

axillary, but is sometimes carried directly by the axillary membrane, while in a genus of beetles (*Cyllene*) it is attached to a special process of the postnotum. In the honey bee the coxo-axillary muscle is inserted upon a sclerite which appears to be an epimeral parapterum.

Legs.—In adults the legs are attached to the ventrolateral regions of each thoracic segment, typically between the pleurum and the sternum, and behind the middle of the segment. The basal segment or *coxa* (figs. 5 and 7, *Cx*) is articulated above to the pleural coxal process (*CxP*) at the lower end of the pleural suture (*PS*), and below to the lower end of the trochantin (*Tn*). If the trochantin is absent, as it generally is in the higher orders, the coxa either has no ventral articulation or it articulates with a knob of the sternum. When the trochantin appears to be absent it might, of course, simply be fused with the sternum, in which case the apparent sternal coxal process may be really the trochantinal condyle.

The coxa is a double structure in the mesothorax and metathorax of Neuroptera, Mecoptera, Trichoptera, and Lepidoptera. Some writers have argued that this is evidence of each segment's being composed of two fused primitive segments. The writer, however, has elsewhere (1909) shown reason for believing that the posterior subdivision of the coxa in such cases is simply the lower part of the epimerum detached from the latter and fused upon the true coxa. This is indicated by a study of larval and pupal forms, and consequently, if so, the double nature of the coxæ in these orders is a purely secondary character and can have no morphological significance, unless, indeed, it be assumed that the simple larval coxæ are specialized and that in the pupal and adult stages the legs revert to a more primitive ancestral character.

The next joint of the leg, the *trochanter* (fig. 5, *Tr*), is apparently double in some of the Hymenoptera, but in such cases it looks more reasonable to regard the "*second trochanter*" as a basal subdivision of the third joint or *femur* (*F*).

The characters of the *tibia* (*Tb*) and *tarsus* (*Tar*) are too familiar to require any special discussion here. The under surface of each tarsal joint is sometimes provided with a pair of small cushion-like pads, which were named the *pulvilli* (*Pv*) by Kirby and Spence (1826). Most authors, however, would understand by "the pulvilli" only those pads of the terminal segment occurring at the bases of the claws. The terminal segment frequently bears also a median fleshy appendage between the claws, which is known as the *empodium* (*Emp*). All of these soft appendages of the tarsus enable the insect to adhere to smooth surfaces by a sticky liquid excreted upon them. The Hymenoptera possess only the median appendage of the terminal segment.

3. MORPHOLOGY OF THE POSTNOTAL PLATES (POSTSCUTELLA) AND THE PHRAGMAS.

Almost all writers have recognized under some name the postnotal sclerites of the thoracic terga. The nomenclature current amongst Hymenopteran systematists, however, attaches the name "postscutellum" to the plate on the surface of the dorsum immediately following the mesoscutellum (pl. 14, fig. 63, N_3), but which, in this order, is the metanotum, since it carries the hind wings. This mistake has arisen from the fact that the earlier students of these insects were ignorant of the fact that the true postscutellum (the postnotum) of the mesothorax is deeply invaginated and entirely concealed within the body between the mesothorax and the metathorax. A further consequence of this error is the application of the name "metathorax" to the propodeum or first abdominal segment (*IT*) of the thoracic mass, in spite of the fact that it has no connection whatever with the hind wings. The incorrectness of such a nomenclature is at once apparent when it is seen that it assigns both pairs of wings to the mesothorax.

The usual interpretations of the back sclerites in the Diptera have been more correct because there is present a large and unmistakable postnotal plate in the mesothorax (fig. 4, *PN*) distinct from the wing-bearing metanotum. Lowne (1892) calls this the "postscutellum" in the blow-fly. Crampton (1909) distinguishes its three subdivisions in the Tipulidæ as the "mediophragmite" and the "pleurophragmites." Berlese (1906), however, confuses it with the metathorax in both *Tipula* and *Calliphora*.

Various names have been given by different authors to this postnotal plate. Chabrier (1820) called it the "cloison costale." Strauss-Durckheim (1828) called that of the metathorax in *Melolontha* the "tergum." Amans (1885) included both the postnotum and the attached phragma under the name of "subpostdorsum." Kolbe (1889) applied the term "phragma" to both the postnotum and its phragma. Audouin (1824) first used the term "postscutellum" in describing the tergum of *Dytiscus*, but he did not correctly distinguish the parts anatomically, as the present writer has elsewhere shown (1909), yet, the term *postscutellum* may very appropriately be given to the tergal plate following the scutellum when the latter is present. However, as will be shown later, the postscutellum in this sense is not one of the subdivisions of the notum, corresponding with the pre-scutum, scutum, and scutellum, but is a separate plate developed independently back of the true notum. Therefore, the writer formerly (1909) adopted the term "pseudonotum," used by Verhoeff (1903) in the Euplexoptera (Dermaptera), as a general term, but suggested as an alternative the name *postnotum*. Since, however, Verhoeff did not

define "pseudonotum" as a general term, the name "postnotum" is used as such in the present paper, while "postscutellum" is used as an alternative in the higher orders where the scutum and scutellum are well differentiated.

The simplest thoracic terga occur amongst nymphal and larval forms. The nymph of a stonefly (fig. 11) has each segment protected above by an undivided notal plate, those of the mesothorax and metathorax carrying the rudiments of the wings. Between these dorsal plates are wide white membranous areas, which, as shown by sections (fig. 14 Mb_1 , Mb_2 , Mb_3), belong to the posterior parts of the segments *because they lie in front of the intersegmental constrictions*. The dorsum of each thoracic segment of this nymph consists, therefore, of a chitinous notum (N) and of a non-chitinous postnotal membrane (Mb).

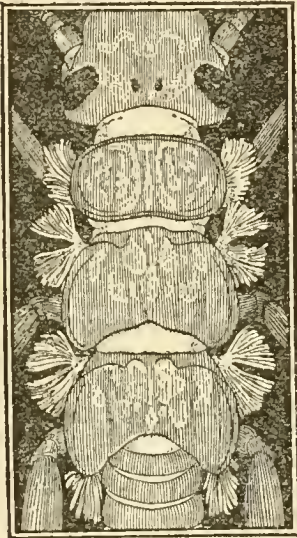


FIG. 11.—NYMPH OF A STONEFLY, DORSAL VIEW, SHOWING WIDE POSTNOTAL MEMBRANOUS AREAS, WHICH, IN THE MESOTHORAX AND METATHORAX OF THE ADULT, ARE OCCUPIED BY THE POSTNOTAL PLATES.

Amongst winged adults the simplest terga are probably to be found in some of the smaller cockroaches. A good example is afforded by the mesothorax of *Blatella germanica* in the dorsum of which there is but one plate present, and this one is unquestionably the true notum (fig. 2), since it carries the wings and has the axillary cords (AxC) arising from the outer ends of its posterior reduplication (Rd). On the sides are the two wing processes (ANP and PNP) separated by a deep emargination. On its anterior part is a thin flap (a) which is attached to the pronotum, being reflected upon the posterior overlapping part of the latter from the anterior phragma. The surface is gently convex and there are no divisions into subsclerites corresponding with those of the

higher orders, though there are several lines on the surface due to the internal ridges shown in figure 3. There is no postnotal plate present. The notum of the metathorax is almost identical with that of the mesothorax, and, if there is a postnotum present, it is fused with the first abdominal segment. In the Isoptera, likewise the terga of the wing-bearing segments consist each of a single notal plate, which, however, is often greatly constricted in the middle by the deep lateral emarginations.

In almost all other adult winged insects the tergum consists of two plates in those segments that have the wings well developed as organs of flight. The anterior plate is the true *notum*, being identical with the entire nymphal tergum, since it alone carries the wings. The posterior plate is the *postnotum* and is not represented in the nymphal tergum. The Ephemera, Odonata, Plecoptera, Neuroptera, and

others (except the Isoptera), having the wings equally developed, possess a well-developed postnotum back of each wing-bearing plate. In the Diptera and the higher Lepidoptera the postnotum of the metatergum is reduced or obliterated. In the Tenthredinoidea and Siricoidea it is distinct in each segment. In the other Hymenoptera the postnotum of the mesothorax is hidden by invagination within the body, while that of the metathorax is usually fused with the first abdominal tergum. In the mesothorax of the Orthoptera, Euplexoptera, and Coleoptera, where the front wings are developed as protective structures rather than as organs of flight, the postnotum is lacking, or is possibly represented in a very rudimentary condition in a few species by two small plates yoking the mesonotum to the metanotum.

The writer (1908, 1909) has heretofore contended that the Orthoptera have no postnotum in either segment. Crampton (1909) opposes this with the statement that "the postscutellum of *Gryllus domesticus* is quite well developed." Other writers, including Voss (1905), have likewise described a postnotum under some name in the metathorax of various members of the Orthoptera, but in all such cases the sclerite referred to is actually, i. e., by anatomical continuity, a part of the first abdominal segment. The present writer has examined species of *Gryllus*, *Gryllodes*, and *Nemobius* and finds that there is in each an anterior subdivision of the apparent first abdominal tergum, to the internal surface of which are attached the posterior ends of some of the longitudinal dorsal muscles of the metathorax, especially two lateral bands. Hence, this may be taken as evidence that the subsclerite in question is the true postscutellum or postnotum of the metathorax. It is largest in *Nemobius*, but is more distinct from the first abdominal tergum in *Gryllus* than in the other two genera, while in *Gryllodes* it is so small and so intimately a part of the abdominal tergum that it certainly taxes one's credulity to believe it is anything else. In *Blatella* there are two small lobes, situated laterally upon the front edge of the first abdominal tergum, to which are attached the posterior ends of some of the lateral longitudinal muscles of the metanotum. By the same reasoning, as in the case of the Gryllidæ, these lobes may be argued to be rudiments of the metapostnotum in the Blattidæ. In the Acridiidæ the first abdominal tergum presents a large subdivision extending downward on the sides before the lateral tympana of this segment. A longitudinal section of *Triemerotropus maritima* (fig. 12) shows that, to the middle of this apparent subdivision (PN_3) of the first abdominal tergum (IT), is attached the posterior phragma (βPh), and that upon this plate and the phragma are inserted the posterior ends of the great dorsal longitudinal muscles of the metathorax ($DMel$). Finally, in the Locustidæ (fig. 13) there is a conspicuous arched anterior subdivision (PN_3) of the

apparent first abdominal tergum (*IT*), which fits closely into the concavity under the posterior edge of the metanotum (*N*₃).

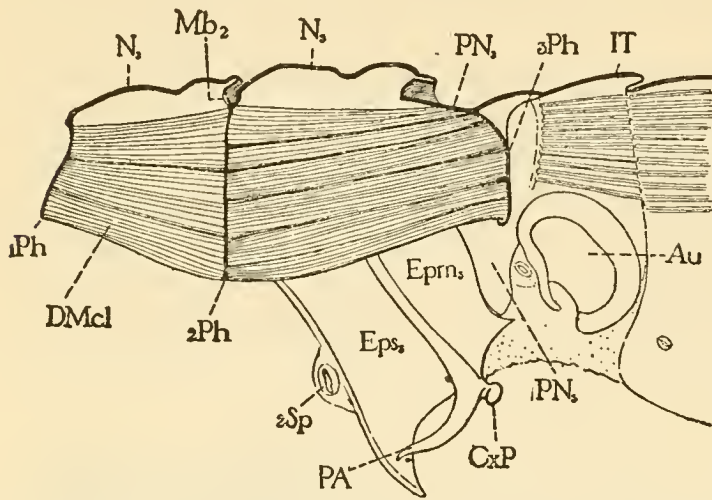


FIG. 12.—LONGITUDINAL SECTION THROUGH BACK OF MESOTHORAX, METATHORAX, AND BASE OF ABDOMEN OF A LOCUST (*TRIMEROTROPUS MARITIMA*): *Au*, "AUDITORY ORGAN;" *CxP*, COXAL PROCESS OF METAPLEURUM; *DMcl*, DORSAL LONGITUDINAL MUSCLES; *Epm*₃, EPIMERUM OF METATHORAX; *Eps*₃, EPISTERNUM OF METATHORAX; *IT*, FIRST ABDOMINAL TERGUM; *Mb*₂, POSTNOTAL MEMBRANE OF MESOTHORAX; *N*₂, MESONOTUM; *N*₃, METANOTUM; *PA*, PLEURAL ARM; *PN*₃, PLATE FUSED WITH FIRST ABDOMINAL TERGUM (*IT*), WHICH IS PROBABLY THE POSTNOTUM OF METATHORAX; *1Ph*, *2Ph*, *3Ph*, ANTERIOR MIDDLE AND POSTERIOR PHRAGMAS; *2Sp*, SECOND THORACIC SPIRACLE.

mesothorax and in others to the anterior edge of the metathorax, there would seem to be no logical reason why the posterior phragma should not sometimes be attached to the front of the first abdominal tergum. Woodworth (1909), in fact, argues that the phragmas really belong in all cases to the segment following them. The writer, however, believes that the phragmas are intersegmental, or are composed of lamellæ derived from both segments, and that they become secondarily more solidly associated with the one segment or the other. Ber-

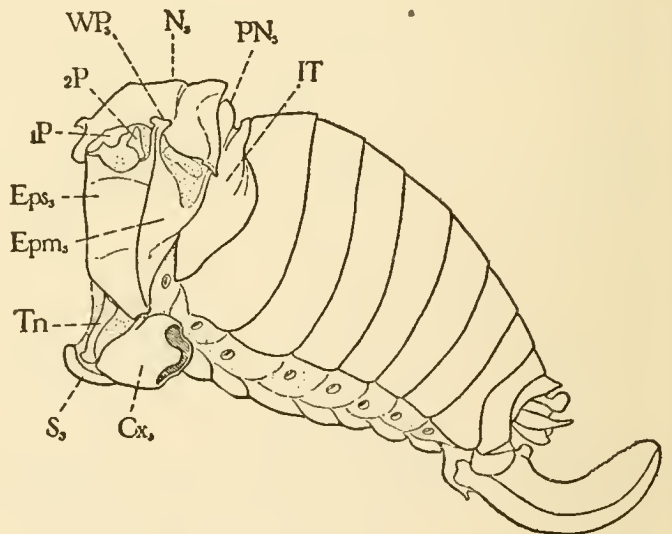


FIG. 13.—METATHORAX AND ABDOMEN OF A LONG-HORNED GRASSHOPPER (*SCUDDERIA FURCATA*), SHOWING THE APPARENT POSTNOTUM OF THE METATHORAX (*PN*₃) INTIMATELY FUSED WITH THE FIRST ABDOMINAL TERGUM (*IT*): *Cx*₃, METACOXÆ; *Eps*₃, *Epm*₃, EPISTERNUM AND EPIMERUM OF METATHORAX; *IT*, FIRST ABDOMINAL TERGUM; *N*₂, MESONOTUM; *1P*, *2P*, EPISTERNAL PARAPTERA; *PN*₃, THE APPARENT POSTNOTUM OF METATHORAX; *S*₃, METASTERNUM; *Tn*, TROCHANTIN; *WP*₃, PLEURAL WING PROCESS.

lese (1906) regards the plate in question in the Orthoptera as the "acrotergite" of the first abdominal segment, but he homologizes it

The question hence arises, in making an interpretation of these parts in the Orthoptera, whether the true postnotum of the metathorax has been fused with the first tergum of the abdomen, or whether the posterior ends of the dorsal muscles and the phragma, when present, have become attached to the first abdominal tergum. Since the middle phragma, as will presently be shown, is in some orders attached to the posterior edge of the

with the metapostnotum of some other orders, such as the Coleoptera, which he also refers to the abdomen. In the Coleoptera the postnotum of the metatergum is a very distinct plate. While it is sometimes attached to the front of the abdomen, it seldom appears in this order to be a part of the abdominal tergum, and it nearly always retains a connection with the epimera of the metathorax.

With regard to the so-called "postscutellum" of the metathorax in the Orthoptera, then, the writer reiterates his former statement, that it is, by anatomical continuity, a part of the first abdominal tergum. Theoretically, it may be the postnotum of the metathorax, but reason should be shown why the dorsal muscles of the metathorax and even the posterior phragma may not, in some cases, be attached to the first abdominal tergum, just as these muscles of the mesothorax (fig. 12, *D Mcl*) and the middle phragma (*2Ph*) are, in many cases, attached to the front of the metathoracic tergum (*N₃*). The Mantidæ and Phasmidæ do not show any anterior subdivision of the first abdominal tergum, nor do they have any trace of an independent postnotum in either segment. Hence, the Orthoptera do not have a postnotum at all in the mesothorax and, if they have this plate in the metathorax, it is developed best in the higher families and always apparently as an intimate part of the first abdominal tergum.

This brings us to the question concerning the nature of the phragmas and the reason for their relation to the postnotal plates stated on page 45. The phragmas, as already described, are the internal transverse plates descending into the body cavity from between the thoracic and first abdominal terga. There are consequently never more than three of them present; often only one or two are well developed, while in some cases there are no traces of any phragmas at all. Kirby and Spence (1826) named them the "prophragma," the "mesophragma," and the "metaphragma," but, since their connections with individual segments are secondary and variable, it seems best to call them the *anterior*, *middle*, and *posterior* phragmas. Each is composed, in its upper part at least, of two closely appressed or fused laminae, and, in the adult stage, is attached to one of the two adjoining terga or to both. The first or anterior phragma is always, so far as the writer has observed, attached to the front of the mesotergum. The second or middle phragma is sometimes attached to the posterior edge of the mesotergum and sometimes to the anterior edge of the metatergum, or, when these two plates are anchylosed, to both of them. The third is always, unless the Orthoptera constitute an exception, attached to the posterior edge of the metatergum, or to both this plate and the first abdominal tergum when these two parts are anchylosed.

That this association of the phragmas in the adult stage with one or the other of the adjoining terga is a secondary condition is suggested by a study of figures 14, 15, and 16. The section through

the back plates of the nymph of a stonefly (fig. 14) shows that the dorsal muscles (*DMcl*) are segmentally arranged, being attached to the anterior and posterior parts of the same segment, i. e., just back of and just before the intersegmental constrictions. The corresponding sections of adult stoneflies (figs. 15 and 16) indicate that the phragmas (*2Ph* and *3Ph*) are simply downward ingrowths from the deepest parts of the intersegmental grooves to accommodate the increased thickness of the dorsal muscles (*DMcl*). Hence, the phragmas appear to be truly intersegmental in their origin, and it may easily be imagined that the common bilaminar structure results

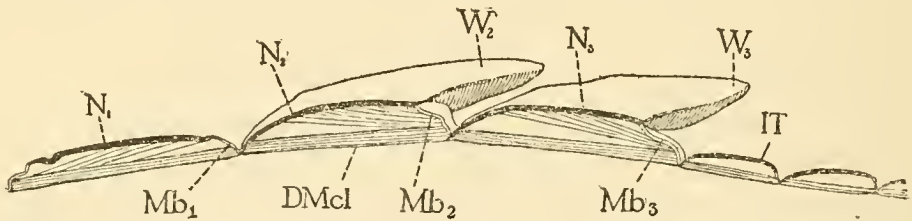


FIG. 14.—LONGITUDINAL SECTION THROUGH BACK OF THORAX AND BASE OF ABDOMEN OF A STONEFLY NYMPH (ISOGENUS), SHOWING EACH BACK PLATE OF THE THORAX SEPARATED FROM THE ONE BEHIND IT BY A WIDE POSTNOTAL MEMBRANE: *DMcl*, DORSAL LONGITUDINAL MUSCLES; *IT*, FIRST ABDOMINAL TERGUM; *Mb1*, *Mb2*, *Mb3*, POSTNOTAL MEMBRANES; *N1*, PRONOTUM; *N2*, MESONOTUM; *N3*, METANOTUM; *W2*, FRONT WING; *W3*, HIND WING.

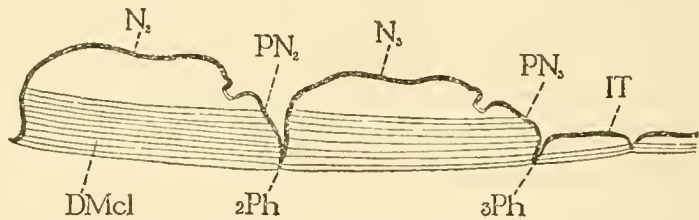


FIG. 15.—LONGITUDINAL SECTION THROUGH BACK OF MESOTHORAX, METATHORAX AND BASE OF ABDOMEN OF AN ADULT STONEFLY (*ALLOPERLA*) SHOWING POSTNOTAL PLATES (*PN2*, *PN3*) OCCUPYING POSITION OF POSTNOTAL MEMBRANES (*Mb2*, *Mb3*) IN FIG. 14: *2Ph*, *3Ph*, SECOND AND THIRD PHRAGMAS; OTHER LETTERING AS IN FIG. 14.

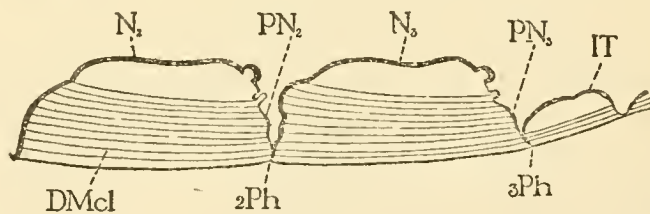


FIG. 16.—CORRESPONDING SECTION THROUGH ANOTHER ADULT STONEFLY (*TÆNIOPTERYX FRIGIDA*), SHOWING SAME THING AS FIG. 15: LETTERING AS IN FIGS. 14 AND 15.

from an apposition and fusion of the infolded surfaces of the adjoining terga, thus increasing the depth of the phragmas.

In such forms as *Alloperla* (fig. 15) and *Tæniopteryx* (fig. 16) it is seen that there is no movable articulation between the mesotergum and the metatergum, the two being united in the middle phragma (*2Ph*). But in most insects there is more or less motion possible between these two parts due to an intervening membranous area, as in the Orthoptera and Coleoptera. Fig. 12, representing a longitudinal section through the back of a grasshopper, shows that while the middle phragma (*2Ph*) is solidly attached to the front of the metanotum (*N3*), it is separated from the mesonotum (*N2*) by a narrow mem-

brane (Mb_2). Hence, while the latter would ordinarily be called the "intersegmental membrane," it is clear that it lies before the original intersegmental line and really belongs to the posterior part of the mesodorsum. The same must be true of the membrane between the prothorax and the mesothorax, since the anterior phragma ($1Ph$) is solidly attached to the front of the mesotergum. In other insects, where the middle phragma is attached to the posterior edge of the mesotergum, the "intersegmental membrane" behind it must really belong to the front of the metadorsum. Therefore, in general, if the phragmas are truly intersegmental structures, the real intersegmental lines pass through them, where phragmas are present, and the deepest part between the two laminae of any one is the true demarkation between the segments adjoining it. Woodworth (1909) is inclined to doubt this view, holding that "a more reasonable position would seem to be that the infolding for the attachment of intersegmental muscles marks the posterior boundary of the prescutum, that the phragma belongs entirely to the following segment, and that with the completion of the chitinization of the articular membrane, the division is lost somewhere immediately anterior to the phragma." Thus he claims that "the anterior phragma is mesoprescutal; the posterior is a part of the first abdominal segment." The present writer objects to this theory on the ground that, as he thinks, the facts do not substantiate it, but demonstrate the opposite view stated above.

The function of the phragmas is to give an increased surface of attachment for the longitudinal muscles of the back. These muscles are greatly developed in the wing-bearing segments of nearly all strong-flying insects (the dragon flies excepted) because they are the ones that produce the downward stroke of the wings during flight, the upward stroke being produced by the vertical muscles of the thorax. When the latter muscles contract they depress the back plates, which in turn pull down the bases of the wings, thereby throwing up the distal parts of these organs, the fulcra being the wing processes of the pleura. The succeeding contraction, then, of the longitudinal muscles restores the shape of the thorax and consequently elevates the back plates, which, by the same mechanism as before, force the wings downward. It is thus seen that the phragmas have an important association with the function of the wings. The other elements in the wing motion are produced by smaller muscles inserted directly upon the wing bases, but these are not material to the present discussion.

Furthermore, there is a relationship between the phragmas and the postnotal plates which, in general, may be stated as follows: When a phragma is associated with the posterior part of a segment it is attached to a postnotal plate of the tergum, which plate is usually otherwise lacking. Or, conversely, when the tergum of either segment possesses a postnotal plate it usually possesses also a post-

phragma. Consequently, in the case of the mesothorax a postnotum is present in most cases only when the middle phragma is present and attached to the mesotergum; in the case of the metathorax, a postnotum is present in most cases only when the posterior phragma is present. The anterior phragma being never attached to the protergum, the prothorax never possesses a postnotum. The postnotum is lacking in the mesothorax of Orthoptera, Euplexoptera, and Coleoptera, in which orders the middle phragma is attached to the front of the metatergum. It is greatly reduced or obliterated in the metathorax of the Diptera and in most of the higher Lepidoptera, which have but a weakly developed posterior phragma or none at all. On the other hand, it is present in both segments of the Ephemeroidea, Odonata, Plecoptera, Corrodentia, Neuroptera, Trichoptera, and the lower Lepidoptera, while it is well developed in the mesothorax of the higher Lepidoptera, and reaches its greatest size in the mesothorax of the Diptera, which have an extremely large middle phragma attached to this segment. In the Tenthredinoidea and Siricoidea of the Hymenoptera it is well developed in each segment; in the other Hymenoptera the postnotum of the mesothorax becomes buried between the segments, while that of the metathorax fuses with the first abdominal tergum.

If, now, we compare this distribution of the postnotum through the various orders with the development of the wings, it at once becomes evident that the postnotum is present in those segments that have the wings developed as organs of flight and that its size varies directly with the development of the power of flight. Thus, the front wings of the Orthoptera, Euplexoptera, and Coleoptera are developed principally as protective organs, while in the higher Lepidoptera and Hymenoptera they are the principal, and in the Diptera the only, organs of flight. In the other orders that use the two wings more equally, the postnotal plates are about equal in the two segments, except the Isoptera, which, as has already been stated, do not possess a postnotum in either segment.^a

The Hemiptera appear to be somewhat contradictory to the above statements in some ways. *Belostoma*, for example, and probably all

^a Each wing-bearing tergum of the Isoptera consists of only one plate which, though in some cases almost cut by the deep lateral emarginations into two parts, the "antedorsum" and "postdorsum" of Enderlein (1903), is yet clearly the notum because of the wing attachments to it. The writer has examined representatives of *Termopsis*, *Calotermes*, *Copritermes*, *Microtermes*, *Armitermes*, and *Eutermes* but has found no trace of a postnotum in either segment. A very small set of dorsal longitudinal muscles is present *attached to the front and rear of each segment*, just as in the stonefly nymph. On the other hand the lateral dorso-ventral muscles are very large and extend from the anterior part of the notum to the epimeral plate of the coxa on each side. Each coxa has the appearance of being double—a distinctive character of the Neuroptera, Mecoptera, Trichoptera, and Lepidoptera. This and the absence of the postnotal plates would separate the Isoptera from the Corrodentia, with which they are frequently associated.

the Heteroptera, has a large postnotum in the mesothorax which carries the middle phragma, but it is deeply fused mesially into the front of the metanotum and looks like a prescutum of this segment. For this reason the writer made the erroneous statement in a former paper (1909) that the Belostomidæ have no postnotum in the mesothorax. However, that the plate in question is such is amply proven by its solid lateral connections with the mesepimera. *Cicada*, on the other hand, has a much smaller postnotum in the mesothorax, but the very large middle phragma is solidly attached to the lateral parts of this segment. In both *Cicada* and *Belostoma* the great mass of the thoracic muscles is in the mesothorax, though, judging from analogy with beetles, one would suppose that in *Belostoma*, at least, the hind wings must do most of the flying.

In general, however, it is evident that the attachment of a phragma to the posterior part of either segment and its size are dependent upon the development of the power of flight in that segment, and that the postnotal plates are developed to support the phragmas. There are, of course, many apparent minor exceptions to this where a comparatively large postnotum is present bearing only a small or even a rudimentary phragma. But, in such cases, the dorsal muscle fibers are attached posteriorly to the postnotum itself, which thus serves as both postnotum and phragma.^a In fact, many writers have made no distinction between the phragmas and the surface plates to which they are attached, defining the "prescutum" as the exposed part of the prephragma and the "postscutellum" as the exposed part of the postphragma of any segment. The present writer, however, for reasons based on the following facts, prefers to distinguish between the phragma and its surface support.

The reader's attention has already been directed to figure 11, showing the back of a stonefly nymph, in which each thoracic tergum consists of a simple notal plate separated from the one behind by a wide membrane. Figure 14 is a longitudinal section through the back of a similar form. The depressions mark the constrictions between the segments. It is, hence, evident that the membranes (Mb_1 , Mb_2 , Mb_3) are not truly intersegmental, but are postnotal in position, since they occur between the notal plates (N_1 , N_2 , N_3), and the posterior limits of the segments. If, now, this figure be compared with figures 15 and 16, showing corresponding sections through the mesothorax and metathorax of adult stoneflies, it will be seen that the postnotal membranes are mostly replaced by postnotal chitinizations

^aThe Odonata constitute a very prominent exception to many of the above statements. They have large postnotal plates in each wing-bearing segment but possess neither phragmas nor longitudinal thoracic muscles. Their wings are moved entirely by the great dorsoventral muscles which are inserted by means of stalked disks upon the bases of the wings themselves and upon the adjoining parts of the nota. It may be that the postnotal plates here serve the purpose of lengthening the terga so as to give more space for the play of the wings.

(PN_2 , PN_3), which form conspicuous wide transverse plates on the surface of the dorsum behind the wing-bearing nota. In *Alloperla* (fig. 15) they are weakly continuous with the notal plates, but in almost all insects, where they occur, they are separated from the latter by narrow membranous sutures, as in *Tæniopteryx* (fig. 16). Therefore, it is clear that the so-called "postscutellum" is not a differentiation of the true notum, as is the prescutum, scutum, or scutellum, but is an additional plate, and, hence, the writer's ground for designating it by the more generally significant term of "postnotum."

Again examining figure 14 it will be seen that the dorsal longitudinal muscles (*DMcl*) are truly segmental at this stage of development. Woodworth (1909), however, thinks otherwise, for he says, "The great dorsal muscle of flight for which the phragma was developed is probably only a dorsal intersegmental muscle. These extend from the anterior edge of one segment to the corresponding part of the next." The writer can not see how the annular constrictions of any nymphal form can be anything else than the intersegmental lines. They certainly appear to correspond with the grooves between the embryonic somites. Moreover, the muscle somites of the embryo correspond with the body somites. This is true even in adults. If the thoracic and abdominal terga of *Machilis* be removed there are uncovered muscular segments exactly corresponding with the chitinous segments. As has already been pointed out, the postnotal membranes of the nymph (fig. 14, *Mb*) are not "intersegmental," but lie before the true intersegmental grooves. For this reason the longitudinal muscles of any segment may pull the succeeding segment forward, by their contraction, just as if their posterior ends were inserted upon the anterior edge of the latter segment.

If the ancestral insects were wingless creatures, as is universally conceded, then it must be assumed that the primitive function of the longitudinal muscles was the movement of the segments, principally the retraction of each into the preceding segment for purposes of locomotion or respiration. It follows next, as a corollary to this, that the part these muscles play in the movement of the wings in modern insects has secondarily devolved upon them in the mesothorax and metathorax. Now, in order that the contraction of these muscles may change the shape of these two segments instead of telescoping them, it is clear that the postnotal membranes must be obliterated in some way, so that the chitinous parts shall abut against each other. We can imagine that this might be effected in three ways: (1) By a posterior extension of each notum till it should meet the succeeding notum, (2) by a chitinization of the postnotal membranes, or (3) by a shortening of these membranes. There is no evidence that the first has ever happened—no insect shows a posterior prolongation of the notum behind the scutellum, which would be a true postscutellum, though the scutellum itself is often enlarged

so as to *overlap* the segment behind. The second process has taken place in those segments of all species that have a postphragma, including many that have only a rudimentary phragma, and has resulted in the formation of the postnotum wherever this sclerite occurs. The third process may be supposed to have taken place in the mesothorax of those orders that have no postphragma and no postnotum in this segment, and in which the notum lies close to that of the succeeding segment, if indeed it is to be assumed that this condition is primitive in such cases and not secondary. The reduction or absence of the postnotum in the metathorax is, of course, a secondary modification consequent upon the reduction of the hind wings. The anterior phragma and the posterior phragma are constant in their attachment to the front of the mesotergum and the back of the metatergum, respectively, while the middle phragma is assigned to the segment most in need of it. When the front wings are used in flight as much as the others or more the middle phragma is attached to the mesotergum; when the hind wings are the chief organs of flight it is attached to the metatergum. Thus it results that the principal flight segment is always provided with both a prephragma and a postphragma, while the other is left with only a prephragma or a postphragma. In this way the longitudinal muscles of this favored segment are enabled to act most forcibly on the tergum, though at the expense of some of the power of the muscles of the other segment. In the higher Hymenoptera this specialization has been carried so far that the metathoracic muscles are rudimentary, while the great mesothoracic mass of muscles effects the thorax as a whole, producing the motion of both pairs of wings.

Thus it is possible to see a reason for the fundamental structure of the wing-bearing thoracic terga, a structure which follows logically from the assumption that the flight function has been secondarily acquired, and that extra parts had to be added to the primitive notal plates to enable the longitudinal muscles to depress the wings by elevating the notal plates, instead of pulling the segments together, which latter was their original function. Furthermore, the strain of these muscles on the notum must be held partly responsible for the modifications of this plate. However, since the function of elevating the wings devolved upon the primitive vertical muscles of the mesothorax and metathorax, it can not be doubted that the primary cause of the modifications of the notal plates is to be traced to this latter source.

The foregoing is a brief review of a subject that might be studied and illustrated in much greater detail. The basis of the writer's information is contained in his former paper (1909) on the thorax of insects, in which, however, he would now make certain modifications mentioned in the present paper. It is hoped that enough new material is given here, first, to substantiate the claim that each wing-bearing tergum of the insect thorax is not composed of four con-

secutive elements, as so often described, but consists of one principal wing-bearing plate and of a secondary postalar plate, the first of which becomes differentiated into the secondary regions termed prescutum, scutum, and scutellum; and, second, to show a logical reason for this structure, based on the necessity for it, arising when the primitive segmental muscles had to take on them the newly acquired duties of moving the wings.

4. STRUCTURE OF THE HYMENOPTERAN THORAX.

This paper is designed especially to elucidate the external morphology of the thorax of the nonaculeate Hymenoptera. Therefore the Aculeata have been illustrated by only three forms selected from three representative families. The writer has, furthermore, made no attempt to apply the facts of anatomy to the classification of the families. This must be done by systematists who are widely acquainted with the comparative structure of all the different parts of the body. Writers who become intimately acquainted with one set of characters are ever prone to reconstruct classifications on a basis of their specialty and are as often misled by the narrowness of their horizon. Any system of taxonomy or phylogeny must be founded on a consideration of all the characters of all the forms concerned.

The following is a list of the species studied, arranged according to the present classification by Hymenopteran systematists:

I. TENTHREDINOIDEA.

PAMPHILIDÆ.

Bactroceros pallimacula (Norton).—fig. 17.

TENTHREDINIDÆ.

ARGINÆ.

Arge, species.—figs. 10–12, 14, 15.

NEMATINÆ.

Lygænematis erichsoni (Hartig).—fig. 18.

DOLERINÆ.

Dolerus aprilis Norton.—fig. 13.

CIMBICINÆ.

Trichiosoma lanuginosa Kirby.—figs. 16, 19.

II. SIRICOIDEA.

SIRICIDÆ.

Tremex columba (Linnæus).—figs. 1–9.

III. ICHNEUMONOIDEA.

BRACONIDÆ (Of the numerous subfamilies of this group the following two have been selected as the ones most likely to show the extremes of variation).

BRACONINÆ.

Eurobracon penetrator (Smith).—fig. 20.

APHIDIINÆ.

Diæretus piceus (Cresson).

III. ICHNEUMONOIDEA—Continued.

CAPITONIIDÆ. (This family consists of at most four genera, of which *Capitonus* is the best known).

Capitonus ashmeadi Dalla Torre.—fig. 21.

EVANIIDÆ. (This family includes three subfamilies—the Evaniinæ, Aulacinæ, and Fœninæ.)

AULACINÆ.

Odontaulacus editus (Cresson).—fig. 22. a

ICHNEUMONIDÆ.

OPHIONINÆ.

Erymotylus macrurus (Linnæus).—figs. 23, 33.

TRYPHONINÆ.

Metopius pollinatorius (Say).—fig. 24.

PIMPLINÆ.

Megarhyssa lunator (Fabricius).—fig. 25.

CRYPTINÆ.

Cryptus extrematus Cresson.—fig. 26.

ICHNEUMONINÆ.

Trogus lutorius (Fabricius).—figs. 27, 29, 30, 32.

Allomya debellator (Fabricius).—fig. 28, 31.

IV. CHALCIDOIDEA. (According to Ashmead there are fourteen families in this group. The following eight are selected to show the range in variation of thoracic structure.)

TORYMIDÆ.

TORYMINÆ.

Syntomaspis racemariæ (Ashmead).—fig. 34.

CHALCIDIDÆ.

LEUCOSPIDINÆ.

Leucospis affinis Say.—figs. 35–39.

EURYTOMIDÆ.

EURYTOMINÆ.

Eurytoma diastrophii boltenii Riley.—fig. 46.

MISCOGASTERIDÆ.

TRIDYMINÆ.

Hemadas nubilipennis (Ashmead).

ENCYRTIDÆ.

EUPELMINÆ.

Cerambycobius cushmani Crawford.—figs. 40, 41.

ENCYRTINÆ.

Microterys, species.—figs. 42, 43.

PTEROMALIDÆ.

PTEROMALINÆ.

Catolaccus incertus Ashmead.—fig. 44.

ELASMIDÆ.

Elasmus atratus Howard.

IV. CHALCIDOIDEA—Continued.

EULOPHIDÆ.

APHELININÆ.

Coccophagus lecanii (Fitch).—fig. 45.

Prospaltella berlesii (Howard).—fig. 47.

EULOPHINÆ.

Dimmockia incongruus (Ashmead).—fig. 48.

V. CYNIPOIDEA.

FIGITIDÆ.

FIGITINÆ.

Figites floridanus Ashmead.—fig. 50.

ENCOILINÆ.

Hexaplasta, species.—fig. 49.

CYNIPIDÆ.

CYNIPINÆ.

Rhodites mayri Schlechtendal.—fig. 51.

VI. PROCTOTRYPOIDEA. (The following four families are selected as representative of the seven families comprising this group.)

HELORIDÆ.

HELORINÆ.

Helorus paradoxus (Provancher).—fig. 58.

PROCTOTRYPIDÆ.

Proctotrypes caudatus Say.—figs. 53, 57.

DIAPRIIDÆ.

DIAPRIINÆ.

Tropidopria conica (Fabricius).—fig. 59.

SCELIONIDÆ.

TELENOMINÆ.

Telenomus ashmeadi Morrill.—fig. 60.

VII. ACULEATA. (The following three aculeate families have been selected as representative of the superfamilies included under this head.)

CEROPALIDÆ (formerly POMPILIDÆ).

Pepsis formosa Say.—fig. 61.

MYRMECIDÆ.

Pogonomyrmex transversus (Smith).—fig. 62.

APIDÆ.

Apis mellifera Linnæus.—fig. 63.

1. THE THORAX OF TREMEX COLUMBA AND THE TENTHREDINOIDEA.

Before undertaking a comparative study of the Hymenopteran thorax it is most important to become thoroughly acquainted with the thoracic structure in one of the more generalized members of the order. In most of the higher families the original structure is so obliterated, while secondary characters are so prominent, that the

student of any one group is almost sure to be misled in his interpretations of the morphology. The writer has selected the horntail, *Tremex columba*, as the subject of a preliminary description, both because its thorax is very generalized in structure and because it is a large and widely distributed species.

Figure 1 on plate 1 shows a side view of the thorax and the base of the abdomen, the wings being entirely removed and the legs detached from their basal joints or coxæ (Cx_1 , Cx_2 , Cx_3). Since the latter are unmistakable landmarks, they make good starting points for a morphological orientation. The plate to which the first coxa (Cx_1) is attached is the propleurum, consisting in *Tremex* entirely of the proepisternum (Eps_1). Each curves mesally over the ventral surface of the prothorax, so that the two almost meet along the midline ($2, Eps_1$) in front of the small prosternum (S_1). Above these episternal plates is the large protergum ($1, N_1$), forming a cap over the anterior end of the mesothorax. Just behind its lateral margin on each side is a small sclerite containing the anterior thoracic spiracle ($1Sp$). It will be noticed that the pronotum is associated much more closely with the mesothorax than it is with the pleural and sternal parts of its own segment, these latter, which together constitute the propectus, forming a loose suspensorium for the front legs.

Between the front coxa and the middle coxa on each side are the plates of the mesopleurum—the mesepisternum (Eps_2) and the mesepimerum (Epm_2). They are separated by the distinct mesopleural suture (PS_2) extending upward and forward from the articulation of the coxa into the mesopleural wing process (WP_2) which supports the front wing from below. The small irregular sclerite lying before the wing process is the parapterum of the mesothorax (P_2). The episternum (Eps_2) is not separated in *Tremex* from the mesosternum (S_2), though in many other species the two are divided by a distinct suture. Above the mesopleura is the mesonotum (N_2), consisting principally of the scutum (Set_2) and the scutellum (Sc_2). Beneath the posterior edge of the latter is seen a part of the mesopostnotum (PN_2), whose lateral parts are attached to the mesepimera (Epm_2).

Between the mesocoxa (Cx_2) and the metacoxa (Cx_3) are the two plates of the metapleurum, the metepisternum (Eps_3) and the metepimerum (Epm_3), separated by the oblique metapleural suture (PS_3). The last ends above in the slender metapleural wing process (WP_2) which supports the hind wing. In front of it is the small parapterum of the metathorax (P_3). Between the latter and the mesepimerum (Epm_2) is a small sclerite containing the posterior thoracic spiracle ($2Sp$). Above the metapleura are three dorsal sclerites (N_3 , PN_3 , and IT). The first is the metanotum (N_3) and carries the hind wings. The second is the metapostnotum (PN_3), though it is more closely attached to the plate following it than to the metanotum. The third is the first abdominal tergum (IT) containing the first

abdominal spiracles (*ISp*). Both the metapostnotum and the first abdominal tergum are divided along the median dorsal line into two lateral plates (6, *PN₃* and *IT*). The metasternum, like the mesosternum, is continuously fused with the episterna of its segment.

The thoracic homologies, as presented in the above account, certainly seem indisputable when the parts of each segment are compared with those of any of the generalized orders of insects. For example, compare the mesothorax of *Tremex* with either segment of an adult stonefly such as *Tæniopteryx frigida* (fig. 5). The two pleural plates (*Eps* and *Epm*) of *Tæniopteryx*, separated by the pleural suture (*PS*), are identical with those of the mesothorax of *Tremex* (1). The pleural suture (*PS*) in each case extends from the coxal articulation into the wing process (*WP*). The parapterum (*P*) lies before the latter in both, though it is attached to the episternum in the stonefly. The notum (*N*) is unquestionably the same plate in each case, and the postnotum (*PN*) in each is connected with the posterior angles of the epimera (*Epm*). The ventral parts are different in that the sternum (*S*) of the stonefly is separated from the episternum (*Eps*) by a suture (*q*), and the coxa (*Cx*) is articulated below to a sclerite, the trochantin (*Tn*), which does not occur in *Tremex*. It will be shown later that many Hymenoptera, however, possess a sterno-pleural suture on each side corresponding with that of *Tæniopteryx*. The structure of the metathorax of *Tremex* but duplicates that of the mesothorax, the differences being simply in the size and the shape of the parts.

Marlatt (1896) has described and figured the thorax of a sawfly, *Lygænematus (Pachynematus) erichsonii*. He calls the large mesepisternum (18, *Eps₂*) the "epimeron" of the mesothorax, while he calls the true mesepimerum (*Epm₂*) a "posterior plate of the epimeron." In the metathorax he calls the episternum (*Eps₃*) the "epimeron," while he does not name the true epimerum (*Epm₃*) of this segment. The plates of the first abdominal tergum he calls the "scutellum" of the metathorax, but does not say how they come to carry the first abdominal spiracles (*ISp*). The writer can produce no argument against these interpretations so effective as that to be derived from a comparison of the sawfly (18) with a stonefly (fig. 5) or a grasshopper (fig. 13). Systematists in general, who have attempted to explain the thoracic anatomy of the Hymenoptera, have made so many inconsistent applications of anatomical names that space can not be given here to a review of their works.

We may now more conveniently make a detailed study of each part of the thorax separately and at the same time note the modifications that occur in the Tenthredinoidea, for some of them are, in some ways, more generalized than *Tremex*.

The **pronotum**, as already stated, appears to belong to the front of the mesothorax rather than to the prothorax. Its posterior lateral angles are more or less produced toward the bases of the wings, often forming a distinct lobe (1, N_1 , w) on each side partially overlapping the first spiracle ($1Sp$). In other families it usually completely covers and conceals the spiracle.

The **propectus** is always very loosely connected with the pronotum by membrane, and its lateral parts reach forward in the walls of the neck to the base of the head. In *Tremex*, as already described, the propleurum consists of the episternal plates alone (1, 2, Eps_1), but many other forms show at least a trace of an epimerum. In a species of *Arge* (12) both pleural plates (Eps_1 and Epm_1) are well developed and are separated by a distinct pleural suture (PS), just as in any other segment. *Lygænematus erichsonii* (18) also possesses a comparatively large proepimerum (Epm_1). The posterior angle of the epimerum is produced internally as a large epimeral arm (12, $EpmA$), but when the epimerum is absent this arm appears to arise from the episternum (2). This internal process is apparently not the homologue of the pleural arm of other segments (9, PA), since it does not arise from between the pleural plates.

The prosternum (2, 12, S_1) is a small plate lying between the front coxæ (Cx_1) and behind the ventral parts of the episterna (Eps_1). It carries two internal apodemes constituting the anterior or prosternal furca (2, Fu). In *Tremex columba* a small plate (2, d) lies between the prosternum and the coxa on each side, and in *Arge* there is a smaller one on the side (12, e) between the coxa, the sternum, and the episternum.

Many entomologists regard the prothoracic plates that the writer calls the episterna as the prosternum. Most of them, however, apparently do not observe that the true prothoracic sternum lies behind these plates and between the bases of the coxæ. Berlese (1906) defines the lateral part of each pleural plate as the "episternum" and the ventral part as the "mesosternite" of the mesosternum. The true prosternum he calls the "metasternite." In studying *Scolia rufifrons* he finds two other parts, which are illustrated as well by *Scolia dubia* (fig. 17), the first being a median subdivision (A and B, n) of the episternum (Eps), which he calls the "prosternite," the second a median sclerite (l) in the ventral wall of the neck, which he calls the "acrosternite." Thus Berlese is able to establish in the Hymenopteran prothorax the four consecutive parts which he thinks are the primitive elements of every sternum. The only contrary argument to this homology is that appearances are too strongly against it. The lateral ridge (fig. 17 A, j) simply marks the line where the edge of the pronotum laps over the episternum, while

Berlese's interpretations of the other parts (*l* and *n*) appear purely fanciful to the writer of this paper.

Cervical sclerites are of unusual occurrence in the Hymenoptera. A small chitinous piece occurs on each side of the neck in the honey bee (63, *i*) just below the anterior knob of the proepisternum (Eps_1). The ventral plate in the neck of *Scolia dubia* (fig. 17 B, *l*) appears to be a cervical sclerite rather than a prothoracic sternite. In *Dolerus aprilis* there is a small dorsal cervical (13, *g*). Crampton (1909), from a study of *Dolerus*, concludes that the plate called the proepisternum (Eps_1) in this paper is really in large part a lateral cervical sclerite. In *Dolerus aprilis* (13) it presents a small posterior subdivision (eps_1) just in front of the pleural suture (*PS*) which separates it from the small epimerum (Epm_1). This small piece (eps_1) alone Crampton thinks is the true prothoracic episternum, the larger anterior part (Eps_1) being a lateral cervical sclerite. The slender sclerite

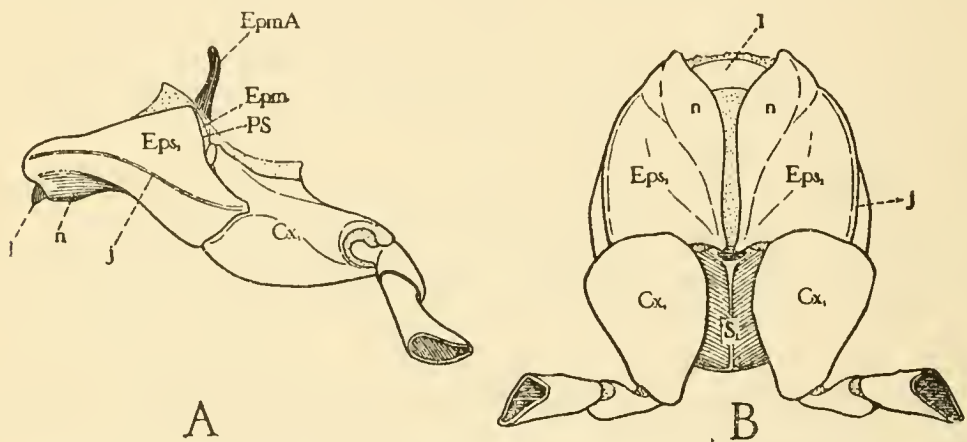


FIG. 17.—PROPECTUS OF *SCOLIA DUBIA*; A, LATERAL VIEW; B, VENTRAL VIEW: Cx_1 , PROCOXA; Epm_1 , EPI-MERUM; $EpmA$, EPIMERAL ARM; Eps_1 , EPISTERNUM; *j*, RIDGE ON SIDE OF EPISTERNUM WHERE EDGE OF PRONOTUM OVERLAPS IT; *l*, VENTRAL CERVICAL SCLERITE; *n*, VENTRAL SUBDIVISION OF EPISTERNUM; *PS*, PLEURAL SUTURE; S_1 , PROSTERNUM.

(*f*) along the upper edge of the latter he regards as a dorsal cervical. Hence, in all other forms he terms the large latero-ventral prothoracic plate, where it is not subdivided into two parts (Eps_1 and eps_1), the "cervico-propleuron." While *Dolerus* may not be a unique example of the subdivision of the lateral propectal plate, it is certainly exceptional, and, to the writer of this paper, the structure of one genus does not seem a sufficient basis for so wide a generalization. The corresponding parts in *Arge* (12) certainly look much more primitive than those of *Dolerus* (13), and the plates (Eps_1 and Epm_1) on opposite sides of the pleural suture (*PS*) certainly here suggest that they are the episternum and the epimerum of the prothorax and nothing more. It is, then, simply a question of condensation *versus* differentiation. Is *Dolerus* primitive and have the simpler forms been produced by a complete fusion of the original parts, or is *Arge* primitive and has *Dolerus* secondarily acquired its

more complicated structure? The reader may take his choice. The writer adopts the second view because it is the simpler.

The **mesotergum** of *Tremex* (1) consists of a notum (N_2) and a postnotum (PN_2). The first is the large plate of the back, consisting of the mesoscutum (Sct_2) and mesoscutellum (Scl_2). The second (PN_2) is, in the normal condition, mostly hidden beneath the posterior edge of the scutellum, but when the metathorax is removed from the mesothorax the postnotum of the latter is found to be mostly invaginated into the groove between the two segments, for it is now seen to be a distinct plate (3, 4, PN_2) carrying a large two-lobed postphragma (Pph_2) projecting far backward through the metathoracic cavity.

On the anterior edge of the mesonotum is a prephragma (3, 4, Aph_2), while the lateral margins form the anterior and the posterior notal wing processes (ANP and PNP). On the under surface is a well-developed V-shaped entodorsal ridge (4, VNR) which forms the line (3, vnr) on the surface separating the scutum (Sct_2) from the scutellum (Scl_2). There is no prescutal division of the mesonotum in *Tremex*, though in many of the sawflies there is a distinct mesopre-scutum (10, 16-19, Psc_2) defined by a V-shaped suture (h). A small lobe on the posterior margin of the scutellum (3, o) might reasonably be termed the postscutellum if this name did not already belong to the postnotal plate.

The **mesopectus** of *Tremex* (5) consists of three principal plates, the combined sternum and episterna, and the two epimera. In many of the Tenthredinoidea, however, there are distinct sterno-pleural sutures, ventrad to the articulations of the mesocoxæ (10, 14, 16, 19, q), which separate the ventral sternum (S_2) from the lateral episterna (Eps_2). On the interior surface of the mesopleurum (9) is seen the heavy pleural ridge (PR) following the line of the pleural suture (1, PS_2), forming the wing process (9, WP) above and the coxal process (CxP) below. Just above the latter it gives off the small pleural arm (PA). In this view the parapterum (P) is seen to support a disk (PD). Upon this disk is inserted the upper end of the pronator muscle of the wing, the parapterum being connected with the head of the costal vein. In most of the sawflies there are two episternal paraptera in the mesothorax (10, 16, 18, 19, $1P$ and $2P$), but in other Hymenoptera the first is lacking. For this reason the single one present will be designated the second parapterum ($2P$). Fig. 5 on plate 1 gives a dorsal view of the interior of the mesopectus, showing the large furca (Fu) of the mesosternum (S_2).

The **metatergum** of *Tremex* consists of a narrow notum (1, 6, N_3) carrying the hind wings, and of two small postnotal plates (PN_3) attached to the first abdominal plates. The metanotum is very simple in all the Hymenoptera. In the Siricoidea and Tenthredi-

noidea it presents two little oval lobes on the dorsal surface called the cenchri (6, 11, *p*). The postnotum is always narrow, but in the Tenthredinoidea it is continuous across the back and is usually fused laterally with the epimera (11, 17, 18, 19, *PN*₃). In all of the Hymenoptera it is more closely attached to the first abdominal tergum than to the metanotum, and, in the higher forms, is often indistinguishably fused with the former.

The **metapectus** of *Tremex* (7) is very similar to the mesopectus (5) except that it is smaller. As in the latter, there are no sternopleural sutures, though in some of the Tenthredinoidea such sutures are present (11, *q*). The interior of the pleurum (8) is identical in structure with that of the mesothorax (9). Its external appearance has already been sufficiently described (1, *Eps*₃, *Epm*₃). The metafurea (7, *Fu*) is somewhat simpler in structure than the mesofurea (5, *Fu*).

The **first abdominal tergum** would scarcely be deserving of a special description in the Siridoidea and Tenthredinoidea were it not for the fact that it is intimately fused into the thorax in all the other Hymenoptera and constitutes the co-called "median segment," "propodeum," or "epinotum." In *Tremex* (1, 6, *IT*), as already described, it consists of two plates, but in most forms it is continuous across the back and always carries the first abdominal spiracles (*ISp*) laterally, in the Tenthredinoids often in a special lateral subdivision (11, 17, 18, 19, *It*).

2. MODIFICATION OF THE THORAX.

In the general study of the Hymenopteran thorax it is found that the structural departures from the comparatively simple thorax of *Tremex* and the Tenthredinoidea consist of progressive modifications along several lines. The chief of these may be stated under the following nine heads:

1. *The separation of the pronotum from the propectus and its attachment to the front of the mesothorax.*

The disassociation of the pronotum from the rest of the prothorax is evident even in the sawflies, as shown by *Bactroceros* (17), *Lygænematus* (18), and *Trichiosoma* (19). In the higher families, such as the bees (*Apis*, 63), it appears to be an integral part of the mesothorax. Its lateral parts nearly always reach far down on the sides, fitting into the angle between the base of the procoxa and mesopleurum. In the honey bee the lower ends extend mesally over the ventral surface till they meet on the midline so that the pronotum forms a complete collar about the front of the mesothorax. In *Proctotrypes caudatus* (57) the lower parts of the pronotum (*N*₁) not only meet each other, but they fuse into a wide ventral plate between the prosternum and the mesosternum, above the bases of the front coxæ. The pronotum in this case forms an entire annulus (54, *N*₁) surrounding the front of the mesothorax and inclosing the propectus (53, *S*₁ and *Eps*₁).

The propectus is freely movable on account of its membranous connection with the rest of the thorax. It serves both as a suspensorium for the front legs and as a support for the head, its lateral episternal parts being produced forward in the side walls of the neck as two processes which loosely articulate with the occiput (1, 2, 12, 13, 53, *v*). The evolution of the pleurum has already been indicated in the description of *Tremex*. In *Arge* (12) the episternum (*Eps*₁) and the epimerum (*Epm*₁) are well differentiated and are separated by a distinct pleural suture (*PS*). The epimerum is also present in *Dolerus* (13), *Lygænematus* (18), and others, but in general it is either absent or very rudimentary, the propleurum consisting of a single plate, the episternum, as in *Tremex* (1, *Eps*₁), *Leucospis* (36), and *Proctotrypes* (53). In *Dolerus* (13) there is a posterior subdivision (*eps*₁) of the episternum (*Eps*₁).

2. *The separation of the mesonotum into an anterior and a posterior plate by a transverse membranous suture.*

The mesonotum of *Tremex columba* is divided into a scutum (3, *Sct*₂) and a scutellum (*Scl*₂) by the line (*vnr*) of the entodorsal ridge (4, *VNR*). In some of the Tenthredinidæ there is an indistinct sutural line on each side, anterior to this ridge, extending toward the lateral emarginations of the notum (16, 17, 19, *k*). In nearly all the higher families of the Hymenoptera these two lines are continuous over the dorsum and constitute a distinct transverse suture (*k*) cutting the notum into two parts. This is shown in all the figures representing the mesonotum of the families from the Braconidæ (20) to the Apidæ (63). It is especially illustrated in *Erymotylus* (33, *k*), *Leucospis* (37, *k*), *Cerambycobius* (41, *k*), *Microterys* (42, *k*), *Eurytoma* (46, *k*), and *Proctotrypes* (55, *k*). This division of the mesonotum is so complete that in most cases it actually comes apart along this suture into two distinct plates, which are normally connected only by membrane. The posterior plate in some species has two flat apodemes on its front margin which slip under the posterior edge of the anterior plate. The anterior notal wing processes always arise from the sides of the first plate just in front of the lateral ends of the transverse suture (33, 46, 55, *ANP*), while the posterior processes (55, *PNP*) are situated on the edges of the posterior plate. The posterior notal plate may be called the scutellum (*Scl*₂), though it is clear that it is more than the equivalent of the scutellar division of the mesonotum of *Tremex* (3, *Scl*₂), which is defined by the line (*vnr*) of the entodorsal ridge (4, *VNR*). In a former paper the writer (1909) has demonstrated the impossibility of drawing strictly homologous lines between the subdivisions of the notum in different families and orders. The posterior edge of the scutum is generally differentiated as a marginal ridge or lobe bearing the axillary cords of the wing bases at its extremities. Such a subdivision as this might appropriately be called

the "postscutellum," but this term is preoccupied by the postnotum as used by most authors.

The anterior mesonotal plate is the scuto-prescutum, though the division into these two parts is often obscured. In most of the Tenthredinoidea there is present a distinct prescutum (10, 16-19, *Psc*₂), separated by a V-shaped suture (*h*) from the scutum (*Sc*₂). A similar prescutum is present also in some of the Ichneumonidæ, such as *Megarhyssa lunator* (25, *Psc*₂). In others, however, such as *Erymotylus macrurus* (33), the sides of the suture (*h*) extend backward toward the scutoscutellar suture (*k*) without meeting. In a great many of the Hymenoptera these separated halves of the scuto-prescutal suture form two distinct longitudinal lines on the anterior notal plate which subdivide the latter into a median and two lateral or parapsidal areas (*Euurobracon*, 20; *Odontaulacus*, 22; *Erymotylus*, 33; *Syntomaspis*, 34; *Eurytoma*, 46; *Tropidopria*, 58). The sutures are commonly called the *parapsidal sutures*, and the entire front plate for convenience may, in such cases, be called the scutum, as it is ordinarily termed. Yet it is evident that the median area (33, 46, *Psc*₂) is the prescutum prolonged posteriorly to meet the scutellum (*Scl*₂), and that the parapsides are the separated halves of the true scutum (*Sc*₂). In some forms, now, these parapsidal sutures (*h*) are absent, as in *Tremex* (3), *Trogus* (27), *Leucospis* (37), *Microterys* (42), *Coccophagus* (45), *Proctotrypes* (55), *Telenomus* (60), *Apis* (63), and others. In such cases it is to be supposed that the prescutal and scutal plates are fused, and while, for convenience, the anterior plate of the notum may be called the "scutum" it must be remembered that it is really a scuto-prescutal sclerite. In the Hymenoptera the anterior phragma is always attached to the anterior edge of the mesonotum and constitutes a prephragma of the mesothorax (3, 4, 10, 16, 30, 31, 37, 43, 52, 55, *Aph*₂).

3. *The concealment of the mesopostnotum and its phragma by invagination within the cavity of the thorax.*

The Tenthredinoidea (*Arge*, 10; *Trichiosoma*, 16, 19; *Lygænematus*, 18; and *Bactroceros*, 17) possess a distinct postnotum in the mesothorax (*PN*₂), consisting of an exposed transverse plate behind the scutellum (*Scl*₂) connected laterally with the mesothoracic epimera (*Epm*₂). It is visible externally also in *Tremex* (1, *PN*₂), but is less exposed here than in the Tenthredinoids. In all the other Hymenopteran families, however, it is normally concealed from view beneath the metanotum, for it is entirely invaginated into a pocket between the mesothorax and the metathorax, but when the mesotergum is removed from the surrounding parts the postnotum (*PN*₂) and its phragma (*Pph*₂) are brought to light (*Trogus*, 30; *Alomya*, 31; *Leucospis*, 37; *Proctotrypes*, 55). Lateral arms of the the postnotum usually maintain a hidden connection with the pos-

terior upper angles of the epimera. In *Apis* the median part of the postnotum is lacking, but the lateral parts remain as two arms attaching the postphragma to the angles of the mesothoracic epimera. The postphragma (*Pph*₂) is of variable size, but it is usually large and often projects through the metathorax far back into the cavity of the propodeum.

4. *The reduction of the metanotum to a simple transverse plate carrying the hind wings.*

In the Tenthredinoidea and Siricoidea the metanotum (1, 6, 11, 17, 18, 19, *N*₃) is a plate with more or less differentiation in its various parts and presents two little dorsal prominences called the *cenchri* (6, 11, *p.*). In the higher families, however, it is usually a very simple narrow plate (20, 26, 28, 57, 60, 63, *N*₃) lying between the mesonotum (*N*₂) and the metapostnotum (*PN*₃), the latter being often indistinguishably fused with the front of the propodeum (*IT*). Except in wingless forms the metanotum remains an individually separate plate of the dorsum, and may always be identified by the fact that it carries the hind wings laterally.

5. *The fusion of the metapostnotum with the propodeum or first abdominal segment.*

In the Tenthredinidæ the postnotum of the metathorax is a narrow transverse sclerite (11, 18, 19, *PN*₃) lying between the metanotum (*N*₃) and the first abdominal tergum (*IT*), though usually attached to the latter. In *Arge* (11) and *Trichiosoma* (19) it is continuous laterally with the metathoracic epimera (*Epm*₃). In *Tremex* (1, 6, *PN*₃) it consists of two narrow plates associated with the front of the first tergal plates of the abdomen (*IT*). In most of the other Hymenoptera, however, it constitutes a simple dorsal transverse yoke between the posterior angles of the metapleura. (*Trichiosoma*, 19; *Eurobracon*, 20; *Erymotylus*, 23; *Cryptus*, 26; *Proctotrypes*, 57; and *Pep-sis*, 61.) While in such cases the metapostnotum is a distinct though often narrow sclerite between the metanotum in front and the propodeum behind, it is nearly always fused with the latter. In the highest phase of its evolution it becomes indistinguishably merged into the front of the propodeum (*Odontaulacus*, 22; *Syntomaspis*, 34; *Catolaccus*, 44; *Coccophagus*, 45; *Dimmockia*, 48; *Rhodites*, 51; *Telenomus*, 60; *Apis*, 63). In such cases the dorsum of the thorax consists of five plates (see *Syntomaspis racemariæ*, 34, or *Dimmockia incongruus*, 48)—the pronotum (*N*₁), the mesoscuto-prescutum (*Psc*₂ and *Set*₂), the mesoscutellum (*Sc*₂), the metanotum (*N*₃), and the propodeum (*IT*), including the metapostnotum. This suppression of the metapostnotum as an individual plate, together with the concealment of the mesopostnotum, has led to a very erroneous nomenclature on the part of Hymenopteran systematists. For example, according to the ordinary application of names to the back plates of any such species

as the examples cited above, the metanotum is called the "postscutellum of the mesothorax," while the propodeum, the true first abdominal segment, is called the "metathorax." Many systematists, of course, recognize the impropriety of such a nomenclature from an anatomical standpoint, but are still constrained from making a change on account of the confusion it would create in taxinomic literature. The object of the present paper is simply the determination of the true morphology of the plates as far as this can be done by a comparative study. As already pointed out in the introduction and elsewhere, morphological terms may often be too awkward for use in systematic descriptions. For example, in those species in which the metapostnotum and the first abdominal tergum are fused this combined plate may for convenience still be called simply the propodeum, though in other forms the first abdominal tergum alone receives this name.

6. *The fusion of the first abdominal segment with the metathorax and its complete incorporation into the thoracic division of the body.*

This character of the Hymenoptera is now so well known that it scarcely needs any discussion here. It is interesting to observe, however, that in such a form as *Sirex* (1) the first abdominal tergum (*IT*) is but slightly separated from the second segment (*ID*), and the same is true in the Tenthredinidæ (18, 19). In *Bactroceros* (17) it is more distinctly separated from the rest of the abdomen, but is still most evidently the first abdominal tergum (*IT*). In all the Hymenopteran families above the Tenthredinoidea and Siricoidea, however, it certainly appears to be a part of the thorax, though it of course always carries the first abdominal spiracles (*ISp*). Its fusion with the metapostnotum has already been described. Laterally it fuses with the metapleura (*Pl*₃ and *pl*₃) in most of the higher families (20, 22, 24, 45), the line of separation being sometimes entirely obsolete (21, 50, 51).

This transferred abdominal segment was first called the "segment mediaire" by Latreille (1821), but the name "propodeon" given to it by Newman (1833) is more convenient to use. Emery (1900), and Wheeler (1910) following him, call it the "epinotum" in ants. One of the few modern authors who have argued that it belongs to the thorax is Marlatt (1896), who, following Westwood (1838) calls it the "metascutellum." A voluminous account of the history of the discussion concerning this plate is given by Gosch (1883).

7. *The formation of a single large mesopleural plate on each side by the narrowing of the mesepimerum and the suppression of the mesopleural suture, and its secondary division into an upper and a lower plate.*

In many of the Hymenoptera the pleurites are developed in a most typical form in both the mesothorax and the metathorax. Such is the case in all of the Tenthredinoidea and Siricoidea (1, 17, 18, 19) where a distinct episternum (*Eps*₂, *Eps*₃) and epimerum (*Epm*₂,

*Epm*₃) are present in each of these segments. The same is true of the mesopleurum of some of the Chalcidoidea (34, 37, 45, 47, 48), in which the episternum (*Eps*₂) and epimerum (*Epm*₂) are equally developed and are separated by a distinct pleural suture extending from the coxal articulation to the wing process (*WP*₂) just as in *Tremex* (1, *PS*₂). In the Chalcids and some other forms, however, the mesopleurum is complicated by the presence of a plate (*Ppct*) in front of the episternum, but this will be described later.

In the rest of the Hymenoptera there is a distinct tendency toward the reduction of the mesepimerum and the obliteration of the mesopleural suture with the result that the mesopleurum comes to consist of one large plate (50, 51, 52, *Pl*₂) carrying the wing articulation (*WP*₂) above and the coxal articulation below. In the Ichneumoidea the mesepimerum (20–28, 31, 32, *Epm*₂) is a narrow, though usually perfectly distinct, plate on the posterior edge of the large mesepisternum (*Eps*₂), being widest, amongst the species figured, in *Odontaulacus editus* (22). The suture separating this plate from the episternum is either a distinct line (20, 22, 23, 25, 26, 28) or is marked by a series of quadrate pits (21, 24, 27). In any case it can be identified as the pleural suture by examining the interior face of the thoracic wall, for its course is here marked by a distinct pleural ridge (32, *PR*) extending from the coxa to the wing process (*WP*₂).

The degeneration of the mesepimerum appears to the writer clearly demonstrated by this series of forms (1, 17–28) just described. When, now, it is found that, amongst the Cynipoidea (49–52) and some of the Proctotrypoidea (59), there is no trace of this kind of a subdivision of the pleurum, the conclusion is inevitable that the true episternum and epimerum are indistinguishably fused. Finally, therefore, when other subdivisions of the mesopleurum are discovered the conclusion that these latter are of secondary formation seems equally certain. In a few cases, already pointed out, the mesopleurum consists of one undivided plate (50–52, *Pl*₂), but it more frequently (*Hexaplasta*, sp., 49; *Proctotrypes caudatus*, 57; *Tropidopria conica*, 59) becomes differentiated into an upper wing-bearing part (*Pl*₂) and a lower leg-bearing part (*pl*₂) by a horizontal or oblique suture. This suture, moreover, is usually near the middle of the pleurum and is always above the articulation of the coxa. Hence, it can not be confused with the sterno-pleural suture (10, 16, 23, 27, *q*) which is always below the coxal articulation. Yet nearly all writers on the Hymenopteran thorax have called this lower mesopleural plate the “mesosternum.” To be sure, in nearly all the higher families as well as in some of the lower forms, it is entirely continuous with the sternum, but those species having a sterno-pleural suture clearly demonstrate where the true division between the sternum and the pleurum occurs when it is present.

In some of the Aculeata (*Pepsis*, 61) in which the mesepimerum (Epm_2) is still distinct, the episternum alone is divided into dorsal and ventral plates (Eps_2 , eps_2). In the honey bee (*Apis*, 63) the epimerum (Epm_2) is well developed above, but reaches only about half way down from the wing process (WP_2) to the base of the middle leg. In a worker ant (*Pogonomyrmex*, 62) the upper pleural plate (Pl_2) is continuously fused with the mesoscutum (Sct_2) and, in this case, might just as reasonably be called a part of the mesonotum, as may the lower plate (pl_2) in other forms be called a part of the mesosternum. In *Pogonomyrmex* (62) the latter plate (S_2) is, however, demarked from the pleurum by a suture.

8. *The formation of a prepectal plate in the mesothorax cut off from the anterior parts of both the mesosternum and the mesopleura.*

This character reaches its highest development in the Chalcidoids. The plate in question ($Ppct_2$) is specially well shown in such species as *Catalaccus incertus* (44), *Coccophagus lecanii* (45), and *Dimmockia incongruus* (48), in all of which species it forms a conspicuous plate on the side of the thorax lying between the pronotum (N_1) and the mesepisternum (Eps_2). An examination of the ventral aspect of the thorax, however, shows that this pleural sclerite ($Ppct_2$) on each side is only the lateral part of a plate that is continuous across the ventral surface in most cases. This is specially well shown by *Prospaltella berlesii* (47), where the plate ($Ppct_2$) forms an anterior subdivision of the entire mesopectus. Hence the writer has given it the name of *prepectus*, signifying that it is derived from the anterior parts of both the sternum (S_2) and the episterna (Eps_2).

The beginning of the mesoprepectus is to be found in the Ichneumonidæ, in nearly all members of which the anterior part of the mesopectus is differentiated as a subsclerite (23-28, 31, 32, $Ppct_2$), marked off by a suture from the sternum (S_2) and the episternum (Eps_2). In the Chalcid, *Leucospis affinis* (35, 37, 39), the median part of the prepectus is not entirely cut off from the front of the mesosternum (S_2). In *Microterys*, sp. (43) there are two prepectal plates, one on each side ($Ppct_2$, $Ppct_2$), which are not connected in front of the sternum, but this is most evidently a secondary reduction. In *Cerambycobius cushmani* (40, 41) the prepectus occurs in a distorted condition ($Ppct_2$) on account of the curious shape of the mesopleurum. Though the prepectus has something of the appearance of the preepisternum (see p. 47) of the more generalized orders of insects, especially if we assume a continuity between the preepisterna and the presternum, yet the phylogenetic gap between them is too great to permit of the homologizing of one with the other. The prepectus of the Hymenoptera appears to be a purely secondary production within this order.

9. *The obliteration of the metapleural suture resulting in the formation of a single metapleural sclerite, which becomes divided again into an upper and a lower plate.*

The evolution of the metapleurum is parallel with that of the mesopleurum. In the Tenthredinoidea and Siricoidea (1, 8, 11, 17, 18) it consists of two approximately equal plates, the episternum (Eps_3) and the epimerum (Epm_3) separated externally by the plural suture (1, 11, PS_3) and internally by the pleural ridge (8, PR). In all the other Hymenoptera, however, the metapleural suture is obliterated, and the metapleurum consists either of one single plate (34, 40, 44, 45, 48, 49, 50, 51, 57, 59, 60, 62, Pl_2) or it becomes more or less divided into a dorsal wing bearing part and a ventral leg-bearing part (20, 23–28, 61, 63, Pl_3 and pl_3). In *Trichiosoma lanuginosa* (19) there is a suggestion of this dorsal and ventral subdivision even before the pleural suture has disappeared, resulting in the formation of four subsclerites (Eps_3 , eps_3 and Epm_3 , epm_3). It has already been shown that the upper parts of the metapleura are nearly always fused with the lateral parts of the metapostnotum (PN_3), but besides this they are nearly always fused also with the sides of the propodeum (IT). In many cases, therefore, all four of these parts, the metapostnotum (PN_3), the propodeum (IT), and the two metapleura (Pl_3) are fused into one large piece in which sometimes all traces of sutures are obliterated (21, 50, 51).

3. SUMMARY OF THORACIC CHARACTERS.

As a result of these various modifications the thoracic division of the body in the higher Hymenoptera looks very different in its composition from that of all other insects. By the rearrangement of some of the parts and the consolidation of others the original metameral structure is obscured, and the thoracic walls come to be made up of seven distinct chitinous plates having but little evident relation to the original four segments. This remodelled structure is well shown by the Proctotrypid, *Helorus paradoxus* (58). The parts may be specified as follows: (1) the propectus, consisting of the prosternum and the proepisterna (Eps_1), which supports the head and carries the front legs; (2) the protergum, or pronotum (N_1), forming a cap over the front of the mesothorax; (3) the scuto-prescutal plate of the mesonotum (Psc_2 and Sct_2) carrying the anterior dorsal articulations of the front wings; (4) the scutellar plate of the mesonotum (Scl_2), separated from the preceding by the suture (k) and carrying the posterior articulations of the front wings; (5) the mesopectus, consisting of the fused mesosternum (S_2) and mesopleurites (Eps_2 , and Epm_2), supporting the front wings from below and carrying the middle legs; (6) the metanotum (N_3) carrying the dorsal attachments of

the hind wings; and (7) the posterior composite mass of the thorax, consisting of the metapostnotum (PN_3) and the first abdominal tergum (IT) above, of the metapleura (Pl_3) on the sides, and of the metasternum below, carrying the first abdominal spiracles (ISp), the pedunculate part of the abdomen (II , III) and the hind legs (Cx_3), and supporting the hind wings on the metapleural wing processes (WP_3).

The wingless Hymenoptera have the thorax the most highly specialized and, at the same time, the most simplified. In the apterous forms of Mutillidæ and the workers of Formicidæ (62) the propectus is detached in the usual fashion from the rest of the thorax and the protergum is separated from the mesothorax, at least on the sides, by a cleavage suture, but otherwise the thoracic walls are solid. The back sclerites (62, Sct_2 , Scl_2 , N_3 , PN_3 and IT) form one continuous plate from the protergum (N_1) to the second abdominal segment (II). The indistinct line (k) across the back appears to be the scuto-scutellar suture. The lateral margins of the dorsal plates, are indistinguishably fused with the pleurites and these latter are continuous with the sterna. The mesopleurum is partially divided by an impressed line (r) into an upper plate (Pl_2) continuous with the mesoscutum (Sct_2) and into a lower plate (pl_2) carrying the middle coxa (Cx_2). This sort of subdivision of the mesopleurum has been pointed out in other forms (59). The mesepisternum alone is frequently so divided ($Pepsis$, 61, Eps_2 , eps_2). The first spiracle of the worker ant is situated as usual behind the angle of the protergum (62, ISp), the second ($2Sp$) is inclosed in the posterior margin of the upper mesopleural plate (Pl_2). The first abdominal spiracle (ISp) is located on the side of the propodeal region (IT).

Other authors have made different interpretations of the morphology of the ant thorax. Janet (1898) calls the proepisternum (62, Eps_1) the "prosternum" and the lower parts of the pleura of the other two segments the "mesosternum" and the "metasternum". Nassanoff (1889), Emery (1900), and Berlese (1908) name these parts in the same way. The writer has already stated the argument against such a disposition of these plates (see pp. 77 and 78). The pleurum of any segment lies normally between the base of the wing and the base of the leg, and it is inconceivable why a line midway between these points should be regarded as the sterno-pleural suture. At least some strong reason should be given for imagining such a distortion to have taken place that would put it there. In the lower Hymenoptera, as already shown, the true sterno-pleural sutures lie ventrad to the articulations of the coxæ (10, 11, 14, 16, 27, q). In most of the higher forms these sutures disappear though they recur in many scattered cases (40, 43, 50, q). Therefore, the line on the middle of the side can be nothing else than a secondary subdivision of the pleurum itself.

The application of anatomical terms to the back plates of the ant thorax by Nassanoff (1889) is such as to indicate that this author's ideas of the thoracic morphology or nomenclature are quite different from those of the present writer. When the same words are used in different senses by two writers an argument on the subject is likely to be very meaningless. The present writer agrees with Janet (1898) in his nomenclature and morphology of most of the thoracic sclerites, except with respect to the limits of the sternum. It is only by dissociating the parts of the thorax, as Janet did, that their true relations become apparent.

Finally, the work of Emery (1900) on the thorax of ants must be given a special discussion because Emery's views have been adopted by Wheeler (1910) in his recent comprehensive work on ants. Emery bases his ideas of the formicoid thorax on a study of the female *Streblognathus æthiopicus*. The present writer has not had access to a specimen of this species but the principal thoracic characters are similar in most of the Ponerine genera. Text figure 18 shows the left side of the thorax of *Leptogonys (Lobopelta) elongata*. The prothorax (N_1 , Eps_1) and the dorsal plates of the other segments (Psc_2 , Sct_2 , Scl_2 , N_3 , IT) do not differ from those of other Hymenoptera. In the mesopleurum, however, the limits of the epimerum (Epm_2) are almost obliterated, yet a comparison with *Pepsis* (61, Epm_2) leaves no doubt that the indistinctly marked subdivision (fig. 18, Epm_2) along the upper part of the posterior margin of the pleurum is the true mesepimerum. A small but distinct internal ridge attests that the faint line (PS_2) is the true pleural suture, though it fades out before it reaches either the wing process (WP_2) or the coxal process. The episternal area is divided by an oblique furrow (r) into an alar and a coxal region (Eps_2 and eps_2) while, again, the dorsal part of the latter is partially cut off by a longitudinal furrow (z). Now, Emery names

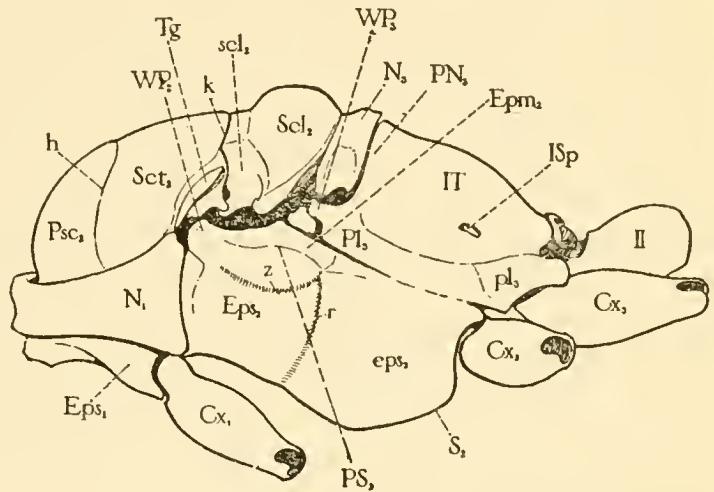


FIG. 18.—LATERAL VIEW OF ANT THORAX (*LEPTOGONYNS ELONGATA*): Cx_1 , Cx_2 , Cx_3 , COXÆ; Epm_2 , MESEPIMERUM; Eps_1 , PROEPISTERNUM; Eps_2 , eps_2 , UPPER AND LOWER SUBDIVISIONS OF MESEPISTERNUM; h , SCUTO-PRESCUTAL (PARAPSIDAL) SUTURE; II , SECOND ABDOMINAL SEGMENT; ISp , FIRST ABDOMINAL SPIRACLE; IT , PROPODEUM (FIRST ABDOMINAL TERGUM); k , SCUTO-SCUTELLAR SUTURE OF MESONOTUM; N_1 , PRONOTUM; N_3 , METANOTUM; Pl_3 , pl_3 , UPPER AND LOWER SUBDIVISIONS OF THE METAPLEURUM; PN_3 , METAPOSTNOTUM FUSED WITH IT ; PS_2 , MESOPLEURAL SUTURE; Psc_2 , MESOPRESCUTUM; r , LATERAL SUTURE OF MESEPISTERNUM; S_2 , MESOSTERNUM; Scl_2 , PRINCIPAL PART OF MESOSCUTELLUM; scl_2 , ANTERIOR SUBDIVISION OF MESOSCUTELLUM; Sct_2 , MESOSCUTUM; Tg , TEGULA; WP_2 , WP_3 , PLEURAL WING PROCESSES; z , DORSAL SUTURE OF MESEPISTERNUM.

the prothorax (N_1 , Eps_1) and the dorsal plates of the other segments (Psc_2 , Sct_2 , Scl_2 , N_3 , IT) do not differ from those of other Hymenoptera. In the mesopleurum, however, the limits of the epimerum (Epm_2) are almost obliterated, yet a comparison with *Pepsis* (61, Epm_2) leaves no doubt that the indistinctly marked subdivision (fig. 18, Epm_2) along the upper part of the posterior margin of the pleurum is the true mesepimerum. A small but distinct internal ridge attests that the faint line (PS_2) is the true pleural suture, though it fades out before it reaches either the wing process (WP_2) or the coxal process. The episternal area is divided by an oblique furrow (r) into an alar and a coxal region (Eps_2 and eps_2) while, again, the dorsal part of the latter is partially cut off by a longitudinal furrow (z). Now, Emery names

the coxal subdivision of the episternum (eps_2) the "mesosternum," while the part of the upper plate above the groove (z) he calls the "epimerum" and the part below the "episternum." A person who has studied ants alone may be excused for making such an interpretation as this, but, in the light of a comparative study of all the Hymenoptera, the writer can not see how the sutures (r) and (z) can be anything other than secondary grooves in the mesepisternum. The writer has not observed a metapleurum in the ants constructed as in Emery's figure of *Streblognathus*. In *Leptogonys* and other Ponerines examined the metapleurum (Pl_3 and pl_3) is very indefinitely demarked from the propodeum (IT), and the metapostnotum (PN_3) is not distinct from either. Emery calls the lower part of the metapleurum the "metasternum" while in the upper part he finds both a metepisternum and a metepimerum. He makes a very curious use of the word "parapternum" which he applies to the anterior subdivision of the mesoscutellum (scl_2). The writer has shown elsewhere (1910, footnote *a*, p. 20) that Audouin's *paraptère* is a little plate in the pleurum before the base of the wing (see p. 47). In *Myrmica piriformis* Emery calls what is apparently a subdivision of the metanotum the "metaparapterum." The writer feels confident that Emery's interpretations of the thoracic parts of ants are due to a deficient study of other Hymenopteran families leading up to them from the Tenthredinoidea and Siricoidea, and that his homologies must appear erroneous to anyone who will ground his morphological ideas on the thoracic structure of these generalized forms.

5. WINGS, THEIR VENATION AND ARTICULATION.

A comprehensive study of the wings is beyond the scope of the present paper, but there are some interesting points brought out in a study of the evolution of their basal parts. The Hymenopteran venation is so different from that of all other insects that any scheme of homology with the other orders involving the branches of the veins is purely speculative. The Comstock-Needham system of nomenclature as applied to the front wing of *Sirex flavicornis* is shown by figure 74. It assumes that the fourth and fifth branches of the radius (R_4 and R_5) have been bent back toward the posterior edge of the wing and fused with the neighboring branches of the media and that the third and fourth branches of the media (M_3 and M_4) have been likewise turned back and united with the cubitus (Cu), while this last vein fuses with the first anal ($1A$). If all the terminal branches of the veins in this wing were to be designated according to the veins that unite in their formation, they would have to be given, in many cases, names entirely too long for practical purposes. For this reason Hymenopteran systematists have not commonly adopted the Comstock-Needham nomenclature, but continue to use that of Cresson (1887). Figure 76 shows the front wing of an Ichneumonid,

Megarhyssa lunator, with the veins named according to the Cresson nomenclature, while figure 75 shows the same wing of *Sirex flavicornis* (74) named by this system as modified to suit the Siricoidea and Tenthredinoidea by Mr. S. A. Rohwer, of the United States Bureau of Entomology. Figure 77 is the front wing of *Leucospis affinis*, and the names applied to the rudiments of its veins are those in use by students of the Chalcidoidea.

The base of the Hymenopteran wing shows an increasing tendency, as the higher families are approached, toward a condensation of the bases of the first five veins. A very generalized wing base is found in the Pamphiliid, *Itycorsia discolor* (64). The costal vein (*C*) consists basally of two little chitinous pieces (*C* and *C*). The subcosta (*Sc*) is well developed, and articulates with the first axillary sclerite (*1Ax*) by a large and contorted base (*Sc*). The radius (*R*) is continuous at its base with the second axillary (*2Ax*). The media is not an independent vein basally in the wing of any Hymenopteran and, by the Comstock-Needham scheme of venation, it is supposed to be fused with the radius, forming a compound vein (*R + M*), which is the principal anterior vein of the wing (74). Nevertheless the little median plate (*m*) of the wing base is generally present with which both the media and the cubitus are associated in the wings of more generalized insects (see fig. 8). The cubitus (*Cu*) is likewise combined with the base of the radius. Consequently the next two veins that enter into the base of the wing are anals. They may be known as such, furthermore, by their association with the third axillary (*3Ax*). Since an apparent branch (74, *2A*) of the first anal is regarded at the true second anal, the second one at the base of the wing is called the third anal (*3A*).

The front wing of *Sirex flavicornis* (65) shows a few structural departures from that of *Itycorsia*. There is only one basal piece of the costa (*C*), and the enlarged base of the subcosta (*Sc*), articulating with the first axillary (*1Ax*), is separated from the shaft of the subcostal vein. These differences are more pronounced in *Tremex columba* (66), one of the Siricidæ. The shaft of the subcosta is not present as a vein, though its site is marked by a short branching trachea (*Sc*). The basal part (*Sc*), however, is very large and conspicuous. In *Megarhyssa lunator* (67), an Ichneumonid, there are no traces of the subcostal shaft, but its basal part (*Sc*) is present and articulates with the first axillary (*1Ax*). In *Pepsis* (69), one of the Ceropalidæ (Pompilidæ), the base of the subcosta (*Sc*) forms a large mass at the humeral angle of the wing, with which is fused the basal part of the radius (*R*). This is evident from the articulation with both the first (*1Ax*) and the second axillary (*2Ax*). Finally, in the Chalcid, *Leucospis* (68), and in the honey bee, *Apis* (70), the basal remnant of the subcosta (*Sc*) forms a large and conspicuous scale-like plate on the humeral angle of the wing base. It looks like a

secondary tegula, but it can not be confused with this organ, because the tegula is present also and overlaps the subcostal scale.

In the hind wing the bases of the subcosta and radius are generally fused into one large humeral mass, as shown in *Tremex columba* (71, *Sc* and *R*), *Apis mellifera* (72), and *Leucospis affinis* (73).

The details of the axillaries of *Tremex columba* and of *Apis mellifera* are shown by figure 19. The first axillary (*1Ax*) always articulates with the anterior wing process of the notum (fig. 8, *ANP*), while its anterior neck articulates with the base of the subcostal vein. The second axillary (*2Ax*) rests below upon the wing process of the pleurum and is associated with the base of the radial vein. Its inner

edge articulates with the body of the first axillary and its posterior end is usually articulated to the third. A muscle disk (fig. 19, A, B, *AxD*) or some sort of muscle-bearing sclerite is usually attached to its posterior end by a long tendon-like stalk and carries the upper end of the slender coxo-axillary muscle, whose lower end is attached to the upper rim of the coxa of the same segment. The third axillary (*3Ax*) is associated with the bases of the anal veins and carries the insertion of the flexor muscles of the wing. It nearly always presents a special lobe for the accommodation of these muscles and is often provided with an accessory sclerite (fig. 19, B, C, *3ax*). The fourth axillary (*4Ax*) is always smaller and simpler than the others. It is present in the front wing of most of the Hymenoptera and in the hind wing of many of them. It is generally absent in other insects except the Orthoptera. When present, it forms the hinge plate of the wing articulating with the posterior wing process of the notum (fig. 8, *PNP*). It is absent in the hind wing of *Apis* (72 and fig. 19 D) and in the hind wing of *Leucospis* (73). In these cases the third axillary (*3Ax*) is associated with the posterior wing process. In the honey bee the fourth axillary of the front wing has a large accessory sclerite (70 and fig. 19 C, *y*) associated with it, upon which is inserted a slender muscle attached to an arm of the sternal furca.

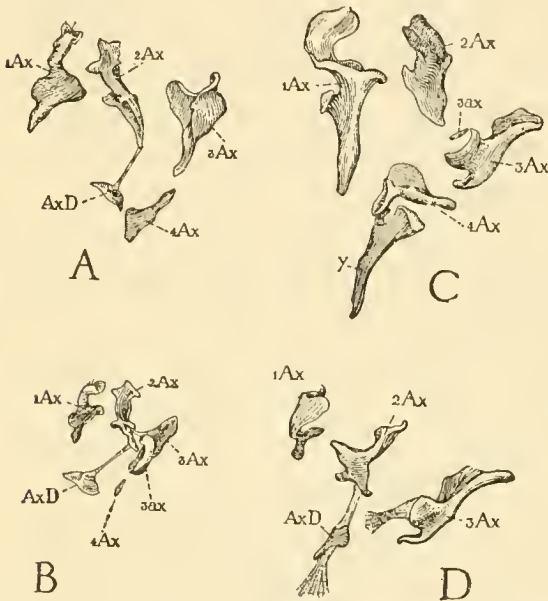


FIG. 19.—AXILLARY SCLERITES; A, OF FRONT WING OF *TREMEX COLUMBA*; B, OF HIND WING OF *TREMEX COLUMBA*; C, OF FRONT WING OF *APIS MELLIFERA*; D, OF HIND WING OF *APIS MELLIFERA*: *1Ax*, FIRST AXILLARY; *2Ax*, SECOND AXILLARY; *3Ax*, THIRD AXILLARY; *3ax*, ACCESSORY SCLERITE OF THIRD AXILLARY; *4Ax*, FOURTH AXILLARY; *AxD*, DISK OF COXO-AXILLARY MUSCLE ATTACHED TO SECOND AXILLARY; *y*, MUSCLE-BEARING SCLERITE ATTACHED TO FOURTH AXILLARY OF FRONT WING IN *APIS MELLIFERA*.

It is present in the front wing of most of the Hymenoptera and in the hind wing of many of them. It is generally absent in other insects except the Orthoptera. When present, it forms the hinge plate of the wing articulating with the posterior wing process of the notum (fig. 8, *PNP*). It is absent in the hind wing of *Apis* (72 and fig. 19 D) and in the hind wing of *Leucospis* (73). In these cases the third axillary (*3Ax*) is associated with the posterior wing process. In the honey bee the fourth axillary of the front wing has a large accessory sclerite (70 and fig. 19 C, *y*) associated with it, upon which is inserted a slender muscle attached to an arm of the sternal furca.

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7. EXPLANATION OF PLATES.

Abbreviations.

The figures 1, 2, 3, etc., placed before an abbreviation signify first, second, third, etc.; the figures 1, 2, and 3 placed after and below an abbreviation refer the latter to the prothorax, mesothorax, or metathorax, respectively, except on the wings where they indicate branches of the veins; the Roman numerals I–X designate the abdominal segments or their respective parts. A subdivision of any part is indicated by a duplicate of its symbol in lower case letters.

A, anal vein.

ANP, anterior notal wing process.

ANR, anterior ventral notal ridge.

anr, line on surface of notum formed by ANR.

Aph, prephragma of any segment.

Ax, axillary sclerites of wing base. *1Ax*, *2Ax*, *3Ax*, *4Ax*, first, second, third, and fourth axillaries.

AxC, axillary cord, the ligament-like thickening of posterior edge of axillary membrane of wing.

AxD, axillary disk, usually attached to second axillary and bearing insertion of coxo-axillary muscle.

AxM, axillary membrane, the membrane of the wing base.

C, costa.

Cer, cervicum.

Cu, cubitus.

cv, cross vein.

Cx, coxa.

CxP, coxal process of pleurum.

Em, lateral emargination of notum.

Emp, empodium.

- Epm*, epimerum.
epm, subdivision of epimerum.
EpmA, epimeral arm.
Eps, episternum.
eps, subdivision of episternum.
Es, Eusternum.
F, femur.
Fu, furca (entosternum.)
H, head.
ISp, first abdominal spiracle.
IT, first abdominal tergum, called the propodeum in Hymenoptera when transferred to thorax.
it, subdivision of propodeum (*IT*).
L, leg.
M, media.
m, small median plate or plates of wing base.
Mb, "intersegmental" membrane.
m-cu, medio-cubital cross vein.
m-m, median cross vein.
N, notum.
P, parapterum: *1P*, *2P*, first and second or episternal paraptera; *3P*, *4P*, third and fourth or epimeral paraptera.
PA, pleural arm, process of pleural ridge.
Pct, pectus, the sternum and pleura together of any segment.
PD, pronator disk.
Peps, preepisternum.
Ph, phragma: *1Ph*, *2Ph*, *3Ph*, first, second, and third phragmas.
Pl, pleurum.
pl, subdivision of pleurum.
PN, Postnotum (postscutellum, pseudonotum).
pn, subdivision of postnotum.
PNP, posterior notal wing process.
PNR, posterior ventral notal ridge.
pnr, line on surface of notum formed by *PNR*.
Ppct, prepectus.
Pph, postphragma of any segment.
PR, internal pleural ridge (entopleurum).
PS, pleural suture, separating episternum and epimerum along line of internal pleural ridge.
Ps, presternum.
Psc, prescutum.
Psl, poststernellum.
Pv, pulvillus.
R, radius.
Rd, posterior reduplication of edge of notum.
r-m, radio-medial cross vein.
S, sternum.
Sc, subcosta.
Scl, scutellum.
scl, subdivision of scutellum.
Set, scutum.
Sl, sternellum.
Sp, spiracle (*1Sp*, *2Sp*, first and second thoracic spiracles; *ISp*, first abdominal spiracle).
T, tergum (*IT*, first abdominal tergum, the propodeum when fused with the thorax).

- Tar*, tarsus.
Tg, tegula.
Tn, trochantin.
TnC, coxal process of trochantin.
Tr, trochanter.
VNR, ventral V-shaped ridge of notum (entodorsum).
vnr, line on surface of notum formed by *VNR*.
W, wing.
WP, wing process of pleurum.

Miscellaneous lettering.

- a*, reflected edge of anterior lamina of prephragma.
b, reflected edge of posterior lamina of postphragma.
c, small plate intervening between parapterum and head of costal vein.
d, plate articulating between prosternum and coxa of *Tremex columba*.
e, accessory precoxal plate.
f, cervical sclerite.
g, dorsal cervical sclerite.
h, parapsidal suture.
i, cervical sclerite of honey bee.
j, lateral episternal ridge of *Scolia dubia*, marking the line where the pronotum overlaps the propleurum.
k, scuto-scutellar suture.
l, ventral cervical sclerite of *Scolia dubia*.
m, median plate or plates of wing base.
o, lobe on posterior margin of scutellum.
p, cenchri.
q, sterno-pleural suture.
r, median episternal groove.
u, prealar lobes of prescutum in *Holorusia*.
v, occipital process of propleurum.
w, posterior lobe of pronotum covering the first spiracle.
x, small plate between the presternum and the preepisternum in generalized segment.
y, accessory sclerite of the fourth axillary (*4Ax*) in the honey bee.
z, dorsal episternal groove.

Numbering.

The following are the names of the wing veins on plate 16, as used by Cresson in the Ichneumonidæ (76), transferred to a Siricoid wing (75), and the names current amongst systematists for the veins of a Chalcidoid wing (77):

- 1, costal vein.
- 2, subcostal.
- 3, radial.
- 4, median or externo-median.
- 5, anal, submedian, or interno-median.
- 6, subanal.
- 7, basal.
- 8, transverse radius.
- 9, cubital.
- 10, transverse cubital.
- 11, transverse cubital.
- 12, transverse cubital.
- 13, transverse medial.

- 14, discoidal.
- 15, subdiscoidal.
- 16, first recurrent.
- 17, second recurrent.
- 18, transverse vein in anal cell.
- 19, stigma.
- 20, submarginal.
- 21, marginal.
- 22, postmarginal.
- 23, stigmal.
- 24, intercostal.

PLATE 1.

- Fig. 1. *Tremex columba* (Siricidæ), thorax and base of abdomen.
 2. *Tremex columba*, propectus, ventral, left coxa removed.
 3. *Tremex columba*, mesotergum, dorsal.
 4. *Tremex columba*, mesotergum, ventral.
 5. *Tremex columba*, lateral and ventral parts of mesothorax, from above, tergum removed.
 6. *Tremex columba*, terga of metathorax and first abdominal segment, dorsal.
 7. *Tremex columba*, lateral and ventral parts of metathorax, from above, tergum removed.
 8. *Tremex columba*, left metapleurum, hind coxa, and attached part of first abdominal tergum, internal.
 9. *Tremex columba*, left mesopleurum and middle coxa, internal

PLATE 2.

- Fig. 10. *Arge*, sp. (Tenthredinidæ), mesothorax, left side.
 11. *Arge*, sp., metathorax and first abdominal tergum (propodeum), left side.
 12. *Arge*, sp., propleurum, sternum, and front leg, left side.
 13. *Dolerus aprilis* (Tenthredinidæ), propleurum and base of first leg, left side.
 14. *Arge*, sp., mesopectus, ventral.
 15. *Arge*, sp., metapectus, ventral.
 16. *Trichiosoma lanuginosa* (Tenthredinidæ), mesothorax, left side.

PLATE 3.

- Fig. 17. *Bactroceros pallimacula* (Pamphilidæ), thorax and base of abdomen.
 18. *Lygæncmatus erichsonii* (Tenthredinidæ), thorax and base of abdomen.
 19. *Trichiosoma lanuginosa* (Tenthredinidæ), thorax and base of abdomen. (See also fig. 16, pl. 2.)

PLATE 4.

- Fig. 20. *Euurobracon penetrator* (Braconidæ), thorax and base of abdomen.
 21. *Capitonius ashmeadii* (Capitoniidæ), thorax and base of abdomen.
 22. *Odontaulacus editus* (Evaniidæ), thorax and base of abdomen.

PLATE 5.

- Fig. 23. *Erymotylus macrurus* (Ichneumonidæ), thorax and base of abdomen. (See also fig. 33, pl. 7.)
 24. *Metopius pollinctorius* (Ichneumonidæ), thorax and base of abdomen.
 25. *Megarhyssa lunator* (Ichneumonidæ), thorax and base of abdomen.

PLATE 6.

- Fig. 26. *Cryptus extrematus* (Ichneumonidæ), thorax and base of abdomen.
 27. *Trogus lutorius* (Ichneumonidæ), thorax and base of abdomen. (See also figs. 29, 30, 32, pl. 7.)
 28. *Alomya debellator* (Ichneumonidæ), thorax and base of abdomen. (See also fig. 31, pl. 7.)

PLATE 7.

- Fig. 29. *Trogus lutorius* (Ichneumonidæ), thorax and base of abdomen, legs removed, ventral.
 30. *Trogus lutorius*, mesotergum, left side.
 31. *Alomya debellator* (Ichneumonidæ), mesothorax, left side.
 32. *Trogus lutorius*, left mesopleurum, internal.
 33. *Erymotylus macrurus* (Ichneumonidæ), mesotergum, dorsal.
 34. *Syntomaspis racemariæ* (Chalcidoidea), thorax and base of abdomen.

PLATE 8.

- Fig. 35. *Leucospis affinis* (Chalcidoidea), left side.
 36. *Leucospis affinis*, prothorax, anterior.
 37. *Leucospis affinis*, mesothorax, left side.
 38. *Leucospis affinis*, left metapleurum and left half of propodeum, internal.
 39. *Leucospis affinis*, left mesopleurum, internal.

PLATE 9.

- Fig. 40. *Cerambycobius cushmani* (Chalcidoidea), thorax and base of abdomen.
 41. *Cerambycobius cushmani*, thorax and propodeum, dorsal.
 42. *Microterys*, sp. (Chalcidoidea), thorax and base of abdomen, dorsal.
 43. *Microterys*, sp., mesothorax and metathorax, ventral.
 44. *Catolaccus incertus* (Chalcidoidea), thorax and base of abdomen.

PLATE 10.

- Fig. 45. *Coccophagus lecanii* (Chalcidoidea), thorax and base of abdomen.
 46. *Eurytoma diastrophii boltenii* (Chalcidoidea), mesotergum, dorsal.
 47. *Prospaltella berlesii* (Chalcidoidea), mesopectus and metapectus, ventral.
 48. *Dimmockia incongruus* (Chalcidoidea), thorax and base of abdomen.

PLATE 11

- Fig. 49. *Hexaplasta*, sp. (Cynipoidea), thorax and base of abdomen.
 50. *Figites floridanus* (Cynipoidea), thorax and base of abdomen.
 51. *Rhodites mayri* (Cynipoidea), thorax and base of abdomen. (See also fig. 52, pl. 12.)

PLATE 12.

- Fig. 52. *Rhodites mayri* (Cynipoidea), mesothorax, left side.
 53. *Proctotrypes caudatus* (Proctotrypoidea), propectus, ventral.
 54. *Proctotrypes caudatus*, pronotum, ventral.
 55. *Proctotrypes caudatus*, mesotergum, left side.
 56. *Proctotrypes caudatus*, left mesopleurum, internal.
 57. *Proctotrypes caudatus*, thorax and base of abdomen.

PLATE 13.

- Fig. 58. *Helorus paradoxus* (Proctotrypoidea), thorax and base of abdomen.
 59. *Tropidopria conica* (Proctotrypoidea), thorax and base of abdomen.
 60. *Telenomus ashmeadii* (Proctotrypoidea), thorax and base of abdomen.

PLATE 14.

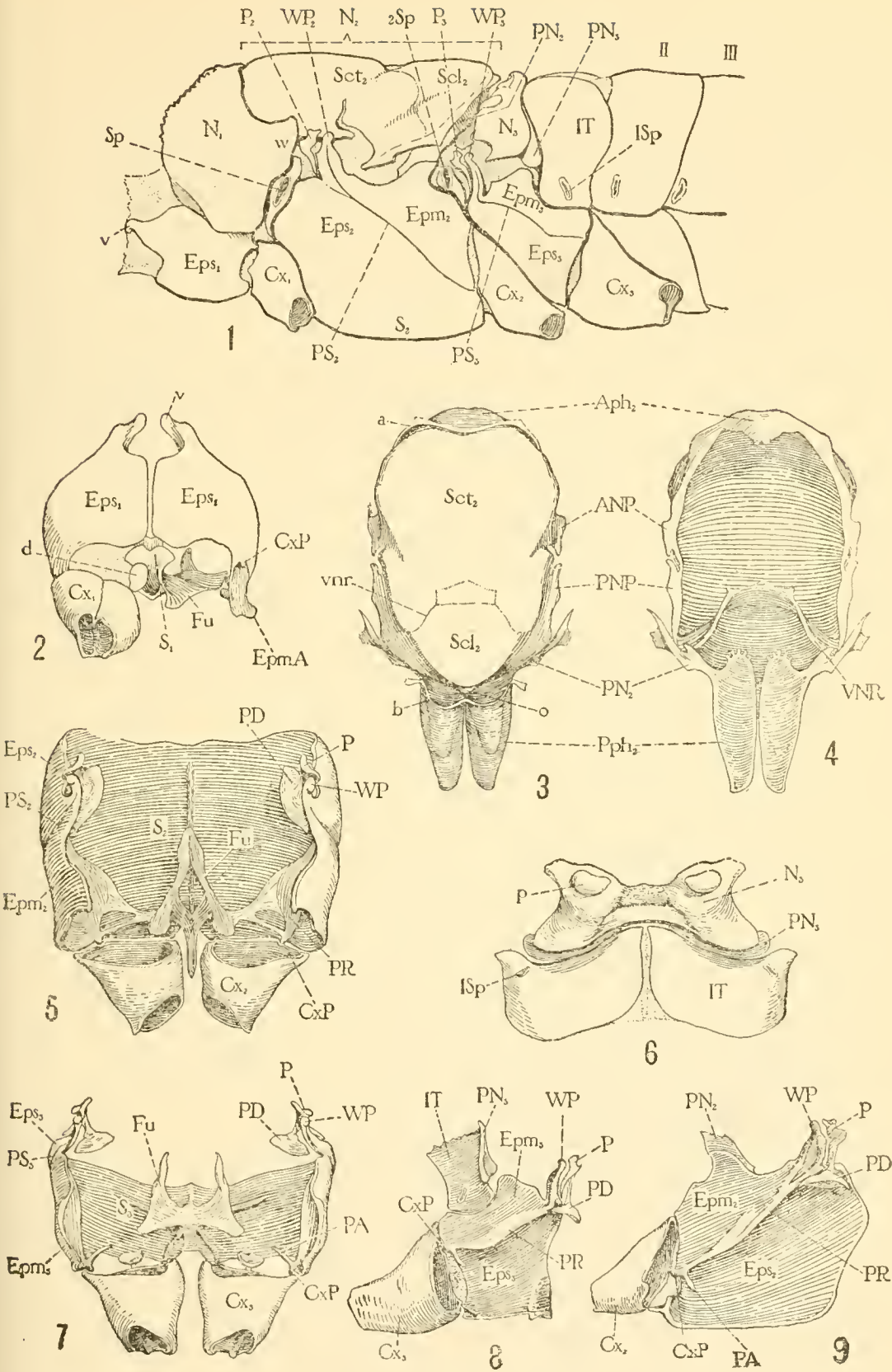
- Fig. 61. *Pepsis formosa* (Ceropalidæ, formerly Pompillidæ), thorax and base of abdomen.
62. *Pogonomyrmex transversum* (Formicidæ), thorax and base of abdomen.
63. *Apis mellifera* (Apidæ), thorax and base of abdomen.

PLATE 15.

- Fig. 64. *Itycorsia discolor* (Pamphiliidæ), base of front wing.
65. *Sirex flavicornis* (Siricidæ), base of anterior half of front wing.
66. *Tremex columba* (Siricidæ), base of front wing.
67. *Megarhyssa lunator* (Ichneumonidæ), base of first wing.
68. *Leucospis affinis* (Chalcidoidea), base of front wing.
69. *Pepsis*, sp. (Ceropalidæ), base of anterior half of front wing.
70. *Apis mellifera* (Apidæ), base of front wing.
71. *Tremex columba*, base of hind wing.
72. *Apis mellifera*, base of hind wing.
73. *Leucospis affinis*, base of hind wing.

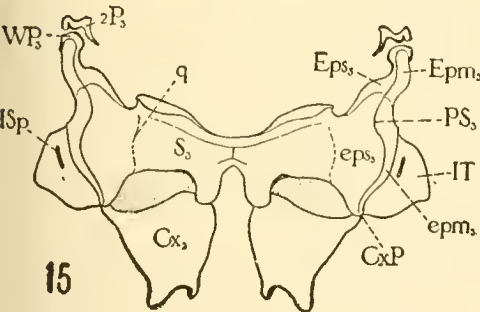
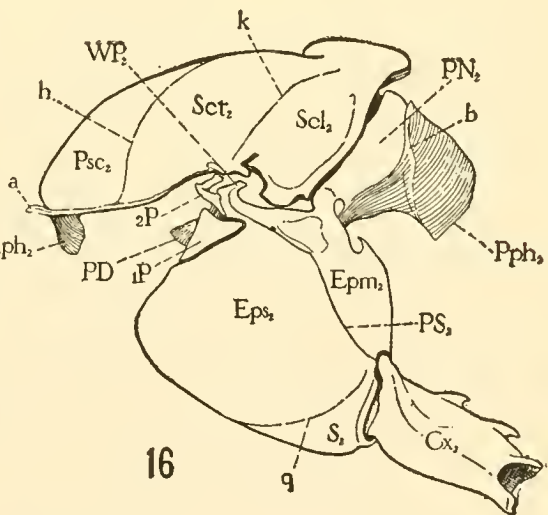
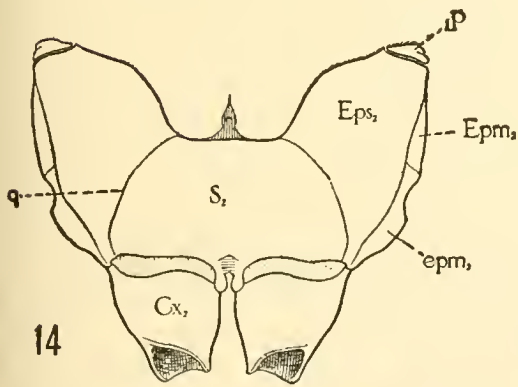
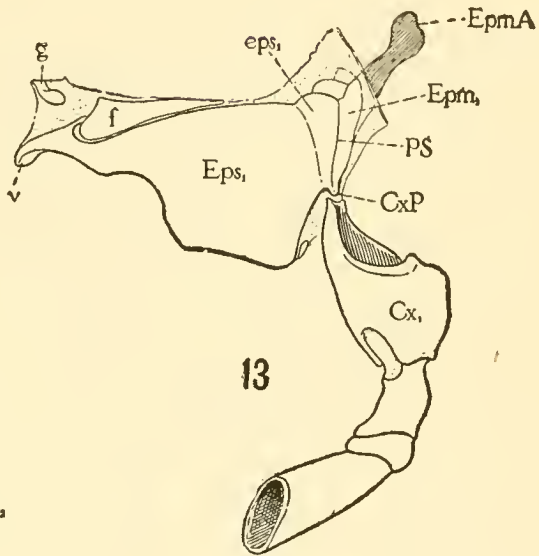
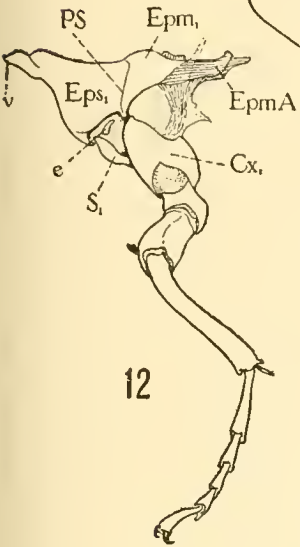
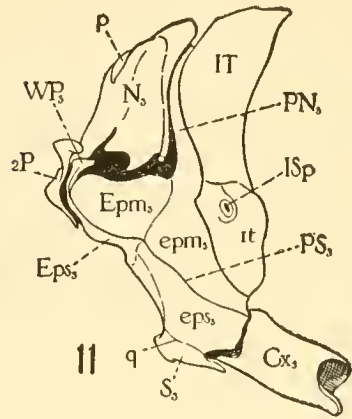
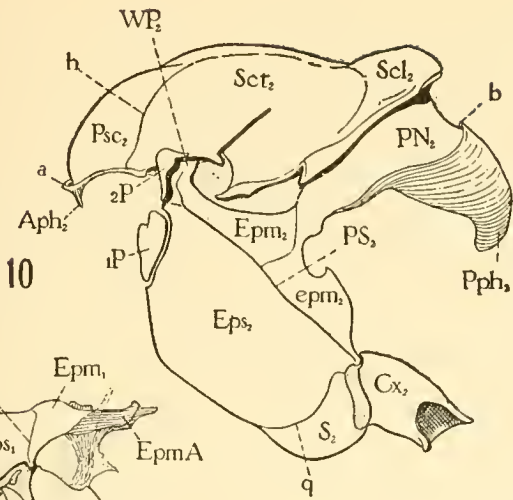
PLATE 16.

- Fig. 74. *Sirex flavicornis* (Siricidæ), front wing, veins named according to Comstock-Needham system.
75. The same, veins named according to Cressonian system.
76. *Megarhyssa lunator* (Ichneumonidæ), front wing.
77. *Leucospis affinis* (Chalcididæ), front wing.



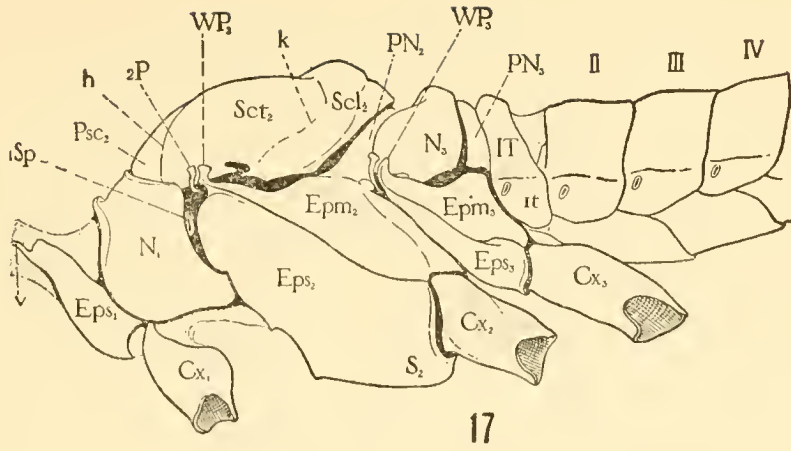
THORAX OF HYMENOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 89.

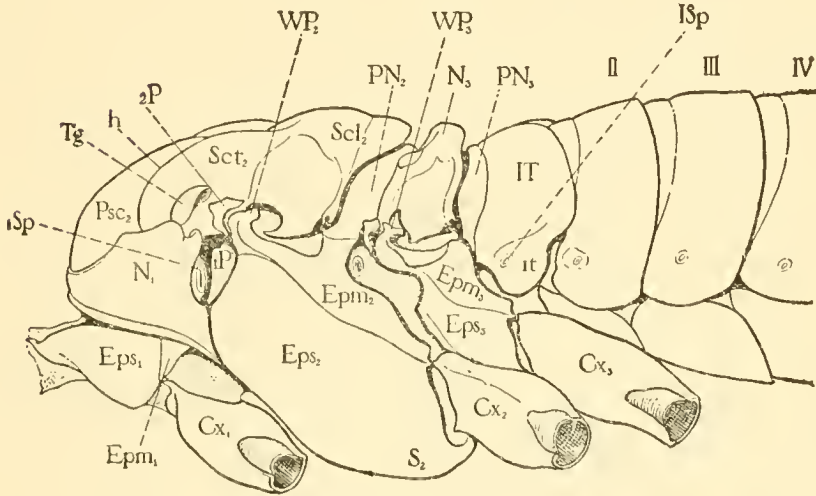


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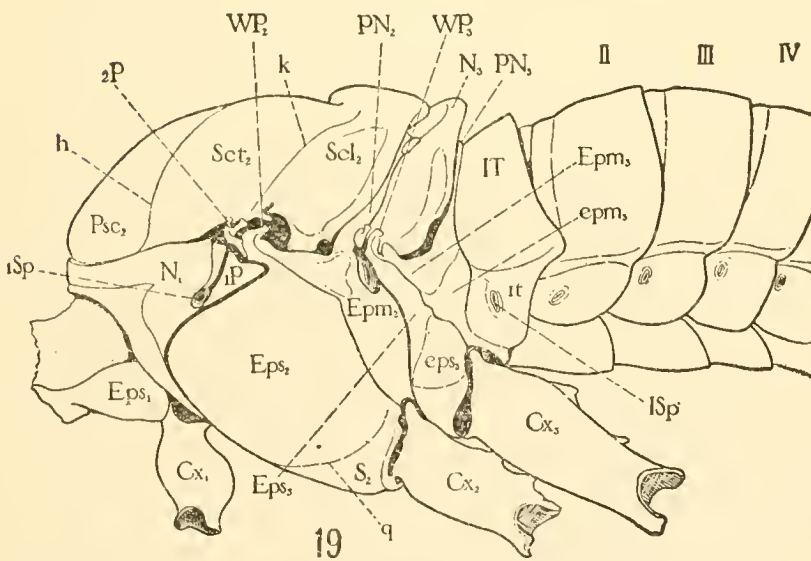
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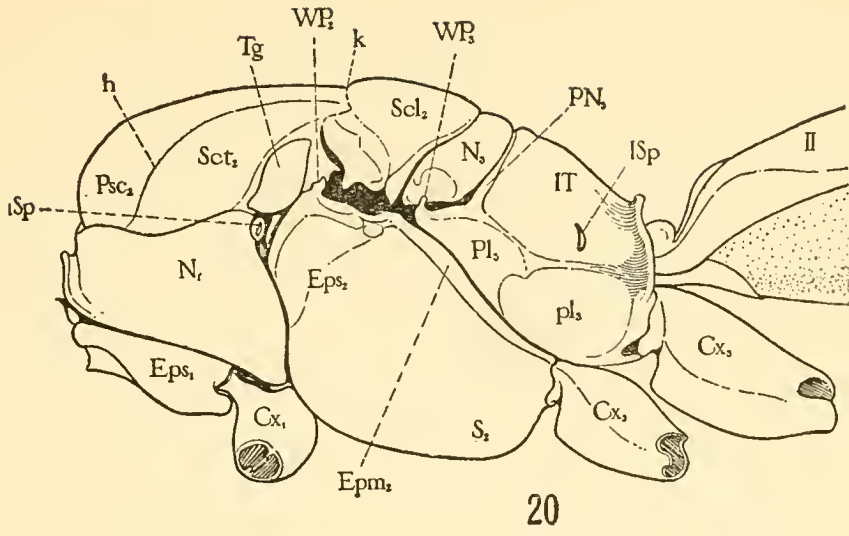
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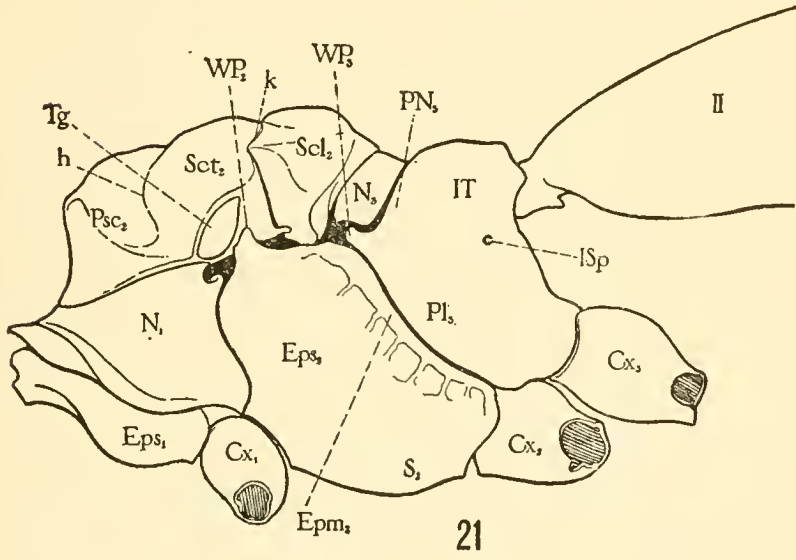
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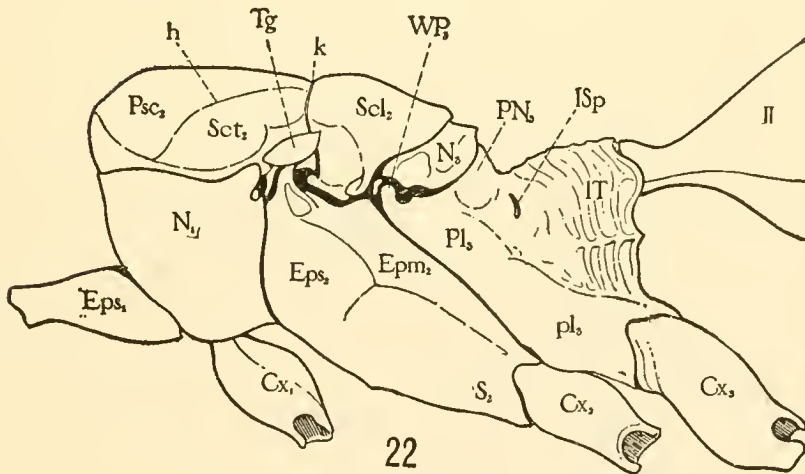
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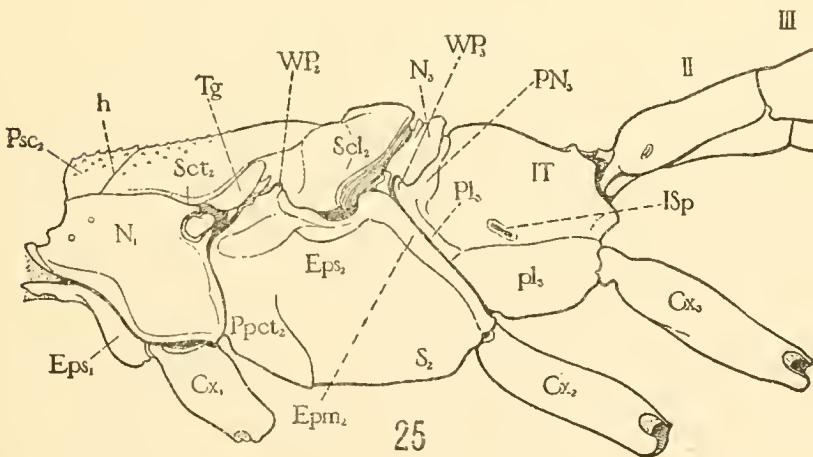
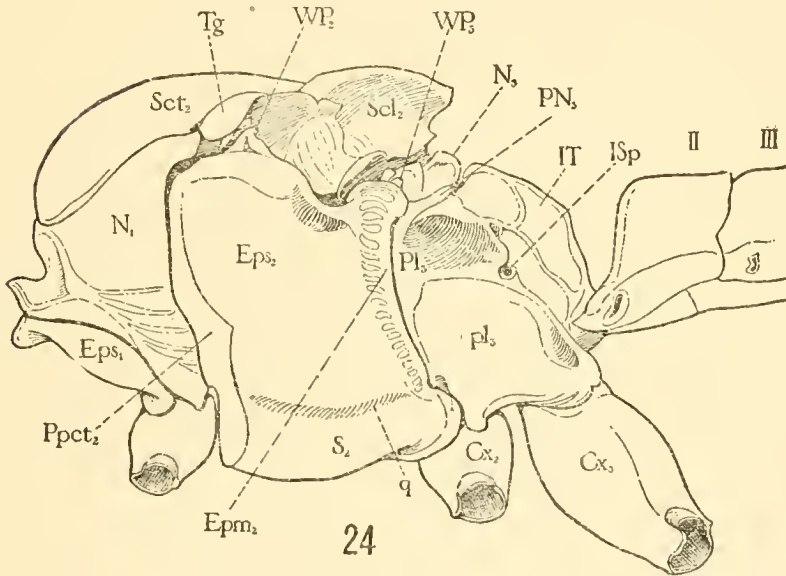
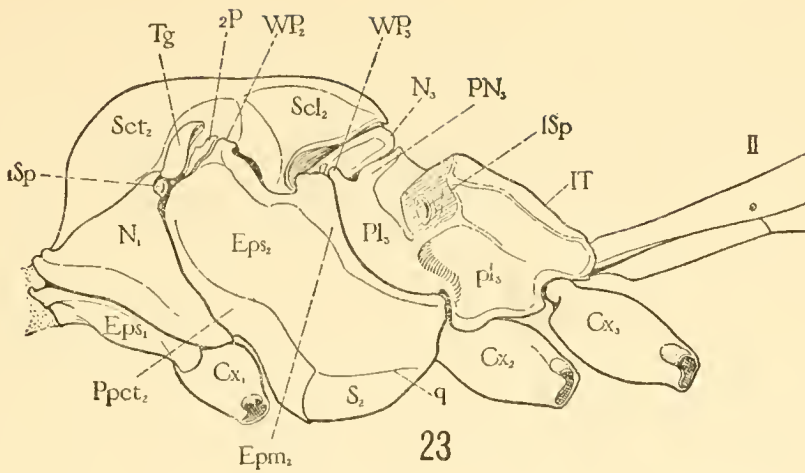
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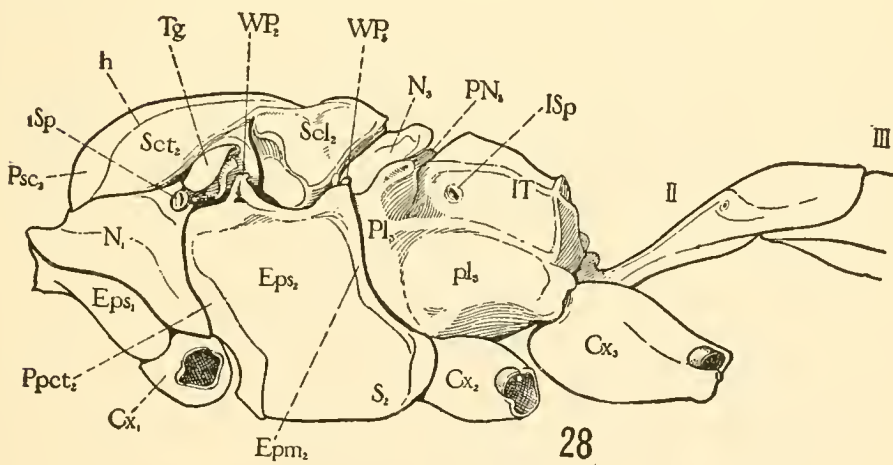
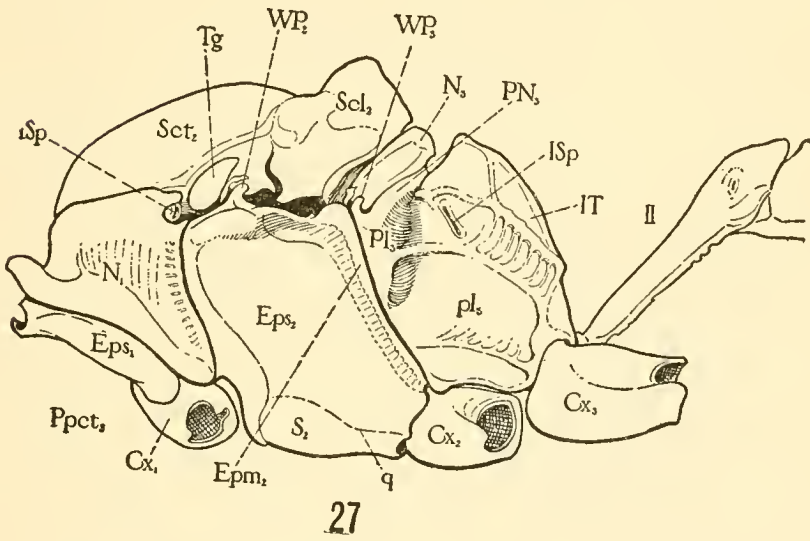
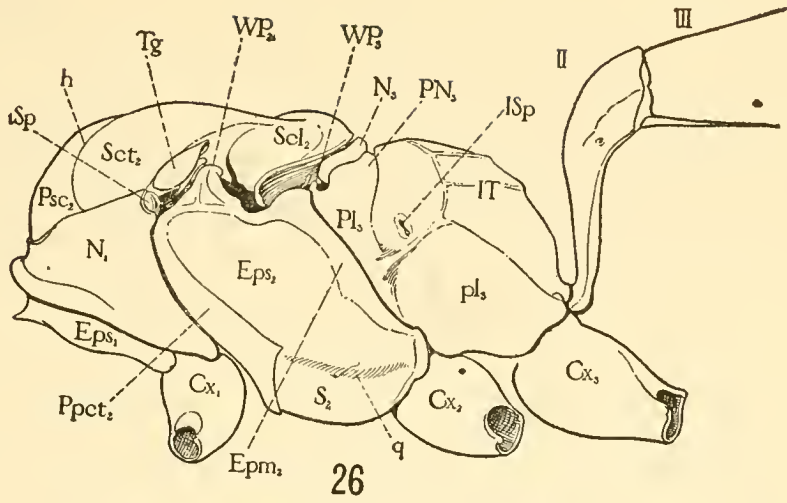
THORAX OF HYMENOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 89.



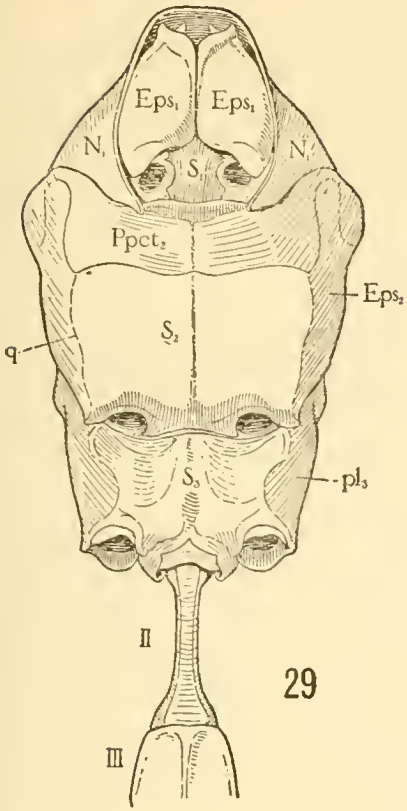
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FOR EXPLANATION OF PLATE SEE PAGE 89.

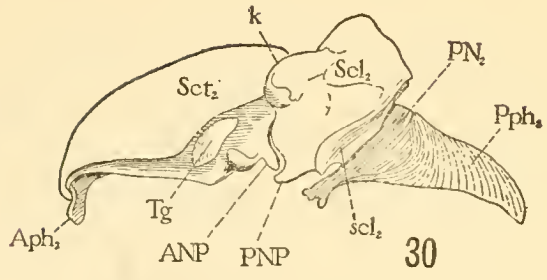


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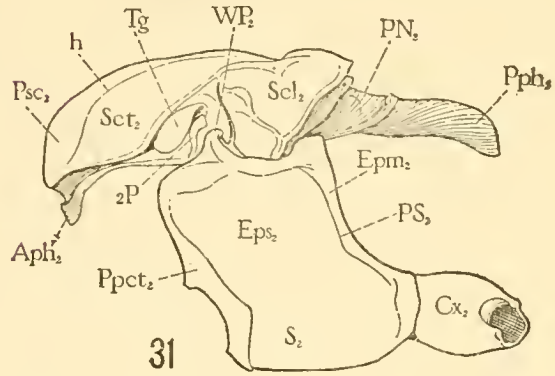
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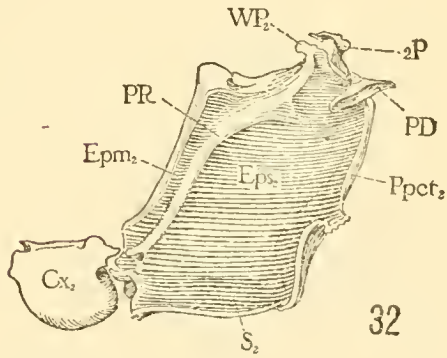
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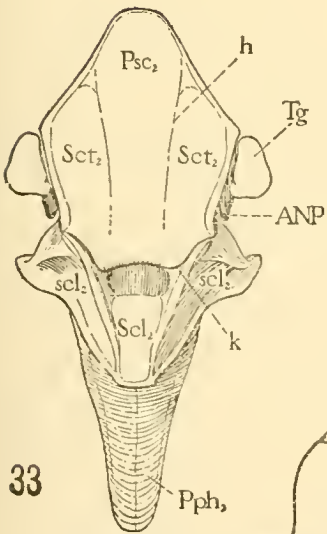
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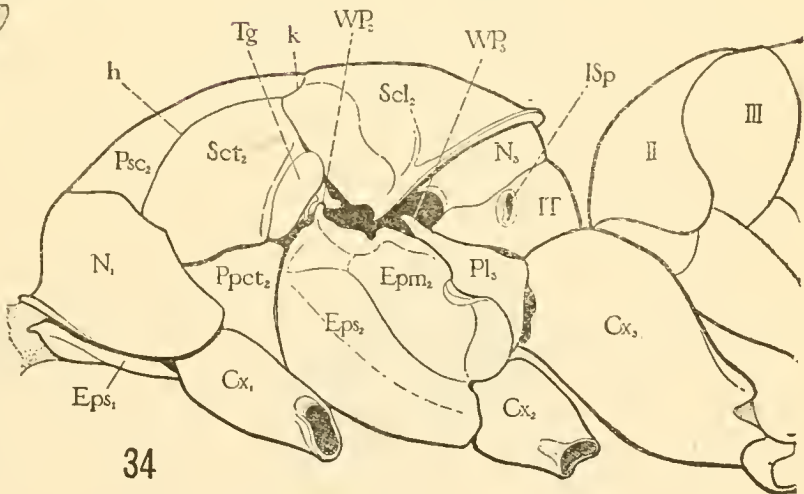
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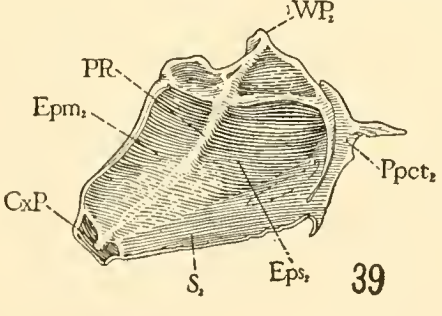
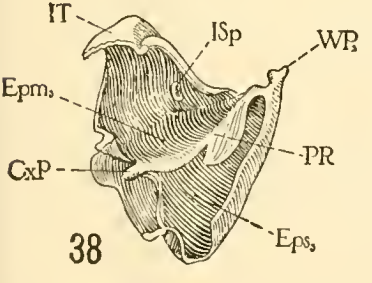
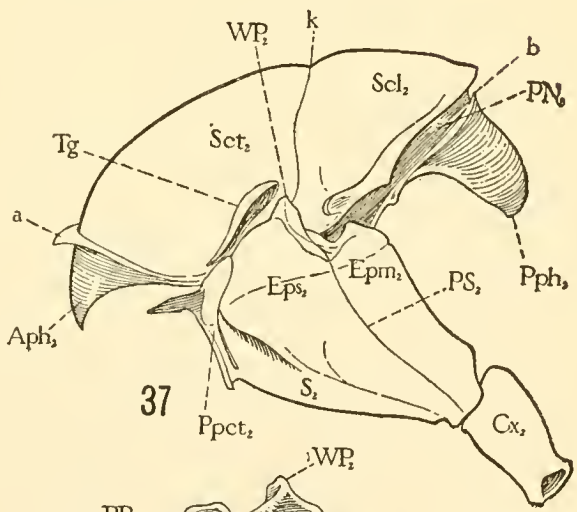
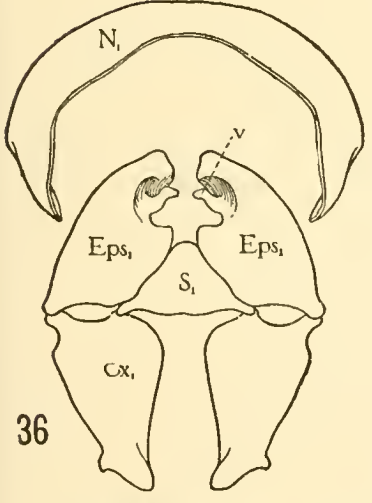
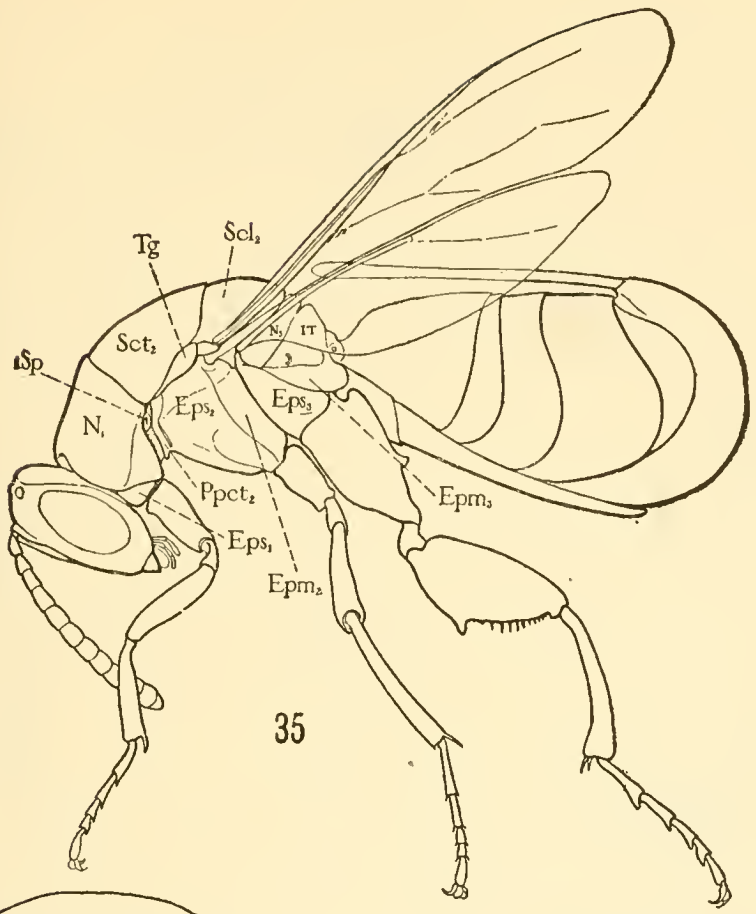
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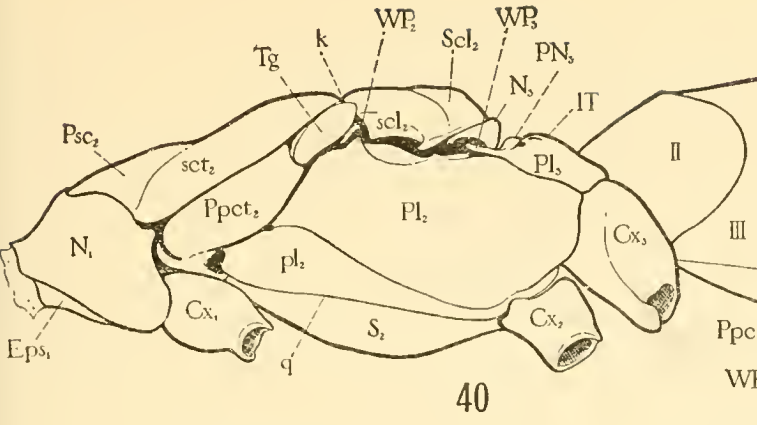
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FOR EXPLANATION OF PLATE SEE PAGE 90.

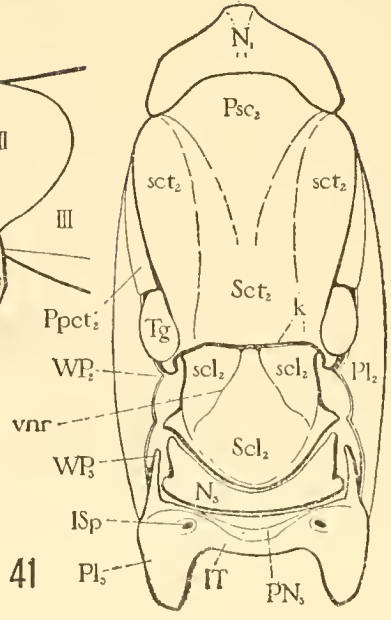


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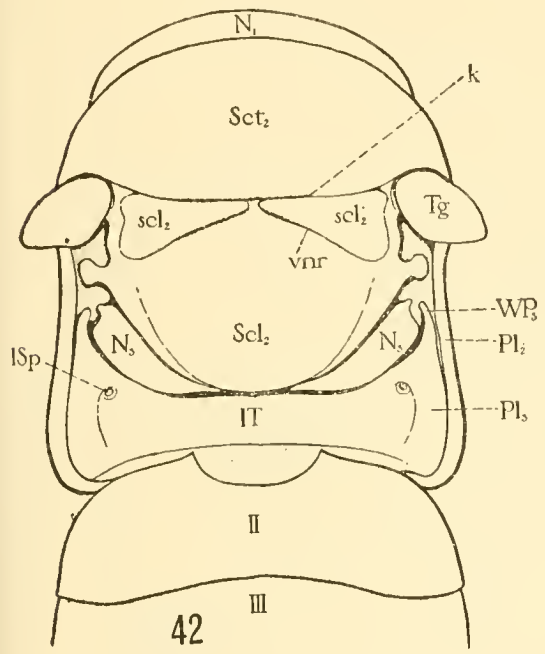
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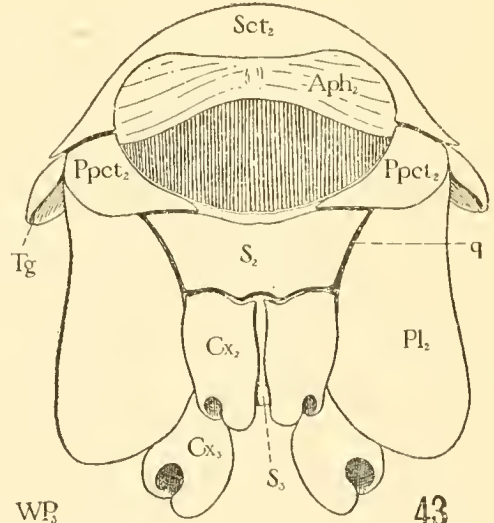
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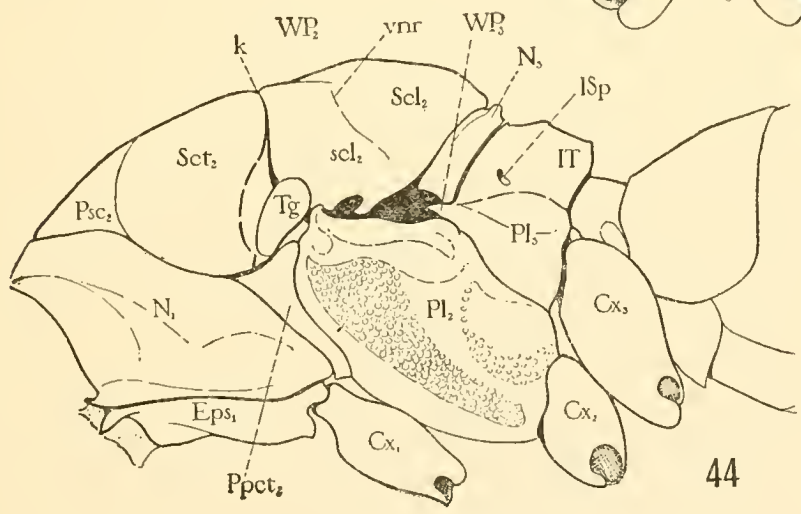
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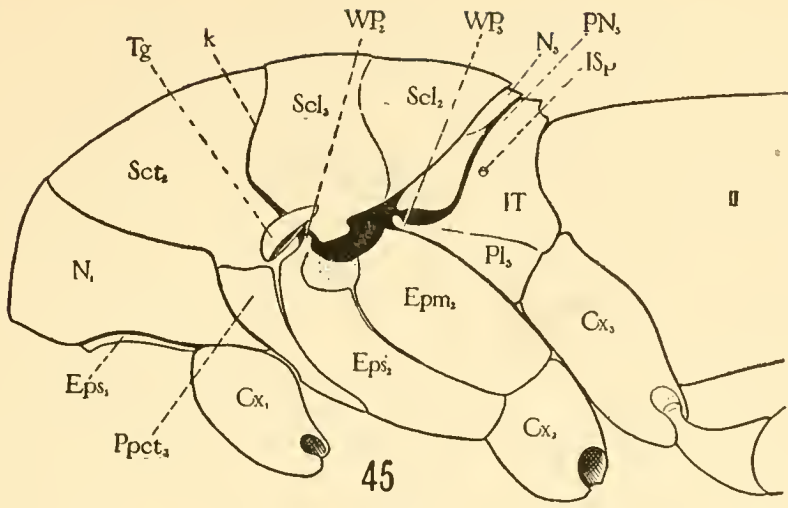
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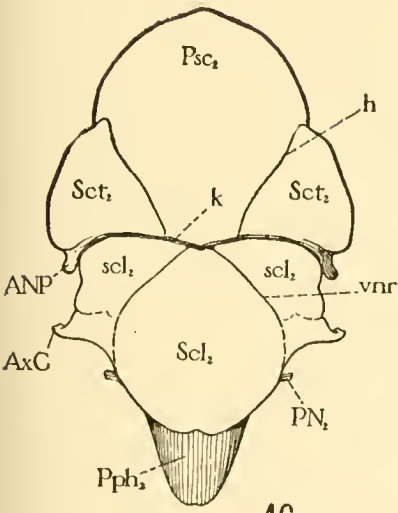
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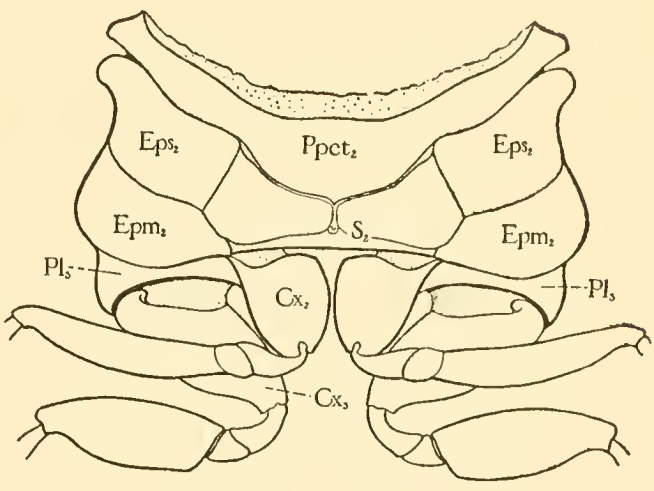
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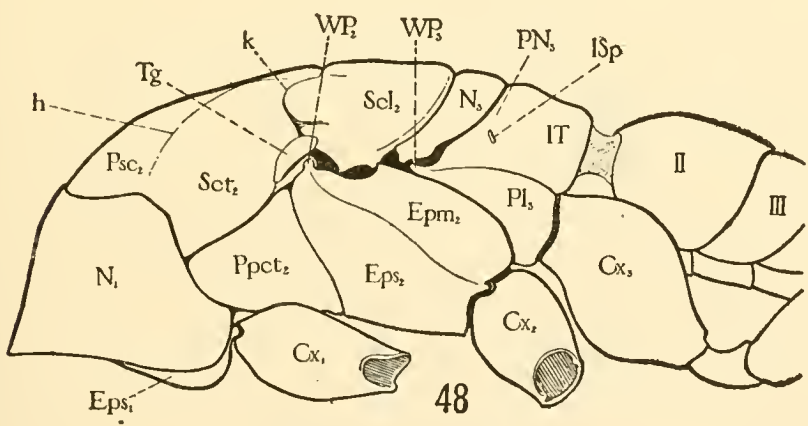
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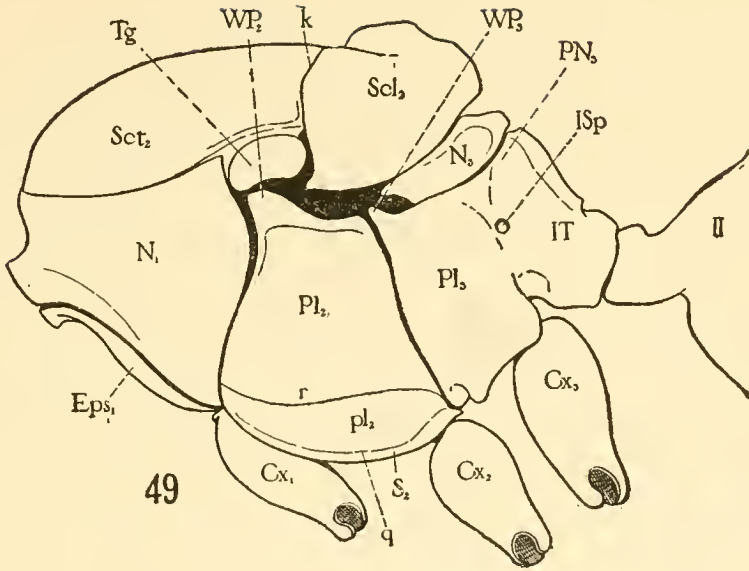
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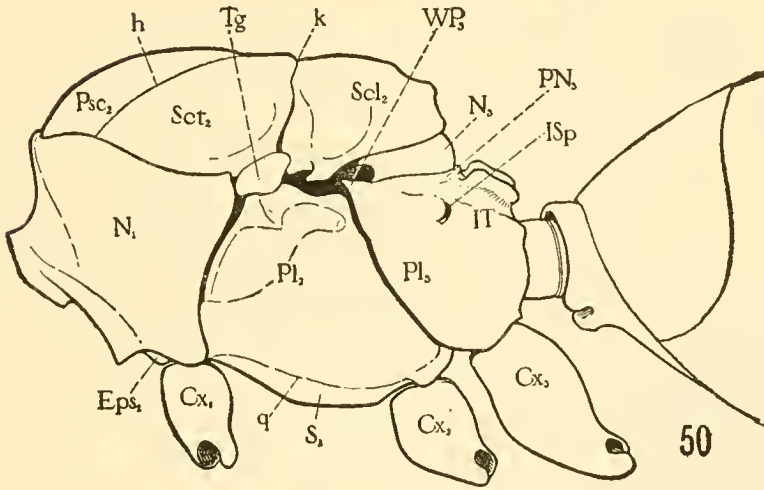
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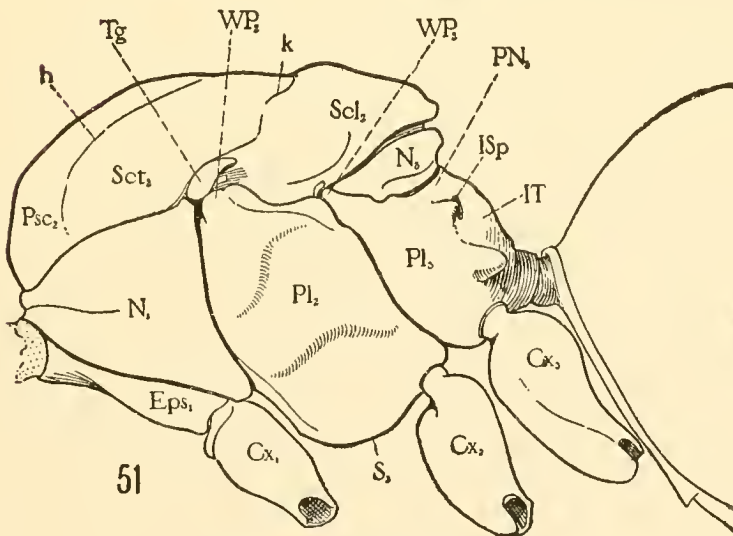
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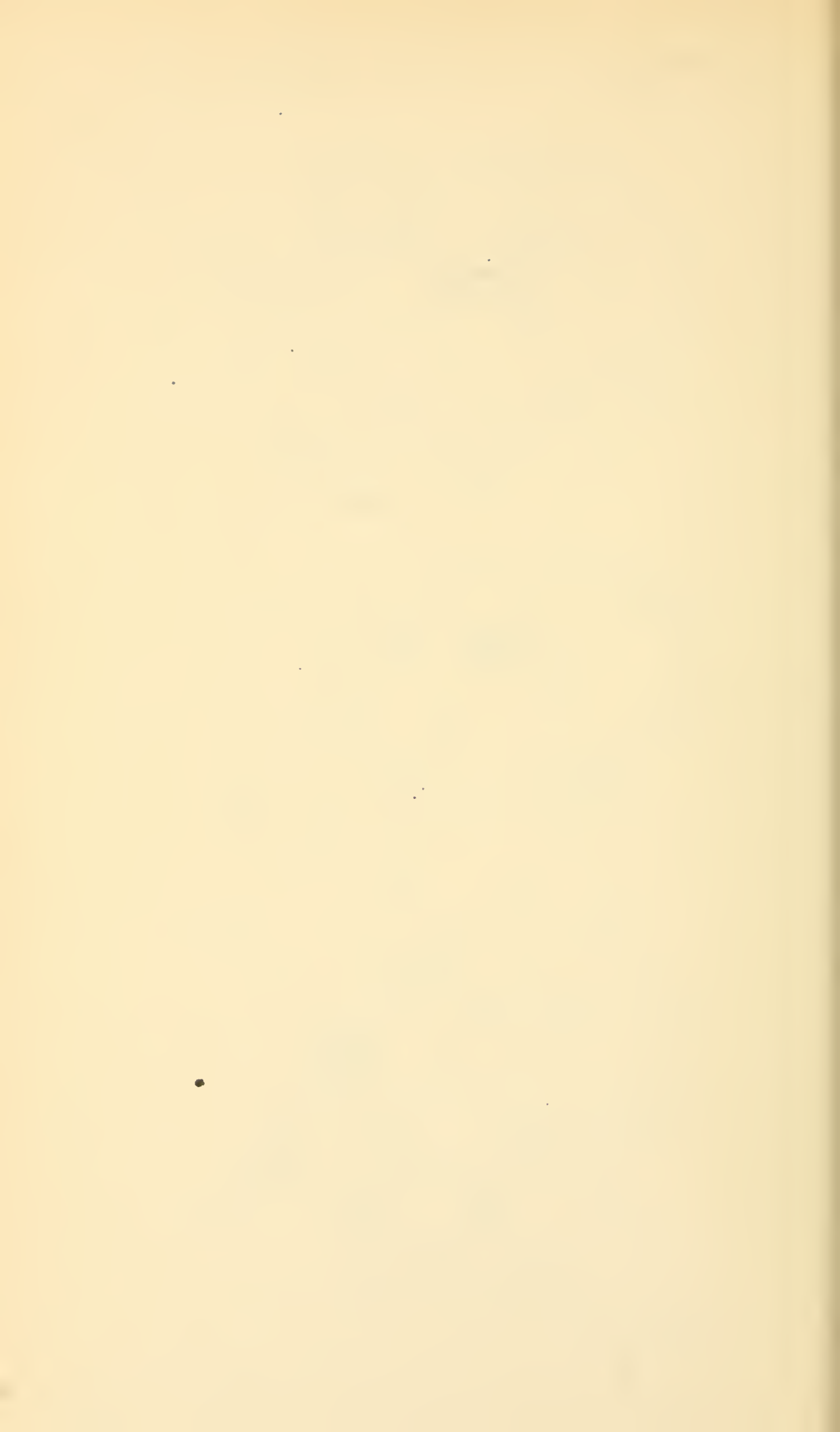
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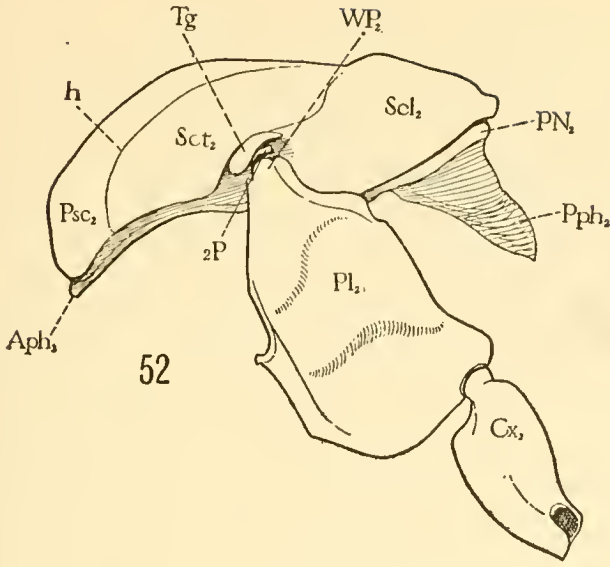


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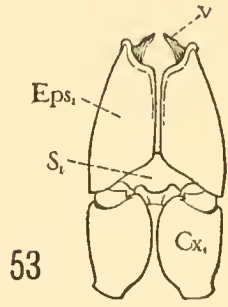
THORAX OF HYMENOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 90.

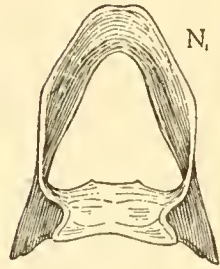




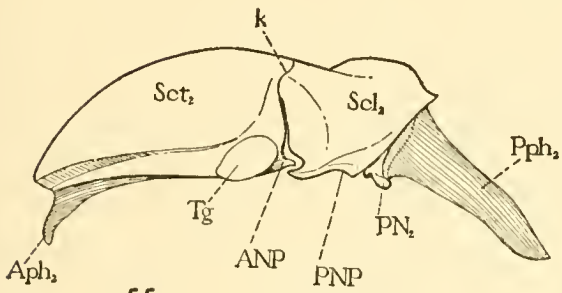
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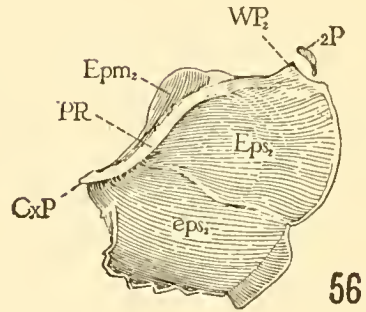
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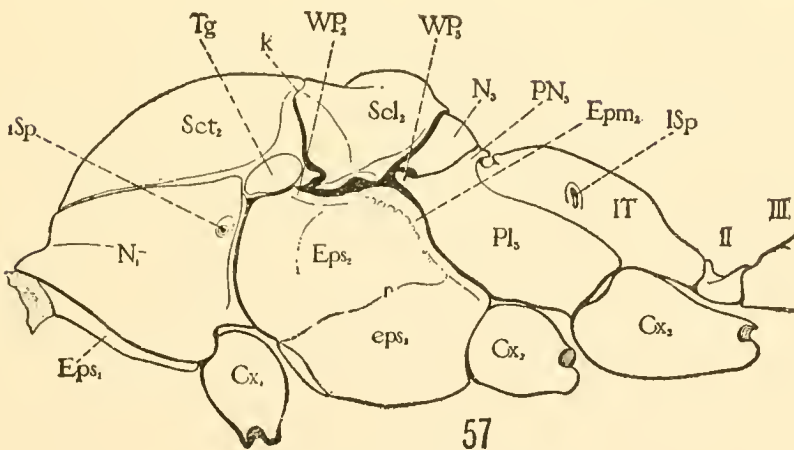
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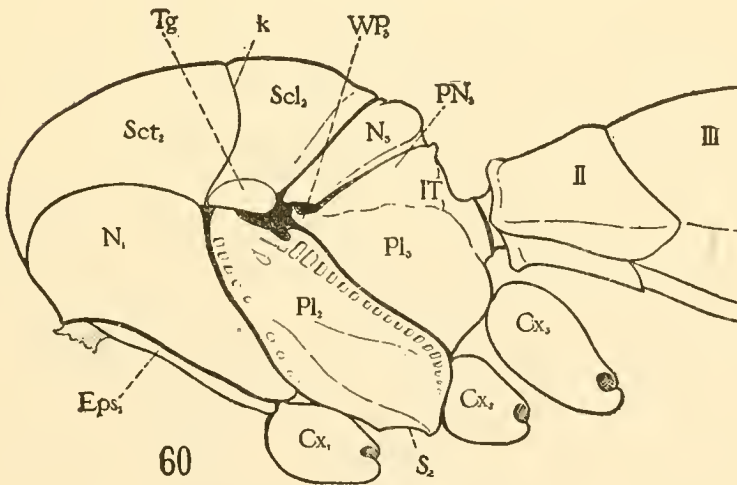
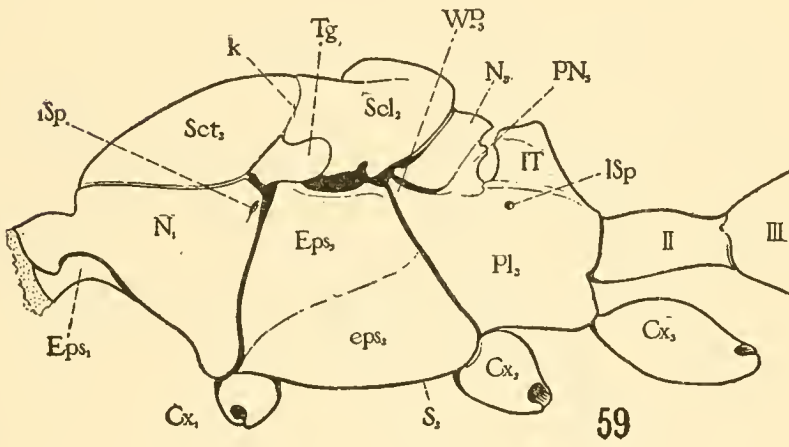
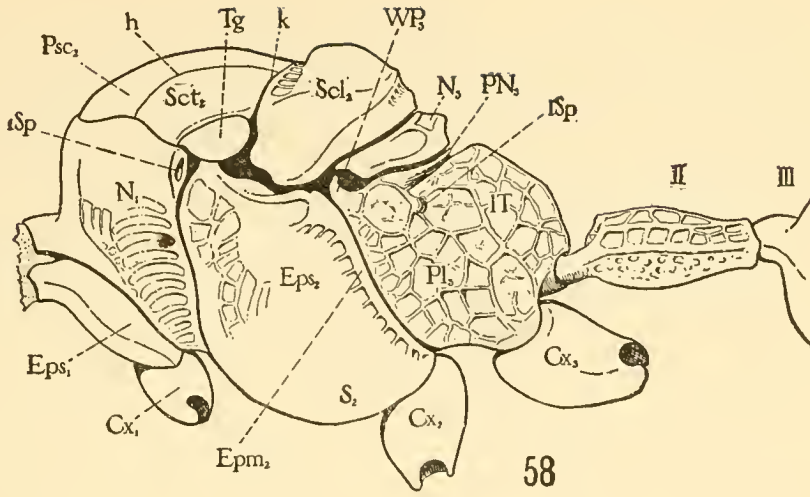
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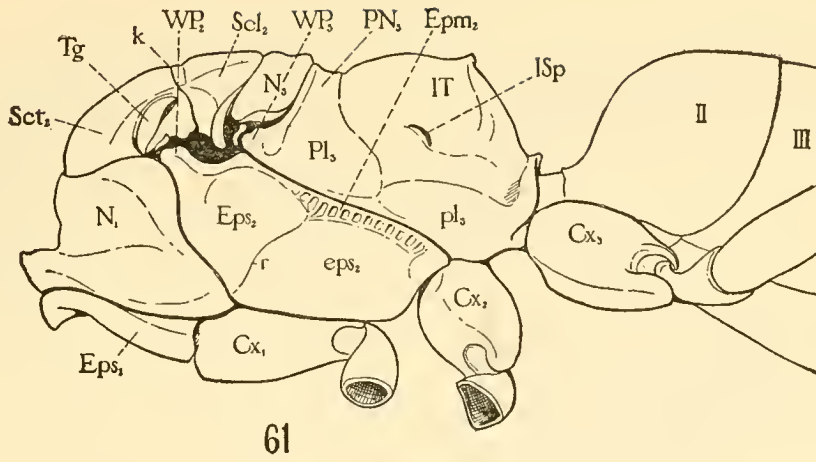
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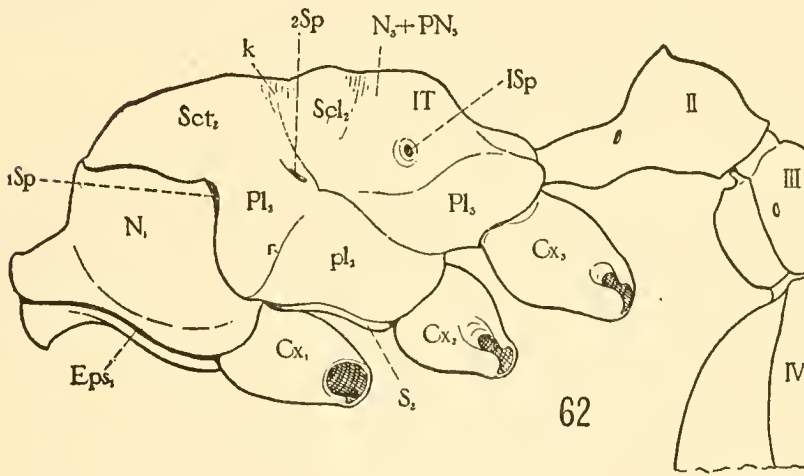
THORAX OF HYMENOPTERA.

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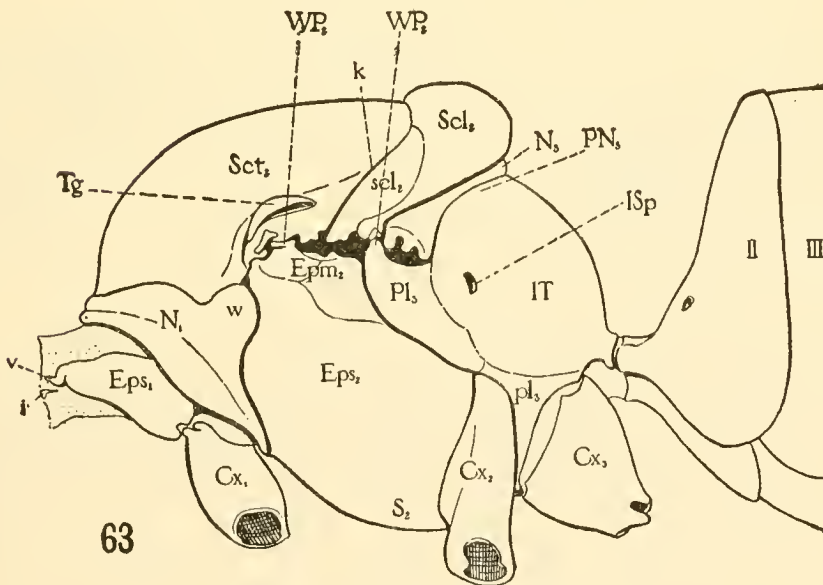




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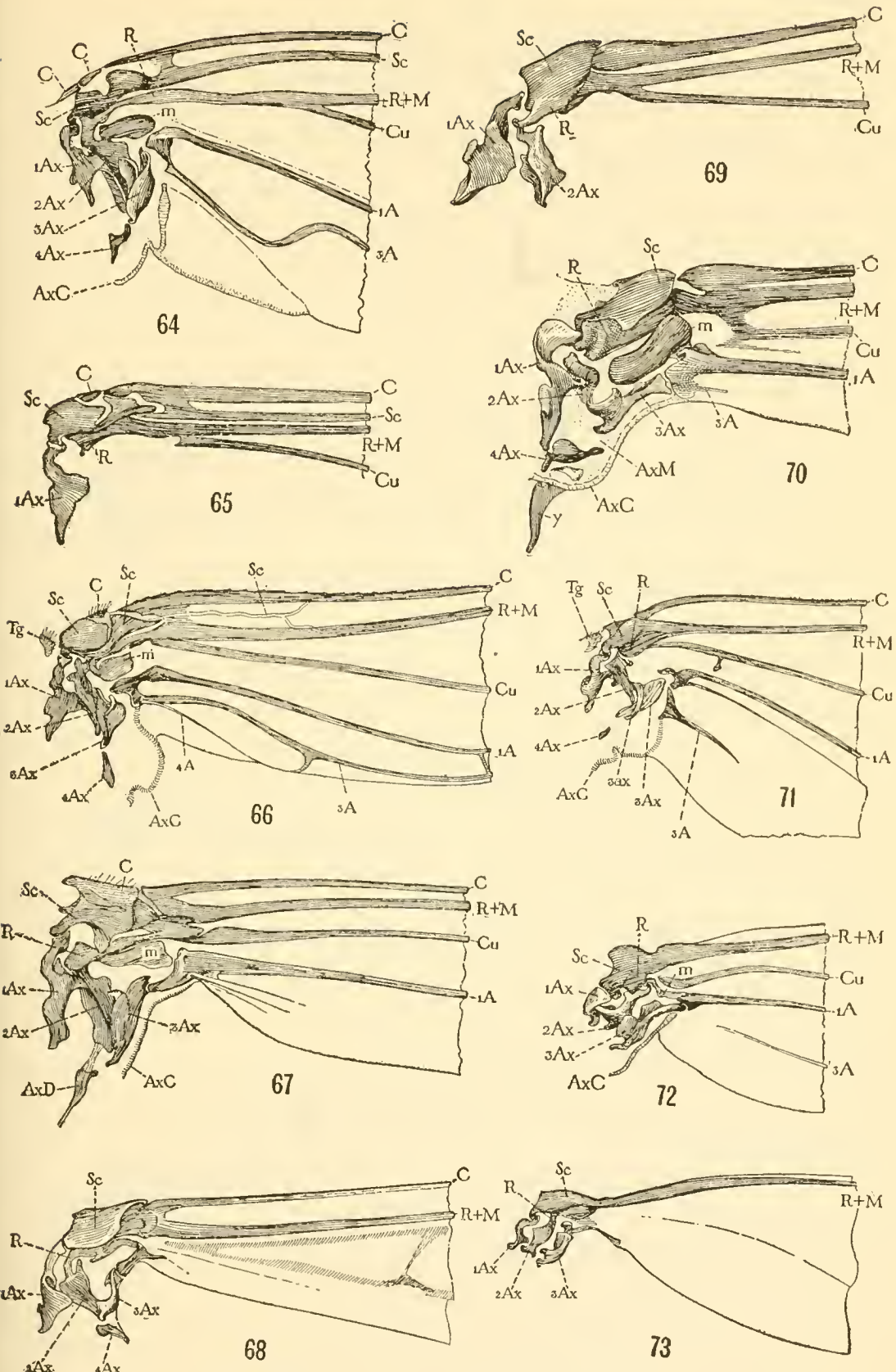
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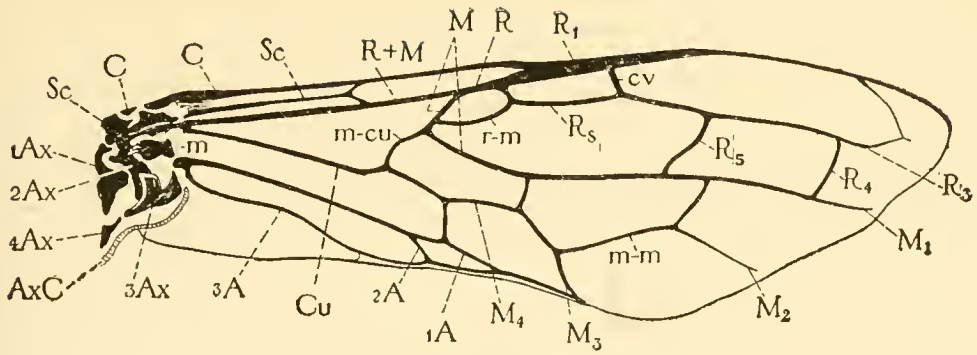
THORAX OF HYMENOPTERA.

FOR EXPLANATION OF PLATE SEE PAGE 91.

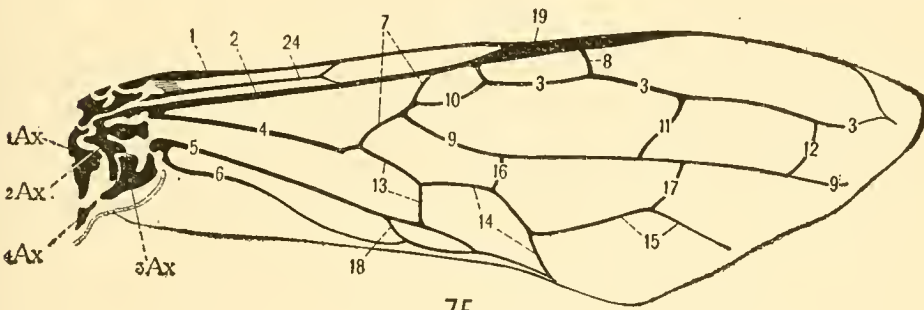


WING ARTICULATION OF HYMENOPTERA.

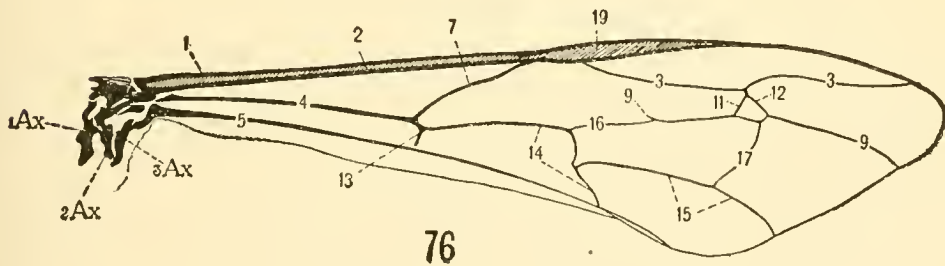
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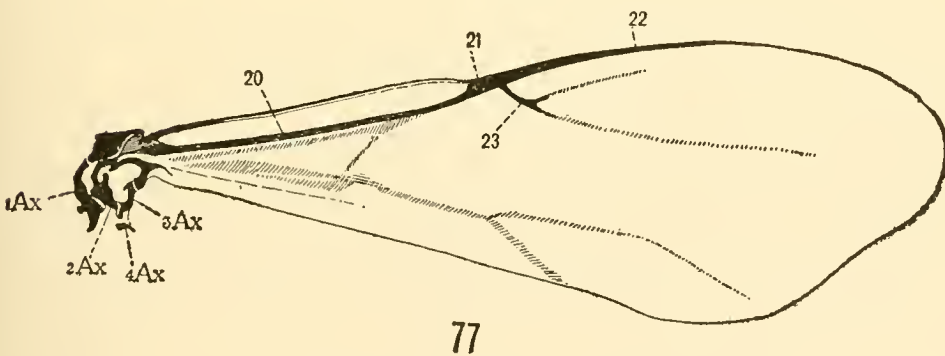
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VENATION OF HYMENOPTERA.
FOR EXPLANATION OF PLATE SEE PAGE 91.

TERRESTRIAL ISOPODS COLLECTED IN COSTA RICA BY
J. F. TRISTAN, WITH DESCRIPTIONS OF A NEW GENUS
AND SPECIES.

By HARRIET RICHARDSON,

Collaborator, Division of Marine Invertebrates, U. S. National Museum.

Among some isopods recently sent to the U. S. National Museum from Costa Rica by Prof. J. F. Tristan were twelve specimens representing a species belonging to a new genus of Armadillididæ. Two previously known species were also found.

COXOPODIAS, new genus.

Body oval, convex.

Eyes distinct, composite.

Second antennæ with a flagellum composed of two articles, the second being twice as long as the first.

Coxopodite of first thoracic segment extending the entire length of the lateral margin, cleft posteriorly, and separated from the segment by a longitudinal furrow; there is also a slight furrow on the dorsal surface of the segment close to the lateral margin. Coxopodites are present on the second and third segments of the thorax on the underside in the form of small, but conspicuous tooth-like processes.

Terminal abdominal segment triangular, with the apex acutely produced. Basal article of the uropoda large, obliquely quadrangular; inner branch about as long as the basal article; outer branch minute, inserted about the middle of the dorsal surface of the basal article.

This genus is close to *Ethelum* Budde-Lund, but differs in the possession of distinct coxopodites on the second and third thoracic segments, in the position of the outer branch of the uropoda, and in the possession of only two plumose processes on the inner lobe of the first maxillæ.

Genotype.—*Coxopodias tristani*, new species.

COXOPODIAS TRISTANI, new species.

Body ovate, very convex, capable of being rolled up into a ball. Color reddish brown, with a lateral band of light wavy lines on either side of the body; surface smooth.

Head wider than long, with the eyes small, round, composite, situated close to the lateral margin; anterior margin straight, the antero-lateral angles acute; front not margined.

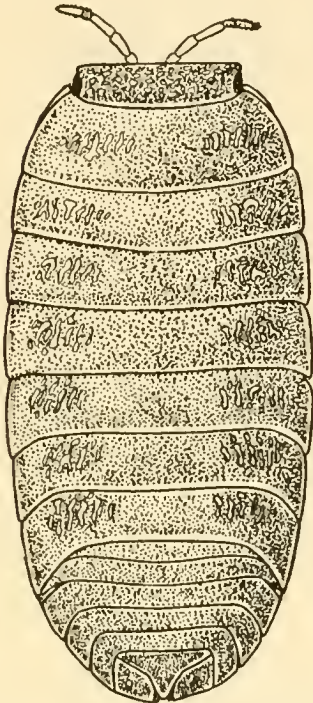


FIG. 1.—COXOPODIAS TRISTANI.

First antennæ rudimentary and inconspicuous; second antennæ with the first article short, the second twice as long as the first, the third about equal in length to the second, the fourth a little longer than the third, the fifth a little longer than the fourth; flagellum composed of two articles, the first of which is about half as long as the second.

First segment of the thorax the longest, about twice as long as the head. The epimeron or coxopodite extends the entire length of the

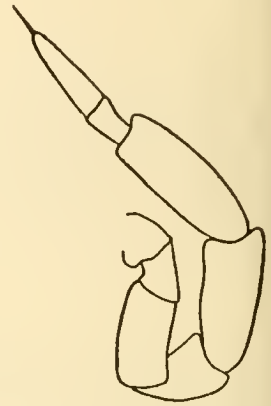


FIG. 2.—COXOPODIAS TRISTANI. SECOND ANTENNA.

lateral margin, separated from the segment by a longitudinal furrow; it is cleft posteriorly. There

is also a slight furrow on the dorsal side of the segment, close to the lateral margin. The second and third segments of the thorax are also furnished, on the underside, with small but conspicuous coxopodites in the form of tooth-like processes.

First five segments of the abdomen short and subequal (the first slightly shorter than the others); lateral parts of the first two covered by the seventh thoracic segment. The abdominal segments complete the oval outline of the body. Sixth or terminal



FIG. 3.—COXOPODIAS TRISTANI. FIRST THREE SEGMENTS OF THORAX (UNDERSIDE).

segment triangular with the apex produced in an acute process. Basal article of the uropoda obliquely quadrangular, occupying all the space between the sixth abdominal segment and the lateral parts of the fifth segment; the inner posterior angle extends a little beyond the apical process of the terminal abdominal segment. Inner branch of the

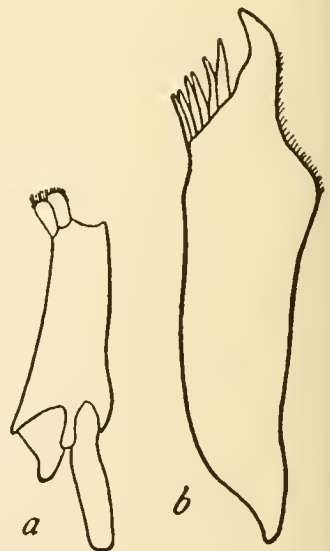


FIG. 4.—COXOPODIAS TRISTANI. FIRST MAXILLA. *a*, INNER LOBE; *b*, OUTER LOBE.

uropoda extends to the tip of the inner postero-lateral angle of the basal article; outer branch minute, situated about the middle of the dorsal surface of the basal article.

Twelve specimens of this species were collected by Prof. J. F. Tristan. The type was found on the road between Juan Viñas and Reventazon. The other specimens came from Turrialba.

Type.—Cat. No. 40896, U.S.N.M.

Named for the collector.

PHILOSCIA MUSCORUM (Scopoli).

Oniscus muscorum SCOPOLI, Entomologia Carniolica, 1763, p. 415.

Philoscia muscorum LATREILLE, Hist. Nat. Crust. Ins., vol. 7, 1804, p. 43; Gen. Crust. Ins., vol. 1, 1806, p. 69.—BUDDE-LUND, Crust. Isop. Terrestria, 1885, pp. 207-209. (See Budde-Lund for further synonymy).—G. O. SARS, Crust. Norway, vol. 2, 1899, pp. 173-174, pl. 76, fig. 1.

Localities.—Santa Maria Dota; road between Juan Viñas and Reventazon, Costa Rica.

Distribution.—Denmark, Germany, Holland, Poland, Austria, Great Britain, France, Spain, Italy, Algeria, and Woods Hole, Massachusetts, U. S. A.

METOPONORTHUS PRUINOSUS (Brandt).

Porcellio pruinosus BRANDT, Bull. Soc. Imp. Naturalistes de Moscou, vol. 6, 1833, p. 19.

Metoponorthus pruinosus BUDDE-LUND, Crust. Isop. Terrestria, 1885, pp. 169-171. (See Budde-Lund for further synonymy).—G. O. SARS, Crust. Norway, vol. 2, 1899, pp. 184-185, pl. 80, fig. 2.

Locality.—Turrubales, Costa Rica.

Distribution.—World wide.

A NEW SCINCID LIZARD FROM THE PHILIPPINE ISLANDS.

By LEONHARD STEJNEGER.

Curator, Division of Reptiles and Batrachians, U. S. National Museum.

A small collection of reptiles recently received from Maj. J. M. T. Partello, U. S. Army, contained several interesting specimens, among them a strikingly conspicuous *Tropidophorus*, which represents a hitherto undescribed species, and which I take great pleasure in dedicating to its discoverer in recognition of his valuable contributions to our knowledge of the fauna of Mindanao.

TROPIDOPHORUS PARTELLOI, new species.

Diagnosis.—Dorsals strongly keeled; fronto-parietals distinct; a single large preanal; fifth and sixth supralabials largest and entering orbit; scales on dorsal and lateral sides of tail forming large erect spines not arranged in whorls or series.

Habitat.—Mindanao, Philippine Islands.

Type-specimen.—Cat. No. 39308, U.S.N.M.; Mataling River Falls, 1,400 feet altitude, Cotabato Province, western Mindanao; December 12, 1908; Maj. J. M. T. Partello, U. S. Army, collector.

Description of type-specimen.—Adult male. Upper head shields smooth; fronto-nasal broader than long; prefrontals broadly in contact; frontal as long as fronto-parietals and interparietal together, in contact with two anterior supraoculars; five supraoculars, first longest, fifth smallest, second in contact with fronto-parietal; two anterior supraciliaries larger, followed by five very small ones, none behind the suture between third and fourth supraocular; fronto-parietals separate, shorter than interparietal; parietals not in contact behind interparietal; nostril a round hole in the middle of a single nasal, which is followed by two loreals, one behind the other; behind the orbit three vertical rows of small scales followed by two rows of large temporal shields; between these and the unprotected ear-opening several rows of scales keeled vertically; seven supralabials, the anterior four low and slightly increasing in size backward, the fifth suddenly much higher, but not much wider, sixth and seventh nearly as large; fifth supralabial under the center of the eye, sixth just touching the orbit anteriorly, and both separated from the orbital scales by a single row of small scales, smaller than the posterior supracilia-

ries; four lower labials, first very small, second and third excessively elongate, together nearly as long as five supralabials; a large unpaired postmental followed by three pairs of large submandibulars, the two anterior pairs of which are in contact on the middle line; ear-opening oval, slightly smaller than eye-opening; 32 scales around the middle of the body; nine dorsals in the shielded part of the head; dorsals and laterals strongly keeled and on the posterior half of the body strongly mucronate, the keels of the dorsals forming six straight lines on the back, the laterals forming numerous oblique lines converging toward the sacrum; ventrals smooth, much smaller than dorsals, about fifteen in a head length; a single very large preanal plate; legs covered above with strongly keeled and mucronate scales; third finger nearly as long as fourth; subdigital lamellæ smooth, 24 under the fourth toe; extended hind leg reaches beyond the elbow; tail slightly compressed with six series of very strong mucronate keels at base, this arrangement soon giving way to a mass of high, nearly vertical spines, each one occupying the whole scale, and all nearly the same size, there being no pronounced serial nor verticillate arrangement; tail underneath with a series of smooth, wide plates, on each side with a single series of mucronate scales; length of tail not one and one-half the length of body. Color (in alcohol) above vandyke-brown, more sooty on the sides, with about eight irregular and more or less interrupted, narrow, pale cross bars; tail with indications of similar pale cross bars; fingers and toes with very distinct cross bars of dark and pale brown of about equal width; head above and on sides uniform glossy brown; throat and lower neck more grayish brown, a narrow pale line crossing the commissure from the third supralabial and another from the fifth across the submandibulars to the throat; underside of abdomen, legs, and basal portion of tail pale, the terminal two-thirds dark brown like the upper side; scale-row nearest subcaudals pale, forming a pale line on more than basal half of tail.

Dimensions.

	<i>mm.</i>
Total length (tip of tail regenerated).....	212
Tip of snout to vent.....	105
Tip of snout to ear-opening.....	25
Width of head.....	19
Vent to tip of tail (regenerated).....	107
Fore leg.....	34
Hind leg.....	46

Remarks.—The most striking feature of this interesting species is the extraordinary spiny tail. The spines, 2 to 2.5 mm. high and very pointed, stand out in all directions, presenting a most formidable appearance, only second to the highly prickly armature of the upper side of the hind legs. This feature alone will distinguish the species from all others hitherto known.

JAPANESE SAWFLIES IN THE COLLECTION OF THE UNITED STATES NATIONAL MUSEUM.

By S. A. ROHWER.

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In connection with work on Nearctic Tenthredinoidea it has been deemed advisable to study the faunæ of the world, and more especially that of the Palæarctic region, to obtain a more perfect knowledge of the genera and to become better acquainted with the work of other writers on these insects. In these days of fast steamship connection between the different countries the possibility of introducing foreign insects into this country is much greater than in former times. A conspicuous example of this has already been observed—when *Nesodiprion* (olim *Lophyrus*) *japonicus* (Marlatt) came to the port of San Francisco on a Japanese pine in 1902.

The following paper is a partial result of the study of the collection of sawflies from Japan in the United States National Museum. The material has been presented by Mr. T. Tukai, Mr. A. Koebele, and Doctor Matsumura, and part is thought to belong to a collection sent by Dr. K. Mitsukuri.

The list of species which follows is believed to be complete. All synonyms are omitted. When the species is unknown in nature, the the generic position given is usually that assigned by Konow.

Family XYELIDÆ.

XYELA JAPONICA, new species.

Differs from the European *Xyela julii* (Brébisson) as determined by Konow as follows: The clypeus has a small rounded tubercle in the middle and is more coarsely sculptured; antennal furrows are wanting near the ocelli and on the front; the postocellar line is less than the ocelloccipital line; the head is darker, and the mesonotum coriaceous.

Female.—Length of body, 3 mm.; length of ovipositor, 1.25 mm.; length of anterior wing, 3.5 mm. Head as wide as the length of the second and third antennal joints, occiput convex; antennal furrows wanting; postocellar area not defined; the postocellar line shorter

than the ocelloccipital line; head and mesonotum coriaceous; stigma a little more than twice as long as wide; venation much the same as *julii*; sheath obliquely truncate from top to venter. Black; legs entirely reddish-brown; antennæ and tegulæ piceous; wings hyaline, vitreous; venation, including stigma, pallid translucent.

Type-locality.—Hakone, Japan. One female collected by Mr. A. Koebele.

Type.—Cat. No. 7303, U.S.N.M.

XYELA VARIEGATA, new species.

May be known from *Xyela julii* (Brébisson), as determined by Konow, in the slender spines on the four posterior tibiæ, the absence of the postocellar furrow, the sheath not narrowing below, and the paler color.

Female.—Length, 3 mm.; length of ovipositor, 1.25 mm.; length of anterior wing, 3.75 mm. Clypeus longer in the middle and slightly lobed, no carina or tubercle; head about the same width as the length of the second and third antennal joints; occiput convex; antennal furrows wanting; middle fovea faintly indicated; anterior ocellus in a faint depression; postocellar line longer than the ocelloccipital line; head and mesonotum shining and not sculptured when magnified 35×; scutellum granular; stigma broadest near the middle and hardly twice as long as wide; venation similar to *julii*; sheath straight below, gently rounded to the apex above. Black and pale yellow; head, except the postocellar area and two lateral spots on vertex, yellowish; thorax piceous with spots on lateral lobes, pleuræ and pectus pale yellow; abdomen, except above, yellowish; legs, antennæ, and sheath pale yellow; wings hyaline, vitreous; venation, including stigma, pallid-translucent.

The paratypes are slightly smaller and in some the pale markings are reddish-yellow.

Type-locality.—Hakone, Japan. Four females collected by Mr. A. Koebele.

Type.—Cat. No. 7304, U.S.N.M.

The shape of the sheath, greater length of the postocellar line, shining head, and mesopleuræ will separate this from *Xyela japonica*.

Family PAMPHILIIDÆ [olim Lydidæ].

CEPHALEIA (CEPHALEIA) NIGROCÆRULEA, new species.

Blue-black; scape, a triangular spot between antennæ and legs pale yellow; below supraorbital line punctured.

Female.—Length 11 mm. Head below supraorbital line, except impunctate areas between antennæ and orbits, covered with large sometimes confluent punctures; behind the supraorbital line shining, and with a few scattered punctures; antennal furrows wanting; postocellar furrow wanting; postocellar area narrowing towards the occi-

put, and on the supraorbital line wider than the length of the postocellar line; third antennal joint about as long as the three following ones united; mesonotum with fine close punctures except along the sutures and apex of scutellum where the punctures are much larger; abdomen finely, transversely, lineolate, reticulate; last ventral plates granular. Blue-black; scape, mandibles, triangular spot from apex of clypeus to between antennæ, tegulæ, and legs below coxæ pale yellow. Wings dusky hyaline; venation black.

Type-locality.—Japan. One female with the following figures on the label: 28, 5, 9, 29.

Type.—Cat. No. 13314, U.S.N.M.

CEPHALEIA (CEPHALEIA) KOEBELEI, new species.

Will come in the group which the Nearctic *Cephaleia fascipennis* (Cresson) belongs, but differs from that species by the emarginate seventh ventral segment, smaller size, and black abdomen.

Male.—Length about 10 mm. Lateral supraclypeal areas polished, impunctate; head below the ocelli granular; clypeus and head behind the ocelli with separate distinct punctures; postgenal area with a carina posteriorly; first joint of the flagel slightly longer than the second and third combined; anterior lobe of the mesonotum shining, impunctate; lateral lobes of the mesonotum with distinct, separate punctures; seventh ventral segment broadly, semicircularly emarginate; hypopygidium narrowed apically and at the apex depressed. Black; clypeus and lateral supraclypeal area pale yellow; antennæ, legs, except a black spot at base above of four anterior femora and all the coxæ, apical margins of all the ventral segments reddish-yellow. Wings hyaline, behind the middle of the stigma dusky and with a faint tendency to a band below the stigma; venation brown.

Type-locality.—Japan. One male collected by Mr. A. Koebele.

Type.—Cat. No. 13313, U.S.N.M.

PAMPILIUS (ANOPLYLYDA) LUCIDUS, new species.

A distinct species, easily recognized by the concolorous, black abdomen, shining appearance, vitreous wings, and absence of distinct sculpturing.

Female.—Length 10.5 mm. Frontal carina, distinct but not sharp, extending to apex of clypeus; entire insect shining and impunctate; antennal furrows extending to occiput, very slightly interrupted near the ocelli; postocellar furrow present; postocellar area nearly quadrate, a very little wider at the occiput; pedicel nearly as long as the fourth joint, third joint not quite as long as fourth plus fifth; inner tooth of claw slightly shorter than outer; stigma broadest where the transverse radius leaves it; last ventral segments finely closely granular. Black; anterior margin of clypeus (broader in the middle), large quadrate spots on upper inner orbits, quadrate spot above the

antennæ, curved line from superior orbits to occiput, tegulæ, scutellum and legs below middle of femora sulphur-yellow. Wings hyaline, vitreous; venation black.

Type-locality.—Japan. One female bearing the following numbers: 28, 912, 424, 28.

Type.—Cat. No. 13315, U.S.N.M.

Family SIRICIDÆ.

SIREX MATSUMURÆ, new species.

Separated at once from other species of *Sirex* by second cubital cell receiving both recurrent veins. Otherwise related to *gigas* Linnæus, *flavicornis* Fabricius, and *japonicus* F. Smith, but differs from all of these.

Female.—Length to apex of abdominal appendage 4 to 40 mm.; length of ovipositor 21 mm. Head entirely coarsely granulatopunctate; clypeus with a narrow median notch; lateral ocelli distinctly below the supraorbital line; the postocellar line slightly longer than the ocellorbital line; antennæ 20 jointed, the apical joints somewhat angular; pronotum large, well developed laterally, smooth, with separated, small tubercles over the surface; mesonotum and scutellum with close usually distinct punctures; the second cubital cell long, receiving both recurrent veins; cross-vein in the anal cell distantly basad of the transverse median; caudal appendage long, smooth, the apical lateral margins with sharp teeth; ovipositor about as long as the abdomen. Black; head except a spot between the orbits and apex of mandibles, basal part of the antennæ, pronotum, legs below femora (posterior legs wanting), and abdomen except the apical margins of the segments, ovipositor and appendage yellow; wings yellowish hyaline, costa and stigma yellowish, venation dark brown; hair of head and thorax mostly black.

Type-locality.—Sapporo, Japan. One female collected by Mr. Matsumura. No. 42. There is also a label which bears some Japanese characters on the pin.

Type.—Cat. No. 13316, U.S.N.M.

Named for the Japanese entomologist, Doctor Matsumura, who collected the specimen.

Family ARGIDÆ [olim Hylotomidæ].

ARGE NIPPONENSIS, new species.

Differs from the description of *Arge semicærulea* (Kirby) in entirely pale hind femora, a character which will also separate it from *A. pagana* (Panzer).

Female.—Length 8 mm. Clypeus and labrum gently arcuately emarginate; median carina strong, sharp; middle fovea narrow elongate, extending from level of antennæ to anterior ocellus, pointed below, with a pit below the middle, and nearly parallel-sided above

the pit; antennal furrows nearly continuous; postocellar furrow wanting; postocellar line subequal with the ocellorbital line; stigma broadest at base, tapering; sheath more sharply pointed than the sides of the ninth segment; cerci robust. Metallic blue; antennæ and four anterior legs black; abdomen and posterior legs beyond the trochanters, except the brownish apex of tibiæ and their tarsi, reddish-yellow. Wings brown, paler beyond the stigma, a dark cloud below the stigma; venation black.

Type-locality.—Osakura, Japan. Three females and one male from Dr. K. Mitsukuri.

Type.—Cat. No. 13317, U.S.N.M.

The male agrees with the female in color; the head is wanting. The hypopygium is broadly rounded.

Family DIPRIONIDÆ [olim Lophyridæ].

Genus DIPRION Schrank.

=*Lophyrus* LATREILLE (not POLI).

The generic name *Lophyrus* was used by Poli in Mollusca in 1791. *Diprion* Schrank was described the same year as *Lophyrus* Latreille (1802), but with 93 pages priority so should be used in place of *Lophyrus* Latreille (not Poli).

Type.—*Tenthredo pini* Linnæus.

DIPRION NIPPONICA, new species.

Differs from *D. variegata* (Hartig),^a its nearest ally, in its larger size, distinct postocellar furrow, not impressed and more coarsely punctured postocellar area, coarsely punctured clypeus, the deeply arcuate false clypeal margin, and black legs.

Female.—Length 8.5 mm. Clypeus subdepressed apically, the apical part punctured, similar to the upper, anterior margin arcuately emarginate, the false margin more deeply emarginate; antennæ 20 jointed, the third joint much longer than the fourth, of the type of *pini*; antennal foveæ well defined, not very large; middle fovea rather distinct, nearly circular in outline; ocelli in a curved line, anterior one not in a basin; postocellar area not sharply defined laterally, not impressed, punctured like the rest of vertex and front; postocellar furrow sharply defined, but little longer than the postocellar line; postocellar line shorter than the ocellorbital line, and hardly one-fourth longer than the ocelloccipital line; dorsulum coarsely punctured, with rather large punctures; metanotum punctured all over; inner calcarium of posterior tibiæ simple; claws with an erect median tooth; basal plate with poorly defined punctures; venter with distinct punctures; last ventral plate produced in the

^a *D. variegata* Hartig is said to be a synonym of *D. frutetorum* (Fabricius), but the two are easily separated by color, and until more evidence has been obtained they should be kept separate.

middle; sheath concealed; cerci small, not very hairy. Black; pronotum, upper part of mesopleuræ, margins of lobes of mesonotum, scutellum, sides of metanotum, basal three and apical four dorsal segments yellow. Legs black; four anterior tibiæ and tarsi yellow. Wings yellowish hyaline; venation testaceous base of stigma darker.

Type-locality.—Japan. A female with a label bearing Japanese characters and the number "28."

Type.—Cat. No. 13318, U.S.N.M.

NESODIPRION, new genus.

Type of genus—*Lophyrus japonica* Marlatt.

Differs from *Diprion* Schrank (olim *Lophyrus* Latreille) in the malar space being nearly wanting; the maxillary palpi five-jointed, the labial palpi three-jointed; the longer spur of the hind tibiæ equal, or nearly, in length to the basitarsis; and the biramose antennæ of the female. The rami are not as long as in the male. Sexes as far as known similar. Larvæ feeding on coniferous trees.

TABLE TO THE SPECIES OF NESODIPRION.

Species mostly black.

Femora entirely black; basal dorsal segment not punctured. Japan.

japonica (Marlatt).

Femora at the apex pale; "segmento primo dorsali medio sparsim punctato."

Hongkong, China *biremis* (Konow).

NESODIPRION JAPONICA (Marlatt).

This species was originally described from Japan. It has been introduced into United States through San Francisco, California—teste a male and female bred from a pine received from Japan, April 30, 1902, by Mr. Alex. Craw, San Francisco, California, now in the collection of the U. S. National Museum.

NESODIPRION BIREMIS (Konow).

Konow's species may only be a race, but the above differences were noted by comparing *japonica* with the original description of *biremis*.

Family CIMBICIDÆ.

AGENOCIMBEX, new genus.

Type of genus—*Cimbex maculata* Marlatt.^a (Japan.)

Rather large robust species with the habitus very like *Cimbex*; labrum small, triangular in outline, similar to *Cimbex*; supraclypeal suture wanting; malar space large; eyes converging to the clypeus; posterior orbits not extending beyond the eyes; ocelli in a triangle,

^aF. W. Konow (1906) has suggested that *Cimbex maculata* Marlatt (1898) is a synonym of *Cimbex jucunda* Mocsary (1896); and the description of Mocsary's species and his figure agree very well with the type of Marlatt's species, but in view of the fact that there is no positive evidence the name *maculata* is still retained.

the lateral ones below the supraorbital line; antennæ clavate, with five joints before the gradually formed club, the third much the longest, club with two distinct joints and a very indistinctly defined one; maxillary palpi six-jointed, labial palpi four-jointed; first perapteron smaller than in *Cimbex*; femora robust without spines; coxæ contiguous; tarsal claws cleft; basal plate deeply, arcuately emarginate posteriorly; wings similar to *Cimbex* except the cross-vein in the anal cell is much nearer the base of the wing.

Belongs to Cimbicinæ and is related to *Cimbex olivier*, but may be easily distinguished from that genus by the contiguous coxæ, and the posterior orbits not extending beyond the eyes.

ABIA RELATIVA, new species.

Related to *Abia japonica* Cameron, but differs from the description of that species in not having a pad-like elevation on the vertex, and only the tarsi are white.

Female.—Length 15 mm. Labrum concealed; clypeus broadly arcuately emarginate; frons large, the ridges forming a large basin which incloses the anterior ocellus; a distinct furrow from the anterior ocellus to the occiput; third antennal joint long and slender, nearly as long as the following joints; head sparsely punctured; thorax with distinct, separate punctures; inner claw tooth as long as outer; transverse radius basad of middle of the third cubital cell; first transverse cubitus wanting; abdomen normal. Head, legs and most of the abdomen dull black; thorax and basal segment of abdomen dark green; antennæ entirely black; head, legs, pectus, and anterior part of the scutellum with black hair; mesonotum and pleuræ with fulvous hair; all the tarsi yellowish-white. Wings yellowish-hyaline, apical margin, a small spot around stigma and the first discoidal cell distinctly dusky; venation basally yellowish, apically brown; stigma at base brown, at apex yellowish.

Male.—Length about 11 mm. Differs from the female in the usual sexual characters, and in the hair being almost entirely black, that of the mesonotum having a faint fulvous tinge; the apex of the club beneath is reddish. Hypopygidium is truncate at the apex.

Type-locality.—Japan. One female collected by Mr. Koebele.

Type.—Cat. No. 13319, U.S.N.M.

Family TENTHREDINIDÆ.

PACHYNEMATUS ALNI, new species.

Runs in Konow's revision of the Palæartic Pachynemati^a to the German species *ravidus* Konow, but does not seem very close to that species. The entirely black pronotum will distinguish it at once.

Male.—Length 6 mm. Anterior margin of the clypeus deeply, rather narrowly emarginate, the lobes broad and obtusely rounded

^aZeit. Hym. Dipt., vol. 3, 1903.

at the apex; head somewhat broader behind the eyes; ocellar basin poorly defined, the lateral walls subparallel; an elongate fovea in front of the anterior ocellus; middle fovea not sharply defined, spreading over the antennæ; frontal crest unbroken; postocellar furrow drawn down by the furrow from the anterior ocellus; antennæ not quite as long as the insect, the third and fourth joints equal; thorax shining, almost impunctate; suture in front of the scutellum deep and well defined, sharply angled; stigma hardly twice as long as wide at the base, tapering to the apex; sides of the third cubital cell parallel; hypopygidium of the short type, rounded at the apex. Black; antennæ beneath rufoferruginous; tegulæ pale brown; legs below the trochanters except the darkened apices of hind tibiæ and tarsi ferruginous. Wings hyaline, iridescent; venation black, stigma brownish-yellow.

The posterior tibiæ are sometimes pallid, and there is sometimes a pale brown spot at the apex of the hypopygidium.

Type-locality.—Konosu, Saitama, Japan. Four males collected April 18, 1909, on foliage of *Alnus* by Mr. T. Fukai.

Type.—Cat. No. 13320, U.S.N.M.

PRISTIPHORA INSULARIS, new species.

Related to *P. alnivora* Hartig, but differs in a number of ways from that species.

Female.—Length 5.5 mm. Head rather closely granular all over; antennal foveæ small; antennal furrows wanting; middle fovea rather poorly defined, elongate; ocellar basin wanting; postocellar area poorly defined laterally, about four times as wide as the cephal-caudad width; postocellar furrow well defined; postocellar line longer than the ocellorbital line; third antennal joint slightly longer than the fourth; dorsulum shining with poorly defined, scattered punctures; stigma robust, widest at the base; third cubital cell but little wider at apex; upper discal cell exceeding the lower on the outer margin; sheath robust, obtusely pointed, the lower margin emarginate; saw with rather small, regular, obtusely pointed teeth. Black; labrum, mandibles (apices piceous), angles of pronotum, tegulæ, legs below middle of coxæ, except the apices of femora tibiæ and tarsi which are dusky, *yellowish*; wings hyaline, iridescent; venation brown.

Type-locality.—Japan. One female. Collector unknown.

Type.—Cat. No. 13321, U.S.N.M.

NESOTOMOSTETHUS, new genus.

Type of genus.—*Blennocampa religiosa* Marlatt.

Robust species. Malar space very narrow, almost wanting; clypeus nearly truncate; posterior orbits broad; lateral ocelli on the supra-orbital line; antennæ not hairy, of the normal *Blennocampine* type,

pedicellum subequal in length with the scape, longer than wide, third joint longer than fourth; mesopleuræ without a præpleuræ; mesosternum with a distinct præsternum; scutellum of the metathorax well defined; venation normal; transverse radius and third transverse cubitus at different angles, third cubital cell large, transverse median in about the middle of the cell, hind wings with a closed discal cell, anal cell longly petiolate; hind basitarsis much shorter than the following joints; tarsal claws cleft, and with a basal tooth; last ventral segment in the middle produced; sheath of the normal type; hypopygidium normal.

This genus can be recognized by the tarsal claws, the short basitarsis, the normal antennæ, the absence of the præpleuræ on the mesopleuræ, and the presence of a meso-præsternum.

Marlatt's description of the tarsal claws should be corrected. The male has the head mostly black.

MONOPHADNOIDES CRASSICORNIS, new species.

Black; wings strongly dusky; antennæ thickened in the middle.

Male.—Length 6.5 mm. Clypeus truncate, irregularly punctured; antennal foveæ well defined above; middle fovea wide, elongate, extending from near ocellar basin to near base of clypeus, open above and below; ocellar basin triangular, poorly defined below; postocellar area well defined laterally; postocellar furrow wanting; postocellar line slightly shorter than the ocellorbital line; antennæ short, thickened in the middle, the third joint nearly as long as fourth plus fifth; thorax normal; third cubital cell as long as one and two on the radius; hypopygidium broadly rounded apically. Black, rather densely clothed with gray hair; trochanters and base of hind tibiæ dirty white. Wings dusky hyaline; venation black.

Type-locality.—Wakasa, Japan. One male collected by Mr. T. Fukai.

Type.—Cat. No. 13322, U.S.N.M.

PARACHARACTUS LEUCOPODUS, new species.

Clypeus, labrum, and legs entirely straw-white; mesonotum marked with dark red.

Male.—Length 6 mm. Eyes distinctly converging to the clypeus; clypeus truncate; antennal foveæ small; middle fovea circular in outline, rather well defined; ocellar basin nearly wanting; postocellar area bounded laterally by punctiform fovea; postocellar furrow well defined, slightly bent, longer than the postocellar line; postocellar line slightly shorter than the ocellorbital line; antennæ filiform, the third joint but little longer than the fourth, apical joint slightly longer than the preceding; stigma rounded on the lower margin, third cubital cell about the same length as the second on the radius; hypopygidium broadly rounded at the apex. Black; clypeus,

labrum, and all of the legs straw-white, hind tarsi infuscated; pronotum, tegulae, lateral lobes of the mesonotum and margin of the anterior lobe rufous. Wings hyaline, iridescent; venation black, stigma dark brown.

Type-locality.—Japan. One male collected by Mr. Koebele.

Type.—Cat. No. 13323, U.S.N.M.

MONOPHADNUS GENTICULATUS NIPPONICA, new subspecies.

Differs from the typical form by the larger middle fovea, more sharply defined ocellar basin, sheath not so slender, and the legs below apices of femora whitish.

Type-locality.—Konosu, Saitama, Japan. One female collected April 14 by Mr. T. Fukai.

Type.—Cat. No. 13324, U.S.N.M.

MONOPHADNUS FUKAII, new species.

Related to *M. genticulatus* Hartig, but the antennae are shorter and stouter; the postocellar line is distinctly shorter than the ocellorbital line, not subequal with it; the stigma is rounded on the lower margin; the wings are darker; and the sheath is broader.

Female.—Length 5 mm. Clypeus truncate, almost impunctate; antennal foveae poorly defined; middle fovea large transversely quadrate, well defined; ocellar basin better defined than in *genticulatus*, triangular; postocellar area well defined, the postocellar furrow angled in the middle; postocellar line one-third shorter than the ocellorbital line, but little longer than the ocelloccipital line; antennae short, robust, the third joint but little longer than the fourth, apical joint shorter than the preceding; stigma elongate, the lower margin rounded, the transverse radius leaving it free from the costa; third cubital cell shorter than the second, the transverse radius received near the apex; sheath rather robust, straight above, rounded below. Black; bases of tibiae brownish-white. Wings blackish; venation black.

Male.—Length 4 mm. Male is much like the female except that the legs below the apices of femora are brownish-white. Hypopygium narrowly rounded at the apex.

Type-locality.—Konosu, Saitama, Japan. Males and female collected April 14 by Mr. T. Fukai, for whom the species is named.

Type.—Cat. No. 13325, U.S.N.M.

ANEUGMENUS JAPONICUS, new species.

Related to *A. temporalis* (Thomson), but the venter, clypeus, and labrum are pale.

Female.—Length 5.5 mm. Clypeus nearly truncate; antennal foveae small; middle fovea large transversely subquadrate; ocellar

basin poorly defined, about twice as long as wide, reaching nearly to the middle fovea, angled above; postocellar area well defined laterally; postocellar furrow wanting; postocellar line distinctly longer than the ocellorbital line; third antennal joint nearly as long as four plus five; third cubital cell shorter than the second; stigma angled at base tapering to the apex; sheath straight above, obliquely truncate, broadening apically. Black; scape, clypeus, labrum, mandibles (apices dark piceous), pronotum, tegulæ, venter, and all of the legs pale yellow. Wings dusky hyaline; veins brown.

Type-locality.—Nikko, Japan. One female collected by Mr. A. Koebele.

Type.—Cat. No. 13326, U.S.N.M.

STROMBOCEROS KOEBELEI, new species.

Black; legs, venter, mouth, and part of thorax pale.

Female.—Length 7.5 mm. Clypeus deeply emarginate, lobes narrow and obtuse; antennal foveæ large, extending to the transverse facial carina above; antennal furrow complete above the transverse facial carina; middle fovea subcircular in outline; ocellar basin with very strong ridges, pentagonal, open below, the lateral walls extending to the bases of antennæ, middle fovea below level of basin, sharply angled at vertex; postocellar area with a longitudinal carina; postocellar furrow wanting; postocellar line about the length of the transverse facial carina, which is not complete; antennæ slender; posterior part of the anterior lobe depressed, with a strong median carina; stigma rounded on the lower margin, broadest a little basad of the middle; sheath straight above, rounded below. Black: scape, labrum, clypeus, mandibles (apices piceous), tegulæ, pronotum, sides of anterior lobe of mesonotum anteriorly, spot on posterior part of mesopleuræ; venter and all of legs pale yellow. Wings slightly dusky hyaline; venation dark brown, stigma pale brown, the lower part whitish.

Type-locality.—Nikko, Japan. One female collected by Mr. A. Koebele, for whom the species is named.

Type.—Cat. No. 13327, U.S.N.M.

ATHALIA SPINARUM JAPANENSIS, new subspecies.

Very like the European *spinarum*, but may be distinguished from that form by the black wings and black venation. The typical form of *spinarum* has the lateral lobes of the mesonotum entirely black, although there are occasionally specimens which have the anterior part the color of the sides. All the Japanese specimens have the anterior part of the lateral lobes of mesonotum the color of the sides. The Japanese forms are more pubescent and duller, the saw of the female is somewhat heavier in appearance; the hypopygidium of

the male is gently rounded at the sides, not somewhat angled, as in the European forms.

Type-locality.—Wakasa, Japan. Three females and two males collected by Mr. T. Fukai. A paratype female from Yokohama, Japan, collected "on flowers in hedges and gardens," June 20, 1906, by Mr. Brunetti.

Type.—Cat. No. 13328, U.S.N.M.

F. W. Konow^a considers *spinarum* Fabricius to be a synonym of *colibri* Christ. Inasmuch as no proof is available and *spinarum* Fabricius is a well-known name, it is retained for the present.

ATHALIA JAPONICA (Klug).

A male collected in Japan by Mr. A. Koebele differs from Klug's description of the female in pale clypeus, labrum, mandibles, and scape. There is a small circular depression in front of the anterior ocellus; middle fovea deep, nearly circular; third antennal joint nearly as long as four and five combined; hypopygidium broad, gently round at the apex.

F. W. Konow^b runs *japonica* in with the species which have the tibiae and tarsi black. In this he is wrong—the original description says: "Die Schienen und Fussglieder sind schwärzlich, erstere in der Mitte, letztere in ihrem Nasprunge gelblich."

ATHALIA LUGENS (Klug), INFUMATA (Marlatt).

Phyllotoma infumata MARLATT, Proc. U. S. Nat. Mus., vol. 21, 1898, p. 494.

F. W. Konow^c places *Phyllotoma infumata* Marlatt as a synonym of *Athalia lugens* (Klug). A comparison of the types of *infumata* with specimens of this species from Europe shows racial differences. They may be separated by the following table:

Labrum and palpi dark reddish-brown; tibiae reddish-yellow except at the apex; wings brownish hyaline, venation brown; hypopygidium more sharply narrowed apically.....	<i>lugens lugens</i> (Klug).
Labrum and palpi black; tibiae black, at least the hind tibiae (these first two sets of characters hold for the females, but the males vary, the color of the wings in the males is, however, apparently constant); wings much darker, venation black; hypopygidium gradually narrowing apically and tapering its entire length.	<i>lugens infumata</i> (Marlatt.).

There are three females of the Japanese race from Yokohama, Japan, collected on flowers in hedges and gardens June 20 and July 25, 1906, by Mr. Brunetti in the collections of the National Museum. Mr. Fukai has sent the museum a female from Wakasa, Japan.

^a Genera Insectorum, fas. 29, 1906, p. 93, and his table of 1908.

^b Ann. Mus. Zool. St. Petersburg, vol. 13 (1), 1908, p. 12.

^c Genera Insectorum, fas. 29, 1906, p. 94.

Genus TAXONUS Hartig.

= *Ametastegia* A. COSTA, 1882.

Type.—(*Tenthredo coxalis* Klug) = *Tenthredo equiseti* Fallén.

F. W. Konow^a says, in speaking of Hartig's genus *Taxonus*, "Deswegen muss der *T. agrorum* Typus seiner Gattung bleiben." O. Costa^b in 1859 made *Ermilia pulchella* O. Costa as the type of *Ermilia* O. Costa. A. Costa^c places *Ermilia pulchella* O. Costa as a synonym of *Tenthredo agrorum* Fallén, thus making the species *agrorum* Fallén the type of *Ermilia*. This removal of *Tenthredo agrorum* from the genus *Taxonus* in 1894 makes it impossible to select it as the type of the genus *Taxonus* in 1896; therefore some other type must be chosen for *Taxonus* than the one chosen by Konow. Dr. A. D. MacGillivray^d fixes *Tenthredo equiseti* Fallén as the type of *Taxonus* which has *Tenthredo coxalis* Klug as a synonym, a species which was originally included.

The genus *Taxonus* may be divided into a number of subgenera, some of which are now recognized as good genera. The following may be separated thus:

Malar space present, although not very large; pedicellum longer than wide; postbasitarsis subequal in length with the following joints; tarsal claws cleft, or with an inner tooth..... 1.

1. Clypeus deeply emarginate; claws deeply cleft, the inner tooth shorter than the outer; pleuræ rather roughly sculptured; anal cell of hind wings petiolate; transverse median vein of fore wings in middle of cell; postnotum of metathorax as in *Taxonus*..... subg. *Ermilia* O. Costa.

Clypeus truncate or nearly; pleuræ not coarsely sculptured..... 2.

2. Postnotum of the metathorax without a well-defined, broadly triangular shaped production; anal cell of the hind wings sessile; transverse median vein of the fore wings received near the middle of the cell; hind wings of the male without a surrounding marginal vein; tarsal claws with an inner tooth; rather slender species..... subg. *Taxonus* Hartig.

Postnotum of the metathorax with a well-defined, broadly triangular-shaped lobe, as the scutellum of the mesothorax; anal cell of the hind wings petiolate; transverse median vein of the fore wings received distinctly basad of the middle of the cell; males unknown; tarsal claws cleft at the apex; larger and stouter species.

subg. *Nesotaxonus* Rohwer.

NESOTAXONUS, new subgenus.

Type of genus—*Phyllotoma? flavescens* Marlatt.^e

Rather large robust species of the habitus of *Taxonus* (*Ermilia*); antennæ hairy, normally nine jointed, but in the type of the geno-

^a Entomologische Nachrichten, vol. 22, 1896, p. 313.

^b Fauna Napoli. Tenth., p. 106.

^c Prospetto Imenotteri Italiani, vol. 3, 1894, p. 155.

^d Can. Ent., October, 1908, p. 366.

^e Proc. U. S. Nat. Mus., vol. 21, 1898, p. 494.

type they are ten jointed and the apical joint is not as long as in the paratype; lateral ocelli distinctly in front of the supraorbital line; posterior orbits narrower than in the subgenus *Ermilia*, or *Taxonus* and the occiput and posterior margin of the cheeks are not crenated; anterior tibiæ with only one well-defined apical spur, which is simple at the apex, the second spur being very short; third cubital cell longer than the two basal ones; first segment of the abdomen (basal plates) with a longitudinal suture, but this and the space between the first and second segments is chitinized, while in *Ermilia* they are membranous; sheath robust; cerci concealed.

With more material this may be raised to generic rank.

ERIOCAMPA MITSUKURII, new species.

Related to *E. umbiatica* (Klug), but may at once be distinguished by the strongly punctured head.

Male.—Length 6 mm. Clypeus coarsely punctured, the anterior margin arcuately emarginate; antennal foveæ well defined, shining; middle fovea large, well defined, transversely quadrate; ocellar basin well defined, the lower wall not so well defined, extending to the middle fovea, triangular in outline; postocellar area well defined laterally, with a distinct median longitudinal carina; postocellar furrow wanting; postocellar line not as long as the ocellocipital line; head, including the posterior orbits, strongly coarsely punctured; antennæ slender, the third joint but little shorter than the fourth and fifth; pronotum, mesopleuræ punctured like the head; mesonotum shining with a few widely scattered punctured, scutellum with the punctures closer; mesopleuræ shining; stigma nearly parallel-sided, the apex obliquely truncate; hypopygidium very broadly rounded at the apex. Black; four anterior legs below the femora brownish white. Wings hyaline, faintly dusky; venation brown.

Type-locality.—Nikko, Japan. One male collected by Mr. A. Koebele.

Type.—Cat. No. 13330, U.S.N.M.

Named for Doctor Mitsukuri, of the Imperial University, Tokyo, Japan, a Japanese entomologist.

HEMITAXOMUS JAPONICUS, new species.

Black; clypeus, labrum, angles of pronotum, tegulæ and legs, in part, pale.

Male.—Length 6 mm. Clypeus nearly truncate, granular; labrum rather narrowly rounded; antennæ foveæ sharply defined, extending from the clypeus to the transverse facial carina; middle fovea well defined, broader above; below this fovea is an indistinct angled furrow; ocellar basin sharply defined, hexagonal; postocellar furrow nar-

row, complete; sides of postocellar area punctiform; postocellar line distinctly shorter than the ocellorbital line; antennæ slender, the third and fourth joints subequal; thorax normal; stigma broadest near base, tapering to apex; hypopygidium long and narrow, apex nearly truncate angles rounded; genitalia stipes rounded at the apex. Black; clypeus, labrum, tegulæ, angles of pronotum, legs (the femora and tibiæ brownish) and genitalia stipes pale, the body markings yellow. Wings hyaline, iridescent; venation brown in part pale.

Type-locality.—Hakone, Japan. One male collected by Mr. A. Koebele.

Type.—Cat. No. 13329, U.S.N.M.

DOLERUS INSULICOLA, new species.

Very like *obscurus* Marlatt, but the clypeus is squarely emarginate, not with a U-shaped emargination, the saw is without well-defined transverse folds and the teeth are not as small or numerous.

Female.—Length 8 mm. Labrum impunctate; clypeus deeply squarely emarginate, lobes triangular, obtuse; head emarginate posteriorly; front closely granular, vertex with large punctures; antennal furrows complete; vertex carinated; third antennal joint longer than the fourth; dorsulum, scutellum and tegulæ with close distinct punctures; scutellar appendage large, pointed, with oblique striæ; mesopleuræ granular with a tendency of reticulation; basal plates impunctate; sheath large, obliquely truncate; saw slender, without transverse ridges, teeth sharp and pointing basally. Black; clypeal lobes, pronotum, tegulæ, trochanters, femora and most of tibiæ, dark rufous; head and thorax with short gray hairs; wings hyaline, iridescent; venation except the extreme base of stigma, black.

Type-locality.—Wakasa, Japan. Three females collected by Mr. T. Fukai.

Type.—Cat. No. 13331, U.S.N.M.

One of the paratypes has the clypeus entirely black, only part of the pronotum rufous and the sculpture of the dorsulum is not so dense.

RHOGASTER NIPPONICA, new name.

Tenthredo picta MOTSCHULSKY, Bull. Soc. Imp. Natur. de Moscow, 1866, p. 182. Not KLUG, 1814.

What has been determined as Motschulsky's species is different from both *R. varipes* (Kirby) and *R. viridis* (Linnæus). These three similarly colored species may be separated thus:

Labrum longer than wide.....	<i>varipes</i> (Kirby).
Labrum much wider than long.....	1.
1. Postocellar area carinated, quadrate.....	<i>nipponica</i> Rohwer.
Postocellar area not carinated, rectangular.....	<i>viridis</i> (Linnæus).

MACROPHYA FUKAI, new species.

Female.—Length 8.5 mm. Labrum broader than long; clypeus deeply arcuately emarginate, lobes broad truncate; middle fovea indicated; antennæ furrows wanting; occiput carinate; postocellar area well defined on all sides, about twice as wide as the cephal-caudad length; postocellar line much shorter than the ocellorbital line; antennæ thickening apically, the third joint distinctly longer than fourth; head closely punctured all over; thorax punctured similar to the head but more finely so; stigma angled at base, gradually tapering; third cubital cell much longer than the second; sheath narrow, truncate at apex. Black; head and thorax slightly greenish; clypeus, labrum, mandibles (apices piceous), sides of the third abdominal segment, four anterior legs before, posterior coxæ and trochanters beneath and basal half of posterior tibiæ pale yellow; head and thorax with gray hair. Wings hyaline, slightly yellowish; venation dark brown.

Type-locality.—Wakasa, Japan. One female collected by Mr. T. Fukai, for whom the species is named.

Type.—Cat. No. 13332, U.S.N.M.

LAGIUM JAPONICUM, new species.

Allied to *Lagium platyceros* (Marlatt), but is easily distinguished by the punctured vertex and posterior orbits, the poorly defined postocellar area, black third and fourth antennal joints, black mesonotum, and yellow scutellum.

Female.—Length 16 mm. Labrum rather narrow, a very little wider than long, apex rather acutely rounded; clypeus arcuately emarginate; entire head with close, rather large punctures; posterior orbits narrow for the genus; postocellar area poorly defined; eyes slightly converging to the clypeus, in this this species differs from the genotype; antennæ long, somewhat compressed, third joint much longer than the fourth; mesonotum with close, rather small irregular punctures; scutellum shining, sparsely sculptured; mesopleuræ and posterior coxæ sculptured like the mesonotum; transverse radius almost interstitial with the third transverse cubitus; transverse median in basal fourth of the cell; one closed discal cell in the hind wings; abdomen longer than the head and thorax, broad; sheath nearly straight above, the lower margin rounded. Head and thorax largely black; clypeus, labrum, mandibles (apices piceous), two basal and three apical antennal joints, palpi, large spot on upper posterior orbits, narrow inner orbits, angles of pronotum, tegulæ and scutellum *yellow* or yellowish; legs mostly yellow; coxæ at base, most of posterior femora, and apex of posterior tibiæ

black; posterior tibiæ at base, and the tarsi ferruginous; abdomen ferruginous, the sutures black. Wings yellowish hyaline, vitreous, apices slightly dusky; venation black, costa and stigma ferruginous.

Type-locality.—Japan. One female, No. 13, collector unknown.

Type.—Cat. No. 13335, U.S.N.M.

Differs in some points from the genotype of *Lagium*.

Genus JERMAKIA Jakowlew.

Type of genus.—*Allantus cephalotes* Jakowlew.

Species with much the same habitus as *Tenthredo* (olim *Allantus*). Eyes large and strongly converging to the clypeus; malar space very narrow about half the length of the pedicellum; maxillary palpi five jointed, labial palpi four jointed; mandibles large, robust; labrum rather large; clypeus large, emarginate, and without a suture separating it from the face; no dilations above the antennæ; third antennal joint distinctly longer than the fourth; pedicellum longer than wide; scutellum elevated; suture between the meso- and metanotum strong; a very deep suture between the metathorax and first segment of the abdomen; first segment of the abdomen entire, without the median longitudinal suture; tarsal claws cleft; venation as in *Tenthredo*.

This genus is distinct in the absence of the suture at the top of the clypeus, and the entire first segment of the abdomen.

The characters, given above, were taken from *Jermakia japonica* Rohwer, which seems undoubtedly to belong to this genus. F. W. Konow^a places *Tenthredo flavida* Marlatt in this genus and gives the genus standing on this species. *Tenthredo flavida* Marlatt does not belong to the genus *Jermakia*.

JERMAKIA JAPONICA, new species.

Male.—Length about 13 mm. Clypeus squarely emarginate, with a slight rounded production in the middle, lobes short, truncate at apex; labrum and clypeus shining, impunctate; front and vertex with large well-separated punctures, posterior orbits with closer smaller ones; ocelli in a triangle greater than an equilateral triangle; post-ocellar area not sharply defined, the lateral furrows curved; ocell-occipital line and ocellorbital lines subequal, much longer than the postocellar line; occiput carinated; mesonotum with small, close punctures; scutellum pyramidal, with large punctures at the base but shining at the apex; mesopleuræ with irregular confluent punctures; mesosternum with a tubercle at lateral posterior angles; abdomen smooth, shining; hypopygidium rounded at the apex, broader than long;

^a Genera Insectorum, fas. 29, 1906, p. 132.

genitalia stipes large, apex rounded. Black: a small spot at base of mandibles within, metaepisternum, a broad band on the first and fifth segments of the abdomen straw yellow; legs black, all the tibiae and tarsi beneath reddish yellow; genitalia brownish. Wings hyaline, basal half and cubital and radial areas of the anterior wings brown; venation black, stigma yellow.

Type-locality.—Hakone, Japan. One male from Mr. Matsumura, No. 47, July 27.

Type.—Cat. No. 13333, U.S.N.M.

The species of *Jermakia* may be separated by the following table:

Mostly luteous; "abdomine pallida-testaceo".....	<i>spinifera</i> Mocsary.
Mostly black.....	1.
1. Base of antennæ ferruginous; lateral margins of the first segment yellow.	<i>cephalates</i> Jakowlew.
Antennæ black; first dorsal segment all yellow.....	<i>japonica</i> Rohwer.

TENTHREDINA, new genus.

Type of genus.—*Tenthredo flavida* Marlatt.

In habitus much like *Dipteromorpha* W. F. Kirby, but that genus has a nearly truncate clypeus, the head narrowed behind the eyes, the dilated frons of *Tenthredella*, and the transverse median nearly interstitial with the basal vein.

Large species; labrum large; clypeus deeply emarginate, separated from the front by a suture; no large dilated frons above the antennæ as in *Tenthredella*; lateral ocelli below the supraorbital line; eyes large, strongly converging to the clypeus; malar space wanting; maxillary-palpi six jointed, labial-palpi five jointed; antennæ nine jointed, the third joint longer than the fourth, pedicellum much longer than broad; metathorax short; the first segment closely attached to the metathorax, with a longitudinal suture; abdomen rather narrowed basally; tarsal claws cleft; posterior coxæ rather large but not so long that the femora extend to the apex of the abdomen; legs hairy; wings large, third cubital cell longer than the first and second; transverse median received in the basal third of the cell; intercostal vein wanting; two discal cells in the hind wings, anal cell usually shorter than the submedian, and petiolate.^a

In F. W. Konow's tables in the Genera Insectorum this genus runs to *Tenthredo* (now *Tenthredella*), but will be at once separated by the absence of antennal frons, cylindrical abdomen, and the first segment of the abdomen wider than the second. It may be that when the Tenthredininae of the Orient are better known that this will be restricted to a subgenus of *Tenthredella*, but at present it seems distinct.

^a This character is subject to variation within a species. In one specimen of *Tenthredo flavida*, the hind wings on the right-hand side of the specimen, the anal cell is distinctly petiolate, while the left-hand wing has the anal cell nearly sessile.

Genus TENTHREDO Linnæus.

= *Allantus* Jurine.

Latreille^a fixed the type of *Tenthredo* Linnæus as *Tenthredo serophulariæ* Linnæus. This species was originally included and comes first in the group of Linnian species, which belong to Tenthredininae. *Tenthredo serophulariæ* Linnæus belongs to the genus *Allantus* Jurine and was named as the type of that genus by Curtis.^b *Allantus* Jurine is therefore a synonym of *Tenthredo* Linnæus, the two genera being isogenotypic.

Tenthredo Linnæus 1758.*Allantus* Jurine 1807.

TENTHREDELLA, new name.

= *Tenthredo* of authors.

Tenthredo having *Allantus* as a synonym leaves *Tenthredo* of authors without a name (*Rethra* Cameron not being a synonym of *Tenthredo* of authors). For *Tenthredo* of authors the name *Tenthredella* may be used. The type of *Tenthredella* is *Tenthredo atra* Linnæus.

TENTHREDELLA HAKONENSIS, new species.

Perhaps related to *Tenthredella adusta* (Motschulsky), but has the thorax largely black, and different colored legs.

Female.—Length 17 mm. Labrum wider than long, apex broadly rounded; clypeus narrowly arcuately emarginate, lobes broad; head shining; orbital carina not extending across the postocellar area; postocellar area well-defined on all sides, wider than the cephal-caudad length, with distinct, separate punctures; ocelli in an equilateral triangle; antennæ wanting in the type; mesonotum and mesopleuræ punctured, the lateral lobes more finely so; scutellum more sparsely punctured, the scutellar lobe with large punctures; venation normal; prong on the inner spur of anterior tibiæ nearly at right angles and but little beyond the middle; sheath parallel-sided, the lower apex rounded. Head ferruginous; a black spot inclosing the ocelli and extending above and below it black; clypeus, labrum, mandibles (apices piceous), palpi, cheeks, supraclypeal area, narrow inner orbits, yellow. Thorax black; angles of pronotum, tegulæ, scutellum, scutellar lobe, metascutum, and notum yellow. Legs yellow; bases of coxæ and apical part of posterior femora black. Abdomen rufo-piceous, the apical segments very dark. Wings yellowish-hyaline, venation dark brown, stigma and costa yellow.

Type-locality.—Hakone, Japan. One female collected July 27, by Doctor Matsumura.

Type.—Cat. No. 13334, U.S.N.M.

^a *Considerations Générales*, 1810, p. 435.

^b *Brit. Ent.*, 1839, p. 764.

A LIST OF THE JAPANESE TENTHREDINOIDEA.

Family XYELIDÆ.

Genus *Xyela* Dalma.*japonica* Rohwer.
variegata Rohwer.

Family PAMPHILIDÆ.

Genus *Cephaleia* Panzer.Subgenus *Cephaleia* Panzer.*koebelei* Rohwer.
nigrocærulea Rohwer.Genus *Neurotoma* Konow.Subgenus *Neurotoma* Konow.*iridescens* André.Genus *Pamphilius* Latreille.Subgenus *Pamphilius* Latreille.*smithii* Kirby.Subgenus *Anoplolyda* A. Costa.*archiducalis* (Konow).
lucidus Rohwer.
sulphureipes (Kirby).
venustus (Smith).
volutilis (Smith).

Family CEPHIDÆ.

Genus *Hartigia* Schiodte and Boie.*viator* (Smith).Genus *Astatus* Jurine.*agilis* (Smith).

Family SIRICIDÆ.

Genus *Sirex* Linnæus.*antennatus* Marlatt.
japonicus Smith.
matsumuræ Rohwer.Genus *Tremex* Jurine.*longicollis* Konow.
similis Marlatt.

Family XIPHYDIDÆ.

Genus *Xiphydria* Latreille.*buyssoni* Konow.
eborata Konow.

Family ARGIDÆ.

Genus *Arge* Schrank.*captiva* (Smith).
disparilis (Kirby).
dubia (Kirby).
enodis (Linnæus).
jonasii (Kirby).
japonica (Marlatt).
mali (Matsumura).
nigrinodosa (Motschulsky).
pagana (Panzer).
quadripunctata (Kirby).
rejeeta (Kirby).
similis (Vollenhoven).
simillima (Smith).
usutulata (Linnæus).
nipponica Rohwer.

Family DIPRIONIDÆ.

[olim LOPHYRIDÆ.]

Genus *Diprion* Schrank.[olim *Lophyrus* Latreille.]*nipponica* Rohwer.
sertiferu (Fourcroy).Genus *Nesodiprion* Rohwer.*japonica* (Marlatt).

Family CIMBICIDÆ.

Genus *Cimbex* Oliver.*carinulata* Konow.
japonica Kirby.
nomuræ Marlatt.
taukushi Marlatt.
yorofui Marlatt.Genus *Agenocimbex* Rohwer.*maculata* (Marlatt).
?jucunda (Macsary).Genus *Trichiosoma* Leach.*tibialis* Stephens.Genus *Abia* Leach.*iridescens* Marlatt.
japonica Cameron.
lewisii Cameron.
pilosa Konow.
relativa Rohwer.

Family TENTHREDINIDÆ.

Genus *Cladius* Rossi.*pectinicornis* (Fourcroy).Genus *Pteronus* Jurine.*japonicus* Marlatt.Genus *Pachynematus* Konow.*alni* Rohwer.Genus *Pristiphora* Latreille.*insularis* Rohwer.Genus *Nesotomostethus* Rohwer.*religiosa* (Marlatt).Genus *Monophadnoides* Ashmead.*crassicornis* Rohwer.Genus *Paracharactus* MacGillivray.*leucopodus* Rohwer.*?nigriceps* (Smith).Genus *Monophadnus* Hartig.*fukaii* Rohwer.*genticulatus nipponica* Rohwer.*?lewisii* KirbyGenus *Aneugmenus* Hartig.*japonicus* Rohwer.Genus *Stromboceros* Konow.*koebelei* Rohwer.Genus *Athalia* Leach.*japonica* (Klug).*lugens infumata* (Marlatt).*spinarum japonensis* Rohwer.Genus *Taxonus* Hartig.Subgenus *Nesotaxonus* Rohwer.*flavescens* (Marlatt).Genus *Eriocampa* Hartig.*mitsukurii* Rohwer.Genus *Hemitaxonus* Ashmead.*japonicus* Rohwer.Genus *Strongylogasteroidea* Ashmead.*?iridipennis* (Smith).Genus *Emphytus* Klug.*japonicus* Kirby.*fuscipennis* (Smith).*nigrocæruleus* (Smith).Genus *Dolerus* Jurine.*bimaculatus* Cameron.*ephippiatus* Smith.*insulicola* Rohwer.*japonicus* Kirby.*lewisii* Cameron.*obscurus* Marlatt.*picinus* Marlatt.*subfasciatus* Smith.*umbraticus* Marlatt.Genus *Siobla* Cameron.*ferox* (Smith).*flavipes* (Smith).*pacifica* (Smith).Genus *Rhogogaster* Konow.*nipponica* Rohwer.*varipes* (Kirby).Genus *Pachyrotasis* Hartig.*erratica* Smith.*volatilis* (Smith).*pallediventris* Marlatt.Genus *Lagium* Konow.*japonicum* Rohwer.*platyceros* (Marlatt).Genus *Macrophya* Dahlbom.*apicalis* Smith.*carbonaria* Smith.*femorata* Marlatt.*fukaii* Rohwer.*ignava* Smith.*japonica* Marlatt.*luctifera*, Smith.*nigra* Marlatt.*nigropicta* Smith.*timida* Smith.*vexator* Smith.

Genus *Tenthredopsis* O. Costa.

nigropectus Kirby.

irritans (Smith).

Genus *Tenthredo* Linnæus.

[olim *Allantus* Jurine.]

kohli (Konow).

Genus *Jermakia* Jakowlew.

japonica Rohwer.

Genus *Tenthredina* Rohwer.

flavida (Marlatt).

Genus *Tenthredella* Rohwer.

[olim *Tenthredo* authors.]

adusta (Motschulsky).

fentoni (Kirby).

fuscoterminalata (Marlatt).

gifui (Marlatt).

hakonensis Rohwer.

hilaris (Smith).

montivaga (Marlatt).

providens (Smith).

xanthopus (Cameron).

xanthatarsis (Cameron).

NOTE.

The appearance of a paper on the Palæartic species of *Macrophya*^a necessitates some remarks on two Japanese species.

MACROPHYA FEMORATA, Marlatt.

Marlatt's statement concerning the length of the antennæ is wrong. In Enslin's table this runs to *quadrinaculata*, but may be distinguished from that species by the opaque head, raised frontal area, absence of the ocellar basin, and dark legs. In the type the legs are nearly black.

MACROPHYA JAPONICA, Marlatt.

This species runs in Enslin's table to *timida*, Smith, and differs from the description of that species in the yellow labrum.

^aDeutsche Ent. Zeit., vol. 5, Sept., 1910.

THE FISHES OF THE LAKE OF THE WOODS AND CONNECTING WATERS.

By BARTON WARREN EVERMANN and HOMER BARKER LATIMER,
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The fish fauna of the Lake of the Woods and its tributary waters is but little known. Very little faunal work has been done on those waters. In 1894 Prof. Albert J. Woolman, then of Duluth, Minnesota, now of Urbana, Illinois, and Prof. Ulysses O. Cox, then of the State Normal School at Mankato, Minnesota, now of the Indiana State Normal School at Terre Haute, Indiana, spent several days on Lake of the Woods, where they made the only considerable collections of fishes that have ever been obtained in that region. These collections were made under the direction of the Rathbun-Wakeham Joint Commission relative to the Preservation of the Fisheries in waters contiguous to Canada and the United States. No formal report of the work done by Woolman and Cox has been published. No list of the fishes occurring in the Lake of the Woods has ever been printed.

In August, 1908, and again in 1909, the International Fisheries Commission visited Rainy Lake and Lake of the Woods and obtained specimens of some of the food fishes as well as much valuable data concerning the fisheries of those waters.

In October, 1908, Dr. S. E. Meek, of the Field Museum of Natural History, Chicago, visited Lake of the Woods and Rainy Lake in connection with the work of the International Fisheries Commission. He collected a considerable number of specimens of the food fishes and some information concerning the fisheries of those waters. These collections and notes have been examined by the present writers, who have also studied the Woolman and Cox collections (now in the U. S. National Museum) and all other available material from that region.

Our grateful thanks are due to Mr. Paul Marschalk, of Warroad, and Capt. Arthur Johnson, of Kenora, for valuable data regarding the commercial fisheries of the Lake of the Woods. To their courtesy we are indebted for most of the statistics of the fisheries, given in this paper.

In the present paper is given an annotated list of all the species of fishes known to the writers as occurring in the Lake of the Woods, Rainy River, Rainy Lake, and their tributary waters.

The interest now attaching to the fish faunas of the boundary waters of the United States and Canada because of the treaty between the United States and Great Britain, which provides for federal control of the fisheries in those waters, makes the publication of this list of special importance and value at this time.

The fisheries of the Lake of the Woods are carried on almost exclusively by means of gill-nets and pound-nets, the former being used only on the Canadian side, while pound-nets are used in both Canadian and American waters. All the gill-net fishery grounds lie north of Little Traverse. The nets are placed in 6- to 90-foot water and the fishing season usually extends from about the middle of May to the end of October, which is practically the entire time that the lake is open.

The pound-net fishery in Canadian waters is chiefly on the east shore, about Big and Bigsby islands. The pounds are set in depths of 16 to 28 feet, and the season is the same as for gill-nets. On the American side the pound-net fisheries are on the south shore, about Buffalo Bay, Sandy Beach, Garden Island, and Oak Island, in water 10 to 24 feet deep. In the gill-net fishery meshes of 4 and 5 inches are used for yellow pike, of 5½ inches for whitefish and tullibee, and 4½ inches for jackfish.

The pound-nets are pretty uniform in construction and dimensions, the mesh being 8 inches in the leader, 4½ in the heart, and 3½ in the crib.

On the Canadian side a few fyke-nets are used for taking bull-heads. This fishery is conducted chiefly in October in 6- to 8-foot water around the edges of the marshes.

Only approximately complete statistics of the fisheries of Lake of the Woods are available; apparently complete records have never been kept. From an examination of such published records as are available and from data kindly furnished us by Mr. Paul Marschalk, of Warroad, Minnesota, and Capt. Arthur Johnson, of Kenora, Ontario, we are able to present the following tables, which, though in some cases far from complete, are of interest and value:

Pound-net catch, in pounds, of fish in American waters of Lake of the Woods.

Year.	Yellow pike.	Whitefish.	Jackfish.	Sturgeon.	Total pounds.
1905.....	173,451	65,560	43,887	72,770	355,668
1906.....	129,214	78,041	88,785	34,710	330,750
1907.....	193,079	258,534	96,135	80,123	627,871
1908.....	403,256	207,195	246,993	87,182	944,626

Oak Island pound-net catch, in pounds.

Year.	Yellow pike.	Whitefish.	Jackfish.	Sturgeon.	Total pounds.
1900.....	54,386	21,795	21,685	26,696	124,562
1902.....	60,545	51,469	30,203	50,943	193,160
1907.....	48,050	169,135	32,710	32,678	282,573
1908.....	110,905	101,005	59,465	34,385	305,760

Pound-net catch of whitefish, yellow pike, jackfish, and sturgeon in Lake of the Woods from 1888 to 1909.

Year.	United States.		Canada.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1888.....	95,000	\$2,375			95,000	\$2,375
1889.....	265,000	6,625			265,000	6,625
1890.....	470,000	7,050			470,000	7,050
1891.....	960,000	19,200			960,000	19,200
1892.....	1,521,000	37,481	115,000	\$2,850	1,636,000	40,331
1893.....	2,250,000	61,750	429,300	12,432	2,679,300	74,182
1894.....	2,106,554	58,898	570,000	16,600	2,676,554	75,498
1895.....	2,023,272	59,437	740,000	21,900	2,763,272	81,337
1896.....	1,580,000	46,600	665,000	19,800	2,245,000	66,400
1897.....	768,802	25,136	307,994	10,169	1,076,796	35,305
1898.....	591,514	23,777	395,900	17,695	987,414	41,472
1899.....	541,468	21,771	228,084	10,821	769,552	32,592
1900.....	325,000	14,465	102,334	5,313	427,334	23,584
1901.....	395,000	16,825	86,142	4,220	481,142	21,045
1902.....	460,000	19,700	123,174	5,752	583,174	25,452
1903.....	423,331	15,969	83,000	3,840	506,331	19,809
1904.....	360,000	14,945	107,910	4,775	467,910	19,720
1905.....	355,668	14,553	140,100	7,033	495,768	21,586
1906.....	330,750	11,696	57,700	2,744	388,450	14,440
1907.....	627,871	32,017	266,162	16,726	894,032	48,743
1908.....	944,626	44,467	354,798	18,389	1,299,424	62,856
1909.....	483,451	28,051	240,767	14,142	724,218	42,193
Total.....	17,878,306	582,788	5,013,365	195,201	22,891,671	781,795

Value f. o. b. barge, shipping point.

Gill-net catch of whitefish, yellow pike, and jackfish in Canadian waters of Lake of the Woods from 1892 to 1909.

Year.	Pounds.	Value.	Year.	Pounds.	Value.
1892.....	41,000	\$1,000	1902.....	235,000	\$7,625
1893.....	350,000	8,600	1903.....	160,000	5,300
1894.....	449,280	12,727	1904.....	220,000	7,500
1895.....	150,000	4,400	1905.....	240,650	7,823
1896.....	145,000	4,200	1906.....	193,100	6,277
1897.....	180,000	5,200	1907.....	179,338	7,776
1898.....	150,500	2,950	1908.....	167,757	6,978
1899.....	145,000	4,200	1909.....	366,588	18,948
1900.....	120,181	3,806			
1901.....	170,000	5,450	Total.....	3,663,394	120,760

Value f. o. b. shipping point.

Total pound-net and gill-net catch of sturgeon, yellow pike, whitefish, and jackfish in Lake of the Woods from 1888 to 1909.

Year.	United States.		Canada.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1888.....	95,000	\$2,375				
1889.....	265,000	6,625				
1890.....	470,000	7,050				
1891.....	960,000	19,200				
1892.....	1,521,000	37,481	156,000	\$3,850	1,677,000	\$41,331
1893.....	2,250,000	61,750	779,300	21,032	3,029,300	82,782
1894.....	2,106,554	58,898	1,019,280	29,327	3,125,834	88,225
1895.....	2,023,272	59,437	890,000	26,300	2,913,272	85,737
1896.....	1,580,000	46,600	810,000	24,000	2,390,000	70,600
1897.....	768,802	25,136	487,994	15,369	1,256,796	40,505
1898.....	591,514	23,777	546,400	22,005	1,137,914	45,782
1899.....	541,468	21,771	373,084	15,021	914,552	36,792
1900.....	325,000	14,465	222,515	9,119	547,515	23,584
1901.....	395,000	16,825	256,142	9,670	651,142	26,495
1902.....	460,000	19,700	358,174	13,377	818,174	3,077
1903.....	423,331	15,969	243,000	9,140	666,331	25,109
1904.....	360,000	14,945	327,910	12,275	687,910	27,220
1905.....	355,668	14,553	380,750	14,856	736,418	29,409
1906.....	330,750	11,696	250,800	9,021	581,550	20,717
1907.....	627,870	32,017	445,500	24,502	1,073,370	56,519
1908.....	944,626	44,467	522,555	25,367	1,467,181	69,834
1909.....	483,451	28,051	607,355	33,090	1,090,806	61,141
Total.....	17,878,306	582,788	8,676,759	317,321	24,765,065	864,850

Value f. o. b. barge, shipping point. All totals, 26,555,065 pounds, \$900,109.

Fishing gear used in Lake of the Woods (Canadian waters).

Year.	Gill nets.			Pound nets.		Hoop nets.	
	Number.	Yards.	Value.	Number.	Value.	Number.	Value.
1893.....		28,220	\$2,640	2	\$350		
1894.....		27,700	3,436	14	1,750	2	\$45
1895.....		30,860	1,320	76	12,690	10	400
1896.....	151	48,000	1,620	127	30,150		
1897.....	65	28,000	1,200	60	9,000	15	500
1898.....	35	14,000	1,250	28	3,300		
1899.....		10,000	955	34	3,500		
1900.....		22,200	2,200	30	3,500		
1901.....		4,000	1,000	24	1,800		
1902.....		13,500	1,900				
1903.....		22,000	3,080	12	2,500		
1904.....		22,000	3,025	12	3,500		
1905.....		55,200	9,255	12	3,500		
1906.....		16,000	1,950	14	4,000		
1907.....		12,000	1,625	14	2,000		
1908.....		12,000	1,755	14	3,000	3	75

Number and value of pound-nets in Lake of the Woods from 1888 to 1910.

Year.	American waters.		Canadian waters.		Total.	
	Nets.	Value.	Nets.	Value.	Nets.	Value.
1888.....	4	\$400			4	\$400
1889.....	10	1,000			10	1,000
1890.....	17	1,700			17	1,700
1891.....	21	2,100			21	2,100
1892.....	52	5,200	2	\$200	54	5,400
1893.....	91	9,100	4	400	95	9,500
1894.....	146	14,600	20	2,000	166	16,600
1895.....	193	19,300	100	10,000	293	29,300
1896.....	193	19,300	127	12,700	320	32,000
1897.....	145	14,500	70	7,000	215	21,500
1898.....	107	10,700	40	4,000	147	14,700
1899.....	107	10,700	31	3,400	141	14,100
1900.....	81	8,100	30	3,000	111	11,100
1901.....	74	7,400	24	2,400	98	9,800
1902.....	68	6,800	14	1,400	82	8,200
1903.....	68	6,800	12	1,200	80	8,000
1904.....	62	6,200	12	1,200	74	7,400
1905.....	66	6,600	12	1,200	78	7,800
1906.....	56	5,600	14	1,400	70	7,000
1907.....	50	5,000	14	1,400	64	6,400
1908.....	54	5,400	14	1,400	68	6,800
1909.....	79	7,900	14	1,400	93	9,300
1910.....	90	9,000	14	1,400	104	10,400

Number and value of boats on Lake of the Woods (Canadian side).

Year.	Vessels or tugs.				Boats.		
	Number.	Tonnage.	Value.	Men.	Number.	Value.	Men.
1893.....	1	25	\$1,200	4	21	\$700	41
1894.....	1	48	4,000	6	50	1,350	100
1895.....	6	110	16,200	19	66	4,430	119
1896.....	11	714	17,050	38	81	8,760	151
1897.....	10	304	13,300	27	34	2,650	90
1898.....	4	54	5,800	14	24	2,450	48
1899.....	3	38	4,500	10	20	950	49
1900.....	6	62	4,250	13	13	625	26
1901.....	4	30	5,050	10	11	580	21
1902.....					15	1,300	36
1903.....	4	100	8,000	10	13	1,350	46
1904.....	4	100	8,000	12	19	3,675	40
1905.....	5	165	8,500	14	43	7,775	86
1906.....	4	160	6,000	12	13	2,450	26
1907.....	4	300	6,000	12	9	1,950	19
1908.....	2	150	5,100	6	9	2,225	22

Rainy Lake catch for 1908.

Species.	Catch in pounds.	Value.
Pike.....	20,000	\$900
Whitefish.....	40,000	1,800
Jackfish.....	55,000	825
Suckers.....	41,000	205
Sturgeon.....	4,000	320
Total.....	160,000	4,050

LIST OF SPECIES.

In the following list we include only those species of which we have seen specimens from the Lake of the Woods, Rainy River, Rainy Lake, or their connecting waters.

1. *ICHTHYOMYZON CONCOLOR* (Kirtland).

SILVERY LAMPREY.

Two specimens obtained August 10 by Woolman and Cox at Garden Island, Lake of the Woods. Numerous specimens obtained in 1894 by the Minnesota Natural History Survey. Doubtless abundant; often parasitic on the sturgeon.

Infraoral cusps 7.

2. *ACIPENSER RUBICUNDUS* Le Sueur.

GREAT LAKES STURGEON.

Lake of the Woods is the greatest sturgeon pond in the world. Up to about 1892 sturgeon swarmed in this lake in almost incredible numbers. In that year the sturgeon fishery began to assume considerable proportions. By 1893 to 1896 it had become of great importance. In 1893 the catch in American waters amounted to 1,300,000 pounds, valued at \$26,000. The yield of caviar in the same year amounted to 97,500 pounds, valued at \$19,500; and the amount of sturgeon sounds was 5,830 pounds, valued at \$5,830. Thus the total for 1893 was 1,403,330 pounds, valued at \$51,330. By 1903 the sturgeon catch had dwindled to 45,239 pounds, worth \$2,714, and the caviar taken in that year amounted to only 1,550 pounds, valued at \$1,240. Since 1903 the catch of sturgeon has fluctuated somewhat, but has always been low. In 1908, in American waters, it amounted to 87,182 pounds, worth \$8,718.

According to local fishermen there has been a slight increase in the number of sturgeon within the last few years. They constitute a large part of the pound-net catch.

A 4-foot sturgeon will dress about 15 pounds, which is too small for a minimum size; it would be better to make 20 pounds dressed the minimum.

The spawning season is in the spring and is probably over by the end of May. The principal, if not the only, spawning ground is Rainy River.

The table following gives the statistics of the sturgeon fishery for the Lake of the Woods from 1893 to and including 1909, for both American and Canadian waters, as complete as can be compiled from available figures.

Yield of the sturgeon fishery of Lake of the Woods from 1888 to 1909.

Products.	United States.		Canada.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1888.						
Sturgeon.....	40,000	\$400			40,000	\$400
Caviar.....	3,000	300			3,000	300
Sounds.....	160	160			160	160
1889.						
Sturgeon.....	100,000	1,000			100,000	1,000
Caviar.....	7,500	750			7,500	750
Sounds.....	313	313			313	313
1890.						
Sturgeon.....	200,000	2,000			200,000	2,000
Caviar.....	15,000	1,500			15,000	1,500
Sounds.....	630	630			630	630
1891.						
Sturgeon.....	500,000	5,000			500,000	5,000
Caviar.....	22,500	2,250			22,500	2,500
Sounds.....	1,575	1,575			1,575	1,575
1892.						
Sturgeon.....	800,000	12,000	80,000	\$1,200	880,000	13,200
Caviar.....	60,000	12,000	6,000	1,200	66,000	13,200
Sounds.....	3,300	3,300	330	330	3,630	3,630
1893.						
Sturgeon.....	1,300,000	26,000	350,000	7,000	1,650,000	33,000
Caviar.....	97,500	19,500	26,250	5,250	123,750	24,750
Sounds.....	5,830	5,830	1,450	1,450	7,280	7,280
1894.						
Sturgeon.....	1,059,267	21,185	400,000	8,000	1,459,267	29,185
Caviar.....	79,350	15,870	30,000	6,000	109,350	21,870
Sounds.....	4,413	4,413	1,660	1,660	6,079	6,079
1895.						
Sturgeon.....	1,143,072	22,861	500,000	10,000	1,643,072	32,861
Caviar.....	85,650	25,695	37,500	8,250	123,150	33,945
Sounds.....	4,763	4,763	2,083	2,083	6,846	6,846
1896.						
Sturgeon.....	1,000,000	20,000	500,000	10,000	1,500,000	30,000
Caviar.....	75,000	23,500	37,500	11,250	112,500	34,750
Sounds.....	4,166	4,166	2,083	2,083	6,249	6,249
1897.						
Sturgeon.....	511,159	12,779	214,154	5,353	725,313	18,132
Caviar.....	30,000	18,000	13,000	7,800	43,000	25,800
Sounds.....	1,703	1,703	714	714	2,417	2,417
1898.						
Sturgeon.....	330,033	13,201	295,900	11,836	625,933	25,037
Caviar.....	16,500	13,200	14,700	11,576	31,200	24,776
Sounds.....	1,375	1,375	1,232	1,232	2,607	2,607
1899.						
Sturgeon.....	197,601	9,880	135,984	6,799	333,585	16,679
Caviar.....	7,350	5,880	5,100	4,080	12,450	9,960
Sounds.....	823	823	566	566	1,389	1,389
1900.						
Sturgeon.....	100,000	6,000	52,334	3,140	152,334	9,140
Caviar.....	3,750	3,000	1,350	1,080	5,100	4,080
Sounds.....	416	416	218	218	634	634
1901.						
Sturgeon.....	100,000	6,000	37,367	2,241	137,367	8,241
Caviar.....	3,750	3,000	1,200	960	4,950	3,960
Sounds.....	416	416	155	155	571	571

Yield of the sturgeon fishery of Lake of the Woods from 1888 to 1909—Continued.

Products.	United States.		Canada.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1902.						
Sturgeon.....	120,000	\$7,200	44,049	\$2,643	164,049	\$9,843
Caviar.....	4,300	3,440	1,500	1,200	5,500	4,660
Sounds.....	500	375	183	138	683	513
1903.						
Sturgeon.....	45,239	2,714	31,000	1,860	76,239	4,574
Caviar.....	1,550	1,240	850	680	2,230	1,920
Sounds.....	111	83	78	59	189	142
1904.						
Sturgeon.....	80,000	4,800	41,950	2,517	121,950	7,317
Caviar.....	2,300	1,840	650	520	2,950	2,490
Sounds.....	266	133	106	53	372	186
1905.						
Sturgeon.....	72,770	4,364	63,800	3,828	136,570	8,192
Caviar.....	1,100	880	480	384	1,580	1,264
Sounds.....	243	122	212	106	455	228
1906.						
Sturgeon.....	34,710	1,877	15,000	1,200	49,710	3,077
Caviar.....	750	750	300	300	1,050	1,050
Sounds.....	123	61	50	25	173	86
1907.						
Sturgeon.....	80,122	8,012	83,900	8,390	164,022	16,402
Caviar.....	700	700	900	900	1,600	1,600
Sounds.....	210	105	226	113	436	218
1908.						
Sturgeon.....	87,182	8,718	54,385	5,438	141,567	14,154
Caviar.....	630	787	580	725	1,210	1,512
Sounds.....	230	115	165	82	395	197
1909.						
Sturgeon.....	34,021	4,082	19,295	2,315	53,316	6,397
Caviar.....	346	519	383	574	729	1,093
Sounds.....	120	60	64	32	184	92
Total.....	8,745,688	385,611	2,608,936	167,588	11,593,860	553,603

Sounds given in pounds. Value figured as per prices paid to the fishermen at their fisheries.

The shallow waters of Lake of the Woods are peculiarly adapted to the habits of the sturgeon, which delights to frequent comparatively shoal water. Its food consists largely of crawfishes and the smaller gasteropods, such as the thin-shelled *Physa*, the equally fragile *Planorbis* and *Valvata*, and the more firm *Limnæa* and *Melantho*. Though primarily a bottom feeder, it by no means confines its menu to the food found thereon; for small fishes constitute no inconsiderable portion of its bill of fare. On August 9, 1894, Professor Woolman examined the stomach contents of 55 sturgeon at Garden Island, Lake of the Woods. Of these, 28 contained one or more crawfish, 6 had insect larvæ, 6 contained mollusks, and 22 were empty. Among the miscellaneous objects found were a fish egg of some sort in one, a fish vertebra in one, a hazelnut in another, and gravel in eight.

The senior author in September, 1894, examined the stomach contents of several Oregon sturgeon (a related species) in Snake River near Weiser, Idaho. A young individual 25 inches long contained 11 minnows. In the stomachs of larger examples were found several suckers (*Catostomus macrocheilus*), each about a foot in length. In the lower Columbia the Oregon sturgeon is said to feed largely on sardines, smelts, and other small fishes, and lamprey eels are regarded as excellent sturgeon bait.

The great decrease in the sturgeon catch of the Lake of the Woods is without doubt chiefly due to overfishing, although it is claimed by local interests that recent years show a slight increase in the catch, and the statistics sustain this contention. There is no evidence that the sturgeon have actually increased in abundance. This increased catch is more likely due to closer fishing rather than to an actual increase in the abundance of the species. The International Fisheries Commission is of the opinion that all sturgeon fishing in these waters should cease for a period of four years.

3. *AMIA CALVA* Linnæus.

DOGFISH; BOWFIN.

Probably not uncommon; of no value as food.

4. *AMEIURUS MELAS* (Rafinesque).

BLACK BULLHEAD.

One specimen from Rapid River, August 9. Probably common.

5. *CARPIODES THOMPSONI* Agassiz.

CARP SUCKER.

One specimen from Stevens Point.

Common; one of the most abundant fishes in this lake. Reaches a large size, and is of some value as a food fish.

An example taken in Lake Champlain about April 23, 21 inches long, weighed 7 pounds. It was a nearly ripe female and the roe alone weighed 2.5 pounds.

6. *CATOSTOMUS CATOSTOMUS* (Forster).

NORTHERN SUCKER; RED SUCKER; MEETHQUAMAYPATH OF THE CREES.

Thirty-two specimens, $1\frac{1}{2}$ to $3\frac{1}{2}$ inches long, from Falls River, August 8, and one, $1\frac{7}{8}$ inches long, from mouth of Rapid River, August 9.

Abundant, and of some value as a food fish.

7. *CATOSTOMUS COMMERSONII* (Lacépède).

WHITE SUCKER; FINE-SCALED SUCKER; CARPE BLANCHE; NAMAYPEETH OF THE CREES.

One specimen, $1\frac{3}{4}$ inches long, from Rapid River, August 9, and others obtained in Lake of the Woods.

Less abundant than the preceding.

8. CATOSTOMUS NIGRICANS Le Sueur.

BLACK SUCKER; HOG SUCKER.

Two specimens from Oak Island, August 10; eight from Stevens Point, August 6; and two from Rat Portage, off Coney Island, August 3.

9. MOXOSTOMA ANISURUM (Rafinesque)

REDHORSE.

One specimen from the mouth of Rainy River, August 8, and one, $3\frac{3}{8}$ inches long, from Rapid River, August 9.

Not uncommon.

10. MOXOSTOMA AUREOLUM (Le Sueur).

REDHORSE.

One specimen, $3\frac{3}{4}$ inches long, from the mouth of Rainy River, August 7; two, $1\frac{3}{8}$ and $2\frac{1}{8}$ inches long, from Rapid River, August 9; one, $2\frac{3}{4}$ inches long, from Garden Island, August 10; and one from Oak Island, August 10.

Abundant, and of considerable value as a food fish.

11. PIMEPHALES PROMELAS Rafinesque.

BULLHEAD MINNOW.

Probably abundant, as it is in most waters of northern Minnesota.

12. PIMEPHALES NOTATUS (Rafinesque).

BLUNT-NOSED MINNOW.

Common; often associated with the preceding.

13. SEMOTILUS ATROMACULATUS (Mitchill).

CREEK CHUB.

Common.

14. NOTROPIS CAYUGA Meek.

Two specimens, $2\frac{1}{8}$ and $2\frac{1}{4}$ inches long, from the mouth of Warroad Creek, Lake of the Woods, August 8, and two, $2\frac{1}{8}$ and $2\frac{1}{4}$ inches long, from Rat Portage, August 3.

Common.

15. NOTROPIS BLENNIUS (Girard).

STRAW-COLORED MINNOW.

Three specimens from Garden Island, August 10, and seven from Oak Island, August 10.

16. NOTROPIS HUDSONIUS (De Witt Clinton).

SHINER; SPAWN-EATER.

Twelve specimens, $1\frac{7}{8}$ to $3\frac{1}{2}$ inches long, from Rat Portage, August 3; five, $1\frac{1}{8}$ to $3\frac{7}{8}$ inches long, from Stevens Point, August 6; seven, $2\frac{3}{8}$ to

$3\frac{3}{8}$ inches long, from the mouth of Rainy River, August 7; four, $1\frac{1}{8}$ to $1\frac{1}{4}$ inches long, from the Rainy River, August 8; twelve, $2\frac{3}{4}$ to $3\frac{1}{2}$ inches long, from Rapid River; two, $3\frac{1}{2}$ inches long, from Garden Island, August 10; ten, $1\frac{1}{4}$ to $3\frac{5}{8}$ inches long, from Oak Island, August 10; and one from mouth of Rainy River, August 7.

Perhaps the most abundant minnow in these waters; doubtless constitutes a large part of the food of the carnivorous species.

17. NOTROPIS CORNUTUS (Mitchill).

SILVERSIDE.

Fifteen specimens, $2\frac{1}{8}$ to $2\frac{7}{8}$ inches long, from Stevens Point, August 6.

Common, and of importance as food for other fishes.

18. NOTROPIS JEJUNUS (Forbes).

Eleven specimens, $2\frac{1}{4}$ to $2\frac{3}{4}$ inches long, from Stevens Point, August 6; ten, $2\frac{1}{2}$ to $3\frac{3}{4}$ inches long, from the mouth of Rainy River, August 7; eight from Garden Island, August 10; sixteen from Oak Island, August 10; four from Asmus Point, August 7; and sixteen from mouth of Rainy River, August 7 and 8.

Apparently abundant.

19. NOTROPIS ATHERINOIDES Rafinesque.

Five specimens from Oak Island; ten, $2\frac{1}{4}$ to $3\frac{1}{2}$ inches long, from Stevens Point, August 6; and five, $2\frac{3}{4}$ to $2\frac{7}{8}$ inches long, from Asmus Point.

Common.

20. NOTROPIS RUBRIFRONS (Cope).

Four specimens from Rapid River, August 9, and twenty-four, from Asmus Point, August 7.

Common.

21. NOTROPIS UMBRATILIS CYANOCEPHALUS (Copeland).

One specimen, $1\frac{3}{4}$ inches long, from Rat Portage, August 3, and fifty-three, $1\frac{1}{2}$ to $3\frac{5}{8}$ inches long, from Rapid River, August 9.

22. RHINICHTHYS CATARACTÆ (Cuvier and Valenciennes).

NIAGARA DACE.

Three specimens, $2\frac{1}{8}$ to $2\frac{1}{2}$ inches long, from Rapid River, August 9. Not abundant.

23. RHINICHTHYS ATRONASUS (Mitchill).

BLACK-NOSED DACE.

One specimen $1\frac{7}{8}$ inches long from Falls River, August 8, and four $1\frac{1}{2}$ to $2\frac{1}{8}$ inches long, from Rapid River, August 9.

More common than preceding.

24. AMPHIODON ALOSOIDES Rafinesque.

GOLDEYE.

The goldeye is common in Lake of the Woods where numerous specimens were obtained by Doctor Meek. Although an excellent food fish and extensively utilized at Winnipeg it is not much used at this lake. Occasionally shipments are made to Winnipeg. Smoked, it is really delicious, and as a pan fish it is excellent. Sir John Richardson says: "The flesh is white, resembling that of the perch in flavor, but excelling it in richness."

There is no good reason why the fishery for this interesting species should not be developed and become of considerable importance.

25. HIODON TERGISUS Le Sueur.

MOONEYE; TOOTHED HERRING.

Three small specimens from Oak Island, August 10; one from mouth of Rainy River, and one from Stevens Point.

Probably less common than the preceding. This species is not valued as a food fish.

26. COREGONUS CLUPEAFORMIS (Mitchill).

LABRADOR WHITEFISH.

Abundant, and a valued food fish. The common whitefish (*Coregonus albus*) of Lake Erie apparently does not occur in the Lake of the Woods nor in any of its connecting waters.

Catch of whitefish in Lake of the Woods from 1888 to 1909.

Year.	United States.		Canada.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1888.....	20,000	\$200	.....	.....	20,000	\$200
1889.....	60,000	600	.....	.....	60,000	600
1890.....	100,000	1,000	.....	.....	100,000	1,000
1891.....	175,000	1,750	.....	.....	175,000	1,750
1892.....	250,000	3,750	30,000	\$450	280,000	4,200
1893.....	350,000	5,250	309,300	4,639	659,300	9,889
1894.....	411,018	8,220	449,280	8,985	860,298	17,205
1895.....	280,563	5,611	230,000	4,600	510,563	10,211
1896.....	200,000	4,000	180,000	3,600	380,000	7,600
1897.....	71,907	1,438	160,000	3,200	231,987	4,638
1898.....	112,624	2,252	100,000	2,000	212,624	4,252
1899.....	179,242	3,584	80,000	1,600	259,242	5,184
1900.....	85,000	2,115	50,000	1,250	135,000	3,365
1901.....	115,000	2,875	60,000	1,500	175,000	4,375
1902.....	130,000	3,250	85,000	2,125	215,000	5,375
1903.....	110,048	2,751	80,000	2,000	190,048	4,751
1904.....	65,000	1,625	93,000	2,325	158,000	3,950
1905.....	65,560	1,639	115,000	2,885	180,560	4,524
1906.....	78,041	1,951	85,000	2,125	163,041	4,076
1907.....	258,534	9,048	165,000	5,775	423,534	14,823
1908.....	207,195	7,251	180,000	6,300	387,195	13,551
1909.....	140,642	7,031	220,000	11,000	360,642	18,031
Total.....	3,465,374	77,391	2,671,580	56,359	6,137,034	143,630

Value as per prices paid fishermen at their fisheries.

27. LEUCICHTHYS TULLIBEE (Richardson).

TULLIBEE.

Five specimens, 2¼ to 5¾ inches long, from Kettle Falls, Rainy Lake, Minnesota, July 26, 1895; also obtained by Doctor Meek in October, 1908.

Abundant; less valued as a food fish than the preceding species.

28. CRISTIVOMER NAMAYCUSH (Walbaum).

LAKE TROUT.

Said to be very rare; perhaps most frequent in Whitefish Bay.

29. LUCIUS LUCIUS (Linnæus).

COMMON PIKE; PICKEREL; JACKFISH.

This fish is variously known in the Lake of the Woods district as jack, jackfish, grass pike, or pickerel, where it is an abundant and important food fish. In the American waters of the Lake of the Woods this fish is taken in pound nets set in 10 to 24 feet of water at Buffalo Bay, Sandy Beach, Garden Island, and Oak Island. The nets are the same as those used for whitefish. The jackfish average 2 feet in length and 5 pounds in weight. Their spawning season is in April, in marshy and grassy places in shallow water. They are voracious fish and feed largely on other fishes. The usual price received by the fishermen is 2½ cents a pound; the wholesale price 3½ cents.

Catch of jackfish in Lake of the Woods from 1888 to 1909.

Year.	United States.		Canada.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1888.....	10,000	\$100			10,000	\$100
1889.....	30,000	300			30,000	300
1890.....	50,000	500			50,000	500
1891.....	85,000	850			85,000	850
1892.....	115,000	1,150	10,000	\$100	125,000	1,250
1893.....	200,000	2,000	40,000	400	240,000	2,400
1894.....	231,165	2,311	80,000	800	311,165	3,111
1895.....	125,861	1,258	40,000	400	165,861	1,658
1896.....	80,000	800	30,000	300	110,000	1,100
1897.....	48,275	482	33,760	337	82,035	819
1898.....	56,676	566	30,500	305	87,176	871
1899.....	39,903	399	25,000	250	64,903	649
1900.....	40,000	600	50,000	750	90,000	1,350
1901.....	50,000	750	60,000	900	110,000	1,650
1902.....	60,000	900	70,000	1,050	130,000	1,950
1903.....	42,963	644	44,900	673	87,863	1,317
1904.....	45,000	670	66,900	1,003	111,900	1,673
1905.....	43,887	658	71,300	1,069	115,187	1,727
1906.....	88,785	1,331	58,100	871	146,885	2,202
1907.....	96,135	1,922	66,600	1,332	162,735	3,254
1908.....	246,993	4,939	111,889	2,237	358,882	7,176
1909.....	133,354	3,333	188,060	4,701	321,414	8,034
Total.....	1,918,997	26,463	1,077,009	17,478	2,996,006	43,941

Value as per prices paid to fishermen at their fisheries.

30. *EUCALIA INCONSTANS* (Kirtland).**BROOK STICKLEBACK.**

One specimen $1\frac{7}{8}$ inches long, from Rapid River, August 9.
Probably common.

31. *PERCOPSIS GUTTATUS* Agassiz.**TROUT PERCH.**

Two specimens from Stevens Point, August 6; five from Rapid River, August 9, and three from Rat Portage, August 3.

32. *POMOXIS SPAROIDES* (Lacépède).**CALICO BASS.**

One specimen from the mouth of Rainy River, August 8; eight, $1\frac{7}{8}$ to $2\frac{1}{4}$ inches long, from Rapid River, August 9; four, $1\frac{5}{8}$ to 2 inches long, from Oak Island, August 10; one, $2\frac{1}{4}$ inches long, from Garden Island, August 10, and three, $\frac{7}{8}$ to 2 inches long, from Rat Portage, August 3.

33. *AMBLOPLITES RUPESTRIS* (Rafinesque).**ROCK BASS.**

Apparently not common; one specimen obtained by Doctor Meek at Baudette, on Rainy River.

34. *STIZOSTEDION VITREUM* (Mitchill).**WALLEYED PIKE; YELLOW PIKE; DORÉ.**

Numerous specimens from Stevens Point, Asmus Point, Oak Island, Rat Portage, Rapid River, and mouth of Rainy River.

The walleyed pike is one of the most valuable fishes of Lake of the Woods, in which it occurs in abundance and in the dark but clear waters of which it reaches its highest development.

The yellow pike fishery in American waters of the Lake of the Woods is carried on at South Shore, Buffalo Bay, Sandy Beach, Garden Island, and Oak Island by means of pound nets set in 10 to 24 feet of water. The mesh of these nets is 8 inches in the leader, $4\frac{1}{2}$ in the heart, and $3\frac{1}{2}$ in the crib. The fishing season is normally from May 20 to the last of October. The average length of the fish taken is about 16 inches and the weight 3 pounds. The fishermen receive 5 cents a pound, and the average wholesale price is 6 to 7 cents.

The yellow pike spawns in these waters from the latter part of April to May 15, or perhaps as late as May 30, or soon after the ice goes out. The spawning grounds are near shore on gravel bottom, along whole shore line.

Catch of yellow pike in Lake of the Woods from 1888 to 1909.

Year.	United States.		Canada.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1888.....	25,000	\$250	.....	.....	25,000	\$250
1889.....	75,000	750	.....	.....	75,000	750
1890.....	120,000	1,200	.....	.....	120,000	1,200
1891.....	200,000	2,000	.....	.....	200,000	2,000
1892.....	300,000	4,500	36,000	\$540	336,000	5,040
1893.....	400,000	6,000	80,000	1,200	480,000	7,200
1894.....	405,104	6,076	90,000	1,350	495,104	7,426
1895.....	473,776	9,475	120,000	2,400	593,776	11,875
1896.....	300,000	6,000	100,000	2,000	400,000	8,000
1897.....	137,461	2,749	80,000	1,600	217,461	4,349
1898.....	92,181	1,843	120,000	2,400	212,181	4,243
1899.....	124,722	2,494	132,100	2,642	256,822	5,136
1900.....	100,000	2,500	70,181	1,754	170,181	4,254
1901.....	130,000	3,250	98,775	2,468	228,775	5,718
1902.....	150,000	3,750	159,125	3,978	309,125	7,728
1903.....	225,081	5,627	87,100	2,177	312,181	7,804
1904.....	170,000	4,250	126,060	3,151	296,060	7,401
1905.....	173,451	4,336	130,650	3,266	304,101	7,602
1906.....	129,214	3,230	92,700	2,317	221,914	5,547
1907.....	193,079	6,757	130,000	4,550	323,079	11,307
1908.....	403,256	14,113	176,281	6,169	579,527	20,282
1909.....	175,434	8,771	180,000	9,000	355,434	17,771
Total.....	4,502,759	99,921	2,008,972	52,962	6,511,731	152,883

Value as per prices paid to fishermen at their fisheries.

35. STIZOSTEDION CANADENSE (Smith).

SAUGER; SAND PIKE.

Obtained by Doctor Meek at Baudette. Not common.

The catch of saugers in the commercial fisheries is combined with that of yellow pike, all being sold as yellow pike.

36. PERCA FLAVESCENS (Mitchill).

YELLOW PERCH.

Common, especially in the lakes. Specimens are in the collections from Rat Portage, Oak Island, Garden Island, Asmus Point, Stevens Point, Rainy River, Falls River, and Rapid River, all taken in August. Doctor Meek saw none at Baudette when he was there in October.

37. PERCINA CAPRODES ZEBRA (Agassiz).

LOG PERCH.

Five specimens, $1\frac{3}{4}$ to 2 inches long, from Stevens Point, August 6, and two $1\frac{1}{4}$ and $1\frac{7}{8}$ inches long, from Oak Island, August 10.

38. HADROPTERUS GUNTHERI (Eigenmann and Eigenmann).

Eight specimens, $1\frac{1}{8}$ to $1\frac{1}{2}$ inches long, from Rapid River, August 9; fourteen, $1\frac{1}{4}$ to $1\frac{7}{8}$ inches long, from the mouth of Rainy River; and two, $1\frac{1}{4}$ and 2 inches long, from Stevens Point.

39. *BOLEOSOMA NIGRUM* (Rafinesque).

JOHNNY DARTER.

Forty-two specimens, $1\frac{1}{2}$ to $2\frac{1}{8}$ inches long, from Rat Portage, August 3; three, $1\frac{1}{4}$ to $1\frac{3}{4}$ inches long, from the mouth of Rainy River, August 8; and one, $1\frac{1}{8}$ inches long, from White Oak Lake at Deer River, August 21.

40. *LOTA MACULOSA* (Le Sueur).

LING; LAWYER; EEL POUT.

One of the most abundant fishes in Lake of the Woods and one of the most useless. It is very destructive to other fishes, particularly whitefish, of which it will take examples of its own size or even larger.

Although there is no market for the ling and it is regarded as worthless at Lake of the Woods, it is in truth a very good food fish, and it ought to be possible to develop a market for it.

DESCRIPTION OF A NEW SPECIES OF ANILOCRA FROM
THE ATLANTIC COAST OF NORTH AMERICA.

By HARRIET RICHARDSON,

Collaborator, Division of Marine Invertebrates, U. S. National Museum.

Through the Biological Survey of the U. S. Department of Agriculture, three specimens of a new species of *Anilocra* were sent to the U. S. National Museum by Mr. W. J. Hoxie, of the Natural History Society of Savannah, Ga. This is the third species of the genus known from the Atlantic coast of North America, the two species previously described being *Anilocra laticauda* Milne Edwards and *A. plebeia* Schiøedte and Meinert.

ANILOCRA ACUTA, new species.

Body 34 mm. long and 12 mm. wide. Surface smooth.

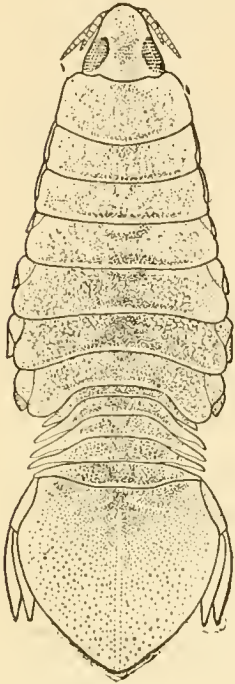
Color yellow, marked with numerous brown dots, which in the middle of the dorsal surface of the last three segments of the thorax almost merge into a dark brown background, leaving a few wavy light areas on either side of the median line.

The head is as long as wide, 4 mm. by 4 mm. The lateral margins converge slightly to a widely rounded anterior extremity. The eyes are large (1 mm. wide and 2 mm. long), distinct and composite, and are placed in the post-lateral angles. The antennæ of the first pair are composed of eight articles and extend to the middle of the eye on the lateral margin. The antennæ of the second pair are composed of ten articles and reach the posterior margin of the head.

The first segment of the thorax is the longest, 3 mm.; the five following segments are subequal, each about 2 mm. in length; the seventh segment is the shortest, 1½ mm. The thorax widens gradually from the first segment, which is 7 mm. wide, to the sixth, which is 12 mm. wide. Epimera are present on all the segments with the exception of the first; those of the second and third segments are narrow, elongate, and posteriorly rounded; the last four

are more acute at their extremities. The epimera of all the segments reach the post-lateral angles of their respective segments.

The first segment of the abdomen is the shortest, one-half mm. long; the three following are subequal, each being 1 mm. in length; the fifth segment is $1\frac{1}{2}$ mm. The lateral parts of the segments are drawn out posteriorly in acute processes. The sixth or terminal segment is as long as wide, 9 mm. by 9 mm. At the base it is 8 mm. and then widens a little before converging to a triangular extremity with the apex rounded. The branches of the uropoda are equal in length and do not reach the tip of the terminal abdominal segment by nearly 2 mm.; the outer branch is produced to an acute extremity; the inner branch is oblique, with the outer post-lateral angle acutely produced; the inner branch is somewhat wider than the outer branch.



ANILOCRA ACUTA. $\times 2$.

All the legs are prehensile.

Three specimens were taken from a gar-pike.

Type-specimen.—Cat. No. 40939, U.S.N.M.

This species differs from the other two found on the Atlantic coast, in the larger head, shorter antennæ, larger eyes, which are also closer together, in the shape of the head and the terminal abdominal segment, the much shorter uropoda, and in the shape of the uropoda.

A NEW SPECIES OF CESTODE PARASITE (TÆNIA BALANCEPS) OF THE DOG AND OF THE LYNX, WITH A NOTE ON PROTEOCEPHALUS PUNICUS.

By MAURICE C. HALL,

Junior Zoologist, Bureau of Animal Industry.

The tapeworms of the dog have received considerable attention from scientists, and the great amount of work on the commoner forms led at an early date to a number of valuable discoveries which have given these forms permanent scientific importance. From an economic standpoint the tapeworms of the dog are likewise of great importance, as several species have an intermediate stage which develops in man and the domestic animals, often with serious or fatal consequences.

The tapeworm described in this paper was first found in a dog which had been fed larval *Multiceps serialis* in Fallon, Nevada, in the spring of 1908 and shipped to this laboratory. Apparently the dog received an overdose of *Multiceps*—it had been fed six clusters—and the infection with the strobilate *Multiceps serialis* did not develop. When the dog arrived in Washington, thirteen days after being fed the first four clusters of *Multiceps*, the feces already showed numerous cestode eggs. These could hardly be attributed to strobilate forms resulting from the ingestion of the *Multiceps* larva, as the brief period of thirteen days would be too short a time for the adult worm to have developed, judging from the experiments of Baillet (1863) and from the time required for the development of other dog tapeworms of nearly the same size. In subsequent investigations on the life history of the parasite, the larval form failed to develop on feeding the eggs to the rabbit, a point which also indicates that the tapeworms present did not include *M. serialis*.

Two weeks after the dog's arrival a proglottid was found in the feces. A little more than a month later a chain of thirty-six attached proglottids was found in the feces and an examination of these showed that the tapeworm belonged to an undescribed species. For over six months proglottids, either singly or in chains, were collected from time to time from the feces. One specimen having a

head attached is hereby designated as the type-specimen and has been entered in the Helminthological Collection of the U. S. National Museum as No. 7314. A specimen without the head is designated as the paratype and has been entered in the same collection as No. 7315. The longest specimen collected is headless and is 24 cm. long.



FIG. 1.—HEAD OF DOG TAPEWORM.

In fact, certain peculiar characteristics leave little room for doubt on this point. Not only is the general shape of the head the same, but the form and dimensions of the hooks and the suckers are the same and there is the same tendency to lose the large hooks. It is further evident from a study of the tapeworms from both hosts that the parasite is a new species of the genus *Tænia* and the name *Tænia balaniceps* is here proposed for it.

As the specific name indicates, the shape of the head resembles to some extent that of an acorn, due to the very prominent rostellum which projects anterior of the suckers much as the seed of the acorn projects from its cup. The rostellum, being a protrusible muscular organ, is not of constant dimensions. In the head of the tapeworm collected from the dog and mounted in balsam (fig. 1), the distance from the anterior edge of the sucker to the tip of the rostellum is 300μ and the maximum breadth of the head is 668μ . The entire length of the head in this specimen can not be accurately measured owing to the contracted condition of the neck. In a specimen collected from the lynx and mounted in glycerine (fig. 2), the distance

While proglottids were still being found in the feces of this dog, a post-mortem examination of a lynx, *Lynx rufus maculatus*, from southern New Mexico disclosed the existence of a very recent tapeworm infection indicated by the presence of a number of tapeworm heads with a neck, but no segments as yet developed. The heads were apparently of the same species as the one obtained from the dog.

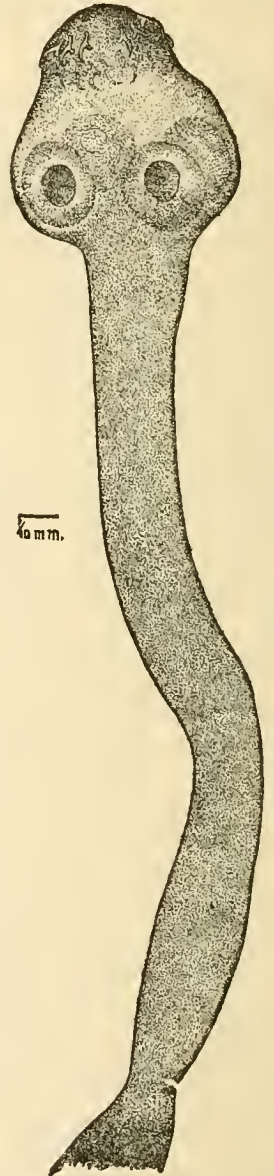


FIG. 2.—HEAD OF LYNX TAPEWORM.

from the anterior edge of the sucker to the tip of the rostellum is $370\ \mu$, the entire length of the head being $735\ \mu$ and the maximum breadth being $676\ \mu$. In another specimen, mounted in glycerine and viewed *en face*, the breadth was 534 by $752\ \mu$. The bulb of the suckers has a diameter of 215 to $265\ \mu$ in mounted specimens. The muscular bulb bearing the hooks has a diameter of $307\ \mu$. The hooks are located on the anterior end of the rostellum at some distance from the suckers. In the specimen from the dog, the small hooks, fifteen in number, are all that are present. A marked hiatus shows where another is missing from the original circlet of sixteen. In examining specimens of the lynx tapeworms, no large hooks were found in the first specimens studied. Later, heads were found with an occasional large hook present, though it appears that the attachment of the large hooks is very weak. One perfect specimen had only twenty-eight hooks, making the apparent range of twenty-eight to thirty-two in number of hooks.

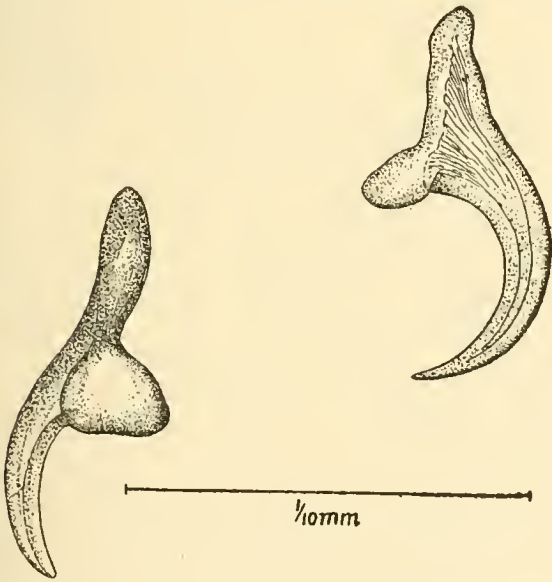


FIG. 3.—SMALL HOOKS OF DOG TAPEWORM.

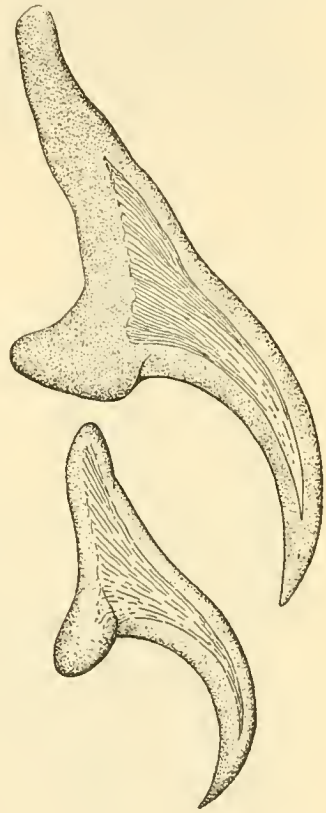
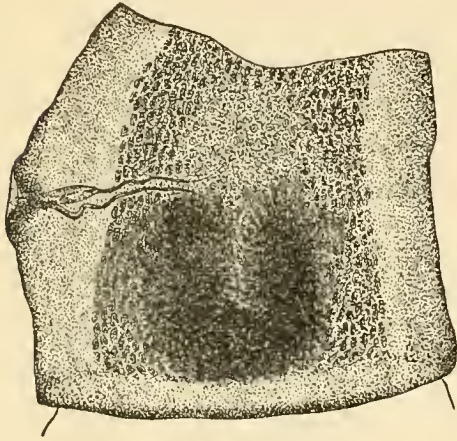


FIG. 4.—LARGE AND SMALL HOOKS OF LYNX TAPEWORM.

The small hook has a strongly curved blade, a very short posterior root or handle, and a broad, almost cordiform, anterior root or guard. (See figs. 3 and 4.) The hook length from tip of the blade to the distal end of the posterior root is 93 to $95\ \mu$ in the tapeworm from the dog, and 93 to $98\ \mu$ in the tapeworm from the lynx. In the large hook as found in the tapeworm from the lynx, the blade is less curved than in the small hook, the anterior root or guard is of almost the same dimensions as in the small hook, but the straight posterior root or handle is longer, so that the total length of the large hook is $145\ \mu$. (See fig. 4.)

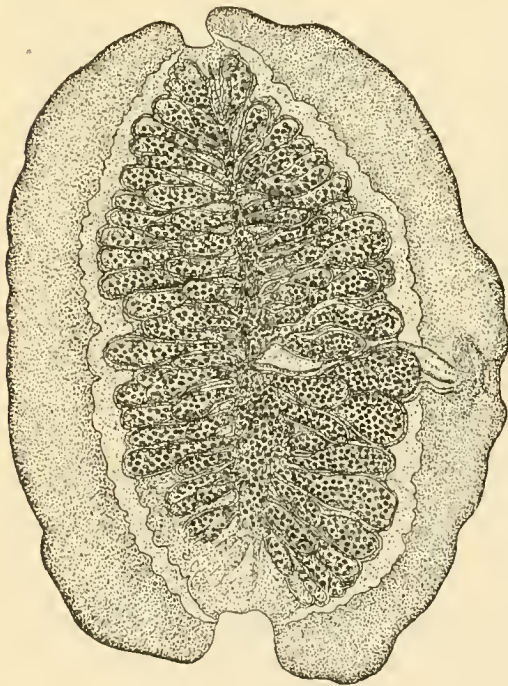
The primordia of the genital organs appear a short distance back of the head. The testes, genital canals, shell-gland, and the main trunk of the uterus are clearly defined in toto mounts before the ovaries and yolk-gland can be detected.



1mm.

FIG. 5.—MATURE PROGLOTTID.

glottid where the testes are located. At the plane of the ventral excretory canal, or just past it, the vas deferens opens into a tubular cirrus pouch 300 to 370 μ long and with an average length just



1mm.

FIG. 7.—GRAVID PROGLOTTID.

between these two extremes, or 335 μ . The diameter of the cirrus pouch also varies considerably, the maximum diameter noted being about 110 μ . There is no vesicula seminalis present. The length of the cirrus varies from 418 to 518 μ , and the maximum diameter noted was about 33 μ . The lumen measured about 8 μ . The cirrus was often found extruded from the genital pore to a distance of 134 to 175 μ .

The marginal genital pores have an irregular alternate arrangement. They are especially prominent in proglottids full of developing eggs. One such proglottid 1.25 mm. long has a genital pore 0.48 mm. in antero-posterior diameter. Such proglottids in the paratype specimen are 1.25 to 1.5 mm. long by 2.5 to 3 mm. broad.

In the type-specimen, mounted in balsam, mature proglottids measure 2 mm. long by 2 to 2.5 mm. wide.

In the mature proglottids the testes occur on the median side of the lateral excretory canals. (See fig. 5.) There are no testes in the middle line of the proglottids, except at the anterior end, where a band unites the two lateral fields. The vas deferens forms a series of involved loops in passing through that portion of the proglottid



1mm.

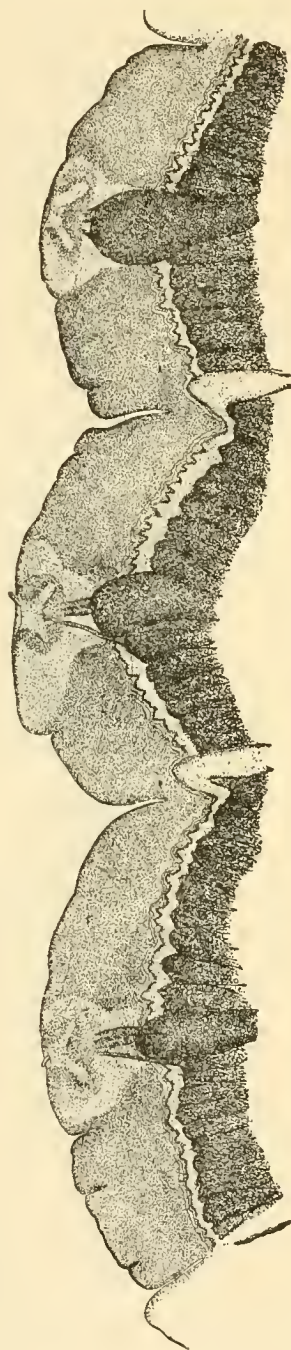
FIG. 6.—GRAVID PROGLOTTID SHOWING UNUSUAL UTERINE BRANCHING.

where the testes are located. At the plane of the ventral excretory canal, or just past it, the vas deferens opens into a tubular cirrus pouch 300 to 370 μ long and with an average length just between these two extremes, or 335 μ . The diameter of the cirrus pouch also varies considerably, the maximum diameter noted being about 110 μ . There is no vesicula seminalis present. The length of the cirrus varies from 418 to 518 μ , and the maximum diameter noted was about 33 μ . The lumen measured about 8 μ . The cirrus was often found extruded from the genital pore to a distance of 134 to 175 μ .

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The female reproductive system shows no notable peculiarities in the mature proglottid. From the genital pore the vagina swings in a wide curve to the neighborhood of the shell-gland, where it opens into a small receptaculum seminis. Around the shell-gland the ovaries are arranged in somewhat crescentic fashion, and the vitelline gland lies partly posterior to the median portion of the ovaries. The uterus outline in the mature proglottid is not shown in figure 5, owing to its failure to stain differentially.

Gravid proglottids, collected from the feces and mounted in glycerine jelly, measure 5.5 to 8 mm. long by 2 to 2.5 mm. broad. One mounted in balsam measures 10.5 by 4 mm. broad. In the gravid proglottid the uterus develops a form somewhat different from that typical of the genus *Tænia*. Originating as a median longitudinal stem, it develops at times branches of unusual form, quite unlike the more uniform and regular branches of the commoner mammalian cestodes of the genus *Tænia*. An illustration of this unusual branching is given in figure 6. Usually the median stem enlarges greatly, and the numerous club-shaped lateral branches are so closely approximated and at times so united that the ultimate result resembles a lobed sac filling the proglottid between the lateral and transverse excretory canals and the muscular layers. (See fig. 7.) A striking peculiarity is the formation in many proglottids of a uterine lobe which at the genital pore extends out over the lateral excretory canals to a variable distance. (See fig. 8.) In two cases noted, this lobe extended to within 134μ of the tip of the genital pore. The lobe in question occupies a position close to the cirrus pouch and vagina, and these appear to be compressed or crowded aside by this uterine growth. The appearance of the segments suggests that there is an area of weakness in the vicinity of the genital pore, and that the growing uterus has profited by this weakness to make an excessive growth at the point occupied by the now useless and partly atrophied genital canals. A large number of the proglottids obtained from the feces of the dog showed the uterus empty or



1mm.

FIG. 8.—MARGIN OF PROGLOTTIDS WITH DEVELOPING EGGS IN UTERO.

with perhaps a few lobes filled with eggs or containing only a few eggs. This suggests that we have here a condition similar to that in *Calliobothrium* and allied genera, where the uterus ruptures on the dorsal or ventral side. A further suggestion of this is found in some sections where a uterine lobe extends past the limiting musculature of the inner parenchyma and reaches clear to the cuticula. The eggs in this lobe are not yet completely developed. Eggs were observed to escape from one end of a loose proglottid as it crept about with a leech-like movement, but this method of releasing eggs is common enough in other *Tænia* forms in which a similar large number of fresh gravid proglottids do not show a uterus nearly or quite empty.

The eggs are ovoid in shape, the long diameter varying from 29 to 37 μ and the short diameter from 27 to 33 μ , the average dimensions being 35 by 31 μ . The shell is about 4 μ thick.

In some cases the genital canals pass to the genital pore dorsad of the main nerve and the main or ventral excretory canal and ventrad of the dorsal excretory canal. Where this happens the main nerve trunk and the ventral excretory canal lie side by side in almost the same plane. In other cases the genital canals pass between the main nerve trunk and the ventral excretory canal, in which case the nerve trunk rises to pass dorsad of the canals at that point.

The excretory system is notable for the great development of the transverse canal. In the gravid proglottids this occupies a position between two proglottids instead of being in the posterior part of the anterior proglottid. This condition is indicated in figure 8, showing a toto mount and shown in sagittal section in figure 9. The valve in the ventral canal, located at the posterior end of the proglottid is so well developed that in toto mounts of gravid proglottids there appears to be no connection between the transverse canal and the ventral canal of the same proglottid. This is indicated in figure 8. Where the two canals join the transverse canal is dilated to form a sort of reservoir. The valve-guarded aperture of the transverse canal opening into this from the anterior end has a diameter usually only a third or fourth as great as that of the unguarded aperture of the lateral canal of the following proglottid. The lateral canal, where it passes back from the transverse canal, in gravid proglottids turns toward the median part of the proglottid, forming a sharp angle with the transverse canal. (See fig. 8.)

The worm has a well-developed layer of transverse muscles and several discontinuous and ill-defined layers of longitudinal muscles.

Calcareous corpuscles are abundant and of variable shape. Some of the larger measure about 20 μ in the long diameter.

In an attempt to determine the life-history, proglottids showing the hexacanth embryo were fed at various times to six rabbits, two

white mice, and one field mouse, *Microtus pennsylvanicus*, these being animals closely related to those which would probably form part of the food of the dog and lynx from which the tapeworms were obtained. The rabbit was especially indicated as a possible host in that the remains of a rabbit were found in the cage with the lynx when it arrived in Washington, and the infection in the case of the lynx was evidently of very recent occurrence. The rabbits were killed and examined at intervals of from one week to three months eighteen days after feeding, the white mice after an interval of one month, and the field mouse after an interval of two months thirteen days. Care was taken to use proglottids that had been kept moist for some time as well as fresh ones and it seems fairly certain that the eggs were capable of infecting the proper intermediate host. Nevertheless, no signs of infection were found in any of the experiment animals. During a visit to Fallon, Nevada, the writer was struck by the abundance of rodent burrows in that locality, and it seems not unlikely that the intermediate hosts of the tapeworm belong to one or several of the numerous species of rodents around Fallon.

The salient characteristics of *Tænia balaniceps* are as follows: A prominent rostellum with the hooks set well forward of the suckers; large hooks which display a tendency to fall off readily; a uterus which forms so many lateral branches which become approximated or fused that the uterus becomes practically a lobed pouch,

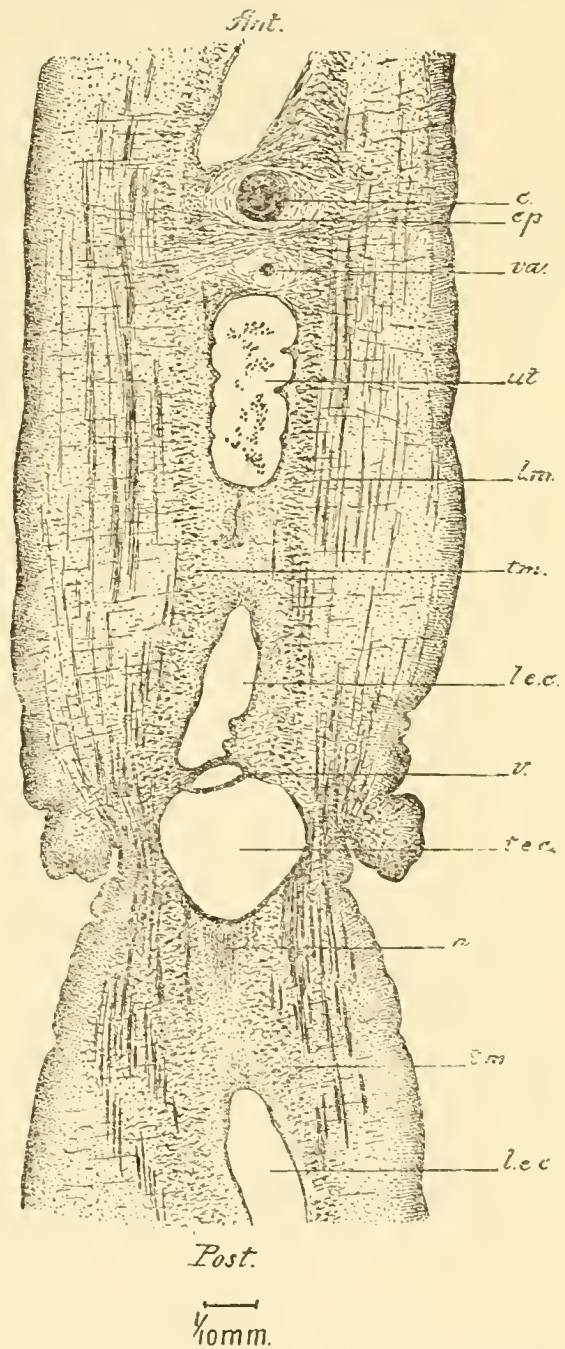


FIG. 9.—SAGITTAL SECTION SHOWING CROSS SECTION OF TRANSVERSE CANAL BETWEEN ADJACENT PROGLOTTIDS. *c.*, CIRRUS; *c. p.*, CIRRUS POUCH; *l. e. c.*, LONGITUDINAL EXCRETORY CANAL; *l. m.*, LONGITUDINAL MUSCLES; *n.*, NERVE; *t. e. c.*, TRANSVERSE EXCRETORY CANAL; *t. m.*, TRANSVERSE MUSCLES; *ut.*, UTERUS; *v.*, VALVE; *va.*, VAGINA.

one lobe often projecting over the lateral excretory canals near the genital pore; and, in the region of the gravid proglottids, a large transverse excretory canal occupying a position directly between proglottids.

In compiling a key to the dog tapeworms, an examination of Kholodkovski's (1908) description and figures of *Tænia punica* from the dog showed that the cestode in question probably belongs in the genus *Proteocephalus* Weinland. The head, the uterine stem, the position of the ovaries at right angles to the uterine stem, and the position of the testes and the genital canals all indicate this. The granular strand of uncertain nature which Kholodkovski noted in the position of the excretory canals can hardly be anything other than the vitellaria, in the location usual for species of the genus *Proteocephalus*. Kholodkovski states that the vitellarium is very small, but it seems likely that he has mistaken something else for the vitellarium. A comparison of the figures with mounted specimens of worms of the genus *Proteocephalus* leaves no reasonable doubt on this point, and it is the opinion of the writer and Dr. B. H. Ransom, with whom the point was discussed, that it is more likely that the dog from which the tapeworms were obtained had just eaten the true host, some fish, reptile, or batrachian, than that the dog was the true host by virtue of a normal, even though unusual, infection with larval form. Fuhrmann appears to have overlooked the unusual features of this worm in his review of Kholodkovski (1909), and states that the anatomy is that of species of *Tænia*.

The desirability of removing this species from the genus *Tænia* at once raises the question as to whether it shall take the generic name *Proteocephalus* Weinland (1858) or *Ichthyotænia* Lönnberg (1894). The writer and Doctor Ransom have gone over the literature of this subject and base a preference for the name *Proteocephalus* on the following points.

Weinland (1858) proposes the genus *Proteocephalus* in a footnote in the following terms:

Proteocephalus Weinkl. . . . The shape of the head in this genus is extremely variable. There is no proboscis, nor hooklets. The eggs are provided with two shells, the outer shell being mucilaginous. These Tænioids live in reptiles and fishes. The type of the genus is *Tænia ambigua*, Dujardin. Here belong *Tænia filicollis* and *T. dispar*.

Lönnberg (1894) proposed for the fish tapeworms the generic name *Ichthyotænia*, noting for this genus the following characteristics: The vagina opens beside and anterior to the cirrus pouch, and the vitellaria are peripheral and follicular. As type of the genus he names the following species in the order given: *Ichthyotænia filicollis* (Rudolphi), *I. ocellata* (Rudolphi), *I. longicollis* (Rudolphi), *I. torulosa* (Batsch), and *I. coryphicephala* (Monticelli).

It is obvious that if these two genera are strictly synonymous, *Proteocephalus* must be retained by virtue of many years priority. Whether they are synonymous depends on the application of Weinland's *Proteocephalus*. Unfortunately, Weinland selected as a type species *Tænia ambigua* Dujardin. This has been stated by Lühe (1899) to be at present a species inquirerenda. In the same article, Lühe raises the point that he himself has created the new genus *Nematotænia* and taken as its type *Tænia dispar*, the last of the three species mentioned by Weinland. *Proteocephalus* is left then with a type species, *Tænia ambigua*, now regarded by Lühe as a species inquirerenda, and the included species *Tænia filicollis*, which latter species Lühe (1899) regards as identical with *Icthyotænia ocellata* (Rudolphi) Lönnberg. Unless *Icthyotænia* applies to forms generically different from those of *Proteocephalus* it must fall into synonymy by virtue of the law of priority. A consideration of Dujardin's (1845) descriptions of *Tænia ambigua* and *Tænia filicollis* (*Icthyotænia ocellata*) does not warrant us in considering the two species generically different, and unless this can be shown, the generic characters of *Proteocephalus* may be taken from the better known *Tænia filicollis* in the absence of adequate data regarding *T. ambigua*, since Weinland mentions *T. filicollis* as belonging in the genus *Proteocephalus*. In other words, unless sufficient data exist to warrant a belief that the type species and the included species of a given genus are generically different, they should be considered as generically identical and the characters of the genus regarded as fixed by the included species in the absence of the type material. Lühe (1899) apparently believes that such data exist in the case of *Tænia dispar* and proposes for it the generic name *Nematotænia*. The only distinguishing character suggested in proposing the name, the circular cross section of the proglottids, is one already noted by Dujardin (1845). No such adequate difference has been shown to exist in the case of *Tænia ambigua* and *T. filicollis* and in our opinion such differences are not indicated in Dujardin's descriptions.

Lönnberg (1894), in proposing the name *Icthyotænia* for certain fish tapeworms, was apparently unaware of the existence of the generic name *Proteocephalus* and gave it no consideration. In making *T. filicollis* the first of his so-called type species, he made *Icthyotænia* a synonym of *Proteocephalus*, unless it can be shown that good reason exists for considering *T. ambigua*, the type of *Proteocephalus*, generically distinct from the included species *T. filicollis*, which is type of *Icthyotænia*. Railliet (1899) states that *T. ambigua* falls clearly in the genus *Icthyotænia*, and that *Proteocephalus* should be retained on the grounds of priority. The only evident reason why Braun (1900) and others should make *Proteocephalus* a syno-

nym of *Icthyotænia* is by following Lühe (1899) in considering *Proteocephalus* preoccupied, and hence unavailable. Otherwise *Icthyotænia* is a synonym of *Proteocephalus*, or the two genera are distinct and valid, with characters fixed by the type species *T. filicollis* and *T. ambigua*, respectively. Even Lühe (1899), in commenting on *T. ambigua* as a species inquierenda, has not seriously proposed that two different genera are involved in this question of synonymy. Riggenbach (1896) has listed *Icthyotænia ambigua* and *I. filicollis* among his species of *Icthyotænia*. Benedict (1900) bases his preference for *Proteocephalus* on this action of Riggenbach's. Larue (1909) notes that Lühe has given certain reasons for retaining *Icthyotænia*, but he uses *Proteocephalus* on the grounds of priority without further discussion.

Lühe (1899) has objected to the generic name *Proteocephalus* Weinland (1858) on the grounds that de Blainville (1828) proposed the name *Proteocephala* for a cestode family. Stiles (1901) has rejected Lühe's conclusions on the grounds that *Proteocephalus* and *Proteocephala* are not identical and hence not homonyms and that the prior use of a name to distinguish a family does not preclude its later use as a generic name, a point on which we agree with Stiles.

Lühe (1899) and Braun (1900) regard *Tetracotylus* Monticelli, 1892, as a synonym of *Icthyotænia*, Lühe giving as his reason that *Tetracotylus* is preoccupied by virtue of the earlier name *Tetracotyle* Filippi, 1854. Here again we agree with Stiles (1901) that these two names are not homonyms, but we regard *Tetracotylus* as a synonym of the earlier *Proteocephalus*. Monticelli (1892) does not designate a type species. Braun (1900) states that *Tetracotylus* is based on *Tænia coryphicephala*, which is the species Monticelli describes most thoroughly. This action of Braun is tantamount to the designation of a type-species, and *T. coryphicephala* is here considered as type-species of *Tetracotylus* by Braun's designation. Braun, however, regards *Tetracotylus* as synonymous with *Icthyotænia*, which makes it a synonym of *Proteocephalus* for reasons already given in this article. Monticelli gives a list of three new and seventeen old species as belonging in his new genus *Tetracotylus*, and includes among the old species *Tænia ambigua* Dujardin and *T. filicollis* Rudolphi, the first being the type of Weinland's *Proteocephalus* and the second an included species. No records are available showing that *Tetracotylus* has been accepted on the grounds that *T. coryphicephala* belongs to a genus different from the one to which *T. ambigua* and *T. filicollis* must be referred, and it is held here to be a synonym of *Proteocephalus*.

Tænia punica Kholodkovski, 1908, should therefore be known as *Proteocephalus punicus* (Kholodkovski, 1908) Hall, 1910, a combination proposed here for the first time and used in the following key to the tapeworms of the dog. The key is intended to show the rela-

tion of *Tænia balaniceps* to other dog tapeworms, and hence the species of *Dibothriocephalus* and *Mesocestoides* are not given.

1. Head armed with two slit-like suckers *Dibothriocephalus*.
 Head armed with four cup-like suckers..... 2.
2. Head armed with hooks; genital pores marginal..... 3.
 Head not armed with hooks..... 12.
3. Head small, armed with four rows of hooks; two genital pores in each segment,
 one on each side..... *Dipylidium caninum*.
 Head armed with two rows of hooks; one genital pore in each segment..... 4.
4. Entire body of tapeworm less than 1 centimeter long and with only three or four
 segments..... *Echinococcus granulosus*.
 Body at least several centimeters long and with numerous segments..... 5.
5. Gravid uterus with branches so numerous and so closely approximated as to give
 the outline of a lobed sac, one lobe often crossing the lateral excretory canal.
Tænia balaniceps.
 Gravid uterus forms a system of fairly distinct lateral branches, none of them
 crossing the lateral canal..... 6.
6. Large hooks 225 to 250 μ long..... *Tænia pisiformis*.
 Large hooks not over 220 μ long..... 7.
7. Mature segments broader than long..... 8.
 Mature segments longer than broad..... 9.
8. Head small, genital pore unusually large and prominent..... *Tænia krabbei*.
 Head large, 1 millimeter broad, genital pore not prominent.... *Tænia hydatigena*.
9. Guard of small hook twisted so that its flat surface tends to lie in the plane of the
 blade and handle *Tænia brachysoma*.
 Guard of small hook not twisted..... 10.
10. Adult strobila not over 20 centimeters long; large hooks 95 to 140 μ long.
Tænia brauni.
 Adult strobila 40 to 100 centimeters long..... 11.
11. Large hooks 150 to 170 μ long; eggs spherical and 31 to 36 μ in diameter.
Multiceps multiceps.
 Large hooks 135 to 156 μ long; eggs ovoid and 33 to 41 μ long by 26 to 31 μ wide.
Multiceps serialis.
12. Genital pores ventro-median *Mesocestoides*.
 Genital pores marginal..... *Proteocephalus punicus*.

Tænia erythraea has been erroneously included as a tapeworm of the dog by von Linstow (1905); Setti (1897) described it from *Canis mesomelas*.

The only tapeworms which the writer has found recorded from the lynx are *Tænia laticollis* Rudolphi, *Tænia monostephanos* v. Linstow, and a species of *Mesocestoides*. *Tænia laticollis* can readily be distinguished from *T. balaniceps* from the fact that the former has very large hooks, the smaller ones measuring 128 μ in length and the larger 239 μ , according to von Linstow (1905). *Tænia monostephanos* can readily be distinguished from the fact that it has a single circle of hooks all of the same size instead of the customary double circle of large and small hooks. *Mesocestoides* differs from *T. balaniceps* in that the head is unarmed and the genital pores are ventro-median, as indicated in the above key.

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THE WEST AMERICAN MOLLUSKS OF THE GENUS ALABA.

By PAUL BARTSCH,

Assistant Curator, Division of Mollusks, U. S. National Museum.

The genus *Alaba* received a most unfortunate treatment by Dr. P. P. Carpenter in his Catalogue of Mazatlan Shells (pp. 365-370, 1856), in which he described no less than ten species, bestowing specific names upon eight, only one of which has been found identifiable to date. Mr. E. A. Smith, who has charge of the conchological collections in the British Museum, in reviewing the genus *Alaba*,^a writes on pages 538-539:

All the species above enumerated are represented in the British Museum, as are also those species described by P. P. Carpenter in the "Catalogue of Mazatlan Shells." But these, with one exception, I have purposely omitted, for the mutilated condition of the specimens is such that it is impossible to say to what genus they (when perfect) may have belonged. And here I can not refrain, although always averse to censuring criticism, from condemning most energetically that pernicious practice of describing fragments of minute specimens and assigning specific names to them. It merely results in burdening science with a mass of literature almost useless, for it is simply an impossibility for anyone to identify their specimens from the description of those miserable fragments characterized in the Mazatlan Catalogue. Describe them and welcome, for no harm is thereby done, albeit but little good; but for the sake of others let us not name them.

I heartily agree with the above sentiments.

The species described by Doctor Carpenter are:

- Alaba supralirata.*
- Alaba violacea.*
- Alaba terebralis.*
- Alaba alabastrites.*
- Alaba scalata.*
- ? *Alaba conica.*
- ? *Alaba mutans.*
- ? *Alaba laguncula.*
- ?? *Alaba*, sp. ind. (a).
- ? *Alaba*, sp. ind. (b).

^a Proc. Zool. Soc. London, 1875, pp. 538-540.

The first of these, *Alaba supralirata* Carpenter, is the only shell we have been able to recognize and we very much doubt if any of the other species described in the Mazatlan Catalogue as *Alaba* belong to this genus.

In 1905 Doctor Dall described *Alaba oldroydi*,^a which must be referred to the *Rissoina*.

To the above we now add another form, the most abundant on the west coast.

The drawings accompanying this paper were made by Miss Evelyn G. Mitchell.

ALABA SUPRALIRATA Carpenter. ^b

Alaba supralirata CARPENTER, Cat. Maz. Shells, 1856, p. 366.

Shell elongate-conic, with very strong varices, which form more or less continuous lines over the whorls, semitransparent. Nuclear whorls four, continuing the general outline of the spire with scarcely

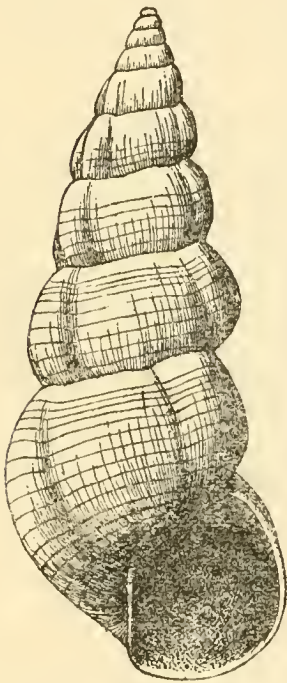


FIG. 1.—ALABA SUPRALIRATA.

any interruption; the first smooth; the rest marked by slender, axial riblets of which about forty-two occur upon each of the last two turns. The spaces separating these axial threads are about twice as wide as the threads. In addition to the axial riblets the last two turns are marked by a slender, spiral cord about one-third of the distance between the sutures, anterior to the summit. Post-nuclear whorls well rounded, appressed at the summit; the first three smooth; the fourth showing fine, irregularly spaced, incised lines, which increase steadily in size on the succeeding turns, becoming very pronounced on the last volutions; on the penultimate whorl there are ten between the summit and the periphery, and these, equally strong, pass over the varices and the spaces between them. In addition to the spiral sculpture, the



FIG. 2.—NUCLEUS OF ALABA SUPRALIRATA.

whorls are marked by conspicuous lines of growth. Suture strongly constricted. Periphery of the last whorl and the moderately long base somewhat inflated and strongly rounded, sculptured like the

^a The Nautilus, vol. 14, 1905, p. 15.

^b In the preparation of the present diagnoses the following terminology is used: "Axial sculpture," the markings which extend from the summit of the whorls toward the umbilicus.

The axial sculpture may be—

"Vertical," when the markings are in general parallelism with the axis of the shell;

"Protractive," when the markings slant forward from the preceding suture;

"Retractive," when the markings slant backward from the suture;

"Spiral sculpture," the markings following the directions of the coils of the whorls.

space between the sutures. Aperture rather large, very broadly oval; posterior angle obtuse; outer lip thin, showing the external sculpture within; columella oblique, somewhat curved and slightly revolute; parietal wall covered with a moderately thick callus.

The above description is based on two specimens. One (Cat. No. 213367, U.S.N.M.) has furnished the nuclear characters, while another (Cat. No. 4066, U.S.N.M.) has furnished the characters of the adult whorls. The latter has lost the first two nuclear whorls, has eight post-nuclear whorls, and measures: Length 6.8 mm., diameter 2.6 mm.

Specimens examined.

Cat. No.	Locality.	Number of specimens.
4066	Cape San Lucas, Lower California (described and figured).....	2
46179	Gulf of California.....	7
213367	Off La Paz, Gulf of California (nucleus described).....	2
194870	Off Cacachitas, Gulf of California.....	2

ALABA JEANNETTÆ, new species.

Shell elongate-conic, semitransparent, with strong varices scattered at irregular intervals. Nuclear whorls four, continuing the general outline of the spire, well rounded, smooth except for very faint, slender, axial threads which, in most instances, are only apparent at the summit of the whorls. Post-nuclear whorls well rounded, appressed at the summit; the early ones smooth; the later ones marked by slender, incised, spiral lines, of which those on the anterior half of the whorls between the sutures and those on the posterior half of the base are usually stronger than the rest. In addition to the spiral sculpture, the whorls are marked at irregular intervals by strong, oblique varices. Suture strongly constricted. Periphery of the last whorl inflated, well rounded. Base moderately long, well rounded, and inflated, its posterior half marked like the anterior half between the sutures, bearing the feeble extensions of the varices. Aperture very large, broadly oval; posterior angle obtuse; outer lip thin and transparent; columella very oblique and somewhat curved, slightly reflected over the reenforcing base; parietal wall glazed with a thin callus.



FIG. 4.—NUCLEUS OF *ALABA JEANNETTÆ*.

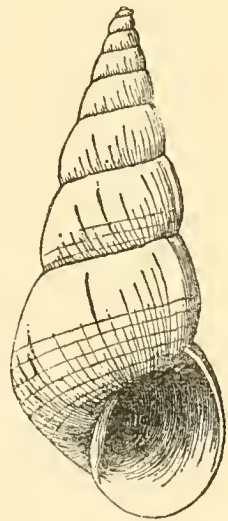


FIG. 3.—*ALABA JEANNETTÆ*.

The type (Cat. No. 182565, U.S.N.M.) has six post-nuclear whorls and measures: Length 5 mm., diameter 2.1 mm. The present species has been confounded with *Alaba supralirata* Carpenter. It

differs from this in the sculpture of the nucleus, which in *supralirata* is very pronounced, and also in the strength and disposition of the varices, *supralirata* usually having them form continued ridges from whorl to whorl. The spiral sculpture is also much stronger in this than in the new form.

This species is named for the late Miss Jean O'Connor, from whom over 2,500 specimens of this shell were received, collected by the late Capt. H. E. Nichols.

Specimens examined.

Cat. No.	Locality.	Number of specimens.
199178.....	San Diego, California.....	1
127541.....	San Hipolite Point, Lower California (shell drift).....	3
105472.....	Point Abrejos, Lower California (shell washings).....	3
105473.....	Scammon's Lagoon, Lower California.....	1
105556.....	Scammon's Lagoon, Lower California (on sand beach).....	2
182565 (type).....	Margarita Bay, Lower California.....	191
4066b.....	Cape San Lucas, Lower California.....	1
149344.....	Gulf of California.....	99
46178.....	do.....	2
126770.....	do.....	2,385
128226.....	San Jose Island, Gulf of California.....	56

NOTES ON THE STRUCTURE AND HABITS OF THE WOLFFISHES.

By THEODORE GILL,

Associate in Zoology, U. S. National Museum.

INTRODUCTION.

In order to be able to appreciate the influence of structure on the habits of the wolffishes, the writer undertook the examination of the specimens preserved in the U. S. National Museum and was surprised to find the range of variation revealed through the examination of the skeletons. As in many other cases, the relations of the species to each other can not be understood without a comparative examination of the inner structure. The head curator of biology of the Museum, Dr. F. W. True, kindly had what were supposed to be unique specimens of different species skeletonized, and they proved to be of species decidedly different from those they were believed to represent and to be undescribed. Further, the manner in which previously described species had been arranged in dichotomous synopses was found to be quite unnatural and contradicted by the skeletal characters. The facts in the case are set forth in the following article.

PART 1.

THE STRUCTURAL CHARACTERISTICS OF THE ANARRHICHADOID GENERA.

The wolffishes have been regarded as pertinents of the family of Blenniids by most authors, but in 1865 Gill proposed an independent one (*Anarrhichadidæ*) for them, and that view has since been generally adopted in the United States and by a few in Europe, especially F. A. Smitt in his *Scandinavian Fishes*. The Swedish naturalist has based the family chiefly on the dentition, describing the "jaw and palatine teeth of extraordinary strength, partly obtuse molars (on the vomer and palatine bones and in the lower jaw), partly conical or curved canines on the intermaxillary bones in the front part—sometimes in the back part as well—of the lower jaw." These characters, however, are of generic rather than family value. The most important distinc-

tion between the Anarrhichadids and Blenniids are manifest in the scapular arch (especially the suprascapula), the actinosts, and the absence of ventral fins.

The family may be defined as follows:

Family ANARRHICHADIDÆ.

SYNONYMS AS FAMILY.

Anarrhichadaidæ (misprint) GILL, Can. Nat., (2), vol. 2, 1865, pp. 247, 252.

Anarrhichadæ GILL, Arr. fam. Fishes, 1872, p. 4.

Anarrhichæ FITZINGER Sitzungsber. k. Akad. Wiss., Berlin, vol. 67, abth. 1., 1873, p. 43.

Anarrhichadidæ SMITT, Scand. Fishes, pt. 1, 1892, p. 231.

Anarrhichadidæ JORDAN and EVERMANN, Fishes North and Middle Amer., pt. 3, 1898, pp. 2343, 2445.

Gobioides, part, CUVIER,

Zoarcidæ, part, SWAINSON,

Blenniidæ, part, GÜNTHER and others.

SYNONYMS AS SUBFAMILY ANARRHICHADINÆ.

Anarrhichæformes BLEEKER, Enum. sp. Piscium Arch. Ind., 1859, p. xxv.

Anarrhichaninæ (misprint) GILL, Cat. Fishes North Amer., 1861, p. 46.

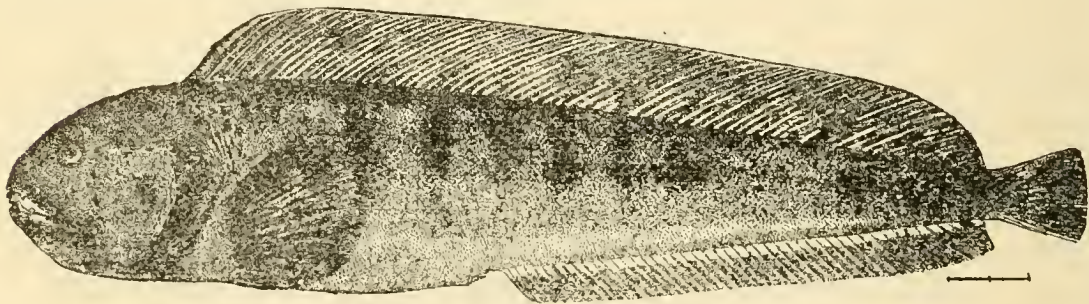


FIG. 1.—ANARRHICHAS LUPUS.

Anarrhichadinæ JORDAN and GILBERT, Syn. Fishes North Amer., 1882, p. 755.

Anarrhichadinæ JORDAN and EVERMANN, Fishes North and Middle Amer., pt. 3, 1898, p. 2445.

SYNONYM AS SUBFAMILY ANARRHICHTHYINÆ.

Anarrhichthyinæ JORDAN and EVERMANN, Fishes North and Middle Amer., pt. 3, 1898, p. 2445.

Blennioidean fishes of a more or less elongated form without ventral fins, with the head decurved around the snout, mouth deeply and obliquely cleft, intermaxillaries abutting on and attached to front of ethmoid, teeth on jaws, vomer and palatine bones atypically crowded and molariform, the main ones of the lower jaw acrodont, others external, dorsal with inarticulate rays or spines; cranium without a myodome, atypically compressed behind eyes, and with the occipital region declivous backward; suborbital semiring narrow and with a slight ophthalmophorous shelf; suprascapula simple (not forked), hypercoracoid and hypocoracoid separated by membrane-like carti-

lage and the former perforated near base; four actinosts squarish, uppermost behind hypercoracoid and smallest, lowermost behind hypocoracoid, intervening second and third behind membrane; pectoral rays all connected with actinosts; pelvis V-shaped, with its free limb decurved and its anterior limbs applied to inner faces of cœnostea and reaching forward to the crests; abdominal vertebræ (except foremost two) with transverse processes or parapophyses with which the ribs are connected.

The teeth of the lower jaw are acrodont in that the main series is borne on the ridges of the dentaries, but, in addition to the main row, one or more others may be developed, and in such cases the *outer sides* of the bones are more or less inflected. In the common wolffish (*Anarrhichas lupus*) in which the multiplication and enlargement of the teeth are carried to a maximum, the inflection is manifest to such an extent that the dentigerous area actually slopes inward and downward. In *Lycichthys paucidens*, whose lower lateral teeth are uniserial, the inflection is scarcely noticeable. In *Anarrhichthys* a somewhat intermediate condition is manifest, although the dentition is much more like that of *Anarrhichas* than of *Lycichthys*.

In brief the family is composed of a few large fishes with unmistakable characters and physiognomy. The body is more or less elongated and covered with rudimentary scales, or naked, the head decurved around the snout, the mouth moderately deep and oblique; the dentition in the typical forms is quite characteristic, the front jaw-teeth being canine-like, the vomerine and palatine more or less thick and molariform, and the lateral mandibular molariform or blunt; the branchial apertures are confined to the sides; the dorsal fin is composed entirely of inarticulate rays or spines but is manifest under two distinct modifications; ventral fins are entirely absent in all.

Such are the principal superficial characters which distinguish the wolffishes, but better indications of relationship and differential char-

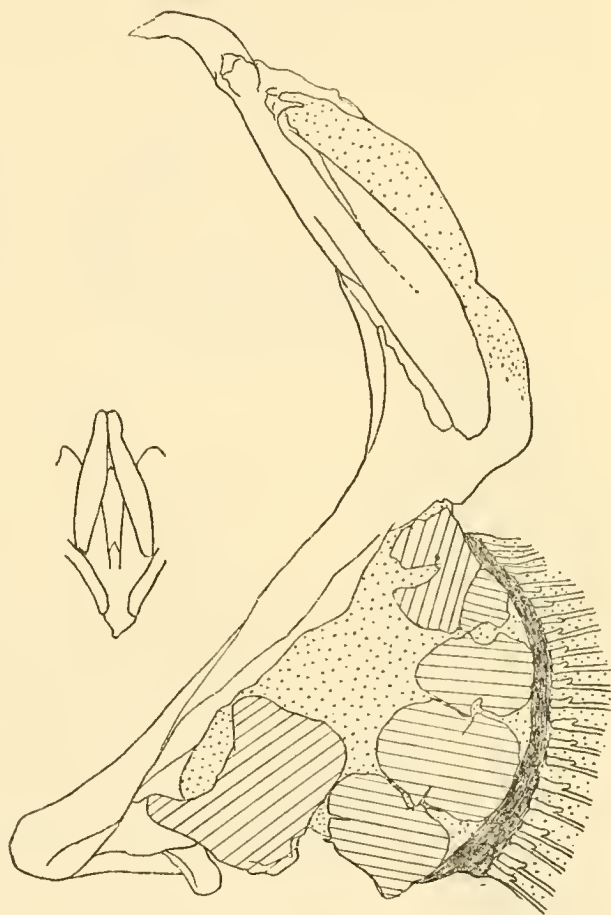


FIG. 2.—ANARRHICHAS LUPUS, SHOULDER GIRDLE.

acters are furnished by the skeleton. The abdominal vertebræ (except the first two) have robust transverse processes to which the ribs are attached; the cranium is more or less compressed behind the orbits, the occipital region is declivous backward, and the intermaxillaries connect by close suture with the ethmoid as in the Blennies.

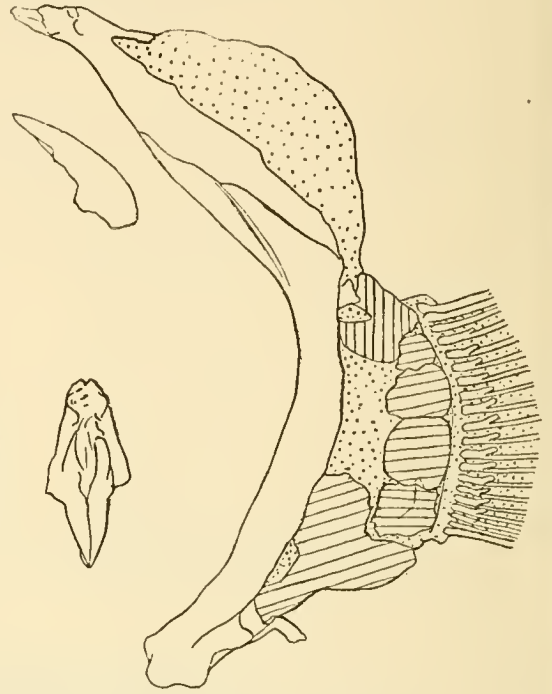
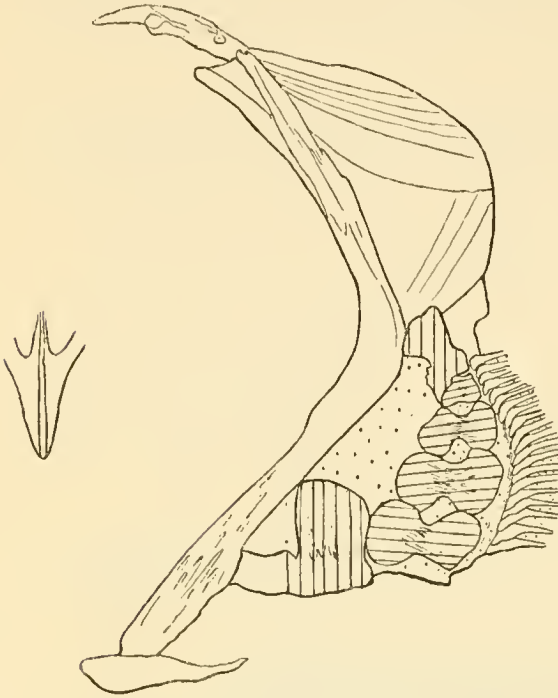


FIG. 3.—LYCICHTHYS PAUCIDENS, SHOULDER GIRDLE. FIG. 4.—ANARRHICHTHYS OCELLATUS, SHOULDER GIRDLE.

They differ from the Blennies by the dentition, the enlargement of the vomer for a dental armature, the extension downwards of a parasphenoid keel, the approximation of the exoccipital condyles, and more especially in the composition of the shoulder-girdle. The suprascapular bones are simple (unforked); the hypercoracoid and hypocoracoid normal, save that they are small and separated by the interposition of the four actinosts which are squarish or irregularly formed; the uppermost one is much reduced. The pelvis is represented by a Y-shaped piece whose limbs are foremost, lie on the upper surface of the cœnosteon, and connect with the anterior ridges of the latter.^a



FIG. 5.—LYCICHTHYS SCALE. AFTER THORNAM (GAIMARD).

The genera have been combined by Doctor Boulenger (as well as by most other European ichthyologists) with the Blenniidæ under that family name, although he has attributed to the family a suprascapula or "post-temporal forked" and "hour-glass-shaped pterygials" or actinosts. These attributes are certainly not manifest in any of the Anarrhichadids and must have been assumed for them in consequence of the previous assumption of their close relationship to the Blenniids.

^a Skeletons of *Anarrhichas lupus*, *Lycichthys denticulatus*, and *Anarrhichthys ocellatus* are before me.

PALEONTOLOGY OF ANARRHICHADIDS.

The paleontological history of the wolffishes is practically unknown. From the Pliocene Coralline crag of England (Gedgrave in Suffolk) a tooth was obtained which was supposed by E. T. Newton (1891) to be derived from the *Anarrhichas lupus*. This is the only fossil that has been recorded. Cranial remains of a cretaceous fish (London clay) named *Laparus alticeps* by Agassiz (1844) were supposed by that ichthyologist to be related to *Anarrhichas*, but according to Woodward (1901) "they exhibit too many differences to be definitely ascribed to the family Blenniidae" and still less to the family *Anarrhichadidae*. Nothing in fact has been discovered that lessens the gap between the family and others.

ANARRHICHADOID SUBFAMILIES.

The characteristics above detailed are manifest under two very distinct types so far as the body (cauditrunk) is concerned, but the head is essentially similar in both. These types may be distinguished as subfamilies—*Anarrhichadinae* and *Anarrhichthyinae*.

In the *Anarrhichadinae* (the true wolffishes) the body is robust behind and contrasts with almost all other acanthopterygian fishes in that in the wolffishes the hindmost spines are abbreviated, rigid, and sharp-pointed, while all the preceding are flexible at their tips; the caudal fin is free and normally developed. Only one genus is generally recognized—*Anarrhichas*. A second very distinct one (*Lycichthys*) is, however, represented by the *A. latifrons*.

In another group for which unfortunately we have to use the barbarous name *Anarrhichthyines* (which may be designated in English as wolf-eels), the body is attenuated backwards and eel-like, and the dorsal, as well as anal, is united with the caudal fin; all the dorsal spines are flexible. The only genus, *Anarrhichthys*, is known from a single species, *A. ocellatus* or the wolf-eel.

ANARRHICHADOID GENERA.

The *Anarrhichadines* have been referred by all authors to one genus, *Anarrhichas*, although two of the four species formerly referred to it were distributed among two subgenera more than a quarter century ago.

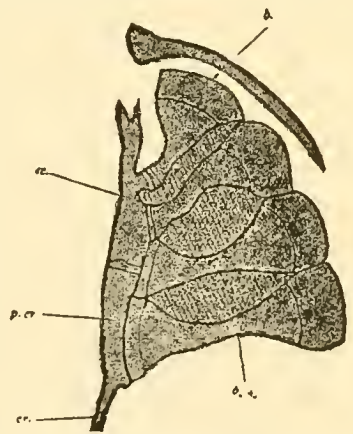


FIG. 6.—*BLENNIUS PHOLIS*, SHOULDER GIRDLE (AFTER PARKER).

In 1877, Gill, in Baird's Annual Record of Science and Industry for 1876 (p. clxvii), noticed Steenstrup's then recently published monograph on *Anarrhichas*, and concluded with the statement that "in the extreme northern seas, and especially the Greenland waters, no less than four species [of Anarrhichadids] are found, which represent

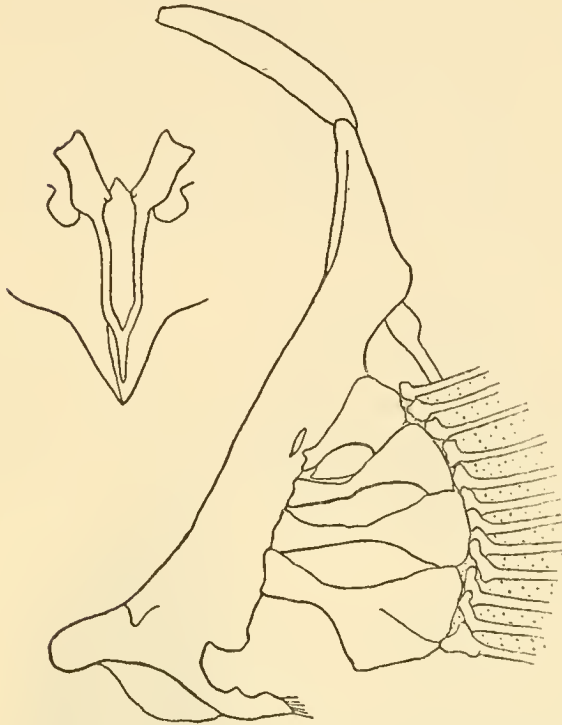


FIG. 7.—BLENNIUS OCELLARIS, SHOULDER GIRDLE.

two quite distinct types or subgenera, one (*Anarrhichas* proper) containing two species (*A. lupus* and *A. minor*), and the other (*Lycichthys*) containing also two, but less known species (*A. latifrons* and *A. denticulatus*)."

This suggestion has been completely overlooked by all subsequent writers and Jordan and Evermann have even associated *A. latifrons* with *A. minor* in a section (*a b*) contrasted with one (*a b b*) including *A. lupus*, and all those in a primary section (*a*) contrasted with another (*a a*) including *A. lepturus* and *A. orientalis*.

In view of such discrepancy the present author appealed to the curator in charge of the biological department of the U. S. National Museum (Dr. F. W. True) to have skeletons made of representatives of each of the genera. This has been done and the differences between *Anarrhichas* as restricted and *Lycichthys* proved to be far greater than were expected. The principal ones are here contrasted in parallel columns.

ANARRHICHAS.	|	LYCICHTHYS.
	<i>Teeth</i>	
more or less blunt;	|	mostly acute or subacute;
	<i>Intermaxillary</i>	
very robust, nearly straight, about 6 in an outer row, small and irregular in an inner row, and a few intervening between rows;	|	rather slender, curved, 4 to 8 in an outer row, smaller (6-12) in an inner row;
	<i>Mandibular</i>	
4 large in front with blunt summits; crowded and molar on sides; the ridge of the dentary inflected and with largest teeth, the outer on the inflected sides and smaller;	|	4 to 8 slightly enlarged in front, curved and with subacute summits; well separated acute and biserial or uniserial on sides; those of inner row sometimes molar; the dentary ridge scarcely inflected;

Vomerine

in a wide patch longer than palatine, molar and closely crowded, in 2 rows and intervening smaller teeth;	in small patch much shorter than palatine, in some species subacute and well separated; in others molar and closely crowded;
---	--

Palatine

molar, crowded and biserial;	subacute, well separated and biserial; in some bluntish in inner row;
------------------------------	---

Hypopharyngeal teeth

subequal in a broad band;	enlarged in an inner row and a few scattered outside;
---------------------------	---

Branchiostegal rays

8, 4 slender to inferior edge of ceratohyal, 2 stout to hinder edge of ceratohyal, and 2 stout in depressed lower half of epihyal (8 arranged in 2 groups of 4 each, 4 slender with insertions internal, and 4 stout with insertions external);	7, 3 slender to inferior edge of ceratohyal, 2 stout to hinder angle of ceratohyal, and 2 stout to outer surface of epihyal near lower edge (7 arranged in 2 groups, 1 of 3 slender with insertions internal, 1 of 4 stout with insertions external);
---	---

Ossification

complete.	incomplete, the appearance sponge-like.
-----------	---

Cranial axis

angular, the vomer subtending a high angle with the parasphenoid.	nearly rectilinear, the vomer being on the same line as the parasphenoid.
---	---

Parasphenoid

much compressed, very narrow in front of cerebral chamber.	rather wide and expanded sideward in front of cerebral chamber.
--	---

Postfrontal region

much compressed and very narrow (pinched) between interorbital region and supraoccipital.	rather depressed and broad between interorbital region and supraoccipital.
---	--

Sphenotic and parietal

separated by a large deep pit circumscribed by the approximation of the bones before and behind.	separated only by regular suture and meeting in a ridge.
--	--

Suprascapula

undivided and prolonged forward over the sphenotic-parietal pit, and connected with the ridge in front and clamped behind by the approximated sphenotic and parietal.	undivided and attached to the inner surface of the periotic ridge.
---	--

Actinosts

(two and three) not or little constricted at middle.	(two and three) much contracted at middle.
--	--

These contrasted characteristics are merely the most salient or obvious of the many that confront the observer;^a they are assuredly enough to certify to the generic distinction between *Anarrhichas* and *Lycichthys*. In fact, in most respects the cranial and scapular differences between the genera in question are not only more obvious but of greater taxonomic importance than those between *Anarrhichas* and *Anarrhichthys*. Further, the distinction between the last two genera, based on the relative length and size of the tail has been exaggerated. The caudal fin of *Anarrhichthys* is of the same type as that of *Anarrhichas* and merely reduced in size.

The relations and most important, or rather most easily ascertained diagnostic peculiarities of the three genera of the family are now indicated.

ANALYTICAL CHARACTERS.

Key to genera of Anarrhichadids.

- a*¹. Body moderately elongated and robust backward and vertebræ moderately numerous (74–81, *e. g.* 26+50 pm.); dorsal and anal with a moderate number of rays; caudal distinct.....ANARRHICHADINÆ.
- b*¹. Teeth mostly subacute and not crowded; vomerine patch rather short (not extending as far back as palatine patches); cranium flattened behind interorbital area; cranial axis almost rectilinear; branchiostegal rays 7...*Lycichthys*.
- b*². Teeth chiefly blunt, or molar and crowded; vomerine patch elongated (extending backward beyond palatine patches); cranium pinched behind interorbital area; cranial axis highly angulated by the extension downward of the vomer; branchiostegal rays 8.....*Anarrhichas*.
- a*². Body greatly elongated and attenuated backward and vertebræ extremely numerous (*e. g.* 350=38+212 pm.); dorsal and anal with corresponding number of rays (D. 250; A. 230 pm.); caudal connected with dorsal and anal.....ANARRHICHTHYINÆ.
- Teeth blunt, or molar and crowded, vomerine patch elongated; cranial axis moderately angulated.....*Anarrhichthys*.

The primary groups of the family—the subfamilies—are sufficiently defined here, and clearness of conception of their differences would be marred rather than enlarged by the few coordinated characters, so relatively unimportant are they. The genera, however, are so distinct that their characteristics are numerous, as will appear by a comparison of those now to be given.

The genera are considered in the order of their assumed development, the most generalized first, the most specialized last.

^a Among other notable differences between the genera are those manifested between the dorsal rays signalized by Steenstrup and Collett.

Genus LYCICHTHYS.

Lycichthys GILL, Ann. Rec. Sci. and Ind. 1876, 1877, p. clxvii.

Anarrhichas, sp. auct. pl.

Type.—*Anarrhichas latifrons* Steenstrup.

Anarrhichadids with a moderately elongated body, rudimentary scales, dorsal fin regularly elevated and with its hindmost spines especially stiffened.

Teeth acute or subacute; *intermaxillary* rather slender, curved and about 4 in an outer row, smaller (about 6) in an inner row; *mandibular* 4 to 6 slightly enlarged in front, curved and with subacute summits; well separated, acute and biserial or uniserial on sides; the dentary ridge not inflected; *vomerine* in small patch much shorter than palatine, subacute and well separated; *palatine* subacute, well separated and biserial.

Hypopharyngeal teeth enlarged in an inner row and a few scattered outside.

Branchiostegal rays 7, 4 to inferior edge of ceratohyal, 1 to hinder angle of ceratohyal and 2 to surface of epihyal near lower edge.

Ossification incomplete, the appearance sponge-like.

Cranial axis nearly rectilinear, the vomer being on the same line as the parasphenoid.

Parasphenoid rather wide and expanded sideward in front of cerebral chamber.

Postfrontal region rather depressed and broad between interorbital region and supraoccipital.

Sphenotic and *parietal* bones separated only by regular suture and meeting in a ridge.

Suprascapula undivided and attached to the inner surface of the periotic ridge.

Actinosts (2 and 3) much contracted at middle.

The genus thus defined is confined to the deep cold seas of the Northern Hemisphere and has apparently four very distinct species exhibiting quite a remarkable range of dental variation, so great indeed as to call for the differentiation of one of them from the others to represent a peculiar group, were we to adopt for this genus the principles in vogue for most others.

The relative differences of the species, so far as regards dental characters, are indicated in the following dichotomous table:

Key to species of Lycichthys.^a

a¹. Mandibular teeth biserial; palatine and intermaxillary teeth numerous.

b¹. Vomerine teeth enlarged and crowded.

c¹. Vomerine teeth much enlarged and with flattened crowns, 7 or thereabouts, palatine teeth of outer row (about 6-7) erect, elongated and conic; of inner

^a I hope later to be able to go into more detail respecting the species of *Lycichthys*.

- row (about 5-6) inclined inward, short and blunt; large intermaxillary teeth in outer row 6; smaller in inner row 10-12.....*L. fortidens*.
- c². Vomerine teeth little enlarged with mammiform crowns, 10 or thereabouts; palatine teeth weaker than in *L. fortidens* (about 8-9).....*L. latifrons*.
- b². Vomerine teeth scarcely enlarged and in two rows, separated by an elliptical interval; palatine teeth of outer row (about 7) much stronger than those of inner (about 7).....*L. denticulatus*.
- a². Mandibular teeth uniserial (9-10), palatine and intermaxillary teeth few. Vomerine teeth few and subacute (about 5); palatine teeth of outer row (about 5-8) erect but curved, scarcely if any larger than those of inner (about 4-6) which are suberect; intermaxillary teeth in outer row 4 (2+2) in inner row 6 (3+3).....*L. paucidens*.

Great as these differences are, in view of the range of variation manifest in the related genus *Anarrhichas*, it is not impossible that they may intergrade and prove to be merely individual characteristics within a single species. It would, however, be too violent a strain on our present knowledge to anticipate such a result and the variants are allowed provisional specific rank. Besides, it would scarcely be expected that in a type like *Lycichthys*, in which the teeth are not crowded, the teeth would be as irregular as in *Anarrhichas*, in which the irregularity is to a great extent the consequence of crowding. If, indeed, we were guided by the example of students of other group, a distinct genus might be considered called for on account of the form named *L. paucidens* distinguished by uniserial mandibular teeth while the others have biserial teeth.

According to Goode and Bean^a "many specimens [of *Lycichthys*] have been received from the halibut schooners," presumably from "the deep waters in 200 to 400 fathoms on the offshore banks," but unfortunately none except the two herein noticed have been preserved.^b It is much to be hoped that other specimens may be received to enable us to understand the nature and value of the differential characters in question. So far as known, there are no external differences coincident with the dental, and consequently suspicion of the taxonomic significance of the latter may be entertained until confirmed or refuted.

LYCICHTHYS FORTIDENS, new species.

Anarrhichas latifrons GOODE and BEAN, *Oceanic Ichthyology*, 1895, p. 301, fig. 271.

North Atlantic, in deep water, off the coasts of Maine and Nova Scotia.

Type 21845 Banquereau obtained at a depth of 300 fathoms by a Gloucester fishing vessel, the *Marion*.

^a*Oceanic Ichthyology*, p. 302.

^bThe specimen figured and subsequently made into a cast appears not to have been preserved; it was 21373 of the collection.

Full measurements of the specimen compared with Collett's measurements of a West Finmark specimen named *latifrons* are given by Goode.

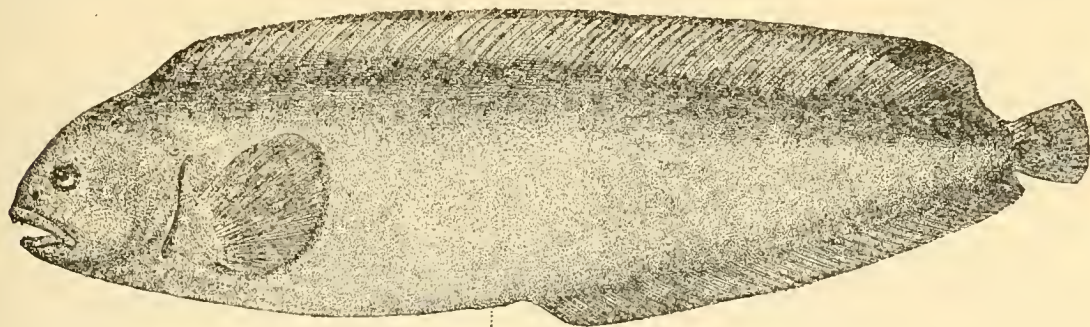


FIG. 8.—LYCICHTHYS FORTIDENS.

LYCICHTHYS LATIFRONS.

Anarrhichas latifrons STEENSTRUP and HALGRIMSSON, Förh. Skand. Naturf. 1842, p. 647.

North Atlantic (Iceland and Western Greenland, according to Steenstrup).

LYCICHTHYS DENTICULATUS.

Anarrhichas denticulatus KRØYER, Overs. Vid. Selsk. Kjøb., 1844, p. 140—GAIMARD Voyage en Scand., en Lapponie, etc., Atlas, pl. 12, fig. 1.

Anarrhichas latifrons, part, SMITT, JORDAN and EVERMANN.

North Atlantic (Western Greenland), in deep water.

LYCICHTHYS PAUCIDENS.

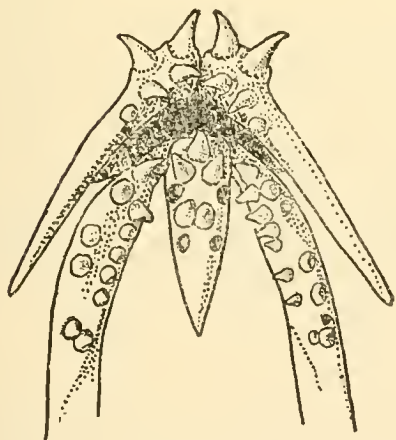


FIG. 9.—LYCICHTHYS PAUCIDENS, UPPER TEETH.

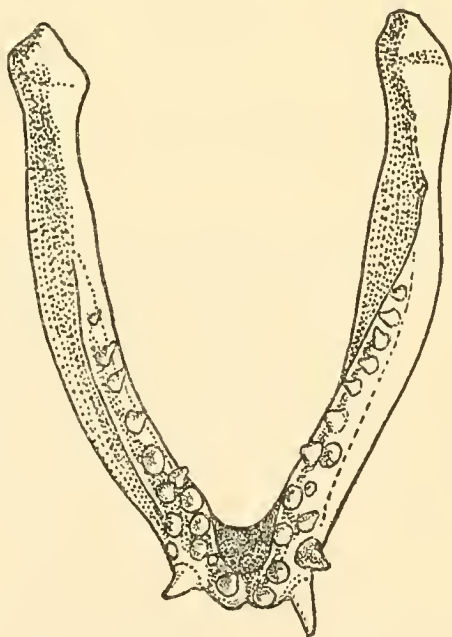


FIG. 10.—LYCICHTHYS PAUCIDENS, MANDIBULAR TEETH.

Lycichthys paucidens GILL, Bull. Biol. Soc. Wash., Dec. 9, 1905, vol. 18, p. 251. (Banquereau near Nova Scotia.)

North Atlantic, in deep water, off the coast of Maine and Nova Scotia.

(Type 23915 Banquereau obtained at a depth of 200 fathoms September, 1879, by the Gloucester fishing vessel *Marion*, Capt. Philip Merchant.—Skull 467.)

Genus ANARRHICHAS.

Anarrhichas (GESNER) LINNÆUS, Syst. Nat., 10th ed., 1758, vol. 1, p. 247.—STEENSTRUP, Vid. Medd. Naturf. For. Kjøbenhavn, 1876, pp. 159–292 (extended to include *A. latifrons* and *A. denticulatus*).—GILL, Ann. Rec. Sci. and Ind., 1876, 1877, p. clxvii.

Type.—*A. lupus* Linnæus.

Anarrhichadids with a moderately elongated body, rudimentary scales, dorsal fin elevated and with its hindmost spines especially stiffened.

Teeth more or less blunt; *intermaxillary* very robust, nearly straight, and about 6 in an outer row, small and irregular in an inner row, and a few intervening between rows; *mandibular* 4 large in front with blunt summits; crowded and molar on sides; the ridge of the dentary inflected and with largest teeth, the outer on the inflected sides and smaller; *vomerine* in a wide patch longer than palatine, molar and closely crowded, in 2 rows and intervening smaller teeth; *palatine* molar, crowded and biserial.

Hypopharyngeal teeth subequal in a broad band.

Branchiostegal rays 8, 4 to inferior edge of ceratohyal, 2 to hinder edge of ceratohyal and 2 in depressed lower half of epihyal.

Ossification complete.

Cranial axis angular, the vomer subtending a high angle with the parasphenoid.

Parasphenoid much compressed, very narrow in front of cerebral chamber.

Postfrontal region much compressed and very narrow (pinched) between interorbital region and superoccipital.

Sphenotic and parietal separated by a large deep pit circumscribed by the approximation of the bones before and behind.

Suprascapula undivided and prolonged forward over the sphenotic-parietal pit, and connected with the ridge in front and clamped behind by the approximated sphenotic and parietal.

Actinosts (two and three) not or little constricted at middle.

The genus *Anarrhichas*, as now limited, includes three well-marked species known to me through autopsy and another (*orientalis*) which can not be identified with the only one seen by me (*lepturus*) occurring within essentially the same geographical range. The measurements attributed to the *A. orientalis* by Pallas are, however, irreconcilable with the form typical of the genus.

There is either a remarkable range of variation in the dentition of species of the genus or more than one have been confounded under

the names *A. lupus* and *A. minor*. The peculiarities manifested by examples of species examined by the writer are collated in the following table, but probably will not be found to be fully exemplified in all others. The Scotch and Scandinavian naturalists, who have ready access to many specimens, would confer a favor on ichthyology by instituting a systematic comparison. A few of the variations manifest are illustrated in the accompanying figures. Every individual examined has been found to be peculiar, no two specimens being exactly alike. Nevertheless, American specimens were considered for a time to belong to an independent species. A distinctive name ("*Anarrhichas vomerinus* Agassiz Ms.") was conferred on it by D. H. Storer in 1855, but the only character given was based on the vomerine dentition—"Vomerine teeth perfectly united together, forming a solid mass;" it was only added that "Mr. Agassiz considers this a distinct species from the European, basing his opinion upon a difference in the number and disposition of the vomerine tubercles." It is probable that Storer did not mean what he said; it is unlikely that he could have seen a specimen with teeth "forming a solid mass." The teeth are conglomerated into a compact area, but the interspaces of the separate teeth are evident, however narrow they may be. No distinctive characteristic has been found between American and European representatives of the genus.

Key to species of Anarrhichas.

- a*¹. Dorsal spines 62-77; vomerine teeth not extending forward much beyond palatine (by only 1 pair), all bluntly molar; palatine teeth all molar crowns.
- b*¹. Palatine teeth in moderately long patches (extending as far back as front of last vomerine teeth), those of outer row little larger than inner; color yellowish or grayish blue, on back and sides manifest in numerous roundish blackish spots.....*A. minor*.
- b*². Palatine teeth in quite short rows (extending only as far back as penultimate vomerine teeth), those of outer row much larger than inner; D. 70-77; A. 43-48; color dark gray, on back and sides manifest in darker cross bands (9-12) and on shoulders in darker spots.....*A. lupus*.
- a*². Dorsal spines 81 pm; vomerine teeth notably extending forward beyond palatine (by nearly 2 pairs), foremost with mammiform crowns, hindmost flattish convex; palatine teeth in outer row erect and conic or with mammiform crowns (extending as far back as centers of last vomerine teeth), those of outer row larger than inner; color dark brown, without bands or spots.....*A. lepturus*.

ANARRHICHAS MINOR.

Anarrhichas minor OLAFSEN, Reise i Island, 1772, p. 592 (Iceland).

Anarrhichas pantherina ZUIEW, Nova Acta Petropol., vol. 5, 1781, p. 271, pl. 6.

Anarrhichas karrak BONNATERRE, Encycl. Ich., 1788, p. 38. (After Olafsen.)

Anarrhichas maculatus BLOCH, Syst. Ich., Schneider ed., 1801, p. 496. (After Olafsen.)

Anarrhichas leopardus AGASSIZ, Pisc. Brasil, 1829. (Atlantic Ocean.)

Anarrhichas eggerti STEENSTRUP, Forh. Naturf., 1842.

North Atlantic, in deep water, south to Scotland and Maine.

ANARRHICHAS LUPUS.

Anarrhichas lupus LINNÆUS, Syst. Nat., 10th ed., 1758, vol. 1, p. 247. (Northern seas.)

Anarrhichas strigosus GMELIN, Linn. Syst. Nat., 1788, vol. 1, p. 1144. (British seas.)

Anarrhichas vomerinus AGASSIZ, STORER, Mem. Amer. Acad. Arts and Sci., vol. 5, p. 265.

North Atlantic along the shore of Europe to British Channel and of America to Cape Cod.

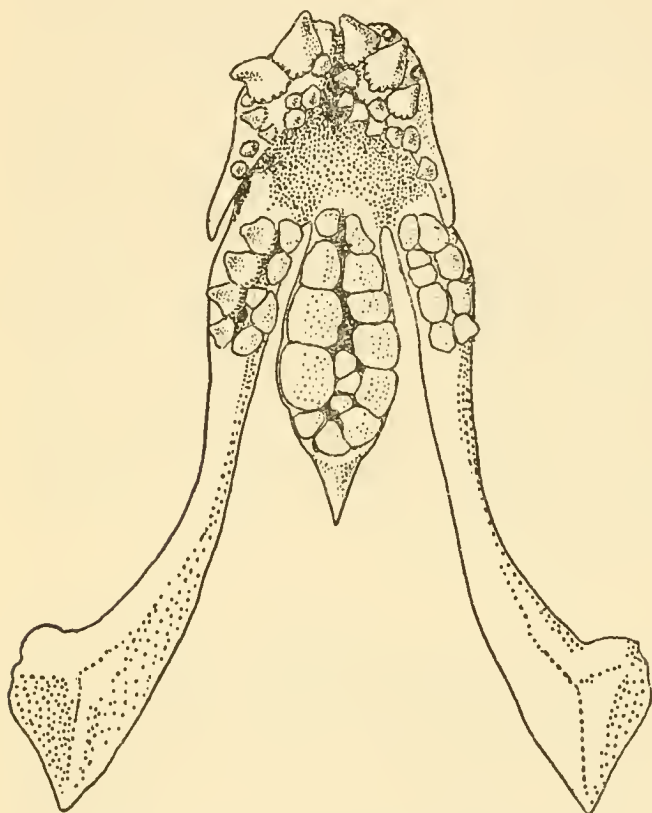


FIG. 11.—ANARRHICHAS LUPUS, UPPER TEETH.

ings by Chinese artists, collected by J. Senn van Basel and deposited in the museum of the University of Gröningen. The drawings of fishes (440) were examined by Dr. P. Bleeker and a number of supposed new species described from them. One of these was the *A. fasciatus*, of which nothing was known as to habitat or habits, and nothing further can be known until specimens are obtained. The descriptive notice of the figure was published in 1873^a and here follows:

Anarrhichas fasciatus Blkr.

Corpus altitudine 5 $\frac{3}{4}$ circ. in ejus longitudine, viridescens, fasciis 14 circ. transversis profundè viridibus spatiis intermediis latioribus, pinnam dorsalem intransibus. Operculum macula rotunda nitente viridi vel coerulea. Caput, dorsum lateraque insuper coerulescente et rubro arenata.

ANARRHICHAS LEPTURUS.

Anarrhichas lepturus BEAN, Proc. U. S. Nat. Mus., vol. 2, 1879, p. 212. (St. Michaels, Alaska.)

North Pacific south to Vancouver Island; common around the Aleutian Islands.

ANARRHICHAS ORIENTALIS.

Anarrhichas orientalis PALLAS, Zoograph. Rosso-Asiatica, vol. 3, 1811, p. 77. (Kamchatka.)

Coast of Kamchatka.

Another nominal species of a very doubtful character is one known only from a Chinese figure and named *Anarrhichas fasciatus* by P. Bleeker. The figure was one of many (462) paintings

^a Nederlandsch. Tijdschrift voor de Dierkunde, vol. 4, p. 151.

Genus ANARRHICHTHYS.

Anarrhichthys AYRES, Proc. Cal. Acad. Nat. Sci., vol. 1, 1855, p. 32.—GIRARD, Expl. and Surv. for R. R. route to Pacific Ocean, vol. 10, Fishes, 1858, p. 124.

Type.—*A. ocellatus* Ayres.

Anarrhichadids with the body greatly elongated and tapering backwards into a very long and compressed tail terminated by a caudal fin of normal type but much reduced in size; rudimentary scales, dorsal fin elevated (about twice as high as the anal) and graduated to caudal; without enlarged hinder spines.

Teeth more or less blunt; *intermaxillary* very robust, especially foremost, about 6 in an outer row, small and irregular in an inner row; *mandibular* 4 large in front with moderately blunt tips, crowded and molar on sides, the ridge

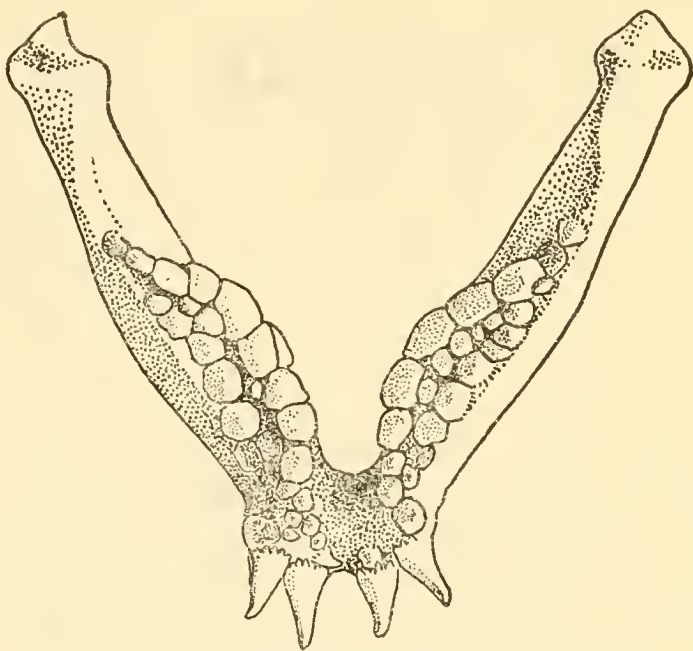


FIG. 12.—ANARRHICHAS LUPUS, MANDIBULAR TEETH.

of the dentary inflected and with largest teeth, those of the inner row smaller and irregular; *vomerine* in a wide patch longer than palatine, molar and closely crowded in two rows only; *palatine* molar, crowded and imperfectly biserial.

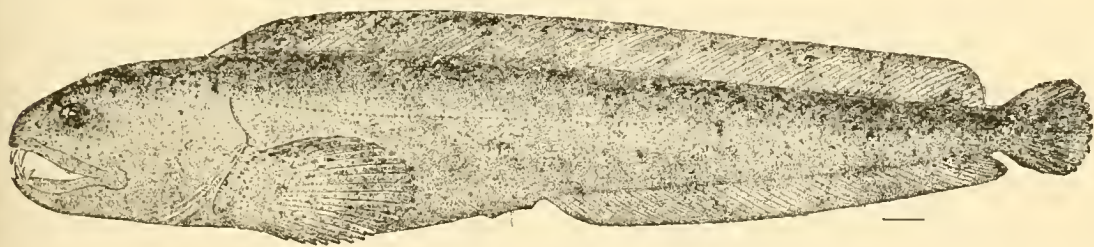


FIG. 13.—ANARRHICHIS LEPTURUS (AFTER TURNER).

Hypopharyngeal teeth rather slender, but blunt and irregularly biserial.

Branchiostegal rays 8, 4 to inferior edge of ceratohyal, 2 to hinder edge of ceratohyal, and 2 to upper surface of epihyal.

Cranium with ossification complete, but frontal and ethmoid spongy; the cranial axis nearly rectilinear, the vomer being but little extended below the axis; parasphenoid much compressed, narrow in front of cerebral chamber; post frontal region much compressed

and very narrow and sharply carinated between interorbital region and supraoccipital.

Actinosts (second and third) almost square and not constricted at middle.

ANARRHICHTHYS OCELLATUS.

Anarrhichas felis GIRARD, Proc. Acad. Nat. Sci. Phila., vol. 7, 1854, p. 150. (Not described.)

Anarrhichthys ocellatus AYRES, Proc. Cal. Acad. Nat. Sci., vol. 1, 1855, p. 31. (San Francisco.)

Anarrhichthys felis GIRARD, Expl. and Surv. for R. R. route to Pacific Ocean, vol. 10, Fishes, 1856, p. 125, pl. 25a, figs. 1-3.

Pacific coast, North America, from Alaska to Monterey.

A "description of the skull and separate cranial bones^a of the Wolf-eel (*Anarrhichthys ocellatus*)" has been published by L. A. Adams in the Kansas University Science Bulletin (vol. 4, Sept., 1908, pp. 331-355) and is illustrated by 12 excellent plates (25-36).

PART 2.

HABITS OF THE WOLFFISHES.

One of the most remarkable fishes of the northern Atlantic is that known as the wolffish, or, in common with many other very different species, as the catfish. Wolffish, as the only distinctive name, naturally has been adopted in most works on fishes. Many data respecting its life history have been obtained in recent years, but above all by the investigators connected with the "Fishery Board for Scotland." Such are scattered through many volumes and are for the first time collected in the present article.

I.

The technical name of the wolffishes (*Anarrhichas*) is the result of a singular misconception. Konrad Gesner received a specimen from the German Ocean and was told (or thought he was told) that the fish climbed out of the water on the rocks; consequently he devised for it the name *Anarrhichas* (1560) from the Greek verb ἀναρριχᾶσθαι (*anarrhichasthai*), to clamber or scramble up. As this name was retained by Linnæus it must be retained by us, inapplicable as it is.

The most common vernacular names are *wolffish* and *catfish*. *Wolffish* is given with reference to its enlarged pointed front teeth and savage disposition and is the one adopted in most works on fishes. *Catfish* (given partly with reference to the teeth and partly in allusion "to the somewhat cat-like form of its large rounded head") is likewise in quite general use—more than wolffish, indeed—especially along the eastern coast of Scotland and the New England coast (Massachusetts, etc.). *Seawolf* and *seacat* in some localities are used instead.

^aThe opercular, branchiostegal and branchial systems are not described or figured.

Wauffs or *wuffs*, accredited to Yorkshire, are evidently provincialisms for wolves. Equivalent terms are *wolffisch*, *seewolf*, and *wolffisch* of the Dutch, *Soulv* and *Ulvfisk* of the Danes, and *Loup marin* of the French. The Swedes prefer the analogy to the cat (*Hafkatten* or *seecat*). In Orkney, *swinefish* is in vogue, and allusion thereby, according to Day,^a is made to "a sort of muscular motion of its nostrils which the fishermen say resembles that in the nose of a swine." In Norway its current name is *Steenbider* or *Stonebiter*.

II.

The wolffishes are inhabitants of cold and moderately deep water of the Northern Hemisphere, but in varying degrees, according to species. In the Atlantic, the common species (*A. lupus*) at times approaches shallow water and sometimes even is left in tide pools, as in the Bay of Fundy and along the coast of Maine at Eastport, where the tides are abnormally great; on the other hand, as Goode and Bean have truly remarked, farther south "on the New England coast it is frequent in the deep waters" and "is associated with many deep-water forms." The other Atlantic species never goes into shallow water; the spotted wolffish (*A. minor*) has been found as low down as 200 fathoms at least. In the Pacific one of the species (*A. lepturus*), more even than the *A. lupus*, ascends into quite shallow water. The common wolffish, however, seems not to be entirely confined for its whole life to a particular locality.^b There is, it has been claimed, a partial migratory movement from deep water into shallow and the reverse. According to T. Wemyss Fulton (1903), there "appears to be a migration of the large catfishes from the deeper water shorewards in winter and spring for spawning." This being effected, a limited reverse movement takes place.^c Small individuals are rarely taken and it has been assumed that such hide among the rocks and thus escape capture.

As in the depths, where darkness ever reigns, it is always night, so in the night the common wolffish in shallow waters is most at home and most active. The habits of some, confined in the Manchester Aquarium, specially observed by Saville Kent, were found to be "essentially nocturnal, the fish remaining perfectly quiescent through-

^a Low (George) in his *Fauna Orcadensis* (1813), was the first to publish the data in question.

^b According to J. Epton, of Grimsby (in Herbert (editor), *Fish and Fisheries*, 1883, p. 248), "it chiefly inhabits the northernmost side of the Doggerbank, in depths of 17 to 45 fathoms. This fish does not appear to roam about."

^c The Alaska wolffish (*A. lepturus*) is especially declared by Turner (1886) to be "a migratory fish, coming to the shores at Saint Michael's as soon as the ice leaves the beach. It remains until ice forms in November. During the period between those dates it is quite plentiful. It frequents the rocky ledges, shelves, and points which have vegetation growing near the edge of the water."

out the day on the shingle at the bottom of their tank, but arousing from their lethargy and swimming about in search of food on the approach of night." The Alaskan wolffish (*Anarrhichas lepturus*) is also well known to the Eskimos to be "mostly nocturnal in its habits," and is generally caught during night.

A favorite attitude of rest is to lie "with the body doubled up." A spot by the side of a rock or in a rocky recess is chosen when it can be had. If seaweeds abound about its lurking place it is so much the more acceptable. If such are not readily accessible, however, the bare ground may afford a resting place.

Its natatory movements are said to be much like an eel's, although of course less sinuous on account of its stouter form; according to Smitt "the long soft body, tapering tail, and small caudal * * * probably render it a poor long-distance swimmer. Its movements, too, are slow."

III.

Old writers gave the wolffish a very bad character. Lacépède charged that, "cruel as the shark, it works terrible havoc among its own kind, and displays the same voracity in the piscine world as the wild beast from which it derives its name, among the defenceless herds." Doubtless the fish's aspect as well as name led to the inference. The structure, however, is not adapted for piscivorous habits. The strong and projecting front teeth are chiefly used and are efficient for picking or raking out from their coverts the shells, crabs, and echinoderms lurking therein; the array of grinding teeth in the roof and sides of the mouth for crushing them.^a The powerful teeth and jaw muscles, while not the best armature for a fish-eating animal, are admirably adapted, some for collecting, others crushing, shells. "Of the power of the jaws," says Smitt, "one may convince oneself by opening the stomach, which may be chock-full of crushed thick-shelled mussels and other shellfish. It eats them in great quantities, and the thin-walled intestine is often full of thin shells." One of the earliest observers (Bellamy in 1843) found "the stomach contained small crabs, *Pecten opercularis*, *Fusus corneus*, etc., all fractured by the conical and flat sets of teeth prior to being swallowed." But large drafts are also made on the thinner-shelled crustaceans. According to W. Ramsay Smith (1890), "in the Firth of Forth arthropods (*Eupagurus*, *Hyas*, *Portunus*, *Nephrops*, *Crangon*, *Gala-*

^a A comparison of the conchifragous Sciaenids of America (*Pogonias chromis* and *Aplodinotus grunniens*) is interesting as showing how the same function (shell-crushing) may be effected in quite different ways. In the wolffishes the shells are crushed as soon as they enter into the mouth by the side teeth of the jaws and palate; in the drumfishes the jaws have no crushing teeth, and the palate no teeth at all, but the pharyngeal bones (hypopharyngeal and middle epipharyngeal) are enlarged (the former consolidated) and paved with huge molar teeth.

thea)”—that is, crabs, hermit crabs, lobsters, and shrimps—“were found in about 50 per cent” of the wolf- or “catfishes” caught in 1889; “sandstars and molluscs were found each in about 30 per cent,” and “annelids and fish as articles of food were merely represented.”

Fulton (1903) examined eight fishes caught in the Moray Firth in May, 1902, and found, besides crabs and shells, many brittle-stars (ophiurids) and, in one fish, “a specimen of *Aphrodite aculeata* [an annelid worm] and a fragment of a zoophyte.”

Verrill (1871) found in the stomach of a large fish caught at Eastport, Me., “at least four quarts of the common round sea-urchin (*Euryechinus drobachiensis*), most of them with the spines on and many of them quite entire.” From another he took “an equal quantity of a mixture of the same sea-urchin and the large whelk (*Buccinum undatum*). Many of the latter were entire or but slightly cracked.” It would thus appear that the crushing apparatus of the fish is not called into requisition as often as might be expected, but, in the stomach of one mentioned by Buckland, “nearly two pints” of crabs had been ground “up to mince meat.”

Observations made in 1903 by R. A. Todd^a corroborated the shellfish diet of the wolffish. In the stomachs of six individuals no fishes were found. The contents were shellfishes (scallops, etc.), crabs, hermit crabs, and echinoderms. In fine the food depends very much on what it can find for the time being, with instinctive preference for that which can be crushed.

A habit of an Alaskan wolffish (*Anarrhichas lepturus*) has been indicated by L. M. Turner (1886) which has not found a parallel observer for the corresponding Atlantic form. “The strong [front] teeth are used to tear the sods of grass that may wash into the sea from the shore or cliff ledges into pieces to eat.” His “attention was once directed to a floating sod, a short distance from the shore, going through strange motions.” A native informed him that it was a wolffish and he “directed the canoe toward the sod and saw the fish tearing it. It was with difficulty that” the fish was made to “leave its food, and only after several thrusts at it with the paddle did it swim off.” The natives, it seems, also catch the fish “with hooks baited with grass roots.” It is probable that such assaults upon vegetable masses are for obtaining the crabs and shells lurking in them rather than for the plants themselves.

Smitt asserts that a wolffish “apparently leaves its companion fishes in peace, being perhaps of too sluggish temperament to trouble them.” W. R. Smith (1892) found remains of fishes in only two wolffishes out of twelve examined, herrings in one case and unidenti-

^a North Sea Fisheries Investigation Co., Report No. 2, 1905, p. 233.

fied in the other. It indeed mangles fishes caught with it in a net, but it does so in unreasoning wrath and not for food.

That organization which so well fits the fish for a conchifragous habit, however, renders it capable of inflicting severe injuries on fishes and even man, if occasion provokes or requires. Conscious of its power, it disdains to flee, and will even attack one who intrudes on its near neighborhood. Goode tells that it is "pugnacious in the extreme" and has been "known to attack furiously persons wading at low tide among the rock-pools of Eastport," Maine. In Olsen's *Piscatorial Atlas* of the North Sea (1883) "divers are warned not to meddle with this fish in the water, or he will be sure to make an attack." It may in fact bite at any object presented to it.

The wolffish's strength of jaw and tenacity of hold are remarkable. Buckland relates that the smaller of two fishes caught in a trawl "on being brought on deck bit at a mop handle which was held out to it so savagely that it was swung overboard without letting go its hold. When it was shaken off, one of its teeth was left behind it fastened in the wood." A full-grown fish, it is claimed, "can snap a broom handle in two with the greatest ease." Steller saw a knife-blade readily broken by one.

IV.

Sexual maturity may be attained by the common wolffish when a length of not much more than 2 feet (possibly less in exceptional cases) has been attained, but generally spawners are considerably larger. Fulton (1890) examined 59 specimens of completely "ripe fish" and the smallest was 27 inches long, while the largest was 42 inches. The average length of the 59 was nearly 3 feet (34.8 inches).

The relative proportion of the sexes seems to be somewhat exceptional. According to the expressed opinion of some naturalists, and the recorded observations of 59 specimens by T. Wemyss Fulton (1890), the males appear to be not only larger but more numerous than the females. Of the 59 examined by Fulton 33 were males and 26 females; the average length of the former was 29.4 inches and of the latter only 27.6 inches, the females being thus only 87/100 as large as the males. The general impression was later expressed by M'Intosh and Masterman in the statement that "the females are smaller in size than the males and are in a slight minority."

Fulton, as late as 1905, considered that the spawning season of "the common species has not yet been well determined," but that "M'Intosh and Masterman are probably right in supposing that the main spawning time of this fish is from November to January, with a margin on either side." At any rate, it is deferred till the commencement of cold weather or winter. Mature eggs were found, however, in one fish caught as early as the "6th August," in 1904, but this case was quite exceptional.

The ovaries present some noteworthy characteristics which were long ago noticed by W. C. M'Intosh (1885) and contrasted with those of the so-called "viviparous Blenny" or Zoareid. "In shape these considerably differ, since they are separate anteriorly and connate posteriorly, as usual in many fishes. Their walls are also much more massive. There is considerable similarity, however, in the arrangement and connexion of the ova with the ovarian wall, to which they are fixed like large flattened bunches of grapes." "In a female procured during the trawling experiments at the end of August [29th, 1884], the majority of the ova were about 4 millim. in diameter, each being attached by fine thread-like bands of tissue. The membranous parts of the folds to which the ova were attached show, in addition, numerous microscopic ova. The vascularity of this tissue is slight, and in striking contrast with the villous processes in the ovary of the viviparous Blenny. The ovaries of a specimen obtained in February were unusually coarse internally from the presence of numerous large ova (5 millim. in diameter) amongst the smaller. Some of the large ova were quite free and apparently ready for extrusion, while others were fixed to the membranous pedicles and folds, which presented many branching blood vessels, as well as more minute ova. The latter seem to be developed everywhere in the stroma" or indifferent tissue "of the ovary and its villous processes. From the variable size of the ova in this instance, the spawning period probably extended over a considerable time. The ova are, further, evidently deposited in the bottom." "In other examples the nearly uniform size of the majority would show that many are deposited simultaneously." In the ovaries of a fish examined "on 28th May," 1890, T. Wemyss Fulton (1891) also found "the great mass consisting of ova of nearly uniform size (2.1 to 2.5 mm.). Along with these there were a large number of ova much more minute (0.8 to 0.9 mm.) scattered in the interstices." Further, Fulton found "a large, fully matured ovum (the only one present), much more pellucid than the others (6.1 mm. in diameter), and weighing exactly 1.5 grains." He "considered it a good example of what occurs in the development of the eggs in many fishes—a more or less gradual growth up to a certain point, and then a sudden expansion. The medium-sized ova had apparently begun to undergo this process preparatory to extrusion. There were a few (but very few) intermediate in size between the latter and the more minute ova, which no doubt served for a second crop. Sixty grains were weighed and counted; they contained 431 large ova and 321 of the very minute ones; so that the total number present in the ovaries would be—large, 14,388; small, 10,682=25,070." The number of eggs thus estimated may be much greater, the number depending on the size of the fish. A large female, according to M'Intosh and Masterman, "may produce as many as 40,000 eggs."

The eggs are of "the demersal type" and are "deposited in large masses by the female amongst the rocks and weed of the shallow waters. Like most demersal types, they cling firmly together by reason of a secretion extruded from the parent. They only adhere at limited parts of the egg-capsule, so that aeration through the mass is easily effected. Their deposition in large masses doubtless facilitates their fertilization by the male. In size they closely approximate those of the salmon; and indeed until quite recently," in spite of the localities in which they are found, "they were commonly mistaken by fishermen and others for those of the latter fish." The eggs are nearly a quarter of an inch ("5.5 to 6 mm.," or even slightly more) in diameter, "the largest marine demersal egg with which we are at present acquainted," though much smaller than the eggs of certain marine catfishes (*Tachisurines*) and fresh water *Osteoglossids* which the males carry in their mouths.

V.

Eggs, probably deposited in December, were hatched near the end of January, and the newly hatched larvæ were nearly half an inch ("12 mm.") long, "the largest British marine Telostean larva yet described." These larvæ were contrasted by M'Intosh and Masterman with those of salmon of the same stage. The yolk and contained oil-globule is of inconspicuous color and the yolk-sac spheroidal; there is but one large oil-globule which is anterior in position; the snout is very blunt and the eyes foremost; the marginal fin is continuous.

Development proceeds rather slowly; in some the absorption of the yolk may be delayed and "the larval period may thus continue till the end of June," but in others "may terminate at the middle of May." Thereafter it grows more rapidly. "In 6 or 7 months—for example, in July—its length may be 6 inches, and the following February," when about a year old, "from 8½ to 10 inches. In its second year it may grow to a length of 18 or 20 inches." Maturity is probably attained during its third year, but growth may continue slowly for years afterwards.

Young less than an inch long (.75–.80) have been found from February to May, "showing," according to M'Intosh (1890) "that the escape of some of this species from the egg must take place at the beginning of the year. "On 11th July a specimen 6¾ in., 5th August another 7¾, and on the 27th of the same month, a third 8¼ in. were obtained" and noticed by M'Intosh (1886). These undoubtedly were of the first year's growth. Those from 14 to 18 inches long, caught in summer, are fishes of the second year's growth. During the third year the length of 2 feet or more may be reached and sexual maturity attained. Growth, however, may not cease for years, and

it has been claimed—as by Günther (1880 and 1886)—that “a length of more than six feet” may be realized,^a but no such instances have been recorded within recent years. The old statements (as by Gronow and Lacépède)^b that a length of 15 or 16 feet is sometimes attained may be relegated to the category of fable.

VI.

The almost universal testimony of those who have been able to conquer the prejudice provoked by the appearance and odor of the fish, is that the common wolffish is one of the most savory of the inhabitants of the sea for the table. “The meat is white, firm, and of a fine flavor.” It has been repeatedly declared to be “excellent eating.” Buckland (1880) considered it to be “very good” and “like a nice veal chop.” Donovan (1803) found that cooking eradicates its unpleasant odor, and then it is “delicious” and somewhat like a mackerel, but better. Fishermen generally regard it highly and some think “it is the best fish that swims.” The fishermen of Bohuslän regard it as “a good catch, and its liver in particular as a delicacy.” But in many places, and in America especially, most persons are repelled by the forbidding appearance of the fish as well as by the smell “which is highly repulsive to most people.” In America, in the words of Storer (1855), “its hideous appearance renders it an object of such disgust that it is not infrequently thrown away as soon as caught. By many of our fishermen, however, it is considered very delicate; the smaller specimens weighing from five to ten pounds, are quite palatable when fried, boiled, or broiled, the skin having been previously removed. It is also occasionally split and salted, or dried, or smoked, and is said to be, when thus prepared, very good.” It is, nevertheless, only exceptionally to be found in any market.

^a Yarrell, in 1836 (I, p. 250), affirmed that “this fish attains the length of six or seven feet”, [etc.]. This has been often repeated since. Olsen, in his *Piscatorial Atlas of the North Sea* (1883), gives the “size, 3 and 4 ft. up to 7 ft.,” with the “weight 20 to 50 lbs.” Goode, in 1884, also recorded that “the largest individuals of this species are 6 or 7 feet in length and would probably weigh 40 pounds. The specimen mentioned by Richardson, 3 feet long, weighed 20 pounds.” If a fish 3 feet long weighed 20 pounds, one double that length, if the same proportions were preserved, would weigh eight times as much—i. e., 160 pounds.

^b Ce poisson peut figurer avec avantage à côté du Xiphias, et par sa force, et par sa grandeur. Il parvient quelquefois, au moins dans les mers très-profondes, jusqu’à la longueur de cinq mètres; [etc.]. Lacépède, vol. 2, p. 300.

Valenciennes, as early as 1836 (CV. XI, 488), well summarized the facts as to size: “L’anarrhique a ordinairement trois à quatre pieds; tous les auteurs qui l’ont observé par eux-mêmes ne lui donnent pas une longueur plus considérable et un poids supérieure à vingt livres. J’ai peine à croire à celle de quinze pieds, annoncée par Gronovius pour ceux des mers du Nord, et répétée avec tant d’emphase par M. de Lacépède.” [etc.].

In England sometimes the flesh is colored with anatto. A. H. Patterson ^a saw some prepared for market at Great Yarmouth cut into "rich yellow sections" looking "uncommonly like filleted haddocks, the colouring being much more ochreous, and the general appearance exceedingly appetising." They sold well so dressed and a piece cooked like haddock was found "fairly good eating, slightly 'twanging' of a skate-like flavour."

Equally worthy of esteem with the Atlantic wolffish are the spotted and Alaskan wolffishes. The deepest-water species or blue wolffish is, however, with one accord, rejected by all. That species, according to Sparre Schneider, is regarded as uneatable by "even the Russians," but a few are utilized by being "flayed and hung up to dry" for their skins.

It is not only the flesh of the wolffishes that is utilized by man. The skin is also appropriated to his use in some places, and, as just noted, even that of the blue wolffish (*Lycichthys latifrons*), which is contemned for its flesh, may be accepted for economical purposes. According to Smitt, "not only the flesh," of the common wolffish, "but also the strong skin is of comparatively high value." Smitt, however, does not give any information as to the mode of utilization of the skin.

The skin of the Alaskan wolffish (*A. lepturus*) is equally valued. Turner (1886) says that "the natives strip the skin from this fish and tan it, to be used in inserting between the seams of boots and other waterproof garments. The skin of the fish is said to swell when moistened and thus draw the threads tighter together. The dried skin is totally different from the fresh skin, in that it is nearly black and beautifully mottled with black and silvery dots."

Partly because there is no general demand for it, and partly because it is a solitary fish and not very common, there is no extensive or exclusive special fishery for the wolffish in any country.

Individuals are elsewhere often taken by lines set for cod and haddock, and sometimes in salmon nets in estuaries. A notable mode of capture is practiced for the Alaskan wolffish at St. Michaels. "The Eskimo bait a large hook with tender grass roots and cast it into the water when the tide is at half-flood in the evening, as the fish is mostly nocturnal in its habits. The part of the line near the hook is usually made of a stiff strip of balcen to prevent the numerous teeth of the fish from cutting the line in two."

The most extensive captures are by the trawl. The most reliable and comprehensive statistics of catches of the wolffish or catfish have been published by the Board of Agriculture and Fisheries in their annual reports. In the Annual Report of proceedings under acts

^a Zoologist, 1908, p. 443.

relating to sea fisheries for the year 1907 (1909, pp. xxiv, xxv, lxxxiv, lxxxv), it is declared that "catfish are entirely confined to the northern regions and the North Sea and are taken almost entirely by steam trawlers." A total of 74,150 hundredweight were landed in Great Britain in 1907; 23,234 hundredweight were taken in the North Sea, 28,958 hundredweight were brought from Iceland, 18,434 hundredweight were received from Faroe, and 2,214 hundredweight came from as far as the White Sea. The rest were caught chiefly around Scotland. These proportions of course vary greatly from year to year. The quantity landed is greater than that of such esteemed fishes as the turbot and sole.^a

The wholesale as well as retail price greatly varies. In the Bulletin Statistique, published by the Conseil Permanent International pour l'Exploration de la Mer (1906), figures are given for Germany, England, and Scotland for 1903 and 1904. In 1903 the wolffish commanded in Germany, for a kilogram (about 2½ pounds), an average price of 0.20 of a shilling, and in 1904, 0.17 of a shilling; in England, respectively, 0.17 and 0.11 of a shilling, and in Scotland (1904), 0.11 of a shilling. The price was approximately equal to that realized for whiting in England and Scotland and much more than that prevailing for the same fish in Germany. It was considerably greater than the price obtained for herring in the same years in England and Scotland, but less than that commanded in Germany.

HABITS OF THE WOLF EEL.

The wolf eel (*Anarrhichthys ocellatus*) is pronounced by Jordan and Evermann (1898) to be "one of our most remarkable fishes." "Wolf eel" is a made name originating from some one acquainted with the wolffish. A more common designation along the Pacific coast, where the true eel was unknown until introduced, is *eel*. According to Jordan (1884), also, "the name 'Agia' is given to it by the Dalmatian fishermen on Puget Sound, and that of 'Morina' by the Italians at Monterey." There may be some misunderstanding as to Agià, for in the Adriatic and along the Dalmatian coast the name Azià, (also spelled Asià, Asiao, and Asiar,) is applied to the piked dogfish (*Squalus acanthias*). Morena (not Morina) is an Italian name of the common moray (*Muraena helena*) and therefore expresses essentially the same appreciation of resemblance as the English name eel.

It is an inhabitant of the Pacific coast from Puget Sound to Monterey, "lurking among the rocks and occasionally left by the falling tide." Sometimes, but rarely, a length of 8 feet or even more is

^a 67,348 hundredweight of the turbot and 63,085 hundredweight of the sole were landed in 1907.

attained. "It feeds chiefly on sea-urchins and sand-dollars" (*Echinarachnius excentricus*), according to Jordan and Evermann. Lockington (1879) found "a very stout-looking example, 5 feet long," whose stomach was "filled with the tests of *Echinarachnius excentricus*, the common cake-urchin of the [Californian] coast, broken into large fragments, many of them considerably more than an inch across." Its diet, in fact, seems to be much like that of the common wolffish. "It is rarely used as food," say Jordan and Evermann (1898), but earlier (1880) Jordan had found that "as a food-fish, it meets with a ready sale." Now, as in 1880, "nothing special is known of its breeding habits, enemies, or diseases." Certainly some fish student of one of the Californian universities or laboratories should supplement this very scanty information.

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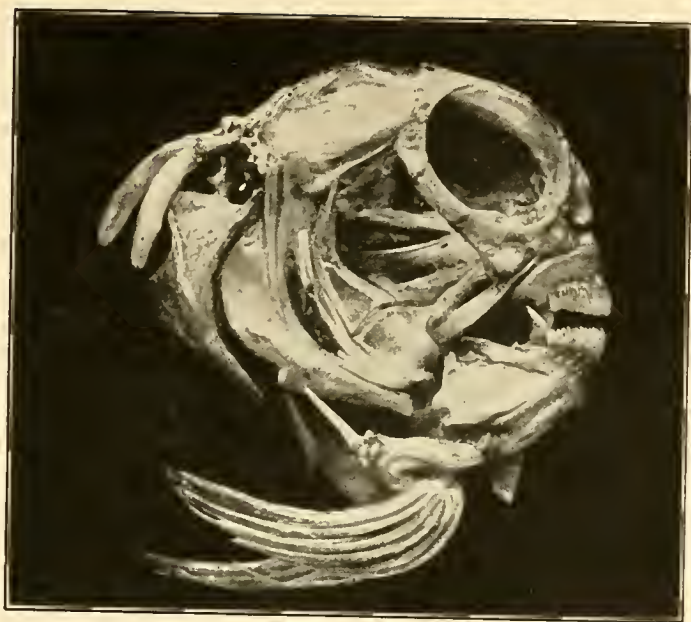
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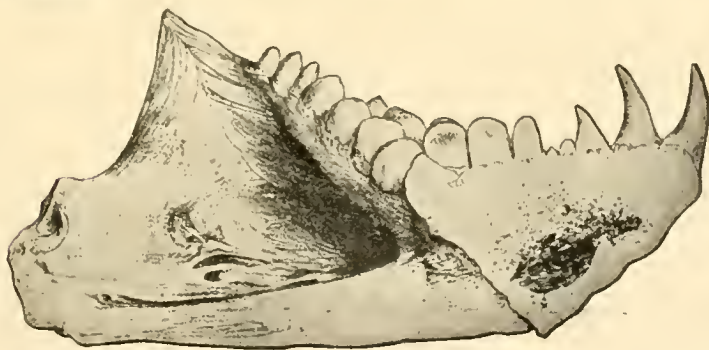
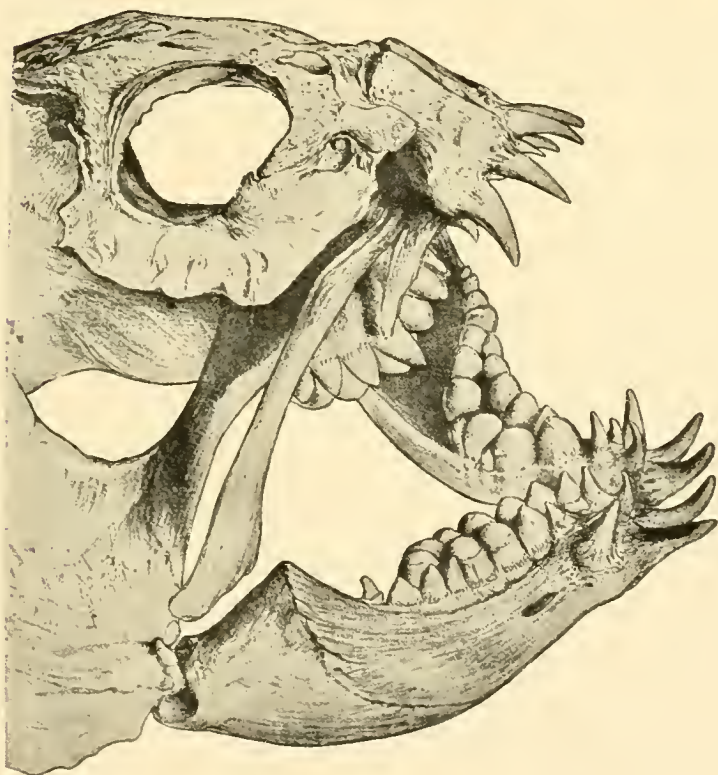
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SKULL OF *BLENNIUS OCELLARIS*.



PART OF SKULL OF *ANARRHICHAS LUPUS*, SHOWING TEETH (AFTER OWEN).



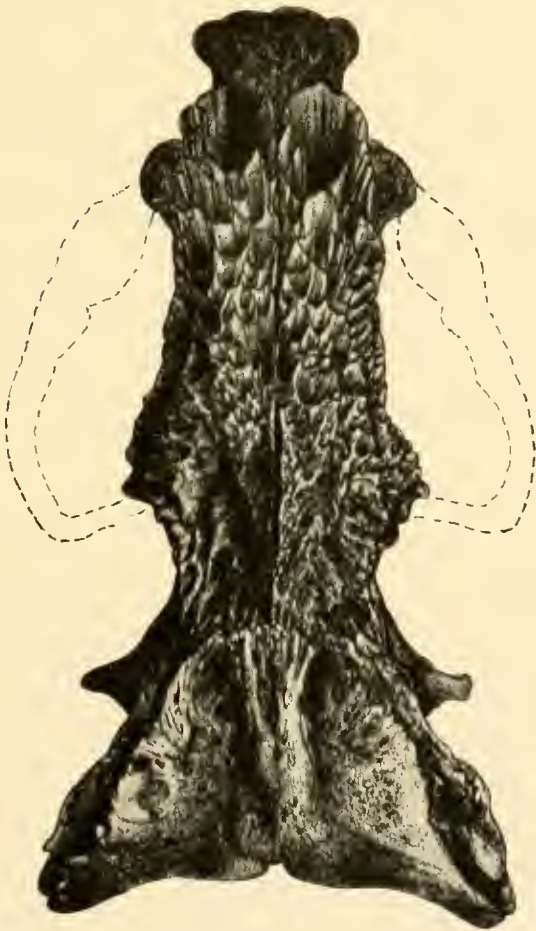
SKULL OF LYCICHTHYS PAUCIDENS.



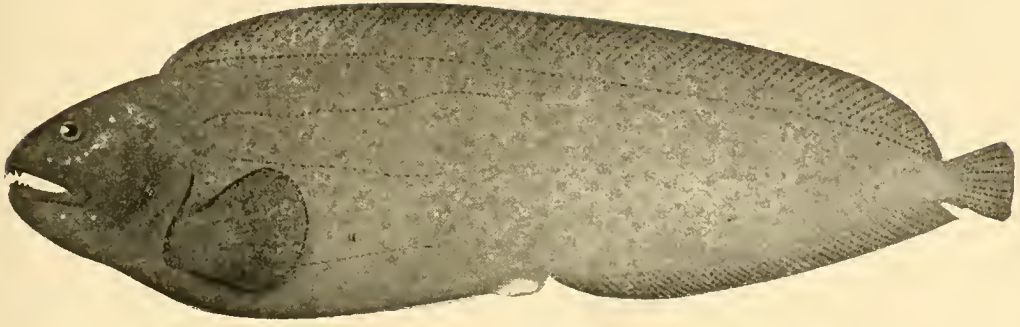
SKULL OF ANARRHICHAS LUPUS.



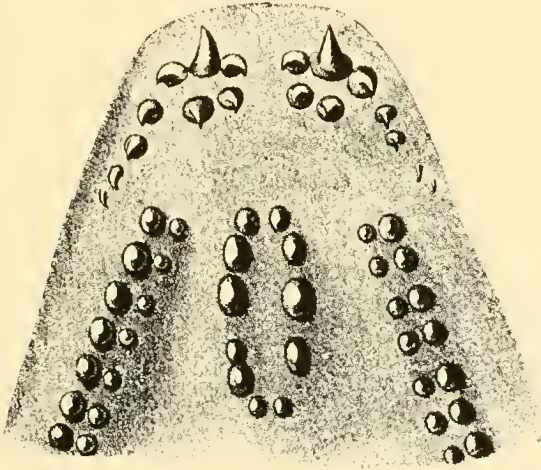
CRANIUM OF LYCICHTHYS LATIFRONS (AFTER STEENSTRUP).



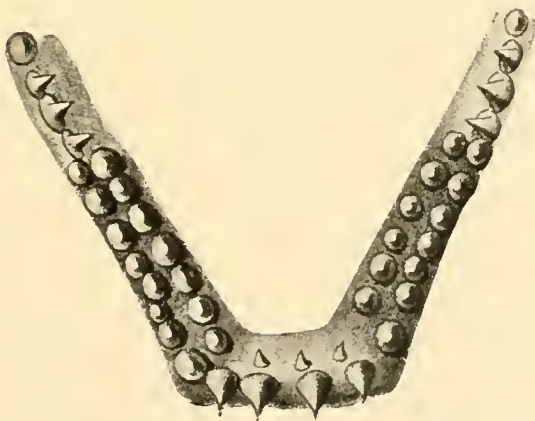
CRANIUM OF LYCICHTHYS LATIFRONS (AFTER STEENSTRUP).



LYCICHTHYS LATIFRONS (AFTER SMITT).



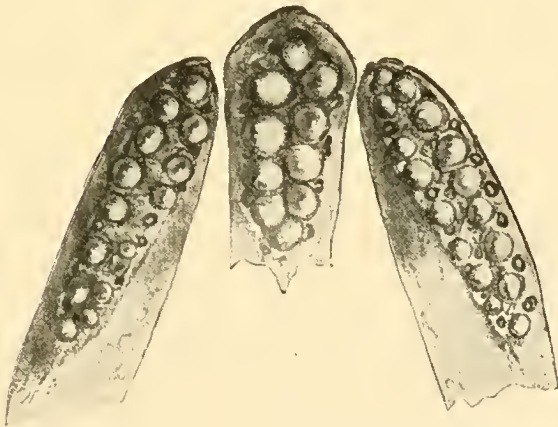
UPPER TEETH OF LYCICHTHYS DENTICULATUS AFTER THORNAM (GAIMARD).



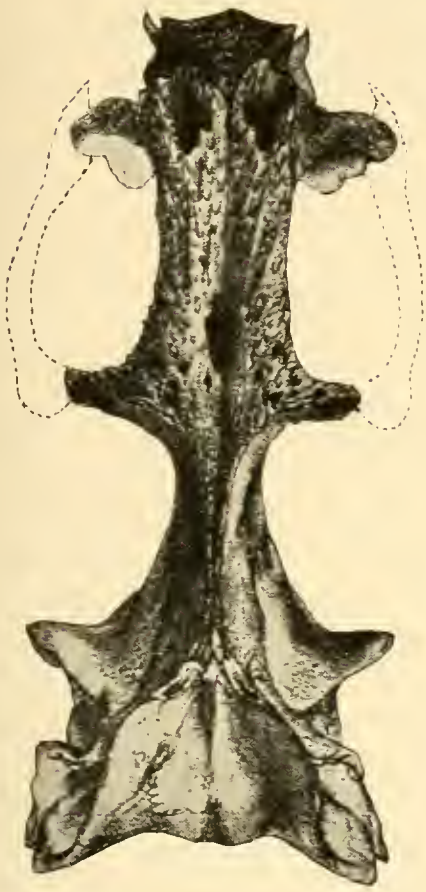
MANDIBULAR TEETH OF LYCICHTHYS DENTICULATUS, AFTER THORNAM (GAIMARD).



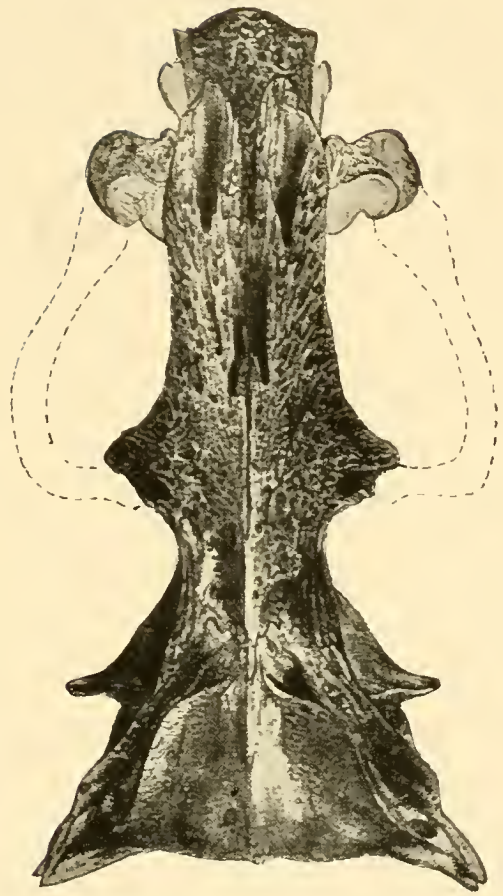
LYCICHTHYS DENTICULATUS, AFTER THORNAM (GAIMARD).



UPPER TEETH OF LYCICHTHYS LATIFRONS (AFTER STEENSTRUP).



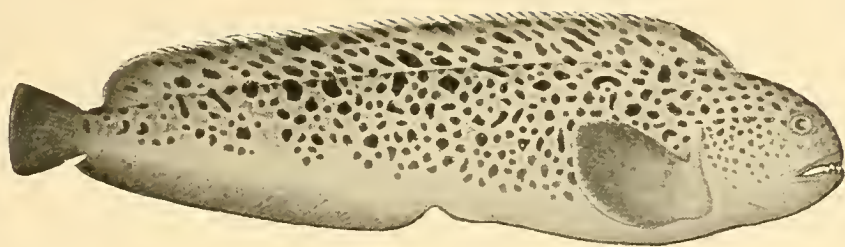
CRANIUM OF ANARRHICHAS LUPUS, FROM ABOVE (AFTER STEENSTRUP).



CRANIUM OF ANARRHICHAS MINOR, FROM ABOVE (AFTER STEENSTRUP).



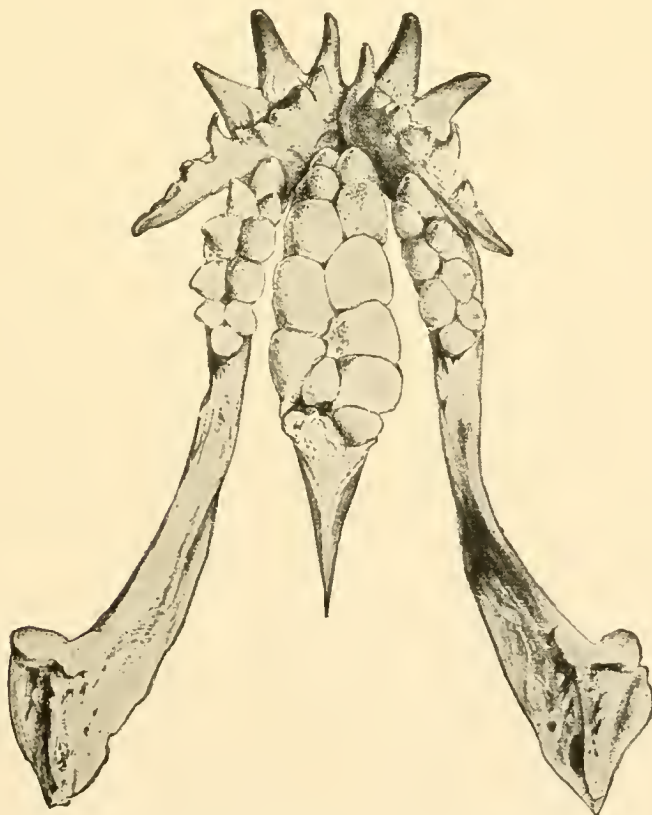
CRANIUM OF ANARRHICHAS MINOR, FROM SIDE (AFTER STEENSTRUP).



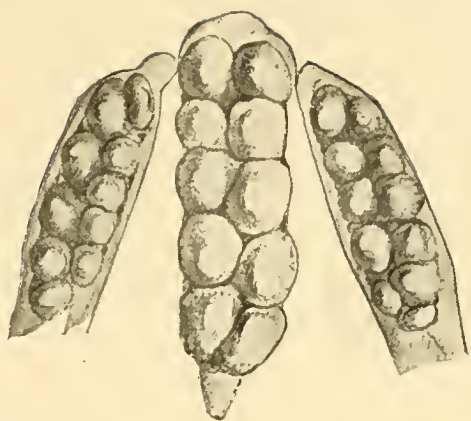
ANARRHICHAS MINOR (AFTER SMITT).



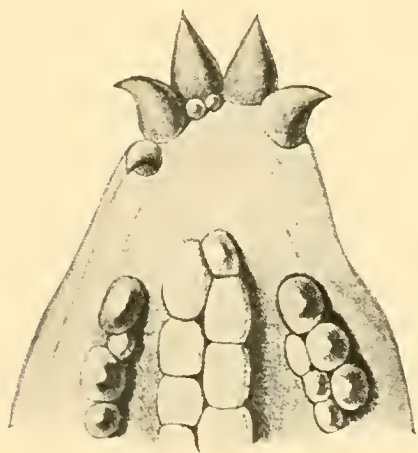
CRANIUM OF ANARRHICHAS LUPUS, FROM SIDE (AFTER STEENSTRUP)



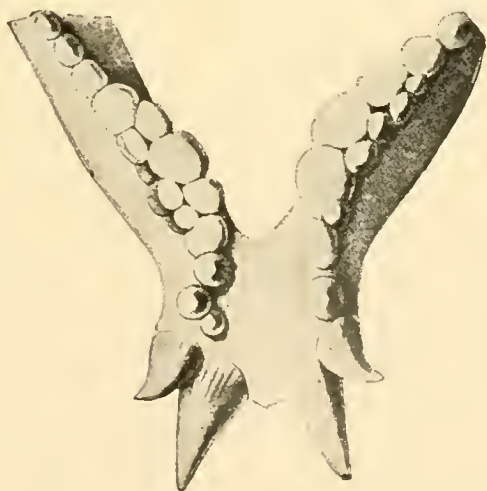
UPPER TEETH OF ANARRHICHAS LUPUS (AFTER OWEN).



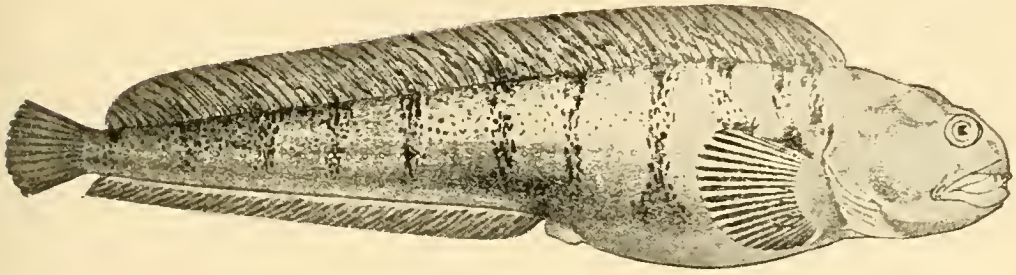
UPPER TEETH OF ANARRHICHAS MINOR (AFTER STEENSTRUP).



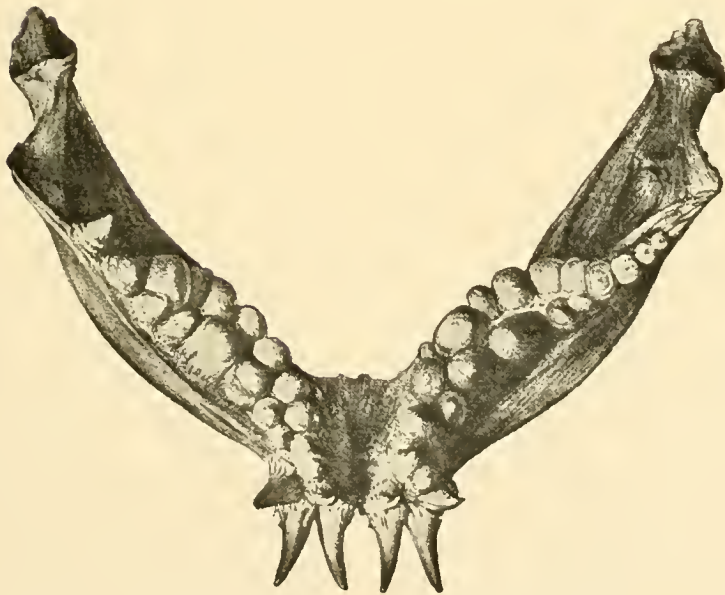
UPPER TEETH OF ANARRHICHAS LUPUS, AFTER THORNAM (GAIMARD).



MANDIBULAR TEETH OF ANARRHICHAS LUPUS, AFTER THORNAM (GAIMARD).



ANARRHICHAS LUPUS (AFTER SMITT).



MANDIBULAR TEETH OF ANARRHICHAS LUPUS (AFTER OWEN).



SKULL OF ANARRHICHTHYS OCELLATUS.



YOUNG OF ANARRHICHAS LUPUS (AFTER MCINTOSH AND PRINCE).



A.



B.

A, UPPER TEETH AND *B*, MANDIBULAR TEETH OF ANARRHICHICHTHYS.

NORTH AMERICAN PARASITIC COPEPODS.—PART 9. THE
LERNÆOPODIDÆ.

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DEVELOPMENT OF *ACHTHERES AMBLOPLITIS* KELLICOTT.

INTRODUCTORY.

The present paper is the ninth^a in the series dealing with the North American Parasitic Copepods. It takes up the development of a species which is the American representative of the European *Achtheres percarum* Nordmann, and which may serve as the type of the family Lernæopodidæ.

This American species is very common upon the gill arches of the rock bass or red-eye, *Ambloplites rupestris*, and is occasionally found upon other species of the Centrarchidæ.

At the present time it has never been obtained from the American perch, or from any other of the Percidæ.

It lives fastened to the inner surface of the gill arches and easily escapes detection, especially in the larval stages, by concealment among the large teeth which cover that portion of the arches, and by being covered with the slime that envelops the whole of the gill surfaces.

The surest method of detecting its presence and the one by means of which all the larval stages here described were discovered, is to cut out the gills carefully, separate each arch from the others, and

^aThe other eight papers are as follows: 1. The Argulidæ, Proc. U. S. Nat. Mus., vol. 25, pp. 635-742, pls. 8-27. 2. Descriptions of Argulidæ, idem, vol. 27, pp. 627-655, 38 text figures. 3. The Caliginæ, idem, vol. 28, pp. 479-672, pls. 5-29. 4. The Trebinæ and Euryphorinæ, idem, vol. 31, pp. 669-720, pls. 15-20. 5. Additional Notes on the Argulidæ, idem, vol. 32, pp. 411-424, pls. 29-32. 6. The Pandarinæ and Cecropinæ, idem, vol. 33, pp. 323-490, pls. 17-43. 7. New species of Caliginæ, idem, vol. 33, pp. 593-627, pls. 49-56. 8. Parasitic Copepods from the Pacific Coast, idem, vol. 35, pp. 431-481, pls. 66-83.

float it out in water under a dissecting microscope. The buoyant power of the water will lift the larva or adult into view above the slime and teeth, particularly if the dish be agitated a little.

The living material upon which the following observations were made was obtained at Lake Maxinkuckee, Indiana, during the summers of 1906, 1908, and 1909, while the author was in the employ of the U. S. Bureau of Fisheries. For this valuable opportunity acknowledgment is gratefully made to the Hon. George M. Bowers, U. S. Commissioner of Fish and Fisheries. The serial sections and the study upon them were made in the biological laboratory of Johns Hopkins University, and the sincere thanks of the author are due to Dr. E. A. Andrews for many valuable suggestions and corrections.

METHODS.

For external study, including the mouth-parts and other appendages, a mixture of 95 per cent alcohol and 5 per cent formalin in equal parts was found to be the most satisfactory preservative. Specimens kept in this mixture for three years have retained their anatomical form and structure perfectly, and have become neither unduly hard nor brittle.

For the histological work the material was preserved in alcoholic corrosive-acetic, the corrosive being removed immediately after fixation with iodine.

The specimens to be sectioned were first stained in bulk with DeLafeld's hæmatoxylin, and after clearing were counterstained with eosin in 95 per cent alcohol.

These methods were found to give excellent results both in fixation of the tissues and in differential staining.

HISTORICAL.

The genus *Achtheres* was established by Nordmann in 1832, with the type species *Achtheres percarum*, found in great abundance on the gill arches of the common European perch, *Perca fluviatilis*. Nordmann not only described the adults of both sexes minutely, but he also gave a good account of the breeding habits and the development up to the first copepodid stage. In the same paper he established another genus, *Tracheliastes*, closely related to *Achtheres*. He did not obtain the male of his type-species, *Tracheliastes polycolpus*, but did secure some newly hatched larvæ, whose development he also followed up to the first copepodid stage. In a third new genus, *Basanistes*, with the type-species *huchonis* described at the same time, he was not so fortunate, and no developmental stages are mentioned.

Three years later (1835), however, Kollar reinvestigated this third species and included with the adults a good description and figures of the first copepodid larva.

Here the development of the Lernæopodidæ rested for nearly thirty years until Claus in 1862 filled in one of the missing stages in the life history of *Achtheres percarum*. But Claus himself stated that he was unable to finish his investigations, and many gaps were still left in our knowledge of this crustacean family.

In 1870 Édouard Van Beneden gave as the fourth paper in his researches on the embryogeny of the crustacea what might be called a mosaic development of the Lernæopodidæ.

His series of stages, which began with the segmentation of the egg and closed with this same first copepodid larva, were selected from the genera *Anchorella*, *Lernæopoda*, *Brachiella*, and *Hessia*.^a

Olsson in 1877 published the figure of a larva of *Achtheres percarum*, but gave an extremely meager description, while the figure itself was so small as to show no details.

Finally Vejdovský in the same year (1877) worked over again the anatomy and development of *Tracheliastes polycolpus*, but like Nordmann and Kollar he followed the metamorphosis only to the first copepodid stage. His description and figures of the development inside the egg, however, are the most complete and the best that have ever been published.

These five papers (beside Olsson's single figure) comprise practically all that has appeared upon the development of this family, the Lernæopodidæ, up to the present time.

The reason why so many of them stop with the first copepodid larva is readily understood when it is recalled that this is the only free swimming stage, and is therefore the one during which the larva seeks out its host. Even Claus, who is the only one to describe any of the subsequent stages, was forced to be content with female larvæ 2 mm. long (really adults) and a male larva that was practically fully developed. But he described both of these in considerable detail and thus furnished an important contribution to their life history.

Claus gave it as theoretically probable that this first copepodid stage, at which all the accounts stop, passed at the next molt into an attached form in which the number of body segments and appendages was not increased, but the frontal filament was put into operation for attachment to the host, the mandibles were inclosed in the proboscis, and the setæ of the swimming legs and the furca were degenerated from lack of use. He was not able to find such a form, but it has been discovered in connection with the present work, and while it does not conform in all details to what he prophesied, it shows a remarkably accurate conception on his part of its general features. But his actual observations were made upon larvæ and

^aThis was a new genus named for the first and as it has proved the last time, but not described or figured, except in one or two embryonal stages.

adults entirely, that is, without the aid of dissection or serial sections, and the same may be said of all the other investigators, whether working with eggs, larvæ, or adult stages. Since all of these are more or less opaque it is not surprising that some mistakes were made in observations. The wonder rather is that so many of these observations of the exterior are substantiated by sectioning the different stages.

COMPARISON WITH OTHER PARASITIC SPECIES.

On comparing carefully and in detail the metamorphoses which the different species exhibit, we may separate the parasitic copepods into five groups according to the relative lengths of the free-swimming and parasitic periods:

I. Those whose larvæ are free swimmers during their entire development and become parasites only upon reaching the sexually mature adult condition.

The Ergasilidæ are examples of this group, and in the genus *Ergasilus* the males never become parasites at all but remain free during life.

II. Those in which the earlier larval stages and the mature adult are free-swimming, while the intervening stages are parasitic and sometimes degenerate.

Here belong the Monstrillidæ and the males of certain genera among the Ascidicolidæ. The males and often the females of some of the Caligidæ might also be well placed here, since the mature adults are frequently captured swimming at the surface, and only attach themselves temporarily to fish in order to obtain food.

III. Those whose larvæ are free swimming during early development, passing through typical nauplius, metanauplius, and copepodid stages, and then seeking a host upon which to become parasitic during the remainder of life.

The stage at which the change is made varies considerably, as does also the life history subsequent to it. In some of the Ascidicolidæ the larvæ remain free-swimming until the second copepodid stage, as in *Enterognathus*. In the Pandarinæ, Cecropinæ and Chondracanthidæ they become parasitic at the beginning of the first copepodid stage. In the latter family they are transformed at the next molt into the adult, the other copepodid stages being suppressed.

IV. Those in which the early stages are often passed inside the egg, while later free-swimming stages alternate with others which are both parasitic and degenerate.

The Lernaeidæ are examples of this group; the larvæ are free-swimming until the first copepodid stage, then become parasitic and degenerate into a pupal form in which the power of movement is lost. Later they regain this power, leave their host, and swim about freely

while a union of the sexes takes place. The male develops no farther but the female seeks a second host and on it undergoes a new degeneration, even greater than the first.

V. Those in which the first copepodid stage alone is free-swimming; all the larval development previous to this is passed inside the egg, while subsequent to it the copepod is a fixed parasite, usually showing degeneration.

GROUP	DEVELOPMENT STAGES												PERCENTAGES		
	NAUPLIUS			META NAUPLIUS			COPEPODID			ADULT			IN THE EGG	FREE	PARASITIC
	1	2	3	1	2	3	1	2	3	1	2	3			
I	[Solid black]			[Solid black]			[Solid black]			[Grid]						75	25
	[Grid]			[Grid]			[Grid]			[Grid]					
II	[Solid black]			[Solid black]			[Solid black]			[Grid]			66	33	
	[Grid]			[Grid]			[Grid]			[Grid]					
III	[Solid black]			[Solid black]			[Solid black]			[Grid]			50	50	
	[Grid]			[Grid]			[Grid]			[Grid]					
IV	[Solid black]			[Solid black]			[Solid black]			[Grid]			42	16	42
	[Grid]			[Grid]			[Grid]			[Grid]					
V	[Solid black]			[Solid black]			[Solid black]			[Grid]			50	8	42
	[Grid]			[Grid]			[Grid]			[Grid]					

TABLE SHOWING COMPARATIVE TIME SPENT IN THE EGG (HORIZONTAL LINES), AS FREE SWIMMERS (BLACK), AND AS PARASITES (SQUARES), BY THE DEVELOPING LARVÆ OF TYPICAL GENERA FROM EACH OF THE FIVE GROUPS MENTIONED.

Here belong the Choniostomatidæ and the Lernæopodidæ. In the latter family, according to Claus and others, some species hatch in an advanced metanauplius stage, all ready for the molt into the first copepodid stage. This molt consequently takes place in a remarkably short time, from ten minutes to an hour. In other species, as observed by Kellicott and the present author, the larvæ hatch directly into the first copepodid stage and seek a host at once.

The details of this extraordinary shortening of the free larval period have never been brought out clearly, and that is the aim of the following account.

THE EGG PREVIOUS TO DEVELOPMENT.

FORMATION OF THE EGG.

Claus (1862) was the first to call attention to the long threads or filaments which are connected with the older oöcytes inside the ovary of *Achtheres*. Beneden (1870) found the same condition in *Anchor-ella* and *Lernæopoda*, while Kerschner (1879) and Giesbrecht (1882) discovered it in *Congericola*, *Doropygus*, and *Notopterophorus*. The same filaments are found in connection with the eggs of *Achtheres ambloplitis*. On being magnified (fig. 1) these filaments are seen to be composed of cells, usually discoidal in shape and packed with their flat surfaces together like rows of coins. A cross section of a uterine process in which the eggs are partly matured shows one of these filaments attached to each egg and packed more or less closely against the surface of the latter. Owing to the crowding of the eggs in these uterine processes, the threads or filaments are often coiled into a sort of ball, as seen at *b* in fig. 1. It will be noticed that the cells at one end of the filament are greatly reduced in size, and Korschelt and Heider suggest that the formation of new cell material possibly takes place here. At the opposite end of the thread is the oöcyte itself, abruptly and enormously (compared with the cell filament) swollen in size.

This increase in size is due wholly to the absorption of food material or yolk globules by the oöcyte, the difference in composition being clearly brought out by staining.

The entire substance of the cell filament takes a deep blue color in hæmatoxylin, while the oöcyte, except the nucleus, takes none whatever, but stains a deep red in eosin.

According to Giesbrecht, the rows of cells loosen themselves from the epithelium of the ovary in order to connect with the oöcytes. But whatever their origin, it is certain that they are no longer connected with any part of the ovary in the present species, and have been pushed far out into the uterine processes. As soon as the terminal cell has become fully developed into the oöcyte it separates from the cell filament, and the cell, which then becomes terminal in the filament, develops in its turn. And thus the process continues until all the cells in the filament have been successively formed into eggs.

As Beneden pointed out, the difference in egg development between this family of Lernæopodidæ and the Caligidæ lies in the fact that the latter possess but a single ovarian filament, in which a series of cells develops simultaneously.

Here in *Achtheres* (the Lernæopodidæ), on the contrary, there are many of these ovarian cell filaments, and in each of them the terminal cells develop successively, one after the other. A similar

method obtains in the Ergasilidæ, whose eggs mature successively and are pushed out into the external strings in bunches, a few at a time.

STRUCTURE OF THE EGG.

Beneden states that he was never able to distinguish any membrane around the ovarian egg of *Anchorella* or *Lernæopoda*, but that the greater density of the protoplasm near the periphery of the egg preserved its spheroidal form.

In *Achtheres ambloplitis* a vitelline membrane is distinctly visible around the enlarged oöcytes, even before they separate from the cell filaments (fig. 2). This membrane is very thin and structureless; inside of it the entire substance of the egg is made up of yolk globules evenly and universally distributed throughout a matrix of fine protoplasm. These globules differ only slightly in size and shape, being usually somewhat ovate or ellipsoidal and occasionally flattened by contact with one another. They are homogeneous in structure, but some of them stain more deeply than others.

Scattered about through the egg are numerous large vacuoles, varying from one to four times the diameter of the yolk globules. In the sections they are entirely empty, save for the intrusion of an occasional yolk globule, but in the living egg are probably filled with a liquid which has been withdrawn by the preservatives. The vacuoles nearest the periphery are usually the smallest, and they increase in size toward the center of the egg. The egg nucleus is about the size of the largest vacuoles and is slightly eccentric, away from the point of attachment of the cell filament. It is approximately spherical and is surrounded by a well-defined membrane. It contains a single spherical nucleolus of small size and situated close to the periphery, and numerous chromatin granules, also gathered near the outer surface of the nucleus. The cytoplasm just inside the vitelline membrane is denser than elsewhere, and particularly in the younger oöcytes takes a bluish tinge in hæmatoxylin. In the matured oöcytes this is scarcely visible, but the increased density and the fineness of the granules are very distinct.

As the eggs pass down through the oviduct they are each fertilized at the opening of the sperm receptacle and are covered with a layer of the cement substance at the opening of the duct of the cement gland just before they pass out into the external sacks. This cement forms a thick outer egg membrane or shell, separated a little from the vitelline membrane and stiffening into a strong and tough covering.

Beneden called the vitelline membrane the chorion and this shell membrane the exochorion. The egg sack itself is made of the same material, only thicker and tougher. Inside of it the eggs lie freely

together and are not separated one from another by secondary walls as in the Caligidæ. But the same free space around each egg, necessary to secure the requisite supply of oxygen for the developing embryo, is obtained by the separation of the two membranes covering the egg. The stiff outer membrane, which ordinarily fuses with the vitelline membrane into a honeycomb substance, here remains separate, and swelling a little after entering the external sack, maintains a narrow space for aeration around the egg. The loose manner in which the eggs are packed inside the external sacks favors such a method of aeration. Instead of being arranged in a single row pressed tightly together and strongly flattened at right angles to the long axis of the sack, they are thrown in loosely without any definite arrangement. The former conditions which prevail in the Caligidæ, Dichelestiidæ, and Lernæidæ necessitate the presence of secondary partitions to prevent the embryos from being smothered. But the latter condition, which is common to free swimming forms and to the Ergasilidæ and Chondracanthidæ as well as the present family, can dispense with these partitions, the stiff shell membrane serving amply to keep the eggs properly aerated.

EMBRYONIC DEVELOPMENT WITHIN THE EGG.

ARRANGEMENT OF EMBRYOS.

Owing to the lack of any definite arrangement of the eggs within the external sacks, there is a corresponding absence of regularity in the position of the embryos.

In the Caligidæ the germinal area is found in the center of the proximal side of each of the flattened eggs, and the longitudinal axes of the developing embryos are closely parallel.

The only general statement that can be made with reference to the present species is that development usually begins at that pole of the egg which is diametrically farthest away from the external surface of the egg sack. This point afterwards becomes the posterior end of the embryo so that, when fully developed as well as during development, the larvæ lie in the egg sacks with their heads toward its outer surface; that is, they are arranged radially.

Further than this there seems to be nothing definite, since the germinal area spreads with equal impartiality over any of the various surfaces toward the egg sack. And in those eggs which lie near the center of the sack and entirely surrounded by other eggs, the point where development begins may be turned in any direction indiscriminately.

CLEAVAGE STAGES.

Segmentation is purely superficial, proceeding gradually from the point just mentioned over the whole surface of the egg. Beneden has stated that in *Anchorella*, *Lernæopoda*, and *Brachiella*, which are

near relatives of *Achthères*, the cleavage is discoidal. This means that a single blastoderm cell originally becomes entirely separated from the food yolk, and that this one cell by subsequent division yields the whole blastoderm. On the other hand Korschelt and Heider have suggested that the increase of blastoderm in these cases is really due to the accession of new elements from the interior of the egg. In the present species we may clearly distinguish a combination of these two methods.

The first cleavage nucleus of the egg divides twice or more, and with some of the cytoplasmic elements found within the yolk migrates to a definite point at the surface (fig. 3).

In the majority of cases, as already stated, this point is diametrically opposite the wall of the egg sack, and, what is more important, it becomes the posterior end of the embryo.

Schinkevitch (1896) has stated that in *Tracheliastes* this migration is toward the wall of the egg sack and toward the places where the eggs touch one another. And he adds in a footnote that the direction of migration is not determined by oxygenotaxis, since in this case it would always be toward the wall of the egg sack. The present species offers still more lucid proof of this statement since the migration is directly away from the outer egg sack. But it must be kept in mind that this eventually brings the anterior or head end of the embryo nearest the outer wall where there is the best oxygenation.

At the time of migration small particles appear between the yolk globules, scattered about rather uniformly. These take a blue stain very readily and are therefore different in nature from the yolk. They look exactly like the particles of chromatin in the original cleavage nucleus, and like those which subsequently appear in the blastoderm cells, but there is no means at present of definitely proving their nature. They are not found in the unfertilized egg and they entirely disappear by the time the blastoderm is completed. They are the small black dots seen in figs. 3 to 7.

When these migrated materials reach the surface they are there transformed into blastoderm cells by an accumulation of the cytoplasmic material around nuclear centers. At first a single large cell is formed (fig. 4), ovoid in shape, its long diameter one-fourth that of the egg. Around this cell is a considerable mass of surplus material, similar in nature and containing one or more nuclear centers.

By the differentiation produced in double staining this material may be followed far down into the yolk of the egg from whence it is migrating. The large cell, however, in this as well as in subsequent stages, is entirely separate from the yolk and simply rests upon the surface of the egg.

The cytoplasmic material goes on collecting around a second nuclear center and shortly we find two large cells of practically the

same size (fig. 5).^a Again these are surrounded by considerable surplus material and now there are several accessory nuclear centers. Again also we can follow the migrating material for some distance into the yolk. We may call this a two-cell stage, but we must remember that it is not such in the sense that the two cells are the halves of the original one. They have rather been built up independently of each other, and are each formed of separate material that has migrated out of the yolk.

This same accumulation of material around nuclear centers goes on until there are four or five of these large cells, of about the same size as the original one. Then, while the same process continues, a segmentation of these large cells also begins, and we find eggs with from 12 to 16 medium-sized cells, only half their former diameter (fig. 6).

There is still much surplus material around them and many small nuclear centers, but the migrating material can not be followed as readily into the yolk.

The amount of migrating material and the rapidity with which it comes out from the egg would seem to exert a controlling influence upon the kind of segmentation which results.

If the cytoplasm and nuclear material emerge all at once, the former gathers around the latter in a single mass, which by subsequent division forms the blastoderm. This is true discoidal segmentation. But if the substances migrate more slowly, those which reach the surface first have time to accumulate while the others are still emerging. The result is not a single cell but several such cells of nearly the same size, as in the present instance. Moreover the removal of the last of this material from between the yolk globules is accomplished more slowly than at first, either because, coming from the center of the egg, it had a longer distance to travel, or because the actual rate of emergence has diminished, or possibly both of these combined. The blastoderm cells first formed thus have plenty of time to segment before the material is all out of the egg. And since there is not as much of the migrating material now as there was at first, the size of the accessory cells which it forms and adds to the blastoderm is about proportional to the size of the cells in the latter. Since these accessory cells become a part of the blastoderm and enter into the formation of the embryo, this can not be regarded as discoidal segmentation.

BLASTULA.

The two processes of aggregation and cell division go on simultaneously until the blastoderm has spread superficially over the entire yolk. In the intermediate stage represented in fig. 7 it can be seen that the blastoderm cells have appreciably diminished in size, and it

^a In the figure the right cell is cut at a different level and so appears smaller than the left one; in the second section following it is fully the size of the latter.

is now very difficult to trace any of the migrating material within the yolk. The disk remains thicker over the point where the cells originally appeared, but elsewhere is only a single cell in thickness. When it is finally completed (fig. 8) its cells are very much reduced in size, and no accessory material can be seen around them; it has all entered into the structure of the blastoderm. As soon as this has been accomplished the cells composing the blastoderm secrete a cuticular membrane in addition to the vitelline and shell membranes. This has been designated as the blastodermic cuticle, and according to Korschelt and Heider its appearance can only be explained by regarding it as a sort of ecdysis or molt, carried back to an early embryonic period. The formation of this cuticle thus constitutes the first molt of the *Achtheres* embryo. Such a cuticle is common among the Malacostraca, but in the copepods is probably confined to those cases like the present, in which many of the stages of development are shifted back into embryonic life.

FORMATION OF THE EMBRYO.

Not until the blastoderm has entirely surrounded the yolk is there any differentiation in it to indicate the position of the larval appendages. The first change is a considerable thickening of the cellular layer which is to become the ventral surface of the embryo (the "Keimstreif").

The multiplication of cells is especially rapid along the axes of the future appendages and builds up there a series of lobes or pads which constitute the "Kopfplatten" of the German embryologists. Ordinarily there are three pairs which have come to be known as the nauplius appendages, which appear simultaneously and develop into the locomotor organs of the first larval stage. These three develop together into certain typical forms without reference to what may be the shape and function of the matured organ which they represent. For instance, the third pair are usually identical, whether they are to become the gnawing mandibles of the free-swimmers or the piercing mandibles of the parasites. Moreover, the three pairs develop and have served their temporary function before the other appendages appear.

In the formation of the nauplius of the present species we notice several radical departures from this established type.

When a longitudinal section of the developing embryo is examined it reveals nuclear centers not only for the first three appendages but also for the other mouth-parts and the first two pairs of swimming legs (fig. 9). These centers all appear simultaneously, but those of the first two pairs develop much faster than the rest. And they form typical nauplius appendages before any of the others have become externally visible. The third pair never become nauplius appendages

but appear as rudimentary mandibles, without showing any traces of division into the usual two rami, of segmentation, or of the ordinary nauplius armature of plumose setæ. All the other appendages and the rudiments of an upper and an under lip appear at the same time with the third pair, and are developed directly into the forms found in the metanauplius. It will be recalled that it was the appearance of the two posterior pairs of mouth-parts side by side in *Achtheres percarum* that induced Claus to first put forward the idea that they developed as the exopod and endopod of the same appendage. Claus himself corrected this idea in almost the last paper he published, having found the two appendages to be distinct on the long-bodied larvæ of certain marine copepods. Moreover he discovered that the posterior pair originated behind the groove separating the head from the thorax, and were therefore thoracic, while the anterior pair were cephalic. The same evidence can now be presented from the very genus upon which Claus originally worked. If fig. 9 be examined again it will be seen that the groove representing the boundary between the head and thorax appears between the last two pairs of mouth-parts, thus making the posterior pair thoracic and the anterior pair cephalic. This groove only shows in sections and between the nuclear centers or very beginnings of the appendages. It also disappears before the appendages become visible externally, but it is very distinct while it lasts and its significance can not be mistaken.

The posterior body develops along with the appendages, and by the time the first and second antennæ are formed we find a thorax and abdomen very similar to that which ordinarily appears in a metanauplius larva. The balancers, which are so typical of nauplius larvæ, never appear at all; in fact, the posterior body seems to start in the metanauplius form from the very beginning and never displays any of the nauplius characters. With these few words of explanation as to the formation of the embryo we shall be the better prepared to understand the remaining development inside of the egg.

NAUPLIUS-METANAUPLIUS STAGE.

In many of the parasitic as well as all of the free-swimming copepods there is a long line of nauplius and metanauplius stages, distinctly separated from one another by a throwing off of the old skin and the formation of a new one.

In the present species there is a complete fusion of all these stages, with nothing left to indicate their presence except the formation of a single nauplius cuticle.

This larval integument, which is the fourth in chronological order, is formed about the middle of the fused stage and may fairly be taken to represent the close of the nauplius and the beginning of the metanauplius stage. It is therefore the second molt of the

developing larva. But the creature inside of this larval integument is very different from an ordinary nauplius.

Body form of nauplius.—If some of the larvæ be dissected out of their surrounding envelopes at this stage and mounted under a gentle pressure, they present in dorsal view the general features seen in fig. 10. The body is ovate in outline, the larger end being anterior, the two diameters in the proportion of 7 to 11, and the greatest width about one-third the distance from the anterior end. Only the first two pairs of appendages are visible, corresponding to the first and second antennæ, and projecting nearly their length beyond the margin of the body. Around these two pairs of appendages the nauplius cuticle forms lobes or pockets, as can be seen in fig. 12. The anterior pair, the first antennæ, are one-jointed and uniramous, of the same diameter throughout, and each terminating in two long plumose setæ.

The second antennæ are biramous, the exopod five-jointed, with each joint terminating in a long plumose seta, the endopod indistinctly two-jointed and terminated by two plumose setæ.

The body itself is transparent throughout and shows no trace of mouth, stomach, or intestine. The anterior portion is made up of fine granular protoplasm, from which is to be derived the material for the formation of the mouth-parts, the beginnings of the nervous system and sense organs, the larval muscles, and the large frontal gland soon to be described.

Along either side, parallel with the margin and close to the dorsal surface, is a broad ribbon-like band of striated muscle fibers, the first beginning of the muscular system which is to operate the swimming legs.

The extreme posterior part of the body is curled over ventrally beneath the anterior portion. In a ventral view (fig. 11) it may be seen to consist of a broad and spatulate abdomen, already well differentiated from the cephalothorax, and made up like the anterior part of the body of fine grained protoplasm, thickly studded with nuclei. The mandibles and upper lip have not yet appeared externally save as a slight transverse ridge with a knob at either end of it, just behind the bases of the second antennæ. The posterior part of the body therefore is like the metanauplius, while the anterior portion is just as typically nauplius, and the two stages are combined in one embryo.

The entire body is uncolored save for three isolated patches of dark-brown pigment. One of these is on the dorsal surface in the center of the widest portion of the body. It is triangular in shape, with one of the corners anterior, and is about one-third of the entire width. The other two patches are on the ventral surface, one on either side near the posterior end of the cephalothorax, and are much smaller than the dorsal one and of no definite shape.

As the nauplii develop these patches enlarge and deepen in color, and as a result the external egg-cases, which up to the present stage have been a uniform pale yellow, gradually show the color of the patches through their walls and become more and more brown, until this hue has become uniform.

Internal structure of the nauplius.—Fig. 12 is a longitudinal horizontal section through the body of the nauplius. It includes quite a portion of the first antennæ (*a'*), simply the bases of the second pair (*a''*), the rudiments of the upper lip (*lb*), and mandibles (*md*), the side walls of the body (*w*), and a section through the abdomen (*ab*). Between the bases of the antennæ may be seen the large frontal gland in process of formation (*fg*). The entire center of the body is filled with yoke globules, among which are scattered the large spherical vacuoles. As can be seen the digestive system has not begun to develop at this early stage, but first appears a little later. It was impossible to distinguish any eye in the living nauplius and this series of sections reveals no trace of it in the internal anatomy.

There is an extremely rudimentary eye formed in the metanauplius, as we shall see later, but it quickly disappears without leaving any traces behind.

Transformation of the nauplius into the metanauplius.—This first portion of the stage which by courtesy we may call the nauplius is gradually transformed into a real metanauplius. The transformation consists in a jointing of the first two pairs of appendages, the appearance of the upper and under lips and all the mouth-parts, the formation of two thoracic segments in front of the abdomen, and the development on each of a pair of swimming legs. At first there is only one of these free thorax segments, while the abdomen is broad and spatulate. But another segment is soon formed, and the abdomen is relatively narrowed. On each of these segments is developed a pair of rudimentary legs, whose long plumose setæ are at first turned forward and inward along the sides of the body. As development progresses the position of the setæ changes, and they turn gradually backward, until in the completed metanauplius they point backward and inward (fig. 15).

Body form of the metanauplius.—On freeing a metanauplius from its surrounding envelopes in the same way as was done with the nauplius, it presents the general appearance seen in fig. 16. The body is very thick and stout; in fact, nearly spherical, as it was inside the egg, and there have been radical changes in the appendages. The first antennæ (*a'*) are now divided into three segments, of which the terminal is much longer than the two basal, and are still each tipped with two plumose setæ. The second antennæ (*a''*) have a five-jointed exopod, each joint ending in a plumose seta, and a two-jointed endopod, which retains the two terminal setæ, but carries at

their base (fig. 17) a well-developed claw inside of the skin. The upper lip is elliptical in shape, wider than long, and evenly rounded, with a small protuberance on either side near the posterior edge.

Just behind the upper lip and a little outside of it lies on either side a short, wide, and bluntly rounded protuberance, one of the paragnaths, which eventually unites with its fellow on the opposite side to form the lower lip. Between the base of the upper lip and the paragnath projects the mandible (*md*), which is short, uniramous, and tipped with a single seta.

The first maxilla (*mx'*) is biramous at the tip, the outer ramus much shorter than the inner and each armed with short spines.

The second maxillæ (*mx''*) are stout uniramous appendages, longer and larger than either pair of antennæ, indistinctly three-jointed and terminated by a weak and slender claw.

The basal joint lies outside of the first maxilla and this appendage does not properly appear in the section shown in fig. 18. It has been introduced, however, from the second preceding section in its proper place with reference to the other appendages. The maxillipeds (*mxp.*) lie inside of and distinctly posterior to the second maxillæ; they also are uniramous and indistinctly three-jointed, and terminate in a stout claw with a small protuberance at its base. The two pairs of swimming legs are very rudimentary, each leg consisting of a basal joint and two one-jointed rami, armed with long plumose setæ. The anal laminae are as large as the rami of the legs, and are also armed with long plumose setæ.

Internal structure of the Metanauplius.—On examining the section shown in fig. 18 it can be seen that there has been considerable internal development. The fine-grained protoplasmic masses at the anterior and posterior ends of the body have increased greatly in size, and the muscles which are to move the appendages are fairly well differentiated.

This is especially true of the powerful muscles which are to operate the swimming legs and which appear on the dorsal side of the body near the posterior end of the cephalothorax (*m*).

The mesenteron (*ms.*) epithelium has also begun to be formed around the ventral surface of the stomach, but is incomplete on the dorsal surface. From this ventrally formed stomach layer a long process extends backward which is to become the intestine, while another shorter one is given off toward the mouth. The space within the epithelium is still filled with tightly packed yolk globules, interspersed with large vacuoles, and contains enough nourishment to supply the larva for some time to come. This being just previous to hatching so that the internal structure is approximately the same as during the following stage, we can readily see from the condition of the digestive tract that the larva will not be able to take any

nourishment during the first copepodid stage. Such a condition must be kept clearly in mind since it will profoundly influence our interpretation of the free-swimming period.

The extremely rudimentary eye (*e*) can now be distinguished inside the coils of the attachment filament. It is made up of three ovate ocelli, two dorso-lateral and one inferomedian, which are entirely separated from one another and devoid of pigment. The structure of each ocellus has also degenerated until all that remains is a more or less granular mass, staining deeply in hæmatoxylin and containing near its anterior end three lighter spots. No trace of lenses can be found in any of the sections and the entire structure disappears during the next stage.

Attachment filament.—By far the most interesting structure in the body of this fused larva remains to be described. This is the attachment filament, already mentioned, which can be seen close to the dorsal surface of the body beneath the patch of brown pigment (fig. 10). It is of interest not only by reason of its intrinsic anatomy, which is very peculiar, but also on account of the function which it subsequently performs. It is an organ which in other parasitic copepods appears at a much later stage, but has here been shifted back to the very beginning of larval development.

It also differs radically from all other attachment devices and is admirably suited to the complicated function it has to perform. In the Caligidæ the filament is manufactured during the process of attachment out of the viscid secretion of a gland, which hardens when it strikes the water. Previous to attachment the larva swims about freely.

In the present species the filament is of solid tissue and is formed slowly inside the body of the larva during the long period it passes within the egg. It is fully developed before the larva is hatched, which is a strong indication that the free-swimming period is to be very short, and we find this fully realized. Furthermore in the Caligidæ the larva is only attached through two or three moults and then becomes free-swimming again. In our *Achtheres* larva the first attachment is maintained by the female throughout life and by the male up to the time of complete sexual development.

The organ of attachment consists of a long filament coiled up like a rope, the two ends extending forward to the frontal margin and considerably enlarged. The ends and the straight portion in front of the coil are surrounded by a large mass of glandular tissue which evidently secretes the filament (fig. 13). The development of this organ is as follows: There appears first very early in the nauplius stage an oval mass of glandular cells (*fg.*, fig. 12) on the midline, close to the frontal margin. This is the frontal gland and corresponds with the one which appears in the chalinus larva of the Caligidæ.

Similarly this gland shows a division into right and left halves along the center. There arises out of it, on the midline between the two halves, a homogeneous body which is at first shaped exactly like a mushroom (*ms.*, fig. 34). The umbrella portion at the anterior end is about four times the diameter of the stalk, and lies with its rounded top in contact with the inside surface of the nauplius epithelium at the frontal margin. The stalk extends backward along the median line and then curves over dorsally and terminates in a small peg (*p*), which lies above and just behind the umbrella enlargement.

This peg is the point of attachment between the filament and the gland, through which the secretion of the latter is conducted into the former (fig. 13). Every part of the organ, umbrella, stalk, and peg, is hollow and is filled with the secretion from the gland. This secretion is a stiff, homogeneous, adhesive substance, which hardens into the filament and is indistinguishable from it in color and transparency.

In his description of the larva of *Achtheres percarum*, Claus says that he regards this organ as the duct of the gland which furnishes the secretion. The present author is obliged to take issue with such an interpretation for the following reasons: 1. The distal end of the filament is completed at the very first, and subsequent growth takes place at the proximal end, the new portion being pushed out against that already formed and gradually coiled up to economize space. The growing point of the filament is thus its point of attachment to the gland. Ducts are not formed in this manner; they begin at the gland and grow away from it, the growing point being at the distal end. 2. The walls of the filament are absolutely homogeneous and transparent, even when first formed, and show none of the structure ordinarily found in ducts. 3. The filament is manufactured directly from the secretion itself; gland ducts are never the product of the secretion of the glands. 4. It is the filament which becomes the attachment organ, and not the secretion which it contains, as will be explained later. A gland duct that was afterwards torn away from the gland and made to serve as an attachment organ would be an anatomical novelty.

When this filament is first formed the stalk is comparatively short and straight (*a*, fig. 14). But as the secretion accumulates the stalk increases in length. Since the two ends are fastened at the very beginning the only way for an increase in length to take place is by a twisting and subsequent coiling of the stalk, and this is what occurs.

At first the stalk twists back and forth (*b*, fig. 14), or into a corkscrew shape, and then, extending back into the tissue behind the gland, it begins to coil. Eventually when fully developed it consists of three large coils, which surround the rudimentary eye, and the two

straight portions, which extend to the frontal margin (fig. 34). The total length is considerably more than the entire length of the larva; as a duct such an increase in length would be difficult to explain; as an attachment filament it explains itself.

As already stated, the increase in length takes place at the proximal end where the filament is brought in contact with the glandular substance by means of the peg. This peg is slightly different in color and structure from the rest of the filament, and stains differently. At the point where it actually joins the gland it spreads out into a sort of funnel, whose walls are extremely thin and delicate (fig. 13). The walls evidently form a viscid film on the outside of the secreted substance, plastic enough at the proximal end to be pushed along gradually by the accumulating secretion, but rapidly growing thicker and firmer distally. The new film constantly forming at the point of union thus becomes continuous with that which has preceded it, and in this manner the entire organ is formed.

Nordmann mistook the ends of the filament for the eyes of the larva, while he supposed the coiled portion to be connected with the mouth-parts. But he makes the following pertinent statement:

The length of the filament (Röhre) is in direct relation with the development and size of the embryo. The longer it is, so much the farther has the development of the animal progressed; the shorter it is, so much the younger is the embryo.

This is exactly true of the present species, and the fact that this filament is completely developed before the larva escapes from the egg indicates that it is to be used *at once*.

Hatching.—The larva is now ready for hatching. This process in the present species is similar to that which has been well described by Claus for *Achtheres percarum*. The thick wall of the egg sack is so constituted that it becomes weak and brittle through the action of the water at just the time when the larvæ have completed their development and are trying their muscles. Through both of these influences, as well as by osmosis, the sack bursts open at one or more places and the larvæ pass out into the water. They are still surrounded by the various membranes that have been formed during their development, but these are quickly and easily gotten rid of.

As soon as the water strikes the egg membrane, which it will be remembered is formed of the same cement substance as the external sack, it swells a little and bursts from the osmotic pressure. The inner membranes are very thin and delicate, and are easily ruptured by the struggles of the larva, which are increased when subjected to the change of environment. In this way it comes about that the molting of the nauplius cuticle is simultaneous with the escape from the egg, or follows it after an interval of only a few moments.

With reference to the actual period of hatching, Nordmann stated that the larvæ of *Achtheres percarum* hatch directly into the first

copepodid stage. Kollar's observations on *Basanistes huchonis* were interrupted, and he was not certain whether there was a brief metanauplius stage after hatching or not. Beneden makes no statement on this point, but he gives us a figure of a metanauplius larva free from enveloping cuticles. Vejdovský states with reference to *Tracheliastes polycolpus* that the metanauplius stage is passed wholly inside the egg, the larva hatching in the first copepodid stage. Kellicott, in describing the larva of *Achtheres corpulentus*, states that he removed some of the brood from the eggs to make sure, and "found them in the form of the swimming ones," that is, in the first copepodid stage. Claus stands alone in his statement that the larvæ of *Achtheres percarum* hatch in the metanauplius stage and molt into the first copepodid stage "after a few hours."

From a careful examination and comparison of a large number of egg strings of *Achtheres ambloplitis* during the period of hatching, the present author has come to the following conclusions:

1. The great majority of the larvæ hatch directly into the first copepodid stage, and it is the evident expectation that all should do so. Under natural conditions it is probable that at least 95 per cent hatch in this way.

2. The actual emergence of the larvæ depends on the texture of the external egg sacks. If they soften and crack rapidly the eggs may be let out into the water early enough for the larvæ to escape as metanauplii. This is more likely to occur if the females have been handled and kept in aquaria than under normal conditions.

3. The few metanauplii thus obtained are all ready for the molt into the copepodid stage, and this occurs in from ten or fifteen minutes to an hour. Such metanauplii are too stocky, their locomotor organs are too weak, and it is too near the molting time for them to move around much. All they can do is to lie inertly on the bottom of the aquarium until the molt into the copepodid stage. Under natural conditions such premature hatching with its attendant helplessness might easily prove fatal to the larva.

4. Ordinarily the egg sack does not break open until the movements of the larvæ become quite energetic. The transformation into the first copepodid form is effected inside the egg membranes and the larva comes forth a vigorous and active swimmer.

In this species therefore the early larval stages up to the molt into the first copepodid stage are so thoroughly fused as to become one single period. There are no definite points of which it can be said, these mark the completion of one stage and the beginning of the next. It is rather one continuous development, and the peculiarities which usually characterize the different stages overlap one another, so that those belonging to several may be present at the same time. The only point of reckoning is the formation of the nauplius cuticle, and even

this occasions no break in the continuity. Development goes on inside of it through the nauplius and metanauplius stages just as if it were not present.

FIRST COPEPODID OR FREE-SWIMMING STAGE.

BODY FORM.

As the larva emerges in this stage from the egg it appears in a form which, by the segmentation of the body and by the structure of the appendages, corresponds with the first cyclops stage of free-swimmers (fig. 23). The body is much elongated and flattened dorso-ventrally; the cephalothorax is elliptical, and nearly twice as long as wide, the proportion being as that of 9 to 17. It is enlarged at the anterior corners above the bases of the second antennæ, and furnished with a distinct notch on either side and a dorsal groove between the head and first thorax segment. It is slightly arched dorsally, but flat on the ventral surface, and carries at its posterior end a wide obcordate process, which projects over the base of the second thorax segment.

The shorter and smaller posterior portion of the body is made up of four segments, sharply separated from one another, the last one carrying the broad anal setæ.

The first of these segments, the second thoracic, is the largest and the third one is the smallest. The first one is half the width of the cephalothorax and has a broad, semicircular, posterior process. The remaining segments are all the same width, which is half that of the first segment.

On each side of the second one at the center is a small papilla, armed with a single long spine, the rudiments of a third pair of swimming legs. The last segment, which is a fusion of the posterior thoracic and abdominal segments, is subquadrilateral in outline, with nearly straight sides.

The anal laminæ are large and broad, and each carries three long and three short setæ. The total length of this larva is 0.48 mm. Length of cephalothorax, 0.32 mm. Width of same, 0.165 mm. Length of free thorax, 0.12 mm. Width of first free segment, 0.08 mm.

These larvæ are transparent and colorless except for four patches of dark brown pigment, one dorsal, the other three ventral. The dorsal patch corresponds to that already described in the nauplius, but has enlarged considerably.

The posterior ventral patch includes the two ventral ones of the nauplius, which are now darker in color and have enlarged until they are fused across the midline (fig. 22). In addition, there is a small anterior patch on either side just behind the base of the maxilliped.

APPENDAGES.

The first antennæ are attached on the dorsal surface, are cylindrical, uniramous, and four-jointed. The first and third joints are each armed with a single seta, the second with two, while the terminal joint ends in a cluster of five.

The second antennæ are attached on the ventral surface, beneath the bases of the first pair (fig. 22). They are biramous, the exopod one-jointed with a blunt and smoothly rounded tip armed with a single spine, the endopod two-jointed and ending in a strong curved claw. Between the bases of the second antennæ on the ventral surface is the conical mouth-tube. This ordinarily projects downward and forward, and reaches a little beyond the anterior margin of the cephalothorax. It is as wide at the base as it is long, and is bluntly rounded at the tip, with a fringe of short hairs around the terminal opening. It is made up of a rather flat and narrow upper lip, and a fluted and grooved lower lip, whose edges overlap those of the upper lip, and whose tip is arched into a cylinder to form the suction opening. This lower lip is made up of two halves which arise from separate protuberances, the paragnaths, on either side of the midline and behind the edges of the upper lip (fig. 16), and are not yet fully fused at the tip. Outside the base of the mouth-tube lie the mandibles and first maxillæ. The former are uniramous and one-jointed and are tipped with two short and stout spines. The latter are also uniramous but two-jointed, the terminal joint ending in a single spine. They also carry on their inner margin a short cylindrical palp tipped with two small setæ.

The second maxillæ are some distance behind the first pair and close to the margin of the carapace. Each is stout and two-jointed, the terminal joint ending in a long and slender claw bent into a half circle. The maxillipeds are close behind the second maxillæ, but are considerably nearer the midline. Each is three-jointed, the terminal joint tipped with a stout claw, nearly straight except at the very end. These maxillipeds are the chief organs of prehension and are considerably longer than the second maxillæ.

The two pairs of swimming legs are biramous, the basal joints broad and laminate and furnished with powerful muscles, the rami small, one-jointed, and about as wide as long. The exopods of each pair terminate in four stout and long plumose setæ, while the endopods have six.

INTERNAL ANATOMY.

Internally there has been but little change from the preceding stage. The frontal filament is now completely developed, and may be seen close to the dorsal surface, with the mushroom end flattened

against the inside of the frontal margin. The opposite end is also enlarged and fastened into the tissue just back of the mushroom. The peg has disappeared, its function having been performed. The eye of the larva is invisible externally, but it is probably present inside the coils of the attachment filament in the same degenerate state as at the close of the preceding stage.

The epithelium of the mesenteron which began to be formed in the metanauplius has now developed further and entirely surrounds the mass of yolk globules. But the stomodeum and proctodeum are not yet completed, and the larva is therefore incapable of taking nourishment. Claus has described this first copepodid stage in *Achtheres percarum* as possessing a completed digestive system, capable of functioning. But he stands alone in such a statement. Nordmann, Kollar, Vejdovský, and Kellicott all represent the larval digestive apparatus at this stage as only partially developed, and thus agree with what is found in the present species. All the available accessory testimony also witnesses to the same fact, that the larva at this time is incapable of procuring or digesting food.

The digestive system did not begin to develop until the latter part of the preceding stage and did not advance very rapidly. At the close of the stage when the larva was ready to molt into the copepodid form, the mesenteron was not yet completed while the stomodeum and proctodeum were scarcely begun. It would be impossible for all three to be finished and ready to function in the short time consumed in molting. Again, the mouth-tube is not yet completed. The halves of the under lip, which are to form the sucking tip of the organ, have not yet grown together and could not, therefore, perform their destined function. Moreover, the mandibles are still on the outside of the proboscis and in a very rudimentary state, entirely unfitted for piercing. This combined testimony practically proves that the larva is nourished by the abundance of yolk still left in its stomach until after it has attached itself to a host.

SEARCH FOR A HOST.

In its search for a host the larva swims about actively, the long rowing setæ furnishing powerful locomotor organs. The motion is not at all jerky like that of the free-swimmers, but is smooth and rapid like that of an *Argulus* or *Caligus*. In an aquarium this energy is kept up for about twenty-four hours and then relaxes, the larva by the second day becoming so wearied that its feeble efforts scarcely move it at all. In fact, it has been the common experience of all investigators that such larvæ usually die within thirty-six hours unless they find a host. This fact, combined with the complete development of the attachment filament and the rudimentary and

incomplete condition of the mouth-parts, indicate strongly that this is a short transition period, just long enough to bring larva and host together.

The present species infests the Centrarchidæ, and fishermen are well aware that these fish are in the habit of catching their food at or near the surface of the water. And this is the place where the *Achtheres* larva awaits its victim. In seizing its prey, as well as in the act of ordinary breathing, a fish takes in water through its mouth and expels it through the gills. The *Achtheres* larva would be easily swept in at such a time by the incurrent water, and when brought in contact with the gills by the outcurrent its powerful grasping organs would enable it to secure a firm hold on the gill filaments or arches.

It is worthy of notice in this connection that those of the Centrarchidæ which feed most persistently at the surface are the very ones most infested by these parasites. The red-eye, *Ambloplites rupestris*, is the common host of the present species.

FIXATION TO THE HOST.

Of course, it is practically impossible to actually witness the fastening of the larva. But from what has been observed in the chalimus larva of the Caligidæ,^a we can infer what occurs here. The outer end of the attachment filament is enlarged into the mushroom form already described and is filled with adhesive fluid. It lies just inside the frontal margin, covered only by the very thin outer cuticle (fig. 23). Doubtless, the larva rubs its frontal margin against the skin of the gill arch of its host and in this way burrows through the slime and outer integument to the solid tissue underneath, holding on meanwhile with its powerful maxillipeds. At the same time the thin covering of the frontal margin of the parasite is broken through and the end of the filament is brought in contact with the gill arch, to which it adheres firmly. By moving away from the point of attachment, the coiled filament is drawn out of the body of the larva. As it comes forth the larva grasps it between the claws at the tips of the second maxillæ. These claws are bent into a half circle whose diameter is one-half larger than that of the filament. The latter can thus slip through the claws easily, but by shutting past each other, as they naturally do, the claws can still retain a firm hold. When the enlarged posterior end of the filament is reached, it is held securely between the claws and is removed entirely from the frontal margin. The attachment filament thus becomes fastened to the ends of the second maxillæ, where it afterwards remains throughout life.

That this transference of the filament from the frontal margin to the tips of the second maxillæ takes place at the time of fixation is manifest from several considerations.

^a Proc. U. S. Nat. Mus., vol. 28, p. 546.

First, no larvæ have ever been found fastened by their frontal margins. Nordmann was fortunate enough to discover a crowd of the copepodid larvæ clinging to the roof of the mouth of a perch. On removing them and placing them in water, it was found that some swam around vigorously in the water while others crawled about by means of their maxillipeds.^a The former had probably just found the fish, while the latter were ready to attach themselves.

Considering that the locomotor organs of these latter, in bringing them to the fish, have entirely served their function and are to degenerate and disappear at once, it seems probable that they cease activity as soon as the larvæ are once fastened to their host, and become practically useless before the moult occurs. At all events, none of these larvæ were fastened to the fish by their frontal margins, for this would scarcely have escaped Nordmann's observation.

The present author has secured every copepodid stage from the adult down to one which was shorter than the free-swimming form just described, and into which the latter molts. But this larva was fastened by the tips of the second maxillæ and not by the frontal margin. Again the second maxillæ, when first found with the filament attached to them, are too short to reach the frontal margin. We can easily understand how at the time of attachment, while the larva is still clinging with its maxillipeds, it could pull its body forward, after the end of the filament was attached to the gill arch, far enough to allow the maxillæ to grasp it. But it is not easy to see how these maxillæ could get hold of the filament after the larva had once cast itself loose from the fish and was hanging by its frontal margin. Since the second maxillæ are to serve as attachment organs throughout life, there is every reason why the transference should be made at once and no excuse to offer for the postponement of it.

SECOND COPEPODID STAGE.

BODY FORM.

Claus predicted for this stage a larva in which the number of body segments was not increased, the mandibles were inclosed in the mouth-tube, and the setæ of the swimming legs had degenerated. He was unable to find such a theoretical larva, but it can now be presented, and the closeness with which it conforms to his prediction proves the accuracy of his interpretation.

This larva is actually shorter than the free-swimming form, owing to a refusion of the segments there separated (fig. 28).

The body has been much thickened dorso-ventrally, so that it is no longer flat but cylindrical, while the thorax and abdomen have been relatively enlarged, and all the joints have stiffened so as to be practically immovable.

^a *Mikrographische Beiträge*, zweites heft, p. 84.

The general shape of the female is that of a spindle, the thickest portion being through the bases of the maxillæ and maxillipeds, the anterior cone much shorter than the posterior.

The first thoracic segment has separated from the head as distinctly as any of the others and is as wide as the cephalon; the others diminish in regular order backward.

The five segments in the body of this larva are thus due to a further separation of the first segment from the head and not to the formation of a new segment. There are really just as many as there were in the first copepodid stage.

On the dorsal surface the dividing groove between the second and third segments is deeper than the others; on the sides and ventral surface they are all equal.

The anal laminae are much reduced in size and consist of short and stout papillæ, projecting from each posterior corner of the abdomen and tipped with four tiny spines.

APPENDAGES.

The first antennæ are three-jointed, the two terminal joints having fused, and are only sparingly armed with short setæ.

The second pair (fig. 27) are very similar to those of the free-swimming larva, but project farther. They are made up of a long and stout basal joint and two rami; the exopod is indistinctly two-jointed and ends in a stout curved claw, with an accessory spine at its base; the endopod is one-jointed and tipped with two minute spines (fig. 30).

The mouth-tube (fig. 26) is more fully developed, the upper lip having increased in size and the halves of the lower lip being thoroughly fused. The mandibles have entirely changed and are now piercing organs, inclosed within the mouth-tube, but easily slipped outside through the slit in the side of the tube between the edges of the two lips (fig. 31). They are attached at the base of this slit; each is enlarged at the proximal end, tapers into a narrow shank, which is curved over ventrally, and ends in another enlargement, with six or eight curved teeth along its ventral edge. They reach about two-thirds of the distance from the point of insertion to the tip of the mouth-tube.

The first maxillæ (fig. 31) are now attached directly to the sides of the lower lip at a point a little above (distal to) the insertion of the mandibles. Each is uniramous, as long as the mandible, and tipped with two spines of equal length, with a very much shorter one at their base.

The second maxillæ have entirely changed; they still remain short but have lost all trace of segmentation and are much swollen laterally, so that they are three-fifths as wide as long (fig. 20). The

end of each is reentrant or bowl-shaped, and the claw is attached in the bottom of the bowl. It is very short and stout, with an enlarged, bluntly rounded or conical tip; the base of the cone forms a flange or barb around the claw and is reentrant at one point on the ventral side (fig. 21). This claw is entirely without muscles and therefore can not be moved, except as the whole maxilla moves.

The two claws can be distinctly seen imbedded in the enlarged proximal end of the attachment filament, and can be easily pried out of the latter (fig. 19). The filament also is a hollow tube whose structure corresponds exactly with that seen in the frontal region of the larva in the preceding stage. And if we follow along to the distal end of the filament, where it is attached (in this instance) to one of the spines on the gill arch, we find there the mushroom-shaped enlargement which was so conspicuous in the free-swimming larva (figs. 27 and 38). There can be no doubt of the identity of the two structures. It often happens that the claws and the filament for some little distance near them are covered with a mass of the adhesive substance arranged in ridges or transverse wrinkles, as though some of the contents of the tube had escaped when it was transferred from the frontal margin (fig. 24). This is exactly what would be expected and strengthens the proof of such transference.

The maxillipeds retain their segmentation and have practically the same structure as before. The only change has been that they have migrated forward a little between the bases of the second maxillæ, so that now the two pairs of appendages are about on a level.

The swimming legs have greatly degenerated; they have diminished in size until oftentimes it is difficult to find them and they have lost their plumose setæ. They are now made up of a tiny basal joint and two still more minute rami, each of which is tipped with two short spines (fig. 28). They disappear entirely at the next molt. The spines which represented the third pair of legs on the sides of the third thorax segment in the free-swimming stage have entirely disappeared.

Total length of this second copepodid larva, 0.42 mm. Length of cephalothorax, 0.30 mm. Width of same, 0.20 mm. Width of second thorax segment, 0.10 mm.

SEX DISTINCTION.

The larvæ show enough differences in this second copepodid stage to enable us to distinguish the sexes.

The male (fig. 25) is shorter and more stocky than the female; in dorsal view the body is distinctly separated into two regions, a cephalon subquadrilateral in outline and nearly half the entire length, and the body proper, cylindrical in form, narrower than the cephalon, and tapering backwards. Between these two regions is a strong

constriction, extending entirely around the body and making a sort of waist. This causes the posterior portion, the body proper, to appear very much like the abdomen in the Hymenoptera. The pigment, which in the female (fig. 28) is confined to a single spot on the dorsal surface of the carapace at the center, is in the male distributed as a narrow dendritic line along either margin of the carapace in addition to the central spot.

The second maxillæ and maxillipeds are larger and stouter in the male, longer and more slender in the female. Especially is this true of the second maxillæ, which now are the attachment organs. In the male they are little if any longer than the maxillipeds, and they *do not increase in length* as development progresses. On the contrary they remain about the same length and retain their terminal claws, together with all the musculature connected with them.

In the female, although the second maxillæ may not be very much longer than the maxillipeds when they first take over the attachment filament, they rapidly increase in length until they become fully twice or three times as long. At the same time the musculature is withdrawn from connection with the terminal claws, and finally the claws themselves disappear.

Of course in subsequent development size enters as a distinctive factor and quickly becomes predominant over the differences just mentioned. The male is to be a pigmy when sexually mature, and hence increases in size very slowly, and never gets to be over a millimeter in length. The female, on the other hand, grows normally and is 4 or 5 millimeters long when fully developed.

The later the stage of development, therefore, the greater will be the size difference between the two sexes, and a point is soon reached where this factor alone will enable one to recognize the sex.

There is very little difference in the appendages between the two sexes. The first antennæ of the male are stouter and longer than in the female, and have only the terminal tuft of three short setæ. The second pair are relatively shorter, so that the tips of the two pairs in the male are on a level. There is a rather larger knob at the base of the terminal claw of the exopod, and the endopod has three tiny spines on its tip. The mandible reaches more closely to the tip of the mouth-tube, but easily slips outside of the tube as in the female. The first maxillæ are shorter and stouter, and the two terminal setæ are more conspicuously jointed at their base. These maxillæ hardly reach beyond the base of the mandible, while in the female they reach its tip (compare figs. 26 and 31).

DIGESTIVE SYSTEM.

Interest of course is centered chiefly on the internal anatomy of the two sexes at this period. On examining a median longitudinal section (fig. 32) of the male larva shown in figure 24, and of a slightly

larger female larva (fig. 33), we find that the digestive canal traverses the entire length of the body, its two openings being virtually terminal.

The mouth-tube is turned forward and its tip projects in front of the frontal margin, making it the most anterior portion of the body. Through its center runs the slender thread-like œsophagus (*oe.*) which extends back opposite the base of the second maxillæ without any turn or sharp bend. There it passes abruptly into the enlarged stomach, entering the center of the anterior end in the male and the anterior ventral corner in the female. At the point of junction a thick sphincter muscle (*sm.*) is formed, which projects strongly into the stomach (*s*). The latter is completely fused with the intestine so that it is impossible to distinguish any point of separation. Both possess thick walls made up of an outer serous membrane, set with nuclei and serving as the point of attachment for the numerous fibers and muscles which suspend the tube within the body cavity, a median muscular layer which produces the peristaltic movements, and an inner glandular layer composed of large cells, whose darkly pigmented contents are gathered around a much lighter nucleus. Some of these cells project into the stomach cavity much farther than others, and their inner free ends are filled with a digestive secretion, as evidenced by differential staining (*gc.*). In the male the intestine stops abruptly at the anterior margin of the last (abdominal) body segment. The entire abdomen beyond it is filled with a plug of loose cells and muscle fibers, through the center of which may be seen the proctodeum (*pc.*) in process of formation. But it is not yet finished and the anus has not broken through, the posterior walls of the abdomen being entire.

In the female larva, however, the posterior portion of the digestive tract is fully formed; otherwise there is no difference in this region between the sexes. At this early stage the body cavity around the digestive tract is open save for the grouping of cells in various places to form the beginnings of other organs. Through the wide spaces thus left the blood can circulate freely.

FRONTAL GLAND.

In the anterior portion of the head, dorsal to the œsophagus, is the large secretory gland which formed the attachment filament in previous stages (*fg.*). The filament itself is gone, and the peg or attachment end has been torn out, leaving a gaping hole filled with a plug (*p*) made of the secretion of the gland. This furnishes the final proof of the transference of the filament from the frontal margin to the tips of the second maxillæ. Claus thought he discovered the remains of the peg in the head of the larva which he has figured, but he was

judging, as he admits, entirely from external appearances. The nature of this plug is clearly proved by the way in which it stains. It is not the peg, for that remains uncolored in both hæmatoxylin and eosin; it is not part of the gland itself, for that takes a deep-blue stain; it is the secretion of the gland, which stains deeply with eosin. The very rudimentary eye, which was found in the nauplius-metanauplius stage within the coils of the attachment filament, has entirely disappeared. It goes without saying that there can be no remnant of the lenses left, for there were no lenses to begin with in this species. Moreover, there was no pigment in the larval eye, and hence the irregular pigment spots found on the dorsal surface of this larva, above the brain, can not be explained as "taking their origin in the pigment of the larval eye," which is the explanation given by Claus for *Achtheres percarum*.

EXCRETORY GLANDS.

In addition to these frontal glands, there are several excretory glands in the head, some of which are more or less connected with one another. The largest starts at three different centers on the level of the bases of the maxillipeds. One center is median and dorsal, between the wall of the anterior end of the stomach and the dorsal body wall (*mpg.*, fig. 32). This may be designated as the median center of the maxillipedal gland. It begins as two or three ellipsoidal balls or accretions of very small cells, gathered just beneath the ectoderm in this region of the back. These are supported by a fine meshwork of connective tissue from the dorsal ectoderm, the outside layer of the stomach wall, and the adjacent dorso-ventral muscles, which operate the second maxillæ and the maxillipeds (fig. 37).

At first these glandular masses are small and, especially in the female, are often spherical; but as they increase in size they accommodate themselves in both sexes to the shape of the cavity in which they are formed. Elongating antero-posteriorly, they become ellipsoidal or cylindrical and often taper into cones (*mc.*, fig. 37). Owing to the position of the ovaries or testes close behind them on the median line, these masses move around to the sides of the stomach as they increase. Here they grow backward until they overlap considerably the anterior end of the sex organs. Sometimes this lateral movement eventually draws the masses away from the midline, leaving that space free for the maturing ovaries and testes.

As soon as this median portion of the gland appears, a similar mass may be found on either side near the bases of the maxillipeds (*lc.*, fig. 32). These lateral maxillipedal centers increase similarly to the median one, and finally fuse with it around the sides of the stomach. A spirally convoluted duct (*d*, fig. 37) is then formed, leading from the fused lateral mass on either side to the base of the maxilliped,

where it opens to the surface. The walls of this duct are composed of a thick homogeneous layer, set with nuclei, and taking both the red and the blue stains.

Another pair of glands, situated in the bases of the second maxillæ, one on either side, may be called the maxillary glands (*mxg.*, fig. 37). Each is a single well-rounded ellipsoidal mass, nearly filling the cavity of the maxilla and giving off from its inner surface at the center of the ellipse a straight duct, which leads toward the distal end of the basal joint, where it opens to the surface on the inner side:

As development proceeds the maxillipeds migrate forward, taking the distal end of the convoluted duct with them, while the second maxillæ in the male point diagonally backward outside of the maxillipeds. It thus comes about in the adult that the bulk of the maxillipedal glands is behind the appendage at whose base their duct opens, but in front of the maxillary glands. Such a relative position would be difficult to explain if we did not have the developmental stages in which to follow the various changes.

NERVOUS SYSTEM.

The nervous system is made up of a very large infra-œsophageal ganglionic mass and an equally small supra-œsophageal portion. The latter can hardly be distinguished in the female from the walls of the gullet (*sog.*, fig. 33). At its anterior end two nerves are given off on either side, one beneath the other. The upper and smaller one (*a'*) goes to the first antenna, but gives off a branch near the base of the antenna which supplies the frontal margin. The lower and larger one (*a''*) goes to the second antenna, but sends a branch to the upper lip. At its posterior end this supra-œsophageal ganglion gives off a large nerve (*n*, fig. 32) on either side, which runs along the anterior wall of the stomach and supplies the dorsal portion of the head, the frontal gland, and the maxillipedal excretory gland.

From the anterior end of the large infra-œsophageal ganglion a good-sized nerve trunk (*lb.*) runs forward to the base of the lower lip, where it divides and sends a branch to the mandible (*md.*).

A slender nerve, given off from the ventral surface of the ganglion, goes to the first maxilla (*mx.*). Another larger one (*mx'.*) just behind it supplies the second maxilla, while from the postero-ventral corner a still larger nerve runs to the maxilliped (*mxp.*). Near the postero-dorsal corner a delicate nerve thread runs down diagonally to the lateral maxillipedal and maxillary glands (*mpg'.*). From the corner itself is given off the slender nerve which extends backward along the ventral wall of the stomach and close to its fellow from the other side. These ventral nerve trunks (*vc.*) are no larger than those which supply the maxillipeds, and although they give off branches to the stomach and body walls, to the various muscles, and to the reproductive organs, they show no ganglionic swellings, and no ganglion cells.

The nervous system, therefore, is practically all concentrated in the infra-œsophageal ganglion, since the part above the gullet is hardly swollen more than enough to serve as the origin of the nerves that arise from it. In this respect the Lernæopodidæ present a strong contrast to the Ergasilidæ and Caligidæ, as also to the free-swimming forms.

The infra-œsophageal ganglion is made up of a peripheral layer of nerve cells and a central mass of fibers. The cells are evenly distributed over the outer portion of the ganglion and are not bunched at the origin of the nerves.

There are a very few cells in the commissures at the sides of the œsophagus and in the supra-œsophageal ganglion, but the great mass of both these portions is fibrous, and nothing but fibers can be found in any of the nerve trunks or branches.

REPRODUCTIVE ORGANS.

The beginnings of the reproductive organs are shown in both sexes at this second copepodid stage. The ovaries and testes are paired and lie in what may be termed the small of the back, between the stomach and the dorsal body wall and just behind the median maxillipedal gland (*t*, fig. 32 and *o*, fig. 33). The ovaries begin as small spherical masses of cells, not very definitely arranged, but gathered together on either side of the midline (*o*, fig. 36). From the posterior end of each is given off a slender oviduct which runs around the stomach wall to the ventral surface and then backward to the opening in the side of the genital segment. At intervals along the duct are gathered rounded masses of cells which later develop into the uterine processes, within which the eggs are matured (*up*). At the posterior end of the duct is an irregular cellular mass in which may be distinguished the beginnings of the cement gland (*cg*), its duct being corkscrew-shaped at this stage. Between these two masses in the center of the body is another cellular accretion which later develops into the semen receptacle and its ducts.

As the sex organs mature the posterior portion of the body of the female increases greatly in size, especially laterally, leaving large spaces on either side of the digestive tract. These are filled as fast as they are formed by the increased convolutions of the oviduct and especially by the development of the uterine processes anteriorly and the large cement glands posteriorly. Claus evidently did not see either the ovaries or the testes of *Achtheres percarum*. The bodies which he has designated as such are a long distance back of their true position, as revealed in serial sections. In the living larvæ as well as in the adults the sex organs are so situated as to be invisible from the exterior. But certain portions of the convolutions of the oviducts and vasa deferentia come close to the body wall and are easily distinguished. And these are what Claus has designated as the organs themselves.

The testes begin in the same manner as the ovaries, the separate masses becoming afterwards the lobes of the fully developed organs (fig. 35). The deferent duct (*vd.*) at first turns forward to the ventral surface, then swings back to the dorsal surface, runs diagonally to about the center of the lateral surface, where it is greatly swollen, and finally turns diagonally forward again to the opening on the ventral surface of the genital segment. The free portion (*fd.*) of the duct is much larger than the oviduct, chiefly owing to the increased thickness of its walls. In the swollen anterior convolutions of the duct may be distinctly seen the cells which are to be transformed later into spermatozoa.

As development proceeds the deferent duct, like the oviduct, becomes more and more convoluted and swollen, until it finally fills the entire cavity on either side of the digestive tract, and it presses against the latter so much that the rectal portion of the intestine becomes flattened laterally into a mere slit, difficult to distinguish except in transverse sections. In this second copepodid larva the entire posterior segment of the body, which is a fusion of the two posterior thoracic segments and the abdomen, is filled in the male with a mass of cells (*k*, fig. 32) containing fine granules (Claus's "Körnchenhaufen"). These become joined later with the posterior portion of the deferent ducts and supply the cement substance which forms the outer covering of the spermatophores. In this manner practically the entire body cavity behind the cephalon is occupied by the sex organs and the various accessories connected with them.

CIRCULATORY SYSTEM.

There are no real circulatory organs in this larva or in the adult. The blood moves about freely through the large open spaces in the body cavity, and is driven back and forth by the movements of the digestive tract. Both the stomach and intestine have muscular walls capable of strong peristaltic movements which show much diversity. At one time they sweep forward, at another backward, and again they start at either end and work toward the center, or they may begin at the latter point and move backward and forward simultaneously. These movements carry along with them the blood which lies in contact with the walls of the digestive tract. But the real movement is accomplished in a much more effective manner. To either side of the digestive tract in the third thoracic segment is attached a bundle of muscle fibers which run directly outward and are fastened to the lateral body wall. These contract rhythmically to the right and to the left, pulling the intestine quite a distance away from the midline to the one side and then to the other. The blood, following these lateral movements of the intestine, streams precipitately forward on the side toward which the intestine is

pulled, and backward on the opposite side. This motion is then reversed when the intestine is pulled to the opposite side. These movements become stronger with the maturing of the larva, and in the adult they produce a complete circulation.

There are no blood vessels nor any heart. What Claus describes as a pulsating organ ("pulsirende Organ") occupies exactly the position of the median maxillipedal gland, already described. The body is strongly narrowed just posterior to this point and the lumen of the body cavity is tightly filled by the median maxillipedal gland, the lateral glands, the ovaries or testes, and the enlarged anterior end of the stomach. Naturally the blood streams through the narrow interstices between these organs with considerable force and often moves the dorsal portion of the organs with every sway of the digestive tract. When seen through the outer body wall this gives the impression of a pulsating organ, but nothing of the sort can be found in the larva.

SUBSEQUENT STAGES.

At the next molt both sexes become mature—that is, they are adults, and although they increase afterwards in size, especially the female, there is no further change in bodily structure or the appendages (figs. 38 to 43). One thing, however, is still left to be accounted for, and that is the coming together of the sexes. At present we have them each attached by a filament to the host, whereas we know that in the matured adults the pigmy male elings with his maxillipeds to the body of the female. How is this transfer accomplished by a creature that can not swim?

From this second copepodid stage there is a steady increase in the difference in size between the sexes. The female grows faster than the male, particularly the posterior portion of the body, and the second maxillæ elongate until they are often as long as the entire body. The attachment filament at the same time shortens until all that is left of it is the slender stalk between the attachment disk and the tips of the maxillæ.

In the male the head and body remain approximately the same size; the second maxillæ do not elongate nor does the attachment filament shorten. The claws at the tips of these maxillæ are retained, as are also the muscles connected with them. Indeed, since the filament in this sex does not become fused with the maxillæ, the only way in which the male retains hold of it is by means of the claws driven into its swollen proximal end. The purposes of these differences is now manifest, for they enable us to understand how the union of the sexes takes place.

The females were permanently attached to their host in the first copepodid stage and can not afterward be changed. On the contrary the little motion at first allowed by the long attachment filament

is steadily diminished until, by the time the female is sexually mature, it is entirely gone and the tips of the maxillæ are in contact with the gill arch of the host. The female, therefore, is an inactive factor in the union. The male was also fastened by an attachment filament in the first copepodid stage, and his swimming legs degenerated like those of the female. Hence he can not swim in his search for the opposite sex.

When the copepodid larvæ attach themselves to their host several fasten in immediate proximity. The author has repeatedly taken two or three adults from the same spot on a gill arch, each female with an attached male. Sometimes the attachment disks are actually fastened together so that they have to be cut apart, and often the discarded male filaments will be found close beside those of the female.

It is scarcely possible that sexual instinct manifests itself thus early in development, and induces the two sexes to attach themselves side by side. But there may well be a general instinct which leads all the larvæ indiscriminately to keep together during this period. And this is exactly what the finding of several adult females attached to the same spot would indicate.

Having attached themselves as members of such a little group the males, as soon as their sex organs are developed, begin moving around in a circle whose radius is the length of the filament. Somewhere within this space they are pretty sure to find a female; the male then fastens to her body with his maxillipeds and withdraws the claws of the maxillæ from the end of the filament, thus becoming permanently fastened to the female. It is probable that, if the male can not find a female by this method, he is able to withdraw his claws from the filament and crawl about over the gill arch in search of one. The discarded filaments found on the gill arches of the red-eye would indicate at least that the male does not retain this attachment after becoming sexually mature.

GENERAL SUMMARY.

1. Long filaments of ovarian cells loosen themselves from the epithelium of the ovary and pass down into the uterine processes of the oviduct, where the terminal cells of each filament develop into oöcytes successively, one after another.

2. Each egg is surrounded by a structureless vitelline membrane, within which are yolk globules evenly and universally distributed through a fine cytoplasmic matrix. There are numerous scattered spherical vacuoles of different sizes. The egg nucleus is about the size of the largest vacuoles, is slightly eccentric, nearly spherical, and surrounded by a membrane. It contains a single nucleolus and numerous chromatin granules near the periphery.

3. As the eggs pass out of the oviduct they are each fertilized at the opening of the sperm receptacle, and are covered with a layer of the

secretion of the cement gland, which forms in the external sacks a thick outer shell membrane.

4. The first cleavage nucleus divides and with some of the cytoplasm migrates to the surface at a point opposite the wall of the external sack. The migrated materials are there transformed into blastoderm cells by an accumulation of the cytoplasm around nuclear centers, until four or five cells of the same size have been produced. Then, while the migration continues, a segmentation of these cells also begins and the two processes go on simultaneously until the completion of the blastoderm, when the cells composing it secrete a cuticular membrane, the blastodermic cuticle.

5. After the blastoderm has entirely surrounded the yolk the portion of it which is to become the ventral surface of the embryo thickens by a rapid multiplication of cells, and builds up a series of lobes, which are to constitute the future appendages.

6. The nauplius and metanauplius stages are passed inside the egg, the larva hatching in the first copepodid stage. The first two stages are so completely fused as to be indistinguishable. The nuclear centers of the usual nauplius appendages, of the mouth-parts, and of the first two pairs of swimming legs all appear simultaneously. The first and second antennæ develop quickly into normal nauplius appendages. The mandibles never do but, with the other appendages, are arrested for a time, and then develop into the usual metanauplius form. The nauplius eye is so rudimentary that it can be seen only in serial sections; it has neither pigment nor lenses.

7. The most interesting nauplius structure is the attachment filament, begun in the nauplius and completed in the metanauplius stage. It is secreted by a large frontal gland which occupies the whole of the anterior dorsal portion of the cephalon. It consists of a long filament, cylindrical and hollow, straight at first then increasing in length and coiling like a rope, the two ends extending forward to the frontal margin. The distal end is shaped like a mushroom and is the part attached to the host; the proximal end is peg-shaped and is the point of attachment between the filament and the gland.

8. The larva emerges in the first copepodid stage a vigorous swimmer, and at once seeks a host and fastens itself somewhere on the gill arches. During attachment or at least before the next molt, the filament is transferred from the frontal margin to the claws at the tips of the second maxillæ. It remains here during life in the female, being gradually shortened down to the length found in the adult. In the male it remains until the union of the sexes, when the claws are withdrawn from it and the male afterwards clings to the body of the female.

9. The attachment button of the adult, therefore, is the mushroom enlargement at the distal end of the larval filament. It is the

second maxillæ and not the maxillipeds to which the filament is transferred. The tips of these second maxillæ do not unite to form the button, they are simply stuck to the proximal end of the filament (fig. 44). Although the claws subsequently disappear and the maxillæ apparently fuse, sections show that each really preserves its identity; that is, the fusion is only apparent and not real.

10. In the second copepodid stage sex distinction is possible. The body of the male is strongly constricted into a waist between the head and thorax; the second maxillæ are stout and no longer than the maxillipeds. The body of the female is long and slender and only slightly constricted; the second maxillæ are much longer than the maxillipeds and slender.

11. In this second copepodid stage the digestive tract of the male is not yet opened at the anus, but it is completed in the female. The sexual organs have begun to develop and the large maxillary and maxillipedal glands are forming. The nervous system is concentrated in the infra-œsophageal ganglion, and there are no ganglia on the ventral nerve cord.

12. This second copepodid larva molts into the adult form. We have here then a marked concentration of development, the nauplius and metanauplius stages passed inside the egg and so fused as to be indistinguishable, the first copepodid the only free-swimming stage, and of very short duration (twenty-four to forty-eight hours), just long enough to find a host, the second copepodid stage showing the beginning of all the organs and molting directly into the adult.

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EXPLANATION OF PLATES.

PLATE 29.

Formation and segmentation of the egg.

- Fig. 1. Section of oviduct, full of developing eggs, each with a cell filament attached to one pole; *b*, coiled filament.
2. A single, fully developed oöcyte, with attached cell filament, more highly magnified.
 3. Division and migration of the germinal vesicle.
 4. The first cell of the germinal layer.
 5. The first two cells of the germinal layer.
 6. The germ layer forming into a blastoderm disk.
 7. Blastoderm disk half surrounding the egg.
 8. Completion of blastoderm disk and formation of blastoderm cuticle.
 9. Longitudinal section of nauplius larva, showing the beginnings of the appendages; *a'* and *a''*, first and second antennæ; *fg.*, frontal gland; *m*, muscles which are to operate the swimming legs; *md.*, mandible; *mx'*, and *mx''*, first and second maxillæ; *m xp.*, maxilliped; *s'* and *s''*, first and second swimming legs.

PLATE 30.

Development within the egg, nauplius stages.

- Fig. 10. Dorsal view of nauplius larva, freed from the egg membranes.
11. Ventral view of same.
 12. Longitudinal horizontal section through a nauplius larva; *a'* and *a''*, first and second antennæ; *ab*, fused genital segment and abdomen; *fg.*, frontal gland; *lb.*, labrum; *md.*, mandible; *w.*, body wall.
 13. A section through the peg end or origin of the attachment filament; *af.*, attachment filament; *fg.*, frontal gland; *p.*, peg.
 14. Attachment filament in two stages of growth; *a*, curved; *b*, cork-screw shaped.
 15. Side view of fully developed metanauplius within the egg.

PLATE 31.

Development within the egg, metanauplius stage.

- Fig. 16. Ventral view of metanauplius larva, freed from the egg membranes; *a'* and *a''*, first and second antennæ; *md.*, mandible; *mx'* and *mx''*, first and second maxillæ; *m xp.*, maxilliped.
17. First and second antennæ enlarged.
 18. A diagonal longitudinal section through the body of a fully developed metanauplius coiled inside the egg membranes; lettering as in fig. 9 with these additions: *af.*, attachment filament; *e*, rudimentary eye; *lb.*, labrum; *ms.*, mesenteron epithelium forming over ventral surface of the stomach; *pg.*, paragnath.
 19. The second maxillæ and the attachment filament of the second copepodid stage, showing the claws of the maxillæ imbedded in the end of the filament.
 20. A single maxilla with the claw pried out of the filament.
 21. Tip of maxilla and claw enlarged.

PLATE 32.

The free-swimming larva, first copepodid stage.

- Fig. 22. Ventral view of first copepodid larva, showing appendages.
23. Dorsal view of same.

PLATE 33.

The second copepodid stage.

- Fig. 24. Side view of male larva.
25. Dorsal view of same.
26. Side view of antennæ and mouth parts.
27. Side view of female larva.
28. Dorsal view of same.
29. A first antenna with only two joints and two terminal setæ.
30. Second antenna.
31. Mouth-tube, mandible, and first maxilla.

PLATE 34.

Longitudinal sections of male and female second copepodid larvæ.

The lettering of the digestive, excretory, and nervous systems applies equally to both figures; that of the reproductive organs is of necessity peculiar.

- Fig. 32. The male: *a'*., nerve to first antenna; *dm.*, dorso-ventral muscles; *fg.*, frontal gland; *gc.*, gland cells; *i*, intestine; *iog*, infra-oesophageal ganglion; *k*, cellular mass or plug, Claus' "Körnchenhaufen;" *lb.*, nerve to labium; *lm.*, longitudinal muscles; *md.*, nerve to mandible; *mpg.*, maxillipedal gland, median center, the lateral center being at *lc.*; *mx'*., nerve to second maxilla; *mxp.*, nerve to maxilliped; *n*, nerve to frontal and maxillipedal excretory glands; *oe*, oesophagus; *p.*, plug of secretion of frontal gland filling hole left by removal of attachment filament; *p c*, proctodeum; *t.*, testes; *vc.*, ventral cord of nervous system.
33. The female: *a*, anus; *a''*, nerve to second antenna; *lm*, longitudinal muscles; *mpg'*, nerve to maxillipedal gland; *mx*, nerve to first maxilla; *o.*, ovary; *s*, stomach; *sm.*, sphincter muscle; *sog.*, supra oesophageal ganglion; *up.*, uterine processes of the oviduct.

PLATE 35.

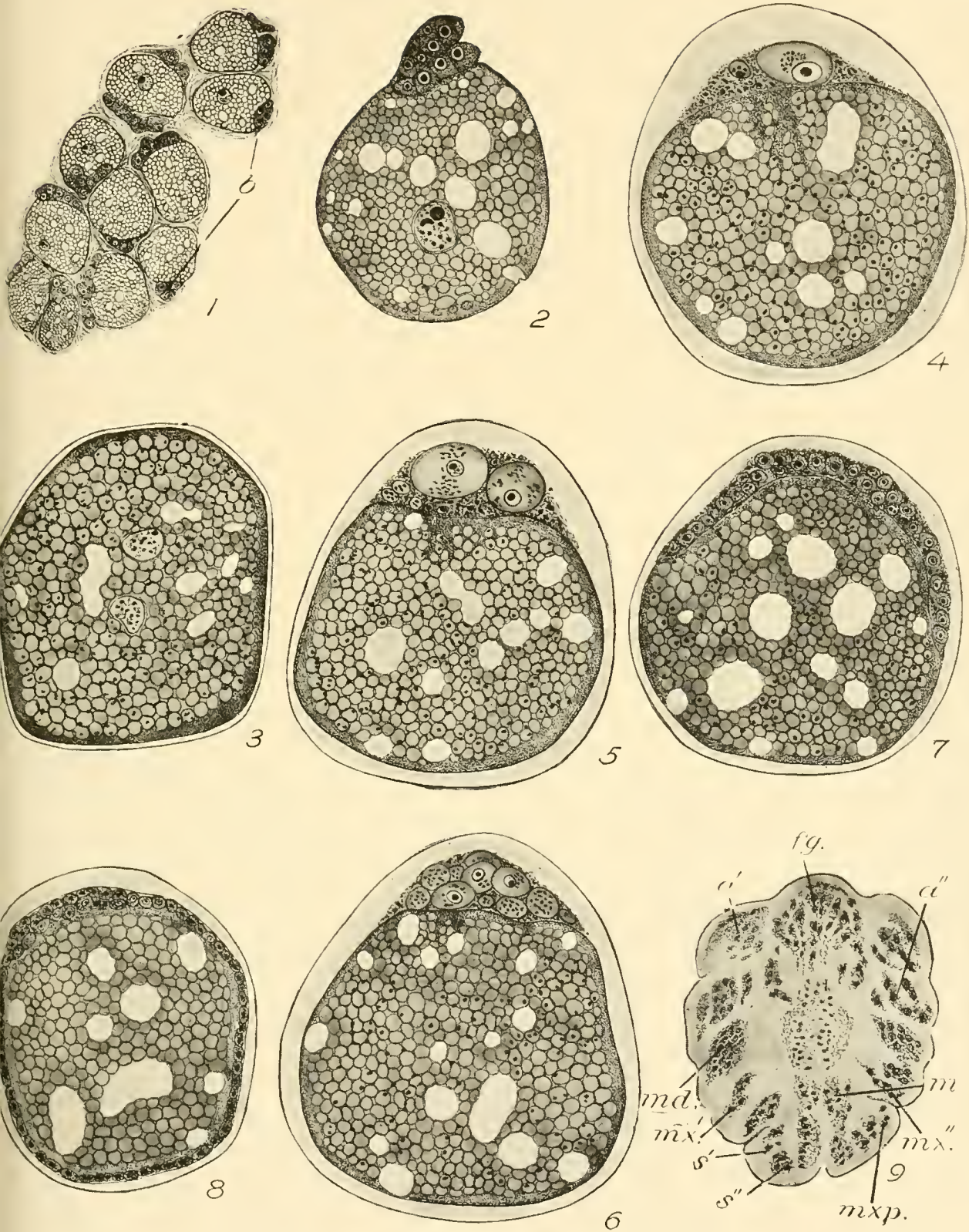
Sections showing internal anatomy.

- Fig. 34. Diagonal section through head of metanauplius larva, showing frontal gland and attachment filament; *a.*, first antenna; *c.*, coils of filament; *e.*, rudimentary eye; *fg.*, frontal gland; *m.*, muscles of swimming legs; *ms.*, mushroom enlargement at anterior end of filament; *p.*, peg at proximal end of filament; *w.*, wall of egg sac.
35. Beginnings of male reproductive organs; *dm.*, dorsoventral muscles; *fd.*, free portion of the deferent duct; *t.*, testes; *vd.*, deferent duct.
36. Beginnings of female reproductive organs; *cg.*, cement gland; *dm.*, dorso-ventral muscles; *o.*, ovary; *od.*, oviduct; *up.*, uterine processes.
37. The maxillipedal gland of an adult male; *d.*, corkscrew duct; *lc.*, lateral center of gland; *mc.*, median center; *mpg.*, main portion of the gland; *mxg.*, maxillary gland; *sm.*, supporting muscles.

PLATE 36.

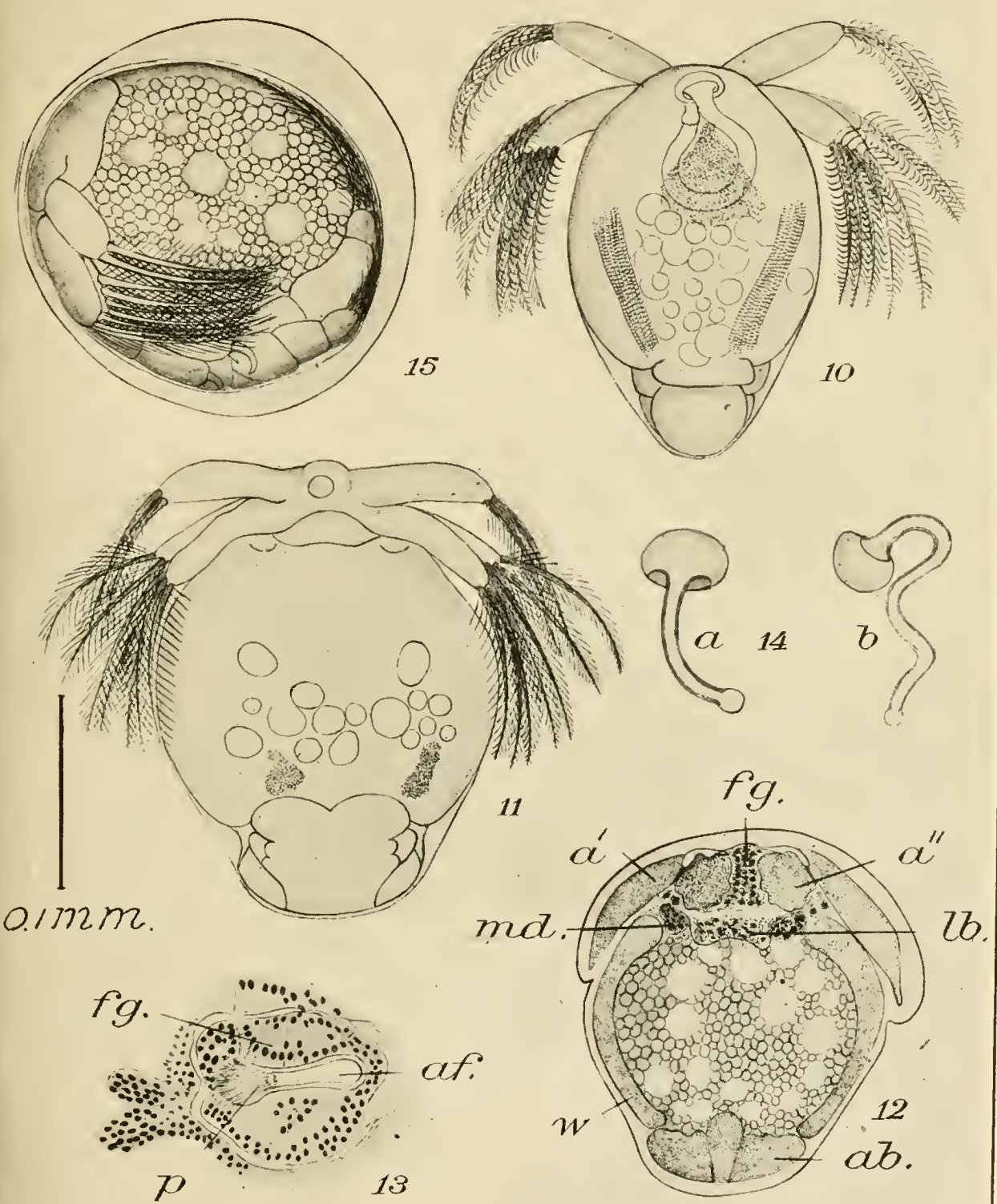
Young adults of Achtheres ambloplitis.

- Fig. 38. Side view of sexually mature male, attached to spine of gill arch
39. Mouth parts of same.
40. First maxilla.
41. Mandible.
42. Side view of young female.
43. Antennæ and mouth parts of same.
44. Section through the tips of the second maxillæ; *af.*, attachment filament; *lm.*, longitudinal muscles; *mx.*, wall of maxilla.



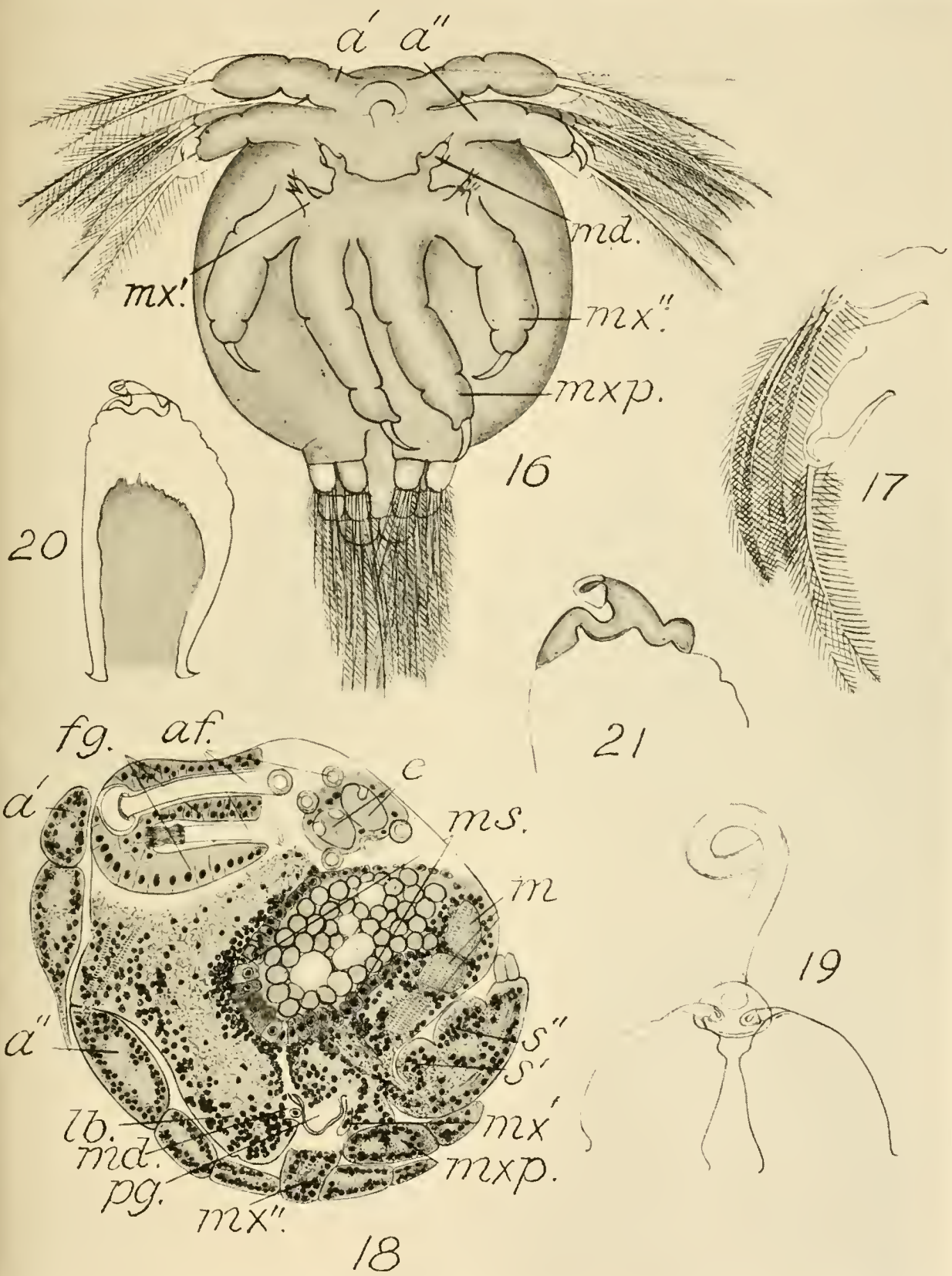
FORMATION AND SEGMENTATION OF THE EGG

FOR EXPLANATION OF PLATE SEE PAGE 225



DEVELOPMENT WITHIN THE EGG, NAUPLIUS STAGES.

FOR EXPLANATION OF PLATE SEE PAGE 225.

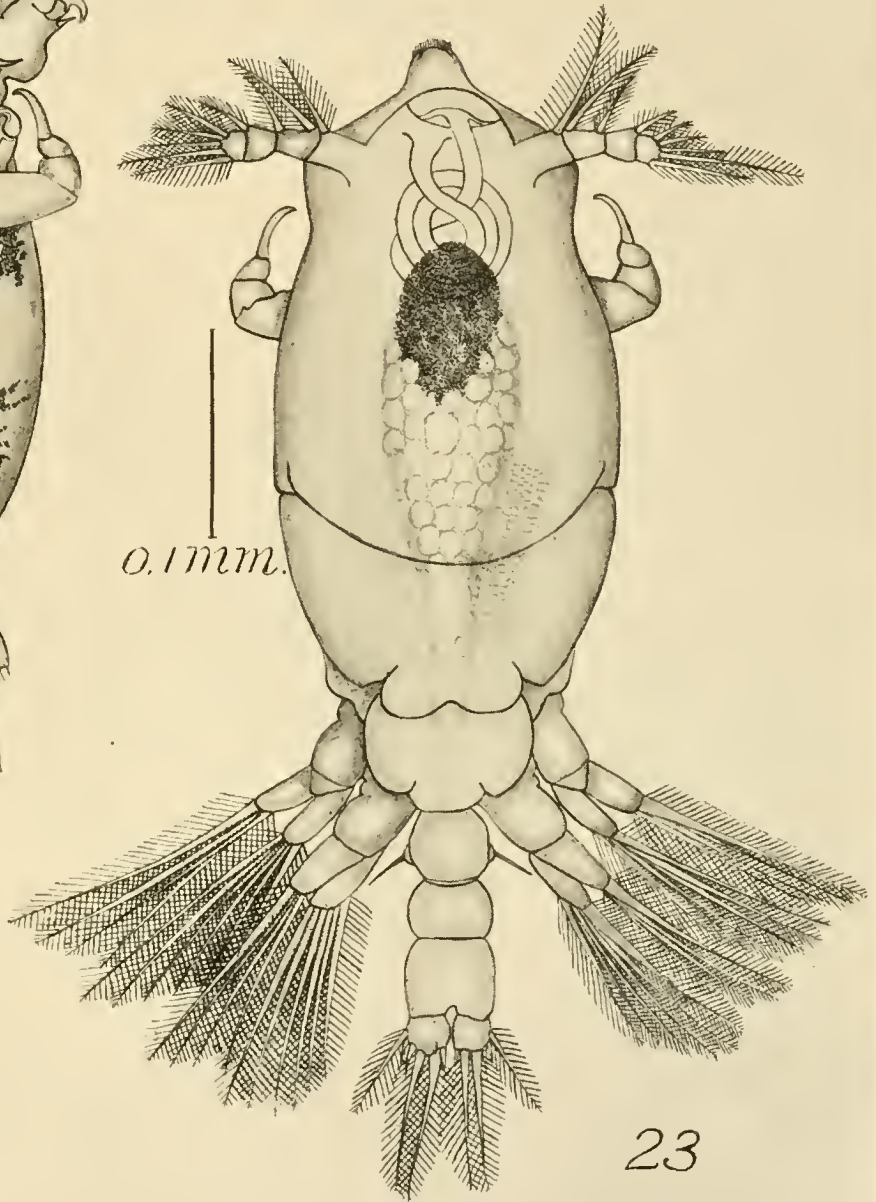


DEVELOPMENT WITHIN THE EGG, METANAUPLIUS STAGE.

FOR EXPLANATION OF PLATE SEE PAGE 225.



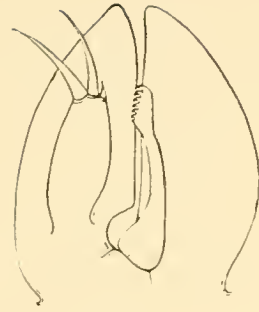
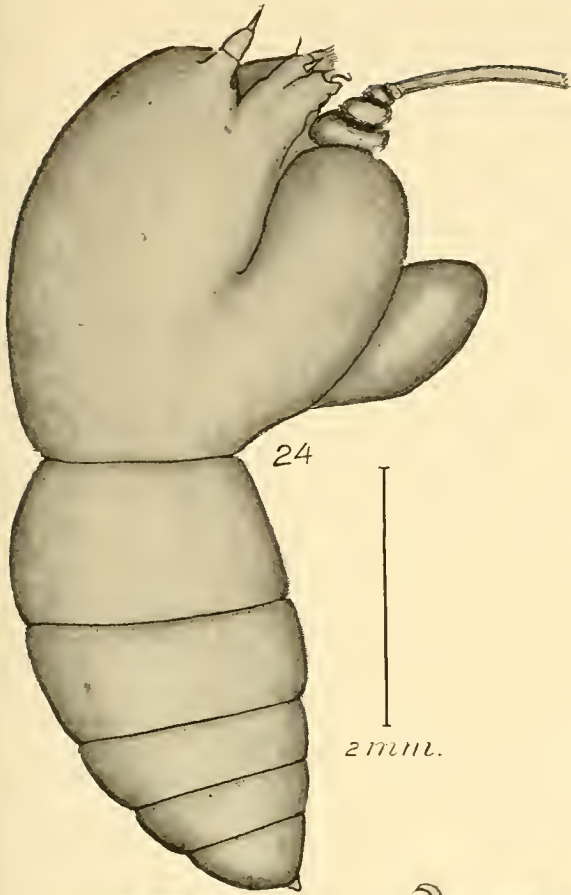
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23

THE FREE-SWIMMING LARVA, FIRST COPEPODID STAGE.

FOR EXPLANATION OF PLATE SEE PAGE 226.



31



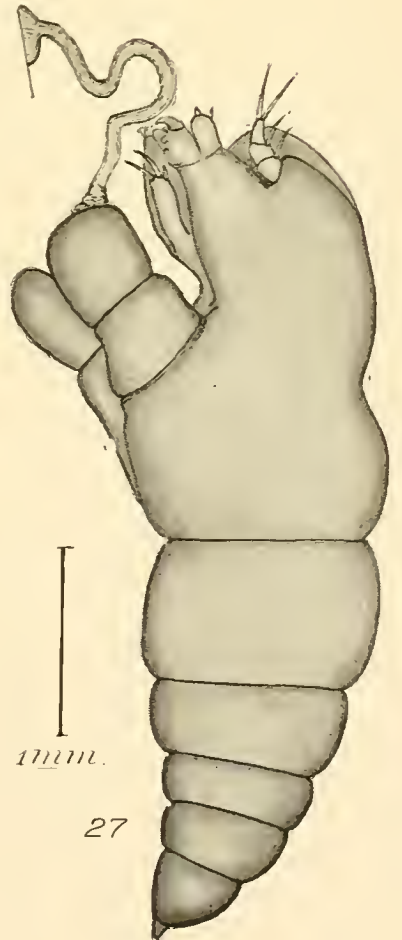
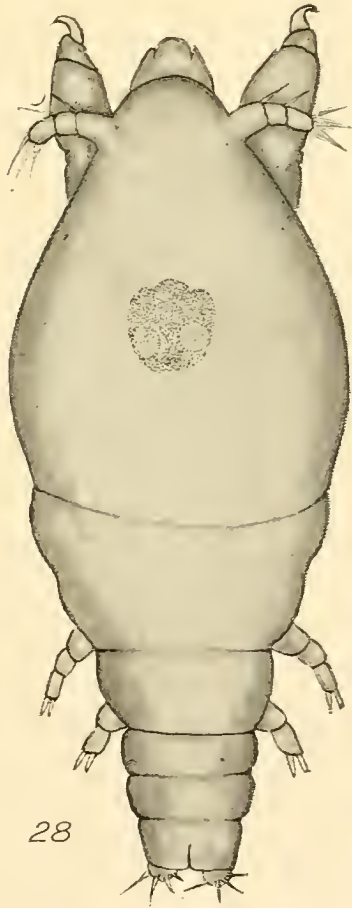
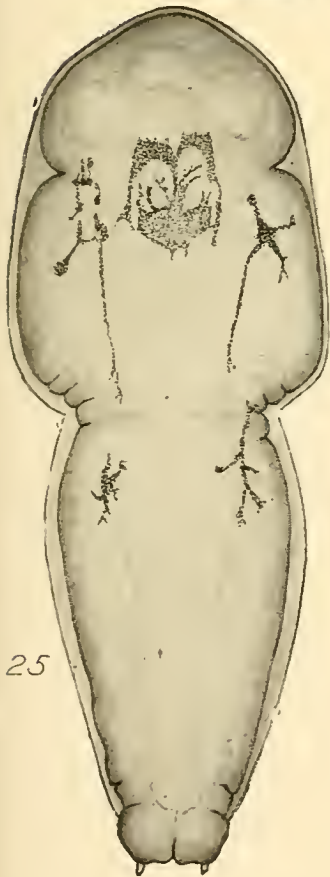
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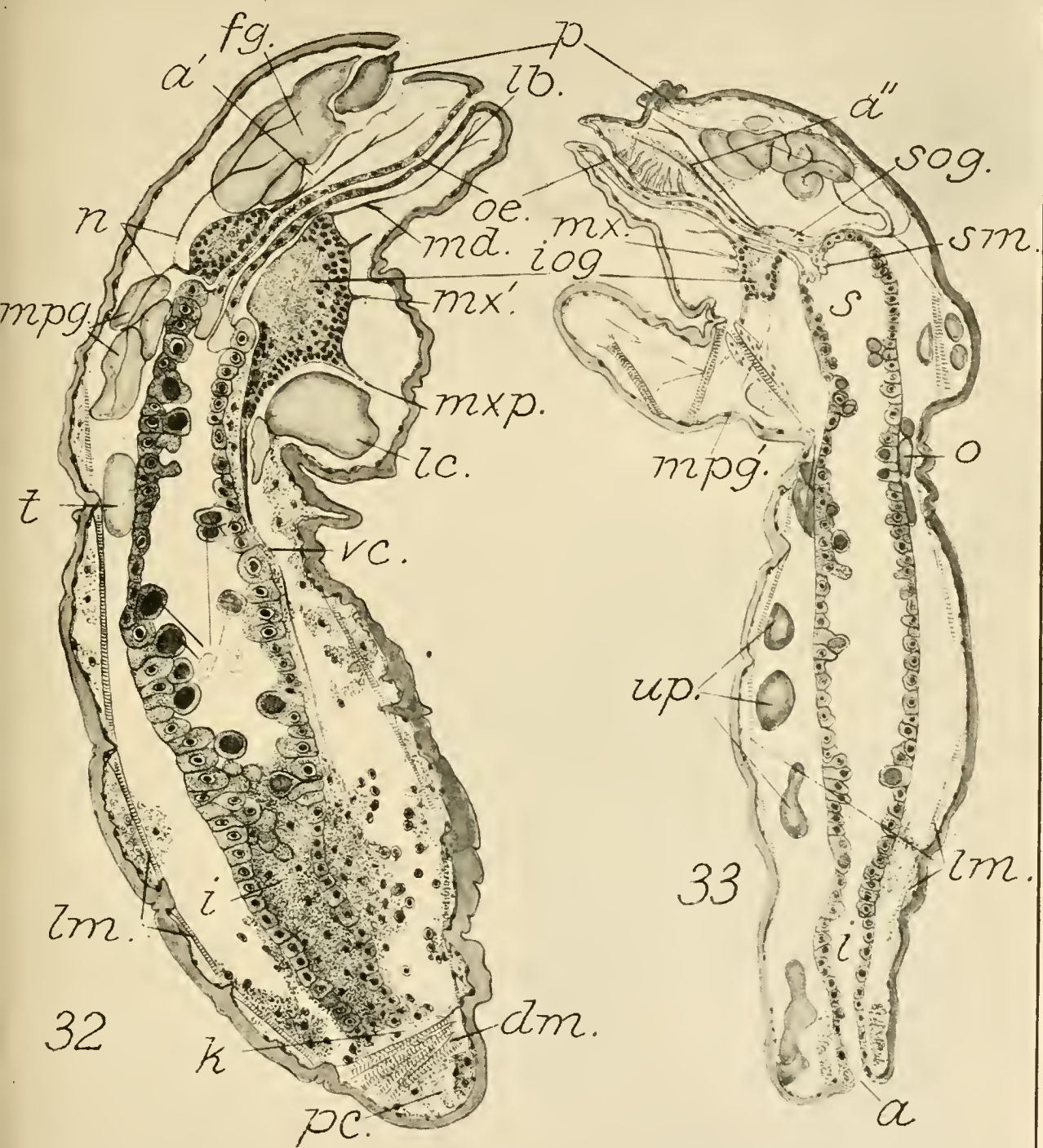


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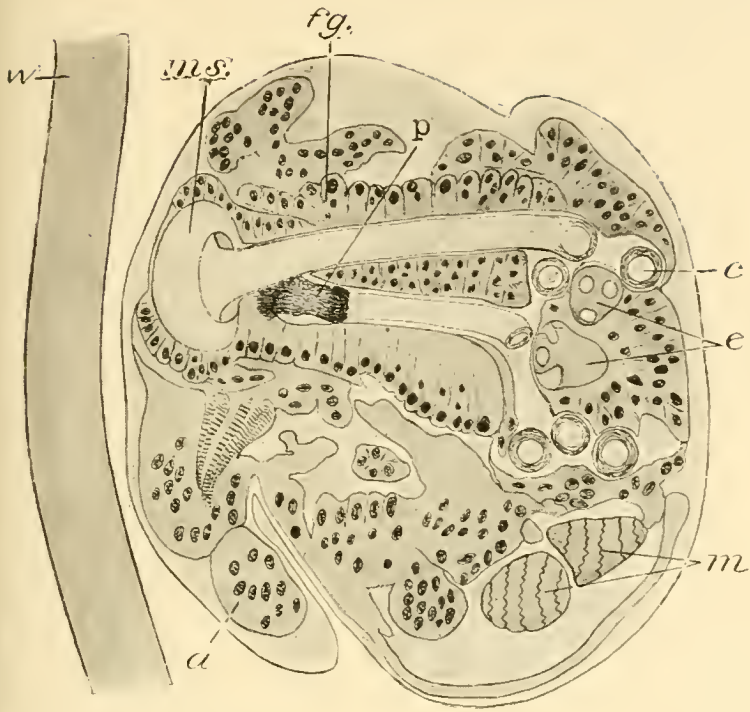
THE SECOND COPEPODID STAGE.

FOR EXPLANATION OF PLATE SEE PAGE 226.

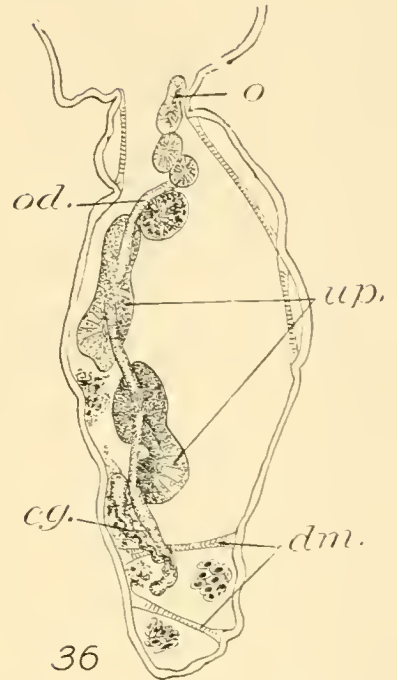


LONGITUDINAL SECTIONS OF MALE AND FEMALE SECOND COPEPODID LARVÆ.

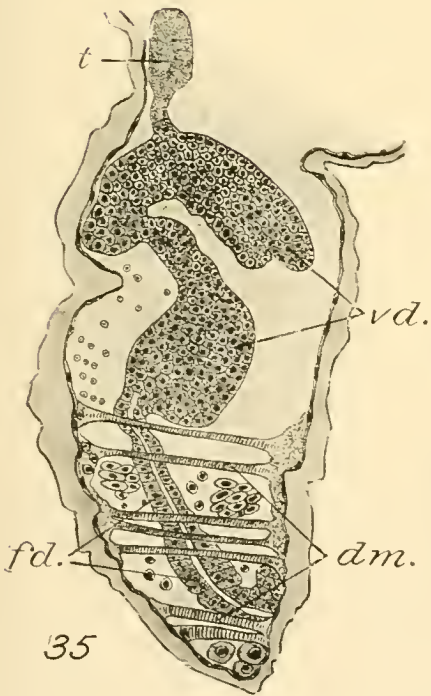
FOR EXPLANATION OF PLATE SEE PAGE 226.



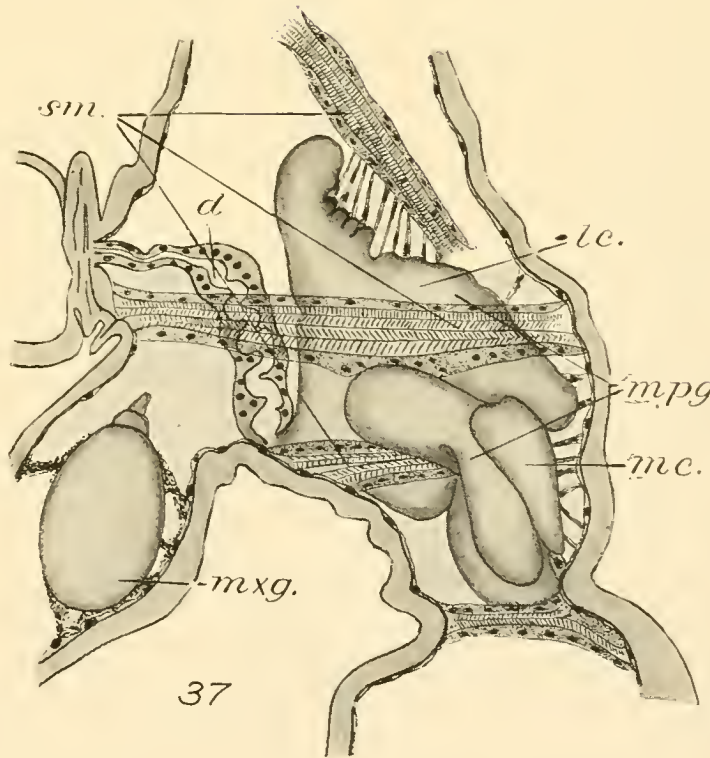
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36



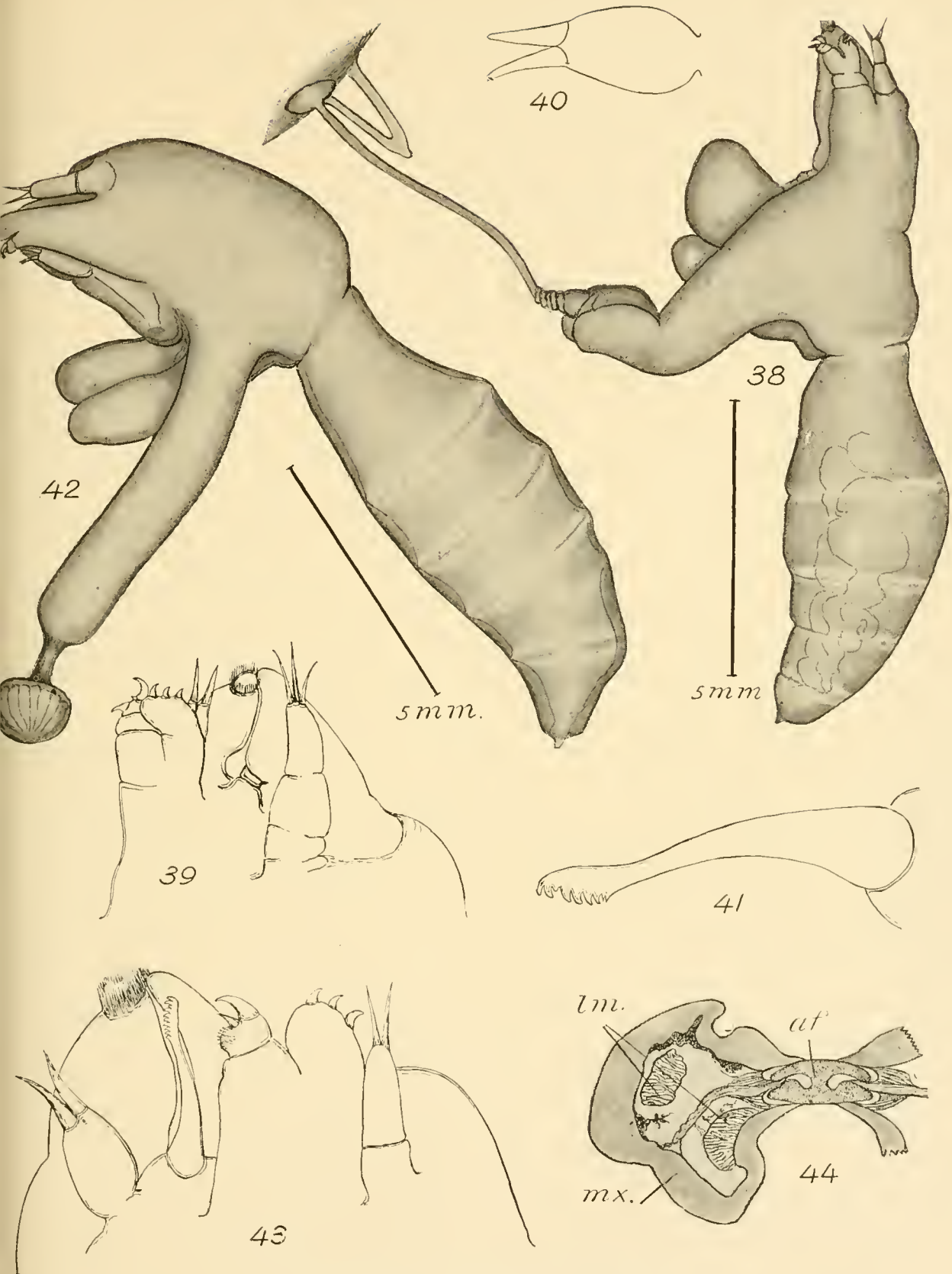
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37

SECTIONS SHOWING INTERNAL ANATOMY.

FOR EXPLANATION OF PLATE SEE PAGE 226.



YOUNG ADULTS OF *ACHTHERES AMBLOPLITIS*.

FOR EXPLANATION OF PLATE SEE PAGE 226.



DESCRIPTION OF A NEW RABBIT FROM ISLANDS OFF THE COAST OF VIRGINIA.

By EDGAR A. MEARNs,
Associate in Zoology, U. S. National Museum.

On a recent visit to Smiths Island, Virginia, in company with Messrs. J. H. Riley and E. J. Brown, the writer obtained skins of a rabbit which proves to be new.

This cottontail is named in honor of Capt. George D. Hitchens, commanding the life-saving station at Smiths Island, who has long been a contributor to the National Museum collections. He informed me that cottontails have existed continuously on the island during the past fifty years. At one time a number of "Australian rabbits" were introduced, but speedily died out. This has given rise to the erroneous but more or less current belief that the Smiths Island cottontail is a hybrid. It is, in fact, a pure cottontail, showing no trace of admixture with the genus *Oryctolagus*.

SYLVILAGUS FLORIDANUS HITCHENSI, new subspecies.

HITCHENs'S COTTONTAIL.

Sylvilagus floridanus mallurus NELSON (part), North American Fauna, No. 29, August 31, 1909, pp. 166 and 168 (as to specimens enumerated from Fishermans and Smiths islands).

Type specimen.—Cat. No. 155577, U.S.N.M. Adult female from Smiths Island, Northampton County, Virginia, collected by Edgar A. Mearns, May 13, 1910.

Characters.—Size of *Sylvilagus floridanus mallurus* (Thomas) from Raleigh, North Carolina. Color paler, with the bright colors (black and rufous) of the upper parts obsolete, giving a pale sandy fulvous shade to these parts; but the backs of the hind legs are a slightly darker chestnut than in the mainland form. The skull is larger, heavier, broader interorbitally, with thickened rostrum and larger audital bullæ. All of the teeth are larger.

Comparative cranial measurements.—Average of four adults, each, of *Sylvilagus floridanus mallurus* and *Sylvilagus floridanus hitchensi*, the latter in parenthesis. Basilar length, 57.6 (61) mm.; length of nasals, 32.4 (32.4); breadth of rostrum above premolars, 20.7 (21.4); depth of rostrum in front of premolars, 15.7 (17.8); interorbital breadth, 19.1 (20.5); parietal breadth, 27.9 (28.9); diameter of audital bullæ, 11 (11.4); length of upper molar series, 13.3 (15.1); breadth across upper molar series, 21 (22.4).

Remarks.—Young individuals in juvenal and beginning postjuvenal pelage differ from corresponding young of the mainland form in about the same manner that adults do, and the cranial differences are similar.

The following average measurements of six male topotypes of *Sylvilagus floridanus mallurus*, taken at Raleigh, North Carolina, and measured in the flesh by H. H. and C. S. Brimley, are given for comparison with those in the appended table of specimens of *Sylvilagus floridanus hitchensi*: Total length (including tail vertebræ), 420 mm.; tail vertebræ, 56.7; hind foot, 91. Ear measurements of one of these specimens are noted as follows on the label: Ear from crown, 71; ear from notch, 58 (ear from notch averages 57 in the six dry skins).

Record of specimens of Sylvilagus floridanus hitchensi.

U.S.N.M. No.	Sex and age.	Total length.	Head and body.	Tail vertebræ.	Hind foot.	Ear from crown.	Ear from notch. ^a	Length of head.	Locality.	Date.	Collector.
83684	Female young.	.....	.....	.....	.....	.....	.....	.....	Smiths Island, Virginia.	June 9, 1897	William Palmer.
84585	Female young.	.....	.....	.....	.....	.....	.....	.....	Fishermans Island, Virginia.	May 28, 1898	Do.
84586	Female ad.	375	...	50	90	70	57	...	Smiths Island, Virginia.	May 26, 1898	Do.
60395	Female ad.	.....	.....	.....	.....	.....	54	.....	.....do.....	May 25, 1894	Charles W. Richmond.
155577	Female ad.	.....	407	70	97	72	56	87	.....do.....	May 13, 1910	Edgar A. Mearns.
155578	Male ad.	.....	370	55	95	75	55	88	.....do.....	May 16, 1910	Do.
155579	— ad b.	.....	.....	.....	.....	.....	.....	.....	.....do.....	May 17, 1910	Do.

^a This measurement was taken from dried skins; other measurements given in this table were taken from fresh specimens by the collectors.

^b Skull only; given me by Mr. J. H. Riley.

EXPLANATION OF PLATES.

PLATE 37.

Figs. 1 and 2. *Sylvilagus floridanus mallurus* Thomas. Male ad., Raleigh, North Carolina, February 5, 1901. (Cat. No. 105241, U.S.N.M.) Female ad., Raleigh, North Carolina, January 17, 1901. (Cat. No. 105240, U.S.N.M.)

3 and 4. *Sylvilagus floridanus hitchensi*. Adult, Smiths Island, Virginia, May 17, 1910. (Cat. No. 155579, U.S.N.M.) Female ad., Smiths Island, Virginia, May 16, 1910. (Cat. No. 155577, U.S.N.M.)

PLATE 38.

Figs. 1 and 2. *Sylvilagus floridanus mallurus* Thomas. Male ad., Raleigh, North Carolina, February 5, 1901. (Cat. No. 105241, U.S.N.M.) Female ad., Raleigh, North Carolina, January 17, 1901. (Cat. No. 105240, U.S.N.M.)

3 and 4. *Sylvilagus floridanus hitchensi*. Adult, Smiths Island, Virginia, May 17, 1910. (Cat. No. 155579, U.S.N.M.) Female ad., Smiths Island, Virginia, May 16, 1910. (Cat. No. 155577, U.S.N.M.)



1



2



3



4

SKULLS OF SYLVILAGUS FLORIDANUS MALLURUS CONTRASTED WITH SKULLS OF SYLVILAGUS FLORIDANUS HITCHENSI.

FOR EXPLANATION OF PLATE SEE PAGE 228.



SKULLS OF SYLVILAGUS FLORIDANUS MALLURUS CONTRASTED WITH SKULLS OF SYLVILAGUS FLORIDANUS HITCHENSI.

FOR EXPLANATION OF PLATE SEE PAGE 228.

DESCRIPTIONS OF NEW MOLLUSKS OF THE FAMILY VITRINELLIDÆ FROM THE WEST COAST OF AMERICA.

By PAUL BARTSCH,

Assistant Curator, Division of Mollusks, U. S. National Museum.

Since publishing the paper on New Mollusks of the Family Vitrinellidæ from the west coast of America,^a which contained descriptions and figures of *Vitrinella oldroydi*, *eshnauri*, and *alaskensis*; *Vitrinella (Docomphala) stearnsi* and *berrysi*; *Cyclostrema xantusi* and *diegensis*; *Circulus cosmius* and *cerrosensis*; *Cyclostremella californica*, and *Scissilabra dalli*, a number of additional forms have come to hand. One of these, *Leptogyra alaskana*, from Port Graham, Alaska, was described by the writer in 1910,^b and six additional species from the west coast are considered in the present paper.

The drawings for the two plates were made by Miss Evelyn G. Mitchell.

CYCLOSTREMA BALDRIDGEI, new species.

Plate 39, figs. 7-9.

Shell rather large, bluish-white, subdiaphanous. Nuclear whorls two and a third, smooth, forming a decidedly depressed spire. Post-nuclear whorls with a strong, broad, rounded keel at the periphery and another almost as strong about one-third of the distance between the periphery and the summit, where it forms a decided shoulder. The space between the appressed summit and the shoulder is marked by twelve subequal and subequally spaced, spiral cords, the spaces between which are crossed by very slender, retractive, axial threads; the latter are about one-fourth as wide as the spaces which separate them, while the spaces between them are only about one-half the width of the spiral cords. The space between the peripheral keel and the strong shoulder is crossed by nine subequal and subequally spaced spiral cords, and the continuations of the axial threads. Here the spiral sculpture is not quite as strong as on the upper surface, and the spaces inclosed between the axial riblets and the spiral threads are more or less quadrangular pits. Base well rounded,

^a Proc. U. S. Nat. Mus., vol. 32, no. 1520, pp 167-176.

^b Nautilus, vol. 23, 1910, pp. 136-137, pl. 11, figs. 4-6.

marked like the upper surface, with the sculpture a little less pronounced. Umbilicus open; parietal wall showing ten equal and equally spaced spiral cords, which are as wide as the spaces that separate them, the latter being crossed by feeble continuations of the axial riblets. Aperture subcircular; outer lip rendered somewhat angular by the two keels; columella evenly curved.

The type (Cat. No. 214100, U.S.N.M.) comes from the Gulf of California. It has one and a third post-nuclear whorls and measures: greater diameter 4.5 mm. It was collected by Mrs. E. E. Johnson and at her request is named for Mrs. Maria Baldrige, of Los Angeles, California.

CYCLOSTREMA MIRANDA, new species.

Plate 39, figs. 1-3.

Shell small, subdiaphanous, depressed. Nuclear whorls two, depressed helicoid, smooth. Post-nuclear turns one and a third, appressed at the summit, marked above with three strong, spiral cords, one of which is at the periphery, while the other two divide the space between the periphery and the summit into three equal areas. The space between the summit and the first spiral cord is decidedly concave, while the space between the first spiral cord and the median one is very slightly concave, that between the median and the peripheral cord being well rounded. Axially, the upper surface of the shell is marked by about sixty-two slender, well-developed, equally-spaced riblets, which are about half as wide as the spaces that separate them. These riblets are decidedly retractorily curved between the summit and the first keel, less so between the first and the median keel, while between the median and the peripheral one they are practically vertical. The junctions of riblets and keels are not nodulose. Periphery of the last whorl strongly angulated; base marked by two spiral cords, one of which bounds the broad, open, funnel-shaped umbilicus and is a little weaker than the other, which appears as a very strong cord half-way between it and the periphery. In addition to these spiral cords, the base is marked by the undiminished continuations of the axial riblets, which become bifurcated here and extend deep within the umbilicus. Aperture very large, ovate, very oblique, the columellar border being considerably behind the outer lip; the posterior and anterior angles are acutely angulated; outer lip thin, showing the external sculpture within; columella slender, decidedly curved, the free edge continuing to the posterior angle of the aperture, rendering the peritreme complete.

The type (Cat. No. 211108, U.S.N.M.) measures: greater diameter, 2.1 mm. It and two other specimens, in Mrs. Oldroyd's collection, were collected by Mrs. Oldroyd at San Pedro, California.

CYCLOSTREMA ADAMSI, new species.

Plate 39, figs. 4-6.

Shell very small, depressed helicoid, white. Nuclear whorls two and a third, smooth, well rounded. Post-nuclear whorls one and a third, very strongly sculptured, having a slender, spiral, nodulose keel at the summit, an exceedingly strong one at the periphery, and two others almost as strong as the peripheral keel in the space between the summit and the periphery. The space between the peripheral and the suprapерipheral is a little wider than the space between the cord at the summit and the keel anterior to it, while the space between the second and third keels is about twice as wide as that between the cord at the summit and the second keel. In addition to these nodulose keels, the whorls are marked by strong, retractive, axial ribs, of which twenty occur upon the last turn. The junctions of the ribs and keels form prominent tubercles, while the spaces inclosed by them are deep, rhomboidal pits. Those occurring between the peripheral and the first suprapерipheral keel are about as long as broad, while those between the next two keels, posteriorly, are much longer in their axial diameter than their spiral, and those occurring between the summit and the first keel below it, are a little longer in the axial diameter than the spiral. Base of the shell openly umbilicated, marked by two strong, nodulose keels, the weaker of which bounds the umbilicus, while the stronger is half-way between this and the peripheral keel. The axial ribs extend prominently over the base to the umbilical keel, rendering the middle keel strongly tuberculate. The spaces inclosed between the keels and ribs are quadrangular immediately below the periphery, and wedge-shaped between the median and the umbilical keel. Umbilicus narrowly funnel-shaped. Aperture subcircular; peritreme complete, stout, thinning to a slender edge.

The type (Cat. No. 211563, U.S.N.M.) comes from Panama and measures: greater diameter, 1.3 mm.

It is named for C. B. Adams.

CIRCULUS LIRIOPE, new species.

Plate 40, figs. 7-9.

Shell small, depressed, helicoid, creamy-white. Nuclear whorls two and a third, smooth, well rounded, separated by a well-marked suture. Post-nuclear whorls well rounded, appressed at the summit, with a strong keel at the periphery and a less strong one on either side of the periphery, these two appearing as if joined to the peripheral keel by a smooth band, the whole having the effect of a thick ribbon drawn over the peripheral keel, with the two edges rolled up to form the other two keels. The entire upper surface is marked by

numerous, exceedingly fine, retractive lines of growth, and very many, exceedingly fine, closely-spaced, spiral striations. Under surface broadly, openly umbilicated, moderately rounded, the umbilical edge being bounded by a slender thread; entire surface marked like the upper surface. Aperture subcircular; outer lip rendered }-shaped by the peripheral keel; columella short, strongly curved, with a strong cord in the middle of the umbilical side.

Two specimens of this species (Cat. No. 211800, U.S.N.M.) were dredged at U. S. Bureau of Fisheries station 2822, in 21 fathoms, on gray sand and broken shell bottom, off La Paz, Gulf of California. The larger of these, the type, has one and a third post-nuclear whorls and measures: greater diameter, 1.6 mm.

CIRCULUS DIOMEDEÆ, new species.

Plate 40, figs. 1-3

Shell small, planorboid, creamy-white. Nuclear whorls two and a half, regularly coiled, forming a depressed spire, with the whorls well rounded and smooth, separated by a well-impressed suture. Post-nuclear whorls appressed at the summit, the appressed portion forming a slender, spiral thread, with a slender, acute keel at the periphery, the space between the peripheral keel and the thread at the summit being evenly curved and smooth, except for the decidedly retractively curved, faint, incremental lines. Under surface very broadly, openly umbilicated, and evenly curved from the peripheral keel to within the umbilicus; marked by incremental lines only. Within the umbilicus all of the preceding whorls are visible to the very apex. Aperture decidedly oblique, subcircular; posterior angle acute; outer lip thin, rendered }-shaped by the peripheral keel; columella slender, decidedly curved; parietal wall covered with a thick callus, which renders the peritreme complete.

The type and three additional specimens of this species were dredged by the U. S. Bureau of Fisheries' steamer *Albatross* at station 2794, in 62 fathoms, on gray sand and broken shell bottom; bottom temperature 59.6°; in the Bay of Panama. The type measures: greater diameter, 2.2 mm.

CYCLOSTREMELLA DALLI, new species.

Plate 40, figs. 10-12.

Shell very small, depressed, helicoid, subdiaphanous. Nuclear whorls two and a half, well rounded, separated by a well-impressed suture, smooth. Post-nuclear whorls one and an eighth, evenly rounded from the impressed suture to the periphery; marked by numerous, irregular, wavy, incised, spiral lines, which lend the entire surface a ripple-marked aspect. On the upper surface the preceding

whorl can be plainly seen through the substance of the last turn. Periphery of the last whorl evenly rounded. Under surface broadly, openly umbilicated to the very apex, well rounded from the periphery to the umbilical margin. There is no limiting umbilical keel, but the parietal wall bends inward with about the same curvature that it is bent outside of the umbilicus. The entire under surface, including that seen within the umbilicus, is marked by incised, wavy lines like those on the upper surface, the whole having the same ripple-marked aspect. Aperture decidedly oblique, subcircular; posterior angle acute; outer lip very thin, showing the external markings within; columella slender, decidedly curved; parietal wall covered with a thick callus, which renders the peritreme continuous.

The type and four other specimens of this species (Cat. No. 198904, U.S.N.M.) come from the head of the Gulf of California. The type measures: greater diameter, 1.3 mm.

The species is named for Dr. William H. Dall, the honorary curator of the Division of Mollusks.

LEPTOGYRA ALASKANA Bartsch.

Plate 40, figs. 4-6.

Leptogyra alaskana BARTSCH, Nautilus, vol. 23, 1910, pp. 136-7, pl. 11, figs. 4-6.

Shell minute, depressed helicoid. Nuclear whorls one and one-half, light yellow horn color, marked by faint incremental lines. A single post-nuclear turn follows which is bluish-white, rather broad and gently, almost evenly curved from the well-impressed suture to the periphery. This whorl is marked by about twelve, fine, incised spiral lines between the suture and the periphery which are stronger toward the periphery than at the suture. Periphery of the last whorl rounded. Base broadly and deeply umbilicated, strongly arched, with a slender cord at the junction of the basal and parietal wall, surface of the base marked by incised lines which are equal in strength and number to those occurring upon the upper surface. Wall of the umbilicus almost flat, marked by faint spiral lines. Aperture very large, subcircular, posterior angle obtuse; outer lip thin; columella curved, somewhat expanded and thickened basally; parietal wall covered with a thin callus. Operculum thin, horny.

Twelve specimens of this species were collected by Dr. Fred. Baker at Port Graham, Alaska, four of which are in the U. S. National Museum, Cat. No. 208433. One of these, the type, measures: greater diameter, 0.85 mm., lesser diameter 0.7 mm., altitude 0.4 mm. The remaining eight specimens are in Doctor Baker's collection.

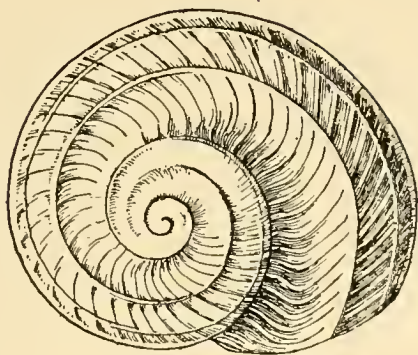
EXPLANATION OF PLATES.

PLATE 39.

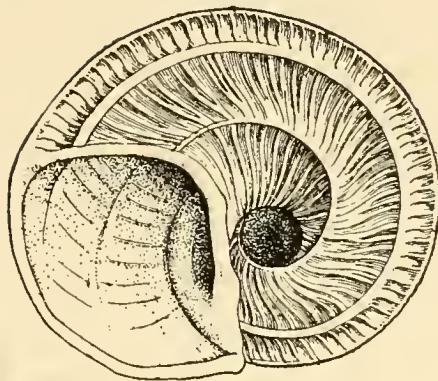
- Figs. 1-3. *Cyclostrema miranda*, greater diameter, 2.1 mm.
4-6. *Cyclostrema adamsi*, greater diameter, 1.3 mm.
7-9. *Cyclostrema baldridgei*, greater diameter, 4.5 mm.

PLATE 40.

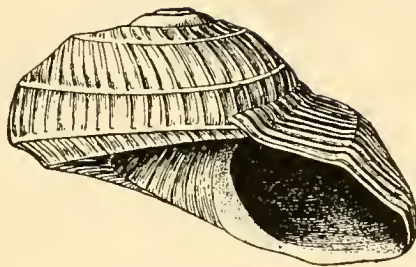
- Figs. 1-3. *Circulus diomedæ*, greater diameter, 2.2 mm.
4-6. *Leptogyra alaskana*, greater diameter, 0.85 mm.
7-9. *Circulus liriopæ*, greater diameter, 1.6 mm.
10-12. *Cyclostremella dalli*, greater diameter, 1.3 mm.



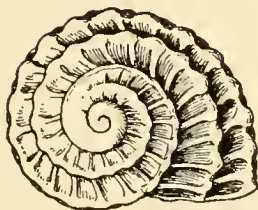
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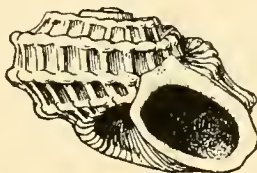
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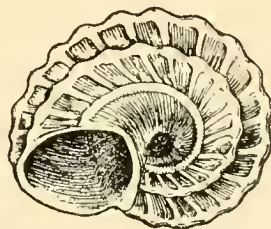
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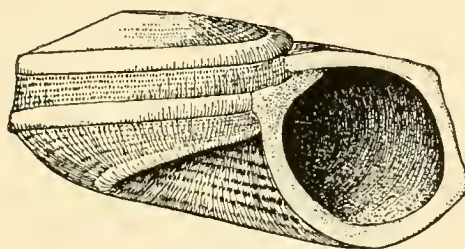
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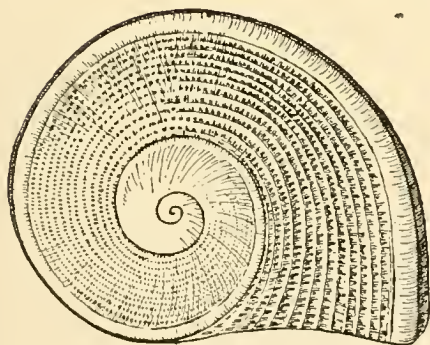
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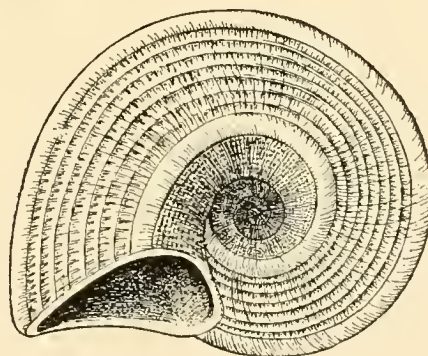
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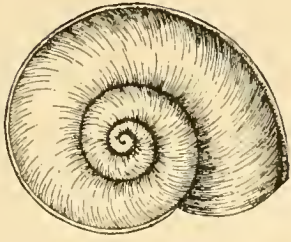
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WEST AMERICAN VITRINELLIDS.

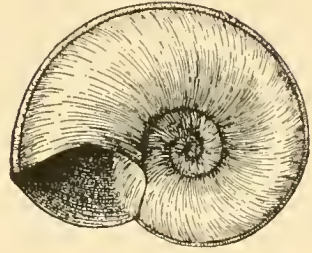
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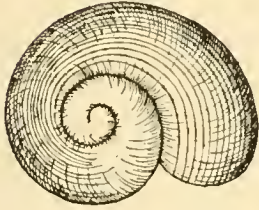
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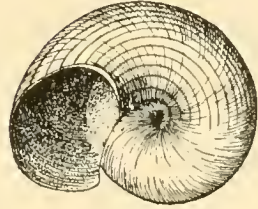
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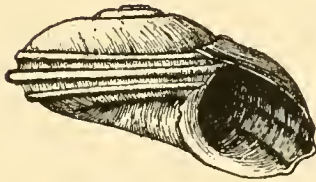
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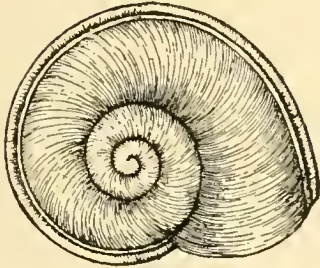
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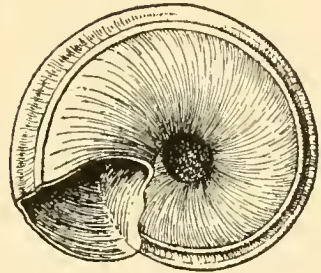
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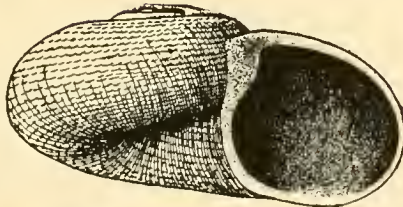
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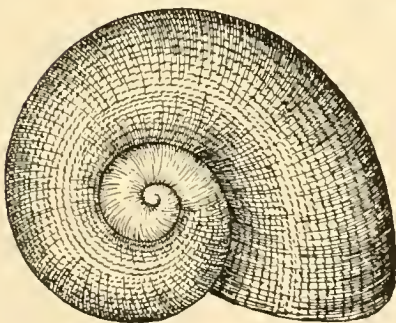
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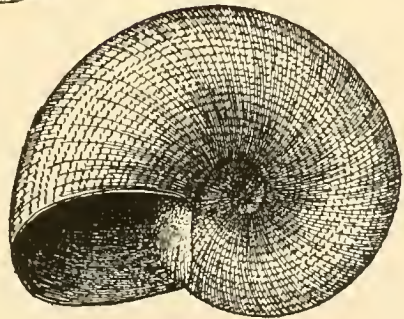
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WEST AMERICAN VITRINELLIDS.

FOR EXPLANATION OF PLATE SEE PAGE 234.

NEW SOUTH AMERICAN PARASITIC HYMENOPTERA:

By J. C. CRAWFORD.

Assistant Curator, Division of Insects, U. S. National Museum.

In this paper three new genera and four new species are described. The new genus in the Monodontomerinæ is remarkable in the location of the spurs on the hind tibiæ, while the one in the Perilampidæ adds a fourth genus to the group of gall-making chalcids.

The term propodeum is used in this paper for the true first abdominal segment, usually called the "metathorax," and the latter term is applied to the real metathorax.

Family TORYMIDÆ.

Subfamily MONODONTOMERINÆ.

PERISSOCENTRUS, new genus.

Type.—*P. chilensis* Crawford.

Related to *Monodontomerus*, but the spurs on the hind tibiæ not apical, situated about two-thirds the length of the tibiæ, from the base (fig. 1); spurs very long, projecting beyond the apex of the tibiæ; hind femora with a large tooth and basad of this a smaller triangular one; occipital foraminal depression margined; eyes hairy; scutellum with a transverse furrow; first segment of abdomen with the apical margin straight.

This genus is readily separated from all the others in the subfamily by the location of the spurs on the hind tibiæ.

PERISSOCENTRUS CHILENSIS, new species.

Female.—Length about 3.5 mm.; ovipositor about 0.6 mm. Dark bronzy or purplish, with green in varying lights, the head more brassy and the abdomen æneous; face finely rugulose, below insertion of antennæ with scattered fine punctures; occiput finely reticulately lineolate; antennæ dark brown, the scape metallic; thorax finely reticulately striate, back of the transverse furrow on scutellum finely longitudinally striate; the row of pits on the depressed apical margin of scutellum complete; propodeum with a strong median carina, the surface on each side of this finely irregularly longitudinally

rugulose; femora and hind tibiæ metallic-purplish; front and middle tibiæ within, knees, bases and apices of all tibiæ, and tarsi entirely, reddish-testaceous; outer side of front and middle tibiæ deep brown with slight purplish reflections; spurs on hind tibiæ light colored; wings subhyaline, veins dark brown, the stigmal vein short, the postmarginal somewhat longer; abdomen beyond the basal segment finely transversely lineolate.

Male.—Length about 3 mm. Similar to the female except in secondary sexual characters, but more greenish, the tibiæ mostly reddish.

Bred from *Ormiscodes crinita*, at Santiago, Chile, by Prof. M. J. Rivera.

Type.—Cat. No. 13349, U.S.N.M.

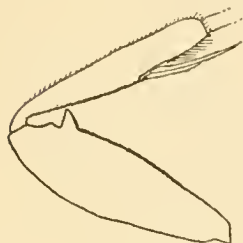


FIG. 1.—PERISSOCENTRUS CHILENSIS, FEMALE. HIND FEMUR AND TIBIA, INNER SIDE.

PERISSOCENTRUS ARGENTINÆ, new species.

Female.—Length about 3.5 mm.; ovipositor about 1 mm. Dark olive green, the head bright green; head finely reticulately rugulose; antennæ reddish-brown, the scape testaceous; thorax finely reticulately striate; scutellum back of transverse furrow longitudinally striate; propodeum with a strong median carina, excavated on each side of this, and the surface finely reticulately rugose; basad on each side of the median carina is a fovea formed by two short carinæ; legs reddish testaceous, hind tibiæ and femora metallic, front femora suffused with brown; abdomen beyond the basal segment faintly transversely lineolate.

Male.—Length about 2.5 mm. Very similar to the female except in secondary sexual characters; scape metallic.

Three females and one male from Ceres, Argentina.

Type.—Cat. No. 13350, U.S.N.M.

This is the species identified for Dr. J. Künckel d'Herculis by Doctor Ashmead as *Monodontomerus phormio* Walker, but that species is said to have all the femora green and Walker in the original description mentions long apical spurs on the tibiæ while in the species now described the spurs are not apical.

Family EURYTOMIDÆ.

Tribe RILEYINI.

CALORILEYA, new genus.

Type.—*C. cearæ* Crawford.

Belongs to the tribe Rileyini; antennæ thirteen jointed, with three ring joints, inserted about as high as the middle of the eyes; eyes almost round; mandibles four toothed; face concave, with a deep antennal fossa extending to the vertex, the middle ocellus situated at the head of the fossa; head and thorax umbilicately punctured; parap-

sidal furrows complete; stigmal knob enlarged, stigma with a distinct tooth pointing obliquely toward front of wing; wing with a small stigmal cloud; propodeal spiracles oval, situated basad; segments one to three of abdomen short, the fourth much the longest.

This genus differs from *Rileya* by the enlarged stigmal knob and the umbilicate punctures, and from *Neorileya* and *Macrorileya* by having three ring joints in the antennæ. Doctor Ashmead, in his classification of the Chalcid flies, has erroneously stated that *Macrorileya* has three ring joints, but the type material shows only two, these each longer than wide.

CALORILEYA CEARÆ, new species.

Female.—Length about 4 mm. Light yellow, translucent, with darker stains; head umbilicately punctured; mandibles yellow, the teeth dark brown; antennæ brownish-yellow, pedicel longer than the first joint of the funicle; pronotum over twice as wide as long; pronotum, mesonotum, and metathorax umbilicately punctured; middle lobe of mesonotum with a median stripe of dark brown; propodeum with several longitudinal carinæ and a transverse one, making it appear areolated; stigmal cloud reaching about halfway across wing; legs



FIG. 2.—CALORILEYA CEARÆ, FEMALE.

light yellow; abdomen finely reticulated, with a median stripe of dark brown reaching about the middle of fourth segment; following segments medially stained brown.

Male.—Length about 4 mm. Similar to the female, but the stigmal knob much more enlarged, median stripe on abdomen wider, complete, that on mesonotum continues on the postscutellum.

Habitat.—Ceara, Brazil, bred from galls of *Mayrellus mirabilis*.

Described from 12 specimens.

Type.—Cat. No. 13351, U.S.N.M.

Family PERILAMPIDÆ.

MAYRELLUS, new genus.

Type.—*M. mirabilis* Crawford.

Mandibles two toothed; antennæ inserted on the middle of the face, thirteen jointed, with four ring joints, the funicle four-jointed, (fig. 3) joints of club fused; antennæ of male similar to female; clypeus medially deeply notched; head antero-posteriorly very thin, the lateral ocelli on the vertex, the eyes above touching the vertex; pronotum transverse; parapsidal furrows complete, deep; scutellum

elongate, as long as the mesonotum and prothorax together and extending over the metathorax and propodeum to the base of the abdomen; axillæ widely separated but nearer together than the parapsidal furrows; propodeal spiracles large, round; stigmal joined to marginal by a triangular infuscated area making the marginal vein appear enlarged apically; claws with a tooth beneath near base; hind tibiæ with two apical spurs; abdomen flattened above.

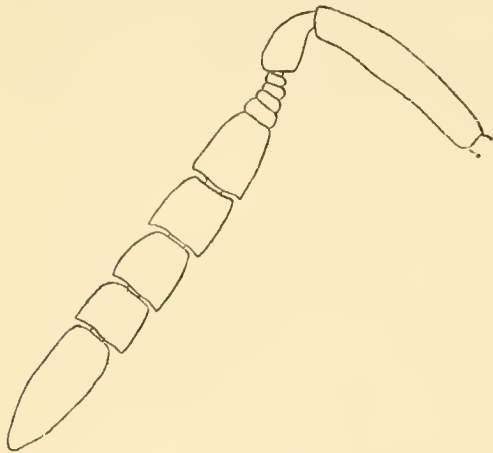


FIG. 3.—MAYRELLUS MIRABILIS, ANTENNA OF FEMALE.

This genus belongs to the group of *Asparagobius*, *Trichilogaster*, and *Monopleurothrix*, all being gall makers. To show the relationships these genera may be briefly characterized as follows: *Asparagobius*, antennæ with one ring joint, parapsidal furrows widely separated, inner ends of axillæ touching inner ends of parapsidal furrows; *Trichilogaster*, antennæ with two ring joints, parapsidal

furrows widely separated, axillæ meeting medially; *Monopleurothrix*, antennæ with two ring joints, parapsidal furrows uniting before reaching scutellum, axillæ meeting medially.

This genus is named in honor of Dr. Gustav Mayr, who described the other genera belonging to this group.

The placing of this series of genera in the Perilampidæ is subject to much doubt. They will probably form an independent group.

MAYRELLUS MIRABILIS, new species.

Female.—Length about 3 mm. Form stout, head and thorax black, finely rugulose; face above sparsely, umbilicately punctured down to a point about one-half way from the ocelli to the insertion of the antennæ; below with sparse, shallow punctures; antennæ brown, scape and pedicel, yellowish, fourth ring joint about twice as long as third; mesonotum, except middle of parapsidal areas at rear, closely, umbilicately punctured; axillæ with umbilicate punctures only at inner ends; scutellum with a median furrow extending back from base about two-thirds its length; this furrow with more or less distinct longitudinal rugæ and at times with a median longitudinal carina; scutellum rugoso-umbilicately punctured, except area at end of furrow, which is finely rugulose with a few longitudinal rugæ; front wings on anterior half

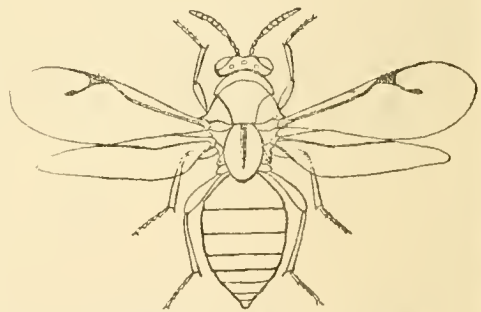


FIG. 4.—MAYRELLUS MIRABILIS, FEMALE.

slightly dusky from base of marginal vein to end of stigmal; veins yellowish, triangular area at base of stigmal vein and stigmal knob dark brown; femora stout, especially hind, brown; tibiæ and tarsi yellowish; abdomen brown, dorsal plates closely punctured, viewed laterally, the abdomen is shaped very like that of a cynipid.

Male.—Length about 2.5 mm. Similar to female except in secondary sexual characters.

Ceara, Brazil. Bred from galls on unknown plant. F. D. da Rocha collector.

Type.—Cat. no. 13352, U.S.N.M.

This species is probably the author of the galls from which it was collected.

A REVIEW OF THE SCIÆNOID FISHES OF JAPAN.

By DAVID STARR JORDAN and WILLIAM FRANCIS THOMPSON,
Of Stanford University, California.

In the present paper is given a review of the Japanese fishes belonging to the family of Sciænidae or Croakers. It is based on the collections made by Professors Jordan and Snyder in 1900, series of these being in the United States National Museum and in the Museum of Stanford University. The drawings are by Mr. William S. Atkinson.

The few Japanese species are all closely interrelated, belonging to the same subfamily, Sciæninæ. They are allied to the numerous Chinese and Indian species.

Family SCIÆNIDÆ.

Body compressed, more or less elongate, covered with rather thin scales which are usually more or less ctenoid. Lateral line continuous, more or less concurrent with the back, extending on caudal fin. Head prominent, covered with scales; bones of the skull cavernous, the muciferous system highly developed, the surface of the skull, when the flesh is removed, very uneven. Suborbital bones without a backward projecting "stay." Chin usually with pores, sometimes with barbels. Mouth small or large, the teeth in one or more series, one series sometimes being enlarged; canines often present. No incisor nor molar teeth; no teeth on vomer, palatines, pterygoids, nor tongue. Maxillary without supplemental bone, slipping under the free edge of the preorbital, which is usually broad. Premaxillaries protractile, but not freely movable. Nostrils double. Pseudo-branchiæ usually large, present in most of the genera. Gills four, a slit behind fourth. Branchiostegals seven. Gill membranes separate, free from the isthmus. Lower pharyngeals separate or united, often enlarged, the teeth conic or molar. Preopercle serrate or entire. Opercle usually ending in two flat points. Dorsal fin deeply notched or divided into two fins, the soft dorsal being the longer, the spines depressible into a more or less perfect groove. Anal fin with one or two spines, never more than two. Ventral fins thoracic,

I, 5, below or behind pectorals. Pectoral fins normal. Caudal fin usually not forked. Ear bones or otoliths very large. Pyloric cæca usually rather few. Air bladder usually large and complicated, rarely wanting. Most of the species make a peculiar noise, called variously croaking, grunting, drumming, and snoring; this sound is caused by muscular action on the air bladder. An important family of food fishes found on sandy shores in all warm seas, a few species being confined to fresh waters. None occurs in deep water and none among rocks. Many of them reach a large size, and nearly all are valued for food. All are carnivorous and some are of interest as game fishes.

KEY TO GENERA.

- a*¹. Preopercle with spine-like teeth, the lowermost largest, plectroid, directed abruptly downward; gill rakers comparatively long and slender, about 8 + 12 to 30 in number *Bairdiella*, 1.
*a*². Preopercle entire, or with feeble serrations, without plectroid spine; gill rakers comparatively short and thick, the number usually 5 to 8 + 8 to 15.. *Sciæna*, 2.

1. Genus BAIRDIELLA Gill.

Bairdiella GILL, Proc. Acad. Nat. Sci. Phila., 1861, p. 33 (*argyroleuca*=*chrysuræ*).
Nector JORDAN and EVERMANN, Fish. North and Middle America, vol. 2, 1898, p. 1436 (*chrysoleuca*).

This genus is characterized by the oblique mouth, little cavernous skull, few rows of small teeth, slender gill rakers and the preopercle armed with a plectroid spine. It is certainly a very natural group, and worthy of recognition as a distinct genus. The numerous species are all American with one exception. They are all small in size and silvery in coloration, and some of them are remarkable for the great size of the second anal spine. In others this spine is quite small. These variations among species unquestionably closely allied show how slight is the systematic value to be attached to the size of this spine. The single Japanese species has been recorded but once. It belongs to the subgenus *Nector*, and it is related to *Bairdiella armata* from Panama, and to *Bairdiella veræ-crucis* from the Caribbean Sea.

1. BAIRDIELLA ACANTHODES (Bleeker).

- ? *Bairdiella armata* GILL, Proc. Acad. Nat. Sci. Phila., 1863, p. 164; Panama.
Pseudosciæna acanthodes BLEEKER, Verh. Kon. Akad. Wet. Amsterdam, vol. 18, 1879, p. 29, pl. 1; Japan, from a specimen in the Museum at Hamburg.
Bairdiella acanthodes JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2, 3, 1901, p. 81, name only.

Habitat.—Southern Japan (the record perhaps open to question, as the genus *Bairdiella* is otherwise confined to the warmer parts of America and only the single specimen in the museum at Hamburg is known from Japan).

Description after Bleeker: Specimen described about 225 mm. long. Head $3\frac{3}{4}$ in body, $4\frac{1}{2}$ in total with caudal; depth $3\frac{1}{2}$ in length without caudal, $4\frac{1}{4}$ with caudal; maxillary $2\frac{1}{4}$ in head; longitudinal diameter of eye a little more than 4 in head; interorbital space 4; distance between eye and maxillaries less than half eye; D. X—I, 24 or 25; A. II, 8 or 9; scales in series above lateral line 63, below 53; between first dorsal and lateral line 8 or 9, between ventrals and lateral line 15.

Body oblong, compressed. Head somewhat acute, its height somewhat less than its length; profile straight above eyes; snout shorter than eye, not projecting over mouth, with slight incisions in free edge of skin laterally and medially; upper jaw a little longer than lower; maxillary extending to below posterior half of eye. Mouth very oblique, teeth on jaws anteriorly in a number of series, laterally in two. Internal series on upper jaw very small; external series conical, moderately distant, becoming shorter posteriorly, with no canines. Mandibular teeth in outer row very small and crowded together; inner series conical, moderately spaced, not as large as external teeth of upper jaw, 2 to 4 somewhat larger and much curved teeth just before the symphysis. Pharyngeal teeth acutely conical, lower internal series much longer than the rest. Preopercular breadth about half diameter of eye, posterior margin serrated, at the angle 2 or 3 larger, strong spinelike teeth, the lower longer than the others and pointing downward. Opercle ending in two weak flat points; suprascapular bone denticulated.

Dorsal fins separated to their bases; dorsal spines not very high, thin, rigid, somewhat pungent, third and fourth longer than the rest and contained $1\frac{1}{2}$ in height of body, conspicuously longer than post-orbital part of head; dorsal soft rays about $1\frac{1}{2}$ in dorsal spines.

Pectorals and ventrals pointed, caudal truncate, not much shorter than head without snout. Anal not convex, acutely angled at base, less than one-third length of soft dorsal; second spine very strong, scarcely shorter than head without snout, first soft ray about equal to dorsal spines. Lateral line moderately curved, each scale marked by a simple tube.

Color grayish above, sides silvery, iris yellow; fins yellowish, the vertical fins more or less dusky.

This species is known only from the description and figure of Bleeker, from a specimen in the museum in Hamburg. It is very close to *Bairdiella armata* from Panama, differing chiefly in the presence of 24 instead of 21 rays in the soft dorsal. It is indeed possible that the type is really from South America. The species is also very close to the Atlantic coast analogue of *Bairdiella armata*, *Bairdiella verze-crucis* Jordan and Dickerson. In this species there are twenty-three soft rays in the dorsal. The relative length of the

dorsal spines is, however, notably different in the two species. In *B. verac-crucis*, the fourth spine is much longer than the third. In *B. acanthodes* the two are subequal.

(*ακανθοδης*, spinous).

2. Genus SCIÆNA (Artedi) Linnæus.

Sciæna ARTEDI, Genera, 1738, p. 65 (two species, the one the basis of *S. cirrosa* Linnæus, the other, complex, the references mostly to the "corb," or the species called later *Corvina nigra*).

Sciæna LINNÆUS, Syst. Nat., 10th ed., 1758, p. 289. (*Umbra*; *cirrosa*), the name *umbra* including both the "corb" and the "maigre," the descriptive sentence referring to the former, the name *umbra* taken from the *Sciæna umbra* of Hasselquist, 1757, which is the young of the "corb."

Johnius BLOCH, Ichthyologia, vol. 10, 1793, p. 107. (*Carutta*, etc., restricted by Gill to *carutta*.)

Sciæna CUVIER, Règne Animal, 1st ed., vol. 2, 1817, p. 297. (Restricted to *umbra* and *aquila*, the former being regarded as the Linnæan species and therefore as type. It is here identified with the "corb," and the "maigre," *Sciæna aquila* is treated as a non-Linnæan species.) The "corb" is therefore the type of *Sciæna* CUVIER, 1817.

Bola HAMILTON-BUCHANAN, Fishes of the Ganges, 1822, p. 78. (*Coitor*, etc.; in effect restricted to *Bola coitor*, the first species named, by Bleeker and by Jordan and Eigenmann.) *Bola coitor* may be formally selected as type.

Sciæna CUVIER, Règne Animal, 2d ed., vol. 2, 1829. (Restricted to *umbra*, which in turn is now identified with the maigre=*aquila* it being shown that the Linnæan species is complex, including both the "corb" and the "maigre," the maigre being the proper type.)

Corvina CUVIER, Règne Animal, 2d ed., vol. 2, 1829 (*nigra*). (The "corb" now called *nigra*, the maigre being called *umbra*.)

Argyrosomus^a DE LA PYLAIE, Compt. Rend. Congr. Sci. France for 1834, 1835, p. 534. (*Aquila*, not *Argyrosomus* of Agassiz, 1850=*Leucichthys* Dybowsky.)

Cheilotrema TSCHUDI, Fauna Peruana, Fische, 1845, p. 13 (*fasciatum*).

Rhinoscion GILL, Proc. Acad. Nat. Sci. Phila., 1861, p. 85 (*saturnus*).

Pseudosciæna BLEEKER, Ned. Tydsskr. Dierkunde, vol. 1, 1863 (*aquila*; *cirrosa* being taken as type of *Sciæna*, as the first species named by Artedi. In this view *Sciæna* replaces *Umbrina*).

Pseudotolithus BLEEKER, Poissons de la Côte du Guinée, 1862, p. 59 (*typus*).

Callaus JORDAN, Rept. U. S. Fish Comm. for 1886, 1889, p. 395 (*deliciosus*).

Nibeia JORDAN and THOMPSON, new subgenus (*mitsukurii*).

Othonias JORDAN and THOMPSON, new subgenus (*manchurica*).

^aThe name *Argyrosomus* first appears, as Dr. Theodore Gill informs us, in the Comptes Rendus du Congrès Scientifique de France, second session in 1834 (published in 1835, pp. 524-534). The article is entitled Recherches en France sur les poissons de l'Océan pendant les années 1832 et 1833, par M. de la Pylaie de Fougères.

On page 534, Professor Gill informs us, M. de la Pylaie has the following:

"Dans la tribus des Persèques, nous voyons * * * l'*Argyrosomus procerus*, nouveau genre que j'ai formé avec le *Sciæna aquila*, Cuv., et auquel, j'associe une nouvelle espèce, l'*Arg. sparoides*, de la baie de Bourg Neuf."

No other reference is made to *Argyrosomus* or to these species. The species, *Sciæna aquila* must be taken as the type of *Argyrosomus*. The name thus antedates *Pseudosciæna* Bloch, given in 1863 to the same species, *aquila*.

Body oblong, more or less elevated and compressed, the dorsal and ventral outlines unlike; mouth low, horizontal or oblique, often with conspicuous slits and pores; lower jaw usually included; teeth in two or more series, the upper series above enlarged, and sometimes the inner below; no true canines; preopercle entire, erenulate or with a few small bony serræ near the angle; no barbels; gill rakers more or less shortened, relatively few, and often thick; lower pharyngeals moderate, separate, with bluntish teeth. Dorsal fins well separated; soft dorsal long; anal short; caudal fin usually rhomboidal; second anal spine moderate or strong; pseudobranchiæ present, air bladder large and complicated; scales moderate, normal.

As here understood, a very large genus, mostly of the Old World, comprising a great variety of forms, which differ widely among themselves, but which form an almost continuous series from *Pseudotolithus* (related to *Corvula* and *Bairdiella*) on the one extreme to *Cheilotrema* at the other.

In *Pseudotolithus* and *Nibeia* the preopercle has bony serrations, as in *Micropogon*, and the gill rakers are relatively long and numerous, as in *Corvula*. In *Pseudotolithus* the lower jaw projects. In *Argyrosomus* (*Pseudosciæna*) the lower teeth are few rowed and unequal, while the slits and pores about the mouth are little developed, and the soft dorsal is sealeless.

In the other subgenera the lower teeth are subequal, in bands, and the mouth is smaller, its pores and slits more developed, and the gill rakers are shorter.

In *Johnius* (including *Bola*) the body is elongate and the soft dorsal scaly. In *Sciæna* (= *Corvina*) the body is deep and the soft dorsal naked. In *Cheilotrema* (including *Rhinoscion*) the body is very deep and the soft dorsal scaly. *Callaus* has the general traits of *Argyrosomus*, but with the slits and pores more developed, the gill rakers slender and short, the caudal lunate. In most of the others the caudal is rhomboidal or irregularly S-shaped. It is possible that *Argyrosomus* (including all with the lower teeth unequal) may be set off from the other forms as a distinct genus as in Bleeker's system. In any event, the many species form an almost continuous series from one extreme to the other. The interrelations of these forms have been fully discussed by Jordan and Eigenmann.^a In the same paper the reasons are given why *Sciæna* should take the place of *Corvina*, the two having the same type, *Sciæna umbra* Linnæus, by the restriction of Cuvier in 1817. *Sciæna umbra* of Linnæus is a complex species, but the diagnosis copied from Artedi is based on the "corb," a fact which justifies Cuvier's first restriction, for which his later view could not properly be substituted. Still more important is the fact that *Sciæna umbra* of Hasselquist,^b from whose long

^a Bull. U. S. Fish Comm. for 1886, 1889, p. 395.

^b Iter Palestinum, 1757, p. 352.

description Linnæus took the name *Sciæna umbra*, is the young of *Corvina nigra*.

The subsequent substitution of *Sciæna* for *Umbrina* by Bleeker is not warranted by the rules of the International Zoological Congress.

We follow Jordan and Evermann,^a in excluding from *Sciæna* the groups called *Sciænopis* and *Ophioscion*, both having bony serratures on the preopercle, a distinction probably of small importance.

If we adopt Bleeker's arrangement and separate from *Sciæna* those species with enlarged teeth in the lower jaw, all the Japanese species of this group will stand in *Argyrosomus* (= *Pseudosciæna* of Bleeker).

(*sciæna*, *σκιάνα*, the old name, equivalent to *umbra*, from *σκία*, shade.)

KEY TO SPECIES.

- a*¹. NIBEÆ. Preopercle with a few slender sharp spinules; gill rakers relatively numerous and slender; body not greatly elongate (mouth oblique, lower jaw included),^b soft dorsal naked.
- b*¹. Body with distinct dark stripes along rows of scales; scales in lateral line about 50; second anal spine very strong, and its length at least twice the longitudinal diameter of eye.
- c*¹. Dorsal rays X—I, 28; dark oblique streaks along rows of scales continuous, not interrupted above lateral line; gill rakers 7+13 (besides rudiments); second anal spine usually 2½ to 3 in head. (Type, however, said to be 2½.)
mitsukurii, 2.
- c*². Dorsal rays X—I, 31; dark oblique stripes along rows of scales not continuous, interrupted above lateral line; gill rakers 6+10 (besides rudiments); second anal spine larger and stronger than in *S. mitsukurii*, 2½ in head. *albiflora*, 3.
- b*². Body without dark streaks along rows of scales; scales in lateral line 56; second anal spine weak, its length 1½ times diameter of eye; dorsal rays X—I, 28; gill rakers unknown..... *argentata*, 4.
- a*². ARGYROSOMUS. Preopercle without bony serræ; gill rakers rather few and short; mouth large, oblique; body elongate or not, soft dorsal naked.
- b*¹. Body rather short, depth 3¼ in its length; dorsal rays X—I, 26; second anal spine equal to diameter of eye; peritoneum light colored, not dark, as in *S. nibe*; teeth moderate in size..... *schlegeli*, 5.
- b*². Body rather elongate, depth 3½ in its length; dorsal X—I, 29; second anal spine contained 1½ times in eye; peritoneum very dark or black; teeth large, almost canine-like in outer row of upper jaw..... *nibe*, 6.
- b*³. Body extremely elongate; dorsal rays X—II, 26, length 3 or 4 feet. A doubtful species, known only from a very incorrect figure..... *japonica*, 7.
- a*³. OTHONIAS. Soft dorsal scaly, otherwise as in *a*² (extra limital)... *manchurica*, 5b.

2. SCIÆNA MITSUKURII (Jordan and Snyder).

• NIBE; KUCHI.

Corvina cuja TEMMINCK and SCHLEGEL, Fauna Japonica, Poissons, 1843, p. 58; Nagasaki (not *Bola cuja* HAMILTON, a species from India).

Pseudotolithus mitsukurii JORDAN and SNYDER, Proc. U. S. Nat. Mus., vol. 23; 1901, p. 356, pl. 13; Tokyo.—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, 1901, p. 81; Yokohama.

Habitat.—East coast of Japan.

^a Fish. North and Middle America, p. 1454, 1898.

^b In the closely related subgenus, *Pseudotolithus*, the lower jaw is projecting and the body is greatly elongate.

Description from specimens 230 to 335 mm. in length to last vertebra. Head $3\frac{1}{3}$ to $3\frac{2}{3}$ in length, $4\frac{1}{4}$ to $4\frac{1}{2}$ in total with caudal; depth $3\frac{2}{5}$ in body, 4 in total; depth of caudal peduncle $2\frac{1}{5}$ to $3\frac{1}{3}$; maxillary $2\frac{1}{2}$ in head; longitudinal diameter of eye 5 to 6; interorbital space above pupil 3 to $3\frac{1}{3}$; width of preorbital 8 to 10, two-thirds diameter of eye; snout $3\frac{1}{2}$ to 4; D. X—I, 27 to 31; A. II, 7; pectoral 16; scales in lateral line 50, in longitudinal series above 63, below 54, between lateral line and insertion of dorsal 8 or 9; between lateral line and ventrals 12 to 14. Gill rakers 6 or 7+13 (sometimes 4 or fewer rudiments in addition); their length 2 in eye.

Body somewhat compressed; its width about 2 in depth; dorsal outline not greatly arched, curve from snout to caudal peduncle even; ventral outline somewhat less arched; length of abdomen from ventrals to anus $3\frac{1}{5}$ in body length without caudal; length from anus to last vertebra $2\frac{2}{3}$ in body length to base of caudal. Head conical; snout bluntly rounded, its tip nearly vertical but not overhanging; with slight incisions on sides in free edge of skin above premaxillaries; preorbitals flat, not turgid; lower jaw slightly included; maxillary ending below posterior border of eye; cleft of mouth nearly horizontal, tip of premaxillaries being below lower edge of orbit. Teeth in upper jaw in two series; outer ones small, conical; inner ones in a band 2 or 3 rows wide, minute and bristle like; teeth in lower jaw also in 2 series, the inner somewhat larger, especially posteriorly, becoming also minute at mandibular symphysis, the outer teeth in 3 or 4 rows at symphysis, and one scattered row posteriorly, somewhat indistinct. Preopercle with short conical spinules, set in membranaceous border, somewhat larger at angle, but small; those on angle as small or smaller than teeth of upper jaw, not projecting downward. Opercle ending in 2 soft flat points, the upper smaller.

Dorsal spines weak, third or fourth longest, $1\frac{3}{4}$ to 2 in head; dorsal rays even in length $2\frac{1}{4}$ to $2\frac{4}{5}$ in head, last two rays are much shorter; spinous dorsal base 5 in body to last vertebra; soft dorsal base $2\frac{1}{2}$; anal spines stout, strong, second $2\frac{4}{5}$ to 3 in head ($2\frac{1}{3}$ in type), grooved, as in *Sciæna albiflora*; anal base $4\frac{1}{2}$ in that of soft dorsal. Pectorals equal or slightly longer than ventrals, both pointed, $1\frac{1}{3}$ in head. Caudal rounded.

Lateral line arched, following dorsal contour to above anal, from whence it follows center of caudal peduncle to tip of caudal.

Scales ctenoid, save on anterior and lower part of head, a row along soft dorsal and anal; none on spinous dorsal; caudal with few scales, except along lateral line. No scales on other fins. Scales on body in rows as described below.

Pores on snout five, placed as in *Sciæna albiflora*, one median above free edge of skin, a pair on each side opening on edge, the outermost in the incision. Pores on mandible prominent, one central, imme-

diately below symphysis, a pair on either side, those outermost farthest apart, a row of minute indistinct pores on either side, extending from halfway back on mandible to its articulation.

Air bladder with twenty-four or twenty-five lateral appendages, arborescent anteriorly, less so posteriorly, the posterior end with four or five unbranched appendages, the body of air bladder terminating in a long point.

Color in alcohol silvery, darker above than below, sheath of each scale above level of lower pectoral rays with a central dark spot forming stripes along each row of scales equal to half diameter of pupil in width, from occiput to posterior half of soft dorsal obliquely upward, that from scapular flap rising to first soft rays; three lowermost under posterior half of soft dorsal become parallel to lateral line and pass to end of caudal peduncle, those above still oblique to end of dorsal. Those lines below lateral line nearly parallel to

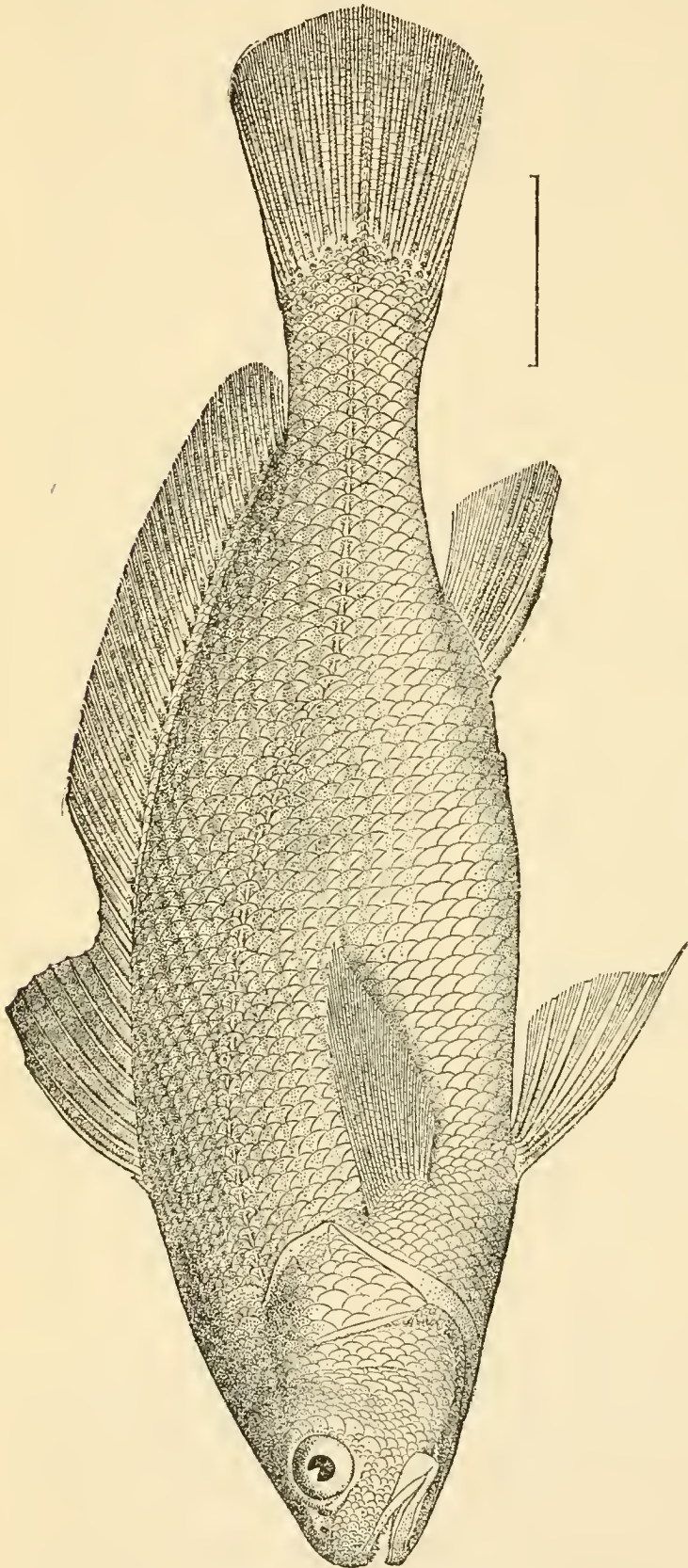


FIG. 1.—SCIAENA MITSUKURIL.

body axis, but rising somewhat to meet lines above until opposite anal fin, where they become parallel to lateral line. Scales along soft dorsal base colorless, breaking scale lines which are continued on

both dorsal fins by a 'brown' spot at base of each ray. Dorsal and caudal fins marked with brown on membranes, spinous dorsal bordered by darker, an indistinct spot in upper axil of pectoral and upper angle of opercle. Anal stippled with brown, other fins colorless. Gill chambers lined with dark, peritoneum clear.

The following is a list of measurements of the type-specimen in hundredths of body length.^a "Length of body 171 mm.; length of head 28; depth of body 30; distance from snout to dorsal 71; depth of caudal peduncle 10; length of snout 7; length of maxillary 12; diameter of eye 6; width of interorbital space 8; length of base of spinous dorsal 20; length of base of soft dorsal 43; length of second dorsal spine 12; third dorsal spine 15; length of longest dorsal ray $12\frac{1}{2}$; length of base of anal $8\frac{1}{2}$; length of first spine 2; second spine 12; length of first ray 16; length of longest pectoral 20; ventral 21; caudal 22." Our specimens showed the following measurements: Head 27 to 30; diameter of eye 5 to $5\frac{1}{2}$; length of third dorsal spine 15 to 17; second anal spine 10 to 11.

The species seems to be rather rare in Japan, the specimens examined by us from Tokyo, Awa, Matsushima, and Wakanoura being the only ones known, unless it should prove that the specimen from the Inland Sea of Japan recorded by Regan as *Sciæna albiflora* belongs to this species.

The fish is called Nibe or Kuchi at Wakanoura.

This is probably the species incorrectly recorded by Schlegel as *Sciæna cuja*. The Indian species, *Sciæna cuja*, is similarly marked, but the anal spine is much larger.

(Named for Kakichi Mitsukuri.)

3. SCIÆNA ALBIFLORA (Richardson).

Corvina albiflora RICHARDSON, Ichth. China, 1846, p. 226; Canton.

Sciæna albiflora GÜNTHER, Cat. Fish. Brit. Mus., vol. 2, 1860, p. 284; Ann. Mag. Nat. Hist., 1873, p. 378; Chifu.—STEINDACHNER, Denkschr. k. k. Akad. Wiss. Wien, 1892, vol. 59, p. 361; Shanghai.—REGAN, Ann. Mag. Nat. Hist., ser. 7, vol. 15, 1905, p. 20; Inland Sea of Japan.

Pagrus macrocephalus BASILEWSKY, Ichth. Chin. Bor., 1855, p. 222, pl. 3, fig. 1; Tschili; Peking. (Coloration well shown; dorsal fin incorrect.)

Pseudosciæna mitsukurii JORDAN and STARKS, Proc. U. S. Nat. Mus., vol. 31, 1907, p. 520; Port Arthur (not of Jordan and Snyder).

Habitat.—Coasts of China, once recorded from the Inland Sea of Japan.

Description of specimen from Port Arthur, 320 mm. long with caudal. Head $3\frac{2}{3}$ in length without caudal, $4\frac{1}{2}$ with caudal; depth $3\frac{1}{2}$ in length, $4\frac{1}{3}$ with caudal; maxillary $2\frac{1}{3}$ in head; longitudinal diameter of eye 5; interorbital space $3\frac{2}{3}$; breadth of preorbital between eye and maxillaries $\frac{2}{3}$ diameter of eye, 7 in head; snout 4 in head; dorsal rays

^a Copied from Jordan and Snyder, Proc. U. S. Nat. Mus., vol. 23, p. 357.

X—I, 31; A. II, 7; scales 52 in lateral line, 84 in transverse rows above, 72 below, between insertion of dorsals and lateral line 9 or 10, between lateral line and ventrals 18. Gill rakers 6 + 10 (and 3 or 4 rudiments); their length one-third diameter of eye.

Body somewhat elongate and compressed, its width twice in depth; dorsal profile evenly arched from snout to base of caudal peduncle, ventrally somewhat less convex; length of abdomen from ventrals to anus about 3 in length to base of caudal; distance from anus to last vertebra $2\frac{1}{2}$ in body. Head conical, dorsal profile little arched, interorbital space only slightly convex from side to side; snout short, blunt, broadly rounded, very convex dorsally, its tip vertical, or slightly overhanging premaxillaries. Suborbitals somewhat broad, flat. Lower jaw much shorter, included. Maxillary extending to vertical from last fourth of eye. Cleft of mouth oblique, anteriorly below level of lower eye by nearly one-third diameter of eye. Teeth in upper jaw in two bands; outer one row of larger, widely set, conical

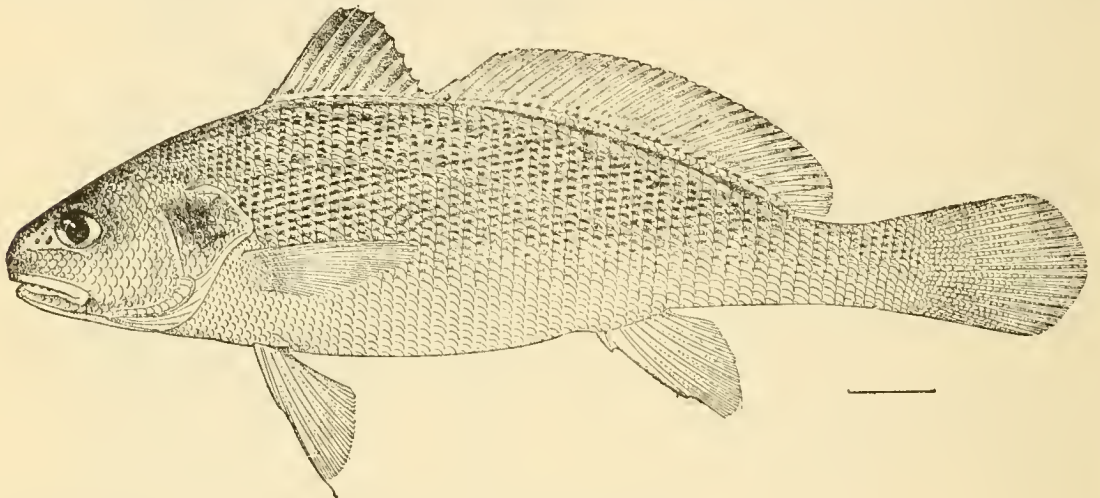


FIG. 2.—SCIAENA ALBIFLORA.^a

teeth, stronger than remainder, but hardly canines; inner of a band of minute bristle-like teeth, 3 or 4 rows wide. In lower jaw an inner single row of very small teeth, but somewhat larger than outer, closely set, conical, moderately stout, with an outer band of bristlelike, minute teeth, 4 or 5 rows wide at symphysis, but laterally only 2 or 3.

Preopercle with rather firm, strong, bony teeth or spines a little larger than inner row of mandibles, becoming larger and more widely set at the angles than on upper and lower edges. Opercle with two flat points, the lower somewhat larger.

Dorsal spines weak, third and fourth highest, about twice in head, first dorsal rays $1\frac{2}{3}$ in length of third spine and $2\frac{3}{4}$ in head, those posterior not increasing much in height, the last four decreasing rapidly, the last about equal to the diameter of the eye. Soft dorsal base contained $2\frac{1}{3}$ in body, that of spinous dorsal five times. Anal higher than soft dorsal, first soft ray equal or somewhat longer than

^aThe scales on this drawing were miscounted. See description.

third dorsal spine. Second anal spine fluted, showing an appearance of longitudinal layers, strong and long, its length $2\frac{1}{3}$ in head, first spine short but stout, about one-third diameter of eye. Anal base $4\frac{1}{2}$ times in soft dorsal base. Pectorals pointed, fourth ray longest, rather short, being contained $1\frac{1}{3}$ in head. Ventrals a trifle shorter, $1\frac{1}{2}$ in head. Caudal irregularly rhomboidal, the upper half having its border somewhat concave, its length $1\frac{1}{4}$ in head.

Lateral line arched anteriorly, dropping slightly posteriorly from parallel to line of back, until opposite insertion of anal at which it becomes straight along center of caudal peduncle to tip of caudal.

Scales strongly ctenoid, except on lower surface of head and preorbitals. Rows of scales on body oblique to lateral line, those from scapular flap ending at middle of spinous dorsal, those from upper rays of pectoral meeting lateral line slightly posterior to below first rays of soft dorsal but continued above to its center. Those posteriorly gradually becoming less oblique until parallel on caudal peduncle. Soft dorsal with a basal sheath of two rows, anal similar, caudal scaled at base, and halfway to tip along membranes. On lateral line anteriorly two small scales between the scales bearing pores, posteriorly on caudal peduncle none, midway one small scale only.

Pores well developed on snout. Lower jaw with a large central pore below symphysis; a large pair just behind; and a slit-like pair just behind these and farther apart; halfway back on mandible of each side a row of small closely set pores extending back to articulation of mandible.

Air bladder pointed sharply posteriorly, with 25 or 26 small lateral arborescent appendages.

Body white, below level of pectorals; above this the sheath of each scale has a brown spot, making brown stripes along each row of scales running obliquely as described for scale rows, but much interrupted and broken above lateral line, where a longitudinal clear space or indefinite line of unpigmented sheaths runs along one or two scales below the line of the back, and another midway between this and the lateral line, becoming still more indefinite anteriorly. Lateral line interrupting these lines on its curved anterior portion. Rows of scale sheaths along bases of dorsals also colorless, but the lines continued on dorsals by a brown spot at base of each ray or spine and another on the membranes a little higher up, smaller and less distinct. Upper part of head very dark, as is upper part of preopercle and opercle, the latter almost covered by a dark blotch. In pectoral axil a small deep blackish spot on inner bases of rays, continued a distance on rays. Dorsals broadly edged with brownish black on distal halves, the spinous dorsal more strongly. Caudal dusky. Other fins colorless. Gill cavities very dark. Peritoneum white, as is mouth cavity.

The following is a list of measurements of our specimen in hundredths of body length to base of caudal: Head 27; depth 28; eye $5\frac{1}{2}$; snout 7; maxillary 11; interorbital space above pupils 8; space between eyes and maxillaries 4; second anal spine 12; pectoral length 20; third dorsal spine 14; longest dorsal ray 10.

From *Sciæna mitsukurii*, to which this species is closely related, it may be readily known by the broken character of the stripes above the lateral line, the stronger preopercular teeth, and by the broader band of bristle-like teeth in the lower jaw. In *S. mitsukurii* the lateral stripes become parallel to the lateral line under the last half of the soft dorsal, whereas in *S. albiflora* this is not true until the last rays are reached.

This species is known to us only from the descriptions of authors, and from the specimen from Port Arthur, described above. This specimen we here figure.

It seemed to us possible that the specimen recorded by Regan from the Inland Sea of Japan is really *Sciæna mitsukurii*, which closely resembles this Chinese species. In fact except for the differences in the dark streaks along the rows of scales there is little difference between the two species. At our request, however, Mr. Regan has reexamined his specimen and he reports that it is identical with *Sciæna albiflora* from China. It is therefore different from *S. mitsukurii*.

(*albus*, white; *flor*, flower; from the Chinese vernacular name.)

4. SCIÆNA ARGENTATA (Houttuyn).

Sparus argentatus ^a HOUTTUYN, Act. Haarlem, vol. 20, pt. 2, 1782, p. 320; Nagasaki. (Not *Sciæna argentata* Gmelin, 1788, which is based on *Sciæna argentimaculata* Forskål, 1776, a species of *Lutianus*.)

Corvina argentata CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 115, after Houttuyn.

Sciæna bleekeri DAY, Fishes India, 1876, p. 185, pl. 45, fig. 4; Bombay, Gwadar.—STEINDACHNER and DODERLEIN, Denkschr. k. k. Akad. Wiss. Wien, vol. 48, 1883, p. 33; Tokyo.

Corvina yeddoënsis DODERLEIN, MS., Denkschr. k. k. Akad. Wiss. Wien, vol. 48, 1883, p. 33; Tokyo. Same specimen.

Habitat.—Southern Japan to India.

Description, after Steindachner, of specimen about 40 cm. long: Head $3\frac{3}{5}$ in length to base of caudal, $4\frac{1}{5}$ to $4\frac{1}{4}$ in total length; depth 4

^a This is a translation of the original description of *Sparus argentatus* Houttuyn:

This fish is thicker of body and less broad than the preceding ("*Sparus auratus*") though not higher than broad. At first sight it resembles the haddock in the silver glow of the scales and the dark blotch behind the opercles, these as well as the whole head being scaly. This the learned Gronovius makes a mark by which to know the Spari from the Labri. The curving of the side stripe, which is here visible, is, according to Linnæus, another mark. Of the dorsal fin the 9 first rays are spiny, the 26 soft. The pectoral has 16, the ventrals 9, as well as the anal fin of which the first is a spine. The caudal fin 18. The length of the object is nearly 8, the thickness $2\frac{1}{2}$ inches.

The account of the black pectoral spot shows that Houttuyn had this species in mind and not the more common *Sciæna schlegeli*.

in length to base of caudal, $4\frac{2}{3}$ in total; interorbital space $4\frac{3}{4}$ in head; longitudinal diameter of eye $5\frac{3}{6}$; snout more than $3\frac{4}{5}$; dorsal rays X—I, 28 (24 to 27, Day); anal II, 7; scales in lateral line to base of caudal 56 (60, Day), in longitudinal series above 90, below 74, between dorsal and lateral line 10, between lateral line and ventrals 18. Gill rakers not described.

Body elongate; head compressed, conical, blunt. Dorsal profile of head and occiput ascending but moderately and evenly to insertion of dorsal, line of back descending still more gradually to caudal peduncle, the least height of which is contained $2\frac{2}{3}$ in body depth. Greatest depth of head equal to its length without snout. Cleft of mouth moderately long, somewhat oblique, maxillary reaching a little behind center of eye, posterior end rounded. Lower jaw little shorter than upper. Premaxillaries with a loosely set row of canine teeth, the anterior 4 or 5 on each side prominent for their size, the remainder a narrow band of close set, minute, bristle-like teeth. In lower jaw only two rows, the inner large and set farther apart, becoming gradually longer and stronger posteriorly but less so than anterior canines in upper jaw. Posterior edge of preopercle nearly vertical, set with not very numerous, delicate spinules, which are slightly larger toward the angle, three noticeably larger flat teeth at the angle. Two flat points on posterior end of opercle.

First dorsal spine short, buried beneath skin at foot of second, whose length is contained $2\frac{2}{3}$ times in head. Fourth and highest nearly equal to half head. Next to last slightly shorter than last, which is equal in length to eye diameter. First soft dorsal ray somewhat shorter than second spine, those following increasing but slightly in height to sixth; from sixth to fifteenth equal; from fifteenth a gradual shortening, becoming rapid in last four rays. Second anal spine straight, exceeding middle dorsal spines only slightly in strength, its length $1\frac{1}{2}$ times eye diameter, about $1\frac{3}{4}$ in first soft anal ray whose height is nearly half that of head. Length of anal base contained $4\frac{1}{2}$ times in that of soft dorsal. Ventrals equal to pectorals in length, both pointed, and contained $1\frac{2}{3}$ times in length of head, the former not extending quite halfway to insertion of anal. Caudal irregularly rhomboidal.

Body scaled everywhere save on lips, upper jaw, and around point of lower jaw; on bases of soft dorsal and anal a low sheath of scales.

Pores present on lower surface of mandible, groove-like, two opposite at symphysis.

Color silver gray, below somewhat lighter. On opercle a very large indefinite dark gray spot; on posterior base of pectoral axil extending back and down, a sharply defined, intensely colored blotch of soiled blue violet.

This species was not seen by us. It must be rare in Japan, as the single specimen recorded by Steindachner and Doderlein is the only one known from outside of India. The specimen brought from Nagasaki by Professor Thunberg and roughly described by Houttuyn must be the same, as is shown by the black pectoral spot, compared to the blotch on the haddock.

(*argentatus*, silvered.)

5. *SCIÆNA SCHLEGELI* (Bleeker).

ISHIMOCHI (STONE-POSSESSOR).

Corvina sina TEMMINCK and SCHLEGEL, Fauna Japonica, Poissons, 1843, p. 58, pl. 24, fig. 2; Nagasaki, bays of the southwest coast of Japan.—BLEEKER, Verh. Batavia Gen., vol. 26, 1857, p. 82; Nagasaki. (Not *Corvina sina* of CUVIER and VALENCIENNES, a Chinese species.)

Pseudosciæna schlegeli BLEEKER, Poissons du Japon, Verh. Kon. Akad. Wet., Amsterdam, vol. 18, p. 9, 1879; Nagasaki, Yedo (after Temminck and Schlegel).

Sciæna schlegeli STEINDACHNER and DODERLEIN, Beitr. Fische Japans, vol. 2, 1883, p. 33; Tokyo.

Corvula schlegeli JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, 1901, p. 81; Yokohama.

Habitat.—Sandy bays of Japan.

Description of an example 170 mm. in length, taken at Onomichi: Head 3 to $3\frac{1}{3}$ in length to base of caudal, $3\frac{2}{3}$ in total; depth 3 to $3\frac{1}{3}$ in body, $3\frac{1}{3}$ to $3\frac{2}{3}$ in total; maxillary $2\frac{1}{4}$ to $2\frac{1}{3}$ in head; longitudinal diameter of eye 4 to $4\frac{2}{3}$; interorbital space above pupil $3\frac{1}{3}$ to $3\frac{1}{2}$; width of preorbital 6 to 7; snout $3\frac{1}{3}$; dorsal X—I, 25 to 27; anal II, 7 or 8; scales in lateral line 50, in series above 50, below 50, between dorsal and lateral line 8 or 9; between lateral line and ventrals 9 or 10. Gill rakers 6+8 or 9 (and 2 or 3 rudiments), length two-fifths eye diameter, one-half in very young.

Body somewhat deep and compressed, its width $2\frac{1}{2}$ times in its depth. Dorsal and ventral outlines equally convex. Abdomen from anus to ventral base 3 in body to last vertebra; distance from anus to last vertebra a little more. Profile of head slightly concave over eyes, convex from side to side. Snout full, descending in a strong curve to tip, slightly overhanging it. Lower jaw a trifle shorter than upper. Maxillary extending to a vertical from posterior margin of pupil. Cleft of mouth oblique, at about an angle of 25° to 30° to body axis. Premaxillaries curved downward in posterior half; their anterior ends at or slightly below level of lower orbit edge. Teeth in two rows on both jaws; outer row largest on premaxillaries, becoming large and strong, canine like, anteriorly on either side of symphysis; inner row largest on dentaries, increasing in size posteriorly but not becoming as large as those of premaxillaries in outer row at symphysis. Inner row above and outer row below on jaws small, conical, distinct from enlarged rows. Gill rakers thick and rather short in adult. Space between orbits and maxillaries moderately broad, two-thirds longitudinal diameter of eye. Preopercular margins with dis-

tinct flexible serrations, more widely set and somewhat larger on rounded angle, less prominent on lower edge than on posterior margin; the latter sloping backward, at slight angle from vertical. Opercle ending in two large flat points of about equal size.

Dorsal spines weak, flexible; longest third and fourth, $2\frac{1}{2}$ in head and $1\frac{1}{2}$ times length of dorsal rays; base of spinous dorsal slightly more than half that of soft, which is contained thrice in length of body to base of caudal fin. Anal spines very weak, first buried beneath skin, second equal to longitudinal diameter of eye in length; longest anal rays $2\frac{1}{2}$ in head, anal base $4\frac{1}{2}$ in that of soft dorsal, its insertion under thirteenth to fifteenth soft dorsal rays. Pectoral somewhat longer than head without snout. Ventrals reaching over half way to vent. Caudal rounded.

Lateral line distinct, concurrent with base of dorsals to above anus, where it follows body axis to tip of caudal; its tubes large, arborescent, one or two branches on a side.

Scales slightly ctenoid over whole body save on cheeks below eye; absent on lips; buried on lower surface of mandible; a sheath-like row along bases of soft dorsal and anal, which are not scaled.

Color silvery on sides and cheeks, in spirits light brownish above lateral line, colorless below, a large indefinite black, pigmented blotch on operculum and a smaller one on inner side of axis of pectoral. Fins all pale save dorsal margins which are somewhat darkened on distal half, and bases of soft rays which are also dusky, leaving a clear stripe midway up on second dorsal.

We have numerous examples from Tokyo, Onomichi, Tsuruga, Naoetsu in Echigo, Hiroshima, Kawatana, and Nagasaki. These agree well with the description given by Steindachner and Doderlein in "Beitrag zur Kenntniss der Fische Japans," and with the account of *Corvina sina* given by Schlegel in the Fauna Japonica.

The species is one of the commonest food fishes of the sandy shores of southern Japan, where it is known as Ishimochi, or stone-possessor, from the ear bones.

(Named for Professor Schlegel.)

The species from Port Arthur recorded as *Corvula argentata* by Jordan and Starks ^a is not identical with this Japanese species.

It may be described as follows:

5b. SCIÆNA MANCHURICA Jordan and Thompson, new species.

Description of eight specimens from Port Arthur, type 285 mm. in total length: Head $3\frac{1}{3}$ in length without caudal, 4 with caudal; depth $3\frac{5}{8}$ in length without caudal, $4\frac{1}{2}$ with caudal; maxillary 2 in head; eye $5\frac{1}{2}$; interorbital space above center of eyes 3; preorbital width between eyes and maxillaries $9\frac{1}{2}$ or 10; snout 4; dorsal IX—I,

32; anal II, 9 or 10; scales in lateral line 60, above in longitudinal series 65, below 72, in transverse series 5 or 6 between insertions of dorsal and lateral line, between lateral line and ventrals 12 or 13. Gill rakers 9+18 (fully developed), length about two-thirds diameter of eye.

Body not greatly elongate, compressed, its width twice in its depth. Dorsal profile evenly arched, that along back somewhat more gradually than from snout to dorsal; ventral profile not much arched; abdomen from ventrals to anus 3 in length of body without caudal; caudal from anus to last vertebra 3. Head cavernous, compressed, its width $1\frac{1}{2}$ times its depth; snout rounded, not strongly convex in profile nor overhanging premaxillaries; preorbitals but little convex; jaws equal or lower somewhat shorter, narrow, included anteriorly and laterally so that teeth of upper jaw close outside of lower jaw; maxillary extending to below posterior border of eye; mouth cleft, very oblique, at 40° or 45° to body axis; premaxil-

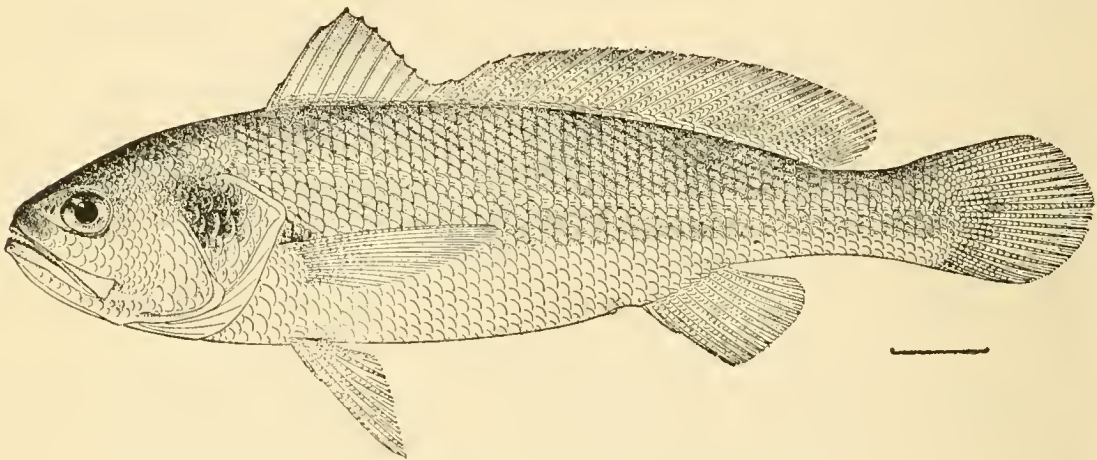


FIG. 3.—*SCIÆNA MANCHURICA*.

laries in level of lower edge of pupil and above that of orbit. Teeth in two rows in upper jaw; the outer of small hooked teeth larger anteriorly; the inner bristle-like, in a band posteriorly in one row at middle of upper jaw, lacking in anterior third, but present again in a single row at junction of premaxillaries. In lower jaw but one row of hooked teeth somewhat larger than those in the upper jaw, well spaced and larger posteriorly, small anteriorly save for a larger one on each side of the mandibular symphysis; between these a few small bristle-like teeth. Border of preopercle membranous crenate, set with minute, radiating, flexible spinules. Opercle with two points, close together, the upper much smaller, indistinct.

Dorsal spines weak, highest from third to fourth and fifth, the former $2\frac{1}{3}$ in head, the last adnate to the first soft ray and nearly equal in length to the next to last. Dorsal rays 3 in head, of nearly equal length throughout, save the last two, which are somewhat shorter. Base of spinous dorsal $5\frac{1}{4}$ in body, that of soft dorsal $2\frac{1}{3}$.

Pectorals pointed, rather long, 4 in body, $1\frac{1}{2}$ in head, sixth and seventh rays longest. Ventrals $2\frac{1}{2}$ in depth, $1\frac{1}{2}$ in pectorals; caudal evenly rounded, about two-thirds length of head.

Lateral line without angle over base of anal, curving down from anterior end somewhat more strongly than line of back, then becoming gradually parallel to axis of body above anal, thence running on middle of caudal peduncle to tip of caudal, its tubes prominent, large, their branches small, usually one on each side, with many subbranches.

Scales present everywhere on body save lips and tip of snout; soft dorsal and anal with small delicate scales from bases to tips; caudal scales on basal third and on membranes to tip. Rows on body oblique, that from scapular flap ending at eighth ray of soft dorsal. Scales ctenoid on body, cycloid on head.

Pores on snout five, one median, a pair on either side opening on free edge of skin, the outermost in a slight emargination of the edge, lobes not present. Pores indistinct on lower jaw, a central one opposite symphysis and a pair just behind.

Air bladder pointed posteriorly, with 25 or more lateral arborescent appendages.

Color uniformly dark above and on sides to level of middle rays of pectoral, where it is sharply divided from clear silvery ventral surface; lower edge of pigmented surface in perfectly straight line to caudal, leaving lower third of caudal peduncle also clear and colorless. Lines of deeper color running along base of dorsal, along edge of premaxillaries, on upper and lower borders of orbits and narrowly along edges of dorsals. Dorsal surface of head and snout darker, cheeks silvery; a dark blotch, indistinctly limited on opercle, and one just above axil of pectoral at bases of its upper rays. A dark indefinite blotch behind last rays of dorsal, on upper surface of caudal peduncle. Caudal somewhat dark, other fins clear and colorless save for slight stippling of black on pectorals. Gill cavities black, mouth colorless, peritoneum dark, sometimes nearly black.

The following is a list of measurements of the type specimen, in hundredths of body length: Length 240 mm. to last vertebra; head 30; depth 27; distance from anus to last vertebra 34; anus to ventrals 35; eye $5\frac{1}{2}$; snout 7; maxillary 14; interorbital space 10; third dorsal spine 14; longest dorsal ray 10; pectoral 25; second anal spine 4; base of spiny dorsal 19, of soft dorsal 43, of anal 11.

The type here figured is Cat. No. 67330, U.S.N.M. A cotype is in Stanford University.

It differs from the type of the subgenus *Argyrosomus*, and from all the Japanese and most of the Chinese Sciænidæ in the scaly soft dorsal fin. It may be made the type of a new subgenus *Othonias*, distinguished from *Argyrosomus* by this character.

6. *SCIÆNA NIBE* Jordan and Thompson, new species.

? *Sciæna japonica* TEMMINCK and SCHLEGEL, Fauna Japonica, Poissons, 1843, p. 58, pl. 24, fig. 1; Nagasaki, after a Japanese drawing.

Habitat.—East coast of southern Japan.

Description of three specimens.—Length 305, 345, 385 mm. with caudal, the longest taken as the type, a sexually mature specimen. Head 4 in total length, $3\frac{1}{3}$ in length to base of caudal (to last vertebra); depth $3\frac{1}{8}$ to $3\frac{1}{4}$ in latter; length of maxillary 2; longitudinal diameter of eye $3\frac{3}{4}$ to $4\frac{1}{2}$; breadth of interorbital space over pupil 3 to $3\frac{1}{3}$; breadth of preorbital between eye and maxillary 10 in head, $2\frac{1}{3}$ to $2\frac{2}{3}$ in eye; snout $3\frac{1}{3}$ in head; dorsal rays X—I, 29 or 30; A. II, 7; scales in lateral line to last vertebra 52; number of transverse series above lateral line 50, transverse series below lateral line 50; between dorsal insertion and lateral line 7 or 8, between lateral line and ventrals 15; gill-rakers 6 to 8+10 or 11 (and 3 or 4 rudiments on lower arch).

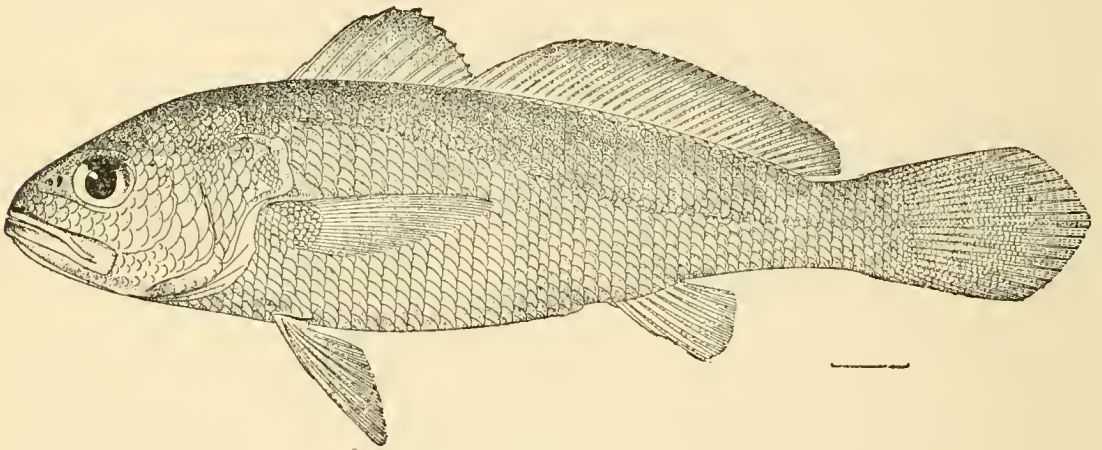


FIG. 4.—*SCIÆNA NIBE*.

Body elongate, heaviest in anterior half, somewhat compressed, its width $1\frac{1}{2}$ in its depth. Dorsal profile not much arched from snout to insertion of dorsal, almost straight above eye, descending in long, gradual slope to caudal peduncle from insertion of spinous dorsal; ventral profile evenly convex. Abdomen from ventrals to vent slightly longer than head; length of caudal peduncle from last anal rays to last vertebra $1\frac{1}{3}$ in head; head conic, compressed, its width $1\frac{1}{2}$ in its greatest depth; snout rounded, blunt, not overhanging premaxillaries, but convex in profile; suborbital space somewhat narrow, flat; jaws subequal or lower slightly longer; maxillary extending to below center of eye; mouth oblique, anteriorly on level of lower border of eye. Teeth in two rows on both jaws; outer row largest, well spaced in upper, becoming canine-like anteriorly, smaller posteriorly, sometimes more prominent enlarged hooked teeth below slits of free edge of skin on snout, showing externally; inner row minute, closely set, well separated from outer row; on lower jaw inner row largest, spaced as outer in upper jaw, becoming largest

in middle of each dentary, but not as large as canines in upper jaw; outer row minute, closely set, not well separated from inner. Gill-rakers one-half diameter of eye, heavier and stouter in larger specimens. Preopercular angle blunt, rounded; posterior edge sloping slightly obliquely back from vertical, lower edge curved; both edges with minute spinules set in membranous border, slightly larger at angle. Opercle ending in two flat points nearly equal in size.

Dorsal spines weak, short; third and fourth longest, third $2\frac{1}{3}$ in head; dorsal rays shorter, $1\frac{1}{5}$ in third spine; base of soft dorsal $1\frac{1}{3}$ times length of head, base of spinous dorsal slightly more than half base of soft. Anal base 5 in soft dorsal base, its first spine very small, hidden, its second 5 to 6 in head, $1\frac{1}{3}$ to $1\frac{1}{2}$ in eye, and about two-fifths to one-half first soft ray. Pectorals long, equal to body depth, $1\frac{1}{6}$ in head; ventrals shorter, at most $1\frac{1}{2}$ in head, reaching more than half way to vent; caudal rhomboidal.

Lateral line running somewhat more obliquely downward than line of back to above anal fin, thence along middle of caudal peduncle to tip of caudal, its tubes arborescent, more so anteriorly.

Scales ctenoid, present everywhere save on lips and lower surface of lower jaw at tip, buried on snout, preorbitals and on lower jaw where present; rows on sides very oblique, that arising at scapular flap ending near last of first dorsal base; a sheath-like row of scales along bases of soft dorsal and anal, the fins otherwise scaleless.

Pores on snout well developed, five in number, a central one just above free edge of skin, a large slit-like pair in emarginations found to either side, and one on each side between the latter pair and the central, the paired slits opening on the edge. Below symphysis of lower jaw four, two immediately below, and two larger ones farther back and farther apart.

Air bladder with 24 or 25 lateral arborescent branches on each side.

Color, silvery on sides and cheeks, slightly darker above along bases of dorsals; a dusky very indefinite blotch on operculum, a small intensely black spot on axil of pectoral above and behind, mostly hidden by the fin; snout and anterior edges of lips dark; pectorals slightly pigmented on upper surface and on distal half; spinous dorsal with a very narrow border of black, other fins colorless; gill cavities and peritoneum black or very dark.

The following is a list of measurements of the type, 310 mm. long to base of caudal, in hundredths of body length: Head 30; eye 7; snout 9; maxillary 14; interorbital space 9; distance between eye and maxillary 3; length of abdomen from ventrals to anus 32; pectorals 25; second anal spine $5\frac{1}{2}$.

Of this species we have three examples taken by Jordan and Snyder at Wakanoura the type (Cat. No. 67331, U.S.N.M.), a female with mature eggs, and two others in the collection of Stanford University.

The species must be relatively rare. It is readily known from the other Japanese species by its strong teeth. It may be that the unrecognized species, *Sciæna japonica*, is identical with the species. But the great difference in the size of the eye, and the fact that *Sciæna nibe* is sexually mature at a foot in length make this identification very improbable.

(*Nibe*, the Japanese name of large fishes of this group, from *nibe*, isinglass, made from the large air bladder of Sciænoid fishes. *Nibe* is used to bind bamboo sticks together.)

7. *SCIÆNA JAPONICA* Temminck and Schlegel.

Sciæna japonica TEMMINCK and SCHLEGEL, Fauna Japonica, Poissons, 1843, p. 58, pl. 24, fig. 1; Nagasaki, on a poor Japanese drawing sent by Bürger to Schlegel.

Habitat.—Southern Japan.

Schlegel has published a crude drawing of a species he calls *Sciæna japonica*. The species has not been recognized. According to the drawing, the body is elongate, the depth about 4, the head small, the eye very small, the mouth moderate with rather strong teeth and subequal jaws. The dorsal rays are X—II, 26, the anal II, 8, the second anal spine small. The color is plain gray, paler below. According to Bürger it reaches a length of 4 to 5 feet, and its depth is 10 inches to 1 foot. It is said to be known as *Nobe*, which is probably an error for *Nibe*, the usual name for the larger Sciænoids in Japan. It is taken in the spring in southern Japan, and is excellent as food. It is eaten boiled.

If any such giant Sciænoid occurs about Nagasaki, it may be recognized as *Sciæna japonica*. As the figure is of the crudest description and the species thus far unknown, Steindachner suggests that it should be erased from the system. It, however, resembles in some degree the species obtained by us at Wakanoura, which we call *Sciæna nibe*. Our species is, however, much deeper in body with much larger eye and a female example has mature ova at the length of a foot.

There is no reason for supposing *Sciæna japonica* to be the same as *Sciæna argentata (bleekeri)* as Steindachner has suggested. Still less can it be identified with *Otolithes argenteus*, as suggested by Doctor Günther.

SUMMARY.

Family SCIÆNIDÆ.

1. *Bairdiella* Gill, 1861.§ *Nector* Jordan and Evermann, 1898.1. *acanthodes* (Bleeker), 1879.2. *Sciæna* (Artedi) Linnæus, 1758.§ *Nibea* Jordan and Thompson, 1910.2. *mitsukurii* (Jordan and Snyder), 1901.

Matsushima, Tokyo, Awa, Wakanoura.

3. *albiflora* (Richardson), 1846.

Port Arthur.

4. *argentata* (Houttuyn), 1782.§ *Argyrosomus* De la Pylaie.5. *schlegeli* (Bleeker), 1879.

Tokyo, Onomichi, Tsuruga, Naoetsu, Hiroshima, Kawatana, Nagasaki.

§ *Othonias* Jordan and Thompson.5b. *manchurica* Jordan and Thompson, Port Arthur.6. *nibe* Jordan and Thompson, 1910.

Wakanoura.

7. *japonica* Temminck and Schlegel, 1843.

NORTH AMERICAN PARASITIC COPEPODS BELONGING TO THE FAMILY ERGASILIDÆ.

By CHARLES BRANCH WILSON,
Department of Biology, State Normal School, Westfield, Mass.

INTRODUCTION.

The present is the tenth^a paper in the series based upon the collection of parasitic copepods in the U. S. National Museum, and deals with the family Ergasilidæ.

As in all the preceding papers, the Museum material has been largely supplemented by a study of living forms, developmental stages, and material derived from other sources.

Much of this study has been accomplished while working for the U. S. Bureau of Fisheries at various laboratories situated both upon salt and fresh water. For these valuable opportunities the author is indebted to the courtesy of the Hon. George M. Bowers, U. S. Commissioner of Fish and Fisheries, to whom acknowledgment is gratefully made.

Thanks are also due to Prof. E. A. Birge and Prof. Chauncy Juday, of the University of Wisconsin, for furnishing a generous supply of tow taken from Lake Mendota, Madison, Wisconsin, from which has been obtained an excellent series of specimens of both sexes of *Ergasilus chautauquaënsis*.

The value of this material is enhanced by the fact that it was the first opportunity for a personal examination of an *Ergasilus* male.

To Dr. Andrew Scott, of the Board of Fisheries of Scotland, the author returns sincere thanks for some finely preserved specimens of

^aThe nine preceding papers are 1. The Argulidæ, Proc. U. S. Nat. Mus., vol. 25, pp. 635-742, pls. 8-27. 2. Descriptions of Argulidæ, idem, vol. 27, pp. 627-655, 38 text figures. 3. The Caliginæ, idem, vol. 28, pp. 479-672, pls. 5-29. 4. The Trebinæ and Euryphorinæ, idem, vol. 31, pp. 669-720, pls. 15-20. 5. Additional Notes on the Argulidæ, idem, vol. 32, pp. 411-424, pls. 29-32. 6. The Pandarinæ and Cecropinæ, idem, vol. 33, pp. 323-490, pls. 17-43. 7. New species of Caliginæ, idem, vol. 33, pp. 593-627, pls. 49-56. 8. Parasitic Copepods from the Pacific Coast, idem, vol. 35, pp. 431-481, pls. 66-83. 9. Development of *Achtheres ambloplitis* Kellicott, idem, vol. 39, pp. 189-226, pls. 29-36.

Bomolochus soleæ, taken from the nostrils of the cod common upon the coasts of the British Isles.

These specimens also included both sexes and proved of great value in a comparison of the mouth-parts. The male of this species has never been described, but Doctor Scott has generously given the author permission to include it in the present paper. In private correspondence he has also furnished many notes and suggestions upon the mouth-parts of the genus *Bomolochus*, which have proved exceedingly helpful in coordinating the accounts of different authors, in the effort to establish an accurate and common basis for future use.

This is the smallest of all the families of parasitic copepods, both in number of species and in bodily size.

As here constituted it contains ten genera, three of which are new to science, while a fourth, *Tucca*, has been so changed by the discovery of its mouth-parts and swimming legs as to make of it virtually a new genus. Hesse has described four other genera which in all probability belong to this family. Two of them, *Megabrachinus* and *Macrobrachinus*, would fall in the subfamily Ergasilinæ, since the second antennæ are developed into long and powerful prehensile organs like those of *Ergasilus*. The other two, *Metopocatacoteinus* and *Metoponanaphrissontes*, as evidently belong to the Bomolochinæ from the structure of the first antennæ and the mouth-parts. But Hesse's figures and descriptions are so full of flat contradictions and palpable errors as to render it impossible to locate these genera with any certainty, and hence they must be left until future investigation shall furnish the necessary data. For the good of systematic zoology it is to be hoped that at least the last two names may prove to be synonyms; there is no chance that they were preoccupied.

The family separates naturally into three groups or subfamilies, which differ in habits as well as morphology, and thus constitute well-marked divisions. (See key, p. 311.)

The first of these subfamilies, the Ergasilinæ, are typically fresh-water forms, and nearly all the species are found upon the gill filaments of fresh-water fishes. The second subfamily, the Bomolochinæ, are as typically salt-water forms, and no one of them, so far as known, has ever been found in fresh water. The third subfamily, the Taeniacanthinæ, are also salt-water forms, and none of them have thus far been found upon fresh-water fishes.

There are one or two species (*Artacolax cornutus*, *Irodes tetradontis*, etc.) that reach a length of 3 or 4 mm., but all the remaining species are much smaller, and many of them are under 1 mm. in length. The Ergasilidæ thus compare more closely in size with the free-swimming forms than do any of the other parasitic copepods. This resemblance is increased by the fact that the eggs are multiseriate and are carried in elliptical or pear-shaped pouches almost exactly like those of *Cyclops* and other free-swimmers.

The Corycæidæ, a family of free-swimmers established by Claus in 1863, offer the greatest affinity with the Ergasilidæ. This resemblance has already been stated by Vogt (1879, p. 98), and is especially noticeable in the genera *Corycæus*, *Antaria*, and *Lubbockia*.

In superficial view the genus *Corycæus* looks very much like *Ergasilus*; there is the same bodily structure, the second antennæ are transformed into powerful prehensile organs, the mouth parts are somewhat similar, and even the unpaired eye is small and well concealed in the tissues.

But in spite of this seeming likeness the Ergasilidæ differ radically from the free-swimmers in both habits and morphology, as can be seen from the account which follows.

The present paper includes all the genera belonging to the family which have thus far been found in North American waters. On examining the species which have been referred by various authors to the genus *Bomolochus*, it was soon found that we have among them sufficient differences to warrant the establishing of at least three new genera, *Artacolax*, *Irodes*, and *Phagus*. A diagnosis of *Artacolax* has already been published.^a

A description of the type-species, *A. ardeolæ*, is here added, the diagnoses of the other two genera are given with their distinguishing characteristics, and the different species belonging to each are clearly indicated. There is also presented a comparison of the mouth parts in the two sexes of the three type genera, *Ergasilus*, *Bomolochus*, and *Tæniacanthus*. The mouth parts of the female of each of these genera have already been published, some of them many times, and the large maxillipeds, which are the distinguishing character of the male, have been described and figured.

But these descriptions have all been isolated and nearly every author has changed the nomenclature of one or more of the mouth parts. The result has been a confusion so great as to make intelligent comparison possible only after long and painstaking study of the published accounts and careful examination of both living and preserved material.

To the best of the author's knowledge no collective account of the family as a whole, showing the interrelation of the subfamilies, genera, and species, has hitherto been published.

ECOLOGY.

Habits.—The Ergasilidæ live almost entirely upon the gill filaments or within the gill cavities of fishes, and this habit has occasioned several departures from the conditions found existing in the Caligidæ. There is about the same difference between the sexes in their morphology, but the difference in habit is considerably greater.

^a Proc. U. S. Nat. Mus., vol. 35, p. 433.

While the adult females become more or less fixed upon their host, the males remain free-swimmers during life, and at least in the genus *Ergasilus* do not appear to practice parasitism at all. In consequence of this difference there is always a great scarcity of males, especially among the Ergasilinæ.

Females can be found in abundance upon nearly all our common food fishes, but the males disappear at the close of the mating season and can then be found only in the tow.

We can thus understand how in the great majority of species the female alone is known. In a very few instances the two sexes are found together, as noted by Mr. T. Scott, an excellent investigator and one who has worked upon free-swimming as well as parasitic forms. In a short paper published in the *Annals of Scottish Natural History* (vol. 9, p. 153) he calls attention to the fact that certain species of *Bomolochus* are habitually found in the nostrils of such fish as the cod (*Gadus callarius*), the lumpsucker (*Cyclopterus lumpus*), and the plaice (*Pleuronectes platessa*). Both sexes and the young live here in the mucus lining of the nostrils, and when removed to an aquarium prove to be lively swimmers.

The mating of the sexes in this family takes place while the female is still very young and in all probability before she seeks out a host. And only at that time would there be any chance of finding the two together.

The evidence for these conclusions is contained in the following facts: The developmental stages of all the Ergasilidæ are free-swimming; none of them are found attached to a host along with the adults, as is the case with the chalimus stage of the Caligidæ. Among the many hundreds of specimens taken by the author from the gills of different fishes in both salt and fresh water no developmental stage has ever been found. Undersized females have been repeatedly obtained, less than half the length of the fully developed adult, and giving unmistakable proof that they had not as yet developed their first pair of egg strings. But they were still sexually mature, the eggs within the ovaries were well advanced, and the spermatophores were already attached to the genital segment.

Again, in all this large number of specimens, as well as among those contained in the National Museum, there have never been found a male and female in union. And there is but a single record of such a find within the author's knowledge, the one given by Bassett-Smith (1898, p. 358) of *Bomolochus megaceros*. If the coming together of the sexes took place upon the gills of the host many more would undoubtedly have been obtained, as among the Caligidæ. That they have not been thus found indicates that mating takes place before the female seeks a host. Fortunately the few males known are well distributed among the genera, and we thus have a good idea of that sex throughout the family.

After the female is once fastened to her host all further incentive to free swimming disappears. She finds on the fish's gills excellent aeration for her eggs and a good position from which to discharge the nauplii when sufficiently matured. There is also an abundance of food so that she remains there in all probability throughout life.

The only instance of a mature female found swimming freely is that of *Ergasilus chautauquaënsis*. Both sexes of this species have been taken in the tow of Lake Chautauqua in New York, and of Lake Mendota in Wisconsin. The females were as abundant as the males, were fully matured, and carried egg cases. As yet neither sex of this species has been found on any host, so that we can not positively affirm that it ever becomes parasitic, but the probability is that it does.

Prehension.—These tiny creatures fasten themselves to the gill filaments, or rarely to the walls of the gill cavity, to the skin or the fins, by means of the second antennæ and the maxillipeds. For this purpose we find both these appendages enlarged and furnished with powerful muscles.

Their terminal joints are in the form of stout and sharp claws, while they are further armed with spines and roughened surfaces to prevent slipping.

The second antennæ are usually the chief organs of prehension and are enlarged in nearly all the species. In the Ergasilinæ they are often as long as the carapace or even the entire body, while the maxillipeds are wanting in the female.

These antennæ are thus long enough to reach around the gill filament and give the parasite a firm hold.

In the Bomolochinæ, however, while the second antennæ are enlarged and well armed with claws, spines, and roughened surfaces, they are not the chief organs of prehension. But this distinction belongs to the maxillipeds whose terminal joint is developed into a stout curved claw, capable of grasping a gill filament or of being driven into the tissue of the wall of the gill cavity, or into a fin.

The Ergasilidæ have no lunules or sucking disks, such as were found among the Caligidæ, and in the majority of the genera this mode of prehension can not be employed.

But in the genus *Bomolochus*, especially those species which frequent the nostrils of the cod and allied fish, and in the Tæniacanthinæ the carapace is so arched as to act like a large sucking disk, its margin being pressed close to the surface of the skin and the contact sealed with mucus and water.

This makes an effective prehensile organ in the quiet of such cavities as the nostrils and often obviates the necessity of setting the claws into the skin.

That the hold maintained by these parasites upon their host is quite secure is realized when one tries to remove them. Long practice

has shown that the best way to accomplish this on the gills is as follows. The body of the parasite is always parallel with the gill filament around which are clasped either the second antennæ or the maxillipeds. The head of the parasite is always toward the base of the filament or the gill arch from which the filament proceeds. If a blunt pointed needle, like a tape needle, be inserted from the base of the filament between the latter and the body of the parasite, the creature may be swept down along the filament and off its end with considerable ease. This method possesses the further advantage of removing as little slime along with the parasite as possible and in particular, by holding the mouth-parts out away from the filament, helps to keep them clean and free from obnoxious matter.

Locomotion.—The two sexes are similar in structure; each possesses four pairs of well-developed swimming legs, which are perfectly capable of functioning during the larval stage of development. But while this power is retained by the adult male, it is usually diminished in the female, and the latter when placed in an aquarium often shows no tendency to swim about, but lies inert upon her back wherever she may be placed. Under sufficient provocation, however, the females can move with considerable rapidity, but never with the agility exhibited by the males.

T. Scott, after noting that *Bomolochus soleæ* is frequently found in the nostrils of the cod, adds (1901, p. 122):

This habit on the part of *B. soleæ* is the more interesting when it is remembered that it is a "free-living" species, and that there appears to be nothing to hinder it from leaving the nostrils of the fish, for it can move freely about amongst the mucus with which the nostrils are usually well supplied, and if the copepods are removed and placed in clean sea water they may be seen swimming or running about with nearly as much agility as the free-swimming species.

Both sexes of *Ergasilus chautauquaënsis* were captured with other crustacea while swimming freely at the surface of Lake Chautauqua in New York. And the males of all the common species of *Ergasilus* are found in the tow of our fresh-water lakes and ponds as has been noted by nearly every observer in recent years who has studied the plankton of such localities at all carefully. These observations all go to prove the close relationship of the present family with the free-swimmers. They show that, in spite of the parasitic habits they have acquired, they still retain to a considerable degree this form of locomotion.

But they have also acquired another method of moving about which has come as a direct result of their parasitism. Vogt has called attention (1877, p. 98) to the fact that the two sexes are never found attached side by side on the same gill filament, but the male is always at some distance from the female. Hence it follows that the males at least must move about in search of the females, and this ability

being recognized for that sex one can not refuse it to the females also. Indeed the present author has repeatedly witnessed it when the gills of some fresh-water fish were placed under the dissecting microscope for the purpose of removing these parasites. On being disturbed they may often be seen to move considerable distances up or down the filament to which they are clinging. This movement is accomplished by alternate motions of the second antennæ and swimming legs, in much the same way as a man uses his arms and legs in climbing a pole.

If there is this freedom of motion on a single filament it is reasonable to believe that they can also move from one filament to another, since the filaments are closely interwoven in the living gill. This belief is strengthened by the fact that the parasites are usually found on those filaments which are nearer the ends of the arches, leaving the ones along the center free. This could hardly happen by chance in so great a majority of the cases, but must be the result of a selective choice, which necessitates the power of moving about over the gills in order to reach these positions. Many species of the genus *Bomolochus* are found in other places upon the fish's body besides the gills. And while in the water they are found capable of moving about over such surfaces with the same scuttling motion shown by *Caligus*, though not with the same rapidity.

This family of copepods therefore possess all the methods of locomotion known in the group.

Because they retain so fully their powers of locomotion the Ergasilidæ do not show as much degeneration as the Caligidæ. Indeed there is but a single genus, *Tucca*, which can be regarded as at all degenerate. The others only exhibit the preparatory stage to degeneration in which the female becomes fixed upon her host and loses her incentive for free swimming.

Hosts.—In general these parasites may be found upon our common food and game fish, often in considerable numbers. Among fresh-water fish the bass, perch, sunfish, pike, and carp are nearly always infested. This is especially true of the red-eye or rock bass, *Ambloplites rupestris*, nearly every specimen of which is sure to yield parasites the number of which from a single fish often reaches the hundreds.

Among salt-water fish the needle fishes (Esocidæ), the gizzard shads (Dorosomidæ), the sauries (Scomberesocidæ), the balaos (Hemirhamphidæ), the soles (Soleidæ), and many members of the large family of Gadidæ are common hosts.

Besides these which may be considered regular hosts, there are of course many others upon which some species of the family may be occasionally found. Owing to the fact that the great majority of them retain so fully their power of free swimming, these Ergasilidæ

are much more widely distributed than the Caligidæ. The latter family contains three or four times as many species as the former, yet only one or two of them are cosmopolitan, while in the Ergasilidæ there are half a dozen or more found in all parts of the world.

Food.—Living as they thus do upon the fish's gills, there can be but little doubt that they feed upon blood.

Such a conclusion is further evidenced by the structure of the mouth-parts, which are so degenerate as to be unfit for biting or chewing but are well suited for piercing such delicate tissues as cover the gill filaments.

MORPHOLOGY.

General body form.—As in the Caligidæ the body of an Ergasilid is made up of four parts or regions, a cephalon or cephalothorax, a free thorax, a genital segment, and an abdomen (fig. 1).

The first thorax segment is generally united with the head to form the cephalothorax, the two being covered with a carapace which in many species is so strongly inflated that it overlaps the following thorax segments to a greater or less degree. In the females of the *Bomolochinæ* and *Tæniacanthinæ* and in the genus *Thersitina* the fusion is complete, and there is no line of demarcation visible between the two. But in the females of the genus *Ergasilus* the fusion is not complete, and there is a well-defined groove or at least a pair of notches in the lateral margins of the carapace to indicate the point of union. In the males of nearly all the genera the first thorax segment is free like the others. This cephalothorax is more strongly arched than in the Caligidæ, and in the genus *Thersitina* it becomes almost hemispherical. This is at

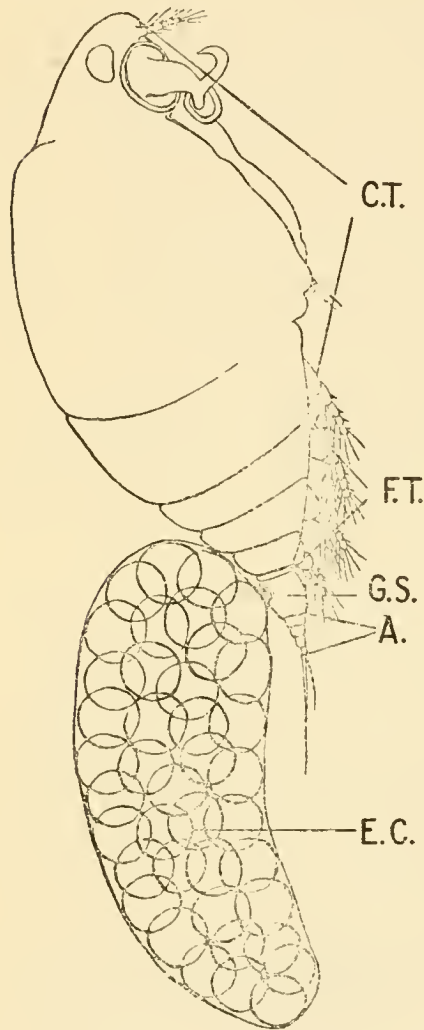


FIG. 1.—SIDE VIEW OF A FEMALE ERGASILUS MANICATUS, SHOWING BODY REGIONS: A, ABDOMEN; C T, CEPHALOTHORAX; E. C., EGG CASES; F. T., FREE THORAX; G. S., GENITAL SEGMENT.

least partly explained by the fact that in the females the ovaries and ovarian diverticula are just beneath the carapace and require considerable space, especially when the eggs are fully developed. The carapace is perfectly plain and without sinuses; the only grooves visible are a horseshoe-shaped groove, which in some species surrounds the cephalon proper, very similar to that in the Argulidæ, and in the genus *Ergasilus* a transverse groove separating from the rest of the

carapace a large anterior shield connected with the bases of the second antennæ (fig. 2). This latter groove does not in any way indicate the limits of the cephalon, since the mouth-parts are situated posterior to it on the ventral surface. Furthermore, in most of the species no groove at all is visible, and consequently it is not feasible to divide the carapace into areas as was done in the Argulidæ and Caligidæ. The cuticles covering the dorsal and ventral surfaces of the cephalothorax are fused along the margins, but they do not form a flexible border as in the Caligidæ. In those species of the Bomolochinæ and Tæniacanthinæ in which the carapace forms a sucking disk for prehension the edges of this disk are formed of the ventral cuticle rather than of a fusion of the two cuticles.

The eyes are situated close to the anterior margin of the carapace and are fused on the mid-line near the ventral surface. Their inner margins, in contact with each other, are heavily pigmented, while the outer portions are clear and transparent. No definite lens is visible. In most of the species of the Bomolochinæ and Tæniacanthinæ the eyes are invisible, but this is probably due to the inflated condition of the cephalothorax and the opacity of its contents. They are certainly present in the genus *Ergasilus* and in some species of *Bomolochus* (*teres*), *Artacolax* (*cornutus*), and *Thersitina* (*biuncinata*). They do not change their position during development as in the Caligidæ, but appear in the same place in the youngest nauplius stage as in the adult.

Free thorax and genital segment.—The thorax is composed of six segments, the first of which is usually joined with the head, while the sixth constitutes the genital segment, thus leaving four free segments, each of which bears a pair of swimming legs. In such males and immature females as have been found the genital segment also bears a pair of rudimentary legs, but these can not be seen in most of the adult females (see pl. 58, fig. 200). The thorax segments usually diminish regularly in size from in front backwards; the fifth is rudimentary and very short, and is often so overhung by the preceding segments as to be invisible in dorsal view. The legs which it bears are also rudimentary, uniramous, and one or two jointed. They are sometimes reduced to mere papillæ, each bearing one or more short spines, or even to simple spines without any papillæ. In the Caligidæ evidence was found that the so-called genital segment is really a fusion of two segments, the anterior of which, the fifth segment, is the larger.

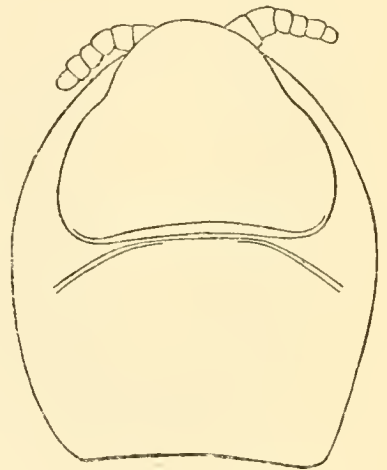


FIG. 2.—DORSAL SURFACE OF CARAPACE IN *ERGASILUS CENTRARCHIDARUM*, SHOWING THE LARGE ANTERIOR SHIELD CONNECTED WITH THE BASES OF THE SECOND ANTENNÆ. FIG. 11 (P. 286) SHOWS THE POWERFUL MUSCLES ATTACHED TO THIS SHIELD.

In the present family the fifth segment is considerably the smaller and is usually well separated from the sixth. But in a few species the two are thoroughly fused, yet even here the fusion is still indicated by the presence of the fifth legs attached to either side of the compound segment near its anterior margin.

The sixth segment is less worthy of bearing the name "genital" than it was in the Caligidæ.

In that family it contains the convolutions of the oviduct within which most of the development of the eggs takes place, the large cement glands which furnish the material for the external egg cases, and the sperm receptacles from which the eggs are fertilized as they pass out into the cases.

Here in the Ergasilidæ it apparently contains nothing but the posterior portion of the sperm receptacles and a somewhat complicated musculature which controls the openings of the oviducts.

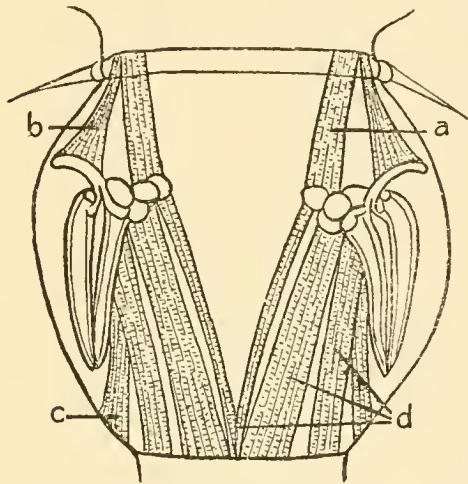


FIG. 3.—DORSAL SURFACE OF THE GENITAL SEGMENT OF *ERGASILUS CENTRARCHIDARUM*, SHOWING THE COMPLEX MUSCULATURE. *a* AND *c*, CLOSING MUSCLES; *b* AND *d*, OPENING MUSCLES.

The convolutions of the oviducts and the cement glands are situated farther forward in the free thorax and cephalon. There the eggs are matured, and when ripe they simply pass out through the genital segment one by one, without remaining in it for any length of time. And yet, understanding this, it is better to retain the old name and thus avoid confusion. In this family, therefore, the genital segment approaches more nearly to the structure of the other thorax segments and varies but little more than they in

shape and size in the two sexes and in different species.

It is somewhat enlarged, to be sure, but never as much as in the Caligidæ, and is fairly uniform in shape throughout the group. It is relatively smaller in the males and immature females, but the difference in size is only trifling.

Accordingly, there is not much danger that the careful systematist will mistake an immature female for a male, as has frequently been done when dealing with the Caligidæ.

And there is not as rigid a demand for absolute precision as to the stage of development or the degree of maturation when comparing different specimens for purposes of classification. The eggs are arranged in several longitudinal rows, the number varying in different species. The length of the rows and the shape of the sacks also varies, but in general the sacks are club-shaped, larger at the posterior end, and are very similar to those of *Cyclops*.

The abdomen is always narrower and nearly always longer than the genital segment, and is three-jointed in the great majority of species. In the genera *Irodes* and *Phagus*, however, it is four-jointed, while in the genus *Tucca* it has but a single joint.

In adult females segmentation is usually indistinct, being indicated only by notches along the lateral margins without a continuous groove. In the males and in the females of a few species the grooving is more distinct.

The anal laminæ are long and narrow, and the setæ with which they are armed are usually much longer than the entire abdomen. We have thus in the general body form a cephalon bearing six pairs of appendages, a thorax of six segments, each bearing a pair of swimming legs, the sixth pair often lacking in the adult female, and an abdomen of one, three, or four segments, the last of which bears the anal laminæ.

The appendages.—There are 12 pairs of appendages, namely, two pairs of antennæ, one pair of mandibles, two pairs of maxillæ, one pair of maxillipeds, and six pairs of swimming legs. These are all on the ventral surface with the exception of the first antennæ, which arise from the frontal margin and curve upward toward the dorsal surface.

There is no one genus, however, in which all these appendages are present and normally developed. One or more pairs are often lacking, such as the maxillipeds, or the sixth pair of swimming legs. Again, the first maxillæ and the fifth pair of legs, which are always present, are also always more or less rudimentary (fig. 4).

The *antennules* or first antennæ are attached to the frontal margin, a little

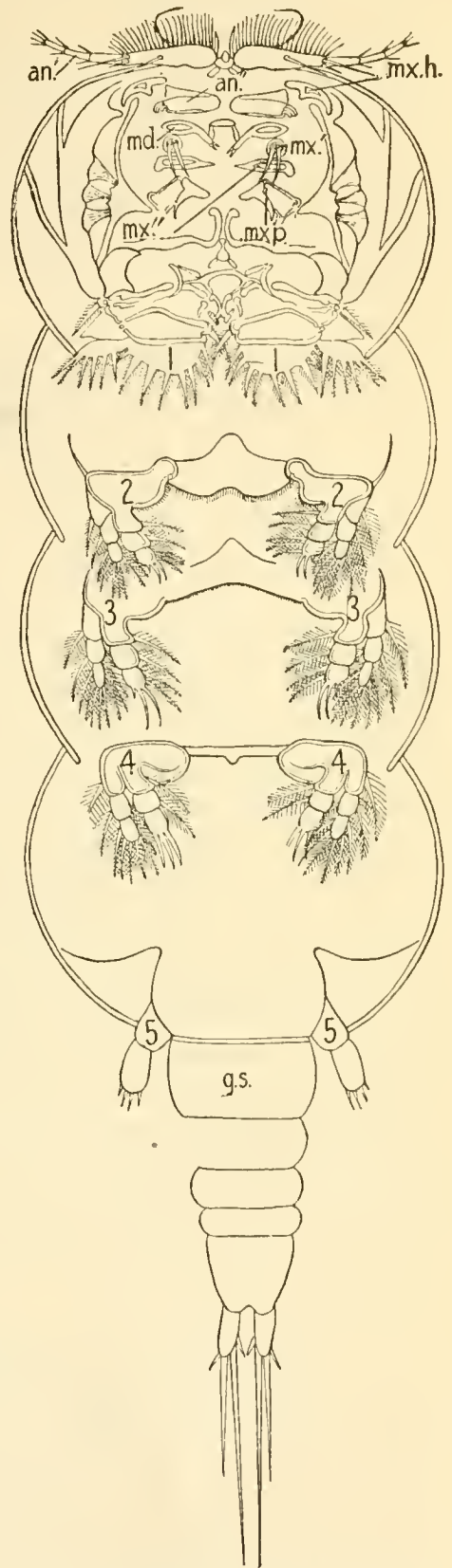


FIG. 4.—VENTRAL SURFACE OF *TÆNIACANTHUS CARCHARIÆ*, SHOWING APPENDAGES (AFTER SUMPF). *an'*, FIRST ANTENNA; *an''*, SECOND ANTENNA; *g s.*, GENITAL SEGMENT; *md.*, MANDIBLE; *mx. h.*, MAXILLARY HOOK; *mx'*, FIRST MAXILLA; *mx''*, SECOND MAXILLA; *mxp.*, MAXILLIPED; 1 TO 5, SWIMMING LEGS.

more on the ventral than on the dorsal surface. Although this family of Ergasilidæ is so closely related to the free swimming copepods, and although in the genus *Ergasilus* the male never becomes parasitic, but remains a free swimmer throughout life, yet there is not in these first antennæ any trace of the locomotor function in the female, or of the prehensile function in the male, which are so characteristic of free forms. On the contrary, they are entirely sensory in function, as is clearly shown in their armature and innervation. They

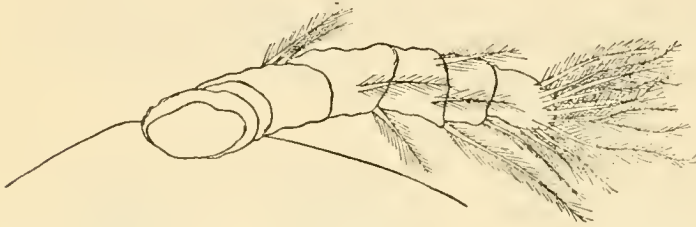


FIG. 5.—FIRST ANTENNA OF *ERGASILUS MANICATUS*, SHOWING THE FORM FOUND IN THE *ERGASILINÆ*.

are curved abruptly near the base in two directions, upward and outward, so that nearly the entire appendage is visible in dorsal view.

They are made up of joints which are indistinctly separated near the base of the antenna, and in most species there is more or less fusion here as a result (fig. 5).

We find the number of joints in these antennæ variously given, three for some species of *Bomolochus* (*denticulatus*), four for other species of *Bomolochus* (*bellones* and *parvulus*), five for the genus *Thersitina*, six for nearly every species of the genus *Ergasilus*, and seven for a few species of *Bomolochus* (*onosi*, *soleæ*, etc.). But this disparity is probably due to the indistinct separation of the basal joints which is most manifest in the fully developed adult. And we may give the number as the same in all the genera and species except *Thersitina*, namely six, a basal portion made up of three indistinctly separated joints and three terminal joints well defined and clearly separated (fig. 6).

In *Thersitina* there are but five joints, all distinctly separated, and this constitutes a good generic character (see p. 349). Each joint is armed with setæ, the longest of which are often as long as the entire appendage. In the genera *Bomolochus* and *Artacolax* the basal joints are enlarged, well fused and furnished with a heavy fringe of stout plumose setæ along their anterior margin. Interspersed with these setæ are tactile hairs without plumes, which are often as long as the entire antenna. In some species (*Bomolochus tricerros*, *Artacolax scomberesocis*, etc.) a process is given off from the ventral surface of the basal joint which terminates in two or three large

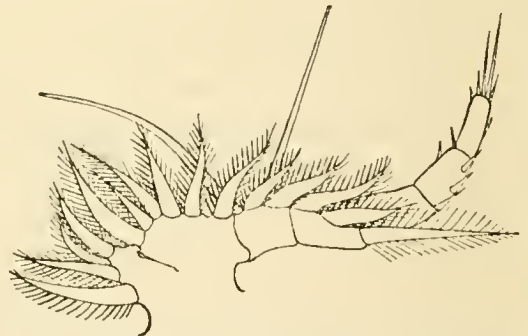


FIG. 6.—FIRST ANTENNA OF *BOMOLOCHUS EMMENS*, SHOWING THE FORM FOUND IN THE *BOMOLOCHINÆ* AND *TENIACANTHINÆ*.

tactile setæ. These are sensory in function and if the innervation is any criterion they must be highly sensitive.

These heavily armed first antennæ, curving around the anterior margin of the carapace, give the parasites a peculiar bristling front. And they stand out so prominently in most species that they can be plainly seen with the naked eye despite the small size of the creatures.

The *second antennæ* are attached to the ventral surface just posterior to the bases of the first pair. They are made up of four joints in each of the genera, but vary greatly in size and shape. Their function is prehensile and they terminate in one or more stout claws, or even become chelate in

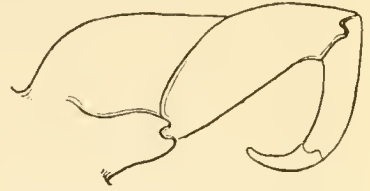


FIG. 7.—SECOND ANTENNA OF ERGASILUS CENTRARCHIDARUM.

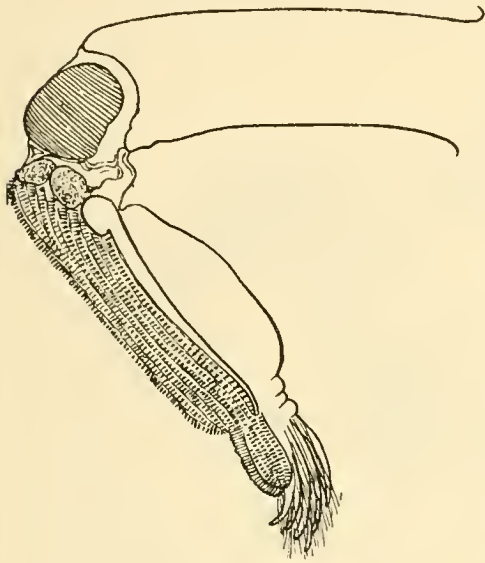


FIG. 8.—SECOND ANTENNA OF BOMOLOCHUS NITIDUS.

some of the males. In the genus *Ergasilus* they are enormously enlarged and become long enough to clasp around the gill filaments of the host, thereby holding the parasite securely in place (fig. 7). In the other genera they are plentifully supplied with spines and roughened surfaces so as to secure a firm hold and prevent slipping (fig. 8).

The *mouth-parts* are peculiar and altogether different from those of any other family of parasites, having more resemblance to those of the free-swimming forms. Most of them are rudimentary, some are usually lacking, and at least in the females of the Bomolochinæ one pair is abortive in position. They consist of an upper lip, the labrum, an

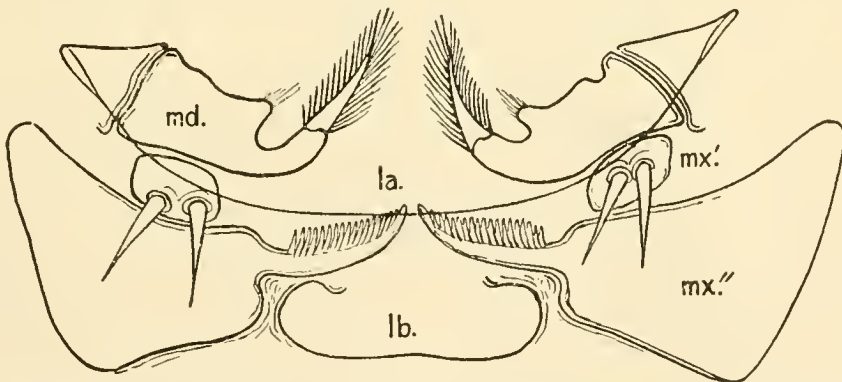


FIG. 9.—MOUTH-PARTS OF ERGASILUS MUGILIS. *la*, LABRUM; *lb*, LABIUM; *md*, MANDIBLE; *mx'*, FIRST MAXILLA; *mx''*, SECOND MAXILLA.

under lip, the labium, a pair of mandibles, a pair of maxillary hooks, two pairs of maxillæ, and one of maxillipeds.

The *labrum* is a chitin plate, usually somewhat obcordate or obovate in shape, often wider than long, and situated between and mostly posterior to, the bases of the second antennæ. Its posterior margin is evenly rounded and often has a large circular flap at either end where it is joined to the ventral surface of the carapace. The lip is well arched and covered in most species with short bristles or hairs. In the *Bomolochinæ* where the mouth-parts are close to the second antennæ the labrum is prominent and well defined, while in the *Ergasilinæ* where there is a considerable interval between the second antennæ and the mouth-parts, the labrum is fused with the ventral surface of the carapace and often difficult to distinguish. But in the early development stages of this latter family the upper lip is prominent and occupies a position similar to that in the *Bomolochinæ*, and is also sparsely covered with hairs. (See fig. 35.)

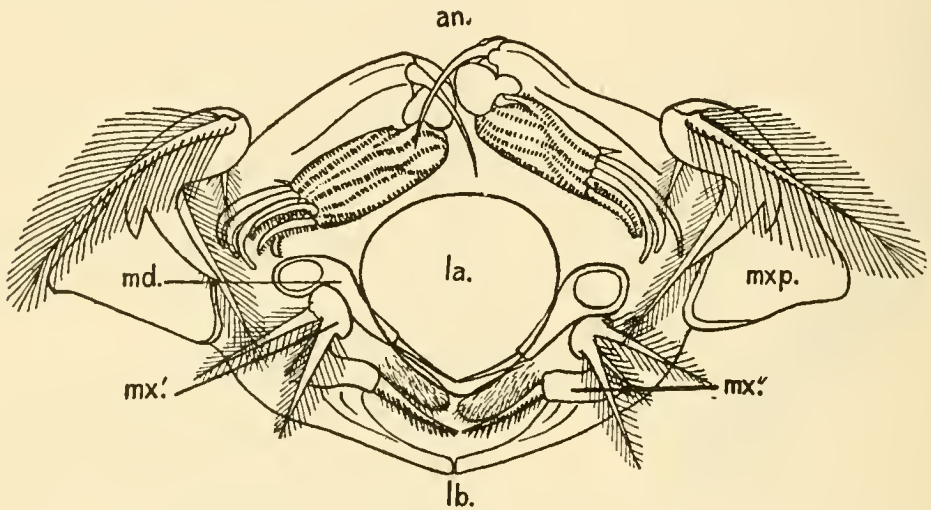


FIG. 10.—MOUTH-PARTS OF *BOMOLOCHUS EXILIPES*. *an.*, SECOND ANTENNÆ; *la.*, LABRUM; *lb.*, LABIUM; *md.*, MANDIBLE; *mx'*, FIRST MAXILLA; *mx''*, SECOND MAXILLA; *mxp.*, MAXILLIPED. BETWEEN THE TERMINAL JOINTS OF THE MANDIBLE AND SECOND MAXILLA CAN BE SEEN A HAIRY STRUCTURE SIMILAR TO THE PARAGNATHS IN FREE-SWIMMING FORMS.

It must be therefore during the migration of the mouth-parts backward away from the second antennæ that the labrum becomes fused with the ventral surface of the head.

The *labium* is developed much later than the labrum, in fact, after the other mouth-parts have been formed. It, too, is a chitin plate attached to the ventral surface of the head. But it is flattened and so thoroughly fused with that surface that it can not be seen in the adults of many species. In some cases it is so narrowed as to become virtually a post-oral bar similar to that described by Claus and Hartog for *Cyclops*. To increase this similarity in the genus *Bomolochus* a process runs forward and inward from either end of the post-oral bar and below the shafts of the mandibles, thus resembling the processes called paragnaths in *Cyclops*. These processes are usually covered with short stiff hairs.

In the interpretation of the other mouth-parts the literature dealing with this family has shown a wide divergence of opinion, due to a variety of causes. We may first mention the excessive minuteness of these appendages and the accompanying opacity of the cephalon. They are so small that it is practically impossible to make any dissection that will reveal the relation of the parts. One is compelled to study them actually in place and the opacity of the cephalon proves a serious obstacle. If the copepod be flattened sufficiently to push out the contents of the cephalon and let enough light through to render the mouth-parts visible, the latter are practically certain to be twisted or folded out of their natural shape. Furthermore most of the investigators have worked with preserved material in which such methods were impossible. Again, as Mr. Andrew Scott, esq., of the Fisheries Board of Scotland, who has done much excellent work upon both parasitic and free-swimming copepods, has well said in a letter to the author: "It has simply been a case of 'follow my leader' with many writers." They have either been unable to personally examine these mouth-parts, or they have come to such an investigation with preconceived ideas of what ought to be found, and of course have been unable to see anything else.

Some of them have had the good sense to content themselves with a very meager notice of the mouth-parts thus examined, or have even said nothing at all about them. But others have felt obliged to describe in some detail these organs which they have seen only in figures, or have examined through "colored spectacles."

Then there has been trouble arising from the degeneration of the mouth-parts, and the consequent abortion or disappearance of some of them. In the Ergasilinæ the maxillipeds have entirely disappeared in the female, while the first maxillæ are so rudimentary as to require careful search to detect them. In the Bomolochinæ the maxillipeds are abortive in position, and the first maxillæ are again so rudimentary as to have escaped the observation of such investigators as Heller, Bassett-Smith, and others. In the genus *Tucca* none of the mouth-parts have ever been described or figured.

In the Tæniacanthinæ the maxillipeds are often fused so thoroughly to the head as to be immovable, while the first maxillæ are as degenerate as in the other subfamilies. None of these causes ought to be effective when acting alone, but their combination has proved very difficult to overcome. The following table states briefly the name of the investigator, the species described, and the name given to each of the appendages; a blank indicates that the author made no mention of the appendage in question.

Author.	Species described.	Mandible.	Maxillary hook.	1° maxilla.	2° maxilla.	Maxilliped.
Burmeister, 1833.	<i>Bomolochus bellones</i> .	Tooth.	Wanting.	Tooth.	Tooth.	2° maxilliped.
Claus, 1864.	<i>Eucanthus balistæ</i> .	Mandible.	Haken.	Maxilla.	1° maxilliped.	Hornhaken.
Heller, 1865.	<i>Bomolochus megaceros</i> .	1° maxilliped.	Wanting.		2° maxilliped.	2° maxilliped.
Heller, 1865.	<i>Bomolochus gracilis</i> .	Mandible.	H a k i g e r		1° maxilliped.	
			S e i t e n a n-			
			h a n g.			
Hartmann, 1870.	<i>Bomolochus belones</i> .	Mandible.	Wanting.	M a n d i b u l a r	1° maxilliped.	2° maxilliped.
				palp.		
Sumpf, 1871.	<i>Tæniacanthus carchariæ</i> .	Mandible.	Chitenhaken.	Maxilla.	1° maxilliped.	2° maxilliped.
Claus, 1875.	<i>Ergasilus sieboldii</i> .	Mandible.	Wanting.	Maxilla.	1° maxilliped.	Wanting in ♀.
Wright, 1882.	<i>Ergasilus centrarchidarum</i> .	Mandible and maxilliped.	Wanting.	Maxilla.	1° maxilliped.	Wanting in ♀.
Fellows, 1888.	<i>Ergasilus chautilaquaënsis</i> .	Mandible and maxilliped.	Wanting.		1° maxilliped.	2° maxilliped in ♂.
Bassett-Smith, 1898.	<i>Bomolochus triceros</i> .	Mandible.	Wanting.			Hamulus.
Bassett-Smith, 1898.	<i>Bomolochus tetradontis</i> .	Mandible.	Hamulus.		1° maxilliped.	2° maxilliped.
T. Scott, 1902.	<i>Bomolochus soleæ</i> .	Mandible.	Wanting.	Maxilla.	1° maxilliped.	2° maxilliped.
Gadd, 1904.	<i>Ergasilus sieboldii</i> .	Maxilla.	Wanting.	M a x i l l a r y	Maxilliped.	Wanting in ♀.
				palp.		
Brian, 1906.	<i>Pseudoecanthus aloseæ</i> .	Mandible.	Wanting.		1° maxilliped.	2° maxilliped.
Brian, 1906.	<i>Bomolochus murænae</i> .	Mandible.	Wanting.	Maxilla.	1° maxilliped.	2° maxilliped.
Brian, 1906.	<i>Anechistrotos gobii</i> .	Mandible.	H a m u l u s	Maxilla.	1° maxilliped.	2° maxilliped.
			l a t e r a l i s.			

From this list it can be seen that each mouth-part has borne at least three different names, while the first maxillæ in the genus *Ergasilus*, and in many species of the genus *Bomolochus* have been overlooked by every author except Claus and Gadd. Both of these investigators describe the same species, *Ergasilus sieboldii*, but give very different names to the mouth parts, as can be seen.

Such being the conditions it remains to determine the correct names for the various appendages, and to state the reasons for the decisions made.

The mandibles.—Most of the authors are agreed that the first pair should be called mandibles. Heller designates them thus in his *Bomolochus (Irodes) gracilis*, but calls the same organs in *B. megaceros* first maxillipeds. In the latter case he claims to have found the mandibles entirely inside of the mouth. If this be true it is the only instance in the entire family, and would at least be worthy of a generic distinction. This, and the fact that Heller wholly overlooked the first maxillæ, while he contends that the maxillipeds correspond to the first maxillæ in *Caligus* and *Lepeophtheirus*, enable us to dismiss his objection as a case of mistaken identity. (See p. 384.)

Wright (1882) and Fellows (1888) call the first pair of appendages mandibles, but the palps attached to them they call maxillæ. This is easily explained from the fact that neither of them found the true maxillæ, and hence they were forced to substitute something for them.

Gadd (1904) describes and figures the mouth-parts of *Ergasilus sieboldii* and claims that the first pair of appendages are maxillæ, and that the true maxillæ are their palps.

As reasons for his belief, he declares (a) that the latter are attached to the former in the manner of palps; (b) that some forms like the genus *Lichomolgus* (which he includes in the Ergasilidæ) possess a rudimentary sucking mouth with inclosed mandibles. Hence if there were any mandibles in *Ergasilus* they would be inside the mouth, where Heller claimed to have found them for *Bomolochus*. And the fact that there are none there means that they have degenerated enough to have disappeared. This sounds plausible, but any assurances the text may have given us are quickly dispelled when we come to examine Gadd's figures.

After all an author's illustrations give us the best idea of what he has really seen; the text may contain much that is imaginary in the way of interpretation.

Gadd figures the mouth-parts of two species which he refers to the genus *Ergasilus*. The first, which he calls *E. biuncinatus*, apparently belongs to the genus *Thersitina*, but however that may be, he has figured the mouth-parts *upside down* (pl. 1, fig. 19). That is to say, the "maxilliped" is placed above (in front of) the "maxilla" on

the plate, and both appendages are inverted. If the figure be turned so as to bring the appendages into their proper positions, then the "maxillary palp," as Gadd designates it, is in front of (anterior to) the maxilla, which is not where such a palp belongs. The second figure (pl. 1, fig. 23) represents the mouth-parts of a female of *E. sieboldii*.

This figure is turned down on its side, and must represent the left side of the mouth parts, as seen in a somewhat diagonal view, partly ventral and partly lateral. Here the "maxillary palp" is behind (posterior to) the "maxilla," and there are two "first maxillipeds," exactly alike and attached one behind the other, which is rather difficult to explain.

Moreover the basal joint of the true mandible (which Gadd calls a maxilla) is not represented at all, but in the figure the appendage looks as if it were attached directly to the upper lip. In the face of such radical mistakes we can only conclude that Gadd's observations were inaccurate, and hence his arguments lose their power.

That this first pair of appendages are true mandibles is evidenced by the following facts:

1. They are the first or anterior pair, are situated in just the right position with reference to the upper lip, and correspond exactly in all the genera belonging to the Ergasilidæ.

2. If they are maxillæ, then the mandibles are lacking, a condition occurring nowhere else among the parasitic copepods and contrary to the facts established by degeneration.

3. In the great majority of species they project into the mouth under the upper lip (see figs. 9 and 10). They are thus partially, and in some species almost wholly, inclosed, a condition which would be anomalous for the maxillæ, but just what we should look for in mandibles.

4. Comparison with free-swimming forms shows that the organs under discussion are analogous in structure and position with the mandibles of the latter.

5. In genera like *Taenacanthus* and *Anchistrotos*, where all the mouth-parts are present, we are certain that this first pair must be mandibles. If so, they are also mandibles in the other genera.

The maxillary hooks.—These are present only in the genera belonging to the subfamily Taeniacanthinæ, where they have been described by Claus (1864), Heller (1865), Sumpf (1871), Bassett-Smith (1898), and Brian (1906). Each of these authors has given them a different name, although the general meaning of the names is the same. (See table, p. 278.)

Heller and Brian state positively that these appendages correspond to the ones found in *Caligus* and *Lepeophtheirus*, and the other authors tacitly agree to this by giving them the same name that each

bestows upon the corresponding organ in the Caligidæ. But A. Scott (1901, pp. 10 and 25) has shown by a careful study of the innervation that these organs in *Lepeophtheirus* are probably the first maxillæ, or some portion of them, migrated from their normal position beside the mouth and transformed into prehensile organs.

• He called them the first maxillæ, and the other pair close to the mouth the second maxillæ. The present author, confirming Scott's observations by an examination of other species of *Lepeophtheirus* (*edwardsi* and *salmonis*) and also certain species of *Caligus* (*rapax* and *bonito*), adopted the same nomenclature in dealing with the Caligidæ (1905, p. 499).

But in both instances these names were given upon the assumption, put forward by Claus and others, that the two posterior pairs of mouth-parts were the exopod and endopod of one and the same appendage. Hansen, however, discovered in the larvæ of certain marine copepoda (*Eucalanus*, *Pontella*, etc.), whose body is more elongated than usual, that the two appendages are entirely distinct. Furthermore the posterior pair arise behind the suture line which separates the head from the first thorax segment. Hence they belong to the latter segment and are true maxillipeds, while the anterior pair become maxillæ. These observations have been confirmed by Giesbrecht and by Claus himself upon the same or similar long bodied larvæ. They are also confirmed in the present paper upon the larvæ of *Ergasilus centrarchidarum* (p. 323). But this definite proof that the posterior mouth-parts are thoracic, while the pair just in front of them are cephalic, makes one of two things necessary. Either there are three pairs of maxillæ in some copepod genera, or the first two pairs are different portions of the same pair. The latter seems much the more probable for several reasons: 1. When completely developed (Calanidæ, Pontellidæ, etc.) the first maxillæ are made up of a distinct endopodite, exopodite, and epipodite, while the protopodite is produced internally into a large masticatory lobe. 2. In all those genera possessing these lateral hooks, the first maxillæ consist of but a single one of these parts, or at the most two of them, and are very rudimentary. The lateral hooks might well be one of the other parts, say the exopodite, migrated outward a little toward the lateral margin of the carapace, while the endopod has remained in close proximity to the mouth. In the Caligidæ the two parts are opposite each other, while here in the Ergasilidæ the outer one remains where it first appears in the metanauplius stage and the inner one migrates backward with the other mouth-parts. 3. The two nerves which supply these appendages are distinct to their very origin in *Lepeophtheirus pectoralis* according to Scott. In *Lepeophtheirus edwardsi* they are united for a short distance from their origin, while in some *Caligus* species they are distinctly branches from a common trunk.

This furnishes a strong argument in favor of the community of origin of the appendages themselves.

This question can be definitely settled only in the same manner as was the origin of the two posterior pairs of appendages. Some species possessing these lateral hooks will give us a larva on whose body the two appendages in question can be traced to their origin. In the meantime we can only say that the hooks in the Ergasilidæ certainly correspond to the similar appendages in the Caligidæ.

They appear to be situated farther forward, but this is largely due to the backward migration of the mouth-parts. For the present, then, we are justified in calling them maxillary hooks and in regarding them as closely related to the first maxillæ.

The first maxillæ.—These were first described for the genera *Bomolochus* and *Eucanthus* (*Anchistrotos*) by Claus in 1864 who designated them correctly as maxillæ, and they have been thus recognized in these genera by all subsequent investigators. In 1875 Claus described the corresponding appendages in the genus *Ergasilus* and called them also maxillæ.

But in this latter genus they have been either overlooked by other authors, or when seen (Gadd, 1904) have been regarded as palps of the mandibles. That they are distinct appendages, although very rudimentary, appears certain from the following considerations:

1. In the genera *Tucca* and *Taeniacanthus* this pair of mouth-parts is separated by a considerable interval from those on either side of them. The space is wide enough to show that they are not attached to any other pair. But the fact that they are distinctly separate appendages here furnishes a strong argument that they are also separate in the other genera. Their juxtaposition is the result of a crowding together of the appendages during their backward migration, and does not indicate actual union.

2. Again, there is altogether too close an agreement in size, shape, position, and armature between these organs in the different genera, and in the two sexes of the same genus, to allow us to consider them as palps. Palps vary greatly in different species, to say nothing of different genera, and they usually show marked sexual variations. These appendages are not only present, but are practically identical in every species throughout the entire family, and thus furnish good proof of their disconnection.

3. Among the Caligidæ this pair of maxillæ show marked degeneration; the exopod is reduced in size and much simplified, while the endopod has degenerated in some species to a mere knob, armed with one or two setæ. Here in the Ergasilidæ the exopod has entirely disappeared from all the species if it is not to be found in the maxillary hooks, as just suggested, and the endopod has degenerated into a knob armed with setæ. The structure therefore is exactly what

we should look for as a result of degeneration in the maxillæ, but it is radically different from anything that can be found in the way of mandibular palps among either the parasitic or free-swimming forms.

4. Finally the mandibles in the genera *Tucca* and *Ergasilus* and in some species of *Bomolochus* already possess well-defined palps attached where one would expect to find them, at the tips of the basal joints and entirely distinct from these maxillæ. Hence the latter, if regarded as palps, would form a second pair on the same appendages and attached at the very base of the basal joints—an untenable supposition.

The second maxillæ.—Burmeister and Heller are the only two authors who have not agreed in calling this pair of appendages the first maxillipeds. But the following considerations identify them as maxillæ and not maxillipeds.

1. From the close relationship between the Ergasilidæ and free-swimming forms we should naturally expect the mouth-parts to correspond in origin and development. By reference to figures 34 and 37 it will be seen that this penultimate pair of mouth-parts arises in front of the suture which separates the head from the thorax, while the last pair arises behind it. The latter appendages therefore are thoracic in origin, and must be regarded as maxillipeds, while the former are cephalic and are just as surely maxillæ.

2. The correspondence of this third pair of mouth-parts with the second maxillæ in free-swimmers is further shown by their relation to the paragnaths in certain species (*Bomolochus soleæ*, *Artacolax sætiger*, etc.). The proximity of the base of the appendages to the paragnaths shows them to be identical with the second maxillæ of free-swimmers.

The maxillipeds.—Two facts have contributed to the confusion in regard to these mouth-parts. In the females of the genus *Ergasilus* they are entirely wanting, while in those of the genus *Bomolochus* they are abortive in position, being attached outside, and partly in front, of the other mouth-parts.

These two discrepancies have bothered many observers and have led to curious blunders. Burmeister failed to find them at all; Heller states plainly that they correspond to the maxillary hooks in *Caligus* and *Lepeophtheirus*; Bassett-Smith implies as much by designating them as "hamuli" and then applying the same term to the true maxillary hooks of *Bomolochus (Irodes) tetrodonis*.

That they are really maxillipeds, as Claus, T. Scott, Brian, and others have named them, seems conclusively proved by the following considerations.

1. Their position: The terminal hooks are situated far forward in the Bomolochinæ, even perhaps in front of the other mouth-parts, but we can not regard the appendage as attached there. Its posi-

tion must be determined by the basal end of the basal joint, even though that joint be fused with the ventral surface of the head for its entire length.

In the mature adult the second joint is usually called basal, but the proximal end of this joint is distinctly posterior to the other mouth-parts. Heller and Bassett-Smith both represent this correctly in their figures, but evidently failed to see its significance.

2. Their development: If we examine a half-grown female we find that these maxillipeds are really three-jointed, made up of two basal joints and a terminal claw. (See pl. 54, fig. 159.) In the mature female, carrying fully developed egg-strings, of the new species, *Bomolochus eminens*, both basal joints are still distinctly visible. (See pl. 53, fig. 151.)

Even the proximal end of the second joint, therefore, is not the true base of the appendage, but this is still farther back and directly behind the second maxillæ, in a position corresponding exactly to that in the male. To be sure, the appendage is turned outward instead of inward, and the second joint is turned forward outside of the other mouth-parts. But there can be no question that the basal joint is posterior to the second maxilla, and therefore this must be the maxilliped.

3. The analogy presented by the genera *Anchistrotos* Brian (*Eucanthus* Claus) and *Tæniacanthus* Sumpf. In each of these genera both pairs of maxillæ and the maxillipeds are present and in their normal position in the female as well as in the male. In *Anchistrotos* the second joint is free, but in *Tæniacanthus* it is fused solidly to the head.

Moreover, in the latter genus it is almost the exact counterpart of that found in the Bomolochinæ, a large triangular second joint and a terminal claw curved into an S-shape, but tipped with setæ. The similarity in shape and structure is sufficient to establish the identity of the appendages. In these two genera, therefore, they are unquestionably maxillipeds, and hence must be so regarded in the Bomolochinæ.

4. The analogy presented by the appendages of the male: This sex was discovered by Claus for the genus *Bomolochus* in 1864, and was found to possess large and powerful three-jointed maxillipeds, which were normally placed behind the other mouth-parts. The structure and position of these organs in the male are so typical that no one would think of calling them anything but maxillipeds. But when we come to examine them we find that their basal joints are attached considerably outside the other mouth-parts, in a position corresponding to that of the proximal end of the second joint of the same appendages in the female.

The one appendage is manifestly the homologue of the other; if we call it a maxilliped in the male, as its position, structure, and function plainly indicate, we must also call it a maxilliped in the female, even though it be degenerate, fused with the head, and considerably changed in form and apparent position.

Having determined here the names and relation of the several mouth parts, brief diagnoses will be given of them as actually found in the two sexes of a selected type under each of the three sub-families (see pp. 311, 350, and 382).

The swimming legs.—The first four pairs of swimming legs are biramose in each of the genera. The rami of the first pair vary greatly; in *Thersitina* and *Ergasilus* alone are they cylindrical and three jointed like those of the other legs.

In all the other genera they are flattened into lamellæ, obscurely jointed if at all, and with a fringe of large plumose setæ around the entire margin. The rami of the second, third, and fourth legs are alike in all the genera, slightly flattened, three or four jointed, and well armed with plumose setæ. The fifth legs are uniramose, rudimentary, and usually two jointed, with setæ only at the tips. A sixth pair of legs is present in most genera upon the genital segment, and are like those found in the same position in the Caligidæ, simple knobs, armed with spines or setæ.

The *Anal laminæ* are slender, cylindrical or flattened, and armed with the usual plumose setæ, one or more of which are greatly elongated, sometimes to half the length of the entire body.

THE MUSCULAR SYSTEM.

The Ergasilidæ have bodies which are much thickened in proportion to their breadth; furthermore, both the ovaries and oviducts are developed inside the cephalothorax.

Hence these copepods are not as transparent as the Caligidæ, and the musculature is usually obscure, especially in the sexually matured female. But in the young of both sexes the body remains flattened and the muscles can be determined with comparative ease. The general arrangement of muscles is very simple as will be seen from figure 11, and their function is the flexion or extension of one part of the body or appendage upon another.

There are no frontal plates like those in the Caligidæ, but there are corresponding flexor muscles. It was suggested under that family that the frontal plates were really the basal joints of the first antennæ, fused more or less completely with the frontal margin of the carapace.

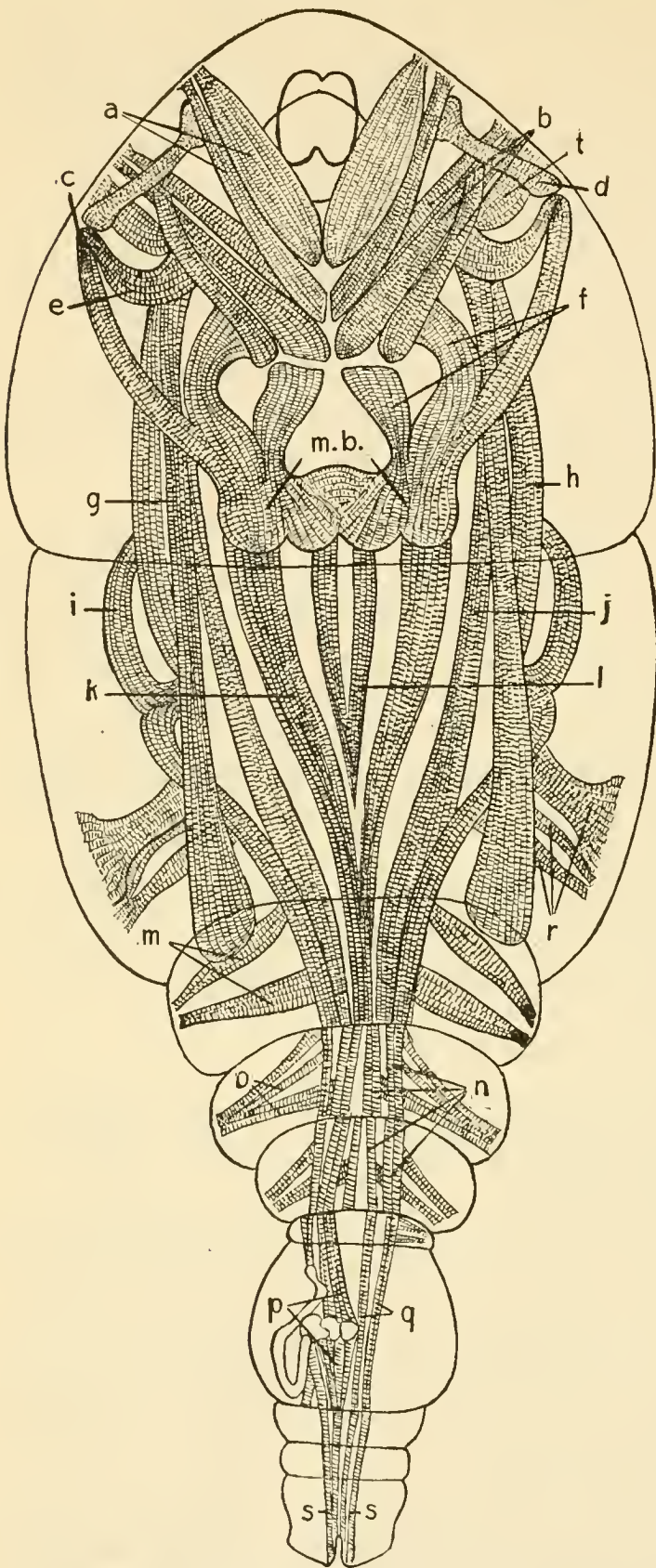


FIG. 11.—MUSCULAR SYSTEM OF *ERGASILUS VERSICOLOR* IN DORSAL VIEW. *a*, MUSCLES MOVING FIRST ANTENNA; *b* TO *f*, MUSCLES OF ENLARGED SECOND ANTENNÆ; *g* TO *l*, FLEXORS OF HEAD AND FIRST TWO THORAX SEGMENTS; *m*, *o*, AND *r*, MUSCLES MOVING SWIMMING LEGS; *m. b.*, TRANSVERSE MUSCLE BAND; *n*, FLEXOR MUSCLES OF THIRD AND FOURTH THORAX SEGMENTS; *p*, MUSCLES CONTROLLING THE OPENING OF THE OVIDUCT; *q*, FLEXOR MUSCLES OF FIFTH AND GENITAL SEGMENTS; *s*, FLEXOR MUSCLES OF ABDOMEN. *t*, ACCESSORY MUSCLE OF SECOND ANTENNA.

Here in the Ergasilidæ these plates are free and are very manifestly a part of the antennæ. They still perform the same functions, being partly tactile and partly prehensile. And we find them operated by a pair of powerful muscles (*a*) on either side, corresponding in position and function with those which operate the frontal plates of the Caligidæ. These muscles are particularly well developed in the Bomolochinæ, where the basal joints of the antennæ are considerably enlarged, and even in the opaque cephalothorax of the mature female they show up prominently in dorsal view. (Pl. 52, fig. 138.)

Behind these and parallel with them are three pairs of strong muscles (*b*), extending from the mid-line diagonally outward to the very edge of the carapace. These produce flexion of the margin of the carapace similar to that produced by the corresponding muscles in the Caligidæ. But there is not the same freedom of motion here, since there are no grooves between the cephalon and the lateral areas, and

so but little flexion. The chief use of these muscles is to act as shoulder flexors in moving the large second antennæ, and in accomplishing this they are assisted by four other muscles on either side. One of these (*e*) is parallel with them and removed some distance farther back. It extends from a point near the mid line diagonally outward and strikes the lateral margin a little behind the three just mentioned.

The second (*d*) starts from this marginal end of the first and runs forward and inward, nearly parallel with the carapace margin. The third (*e*) and fourth (*t*) are curved and extend from the junction of the first and second downward and inward to the base of the second antennæ. These seven muscles on either side thus form an armature sufficiently powerful to manipulate the large second antennæ.

The diagonal muscle (*e*) is united at its posterior end with a pair of broad and ribbon-like curved muscles (*f*), which occupy the center of the head on either side of the mid line, and form a dorsal muscular band (*m. b.*), which serves as a basis of support and attachment for the muscles already described. Just outside this band there is a single muscle (*g*) on either side, which is the longest in the body. It reaches from the base of the second antennæ back through the head and first thorax segment, and into the second thorax segment, to whose dorsal surface its enlarged posterior end is attached. This powerful muscle aids in controlling the second antennæ, and also produces flexion between the head and thorax. Exterior to this long muscle and parallel to it is a much shorter one (*h*), extending from the base of the second antennæ back nearly to the center of the first thorax segment. This muscle produces flexion of the head upon the first thorax segment, and is assisted in this by a curved muscle (*i*), which arises much farther back on the dorsal surface of the head and runs through the first two thorax segments. This last muscle is divided near the center of the first segment and attached to the dorsal surface of the latter. It thus produces flexion not merely between the head and first segment, but also between the first segment and the three which follow it.

The remaining dorsal muscles consist of three on either side of the mid-line, which originate some little distance apart at about the middle of the head and beneath the transverse muscle band, and which converge rapidly backwards.

The outer one (*j*) is narrow in front and widens a little posteriorly, reaching to the posterior border of the second thorax segment. The middle one (*k*) is wider in front and narrows posteriorly, and also stops at the posterior border of the second thorax segment. The inner one (*l*) is the same diameter throughout, but only reaches a little beyond the center of the first segment. These muscles all produce flexion between the head, the first and the second thorax segments.

They are followed by other similar muscles (*n*), approximately parallel to the median line and close to it on either side. These are arranged in series, three pairs extending from each segment of the thorax forward into the preceding segment, from whose dorsal surface they originate. They produce flexion of one segment upon another.

There is a single set of similar muscles (*s*) in the abdomen, extending from the anus forward into the genital segment, where they are attached to the dorsal surface of the latter.

This indicates that while the abdomen may be divided into segments by grooves, it nevertheless operates as a single joint, and there is no flexion between its parts.

For moving the swimming legs there is a set of two muscles, or rather two bundles of muscles, (*m*) extending out from the median line to the basal joint of each leg. The posterior bundle extends outward from the median line itself and nearly at right angles to it. The anterior one is more inclined to the body axis and seldom reaches the center of the segment.

In the case of the first pair of legs both muscles are diagonal (*r*), and extend in but a very little ways toward the center of the segment.

There are finally in the genital segment the muscles which control the genital openings (fig. 3). These openings are irregular in shape and are situated on the dorsal or partly on the lateral surface of the segment, near its posterior end. Each is surrounded by a thickened and somewhat chitinous border, which has the shape of a much twisted letter V. The point of the V is close to the posterior corner of the segment, while the arms extend forward. Each arm is bent inward near its center toward the median line and the inner ends are enlarged. The posterior arm extends farther forward before bending and is bent almost at a right angle, whose terminal branch is considerably shorter than the basal. The anterior arm is bent at an angle of 45°; its two portions are nearly equal, and the tip is prolonged anteriorly and posteriorly into a T shape. The muscles are attached to the ends of the V and are six in number in each half of

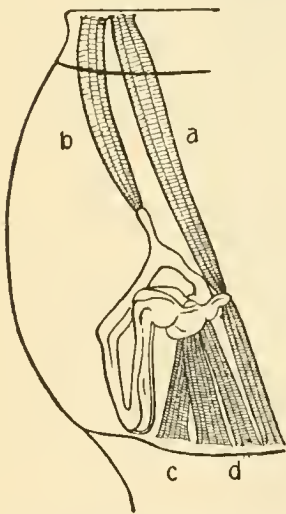


FIG. 12.—MUSCLES CONTROLLING OPENING OF OVIDUCT IN *ERGASILUS VERSICOLOR*. *a* AND *c*, CLOSING MUSCLES; *b* AND *d*, OPENING MUSCLES.

the segment, two extending anteriorly and four posteriorly. The two anterior muscles start from the outer anterior corner of the fifth segment and run diagonally backward and inward side by side. The outer shorter one (*b*) connects with the anterior horn of the T at the end of the anterior arm of the V. The inner and longer one (*a*) connects with the tip of the posterior arm of the V. Of the four pos-

terior muscles the first (*c*) runs from the posterior horn of the T backward and outward to the posterior corner of the segment. The other three muscles are attached to the end of the posterior arm of the V and run backward and inward side by side to the posterior margin of the segment. The working of these muscles to control the genital openings is simple; when muscles *a* and *c* contract the two arms of the V are pulled together and the opening is closed. When *b* and *d* contract the two arms are pulled apart and the opening is widened (fig. 12). In this manner the passage of the eggs outward into the external sacks is controlled.

If this muscular system be compared with that found in the Caligidæ, several conclusions may be drawn from the differences noted.

1. The lack of dorsal grooves on the carapace in the Ergasilidæ is emphasized by the entire absence of those internal muscles which in the Caligidæ produced more or less flexion between the different areas. There the carapace was made up of definite areas put together in such a way as to allow some motion between them. Here it is just as definitely one solid piece, with no possibility of motion between the various parts.

2. The fusion between the three anterior thoracic segments and the head in the Caligidæ is not as complete as is the fusion between the first segment and the head here in the Ergasilidæ. There the flexor muscles all stopped at the groove separating the head and first segment; here they all run past that groove without being changed in the least.

3. These facts magnify the value of the ability possessed by the Caligidæ to arch or depress the carapace and thus make of it an organ of prehension in the form of a large sucking disk. The subfamily Ergasilinæ can not use the carapace in this way at all. To compensate for this loss, witness the grouping of large and powerful muscles in the dorsal portion of the cephalon to control the enlarged second antennæ. These form a notable contrast to the comparatively weak set found in corresponding position in the Caligidæ.

4. The grouping of powerful locomotor muscles over the second and third legs in the Caligidæ show that these two pairs are the chief organs of propulsion. Here the locomotor muscles are distributed equally to the first four pairs of legs. Hence the latter must share equally in the propulsion of the copepod.

THE CÆLOM AND ITS CONNECTIVE AND MUSCULAR TISSUES.

The connective tissues within the cœlom loosely fill the entire cavity, leaving numerous irregular and scattered lacunæ. Being connected with the integument of the body wall, as well as with that which covers the various internal organs, they act as mesenteries to support the alimentary canal and reproductive organs (fig. 15).

In none of the specimens thus far examined do they show any structure. In many cases, especially in the youngest females found attached to the fish's gills and in nearly all the adults that are loaded with Vorticellidæ, these connective tissues are filled with oil globules, which are especially abundant between the stomach and the dorsal wall of the carapace. These globules vary in color from orange to rusty brown, but thus far they have never been found symmetrically arranged, as Hertog has noted in the morphology of *Cyclops* (1888, p. 21).

The muscles are all well striated and are made up exclusively of contractile substance without any nuclei or sarcolemma. The circular muscles which produce the peristaltic movements of the stomach and intestines are inserted in the outer layer of connective tissue surrounding those organs. The muscles which cross more or less of the cœlomic space are inserted directly in the epidermis, and so far as observed there are no tendons.

The cœlomic fluid is colorless and the corpuscles are amœbiform as in the free-swimming copepods. No heart is present, but the circulation of the cœlomic fluid is accomplished by the digestive system, as will be described under the latter.

THE DIGESTIVE SYSTEM.

The alimentary canal begins in a sort of mouth or oral cavity, bounded by the mouth parts and projecting lips. From this a narrow gullet passes upward and backward and opens into the stomach on the ventral surface of the latter a little in front of its center. The stomach is separated by a well-defined constriction at the posterior border of the second thoracic segment from the intestine, which in the abdomen passes insensibly into a rectum and ends at the anus, situated between the anal laminæ and nearer the ventral than the dorsal surface.

The mouth is bounded by the labrum in front and by the labium behind, both of which project from the ventral surface of the head, thereby increasing the size of the oral cavity.

Laterally the mouth is bounded by the sockets and bases of the mandibles and maxillæ; these mouth parts are described under each of the subfamilies.

The gullet leads directly from the mouth cavity upward and backward to the stomach; it is not bent at an angle as in *Cyclops*, but is evenly curved. It enters the stomach on the ventral surface of the latter, some distance behind the anterior end (fig. 15).

The stomach is a long and pear-shaped sac, extending back to the second (first free) thorax segment. The anterior end is considerably larger than the posterior, and from it rounded processes or lobes extend forward and sidewise, in all five in number (fig. 13). From the

center near the dorsal surface an unpaired lobe, nearly spherical in shape, extends forward and slightly upward (*a*). On either side of this and just below it an elliptical lobe extends downward and outward diagonally (*b*). From the ventral surface behind the bases of these paired lobes, another lobe (*c*), spherical or somewhat pointed, extends diagonally downward and outward on either side at right angles to the long axis of the stomach. These lateral lobes are firmly attached by a broad mesentery to the dorsal wall of the head, and do not move during the protraction and retraction of the stomach. Hence their shape remains practically unaltered and they can be discerned at all times.

The anterior end of the unpaired median lobe is attached by a pair of long narrow muscles to the dorsal wall of the head near its frontal margin. By these muscles during protraction the lobe is pulled forward almost to a level with the eye and narrowed accordingly (see fig. 15). The oblique lobes do not appear to be attached at all, or at the most very loosely, and during protraction they are obliterated, leaving only the median and the two lateral lobes in evidence. But during retraction they show distinctly.

In addition to these lobes at the anterior end, the dorsal surface of the stomach is also raised for its entire width in two rounded elevations, of which the anterior is about twice the size of the posterior.

The esophagus enters the stomach behind the base of the unpaired lobe, and between the bases of the first paired lobes.

At the posterior margin of the second thorax segment the stomach is differentiated from the intestine by a well-defined constriction. The whole of the median unpaired lobe, the first set of paired lobes, and the bulk of the second set project into the head, but the remainder of the stomach is within the first two thorax segments.

Two narrow anterior levator muscles run from the upper surface of the stomach forward and upward and are inserted in the dorsal wall of the carapace, just in front of the line of demarcation between the head and first thorax segment.

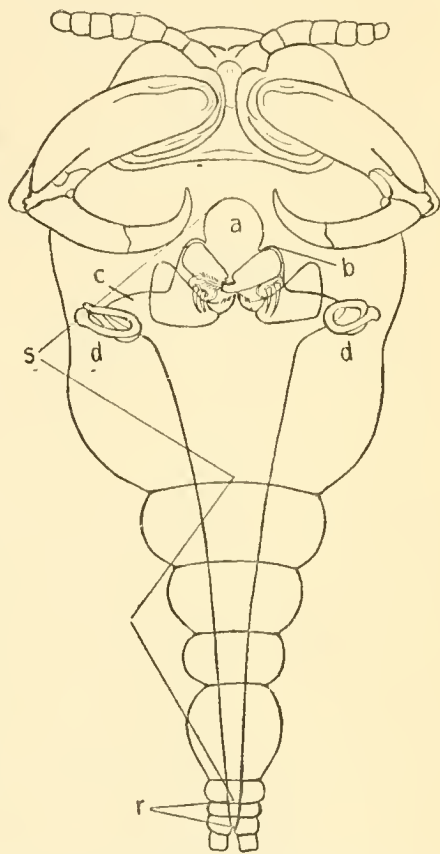


FIG. 13.—VENTRAL SURFACE OF FEMALE ERGASILUS CENTRARCHIDARUM. *a*, MEDIAN LOBE OF STOMACH; *b*, DIAGONAL LOBE; *c*, LATERAL LOBE; *d*, EXCRETORY TUBES; *i*, INTESTINE; *r*, RECTUM, *s*, STOMACH.

Two posterior levators run from the posterior dorsal wall of the stomach backward close together on either side of the mid-line, and are inserted in the dorsal wall of the third thorax segment. The movements of the stomach and intestine show clearly that there must be depressor muscles, anterior and posterior, connected with the ventral walls, and similar to those found by Hertog in *Cyclops*.

But owing to the opacity of the ventral portion of the body it has been impossible to distinguish them in a living *Ergasilus*, and they can not be positively identified in any of the sections thus far examined.

The contents of the stomach just after the parasites have eaten consists of a rusty brown granular mass, usually quite opaque and filled, especially in the anterior portion, with small spherical globules. Both the color and the globules diminish toward the posterior end, and by the time the contents have reached the intestine they become clear and transparent.

The intestine is a cylindrical tube starting from the ventral surface of the stomach and running backward through the rest of the thorax and the abdomen to the anus.

It tapers rapidly in the second and third thorax segments and also descends toward the ventral body wall. For the rest of the distance it is about uniform in diameter, but the relative size varies greatly with the peristaltic movements.

Generally there is a noticeable enlargement in the genital segment, due to the presence of food that has not yet been fully digested. Sometimes specimens may be found which have died with the circular muscles of the intestine wall in a state of rigid contraction. In such instances the intestine appears of the same diameter throughout, and looks like a string of flattened beads.

At or near the posterior end of the second abdominal segment the intestine passes insensibly into the rectum. The latter is a very short and thin walled tube, connected with the walls of the abdomen by stout retractor and protractor muscles. These produce the opening and closing of the rectum which is concerned in anal respiration, as has been repeatedly observed in living specimens under the microscope, and prove that this form of respiration obtains in the Ergasilidæ as well as in the Argulidæ, Caligidæ, and all the free swimmers.

There is apparently only one anal valve in the dorsal wall of the rectum near the anterior margin of the second abdomen segment, instead of the two noted by Hertog in *Cyclops*.

By means of the levator and depressor muscles already described the stomach and intestine are moved backward and forward in regular rhythm, the anal valve opening and closing in unison. In this way the coelomic fluid is moved forward in the dorsal chamber and backward in the ventral chamber, constituting the only circulation perceptible.

The kidneys.—There are two excretory organs (*d*, fig. 13), one on either side, lying near the lateral margins of the carapace and just above the lateral lobes of the anterior end of the stomach, and partially concealed by them. Each is a simple tube, coiled once into a horseshoe shape, the long diameter of the coil at right angles to the body axis. The coils differ somewhat in different specimens as can be seen in figure 14, *a* and *b*. The blind end (posterior) of the tube is a little enlarged; the other end is usually coiled once, in some individuals around the blind end, in others free from it, and then passes into the duct which leads forward and inward toward the maxilliped, and apparently opens just behind the base of the latter. This organ was first described by Zenker as opening near the mouth and probably a poison gland; it was identified by Claus and Leydig with the “schalendruse” of Phyllo pods, and Claus showed that it opened on the base of the second maxillipeds in Phyllo pods and behind the single maxilla in Cladocera, where it also opens in *Ergasilus*.



FIG. 14.—EXCRETORY TUBES OF ERGASILUS CENTRARCHIDARUM. *a* AND *b*, FROM DIFFERENT INDIVIDUALS.

These tubes can be seen in living specimens, but are usually indistinct, owing to the opacity of the contents of the body cavity and the stomach. Often they can not be discerned at all, but occasionally in freshly killed specimens they show up with great distinctness, this being largely a matter of chance rather than skill. In such cases the coiled tube and the duct leading from its anterior end can be easily followed. The contents of the tube and duct are both colorless and structureless. Furthermore the tube is not fastened in place very securely, and frequently becomes displaced under pressure, turning either backward or forward indiscriminately. On the bursting of the body wall under continued pressure this kidney tube passes out of the body with the first loose material that escapes.

Accessory glands.—The only accessory glands to the alimentary canal are what may be called the salivary glands, which surround the esophagus for its entire length (fig. 15). These are made up of elongated pear-shaped cells, the larger rounded ends lying nearest the esophagus and the smaller pointed ends extending away from it. The nuclei are large and spherical and stain deeply with hæmatoxylin. They lie in the larger ends of the cells, close to the esophagus. The cells which are dorsal and ventral to the large nerve ganglia are considerably increased in size; those which lie between the nerve ganglia and the esophagus are smaller.

There is apparently no arrangement into paired masses with a distinct duct, but the cells are thrown together loosely and irregularly. From their structure and staining, however, there can be no doubt they are glandular in nature and that they contribute to digestion.

As can be seen in figure 15, the stomach wall is made up of an outer muscular coat composed of fine muscle fibers arranged in a thin connective tissue. This is lined by an endothelium of large nucleated cells, which covers the entire inner surface of the stomach and extends into all the lobes.

There is no differentiation of the anterior third of the stomach by a thin chitinous cuticle, thrown up into longitudinal folds, and corresponding to the chitinized gizzard found in other crustacea. The only noticeable difference is that the cells toward the posterior end of the stomach are larger and more columnar, while those at the anterior end are smaller and more of a pavement epithelium.

Scattered about among the columnar cells at the posterior end are a limited number of much larger vacuolated cells which project into the stomach cavity (*gc.*). Their free ends are rounded and filled with large spherical or ellipsoidal masses which stain deeply with eosin. This suggests that they probably correspond with the so-called fat globules found by Hartog in the cells of the posterior portion of the stomach of *Cyclops*.

THE NERVOUS SYSTEM AND SENSE ORGANS.

General structure.—The nervous system is made up, as usual, of two ganglia connected by a commissure around the esophagus, and a ventral cord which reaches to about the center of the genital segment. But the structure and arrangement of these different parts presents many striking peculiarities (fig. 15). In the first place, the backward migration of the mouth and esophagus has carried the two ganglia and the connecting commissure along the ventral surface to the extreme posterior margin of the cephalon. This, coupled with the fact that the eye is in actual contact with the ventral surface, has removed every portion of the nervous system from the dorsal part of the body. Ganglia, nerve cord, commissures, and sense organs are as completely ventral as they are dorsal in any vertebrate. The ordinary terms *supra* and *infra* are hence rather out of place when applied to the respective ganglia; *præ* and *post* become far more appropriate.

Furthermore, as a result of this backward migration, or from other causes, each of the ganglia is enormously elongated, so that together they extend practically the entire length of the cephalothorax. They thus become more markedly the ventral counterpart of the dorsal nerve cord in vertebrates.

Præesophageal ganglion.—This is a long and club-shaped mass, extending from the esophagus to the anterior end of the stomach. It is strongly flattened dorso-ventrally, of about the same width for the posterior two-thirds of its length, then tapers rapidly into the comparatively long optic nerves, which lie side by side and partially

fused, and extend to the eye, striking the latter at the level of the ventral surface of the two dorsal ocelli. The cellular elements form a thick superficial layer over the posterior two-thirds of the ganglion, then become abruptly scanty, the optic nerves being composed almost wholly of fibers, with only a very few scattered nuclei among them. The whole center of the ganglion is a broad ribbon-like mass of fibers. The nuclei are also absent from the lateral and dorsal surfaces at the posterior end where the ganglion passes into the commissures, and this portion shows exclusively a fibrous structure. Some of the fibers can be seen to cross from one commissure to the other, or from the commissure on one side diagonally to the ganglion on the opposite side, but there is apparently no definite grouping of either the fibers or the nuclei. From the anterior end of the ganglion, on either side of the optic nerves, are given off the nerves to the first antennæ, which run forward just outside of the lateral ocelli. At the point of their origin the ganglion is somewhat swollen laterally and contains a number of nuclei.

From the dorsal surface of the ganglion, just in front of the stomach, arise the two short frontal nerves which supply the anterior portion of the head, the so-called frontal region.

From either side of the ganglion, a little posterior to the

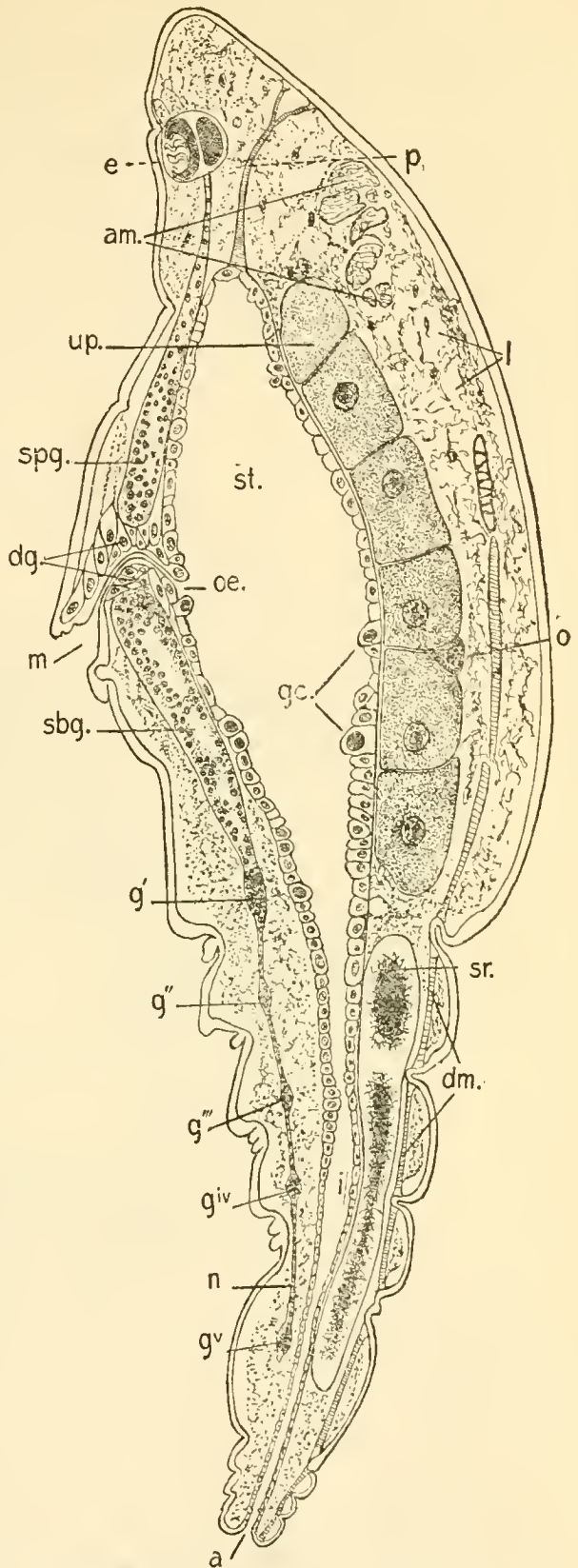


FIG. 15.—MEDIAN LONGITUDINAL SECTION OF ERGASILUS CENTRARCHIDARUM. *a*, ANUS; *am*, MUSCLES OF SECOND ANTENNÆ; *dg*, DIGESTIVE GLAND; *dm*, DORSAL MUSCLES; *e*, EYE; *g'* TO *g^v*, GANGLIA OF THORACIC AND GENITAL SEGMENTS; *gc*, GLAND CELLS; *i*, INTESTINE; *l*, LACUNÆ; *m*, MOUTH; *n*, VENTRAL NERVE CORD; *o*, ANTERIOR END OF OVARY; *ce*, ESOPHAGUS; *p*, PROTRACTOR MUSCLES OF STOMACH; *sbq*, POST (SUB) ESOPHAGEAL GANGLION; *spq*, PRÆ (SUPRA) ESOPHAGEAL GANGLION; *sr*, SEMEN RECEPTACLE; *st*, STOMACH; *up*, UTERINE PROCESS OF OVARY.

front end of the stomach, are given off the large nerves which supply the second antennæ. The ganglion is much swollen at the bases of these nerves and plentifully supplied with nuclei. From the posterior ventral corner of the ganglion close to the esophagus a short and rather swollen azygos nerve extends downward and backward to the labrum. This posterior portion of the ganglion is perforated, as in *Cyclops*, by muscles connected with the mouth-parts.

The circumesophageal cord.—This is made up of two lateral portions, connecting anteriorly and posteriorly with the ends of the ganglia. It is approximately parallel with the body axis and con-

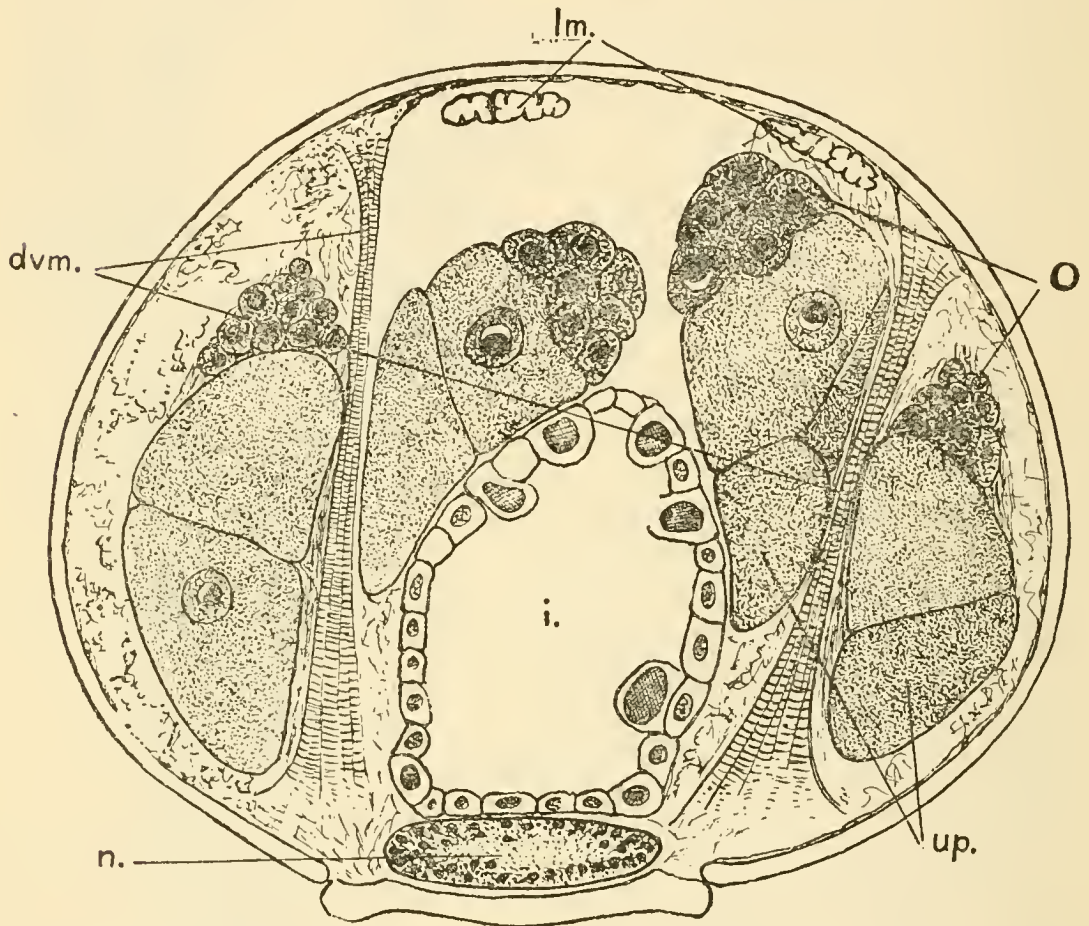


FIG. 16.—TRANSVERSE SECTION THROUGH THE CARAPACE OF *ERGASILUS CENTRARCHIDARUM* BEHIND THE MOUTH. *dvm*, DORSO-VENTRAL MUSCLES; *i*, STOMACH; *lm*, LONGITUDINAL MUSCLES; *n*, VENTRAL NERVE CORD; *o*, UNDEVELOPED EGG CELLS OF OVARY; *up*, UTERINE PROCESSES.

nects the dorsal portions of the ganglia only for about two-thirds of their depth. Each lateral portion is nucleated on its outer surface, leaving the inner surface next to the gullet and the dorsal surface next to the stomach made up of fibers only. It thus possesses the same elements as the ganglia and has been given the name of cord, as suggested by Hartog. Since it has been moved so far back by the migration of the mouth-parts, it could not be expected to give immediate origin to the nerves that supply the second antennæ. Whether any of the fibers of those nerves can be traced backward along the ganglion to the commissure can not be determined with

the material at hand. But the numerous nuclei in the swellings at the bases of those nerves would indicate that some of the fibers at least originate there.

The postesophageal ganglion.—This is also club-shaped in lateral view, but strongly flattened dorso-ventrally. It extends from just behind the gullet to the posterior margin of the first thorax segment, and is made up exactly like the ganglion in front of the gullet. There is a swelling at its posterior smaller end from whence arise the nerves that go to the first swimming legs. From the anterior end of the ganglion are given off nerves which supply the mandibles, the two pairs of maxillæ and the maxillipeds in the male. While the nuclei are noticeably increased in number at the posterior swelling that gives rise to the nerves of the first legs, there are only slight

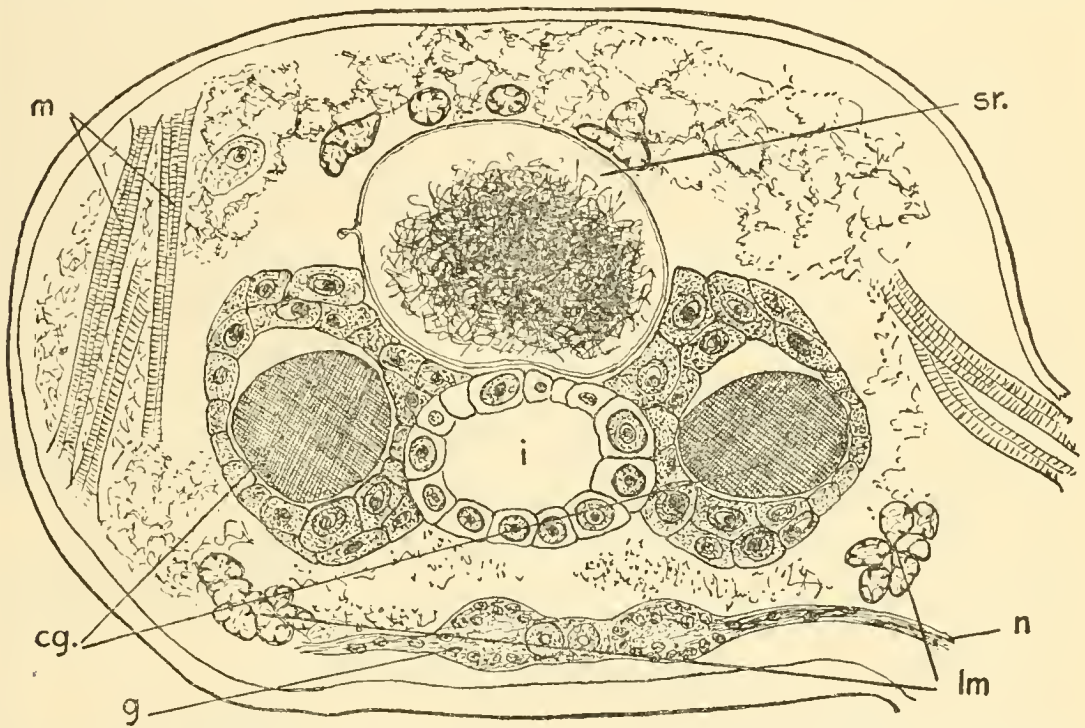


FIG. 17.—TRANSVERSE SECTION THROUGH THIRD THORACIC SEGMENT OF ERGASILUS CENTRARCHIDARUM. *cg*, CEMENT GLAND; *g*, GANGLION OF THIRD SWIMMING LEGS; *i*, INTESTINE; *lm*, LONGITUDINAL MUSCLES; *m*, DORSO-VENTRAL MUSCLES OF THIRD LEGS; *n*, NERVE OF THIRD LEG; *sr*, SEMEN RECEPTACLE.

differences in other parts of the ganglion. Accordingly we may look upon it as a complete fusion of the various ganglia that supply the mouth-parts (*n*, fig. 16).

The ventral cord.—This extends from the end of the posterior ganglion back into the sixth or genital segment, where it divides into two branches which finally end in the anal laminae.

For the entire distance through the thorax it is evidently made up of two cords lying side by side and partially fused. This is most evident at the ganglionic swellings which occur at the origin of the nerves going to the swimming legs (fig. 17). Here there is plainly a separate ganglion on either side (*g*), the two being connected by a

fibrous band in which a pair of giant fibers are visible. The nuclei are practically confined to these ganglia, and even in them they diminish greatly in number from in front backward, so that in the sixth segment it is often impossible to distinguish them. After dividing in the sixth segment the rami run alongside the intestine, giving off branches to the trunk muscles. Toward the posterior end of the abdomen each ramus divides into a dorsal branch going to the anus and a ventral one going to the anal lamina. In each segment of the thorax a pair of nerves is given off to the trunk muscles in addition to those going to the swimming legs.

The eye.—The eye of *Ergasilus* is situated far forward in the frontal region and in immediate contact with the ventral surface (fig. 15). It consists of three hemispherical ocelli, two lateral and one infero-median, imbedded in sockets lined with pigment. Each ocellus is composed of a number of rounded fusiform cells, arranged radially and containing a nucleus near their outer end. The central mass is divided by two partitions, one superomedian, separating the lateral ocelli, the other infero-horizontal, separating the lateral ocelli from the inferior one. The latter looks directly downward on the ventral surface, which bulges slightly outward at this point and probably serves as a cornea. The lateral ocelli also face downward and only slightly outward, and no separate corneal facets for them can be detected.

Summary.—1. The entire nervous system, including both ganglia, the ring around the gullet, the cord, and the eye, is exclusively ventral in position and lies close to the ventral surface.

2. Both the præ and the postesophageal ganglia are enormously elongated, so that together they extend the entire length of the stomach.

3. The ring around the gullet contains cellular as well as fibrous elements, and is therefore a cord rather than a commissure.

4. The nerves supplying the second antennæ originate from the anterior end of the præesophageal ganglion.

5. The ventral cord is really a pair of cords lying side by side and connected by a fibrous band with two giant fibers.

6. Both ganglia are perforated in the vicinity of the gullet by muscles extending to the mouth-parts.

REPRODUCTIVE ORGANS.

In the female the reproductive organs consist of a paired ovary, convoluted oviducts, and a pair of shell glands; the oviducts lead backward on either side to the vulva, which opens on the dorsal surface of the genital segment, while the shell glands extend forward from the genital segment into the free thorax (fig. 21).

The ovaries are small egg-shaped bodies situated on either side of the anterior portion of the dorsal surface of the stomach. Each consists of a mass of small nucleated cells, the ova, which are formed by kariokinetic division at the posterior, free end of the ovary, and gradually pass out into the oviduct which is given off at the wider anterior end. The body of the ovum accumulates yolk granules and increases greatly in size as it passes into the oviduct. The latter seems to be an outgrowth from the ovary as in free-swimming forms. At first it is a simple tube without convolutions, extending backward to the genital segment.

But as the ova issue into it out of the ovary it rapidly sends out uterine processes backward and forward and laterally until in fully mature specimens it fills the entire dorsal portion of the carapace with a mass of opaque white ova tightly packed together. The gradual growth of these uterine processes is well shown in the series of figures (18 to 24) here-with presented.

At first a single large ovum appears in either oviduct just behind the suture which marks the division between the head and first thorax segment, and some little distance from the mid-line (fig. 18).

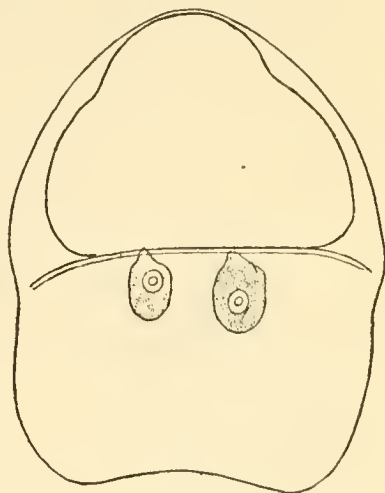


FIG. 18.—DORSAL VIEW OF CARAPACE OF ERGASILUS CENTRARCHIDARUM, SHOWING POSITION OF FIRST TWO EGG CELLS THAT ISSUE FROM THE OVARY.

These ova then extend backward through the first thorax segment to its posterior margin (fig. 19). They next accumulate at the point where they first appeared and push forward into the head, approaching each other on either side of the mid-line (fig. 20). Again accumulating at the same point, each oviduct sends out a lateral process which extends obliquely forward and downward toward the base of the second antenna (fig. 21). The entire portion within the first thorax segment now thickens, approaching close to the mid-line, and another lateral process is sent out in the posterior portion of the segment and

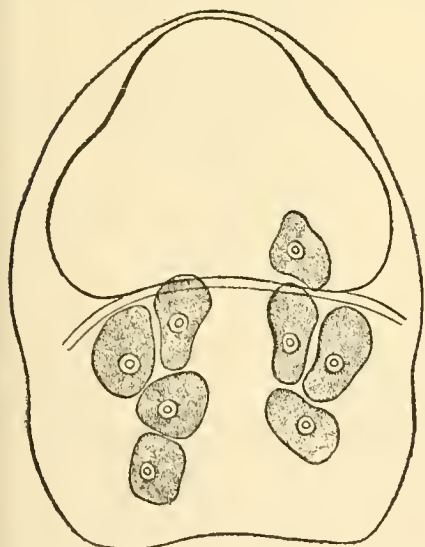


FIG. 19.—THE FIRST UTERINE PROCESSES FORMING POSTERIORLY THROUGH THE FIRST THORAX SEGMENT.

nearly at right angles to the body axis. This process also curves over ventrally and eventually approaches close to the ventral wall of the body (fig. 24). Each of these processes thickens laterally as well as increases in length (fig. 22), until eventually the space in the

cœlom at the top and sides and in front of the stomach is completely filled, the processes almost touching one another and those along either side of the mid-line approaching till they come in actual contact (fig. 23).

The first lateral process is the longest, while the last one given off is usually the thickest. These gravid processes not only fill all the available space in the cœlom, but their growth arches the dorsal surface of the carapace until it is strongly curved (fig. 24); indeed, it goes so far as to become practically spherical in *Thersitina*.

At the same time they push back the posterior margin of the carapace until it overlaps the second and sometimes part of the third thorax segments, giving the fully mature female very much the appearance of a tadpole, except of course for the egg-strings.

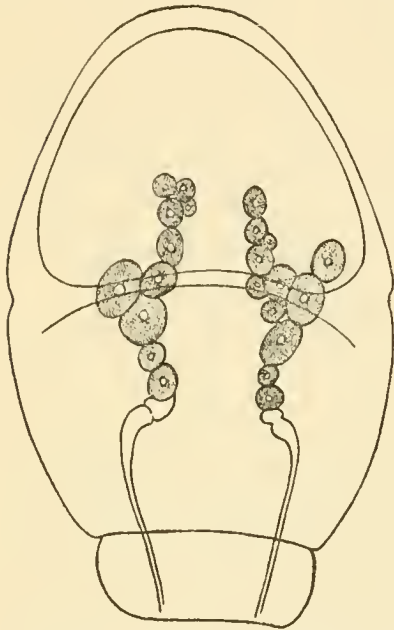


FIG. 20.—THE SECOND UTERINE PROCESSES FORMING ANTERIORLY IN THE HEAD; POSTERIORLY CAN BE SEEN THE OVIDUCTS CONNECTED WITH THE FIRST UTERINE PROCESSES.

Cement glands.—Unlike the free copepods, in which, according to Claus, Gruber, and Hertog, the cement or “Kittsubstanz” is contained in the posterior portion of the oviduct, *Ergasilus* possesses a pair of cement glands similar to those of the Caligidæ. These are situated in the posterior portion of the thorax on either side. Each consists of a long and narrow tube somewhat curved, the one facing the other like two parentheses marks, and each lying below the oviduct on its side (fig. 21). The tube is cylindrical, tapers somewhat anteriorly and posteriorly, and shows faint lines or grooves dividing it transversely into about a dozen segments (fig. 25). Its contents are colorless and structureless, but stain deeply with eosin in sections. At its

posterior end it narrows abruptly into a short duct, which opens into the oviduct close to the vulva. These shell or cement glands are difficult to discern in the living copepod, but preservation in weak formalin often brings them out quite clearly. On examining a section of one of these glands under a high power, it is seen (fig. 25, *b*) that the wall is composed of a single layer of columnar cells, whose nuclei are situated near the inner ends. These cells increase in length from the proximal toward the distal end of the gland.

There is a second increase at about the center of the gland, where the cells from opposite sides approach each other until only a narrow neck-like lumen is left between their inner ends. This probably represents the mouth of the really glandular portion of the organ, the remaining proximal portion being more of a duct. The entire

substance of these cells, and especially the nuclei, stain deeply with hæmatoxylin in strong contrast to the red secretion which fills the lumen of the gland.

Semen receptacle.—It is impossible to distinguish the semen receptacle in the living copepod, since it lies directly above the intestine, is of about the same width as the latter, and its walls are structureless and as transparent as glass.

In both transverse and longitudinal sections, however, it stands out prominently. It consists of a long cylindrical bag (fig. 15), extending from the middle of the genital segment forward through the free thorax to the posterior border of the first segment. This bag occupies the entire body cavity between the intestine and the dorsal wall of the thorax. It is somewhat narrowed at the center, where it passes the groove between the third and fourth thorax segments, and is enlarged at either end, more in front than posteriorly. It is very nearly the same diameter as the intestine, being wider anteriorly (fig. 17). At the posterior end it di-

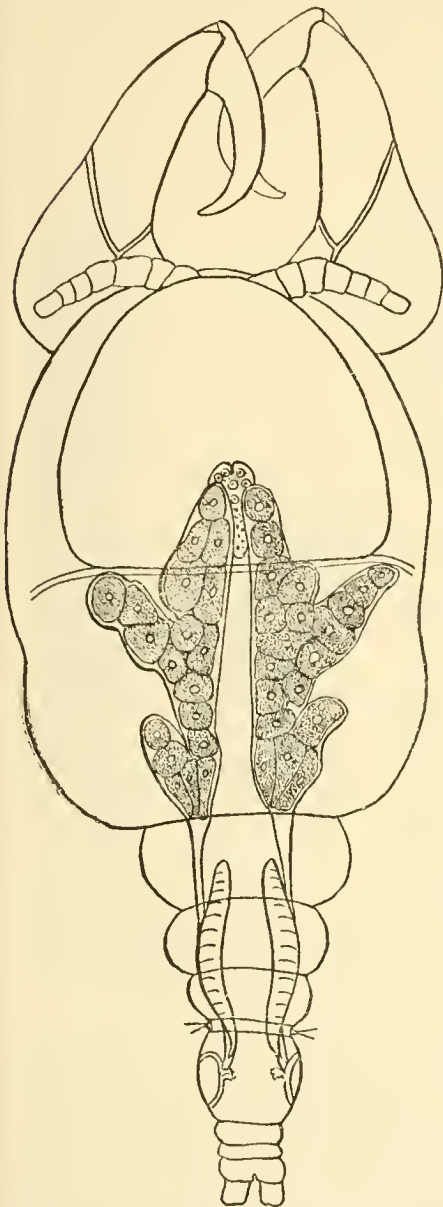


FIG. 21.—THE THIRD AND FOURTH OBLIQUE UTERINE PROCESSES, EXTENDING FORWARD AND DOWNWARD FROM THE OUTER SIDES OF THE FIRST PROCESSES. ANTERIORLY CAN BE SEEN THE FUSED OVARY AND POSTERIORLY THE CEMENT GLANDS.

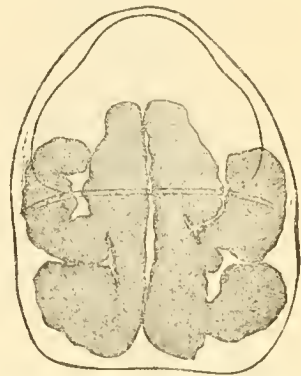


FIG. 22.—FULLY MATURED FEMALE OF ERGASILUSCENTRARCHIDARUM, SHOWING RELATIVE SIZE AND SHAPE OF COMPLETED PROCESSES IN DORSAL VIEW.

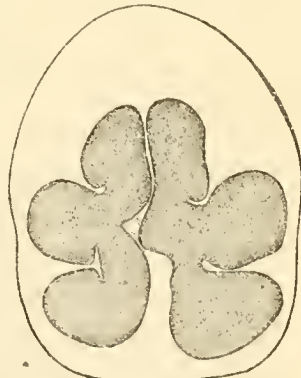


FIG. 23.—THE RELATIVE SIZE AND SHAPE OF COMPLETED PROCESSES AS SEEN IN VENTRAL VIEW.

vides, or, rather, sends out a tube on either side, which extends around the intestine ventrally and posterior to the genital openings. Each tube then turns forward and opens into the oviduct just before the latter reaches the os uterus or external opening. This extraordinarily large receptacle is entirely filled with spermatozoa in the living female, but they cling together and shrink away from the wall somewhat in preserved mate-

rial. Each spermatozoan has the general shape shown in figure 59, Plate 42.

The semen receptacle, the cement glands, and the intestine are firmly bound together by connective tissue in the position shown in figure 17, and are also suspended by the same tissue from the walls and sides of the thorax.

For the discharge of the contents of both the receptacle and the glands the contraction of the dorso-ventral muscles in each thorax segment may well contribute material assistance.

The size of this receptacle renders it practically certain that there is but a single union between the sexes, and that the female derives from this a sufficient quantity of sperm to fertilize all the eggs she can produce during her entire life.

Spermatophores can occasionally be found in position upon the bodies of very young females, but they soon disappear. Evidently they are full of spermatozoa when first attached, these spermatozoa are discharged into the semen receptacle of the female, and then the old shell of the spermatophore gradually decays, loosens, and finally falls off.

In the male the reproductive organs consist of a pair of testes which, like those in the Caligidæ, resemble the ovaries in their position, form, and size. They are situated close to the mid-line and just above the stomach. Each testis is somewhat ovate in form, the long diameter inclined at an angle of about 60° to the body axis, the small end of the oval turned forward.

From this small end is given off the vas deferens, which turns downward toward the ventral body wall and then backward and upward approximately parallel with the body axis to the posterior margin of the fourth thorax segment, where it empties into the semen receptacle (fig. 26).

In each segment of the thorax the vasa deferentia are convoluted or curved in toward each other at the anterior and posterior margins and away from each other at the center of the segment. They are

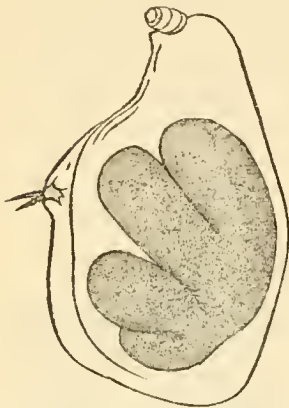


FIG. 24.—THE RELATIVE SIZE AND SHAPE OF COMPLETED PROCESSES AS SEEN IN LATERAL VIEW.

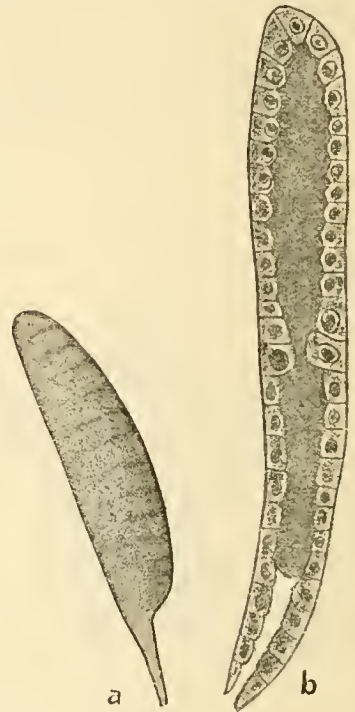


FIG. 25.—CEMENT GLAND OF ERGASILUS CENTRARCHIDARUM. *a*, DORSAL VIEW; *b*, LONGITUDINAL VERTICAL SECTION.

also somewhat enlarged in diameter at the center, which gives them a peculiar crenulated appearance. This structure shows more distinctly in the *Ergasilus* male (*E. chautauquaënsis*) than in *Bomolochus* (*B. soleæ*), but this seems to be the result of the greater transparency of the former rather than of any marked structural difference. Owing to the lack of material it has been impossible to determine with certainty whether there is any loop (epididymis, Hertog) in the vasa deferentia corresponding to that found in *Cyclops* and other free swimmers.

The bodies of the limited number of males examined by the author have been too opaque to show up the internal anatomy with any degree of distinctness. The testes could be located because they were opaque enough to show as dark spots, but the transparent ducts leading from them were so nearly invisible for much of the distance as to leave it in doubt whether they formed a loop or not.

In *Bomolochus soleæ* the semen receptacle is somewhat cigar-shaped, and occupies practically the whole of one side of the fifth segment and the anterior seven-eighths of the genital segment. The posterior end of the receptacle is evenly rounded and projects strongly from the lateral margin of the genital segment near its distal end. The diameter of the receptacle is about uniform throughout the genital segment, but when it passes forward into the fifth segment it narrows rapidly into a cone whose apex falls just behind the anterior margin of the segment.

This apex passes insensibly into the vas deferens at a point much nearer the mid-line than the lateral margin of the segment. In the male of *Ergasilus*

chautauquaënsis the semen receptacles are relatively much shorter and wider, and more ovate in shape. They occupy in the genital segment only the anterior three-fifths, and on passing into the fifth segment taper rapidly down to the diameter of the vasa deferentia (fig. 26).

Each semen receptacle contains one or more spermatophores, ready to be extruded and fastened to the body of the female. Each spermatophore consists of an enlarged body, ovate or ellipsoidal in shape, and a long narrow duct or tube leading from it, very similar to those described by Gruber and others for free-swimming forms. So far as observed each spermatophore is fastened to its own side of the genital segment of the female and there is no crossing of the tubes as in many of the other parasitic forms. Furthermore it is only rarely that a female is found with these spermatophores in position. Out of considerably over five hundred specimens of females belonging to

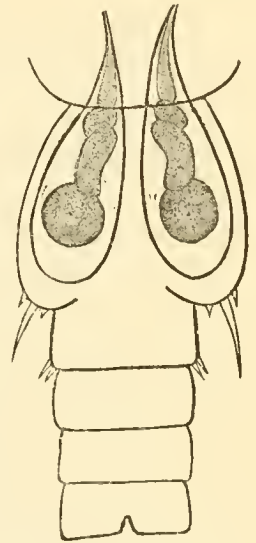


FIG. 26.—GENITAL SEGMENT OF MALE ERGASILUS CHAUTAUQUAËNSIS, SHOWING SPERM RECEPTACLES.

this family only one or two could be found with spermatophores. We thus have another link in the chain of evidence which goes to prove that the union of the sexes takes place while they are still swimming freely at the surface and before they have sought out a host. Or rather before the female has sought one out, for the male remains a free swimmer throughout life.

It also furnishes strong proof that a single union supplies the female with enough spermatozoa to fertilize many broods of eggs, if indeed it is not enough for all she will ever lay.

Furthermore, it explains incidentally the fact that no males are found with the females at any season of the year, upon the host which the female may have selected.

Family ERGASILIDÆ.

Historical.—In spite of the fact that the present family of copepods stand as a connecting link between the two great groups of free-swimming and parasitic forms, they have not received as much attention as would be expected from authors who have dealt with either of these groups. Perhaps the fact that they do thus occupy a middle ground has had some influence in causing the neglect. Authors who were dealing with the free-swimming forms would not naturally include this family of parasites. And on the other hand, those who have described the true parasitic forms, degenerate or with modified mouth parts, have been satisfied with merely mentioning these tiny creatures, in which parasitism has as yet produced but little change. And even the few investigators who have taken up especially the intermediate semiparasitic families have almost without exception neglected the Ergasilidæ. Possibly this is due to the fact that they are fish parasites, while all the others live on invertebrate hosts.

The family was founded in 1832 by Nordmann, who established the two type genera, *Ergasilus* and *Bomolochus*, the former with three species and the latter with one. Nordmann gave an excellent digest of the genus *Ergasilus* after a comparison of his three species, and included even some of the development stages. For the genus *Bomolochus* he had but a single species and contented himself with a description of that, making no attempt at a genus diagnosis. But he found no males of either genus, and while he inferred that there would be a difference between the sexes similar to that in *Cyclops*, there was no direct proof. He recognized the close relationship of the two genera, but left them without creating any new family for their reception. This was done in the following year by Burmeister in his work on the parasitic copepods (1833), who placed the new family, Ergasilina, between the Caligina and the Lernæoda. He included in the family not only Nordmann's genera *Ergasilus* and *Bomolochus*, but also the *Lamproglena* of the same author, Audouin's *Nicotohœ*,

Leach's *Anthosoma*, Hermann's *Dichelestium*, and Risso's *Nemesis*. Naturally the family diagnosis which he gave was made broad enough to include all these genera, and was not of much value for *Ergasilus* and *Bomolochus*.

Seven years later Milne Edwards in his great work on the Crustacea retained this family but changed its name to "Pachycephala," and subdivided it into two tribes or subfamilies, the Dichelestiens and the Ergasiliens, including in the latter but three genera, *Ergasilus*, *Bomolochus*, and *Nicothoë*.

This was a manifest improvement, and his grouping forms the basis of that accepted at the present time, the difference being that his subfamilies or tribes have become separate families.

In 1859 the Swedish naturalist, Thorell, published an excellent paper on the copepods, which live in Ascidians.

While these did not properly include any species belonging to the Ergasilidæ, yet Thorell's contribution is of special interest for two reasons. He introduces a general systematization of the copepods, both free-swimming and parasitic, dividing them into three groups. The first of these he called the Gnathostoma, and described them as having a pair of free mandibles and three pairs of maxillæ without any siphon. The second group were the Pœcilostoma, in which there were no mandibles or siphon, while the number of maxillæ varied from three pairs to none. The third group were the Siphonostoma, whose mouth was produced into a siphon inclosing the mandibles. He placed the Ergasilidæ in the second group with many of the new Ascidian semiparasites, which was equivalent, of course, to declaring that in this family both mandibles and siphon were lacking. To confirm this, in describing his new genus *Lichomolgus*, a near relative of the Ergasilidæ, he introduced figures of *Ergasilus sieboldii* on plates 11 and 12 and tried to show that in this species there are no mandibles.

On this point, however, he was evidently mistaken, as has been clearly shown by many subsequent writers, notably Claus (1864).

Krøyer in 1863 added four new species of *Bomolochus* and four of *Ergasilus*, and he professed to include both sexes of two species of the latter genus.

He made no attempt at a general classification, and so the value of his contribution would lie chiefly in the discovery of the males of *Ergasilus* and in a broadening of our knowledge of the two genera by descriptions and figures of new species were it not for some serious blunders.

The species which he named *Ergasilus gasterostei*, one of the two for which he gave both sexes, had been described by Pagenstecher in 1861 as *Thersites gasterostei*. Krøyer had not seen this description,

for he states in so many words that the species was "hitherto undescribed" (hidtil ubeskrevne Art).

Pagenstecher's generic distinction seems to be a valid one (see p. 349), and hence this species does not belong to the genus *Ergasilus* at all.

The other species for which the male is given, *E. sieboldii* Nordmann, is of course valid, since it is the type of the genus.

But here Kröyer has made the same mistake as in several other instances of designating a young female without egg strings as a male. The true male differs from the female in the presence of well-developed second maxillipeds, and Kröyer's figures distinctly show that these are lacking in the specimen which he calls a male.

Furthermore, it will be seen from the systematic discussion given on page 367 that three of the species which he assigns to the genus *Bomolochus* really belong to other genera.

His contribution, therefore, serves chiefly as a source of material for subsequent correction.

In the next year (1864) Claus gave a detailed account of two new species of *Bomolochus* (*soleæ* and *cornutus*) and a new and closely allied genus which he called *Eucanthus*, with the species *E. balistæ*. He discovered also and described the true males of both these genera. And finally he gave a systematic review of the genus *Bomolochus* and its relatives, bringing out clearly the position of the family and its relation to both the free-swimming and parasitic forms. With this end in view he made a thorough revision of the mouth parts, locating and naming the different appendages around the mouth, which Burmeister had not understood and which Thorell and Kröyer had interpreted incorrectly. He concluded that the mouth parts in the Ergasilidæ are half-way between those of the Corycaeidæ and the Chondracanthidæ. In particular he contended that mandibles are present in all the Ergasilidæ, and that, therefore, they could not be included in Thorell's group of Pœcilostoma. But while thus destroying in a measure the classification Thorell had made, he offered no substitute in its place.

Even in the fifth edition of his Lehrbuch der Zoologie (1891) he makes no mention of a single genus belonging to the Ergasilidæ or the Dichelestiidæ, nor is there any place for them in the classification of the copepods which he gives.

In 1870 Claparède published a Note sur les Crustacés copépodes parasites des Annelides et Description du *Sabelliphilus sarsii*, in which he gave his views upon these troublesome semiparasites. He declared that Claus's statement in regard to the presence of mandibles is correct. But he believed that when the details of the mouth-parts have been fully investigated, it will be found that in *Lichomolgus* and other genera, as well as in his genus of *Sabelliphilus*, the

mandibles can be reduced so much as to be unserviceable for chewing. He gave preference to Thorell's classification, yet admitted that the facts upon which it was founded are not reliable. But, like most of the critics, he contented himself with picking the old classification in pieces and made no effort to modify or improve it.

In the following year (1871) Sumpf described another new genus, *Tæniacanthus*, belonging to this family of Ergasilidæ, and also gave a second thorough revision of the mouth-parts, comparing them carefully with those in the genera *Corycæus*, *Sapphirina*, and *Lichomolgus*. He agreed with Claus that both mandibles and maxillæ are present, and hence declared himself against Thorell's classification.

He showed that Claparède, by some unaccountable error, mistook the upper lip for a pair of fused mandibles, while the structure designated as the maxillary plate was manifestly the true mandibles. He then endeavored to show that the Chondracanthidæ, which Thorell had included in his group of Pœcilostoma, really belong with the Siphonostoma by reason of their limited development, the fixed parasitism of both sexes as well as their sexual dimorphism, and by their degenerate body form and mode of life.

Sumpf thus completed the tearing in pieces of Thorell's classification which Claus had begun and Claparède had continued. But, like those authors, he offered nothing in its place, so that, as far as the Ergasilidæ are concerned, we are left without any arrangement at all.

In 1877 Carl Vogt published his "Recherches Côtieres;" the second section of the second memoir is devoted to the family Chondracanthidæ. In it he described a species of *Ergasilus*, which he named *E. mugilis*, but he believed it to be identical with Hesse's *Mega-brachinus suboculatus*, in which case the latter specific name would take precedence (see p. 346). He then called attention to the close resemblance between the free-swimming family Corycæidæ and the Ergasilidæ. After a very clear cut and logical comparison of these two families with the Chondracanthidæ, he closes with these words:

All these facts authorize us to conclude that the Corycæidæ are the free forms corresponding to the parasitic Ergasilidæ, and are less degenerate, while the retrograde metamorphosis has reached its maximum in the Chondracanthidæ, especially in the females. In this manner these three families, well distinguished by secondary characters, constitute in reality but a single series, which reflects in its successive transformations the analogous phases which the ancestral copepods must have passed through in their passage from a free life to one of parasitism (pp. 99 and 100).

Thus Vogt does not agree with Sumpf that the Chondracanthidæ really belong with the Siphonostoma. He takes the more logical view that they bear the same relation to the Ergasilidæ and Corycæidæ that is borne by the Lernæidæ to the Dichelestiidæ and Caligidæ. This seems to be by far the most sensible statement made with

reference to these parasites, and it proves to be one which is fully substantiated by a careful study and comparison of the mouth-parts.

Three or four years later Gerstaecker published (1881) that portion of Bronn's *Thierreich* which includes the copepoda. Like his predecessors, he also carefully reviewed and criticised the various systems which had been proposed. But unlike them, he went a step farther and made an earnest effort to combine the good points of all the systems and eliminate as far as possible their errors.

As a result he has given us a thoroughly revised classification, in which we find the Ergasilidæ placed among the tenants and half parasites, between the Corycæidæ and the Ascomyzontidæ. But he has included in the Ergasilidæ all the genera referred by other authors to a separate family, the Lichomolgidæ. These latter are only semi-parasites, and hence Gerstaecker was obliged to place the Ergasilidæ where he did. It seems far better to separate these two families and to include in the Ergasilidæ only those forms which live on the gills or the bodies of fish, and thus are as completely parasitic as the Caligidæ.

Moreover, Gerstaecker has placed the Chondracanthidæ among the true parasites, at the very end next to the Lernæopodidæ. And these last two families are separated from all the others with no marks of lineage to connect them, as though he were uncertain where they really belonged.

In 1892 Canu published a work entitled *Les Copépodes du Boulonnais*, in which he presents another revised classification of the copepods, including both the free-swimming and parasitic forms. He adopted the general arrangement of Thorell and Claus, with certain modifications.

His first division was based upon the number of sexual openings in the body of the female; those having but a single opening he called *Monoporodelphya*, and they correspond exactly to the *Gnathostomata* of Thorell and Claus. All the rest of the copepods belong to the group *Diporodelphya*, which is then divided into three subgroups. Recognizing the fact that the Ergasilidæ and their near relatives really do possess mandibles and maxillæ, he changed the name which Thorell had given (*Pœcilostoma*) and called the first of his subgroups *Monochila*. It corresponds exactly to Thorell's *Pœcilostoma* except in name.

In this same year (1892) Giesbrecht, including only pelagic forms, based his first division upon the position of the movable articulation between the fore and hind body, and the structure of the fifth thoracic legs. His second divisions were made with reference to the structure of the first antennæ.

In 1903 Prof. G. O. Sars published volume 4 of his great work on the Crustacea of Norway. This dealt with the Copepoda Calanoida,

and has been followed by other volumes embracing some of the remaining Copepoda, the publication being not yet finished. He separated the Copepoda into seven divisions: (1) The Calanoida, free-living and pelagic; (2) the Harpacticoida, free-living but demersal; (3) the Cyclopoida, partly free-living and fresh-water species, partly commensals and messmates with other animals; (4) the Notodelphyoida, semiparasitic and living upon ascidians; (5) the Monstriloida, partly parasitic and partly free; (6) the Caligoida, parasitic upon fishes, moderately degenerate, and with some freedom of motion; (7) the Lernæoida, fish parasites, strongly degenerate, fixed in position, and with marked sexual dimorphism.

In this scheme the Ergasilidæ are in the third division, along with the Lichomolgidæ and Corycæidæ, while the Chondracanthidæ are in the seventh division. This is a scheme based upon habits and mode of life, though of course substantiated by morphological differences, and is by far the best one yet devised along those lines. It differs from that adopted by Brady in his *Monograph of the Free and Semiparasitic Copepoda of the British Islands* (1880), only in the arrangement of the Cyclopidæ and Notodelphydæ, and has been adopted by the distinguished Scottish investigators, T. and A. Scott.

The two most recent works upon the Crustacea, that in the *Cambridge Natural History*, by Geoffrey Smith, and that in *Lankester's Treatise on Zoology*, by W. T. Colman, both bearing the date of 1909, adopt Giesbrecht's classification.

These different schemes have been fully discussed elsewhere by the present author.^a It is sufficient here to state that there are very serious objections to all of them except that proposed by Sars.

But from a careful comparison of these various schemes of classification we are enabled to draw certain definite conclusions:

1. The free-swimming copepods have mouth-parts suited for biting and chewing, and are to be grouped by themselves at the head of the classification scheme, as is done by every one of the authors quoted.

2. The parasitic copepods have mouth-parts suited for piercing or tearing, the mandibles being inclosed in a tube or siphon, and are to be grouped by themselves at the opposite end of the classification scheme, as is also done by every one of the authors quoted.

3. Between these two groups is a large middle class, including free-swimmers, messmates, commensals, semiparasites, and complete parasites. In these forms the mouth-parts are in the process of transition, but there is no mouth-tube or siphon. Here belongs the family now under discussion, and nearly every author has placed it in a different position with relation to its immediate neighbors. This is the debatable ground, and the conflict is chiefly due to the fact that the

^a *Zool. Anzeiger*, vol. 35, no. 20, pp. 609-620.

members of this middle class are not as yet well enough known to be located with precision. Much more work must be done upon the ecology, morphology, and especially upon the ontogeny of the various families, before any lasting suggestions can be made in the systematization.

The present paper is intended as a contribution toward this end, and if it succeeds in placing the family Ergasilidæ upon a solid basis of morphological and ontogenetic facts it will have accomplished its purpose. With reference to the systematization the author has at present only three suggestions:

1. The Lichomolgidæ should not be included in the same family with the Ergasilidæ, as is done by Thorell and Gerstaecker, but the two should constitute separate families, as given by Sars and T. Scott. The family Ergasilidæ as thus constituted includes only those forms which are parasitic on fish.

2. The Ergasilidæ are closely related to the Corycæidæ and Lichomolgidæ on the one side and to the Chondracanthidæ on the other, the four families forming a series from a free-swimming condition through the various stages of commensalism, semiparasitism, and parasitism to the degeneration and modification which always result from extreme parasitism. These four families ought therefore to be kept close together in the classification scheme.

3. The Ergasilinæ, the Bomolochinæ, and the Tæniacanthinæ are so closely related and form such a natural series that they should be grouped together rather than separated into distinct families. The nature of this relationship appears clearly in the following discussion.

FAMILY DIAGNOSIS.

Body with cyclops form, segmentation perfect or nearly so, first segment fused with head, other segments free or fused among themselves, genital segment enlarged but little, abdomen narrow, anal laminae with very long setæ. First antennæ tactile, never prehensile or locomotor, and alike in both sexes; second pair strongly developed, prehensile, and armed with stout claws. Mouth-parts degenerate, better suited for piercing or tearing, but with no trace of a siphon; maxillary hooks present in some species and like those in the Caliginæ. First four pairs of legs biramose, rami distinctly jointed; fifth pair uniramous, with indistinct joints.

Sex organs paired and situated in the cephalothorax; egg-sacks like those of *Cyclops*, eggs multiseriate and numerous.

Females becoming more or less fixed parasites, males remaining free-swimmers throughout life.

KEY TO SUBFAMILIES.

- a. Second antennæ much elongated, forming stout clasping organs, ending in a single strong claw; maxillipeds entirely wanting in the female. ERGASILINÆ, p. 311.
- a. Second antennæ normal size, terminal joint roughened and ending in several claws; maxillipeds present in both sexes. b.
- b. Maxillipeds turned forward outside, and partly in front, of the other mouth-parts; maxillary hooks not present. BOMOLOCHINÆ, p. 350.
- b. Maxillipeds in their normal position behind the other mouth-parts; maxillary hooks present. TENIACANTHINÆ, p. 381.

Subfamily ERGASILINÆ.

Body cylindrical and elongate, the ventral surface of the carapace projecting so that its edges can not be flattened down upon any surface to act as a prehensile disk.

First antenna small, the basal joints neither enlarged nor flattened, and moderately armed with slender setæ. Second antenna elongated into a powerful clasping organ, often half or even three-quarters as long as the entire body, and ending in a single stout claw. Mouth nearly in the center of the cephalothorax and projecting somewhat from the ventral surface. First swimming legs like the other pairs; fifth pair simple and one-jointed except in *Thersitina*.

Species minute, from 0.6 to 1 millimeter in length.

DESCRIPTION OF THE MOUTH-PARTS.

Female (fig. 27).—Mouth-parts removed some distance from the second antennæ. Labrum transversely elliptical or nearly orbicular,

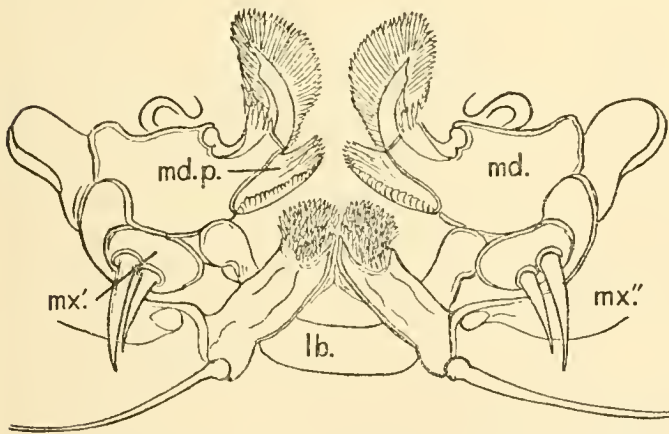


FIG. 27.—MOUTH-PARTS OF FEMALE *ERGASILUS CENTRARCHIDARUM*. *lb*, LABIUM; *md*, MANDIBLE; *md. p.*, MANDIBULAR PALP; *mx'*, FIRST MAXILLA; *mx''*, SECOND MAXILLA.

often so fused with the head in the adult as to be indistinguishable. Labium flattened or even depressed, and without hairs or spines; semicircular or U-shaped, the convex side pointing backward. In the short space between the labium and labrum are found the mandibles and first maxillæ. The mandible consists of a stout basal joint, armed with a palp on its posterior margin, and a terminal joint, curved sharply forward and heavily fringed with short setæ around its entire margin. The palp is also fringed with similar setæ along its posterior margin and at its tip.

The two mandibles turn forward beneath the upper lip and overlap each other across the mid-line. The maxillary hooks are lacking; the

first maxillæ are in the form of stout knobs, each bearing two nearly straight setæ with or without plumes, which point backward and outward, and can be seen projecting from the ventral surface of the head in a lateral view. The second maxillæ are made up of a stout basal joint and a short terminal joint, curved forward similar to the mandible and armed with a thick tuft of setæ at its tip.

The chief difference between different species lies in the shape and armature of the terminal joints of the mandibles and maxillæ; the maxillipeds are lacking.

Male (fig. 28).—Mouth-parts in the same position as those of the female, and the first three pairs similar in all respects. The mandibles are perhaps turned a little more sharply forward, and the first

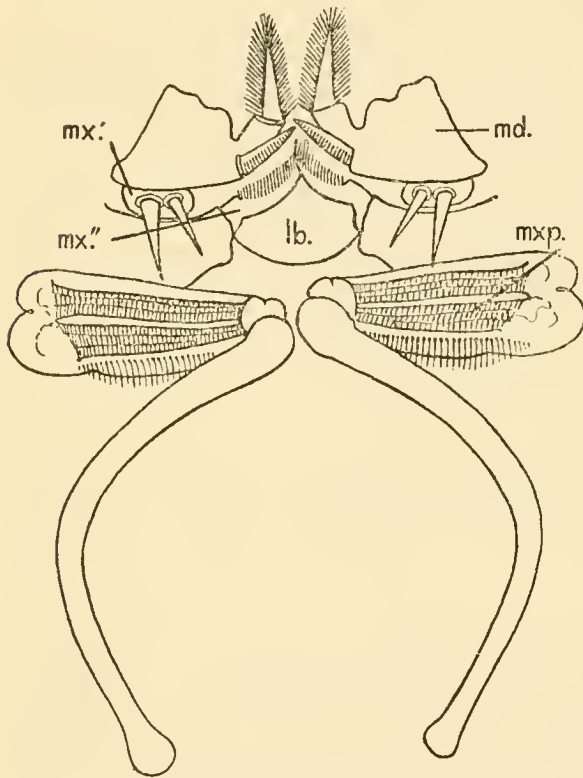


FIG. 28.—MOUTH-PARTS OF MALE *ERGASILUS CHAQUETAENSIS*. *lb*, LABIUM; *md*, MANDIBLE; *mx'*, FIRST MAXILLA; *mx''*, SECOND MAXILLA; *m xp*, MAXILLIPED.

maxillæ are a trifle smaller than in the other sex. But the distinguishing characteristic is the presence of a pair of powerful maxillipeds in normal position behind the other mouth-parts. These are three-jointed and both the terminal joints are entirely free from the head. The basal joint is very short and merely serves to attach the appendages; the second joint is oblong, not much swollen, tapers gradually toward the distal end, and is furnished with powerful muscles, which operate the terminal joint. The latter is in the form of a stout claw, in the particular species (*chaquetaensis*) figured fully twice the length of the second joint, curved into

nearly a semicircle, with the concave side facing that of its fellow across the midline, and slightly enlarged and bluntly rounded at the tip.

In their natural position these large maxillipeds are turned forward and cover the other mouth-parts. The latter are also bunched together, the tips of the mandibles being underneath the tips of the second maxillæ, and the first maxillæ being partially or wholly covered by the basal joints of the same appendages. In the figure here given the distal portions of the mouth-parts have been separated in order to show as much as possible the exact shape of each.

Their bases, however, are in their proper position.

ARTIFICIAL KEY TO THE GENERA.

- a.* Body somewhat flattened, considerably wider than thick; second antennæ slender and nearly as long as the entire body; first and second thorax segments free from the head but fused together..... *Macrobrachinus* Hesse, 1871, p. 264.
- a.* Body cylindrical or spherical; second antennæ stout and no longer than the cephalothorax; first thorax segment fused with the head, the others free..... *b.*
- b.* Carapace inflated into a sphere; first and second antennæ about the same length, short and stout; maxillipeds in the male with several strong apical spines, but without a claw..... *Thersitina* Norman, 1906, p. 347.
- b.* Carapace cylindrical or flattened, much longer than wide; second antennæ four or five times as long as the first pair; maxillipeds in the male with a single terminal claw and no spines..... *Ergasilus* Nordmann, 1832, p. 326.

ONTOGENY.

Historical.—Nordmann, who founded this family, gave also a figure of the newly hatched nauplius of *Ergasilus sieboldii*, his type-species. In his text he presents an account of the development of the genus and a description of the nauplius, which were remarkably good when we consider the date of his work (1832) and the fact that he was dealing with a family previously unknown. His account, however, stopped with the nauplius and included none of the stages which intervene between that form and the fully developed adult.

Subsequent investigators have added practically nothing to our knowledge of this development. One or two of them, like Hesse and Beneden, have given us figures of the nauplius larvæ of other species. But these have not been supplemented by any text description, and the figures themselves have been far too small to give the details of structure.

And so the matter rested until 1904, when Hofer published his *Handbuch der Fischkrankheiten*, in which he embodies the substance of Nordmann's account and adds many statements of his own. He gives us no idea how the facts presented in these statements were ascertained, and unfortunately the most of them are at least questionable. For instance, he says (p. 8) "Die jungen Tiere, welche die Naupliusgestalt aller Copepoden haben, brauchen ca 1 Woche bis zum Ausschlüpfen."

If he means by this that it takes the eggs a week to ripen and hatch after they are extruded into the external sacs, he is probably wrong, for it requires a much longer period in every species observed by the present author.

If, on the other hand, he means that after the eggs are fully ripe and have begun to hatch it requires a week for them all to get out of the envelopes, he is undoubtedly again mistaken, for all the eggs in both strings have repeatedly hatched out under observation within a few hours.

Furthermore, his statement that these nauplii "suchen sich sofort einen neuen Wirt oder eine neue Stelle, an den Kiemen, des alten

Parasitenträgers, wo sie ihre Metamorphose bis zur definitiven Gestalt des erwachsenen Tieres durchmachen" (p. 9) can hardly stand in view of the fact that all copepod nauplii, as well those of parasitic forms as of the free-swimmers, seek the surface of the water and there swim about freely.

Indeed, so far is Hofer's statement from being true that in the Ergasilidæ all the stages in the metamorphosis take place while the larva is still a free-swimmer. No developmental stage of any member of this family has ever yet been recorded as found upon any host.

Later in the same year (1904) Gadd published an account of the Parasitic Copepods of Finland, in which he gives another figure of the nauplius of *Ergasilus sieboldii*, by far the best that has appeared. He also gives the first detailed account of the appendages, but states that he is not fully satisfied as to the number of segments they contain.

He notes the account given by Hofer and takes exception to the same statements that have been discussed above. But he was compelled to stop with the nauplius larva like Nordmann, though he made repeated trials to carry the development farther with water at different temperatures and different degrees of salinity. As will be seen, these accounts all describe the nauplius of *E. sieboldii* and that species alone. The following description includes all the facts thus presented and much additional material, based upon original observations made by the author upon two additional species of *Ergasilus* (*centrarchidarum* and *versicolor*).

Both of these are American species and the first of them was carried successfully through two molts subsequent to the nauplius stage, that is, up to the first copepodid stage. As all these accounts agree in every particular where exact comparison is possible, the development of the genus *Ergasilus* may be considered fairly established. And this development must serve as the type of the family, for at present nothing is known of that in any other genus. But since *Ergasilus* has served also as the type for the ecology and morphology, this only makes the account the more complete.

Mating.—The males of the genus *Ergasilus* remained unknown until 1863 when they were discovered and described by G. O. Sars from specimens captured in the tow. This author rightly concluded that the male leads a free and roving life in comparison with that of the female, and based his conclusion upon the fact that the male had never been observed before, and also upon the small size and comparatively weak development of his second antennæ. Sars then adds in substance as follows:

From this we are justified in assuming that the females are fertilized by the males once for all during their early free-swimming development stages, and that this fertilization is sufficient for the constant production of eggs and young during their subsequent fixed life. In fact it would be absurd to suppose that the males would be able to hunt for the females while the latter were concealed on the fishes' gills.

Subsequent observations, as well as the anatomy of the sexual organs already given (p. 301), have only served to confirm Sars's assumptions, but they still lack absolute proof.

However, it is reasonably certain that after the spermatophores are once fastened to the genital segment of the female, and their contents have passed into the semen receptacles, a sufficient amount is thus stored to fertilize all the eggs which that female can produce during her after life (note size of semen receptacle, figs. 15 and 16).

Breeding seasons.—Like the Caligidæ, the Ergasilidæ have no regular breeding season; females with egg-strings in different stages of development are found on the same host with those which have no egg-strings at all. But there seem to be three periods when females with fully ripe eggs are more common than at other times. These periods are the months of April—May, July—August, and October—November, in each instance including the last two weeks of the first month and the first two weeks of the second. During these times the examination of a few hosts is fairly sure to yield one or more females whose egg-strings are about ready to hatch. The most of the observations of the present author were made at Lake Maxinkuckee, Indiana, during the summers of 1906 and 1908 while in the employ of the U. S. Bureau of Fisheries. Females with ripe eggs began to be found in the middle of July, became more common by the last of the month, and then gradually diminished until by the middle of August they were extremely rare.

The intervals between these breeding seasons, eight or nine weeks, may therefore be taken to represent approximately the time of incubation plus the interval of rest which intervenes after each brood has been hatched.

Fertilization and extrusion of the eggs.—During the winter months from December to March these parasites appear to remain dormant, so far as any sexual activity is concerned.

When captured during this period the females are without egg-strings, and, as Nordmann states, the ovaries are usually empty, leaving the body more transparent than usual. The same thing happens sometimes between the breeding seasons in summer. But with the advent of warmer weather the ovaries quickly fill and the eggs are soon ready to be extruded.

As in the Caligidæ, each egg is fertilized when it passes out of the oviduct into the external sack. The latter is secreted only as there is a demand for more space and is extended by the pressure of the issuing eggs. But this pressure is not exerted along the axis of the sack, as in the Caligidæ, and hence the eggs are not flattened at right angles to that axis. The reason for this is a mechanical one and is to be found in the structure and arrangement of the ovary and oviduct, and in the muscular control of the external openings of the latter.

In the Caligidæ while the ovary is situated in the cephalothorax the eggs formed there are very small, simple nucleated cells, entirely without yolk. In this condition they pass down into the genital segment, which is much enlarged during the breeding season, and in which the posterior portion of the oviduct (uterus) is also enlarged and strongly convoluted. Here the eggs remain some time, increasing in size by the acquisition of yolk particles, and becoming strongly flattened or biscuit shaped in a single row along the terminal portion of the oviduct. But the part of the duct just inside the external opening is so convoluted that quite a little of it lies in the same straight line with the axis of the external sack. Thus the eggs, already flattened, pass out through the os uteri and are pushed straight back along the axis of the external tube. The only change is an increase in width and a corresponding decrease in thickness as they emerge into the external tube.

Here in the Ergasilidæ the conditions are very different. The ovaries are situated in the cephalothorax as before, but the eggs are fully formed there, taking on the yolk particles and attaining their maximum size. They then push back through the oviduct one by one, being compressed a little laterally, but not flattened into a biscuit shape. They pass through the genital segment as rapidly as through any other portion of the oviduct, and are at once extruded into the external sack. The opening of the oviduct, however, is on the side or dorsal surface of the genital segment and not at its posterior end. Hence the terminal portion of the oviduct inside this opening does not point backward in the direction of the body axis, but outward, more or less at right angles to that axis. But the external sack as soon as it acquires any length at all is carried back alongside the body and approximately parallel to the body axis. Hence the issuing eggs, instead of being passed out along a continuous straight line, have to turn almost at right angles as soon as they get into the sacks. This prevents them from forming in a single straight row and produces a multiseriate arrangement, similar to that found in *Cyclops* and other free-swimmers.

The eggs mature in the posterior portion of the ovaries individually or in small groups and not collectively, and pass out through the oviduct similarly. Nordmann, in his admirable account, says:

Die Beobachtung Ramdohrs, dass die Eierstöcke ihren Inhalt nicht auf einmal in die Trauben ausleeren, stimmt mit meiner hierüber gemachten Erfahrung in sofern überein, als auch bei Ergasilus, während die Trauben schon mit Eiern angefüllt sind, zugleich noch in den Eierstöcken minder entwickelte Eiergruppen wahrgenommen werden (p. 12).

Each of these "Eiergruppen" contains but two or three eggs, sometimes only one, and as there is quite an interval between the ripening of successive groups, the external egg-sacks fill out slowly.

Their rate of growth is well shown in figure 29, which gives three stages of development. At the beginning one egg evidently ripened alone; in the second group there were three eggs on one side and four on the other, while in the third group there were again three eggs on one side and four on the other.

So long as the eggs remain in the oviduct they are granular and homogeneous and surrounded by only a single delicate membrane. The formation of the second outer shell takes place in the external sacks. As development proceeds these two shells separate more and more from each other, and the outer one thickens and hardens a little.

Coming thus separately, with intervals between the successive groups, each egg has time to assume a spherical shape in the proximal

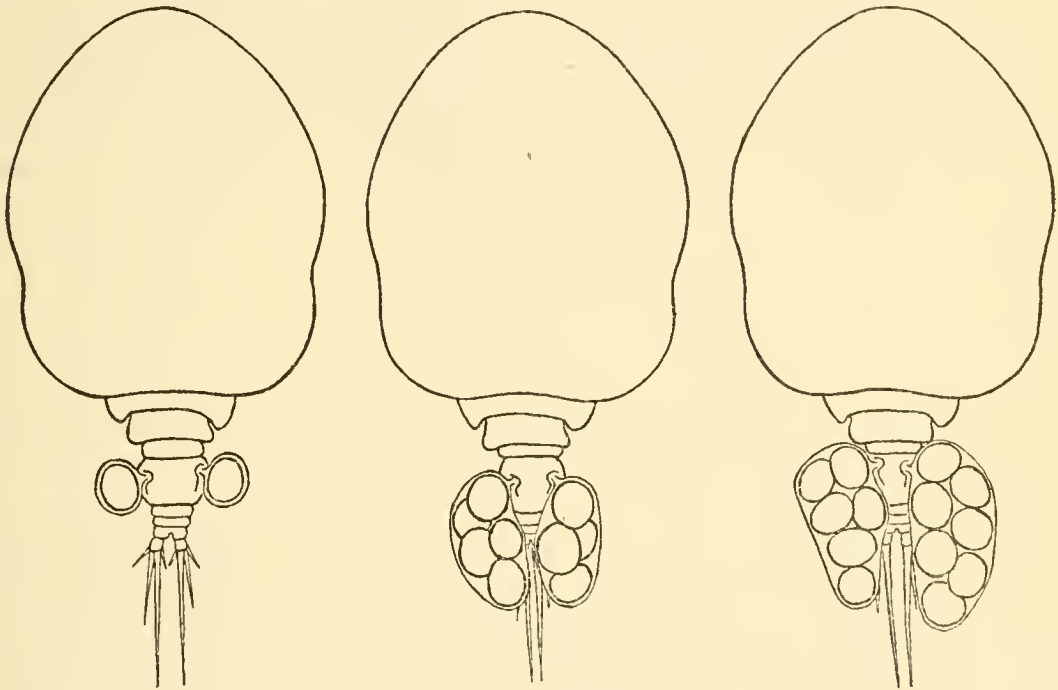


FIG. 29.—THREE SUCCESSIVE STAGES IN THE GROWTH OF THE EGG CASES OF *ERGASILUS CENTRARCHIDÆ*, SHOWING THAT THE EGGS RIPEN IN GROUPS AND NOT SINGLY.

end of the sack before the next lot issues. And the pressure being diffused around an angle, is distributed in different directions; while some of it may continue to be parallel to the axis of the egg-tube by far the greater part is tangential. In consequence the eggs do not assume a biscuit shape but remain more or less spherical, being flattened only where they press against one another.

Again there are no partitions here between the individual eggs as in the *Caligidæ*, but the eggs lie in actual contact one with another. This allows the pressure to be evenly distributed throughout the entire tube, thereby reducing it to the lowest possible terms. The eggs are also capable of moving about within the tube and can readjust themselves whenever necessary. Consequently there is usually very little flattening even at the points of contact.

Furthermore, there can be no such regularity in the arrangement of the germinal areas as was found in the Caligidæ. But in those eggs which remain in contact with the wall of the tube there seems to be a tendency to have the germinal area on the outer side. Yet even here, there is nothing definite in the orientation of the embryo itself.

Maturation in the external sacks.—The eggs change in color with advancing development; at first they are white and opaque but gradually assume the color of the pigment which is to distinguish the nauplius when it finally issues.

This color varies in the different species so far as observed, and is constant in the same species, and so furnishes a good secondary specific characteristic. In spite of the diminutive size of the parasites this color is plainly visible to the naked eye and stands out prominently against the background of the fishes' gills.

Nordmann states that in the case of *Ergasilus sieboldii* a thrice repeated experiment showed that the interval from the first appearance of the blue color in the eggs to the time when the nauplii issued from the egg sacs was fifty to sixty hours. In *E. centrarchidarum* and *E. versicolor* it is slightly longer than this, seventy to seventy-five hours, but it is found to vary greatly with the temperature.

Accordingly this period of maturing will probably be found to be shorter during the August breeding season than during that of May or November. As yet there has been no opportunity to verify this by actual observation.

Hatching of the nauplii.—The whole of the eggs in the external sacks of any female hatch at the same time, so that if several females with ripe eggs can be secured and placed in an aquarium together quite a colony of nauplii will hatch over night. In spite of the fact that most of the nauplii are in contact with the wall of the egg tubes, each one does not break through the latter for itself, but the tube ruptures in one or two places only, and all the nauplii issue through the same opening. Hence the tubes are only rarely broken away from the mother, but are nearly always left as empty bags after the last nauplius has emerged.

The embryos then rupture the outer or vitelline membrane of the egg, issuing forth covered only with the delicate inner membrane. This is much more difficult to break than the outer membrane, and the movements of the inclosed embryo, with the consequent unfolding of its appendages, frequently enlarges this inner membrane fully one-half before it finally gives way. Nordmann makes the statement that the cutting off of the egg sacs or the death of the mother does not disturb the development of the young. This is true only within certain limits, and those limits must be understood if the statement is to be accepted. All the mother can do for the eggs after their

extrusion into the external sacks is to keep them properly aerated. But this is of vital importance here as in all the Crustacea.

If the eggs are so far advanced that they will hatch out in from twenty-four to thirty-six hours after capture, then Nordmann's statement holds true. And if they are placed in fresh water it makes no difference whether the mother is alive or not—they will hatch just

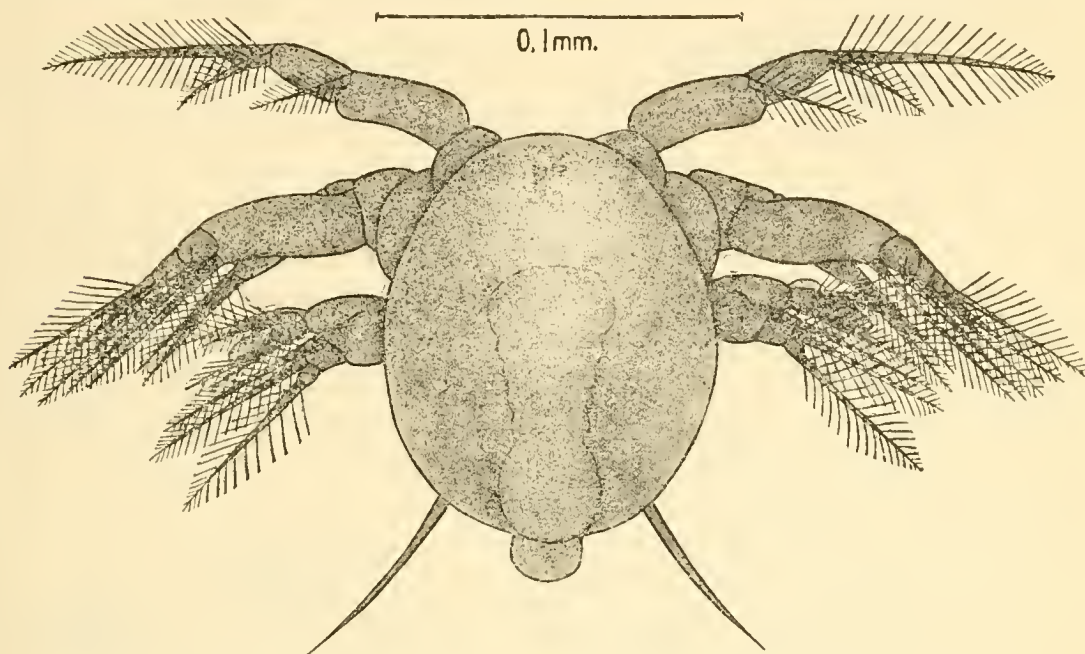


FIG. 30.—NEWLY HATCHED NAUPLIUS OF *ERGASILUS CENTRARCHIDARUM*, DORSAL VIEW.

the same. But if a longer period is required, it will be found almost impossible to keep the eggs sufficiently aerated, and they then die before hatching.

The Nauplius larva.—The newly hatched nauplii are extremely minute and swim at once toward the light, being positively heliotropic. On being viewed under normal conditions they are seen to have the typical nauplius form, elliptical or oval in outline and strongly flattened (fig. 30). Yet they differ very noticeably from the nauplii of the Caligidæ and considerably from those of the free-swimming forms, as can be seen in the following description:

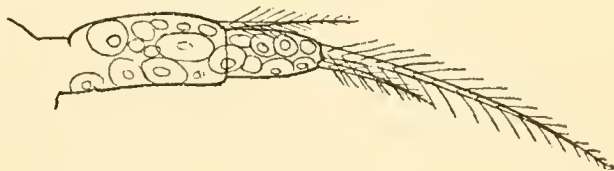


FIG. 31.—FIRST ANTENNA OF NAUPLIUS OF *ERGASILUS CENTRARCHIDARUM*.

In dorsal view there are often apparently only two pairs of appendages, corresponding to the first and second antennæ, which are of the usual structure and proportionally much larger than in the Caligidæ. Each of the first pair is uniramous, two-jointed, and terminates in two unequal setæ, the anterior of which is much longer than the posterior (fig. 31). These first appendages are carried straight forward, side by side, while the second pair extend outward at right angles to the body axis. This latter pair are stouter than the first

and are the principal locomotor organs. They are of the usual form, biramose, and armed with long plumose setæ.

From the ventral surface of the basal joint of each there extends inward a short masticatory process, ending in a stout curved spine, much longer than those found in ordinary free-swimming forms (fig. 32). The two spines from the opposite sides curve around the lower margin of the labium and almost meet at the midline.

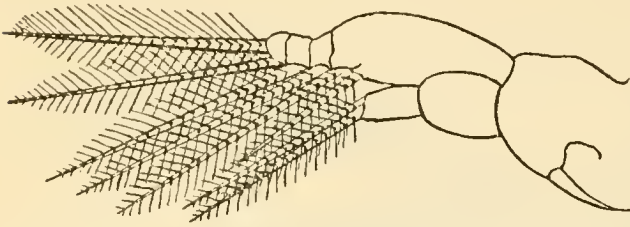


FIG. 32.—SECOND ANTENNA OF NAUPLIUS OF *ERGASILUS CENTRARCHIDARUM*.

There is a third pair of appendages corresponding to the mandibles, but they are much smaller than the others, are seldom used in locomotion, and are usually carried folded back beneath the lateral margin of the body so as to be invisible in a dorsal view. Furthermore when examined they are found to be quite different in structure from the corresponding pair in the *Caligidæ*, and more like those of the free swimmers (fig. 33). They are biramose, with the exopod considerably larger than the endopod and made up of three joints, each armed with a long plumose seta. Thus these exopods, while they are larger than those of the free swimmers, are at the same time smaller than in the *Caligidæ*, where they have the same number of joints as the exopods of the second appendages. This diminution in the mandibles offsets the increase in size of the second antennæ and makes the general average about the same in both families.

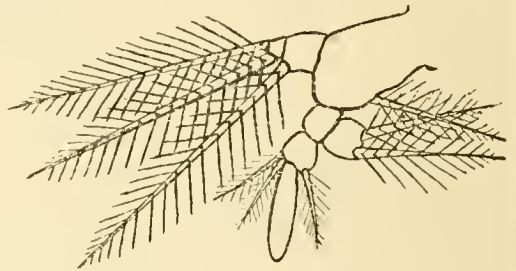


FIG. 33.—MANDIBLE OF NAUPLIUS OF *ERGASILUS CENTRARCHIDARUM*.

The endopods depart radically from the form seen in the *Caligidæ* and approach that of the free-swimmers. Each consists of a tolerably large and spherical proximal joint, the protopodite, to which are attached two distal joints entirely separate from each other, one at the end of the proximal joint and the other on its ventral surface.

The one at the end is attached on a level with the dorsal surface of the proximal joint. It is considerably widened along its distal margin, which is armed with three spines and a curious flattened lamina, shaped like the blade of a case knife. The other joint forms a masticatory blade which extends downward at right angles to the axis of the basal joint. It is also widened at its distal end where it carries two long setæ of equal size.

The median eye is placed far forward and is comparatively large; it is almost entirely concealed in dorsal view by the supraesophageal

ganglion, which lies above it and which is heavily pigmented with black.

The balancers at the posterior end of the body are cylindrical, very slender, and slightly curved, but there is no trace of the spatulate form so characteristic of the Caligidæ. They are attached on the dorsal surface some little distance in front of the posterior end of the body, and project obliquely backward and outward. Between these balancers and projecting from the posterior end of the body is a large hemispherical knob, slightly flattened dorsoventrally. This, combined with the symmetrical elliptical outline, gives a body form quite unlike that of the Caligidæ, but very similar to that of *Cyclops nauplii*.

The body itself is simple and without segmentation, and consists of a cellular exterior surrounding the general body cavity, through the center of which passes the digestive tube.

In the Caligidæ the anterior portion of the body of the nauplius is transparent, while the posterior half is rendered opaque by the presence of numerous yolk cells. There is hardly more than a trace of a digestive tube, and the pigment is distributed along the lateral and posterior margins of the body in various patterns.

Here in the Ergasilidæ, on the other hand, the whole body of the nauplius is equally transparent, and all the pigment except that appearing in the supraesophageal ganglion is confined to the walls of the digestive tube. The cellular exterior is not quite as clear as in the Caligidæ, but the individual cells can be more plainly seen.

The fluid which represents blood and which circulates in the body cavity is also more distinctly visible. Along the sides of the body can be seen the muscles which move the appendages, each extending backward obliquely from the base of the appendage nearly to the posterior end of the body; they are all plainly striated.

The digestive tube is much more distinctly visible than in the *Caligus* nauplius and fills the center of the posterior half of the body. To make it still more prominent all the pigment, as just stated, is confined to its walls, which thus stand out prominently in contrast to the colorless tissues surrounding them. It is enlarged at the anterior and posterior ends into a more or less spherical sac, and constricted in the intervening space.

Not only is it thus more visible, but it is better developed and the peristaltic movements of its walls are plainly in evidence. No opening could be seen at its posterior end, and when, in consequence of the increasing pressure of the cover glass, the body finally burst and its contents escaped the rupture took place at one side of the intestine and not at its end; and the intestine itself was not ruptured nor did its contents pass out for a long time. This is good

evidence that there is no anal opening at this stage of development, and also that the walls of the intestine are stronger than the body walls.

First metanauplius larva.—Three molts occur in from eighteen to twenty-four hours, and the larva then emerges in the first metanauplius stage (fig. 34). The body form as well as the appendages have changed considerably, but there is yet much resemblance to the original nauplius.

The body is now an elongated oval, twice as long as wide, and decidedly narrowed posteriorly. The division into regions is indicated by notches in the lateral margins and by faint grooves running across the body. The cephalothorax is much the largest division and constitutes fully two-thirds of the entire body. It is elliptical

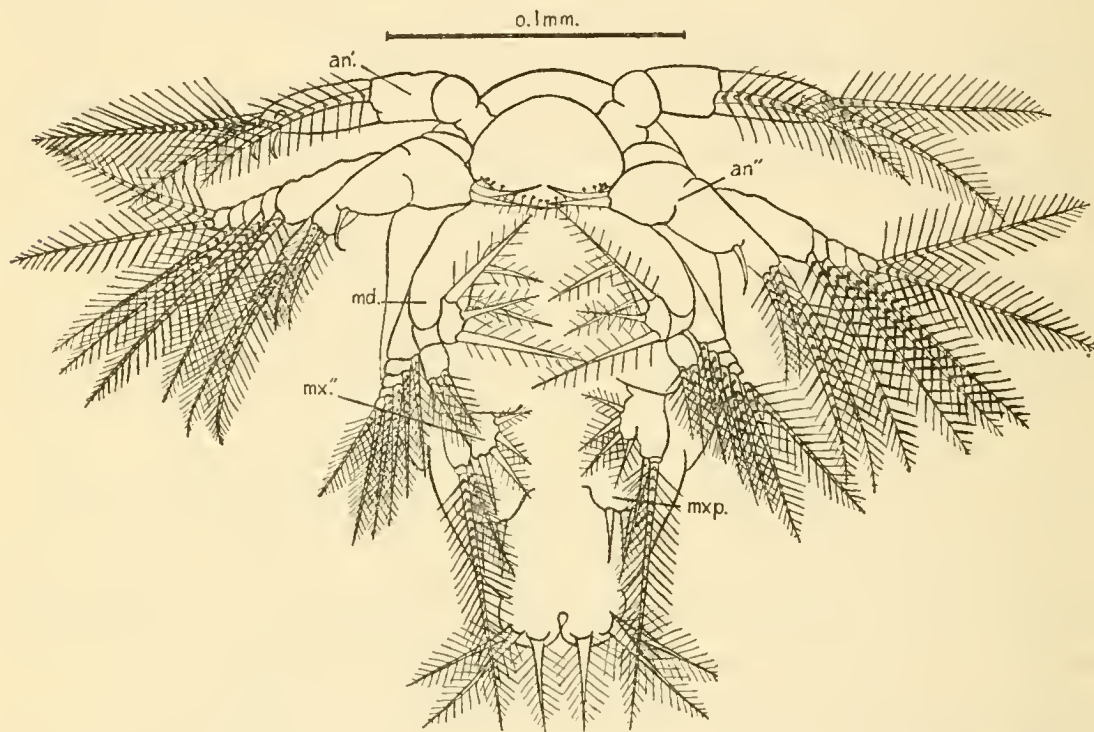


FIG. 34.—FIRST METANAUPLIUS LARVA OF *ERGASILUS CENTRARCHIDARUM*. THE FIRST MAXILLÆ IN THIS FIGURE ARE CONCEALED BENEATH THE MANDIBLES. LETTERING AS IN FIG. 4, P. 273.

in shape, as wide posteriorly as anteriorly, with the lateral margins often reentrant.

The eyes are situated far forward and in contact on the mid-line; they are concealed in dorsal view by the heavily pigmented supraesophageal ganglion, but can be seen fairly well from the ventral side in most larvæ.

The segments of the free thorax are indistinguishably fused and strongly tapered. The segments of the abdomen are also fused, and this region consists of little more than a pair of relatively enormous anal laminae, each of which is armed with three or four stout setæ. The appendages remain very similar to those of the nauplius stage. The first antennæ have now become four-jointed, of which the ter-

minal joint is the longest and is well armed with setæ; there is also a large seta on the ventral surface at the end of the third joint. The second antennæ are still biramose, the exopod exactly like that of the nauplius, while the endopod has become three-jointed, the joints diminishing regularly in size, and the setæ with which they are armed increasing as regularly. The masticatory process from the basal joint of these appendages has increased in size and is now armed with two large claws of about the same length.

The right and left antennæ in these first two pairs are attached close to the lateral margin of the head, leaving a wide space between their bases. This space is entirely filled by the large, transversely elliptical upper lip, which carries a row of stiff hairs along its posterior margin (fig. 35).

In the third pair of appendages the exopod and endopod remain practically the same as before, but the masticatory process has completely changed. It is now flattened and triangular, one angle serving as a point of attachment to the endopod, while from each of the other angles proceeds a large plumose seta, with a third smaller one at the center of the side between them. On these three setæ and on two others which project inward from the inner margin of the basipod the plumose hairs are attached in pairs with long intervals between them.

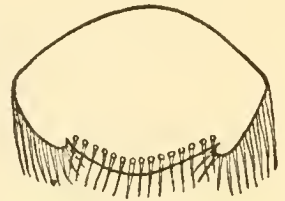


FIG. 35.—LABRUM OF FIRST METANAUPLIUS LARVA.

In addition to these three pairs of appendages the metanauplius has acquired three others, two pairs of maxillæ and a pair of maxillipeds. The first maxillæ are just behind and close to the bases of the mandibles, where they easily escape notice. They are not shown in figure 34, being concealed by the bases of the mandibles, but may be seen in figure 36. The rest of figure 34 showed so well it was considered better to secure the drawing rather than risk its entire loss by trying to manipulate the mandibles. The latter are uniramous processes, one-jointed, and tipped with two spines.

The second maxillæ are some distance behind the first pair, are one-jointed, and bilobed at the tip. The outer ramus is longer than the inner, and is armed with two large setæ, the outer of which reaches back beyond the tips of the setæ on the anal lamina; the four endopod setæ are much shorter. The maxillipeds are very rudimentary and consist of a mere knob projecting slightly from the ventral surface and armed with two short setæ. But that knob is very distinctly posterior to the notch in the lateral margin of the cephalothorax, which marks the dividing line between the cephalon and the first thoracic segment.

Here, then, is another species to add to those already described by Hansen, Giesbrecht, and Claus, in which the maxillipeds are definitely

thoracic in origin, while the other mouth-parts are cephalic. In the internal anatomy of these metanauplii there has been a considerable rearrangement of the muscles which move the appendages. Owing to the insertion of muscles for the two new pairs of appendages, those which move the three original pairs can not extend as far back in the body as formerly, but run more directly inward from the bases of the respective appendages.

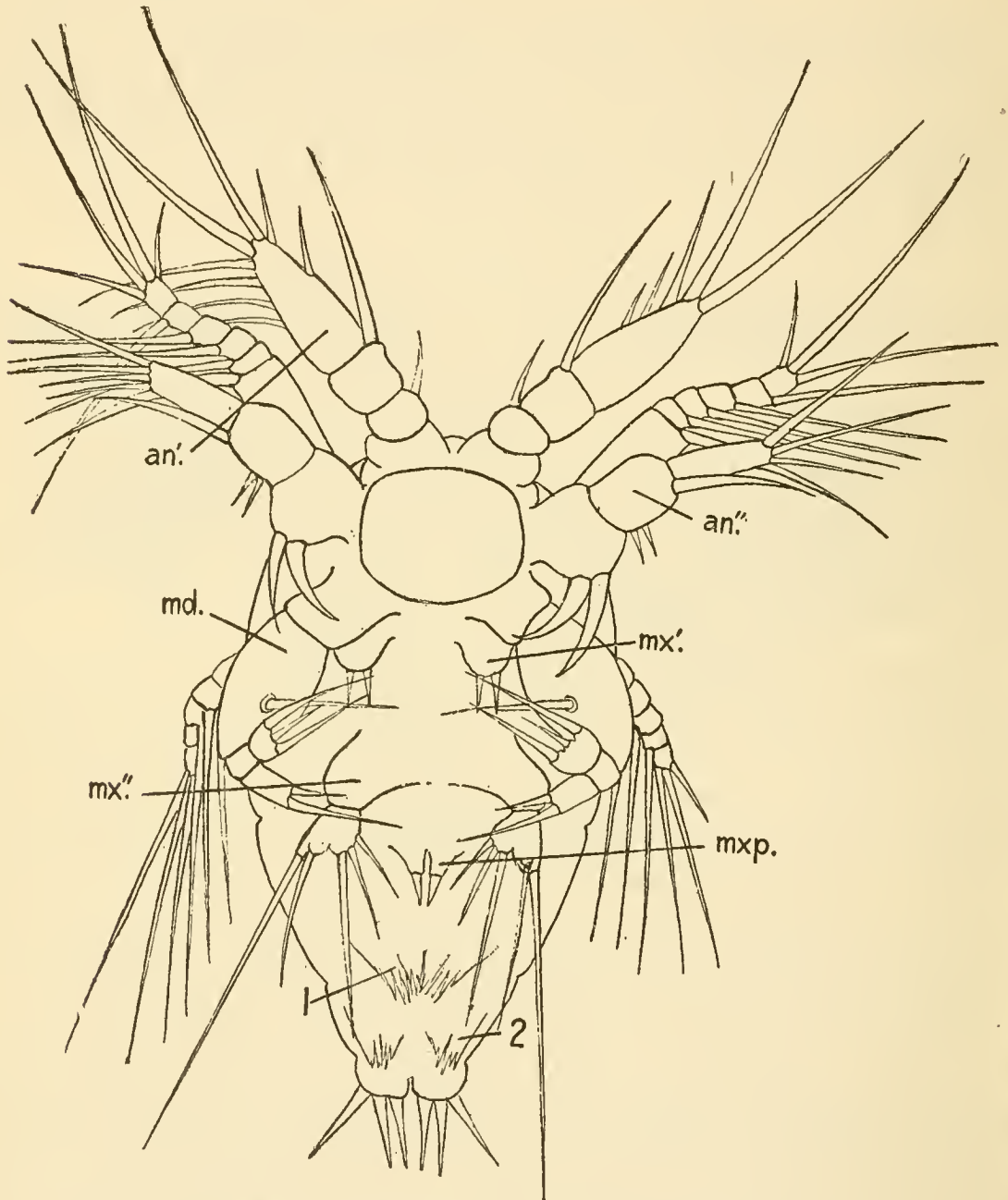


FIG. 36.—SECOND METANAUPLIUS JUST READY TO MOLT INTO THE FIRST COPEPODID STAGE.
LETTERING AS IN FIG. 4, P. 273.

The digestive canal still retains its deep blue pigment, and at its anterior end has developed a well-defined stomach, from which a straight intestine of gradually decreasing width runs back to the anus. This latter is situated between the anal laminae and is now distinctly visible. The larva begins to eat during this period and the peristaltic movements concerned in digestion are very evident. At the same

time the yolk cells gradually disappear, so that by the close of this stage there are only a few left. The brain is now connected behind the nauplius eye and a rudiment of the genital organs can be detected in a small mesodermal growth on either side of the alimentary canal.

The second metanauplius larva.—Two more molts now take place in from twenty-four to thirty-six hours, and the emerging larva shows a more decided oval shape, the body having increased in length, and its posterior end being somewhat narrowed (fig. 36). The anterior antennæ are five-jointed; the terminal joint is about half the entire length and copiously supplied with setæ of all lengths and sizes (fig. 37). The posterior antennæ also have one more joint than in the preceding stage and the number of their setæ have increased. Otherwise they have not essentially changed from their previous condition, and still retain

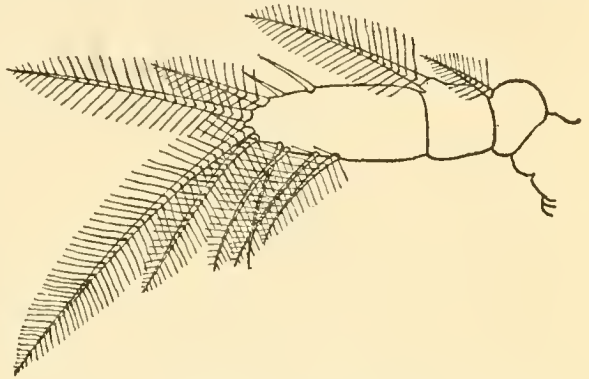


FIG. 37.—FIRST ANTENNA OF SECOND METANAUPLIUS LARVA.

the masticatory claws on their basal joints. In the mandibles (fig. 38) the exopod has increased in the number of segments and correspondingly in the number of its setæ. The endopod has lengthened until it is more than twice as long as wide and carries five setæ, but it is still one-jointed. The masticatory blade is widened and is now

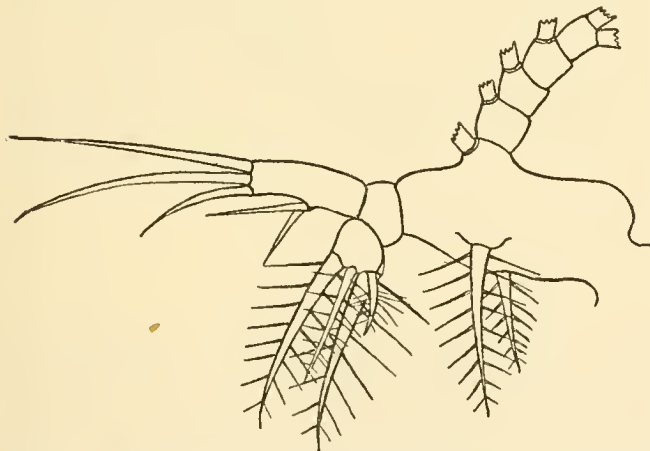


FIG. 38.—MANDIBLE OF SECOND METANAUPLIUS LARVA. THE EXOPOD IS TURNED BACK IN ORDER TO SHOW MORE DISTINCTLY THE ENDOPOD AND THE MASTICATORY PROCESS.

armed with four setæ, while the basal joint (protopodite) of the appendage shows traces of segmentation. The maxillæ remain as in the previous stage, except that they have migrated a little toward the median line. The maxillipeds have moved still farther inward until they have met on the midline. They have also degenerated greatly and are now nothing more than slender papillæ, each tipped with a single spine. Evidently this is a female larva and these appendages will disappear at the next molt into the copepodid stage.

It was impossible to carry the larvæ into this latter stage, but since they remain free-swimming during their entire metamorphosis such

stages must be present in the plankton at the right season and could be obtained by towing, or they could be reared in suitable aquaria.

It would be of particular interest to obtain the complete development of both sexes, following especially the movements of the maxillipeds and the backward migration of the mouth-parts. The rest of the details are doubtless quite similar to those found in free-swimming forms.

Behind the disappearing maxillipeds may be seen the rudiments of the first two pairs of swimming legs (fig. 36, 1 and 2), which will appear more completely developed in the first copepodid stage.

Genus ERGASILUS Nordmann.

Ergasilus, NORDMANN, 1832, p. 7.

Body cyclops-like, narrowed posteriorly; first thorax segment fused with the head to form a carapace which is inflated dorsally, especially in the female when the ovaries are well developed. Under these conditions it usually overlaps and conceals the following free segments, of which there are four, followed by the genital segment, which is but slightly enlarged. Fourth free (fifth) segment very short and not easily distinguished; abdomen also short, narrow, and indistinctly jointed; anal laminae with very long setae. First antennae six-jointed and well armed with setae; second pair stout, four-jointed, very strong in the female, much smaller and weaker in the male. Mouth nearly in the center of the carapace on the ventral surface; mouth-parts already described (p. 311). Five pairs of swimming legs; the four anterior pairs biramose, the fifth pair uniramous and very rudimentary, sometimes apparently wanting. Egg-tubes like those of *Cyclops*, eggs small and numerous. Adult females parasites on the gills of (mostly) fresh-water fish, males always remaining free.

(*Ergasilus*, the name of a parasite in Plautus.)

ARTIFICIAL KEY TO THE SPECIES.

The following published species have been eliminated from the key for the reasons stated. *Biuncinatus* Gadd, 1901, belongs to the genus *Thersitina*; *depressus* Sars, 1862, proves to be a synonym of *sieboldii*; *esocis* Sumpf, 1871, is another synonym of *sieboldii*. Sumpf does not tell us the host of this species, but the name he has given it would make it certain that it came from some species of *Esox*, which is also one of the hosts of *sieboldii*. Furthermore in this portion of his paper Sumpf is discussing only Die Mundwerkzeuge der sogenannten Poecilostomen, and he describes and figures nothing but the mouth-parts of *esocis*, without any mention of its body form or other appendages, or any further description of it as a separate species. Four years later Claus, from whom Sumpf obtained his material, published a description of *sieboldii*, and his figure of the mouth-parts is printed from the same plate as this one of Sumpf's. Hence *esocis* must be regarded as a name wrongly given by Sumpf to *sieboldii*, under the impression that it was a new species. *Gasterostei*, given by some authors as a species of *Ergasilus*, belongs rather to the genus *Thersitina* (p. 349). *Mugilis* Vogt, 1877,

which was put forth as a probable synonym of Hesse's *Megabrachinus suboculatus*, must stand valid until some one can give us confirmation of Hesse's species.

- a. Head completely fused with the first thorax segment, with no indication of the union; carapace elongate, much longer than wide, and more than half the entire length.....b.
- a. Head fused with the first thorax segment, but the fusion indicated by distinct indentations on the lateral margins; carapace half the entire length and violin shaped.....e.
- a. First thorax segment distinctly separated from the head by a well-defined groove; carapace short, as wide as long, and much less than half the entire length.....h.
- b. Anterior margin of carapace evenly rounded; first antennæ hardly reaching the end of the first joint of the second pair; both rami of fourth legs 3-jointed.....c.
- b. Anterior margin of carapace projecting strongly at the center in a rounded knob; first antennæ much longer and heavily bristled.....d.
- c. Second antennæ one-third the entire length; basal joint much swollen and widened distally; second joint with a large process on its outer border.
funduli Kröyer, 1863, p. 328.
- c. Second antennæ half the entire length, the two basal joints without swellings or processes.....*labracis* Kröyer, 1863, p. 329.
- d. Second antennæ normal; terminal claw simple; both rami of fourth legs 3-jointed.....*centrarchidarum* Wright, 1882, p. 331.
- d. Second antennæ normal; terminal claw toothed on the inner margin; exopods of fourth legs two-jointed.....*cæruleus*, new species, p. 334.
- d. Second antennæ with large processes in the form of sleeves around the base of each joint; terminal claw with a large tooth on the inner margin; fourth exopods 2-jointed.....*manicatus*, new species, p. 337.
- e. Both rami of fourth legs 3-jointed.....f.
- e. Exopod of fourth legs with but two joints.....g.
- f. Ventral surface of genital segment smooth; three abdominal segments the same length.....*sieboldii* Nordmann, 1832, p. 338
- f. Ventral surface of genital segment armed posteriorly with a large number of coarse bristles; third abdomen segment much shorter than the other two.....*lizæ* Kröyer, 1863, p. 340.
- g. Second antennæ as long as the carapace; the latter much narrowed posteriorly; fifth legs of good size, armed with three setæ.
nanus van Beneden, 1870.
- g. Second antennæ as long as the carapace; posterior portion of latter as wide as anterior; fifth legs reduced to a single small spine.
versicolor, new species, p. 341.
- g. Second antennæ only half the length of the carapace; posterior portion of latter as wide as the anterior; fifth legs reduced to a single spine.....*chautauquaënsis* Fellows, 1888, p. 343.
- h. Head, thorax, and abdomen diminishing regularly in width; carapace relatively narrow and evenly rounded anteriorlyi.
- h. Carapace relatively wide, with a rounded projection at the center of the anterior margin; first thorax segment as wide as the carapace, second abruptly narrowed to half that width.....j.
- i. Second antennæ one-third the entire length; abdomen one-half longer and a little narrower than the genital segment; fifth legs short and stout, with a single seta.....*peregrinus* Heller, 1865.
- i. Second antennæ one-half the entire length; abdomen shorter and much narrower than the genital segment; fifth legs reduced to a mere spine.....*longimanus* Kröyer, 1863.

- i. Second antennæ two-thirds the entire length, first pair also very long; abdomen one-half longer, and as wide, as the genital segment, fifth legs long and slender and tipped with a pair of long setæ.....*osmeri* van Beneden, 1870.
- j. First thorax segment half as long as the carapace; grooves between thorax segments deep and saddle-like; anal laminæ five times as long as the last abdomen segment, each with two unequal setæ.....*gibbus* Nordmann, 1832.
- j. First thorax segment fully as long as the head; grooves between thorax segments shallow; anal laminæ the same length as the last abdomen segment, each with two unequal setæ.
mugilis Vogt, 1877, p. 345.
- j. First thorax segment less than a quarter the length of the head; grooves between thorax segments shallow and indistinct; anal laminæ five times the length of the last abdomen segment, each with three setæ.....*trisetaceus* Nordmann, 1832.

ERGASILUS FUNDULI Kröyer.

Ergasilus funduli, KRÖYER, 1863, p. 228, pl. 11, figs. 1, a to f.

Female.—Body pyriform, from two and a half to three times as long as wide, strongly narrowed posteriorly. Head completely fused with the first thorax segment, without groove or emargination at the point of union. Carapace two-thirds the entire length, with the antennal area strongly projecting at the center of the frontal margin, and separated from the rest of the cephalon by a well-defined groove.

Free thorax segments diminishing regularly in size; genital segment somewhat oval, with a pair of rudimentary legs near the openings of the oviducts. Abdomen three-jointed, all the joints very short and wider than long; anal laminæ minute, as broad as long, each tipped with three setæ, the inner of which is twice as long as the others. Egg-tubes cigar-shaped, narrow and about as long as the entire body; eggs in three or four longitudinal rows, fifteen or sixteen eggs in a row.

First antennæ very short, not reaching the end of the basal segment of the second pair, and indistinctly segmented; segments broader than long, the last one only with setæ. Second antennæ about one-third the entire length, the first two segments thick and swollen and forming together a stout base, the terminal joints much more slender, the last one in the form of a claw with a small conical knob on the concave side near the base. The second joint also has a stout, thumb-like protuberance at the proximal end on the outer margin. Kröyer makes the structure of these second antennæ the distinctive characteristic of the species.

The mouth-parts have never been described, but Kröyer states that they are the same as those of other species, with no apparent peculiarities. The first four pairs of swimming legs are biramose, each ramus with three joints; the fifth pair are reduced to mere spines on the sides of the fifth segment.

Nothing is said of the color of the specimens.

Total length, 0.70 mm. Length of carapace, 0.285 mm. Width of same, 0.25 mm. Length of egg-strings, 0.8 mm.

(*funduli*, the generic name of the host.)

A few specimens of this species were found on the gills of *Fundulus ocellaris* (*F. limbatus*, Kröyer).

The fish had been obtained near New Orleans, Louisiana, and sent as specimens to the Royal Museum of Copenhagen.

There they were examined and these parasites found and afterward sent to Kröyer. No specimens have been discovered since, but neither have any of the *Fundulus* from that locality been examined for them. In all probability a little search would rediscover this species and there would be a chance to find the male which is as yet unknown.

ERGASILUS LABRACIS Kröyer.

Plate 41.

Ergasilus labracis, KRÖYER, 1863, p. 303, pl. 11, figs. 2, *a* to *e*.

Ergasilus labraces, SMITH, 1874, p. 573.

Ergasilus labracis, LEIDY, 1888, pp. 125 and 166.

Female.—Body elongate, more than twice as long as wide, abruptly narrowed posteriorly. Head completely fused with the first thorax segment, with no indication of the union.

Carapace three-fifths the entire length, projecting somewhat at the center of the frontal margin, nearly squarely truncated posteriorly. Free thorax less than half the width of the carapace, its segments diminishing regularly backwards.

Genital segment small, about the same width as the fifth segment and half as long as the four free segments, with nearly straight sides. Abdomen three-fifths as wide as the genital segment, three-jointed, the joints about the same length but diminishing in width. Anal laminae the same length as the last abdomen joint, each armed with three setae, of which the inner one is very stout and twice the length of the other two. Egg-tubes cigar-shaped, narrowed posteriorly, and as long as the entire body; eggs in four to six longitudinal rows, about twenty in each row.

First antennae very short, hardly reaching the tip of the first segment of the second antennae, six-jointed, each joint as broad as long and fairly well provided with setae of moderate length. Second antennae half as long as the body, distinctly four-jointed; basal joint short, swollen, and very obliquely truncated at its distal end; second joint longer, narrower, and slightly curved, with a small knob at the center of the inner border. The last two joints constitute the claw, which is strongly curved and armed near the joint on the inner margin with several small knobs or teeth.

Mouth-parts large and distinctly defined; the terminal joints of the mandibles very wide and fringed with long hairs, the basal joints large and muscular. The palps are rather narrow, but are fringed with long hairs like the mandible itself. First maxillæ in the form of large and nearly spherical knobs, each armed with two setæ.

Second maxillæ with large and triangular basal joints, which extend outward nearly to the lateral margin, and forward in front of all the other mouth-parts. The terminal joints are also large and stout and are heavily fringed along their anterior margin.

In the swimming legs the endopod of each pair is larger than the exopod; both rami are three-jointed, except the exopods of the fourth legs, which have but a single joint.

The fifth legs are reduced to small spines nearly invisible.

The arrangement of the spines and setæ on the first four pairs of legs is as follows: First exopod, I-0; 0-1; II-6: endopod, 0-1; 0-1; II-3: second exopod, I-0; 0-1; 0-6: endopod, 0-1; 0-2; II-4: third exopod, I-0; 0-1; I-5: endopod, 0-1; 0-2; II-5: fourth exopod, I-4: endopod, 0-1; 0-2; I-3.

Color in sexually mature specimens a uniform milk-white on the dorsal surface; in other individuals with a bluish tinge and translucent, but always with a variegated pattern of blue pigment along the center of the ventral surface on either side of the mid-line (fig. 43).

Total length, 1 to 1.25 mm. Length of carapace, 0.65 mm. Width of same, 0.5 mm. Length of free segments, 0.17 mm. Length of egg-strings, 0.95 mm.

(*labracis*, from *Labrax*, the generic name of its host.)

This species was first found by Krøyer in considerable numbers on the gills of the striped bass, *Roccus lineatus* (*Labrax lineatus* Krøyer) at Baltimore, Maryland, in the year 1860. It was afterwards (1887) found by Leidy to be common on the gills of the same fish in the Philadelphia markets, but he added nothing in the way of description to what Krøyer had given.

The first description and drawings, therefore, are the only ones that have ever been given, and it is hoped that the present account will supplement this in many ways.

The National Museum collection contains four bottles of specimens obtained at different times by Dr. H. M. Smith, of the U. S. Bureau of Fisheries, from the gills of the same striped bass in the fish markets at Washington, District of Columbia. These bottles are numbered respectively 38633, 38653, 38654, and 38657.

The first and the last of these contain the gills themselves, with the parasites still clinging to the filaments, and are very instructive in showing how thoroughly our food fish may become infested with these creatures. Beside these there are two bottles, numbered 38655 and 38656, which also contain infested gills of striped bass

taken at Woods Hole, Massachusetts. These have even more parasites on them than the foregoing, one of the gills being almost literally covered. A seventh lot was collected by S. G. Worth at Franklin, Virginia, from the same host, and is numbered 13019.

These records prove that this species is common on the striped bass along the entire Atlantic coast, and the examination of such fish in any of the markets where they are kept for sale will almost certainly yield specimens of the parasites.

ERGASILUS CENTRARCHIDARUM Wright.

Plate 42, text-figures 2, 3, 7, 13 to 25, 27, 29 to 38.

Ergasilus centrarchidarum, WRIGHT, 1882, p. 243, pl. 1, figs. 12-18.

Female.—Cephalothorax elliptical, projecting a little at the center of the frontal margin and nearly as broad as long, the proportion being about 85 to 110 in young females and 90 to 100 in mature adults. In the latter this region is so strongly inflated by the genital products that it also projects backward over the free segments and hides them in dorsal view. Lateral constriction between the head and first thorax segment barely noticeable in the young, not visible at all in the adult. First three free segments about the same length and regularly narrowed backwards, the first of them (second segment) less than half the width of the cephalothorax. Fifth segment very short and narrow; genital segment no wider and barrel-shaped, with rounded sides. Egg-sacks cylindrical or cigar-shaped and a little longer than the entire body; eggs of good size and arranged in five or six longitudinal rows, about 100 in each sack. Abdomen half the width of the genital segment, three-jointed, the middle joint a little shorter than the other two. Anal laminæ large, as long as the terminal joint of the abdomen and each armed with three setæ, of which the inner one is from two to three times as long as the two outer ones, which are of about the same length.

First antenna six-jointed, the joints unequal in length and not corresponding in different individuals, nor even in the two antennæ of the same individual. Usually the second joint is the longest and the sixth is next.

These antennæ originate on the under surface of the frontal projection and some distance apart; each joint bears one or more simple setæ, the longest of which are as long as the entire antenna. The setæ on the first four joints are directed chiefly downward; on the last two joints backward and outward. To judge from the innervation of these antennæ they must constitute very delicate tactile organs. Second antennæ a little longer than the cephalothorax, but always carried folded up so that they reach only to the mouth, or slightly beyond. Antennary sternum between the bases of these appendages

well developed, entering at either end into the sockets of the antennæ themselves (see fig. 13).

Basal joints much inflated and reenforced on the inner margin by two stout chitin ribs in each joint; second joint the same length as the basal, but tapering considerably; hinge between second and third joints quite complicated; third joint about the same diameter throughout; fourth joint a short, curved claw, bluntly pointed. The last two joints together are not quite as long as the second (fig. 7).

The mouth-parts project strongly from the ventral surface in a side view (see fig. 52), with the maxillæ at the tip of the projection. The labrum is so thoroughly fused with the head that its outlines are often indistinguishable, but the evenly rounded posterior margin is usually visible. Basal joint of the mandible with a large rectangular outer portion set in a socket of similar shape at the extreme lateral margin of the labrum and just posterior to it, so as to allow the mandible to move forward under the lip. At the inner end the posterior border of this portion is cut diagonally forward and inward, while a deep circular incision is cut out of the anterior border. The narrowed neck between the diagonal cut and the circular incision constitutes the inner portion of the basal joint and is turned forward at an angle of about 45 degrees (fig. 27). To the end of this neck is attached the cutting blade, which is triangular in shape, a little longer than the neck, usually curved forward, and armed along its posterior margin and around the tip with a row of long hairs or spines. The palp is also triangular, its base attached to the diagonal cut on the posterior border of the basal joint, its anterior side fastened for a short distance to the posterior margin of the neck. It also has a row of shorter spinelike teeth along its outer margin. First maxillæ reduced to mere knobs, projecting from the ventral surface between the basal joints of the mandibles and those of the second maxillæ. From the top of each knob project two stout curved spines, articulated at the base so as to be movable, the outer one a little longer and stouter than the inner, and both plumose. Second maxillæ similar to the mandibles except that they have no palps; basal joint of the same width and length, triangular in shape, with the apex pointing inward and narrowed to a short neck which is curved forward. The cutting blade is long and triangular; its anterior margin and the entire ventral surface are covered with a dense growth of bristles. Maxillipeds entirely lacking. Labium reduced to a transverse ridge, its posterior margin nearly straight. Rami of first four pairs of swimming legs three-jointed and well armed with spines and setæ. Fifth legs reduced to a comparatively well-developed sternum, at either end of which in young females is a very short, one-jointed process tipped with two spines; in the fully developed adult the process is wanting and there is but a

single spine. The arrangement of spines and setæ on the first four pairs of legs is as follows: First exopod, I-0; 0-1; II-5: endopod, 0-1; 0-1; II-4: second exopod, I-0; 0-1; 0-6: endopod, 0-1; 0-2; I-4: third exopod, I-0; 0-1; 0-6: endopod, I-0; 0-2; 0-5: fourth exopod, 0-0; I-0; 0-4: endopod, 0-1; 0-2; 0-4.

The anatomy of the muscular, digestive, and reproductive organs of this species have been described on pages 285 to 302; the nauplius and two metanauplius stages of development were described and figured under the ontogeny of the Ergasilinæ, pages 319 to 326.

Body a clear cartilage color, translucent in young females, but becoming dense and opaque in the adults; ovaries and testes an opaque white. Eggs also an opaque white when freshly extruded, acquiring blue pigment gradually upon development, until when ready to hatch the entire egg-sacks appear blue to the naked eye.

Total length, 0.8 to 0.9 mm. Length of cephalothorax in adult, 0.66 mm. Width of same, 0.58 mm. Length of egg sacks, 0.9 mm. In young females with their first egg-sacks the body is relatively longer and narrower, and the proportion between the length of the cephalothorax and the remainder of the body is as 11 to 8 (see fig. 21).

(*centrarchidarum*, of or belonging to the Centrarchidæ, the family of fish upon whose gills this parasite is found.)

The red eye (*Ambloplites rupestris*) is the most common host of this parasite, and nearly every one of them which the author has examined has been found infested to some extent. During the summer of 1906 quite a number of red eyes were examined at Lake Maxinkuckee, Indiana, for the purpose of ascertaining their food and the kinds of parasites which infested them. These were all young fish, 2 inches long and upward, in the second year of their growth. Almost every fish showed some of this species on its gills, and several of them, scarcely 3 inches long, yielded from 15 to 25 of the parasites apiece. An adult red eye often has as many as 75 or 100 of these creatures on its gills. The National Museum collection includes four bottles of specimens from this host, taken at Lake Maxinkuckee and numbered, respectively, 38609, 38610, 38620, and 38632; one bottle containing a single female taken from the gill of a pike perch, *Stizostedion vitreum*, and numbered 38616; another single female found on the gill of a blue-gill, *Pomoxus sparoides*, numbered 38634; 15 females taken from the gills of the small-mouth black bass, *Micropterus dolomieu*, numbered 38624; 3 females from the gills of the war-mouth bass, *Chænobryttus gulosus*, taken in Lost Lake, close to Lake Maxinkuckee, and half a dozen females from red eyes and blue-gills, taken at Lake Winona, Indiana, these last two being numbered, respectively, 38613 and 38630.

ERGASILUS CÆRULEUS, new species.

Plate 43.

Female.—Body more elongate than that of *centrarchidarum*, but not as much so as *versicolor*, nearly three times as long as wide. Carapace elliptical, about as wide posteriorly as anteriorly, with the sides only very slightly reentrant, the longitudinal and transverse diameters being in the proportion of eleven to six. Antennal area two-thirds the width of the carapace and projecting much farther than in any known species, bringing the posterior margins of the second antennæ far enough in front of the body of the carapace to leave an open space between the two. Frontal margin evenly rounded; eye removed a little from this margin and covered with an irregular spot of deep blue pigment, so as to be almost invisible (fig. 60). Posterior body (second thorax segment) narrowed abruptly to five-ninths of the width of the carapace.

Thoracic segments diminishing regularly in width, the third one considerably longer than the second or fourth, which are the same length, the fifth one very short and rudimentary.

Lateral processes on the dorsal surface of the second segment projecting considerably beyond its posterior margin, narrow and bluntly rounded. Genital segment nearly twice as wide as long, barrel-shaped, with well-rounded sides.

Egg-strings elliptical, narrower than in *centrarchidarum*, but not as narrow as in *versicolor*, two-thirds as long as the entire body and tapering very little posteriorly.

Eggs large, arranged in three or four longitudinal rows, about 25 or 30 eggs in each string.

Abdomen, exclusive of the anal laminae, the same length as the genital segment, and abruptly narrowed to half the width of the latter; composed of three segments of about the same length. Anal laminae as long as the last abdomen segment, widely separated, sub-rectangular in outline, and each armed with two setæ, the inner of which is twice the length of the outer.

First antennæ apparently seven-jointed, the joints diminishing regularly in width, but of about the same length, except the two basal ones, which together equal one of the others.

These two basal joints have no setæ; the third joint is slightly larger than any of the others, and carries two stout setæ at its outer anterior corner; the fourth, fifth, and sixth joints are each armed with a single seta, the terminal joint with a tuft of four or five, none of them very long.

Second antennæ with two stout basal joints, fully twice as wide as long, and two slender terminal joints; first joint with a short powerful muscle along its anterior margin, its posterior margin projecting and

evenly rounded, sometimes forming a half circle. Second joint projecting on its anterior margin, and abruptly narrowed just beyond its center to furnish the articulation for the third joint.

The latter is as long as the two basal joints, but only one-quarter as wide, narrowed near its proximal end, widened at the distal end, and armed with a small rounded knob on its inner margin. Terminal joint a claw, with a curved outer margin and a nearly straight inner margin, the latter with one or two short teeth near its proximal end.

The structure of these antennæ is thus very different from that in *centrarchidarum* and *versicolor* and furnishes a good specific character.

Mouth-parts resembling those of *centrarchidarum* more than those of *versicolor*, but quite distinct from either. Mandibles so short that they hardly meet at the mid-line, with the knob on the anterior margin of the basal joint prominent and well rounded as in *centrarchidarum*. But the terminal joint is hardly longer than the narrowed portion of the basal joint, tapers rapidly to an acute point, and is armed with setæ along its inner margin only. The palp also is attached farther back on the basal joint than in other species; it is very narrow, almost linear in fact, one-fourth longer than the terminal joint, six times as long as wide, and armed with minute tooth-like setæ on its anterior margin only.

The first maxillæ are similar to those in other species, but are armed with shorter setæ. The second maxillæ resemble those of *centrarchidarum*, but are shorter, acutely pointed at the tips, and with a sharper curve near the base.

Behind these second maxillæ can be distinctly seen on the ventral surface a set of chitin ribs for the attachment of the maxillipeds, but the appendages themselves are lacking, as in all the females of this genus.

The presence of these ribs, however, proves conclusively that it is a pair of mouth-parts corresponding to the maxillipeds in the male which have disappeared, and thus adds one more convincing testimony to the correctness of this interpretation of the mouth-parts.

The swimming legs are similar to those in other species, all biramose and the rami three-jointed, except the exopods of the fourth pair, which have but two joints. The following is the arrangement of the spines and setæ: First exopod, I-0; 0-1; II-5: endopod, 0-1; 0-1; 0-5: second exopod, 0-1; I-1; 0-5: endopod, 0-1; 0-2; 0-5: third exopod, 0-1; 0-1; 0-5: endopod, 0-1; 0-2; 0-4: fourth exopod, I-1; 0-5: endopod, I-1; 0-2; 0-4. Fifth legs reduced to a pair of long spines.

Total length 0.8 mm. Carapace 0.5 mm. long, 0.25 mm. wide. Length of free thorax 0.18 mm. Length of egg-strings 0.55 mm.

Color a transparent horn color, the ovaries opaque but not as white as in *centrarchidarum*. A large spot over the eye on the dorsal surface

and numerous scattered spots covering the entire ventral surface, as seen in figure 61, a deep purplish blue. Near the posterior margin of the first thorax segment and along the median axis of the second, third, and fourth segments the blue spots coalesce into a large area visible to the naked eye, even from the dorsal surface.

This will serve to distinguish the species ordinarily. The eggs when ripe are a pale blue, so that the parasite shows up distinctly against the red gills.

(*cæruleus*, blue.)

This parasite infests the gills of the bluegill, *Lepomis pallidus*, but is local in its distribution. Thus far it has been obtained only from the Twin Lakes in Marshall County, and Tippecanoe Lake in Kosciusco County, Indiana. Blue-gills are plentiful in Lake Maxinkuckee, 7 miles south of Twin Lakes, but although several hundred of them have been examined by the author at different times, only six specimens belonging to the Ergasilidæ were obtained from the entire number. These were *Ergasilus centrarchidarum* and were found on the outside of the gill filaments, as in every other fish which they infest.

The present species, however, is found between the two layers of gill filaments, and more than a hundred specimens were obtained from two small blue-gills scarcely 5 inches long. This radical change of habit and their abundance suggested at once that they were a new species, which was verified upon further examination. The author is not acquainted with any other species of the genus *Ergasilus* that thus habitually frequents the space between the gill filaments. The blue-gill is a vegetable feeder and its mouth is filled with fragments of algæ and other water plants much of the time. These fragments are bound to produce more or less friction over the gills themselves, particularly during breathing. *Ergasilus centrarchidarum*, inhabiting the outside of the gill filaments, does not take kindly to these conditions. Hence they are only rarely found upon the blue-gill or the croppie, another vegetable feeder.

The present species, however, by frequenting the space between the gill filaments escapes the discomforts incident upon vegetable feeding, and is thus enabled to thrive where the other species failed.

There are two lots of specimens of this species obtained at different times from the blue-gills in Twin Lakes. They are numbered, respectively, 39550 and 39554 U.S.N.M.; the former is made the types of the new species, the latter becoming cotypes. A third lot consisting of half a dozen females was obtained from 10 blue-gills caught in Tippecanoe Lake, and is numbered 39548, U.S.N.M.

ERGASILUS MANICATUS, new species.

Plate 44, text figures 1 and 5.

Female.—Head and first thorax segment completely fused, with no visible indication of the union except in the young.

Resultant cephalothorax elliptical, strongly arched dorsally, one-fifth longer than wide, projecting anteriorly in a large median rostrum, and produced posteriorly into a small lobe on either side of the first free segment. The latter only two-fifths the width of the carapace; third, fourth, and fifth segments diminishing regularly in width and length, the fifth being almost entirely concealed between the fourth and genital segments, especially in mature adults. Genital segment narrower than even this fifth segment and about half as long as all the free segments combined; barrel shaped with its sides evenly rounded. Egg-sacks relatively large, each of them longer than the entire body and four-fifths as wide, and tapered posteriorly; eggs large, arranged in four or five longitudinal rows, about fifty or sixty in each sack.

Abdomen the same length as the genital segment, three-jointed, with the joints equal. Anal laminae rectangular, about as long as the last abdomen joint, each tipped with two setæ, of which the inner is three times the length of the outer.

First antennæ six-jointed, the joints of unequal lengths and widths, the five basal ones sparsely armed with setæ, the terminal one tipped with a tuft of about a dozen (fig. 5 and 71).

The basal joint is curiously grooved, so as to appear like three joints, or to be made up of three parts, according to the point of view. But in dorsal view the grooves are concentric and show that they are not dividing lines between joints.

Second antennæ four jointed, each of the two basal joints being prolonged into a large sleeve or hood, covering the dorsal surface of the joint succeeding it. The basal joint itself is triangular, one angle fastened to the ventral surface of the carapace, and the distal end a side. The second joint is attached to the anterior corner of this side, while the whole side is produced into a semielliptical flap or sleeve, twice the width of the second segment and covering the whole of its dorsal surface. In its turn the distal end of the second joint is enlarged to twice the diameter of the third joint, and produced into a sleeve covering the proximal end of the dorsal surface of the latter for about one-third of its length. The third joint is considerably narrower than the second, of the same diameter throughout, and without any sleeve or projection. The terminal joint is in the form of a stout claw, with an accessory tooth on its inner margin near the base.

Mouth-parts projecting quite strongly; mandibles with a short basal joint which is divided through the center longitudinally by an

irregular chitin rib; neck relatively wide and long; cutting blade curved well forward and terminating in a tuft of long bristles; palp the same length as the neck and toothed along the posterior margin. First maxillæ small and weak, each knob bearing two nonplumose setæ, of which the outer is somewhat the larger. Basal joints of the second maxillæ very large and triangular in shape, reaching out on the surface of the head far beyond the base of the mandibles; the terminal joints relatively short and weak, their tips densely covered with spines.

First four pairs of legs biramose, all the rami three-jointed except the exopod of the fourth pair, which is two-jointed; the fifth pair are reduced to a mere pimple tipped with a single tiny spine. The basal joints of all these legs are much narrower than is usual in this genus; the following is the arrangement of the spines and setæ:

First exopod, 0-0; 0-1; II-4: endopod, 0-0; 0-0; 0-6: second exopod, 0-0; 0-1; 0-7: endopod, 0-0; 0-0; 0-7: third exopod, 0-0; 0-1; 0-6: endopod, 0-0; 0-0; 0-6: fourth exopod, 0-0; 0-6: endopod, 0-2; 0-2; 0-4.

Color a uniform milky white in mature specimens, the more the internal ovaries are developed the whiter the color. As the eggs are also white until nearly ready to hatch, these copepods show up in strong contrast to the red gill filaments.

Total length, 0.75 mm. Length of cephalothorax, 0.5 mm. Width of same, 0.33 mm. Length of egg-strings, 0.8 mm. Width of same, 0.28 mm.

(*manicatus*, furnished with long sleeves, in allusion to the overlapping joints of the second antennæ.)

This tiny parasite is very common on the gills of the silversides minnow, *Menidia notata*, along the Atlantic coast. The National Museum collection includes the following lots, all obtained at or near Woods Hole, Massachusetts: 38612, 38614, 38615, 38621, 38623, and 38626. The 25 specimens in No. 38621 are made the types of the new species. Most of the drawings illustrating this species were made by Dr. Richard Rathbun, assistant secretary in charge of the National Museum, and were generously turned over to the author, with many notes. For this efficient assistance sincere thanks are here returned.

ERGASILUS SIEBOLDII Nordmann.

Ergasilus sieboldii, NORDMANN, 1832, p. 15, pl. 2, figs. 1 to 9.—KRÖYER, 1863, p. 237, pl. 13, figs. 2, *a* and *b*.—CLAUS, 1875, p. 339, pl. 23, figs. 12 to 18.—GADD, 1904, p. 4, pl. 1, figs. 20 to 25.

Nordmann's original description and figures of this species were excellent, and as this was the first species he described, it would naturally become the type of the genus. This position it is in every way fitted to fill, since it is by far the most common of the European species and is found upon the greatest number of hosts.

Furthermore, in bodily structure and habits it comes as near to being a golden mean between the extremes shown by other species as could well have been selected. And being thus common, there is far greater chance for the discovery of its life history than in the case of a rarer species.

These facts have combined to make it the best known of all species, and nearly every European author who has dealt with the parasitic copepods has at least mentioned it.

Nordmann, whose description in other respects was singularly accurate, contents himself with a mere mention of the mouth-parts. This defect was amply remedied by Claus, who gave a detailed description of these appendages, with excellent figures. The last author mentioned above, Gadd, has recently tried to assail this description given by Claus; his opinions will be found discussed on page 279.

Nordmann described only the female; Kröyer tried to remedy this by a brief notice of a form which he took to be the male. He tells us first of all that the finding of the young and the males of *E. gasterostei* induced him to make a search for similar specimens of *E. sieboldii*, and that this search was rewarded by the discovery of half a score of males among several hundred females. Many facts, however, combine to prove that these specimens were not males, but simply females without their egg-strings.

1. The males have been proved to be free swimmers throughout life, and the only chance of finding them among females taken from fishes' gills would be in rare instances when the two are found in union. Kröyer's percentage is far too large for anything of this sort, and he makes no mention of finding the two sexes together.

2. The "males" are represented as being of the same size as the females; this is possible, but not very probable, since the male usually shows considerable variation in size.

3. The "males" showed no sex characters whatever; the few trifling differences noted by Kröyer are what would be expected between a young and a fully mature female; but not one of them is worthy of being made a sexual distinction.

4. If they were really males, they should possess the large maxillipeds characteristic of that sex. But Kröyer's figures clearly show that no such mouth-parts were present in his specimens.

5. If the females of Kröyer's new species, *longimanus*, be compared with these "males" of *sieboldii*, both being shown by Kröyer on the same plate, there will be found so complete a similarity between the two as to leave little doubt of their identity.

Gadd (1904) found a single specimen which he considered to be a male of the present species. And his claim seems just, for in this instance the male was fastened to the body of a female, was considerably smaller than the latter, and showed several decided sex

variations, especially in the way of prehensile organs. Unfortunately the specimen was crushed before it had been fully examined, and we do not know whether it possessed maxillipeds or not.

(*Sieboldii*, from Carl Theodor Ernst von Siebold, an eminent authority on the crustacea.)

ERGASILUS LIZÆ Kröyer.

Ergasilus lizæ, KRÖYER, 1863, p. 232.

Female.—Body elongate, length twice the width, narrowed considerably posteriorly. Head fused with the first thorax segment, the two covered by a broad violin-shaped carapace, the posterior portion of which is longer than the anterior.

The emargination on either side is long and rather shallow, and the posterior margin is almost squarely truncated.

Free thorax segments diminishing regularly in size, the last one (fifth segment) very short. Genital segment oval, shorter than the first three free segments but longer than wide; armed on the ventral surface near the posterior margin with a large number of long and coarse bristles.

Abdomen three-jointed, each joint wider than long and the last one much shorter than the preceding ones, the three together about the same length as the genital segment. Anal laminae the same length as the joint to which they are attached, as wide as long, and armed with two setæ, the inner of which is much the larger. Egg-sacks usually much shorter than the body and quite stout, but in some specimens they are longer than the entire creature, seven or eight times as long as broad. Eggs in three or four longitudinal rows, about one hundred in each sack.

First antennæ short, only reaching the basal joint of the second pair; six-jointed, the two basal joints elongate, the others much shorter and all armed with heavy bristles. Second antennæ half the entire length, slender, four-jointed, the several joints in the proportion of 4 : 8 : 7 : 5. The second joint carries a small knob on the center of the concave margin. Eyes fused on the median line, about one-third the distance from the anterior margin of the carapace; eye pigment bright red.

First four pairs of swimming legs biramose, rami three-jointed, the joints diminishing in size distally; fifth legs uniramose, flattened, one-jointed, and nearly squarely segmented at the distal end, from whence arises a pair of long setæ.

In his description Kröyer gives these fifth legs as appendages of the genital segment at its anterior end, but they belong of course to the fifth thorax segment, which is very short in all the species of this genus and often thoroughly fused with the genital segment. With the exception of this and a few other minor corrections the preceding account is little more than a free translation of that given by Kröyer. No mention is made of the color of this species.

Total length of female, 0.9 mm.

(*lizæ*, from *liza*, the specific name which Kröyer gave to the mullet on which this parasite was found.)

A few specimens of this species were taken with other parasites from the gills of *Mugil curema* (*M. liza* Kröyer), captured near New Orleans, Louisiana. As in the case of *Ergasilus funduli*, Kröyer obtained these parasites from the gills of fish which had been sent to the Royal Museum in Copenhagen, and no further specimens have ever been seen. But here again it is also true that no mullet from that region have ever been examined for parasites since Kröyer's time. And it is possible that a little search would show the species to be fairly common.

ERGASILUS VERSICOLOR, new species.

Plate 45, text figures 11 and 12.

Female.—Carapace elliptical, three-fourths longer than wide and violin-shaped, the part in front of the lateral constrictions longer than that behind them. Anterior margin narrowed and projecting strongly between the antennæ; posterior margin somewhat emarginate. First three free segments about the same length but diminishing regularly in width, the fourth a little narrower than the third and not more than a quarter as long. Fourth (third free) segment posteriorly and genital segment anteriorly contracted into a short neck where they join the short fifth segment. Abdomen indistinctly three-jointed, joints about the same length; anal laminæ small, a trifle longer than the last abdomen segment, quadrangular in outline and slightly divergent, each armed with two unequal setæ.

First antennæ six-jointed, the second joint the largest, the fourth joint next in length, and all heavily armed with setæ. Second antennæ long and slender, three-jointed, the basal joint less than half the length of the second, the terminal joint a stout claw, a little longer than the second joint, but bent into a half circle so as to appear shorter.

Labrum not reaching the base of the first maxillæ; mandibles relatively large, the cutting blades curved forward and outward nearly in a half circle, and fringed along the margins with a dense row of stout spines. Palps short and triangular, with a few short and sharp teeth at the apex and a row of rounded teeth along the outer margin.

Basal portion of the first maxillæ in the form of an elliptical papilla, tipped with two stout spines of which the outer is a little larger than the inner. Second maxillæ with a peculiarly stout terminal joint, the two appendages overlapping somewhat at the mid-line, and each armed with a small tuft of bristles, restricted to the center of the distal end. Labium distinctly U-shaped, its ends running forward under the first maxillipeds almost to the base of the mandibles.

Exopods of the fourth swimming legs two-jointed, all the other rami three-jointed; fifth legs rudimentary, each consisting of a small papilla tipped with two spines, the outer of which is longer than the inner. The arrangement of the spines and setæ on the first four pairs of legs is as follows: First exopod, I-0; 0-1; II-4: endopod, 0-1; 0-2; I-3: second exopod, I-0; 0-1; 1-4: endopod, 0-1; 0-2; II-4: third exopod, I-0; 0-1; I-5: endopod, 0-1; 0-2; I-4: fourth exopod, 0-0; I-5: endopod, 0-1; 0-2; I-3.

Color of body in general a pale transparent horn or cartilage tint; ovary a cream yellow; ventral surface covered with a network of brilliant violet purple, in spots and delicate threads; dorsal surface with spots of pale cinnamon brown, irregularly distributed, with very few lines; digestive tube a rich rust color. As the center of the body is transparent this pigment of the digestive tube shows plainly in both dorsal and ventral views as a broad longitudinal line, bordered on either side by the creamy yellow of the ovaries, with an outside margin of the cinnamon brown spots. Eyes a dark reddish brown, almost black; a large space behind the eyes and in front of the digestive tube clear and transparent.

This assemblage of tints makes the present species the most highly-colored of its genus and has suggested its specific name.

Total length, 1.56 mm. Length of cephalothorax, 0.8 mm; width of same, 0.46 mm. Length of free thorax, 0.4 mm. Length of genital segment and abdomen, 0.32 mm. Length of egg-strings, 0.95 mm.

(*versicolor*, variegated, showing many colors.)

This species was fairly common on the two kinds of catfish found at Lake Maxinkuckee, Indiana, *Ameiurus nebulosus*, the common bullhead and *A. natalis*, the yellow cat.

The latter was more often infested with the parasite than the former. This species was never found upon any other fish although many hundreds of them were searched for it. Nor was *Ergasilus centrarchidarum*, which was so common on the other fish, ever found upon either of these catfish.

In this respect the present species appears to have a well-defined habitat. The National Museum collection includes five lots of this parasite distributed as follows: No. 38652 from the gills of *Ameiurus natalis* at Lake Maxinkuckee, contains specimens which are made the types of the new species. Two other lots from the same host and locality are numbered, respectively, 38650 and 38651. No. 38649 includes half a dozen specimens from the gills of *A. natalis* in the Mississippi River at Alton, Illinois. No. 38648 contains eight females from the gills of the channel cat, *Ictalurus punctatus*, captured in the Mississippi River at Clayton, Iowa.

ERGASILUS CHAUTAUQUAËNSIS Fellows.

Plate 46, text figures 26 and 28.

Ergasilus chautauquaënsis, FELLOWS, 1887, p. 175, preliminary notice; 1888, p. 246, 8 figs.

Female.—Body with an elongate cyclops form, about four times as long as wide; head fused with the first thorax segment, the union being indicated by a notch in each lateral margin and a partial groove across the body. This cephalothorax considerably less than half the entire length; contracted anteriorly to a narrow rostrum less than one-quarter the width of the body; somewhat narrowed and squarely truncated posteriorly. First three free thorax segments diminishing regularly in width, the third one (fourth segment) being the same width as the genital segment. The fifth segment is practically indistinguishable between the fourth and genital segments; the latter is barrel-shaped and narrowed considerably posteriorly. Abdomen made up of three joints of the same length and width; on the ventral surface the groove between the genital segment and the abdomen, and each of the abdomen grooves is set with a row of long spine-like teeth (see fig. 87). Anal laminæ as long as the entire abdomen; each nearly half as wide and tipped with two setæ of about the same size and four times as long as the laminæ.

Egg-sacks oval, only reaching to the tips of the anal laminæ; eggs quite large and arranged in four or five longitudinal rows, about 25 in each sack.

First antennæ six-jointed and longer than the second pair, the setæ on the fourth, fifth, and sixth joints very long, reaching to the last thoracic segment. Second pair rather weak for this genus; four-jointed, the basal joint not swollen as in most species. Labrum so thoroughly fused with the head as to be indistinguishable. Mandibles with a short and very wide basal joint, the neck short and narrow, the cutting blade long and narrow and densely fringed with bristles along both margins; palp narrow and with a row of fine teeth along its outer margin. First maxillæ narrow, each furnished with two non-plumose setæ of about the same size. Second maxillæ with a long and narrow basal joint; the terminal joint also rather long and with a dense tuft of bristles at the tip. Both mandibles and maxillæ are so placed that they overlap considerably across the mid-line. Labium well curved but so narrow as to be little more than a chitin rib.

First four pairs of swimming legs biramose; rami three-jointed, except the exopods of the fourth legs, which have only two joints. Fifth legs reduced to a long spine on either side of the fifth segment. The following is the arrangement of the spines and setæ on the first four legs: First exopod, I-0; 0-1; II-5: endopod, 0-1; 0-1; II-4:

second exopod, I-0; 0-1; I-6: endopod, 0-1; 0-2; I-4: third exopod, I-0; 0-1; I-6: endopod, 0-1; 0-2; I-4: fourth exopod, I-0; I-5: endopod, 0-1; 0-1; I-3.

Color transparent, except the digestive canal, which is bright blue for its entire length, making the copepod very conspicuous when alive. This color, however, fades and is not visible in preserved specimens.

Total length, 0.86 to 1 mm. Length of carapace, 0.48 mm. Width of same, 0.4 mm. Length of setæ on anal laminae, 0.4 mm.

Male.—Similar to the female in general body structure, but more slender. First and second antennæ shorter and weaker; maxillipeds present as large, three-jointed, prehensile organs; basal joint short and stout; second joint much longer and tapered toward the distal end, armed with two powerful muscles and with a fringe of stiff hairs along its posterior margin; third joint in the form of a long slender claw, twice the length of the second joint and curved into a half circle, its concave margin facing its fellow on the opposite side of the mid-line; the tip is slightly enlarged and bluntly rounded (fig. 28). Genital segment wedge-shaped, widest posteriorly where it carries a long and stout spine on either side; abdomen and anal laminae as in the female.

Total length, 0.75 to 0.8 mm. Other measurements corresponding; color as in the female.

(*chautauquaënsis*, from Chautauqua, the place where the first specimens were found.)

Several specimens of this beautifully colored species were obtained among free swimming forms at the surface of Lake Champlain during the session of the American Society of Microscopists held at Chautauqua, New York, in 1886.

They were given to Charles S. Fellows, who published a description of them in the proceedings of the above society for 1887. They had never been found by other observers up to the present year. But in some samples of the tow from Lake Mendota at Madison, Wis. sent to the author by Profs. E. A. Birge and Chauncey Juday of the University of Wisconsin, both sexes of this interesting species were again discovered. These specimens have been placed in the National Museum collection and have been numbered 38617.

All of this species have thus been found while swimming actively at the surface and the natural host has not yet been discovered. But it is reasonably certain that they are parasites like all the other species of the genus, and that their host will be discovered in due time.

ERGASILUS MUGILIS Vogt.

Plate 47, text figure 9.

Ergasilus mugilis, VOGT, 1877, pp. 94 to 100.

Female.—Cephalothorax two-thirds the entire length and nearly twice as long as wide. First thorax segment distinctly separated from the head by a deep groove which forms large lateral emarginations. Head transversely elliptical, with a wide and evenly rounded projection at the center of the anterior margin. First thorax segment the same width and length as the head, but more quadrilateral in outline, with rounded corners. Second, third, and fourth segments diminishing regularly in width, but about the same length, the second one less than one-third the width of the first segment. Fifth segment very short and thoroughly fused with the genital segment; sixth or genital segment the same width as the fourth segment and half as long again, barrel shaped, with rather flat sides.

Abdomen three-jointed, the segments diminishing regularly in width and length, the terminal one deeply incised posteriorly. Anal laminae rectangular, about the same length as the last abdomen segment, and each tipped with two rather short setae of unequal length. Egg-cases half as long again as the entire body, somewhat tapered posteriorly; eggs large, arranged in four or five longitudinal rows, from 100 to 125 eggs in each case.

First antennae six-jointed, the length of each less than one-quarter of the width of the carapace, armed with very short setae, evenly distributed among the joints.

Second antennae slender, four-jointed, and reaching but little beyond the margin of the head; basal joint not inflated, second and third joints tapering slightly, the former one-fourth longer than the latter; terminal claw two-thirds the length of the third joint, strongly curved and acutely pointed.

Mouth-parts differing in several particulars from those of other species; labrum very wide, its lateral edges reaching well beyond the bases of the mandibles, its posterior margin nearly straight (fig. 9). Mandibles entirely covered by the labrum, except the posterior proximal corner of the basal joint; the diagonally opposite corner (anterior distal) is armed with a good sized tuft of bristles; the neck at the inner end of the basal joint is narrow; the cutting blade is also narrow and four times as long as wide.

The first maxillae are slightly overlapped by the labrum, and each is armed with two nonplumose setae of about the same length. The second maxillae have an elongate terminal joint, heavily armed with bristles. Both mandibles and maxillae are attached so far apart that they do not meet on the mid-line, but are separated by quite an interval.

Labium well defined and fairly wide, with an almost straight posterior border.

Rami of the swimming legs with three joints except the exopods of the fourth pair, which have but two joints. The arrangement of spines and setæ is as follows: First exopod, I-0; I-1; I-5: endopod, 0-1; 0-1; I-5: second exopod, 0-0; 0-1; 0-6: endopod, 0-1; 0-2; 0-4: third exopod, 0-0; 0-1; 0-6: endopod, 0-1; 0-2; 0-5: fourth exopod, 0-0; I-5: endopod, 0-1; 0-2; 0-4. Fifth legs made up of a single short joint tipped with two small setæ of equal length.

Color yellowish brown at the extreme front of the cephalothorax and along the free thorax, the abdomen, and the egg-strings, deepening to a dark brown through the cephalon and first thorax segment. On the ventral surface there is a line of spots and streaks of dark blue pigment on either side passing through the basal joints of the swimming legs and running forward, about the same distance apart on the cephalothorax, to the bases of the second antennæ. There is a large spot of the same pigment on either side of the mid line and close to it, at the anterior end of the genital segment, and two other similar spots at the bases of the anal laminæ.

Total length, 1.15 mm. Cephalothorax, 0.73 mm. long, 0.46 mm. wide. Width of second segment, 0.15 mm. Length of egg-strings, 1.65 mm.

(*mugilis*, the generic name of its host.)

The collection of the National Museum contains but a single lot of this species, consisting of two females taken from the gills of *Mugil cephalus*, the common mullet, at Beaufort, North Carolina, in the summer of 1901 by Prof. Edwin Linton, and numbered 38631. The species is not a common one, since the examination of many fish yielded but these two specimens. The large cephalothorax, distinctly grooved at the center and the exceptionally long and narrow egg-strings will help to distinguish this from other species.

In 1877 Carl Vogt published in the second mémoire of his *Recherches Cotières* a short description of a species of *Ergasilus*. His specimens also were taken from the gills of the common mullet, which is the same in European waters as on our Atlantic coast. He described nothing but the external appearance of the parasites, having unfortunately mislaid the specimens upon which he intended to work out the mouth-parts and other appendages. He gave the species the provisional name of *E. mugilis*; provisional because to the best of his belief the species was identical with one which Hesse had obtained on *Mugil capito*, and upon which the latter author had founded a new genus and species, *Megabrachinus suboculatus*. If the two proved to be the same, Hesse's generic name would have the precedence: if not, then Vogt's name would become valid.

Vogt's brief description agrees in every detail with that of the present species, and as he never published any figures the description is all there is to guide us.

Furthermore, after careful examination, the present author can not agree that Hesse's *Megabrachinus* is at all likely to be found identical with this *Ergasilus*. It has already been stated (p. 264) that Hesse's species can not be located anywhere with certainty by reason of the manifold mistakes and contradictions in his text and figures.

Again, Vogt has tried to show that the distinctions upon which Hesse founded his species are not generic distinctions at all, but only specific. Be that as it may, Hesse apparently saw one thing and has portrayed it clearly in his figures, which will effectually prevent his species from ever belonging to the genus *Ergasilus*. And that is a pair of good-sized maxillipeds behind the other mouth-parts. In the females of *Ergasilus* the maxillipeds are entirely wanting; if there is any truth in Hesse's figure, therefore, the specimens he was trying to portray certainly did not belong to the genus *Ergasilus*. He does not even mention the appendages in his text, so that we can get no help from that source. We can easily understand how he might omit some descriptions—no author ever describes all the details of his figures. But it would hardly be reasonable to suppose that he deliberately drew a pair of appendages which did not exist. We may safely conclude then that his "*Megabrachinus*" will never prove to be an *Ergasilus*, and may thus with greater assurance restore Vogt's original name for the present species.

Genus THERSITINA Norman.

Thersites, PAGENSTECHEER, 1861; *Ergasilus*, KRÖYER, 1863, and GADD, 1901; *Thersitina*, NORMAN, 1906.

This genus was originally described by Pagenstecher in 1861 under the name *Thersites*, borrowed from the Iliad. His description was fairly good, but he acknowledged that the mouth-parts were "indistinct" and presented no details with reference to the swimming legs, both of which are essential for the determination of specific distinctions.

He found three pairs of mouth-parts, which he designated as maxillæ and first and second maxillipeds, respectively; the mandibles he believed to be inside the mouth, where they could not be seen. But mandibles inside the mouth would make of the latter a sort of proboscis, and Pagenstecher distinctly states that nothing of the sort is formed. Hence we can get no satisfactory data from his description.

Two years later (1863) Kröyer described the same species from the same host, but called it *Ergasilus gasterosteus*. He found what he openly designated as a rostrum or proboscis at the mouth, but he did not have the courage to name definitely any of the mouth-parts.

He also mistook a young female without egg-strings for a male, as he had done in several other instances.

Claus, in speaking of the Ergasilidæ, says:

Thersites mochte demnach generisch mit *Ergasilus* zusammenfallen, zumal auch die Gestaltung der Mundwerkzeuge keine wesentlichen Abweichungen zu bieten scheint und die colossale Auftreibung des Weibschens dem Kopf und ersten Brustsegment angehort (1875, p. 339).

On the next page he states that Pagenstecher mistook the mandibles for the first maxillipeds, but he gives us no description of the mouth-parts as they should be, except the above statement that they correspond to those of *Ergasilus*.

Canu, in his excellent work *Les Copepodes du Boulonnais* (1892), published a short account of the mouth-parts of *Thersites gasterostei*. He found a pair of falciform mandibles, a rudimentary maxilla, reduced to a mere stump, carrying two slender setæ, as in all the genera of the Ergasilidæ, and what he called the second maxilla, posterior to the previous pair and corresponding to the second maxillæ in *Ergasilus* and *Bomolochus*. This is really the first description of the mouth-parts that can be looked upon as at all accurate, and it is unfortunate that it was so well concealed in Canu's systematic treatise.

T. Scott in one of his memoirs (1900) mentions this description by Canu under the synonymy of *Thersites*, and then gives us another excellent description of the female, accompanied by admirable figures. He finds four pairs of mouth-parts, a pair of mandibles with a bilobed and pectinate cutting blade, rudimentary maxillæ, simple "first maxillipeds," and three-jointed "second maxillipeds." These last consist of an enlarged basal joint and a curved terminal two-jointed arm, tipped with four or five strong apical spines. He also gives us the details with reference to the swimming legs.

In the following year (1901) we find Gadd trying to establish a new species, which he calls *Ergasilus biuncinatus*, as distinct from the *gasterosteus* of Pagenstecher and Kröyer. But his specific distinctions are based upon comparisons with the imperfect descriptions of the two authors just mentioned. He was evidently unacquainted with the more accurate descriptions of Canu and Scott, for he does not even mention them. While his distinctions seem fairly valid, there are two facts which greatly weaken his claim.

First, he entirely overlooked the first maxillæ, not only in this "new species," but also in another species of *Ergasilus*, which he presents in the same paper. If he had found these maxillæ, it would have radically changed his interpretation of the mouth-parts. Again, the figure he has given us of the mouth-parts of "*biuncinatus*" is inverted, the "first maxilliped" being represented as superior (or anterior) to the "maxilla" (which latter is really the mandible).

Only these two mouth-parts are shown, and nothing is said of any others in the text. In view of such mistakes, we shall have to wait for further testimony before deciding as to the validity of the species. But this need not hinder us from locating the genus. The present author believes *Thersitina* to be a valid genus and distinct from *Ergasilus*, for the following reasons:

1. Its habitat. *Ergasilus* species are always found clasping the gill filaments with their second antennæ; *Thersitina* is found with its second antennæ buried in the skin on the inside of the operculum.

2. Its body form. In mature females of *Ergasilus* the cephalothorax is sometimes swollen by the development of the ovaries and oviducts and their contents, and becomes more or less cylindrical; but it never approaches a sphere, and the second thorax segment does not share in the inflation.

3. The structure and attachment of the antennæ. The first antennæ are very short and five-jointed in *Thersitina*, while in *Ergasilus* they are relatively longer and six-jointed. The second antennæ in *Thersitina* are short and stout, and closely resemble the second maxillipeds in the Caligidæ. In *Ergasilus* they are long and slender and bear no resemblance to those maxillipeds.

4. The structure and number of the mouth-parts. In *Ergasilus* females the maxillipeds are entirely lacking; in *Thersitina* they are present behind the other mouth-parts and of peculiar structure. T. Scott is a very careful and accurate observer, and one who has had much experience with both parasitic and free-swimming forms. His description, therefore, is entitled to great confidence, especially in view of the fact that the other observers have not given much attention to these maxillipeds. Hence we may concede the validity of the genus and present the following

GENUS DIAGNOSIS.

Head fused with the first thorax segment; resultant cephalothorax and the first free segment inflated into an ellipsoid or sphere, to the ventral surface of which at the posterior end is attached the comparatively minute remainder of the body; other free segments less than a quarter of the diameter of the cephalothorax, diminishing regularly in size. Genital segment not much enlarged; abdomen three-jointed, joints about equal.

Anterior antennæ small, scarcely reaching halfway to the margin of the carapace, five-jointed and well armed with setæ. Second antennæ short and stout, suited for burying in the tissues of the host, like maxillipeds, rather than for clasping. Mouth-parts consisting of falciform mandibles, rudimentary first maxillæ like those of *Ergasilus* and *Bomolochus*, simple second maxillæ, and a pair of three-jointed maxillipeds behind the other parts. Egg-cases ellipsoi-

dal, as long as the entire animal; eggs large and numerous. Male unknown.

Type-species.—*Thersitina gasterostei*.

(*Thersitina*, *Thersites* and an ending denoting likeness.)

Subfamily BOMOLOCHINÆ.

Body flattened; head fused with the first thorax segment and the ventral surface of the resultant cephalothorax reentrant, so that its edges, with the bases of the first antennæ and the first swimming legs, form an effective prehensile disk. Free thorax often as wide as the carapace; genital segment enlarged but little; abdomen small and stunted. Basal joints of the first antennæ enlarged, flattened, bent sharply at a right angle, and furnished with a row of dense setæ and tactile hairs along their anterior margin. Second antennæ transformed into prehensile organs, with spines and roughened surfaces, but much shorter and weaker than those of the Ergasilidæ. First

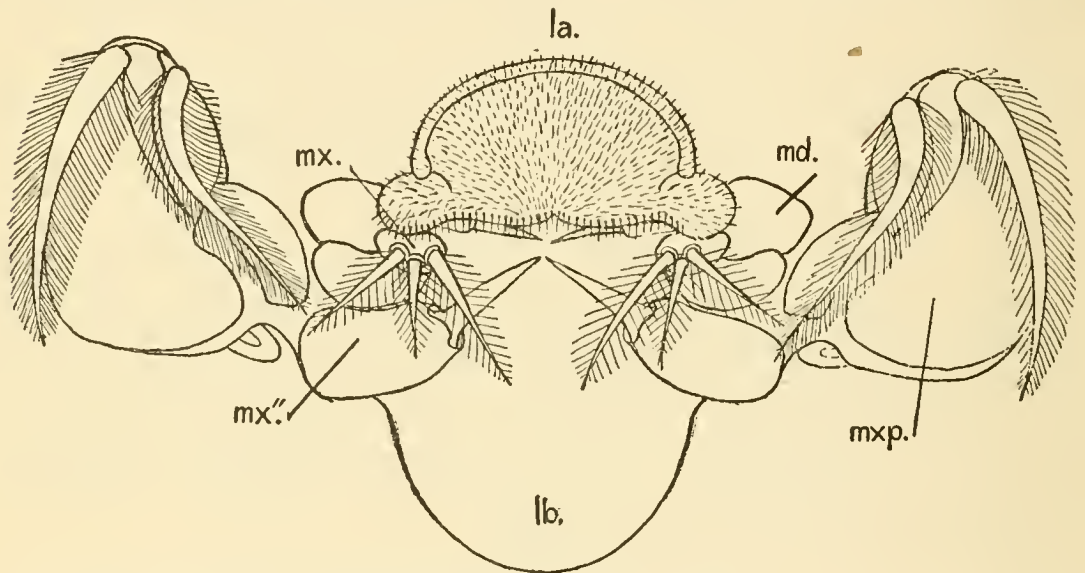


FIG. 39.—MOUTH-PARTS OF FEMALE BOMOLOCHUS TERES. *la*, LABRUM; *lb*, LABIUM; *md*, MANDIBLE; *mx'*, FIRST MAXILLA; *mx''*, SECOND MAXILLA; *mxp*, MAXILLIPED.

swimming legs strongly flattened, not used for locomotion as much as for prehension; fifth legs uniramous, but with two or more joints, each bearing setæ.

Species usually about twice the size of the Ergasilinæ, namely, from one to two millimeters in length.

DESCRIPTION OF THE MOUTH-PARTS.

Female.—Mouth-parts close to the second antennæ. Labrum considerably wider than long, with a roughened surface, projecting prominently from the head and well defined (fig. 39). Labium divided and consisting of a half projecting inward from either side, the two often not meeting at the center. Mandible consisting of a narrow, cylindrical basal joint, which is curved sharply backward

in exactly the opposite direction to that in *Ergasilus*, and armed with a small palp at its posterior distal margin; both palp and terminal joint are conical and destitute of setæ. Maxillary hook wanting. First maxilla made up of a short basal joint, fused to the ventral surface, and a terminal knob armed with three or more divergent plumose setæ. Second maxilla with a wide basal joint fused to the ventral surface of the head, and a conical terminal joint, which may be either simple, as in most species, or bipartite, as in *B. soleæ* Scott and in the genus *Tucca*. Maxillipeds with two stout basal joints, which are turned forward outside the other mouth-parts and fused with the ventral surface of the head, and a terminal claw bent twice into the form of the letter S; both second joint and terminal claw are well armed with plumose setæ.

Male.—Mouth-parts so far forward that the upper lip lies between the bases of the second antennæ. Labrum longer than wide, with a

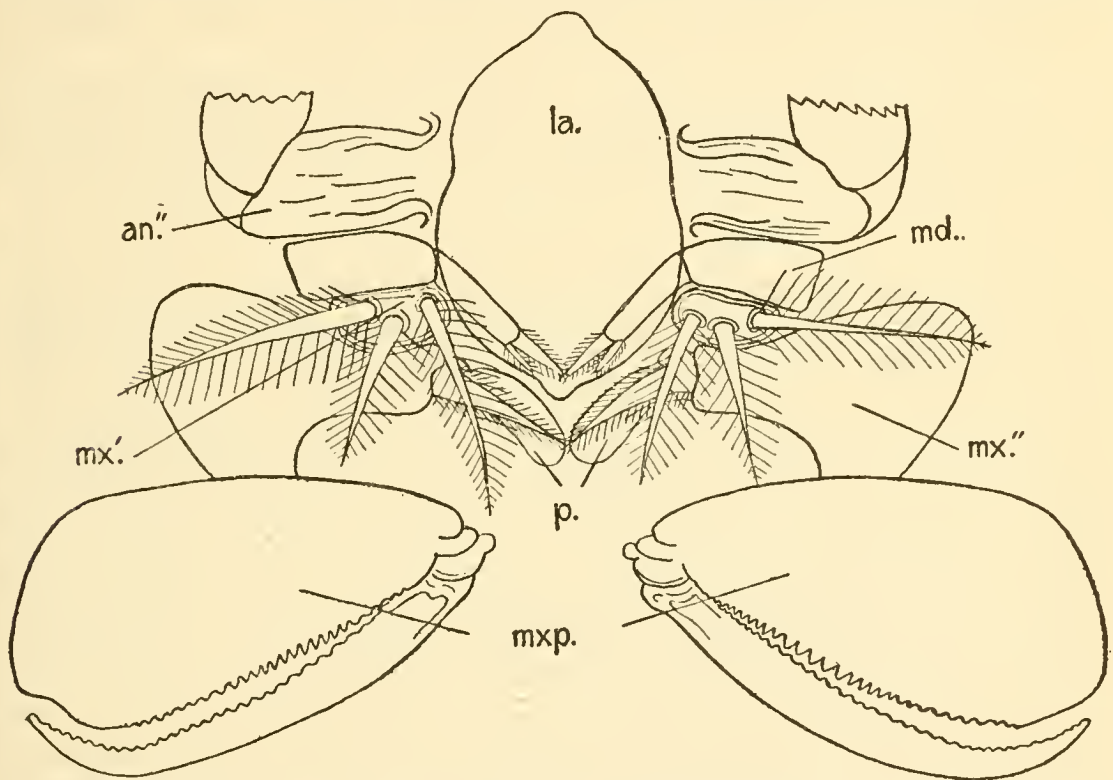


FIG. 40.—MOUTH-PARTS OF MALE *BOMOLOCHUS SOLEÆ*. *an''*, SECOND ANTENNA; *la.*, LABRUM; *md.*, MANDIBLE; *mx'*, FIRST MAXILLA; *mx'''*, SECOND MAXILLA; *mxp.*, MAXILLIPEDS; *p.*, PARAGNATHS.

prominent and well-roughened surface; labium similar to that in the female. First three pairs of mouth-parts also similar to those in the female except that they are longer and more slender. Maxillipeds large, of normal structure, and some little distance behind the other mouth-parts. Their basal joints are strongly inflated, elongate triangular in shape, and are attached as close to the lateral margin as in the female. Indeed, in spite of the large size of the basal joints, their distal ends do not meet at the mid-line by a considerable interval. The terminal joints are in the form of long slender claws, bent

only once and curved just enough to fit closely along the posterior margin of the basal joint. These maxillipeds about evenly divide the space between the other mouth-parts and the first swimming legs, and thus cause the mouth-parts to appear farther back than in the female. But with the exception of the maxillipeds they are really in the same position.

ARTIFICIAL KEY TO THE GENERA.

- a.* Second segment forming a narrow neck between the cephalothorax and the remainder of the segments, which are fused into a body incapable of flexion; all the swimming legs very rudimentary; abdomen invisible.
Tucca Kröyer, 1863, p. 352.
- a.* Third and fourth segments fused, the latter invisible in dorsal view, being covered by the overlapping third segment; endopods of first and second legs with wide and flattened joints.....*Artacolax* Wilson, 1908, p. 360.
- a.* All the thorax segments except the first free and distinct; endopods of all the swimming legs with narrow joints like the exopods.....*b.*
- b.* Basal joints of first antennæ enlarged, flattened, and densely bristled; second maxillipeds armed with large plumose setæ.
Bomolochus Nordmann, 1832, p. 365.
- b.* Basal joints of first antennæ cylindrical, not enlarged, and with only a few setæ; second maxillipeds without setæ....*Pseudoecanthus* Brian, 1905, p. 380.

Genus TUCCA Kröyer.

Female.—Body with three regions, a small cephalothorax joined by a short neck to a fused and inflated thoracic trunk, and a minute posterior portion consisting of the genital segment and abdomen. Cephalothorax inflated dorsally, with a lobed wing on either side; its ventral surface deeply hollowed, with a raised rim composed of the first antennæ, first swimming legs and the border of the wing on either side. Second antennæ and mouth-parts at the bottom of this bowl-shaped depression and so similar to those of *Bomolochus* as to indicate close relationship. Maxillipeds behind and a little outside the other mouth-parts, much enlarged, with powerful terminal claws. First swimming legs with wide rami like those of *Bomolochus*; second pair close behind the first, each ramus two-jointed; third and fourth pairs at a considerable distance on the trunk, each with a one-jointed endopod; fifth pair at the junction of the trunk and posterior body. Genital segment small and triangular; abdomen rudimentary, one-jointed; egg-cases cylindrical, as long as the body; eggs multiseriate, small, and numerous.

Male.—Similar to the female but considerably smaller, with the same body regions, but with the genital segment larger and armed with a powerful hook on either side at the posterior corner. Appendages similar with the usual sexual differences in the antennæ and maxillipeds.

(*Tucca*, a friend of Horace and Virgil.)

Type-species.—*Tucca impressus* Kröyer.

This genus was established by Kröyer in 1837 with a short description and seven figures. He had but a single specimen, a female taken from the inner surface of the pectoral fin of a *Diodon hystrix* in the Danish West Indies. And his account includes only the external characters with none of the appendages except one pair of attachment organs.

From its degenerate form and general shape he placed the parasite in the family of Dichelestiidae.

Twenty-seven years later (1864) Nordmann published a second account, based upon ten specimens obtained from a *Diodon* species on the west coast of Africa. He corrected and supplemented Kröyer's description and gave a figure of the under surface of the cephalothorax showing three pairs of appendages, which he named first and second antennæ and second maxillipeds. He claimed that the structures which Kröyer had described as attachment organs were only the thickened border of the winglike processes on the sides of the cephalothorax and that what he himself presented as second antennæ were the true attachment organs. But Nordmann did not discover any of the other appendages, and simply shows the differences in body shape between his specimens and Kröyer's. He describes the epidermis as covered on both the upper and under surfaces with small conical warts (Warzen). He also saw what he suggested might be a proboscis (Russel) and classifies the genus among the Chondracanthidae.

Bassett-Smith in 1899 puts it back among the Dichelestiidae, following Kröyer. No other writer has done more than to mention the species, and the genus is left where Kröyer and Bassett-Smith placed it, in the Dichelestiidae. And this is where it would naturally be placed by reason of its body form, but a single look at the true mouth-parts is enough to show that it is a Bomolochid genus.

Neither Kröyer nor Nordmann saw any of the mouth-parts except the maxillipeds, which were the appendages Kröyer described as attachment organs, and also those which Nordmann called second antennæ, the difference in structure being due to the fact that they were describing different species.

The appendages which Nordmann called second maxillipeds were probably the second pair of swimming legs, as will be seen in the description hereafter given. The reason why both these investigators failed to find the mouth-parts is simple but effective. They lie, as already stated, in the bottom of a bowl-shaped depression; when taken from the fish's fin this depression is filled with slime, which effectually conceals the appendages. In preservatives this slime becomes hardened and is then very difficult to remove. Both of the investigators above mentioned were working with material that had been in alcohol for a long time, and the only thing visible was the maxillipeds, whose tips project above the rim of the depression.

The discovery of the true mouth-parts as well as the swimming legs upon living specimens examined at Beaufort and Woods Hole has completely changed the nature of the parasite and virtually makes of it a new genus, but still retaining the old genus name. The case is exactly similar to that of *Echetus typicus* described by Kröyer as a Lernæid, but afterward found, when its head was discovered, to belong to the Caliginæ.

ARTIFICIAL KEY TO THE SPECIES.

- a. Posterior portion of the fused thoracic trunk distinctly three-lobed; skin smooth, *impressus* Kröyer, 1837, p. 354.
- a. Posterior portion of fused thoracic trunk evenly rounded, with no trace of lobes.....b
- b. Fused thoracic trunk wider than long, overhanging and concealing in dorsal view the genital segment and abdomen; skin smooth...*corpulentus*, new species, p. 358.
- b. Fused thoracic trunk one-third longer than wide, genital segment and abdomen wholly visible; skin covered with small warts...*verrucosus*, new species, p. 359.

TUCCA IMPRESSUS Kröyer.

Plates 48 and 49.

Tucca impressus, KRÖYER, 1837, p. 479, pl. 5, fig. 2, a to g.

Female.—Body separated into three distinct regions, a cephalothorax, a fused thorax, and a posterior portion consisting of the fifth thorax segment, the genital segment and the abdomen. The cephalothorax is a fusion of the head and the first thorax segment, and is small and hemispherical in shape, being inflated dorsally and flattened ventrally.

The integument along each lateral margin is formed into a wide lobed wing, made up of two layers of skin, dorsal and ventral, separated from each other and supported upon a chitin framework (fig. 112).

The ventral layer is produced inward from the lateral margin toward the mouth, and is separated a little from the ventral surface of the head, leaving a narrow space between the two. In this space are located the bases of the various mouth-parts, of the second antennæ and the first swimming legs.

The thickened edge of the skin is about half way between the lateral margin and the mouth, and forms an elliptical ring around the latter. On the ventral surface of this raised edge appear anteriorly the first antennæ, and posteriorly the terminal joints of the first swimming legs.

The first antennæ are four-jointed, the three basal joints about the same width, the terminal one much narrower; every joint is heavily armed with setæ, which extend in a continuous row along the anterior margin of the basal joint, and diagonally across the ventral surface of the second and third joints. The second antennæ are three-jointed,

the basal joint not much stouter than the two terminal ones and armed with a large spine at its distal end. The second and third joints are of the same size, the third one roughened over its entire surface and tipped with a narrow conical process at the outer distal corner, a thickened claw at the inner corner, and about five long curved and sharp-pointed claws over the rest of the tip.

The upper lip is very wide anteriorly, contracted and with a reentrant curve posteriorly; it is one-third wider than long (fig. 104).

The mandibles are three-jointed, long, slender, and simple; they start out vertically, then bend at a right angle and extend inward to the mouth opening, parallel with the surface of the head; the terminal joint is short and not toothed.

The first maxillæ are reduced to mere knobs, each bearing three plumose setæ. The second maxillæ are short and two-jointed, the terminal joint bipartite, the posterior branch longer than the anterior, both with smooth and acuminate tips. The maxillipeds are much enlarged and are attached diagonally behind and outside of the other mouth parts, not reaching as far forward as in *Bomolochus*, but not directly behind the other parts as in *Tæniacanthus*.

The basal joint is more or less rectangular and attached to the surface of the head except at the very tip; the terminal joint is in the form of a stout chitin claw with a swollen base and a blunt tip. This claw has somewhat of an S-curve, but not very pronounced, and has no teeth or projections (fig. 115).

The cephalothorax is joined to the fused thorax by a neck, formed of the second thorax segment, which varies much in length in different individuals, but is usually very short. The second pair of swimming legs are on this segment and in close proximity to the first pair; each ramus is two-jointed and the joints are about the same size, the terminal one well armed with setæ. The endopod is apparently always carried flattened back against the basal joint where it is often very difficult to find it.

The fused thorax or trunk is made up of the third, fourth, and fifth joints; it is oblong and so much swollen that the thickness is fully equal to half the width; the corners are evenly rounded and project posteriorly in the form of lobes; the lateral margins and the posterior margin between the lobes are somewhat emarginate. On the dorsal surface there is a third lobe in the center between the other two and about the same size. There are four pits or depressions on the dorsal surface of this swollen trunk, and four others upon the ventral surface. The former are arranged at the four corners of a square, the latter in pairs on the median line, the two anterior ones a little closer together than the two posterior. In the ventral pits are to be found the rudimentary third and fourth legs; each consists of a somewhat swollen basal joint and two rami; the exopod is two-

jointed, the proximal joint with a single spine, the terminal joint with eight plumose setæ in the third leg and four in the fourth leg; the endopod is composed of a single tiny joint, armed with one spine. If the entire length of the trunk be divided into thirds, the pits and legs are on the dividing lines between the thirds.

The fifth legs are at the junction of the trunk with the posterior portion of the body; each is narrow, one-jointed, and tipped with three plumose setæ. The legs themselves are found only in the male, but the appropriate muscles for them are present in the female (fig. 103).

The genital segment is relatively very small, only one-fourth the width of the trunk, and forming with the abdomen a triangle whose base, joined to the body, is a little longer than the two sides. The openings of the oviducts are on either side a little in front of the abdomen (fig. 111). The egg-cases are somewhat cigar shaped and a little longer than the entire body. The eggs are exceedingly minute and arranged in 25 to 40 longitudinal rows, about 50 eggs in each row.

The abdomen is one-jointed, considerably wider than long, and carries on its ventral surface a pair of rudimentary anal laminae, each armed with three setæ, of which the central one is the longest, the outer one two-thirds as long and the inner one very short, sometimes lacking (fig. 111). The ovary occupies the entire cœlomic portion of the fused thoracic segments, the eggs being scattered through the body cavity with no apparent regularity.

Total length, 1.67 mm. Cephalothorax, 0.25 mm. long, 0.53 mm. wide. Trunk 1.2 mm. long, 0.9 mm. wide. Length of egg-strings, 1.75 mm.

Color, a light cartilage gray in living specimens; in preserved material anything from opaque white to a dark gray-brown, according to the method of preservation.

Male.—Body similar to that of the female, but with the cephalothorax fully as wide as the trunk, and the genital segment and abdomen proportionally much larger. Lateral wings of the cephalothorax not lobed; antennæ and mouth-parts similar to those of the female. Maxillipeds considerably enlarged and placed behind the other mouth-parts as in the male of *Bomolochus*. Trunk elliptical in shape, with evenly rounded sides and corners; rudimentary third and fourth legs larger than in the female, posterior pair as close together as the anterior. Genital segment enlarged to half the width of the trunk and armed with a pair of stout hooks on the ventral surface at the posterior corners.

Spermatophore receptacles large and plainly visible in both dorsal and ventral views. Abdomen one-jointed, anal laminae larger than in the female and the setæ much longer.

Total length, 1.27 mm. Cephalothorax, 0.3 mm. long, 0.5 mm. wide. Trunk, 0.75 mm. long, 0.51 mm. wide. Width of the genital segment, 0.25 mm.

Color the same as in the female.

(*impressus*, stamped or marked, in allusion to the pits on the dorsal and ventral surfaces.)

This species is a fairly common parasite on the southern puffer, *Chilomycterus schoepfi*. It is not found on the gills, however, like most of its near relatives, but on the fins, seeming to prefer the inside of the pectoral fins to any other locality. To these it is fastened so securely that the attempt to remove it usually results in tearing off the maxillipeds which are its organs of prehension. The museum collection includes three lots of specimens, two from Beaufort, North Carolina, and one from Woods Hole, Massachusetts, all taken from the same host. The last lot is numbered 38625, the two former ones 38627 and 38628, respectively.

Two points in the morphology of this species are worthy of especial mention. The first is the remarkable increase in the number of eggs, which is accomplished by a corresponding decrease in their size. The egg cases are relatively no larger than those of other species, in fact not as large as some, *Ergasilus manicatus*, for example. But the eggs are only 0.05 mm. in diameter, and are crowded into the cases as thickly as they can lie. Consequently we find in the wider portions of the cases from 35 to 45 eggs in a cross section, while there about 50 in the longest longitudinal rows. This means that each case contains between 1,500 and 2,000 eggs, or from 3,000 to 4,000 in the two cases.

Such an extraordinary supply of eggs indicates a corresponding loss somewhere in their development, and a careful study of the life history of this species ought to yield some interesting data.

The other noteworthy fact is a coiling or folding of the intestine. The stomach is elongated within the third and fourth thorax segments, reaches the extreme posterior margin of the latter, and is widest at this posterior end. It then abruptly narrows into the intestine, which is folded back upon itself so as to be cut three times in a single cross section. In the body of the copepod there has been a fusion of the fifth and sixth thorax segments with the abdomen and a marked shortening or telescoping together of these parts. But the intestine has retained its original length and consequently has been thrown back upon itself during the telescoping process. A more complete account of these anomalous conditions will be published later. They also furnish a further incentive to a study of the life history of the species.

The enlarged figures of the mouth-parts in this and the following species are given without the maxillipeds for the reason that the latter, when in position, hide most of the other appendages, as can be seen in figure 124.

TUCCA CORPULENTUS, new species.

Plate 49, figs. 116 and 117: Plate 50.

Female.—Cephalothorax about the same size and shape as in the preceding species, but with the wings divided into four lobes instead of two. Trunk enlarged to three times the diameter of the cephalothorax, nearly circular in outline and much flattened dorso-ventrally; no traces of pits or impressions on either the dorsal or ventral surfaces.

Posterior margin evenly rounded, without lobes, and overhanging the genital segment and abdomen so that the latter are invisible in dorsal view. Genital segment and abdomen relatively very small. Egg cases cylindrical, somewhat narrowed at either end, and about the same length as the trunk. Eggs minute and arranged like those in *impressus*.

First antennæ large, four-jointed, and heavily armed with setæ; the spine between their bases long and narrow. Second antennæ with the two distal joints much stouter than in *impressus*, the terminal one inflated, but with a narrow process and thick, blunt claws. It is thus the exact counterpart of the same appendage in *impressus*, where the terminal joint was slender, with a thick, blunt process, and narrow, sharp claws. Labrum ovate, one-third longer than wide, with evenly curved margins. Mandibles three-jointed; basal joint no wider than the second joint, the latter carrying on its posterior margin near the distal end a large secondary spine, longer than the terminal joint but not as wide.

First maxillæ similar to those of the previous species, the central seta the largest and longest. Second maxillæ with a tripartite tip instead of a bipartite one; the third division is smaller than the other two and is arranged like a palp covering the basal half of the anterior division on its ventral surface. All three divisions are finely toothed along both margins. Maxillipeds much heavier and stouter than in *impressus*; in particular the terminal claw has a decided S-shaped curve, with a thickly swollen base nearly the size of the basal joint, a short knob or branch on the posterior margin at the distal curve of the S, and a bluntly rounded tip, corrugated by several transverse grooves.

First and second swimming legs very similar to those of *impressus*; third and fourth pairs with relatively larger basal joints, each of which has an indentation or notch on the anterior margin opposite the insertion of the small endopod. In the third legs there is a spine at the outer distal corner of the basal joint, and three spines on the outer margin of the proximal joint of the exopod. In the fourth legs there is also a spine at the outer distal corner of the basal joint, but none on the proximal joint of the exopod.

Total length 2.29 mm. Cephalothorax 0.38 mm. long, 0.78 mm. wide. Length of trunk 1.8 mm., width 2 mm. Length of egg-strings 1.75 mm.

Color, a uniform cartilage gray.

(*corpulentus*, large, thickset.)

There is but a single lot of this species, which was taken from the northern swell-toad, *Spheroides maculatus*, at Woods Hole, Massachusetts, and is numbered 38619, U.S.N.M. It includes three females, two of which bear egg-strings. It can be readily distinguished from *impressus* by the fact that the body is nearly circular in outline instead of oblong; it overhangs and entirely conceals in dorsal view the genital segment and abdomen, and there are no pits on either the dorsal or ventral surface. Whether it is as common as the other species can not be determined, since only a few fish have ever been examined for the parasite.

TUCCA VERRUCOSUS, new species.

Tucca impressus, NORDMANN, 1864, p. 491, pl. 6, figs. 7 to 10.

The species described as *T. impressus* by Nordmann (1864) is certainly distinct from the one so designated in the present paper (p. 354).

It follows that either Nordmann's species or that of the present author is new to science. They can not both be identical with Kröyer's *T. impressus*. After a careful examination of the original descriptions of Kröyer and Nordmann, together with the figures which accompany them, it seems most probable that Nordmann was describing a new species, while the present author had secured new specimens, including both sexes, of Kröyer's species.

In evidence of this we find that Nordmann's description differs from Kröyer's in many important particulars:

1. He does not find the "seitlichen Einschnitte" which Kröyer distinctly shows upon the enlarged posterior body.

2. He claims that the posterior portion of this part of the body, as well as the abdomen, are represented by Kröyer as much too broad.

3. He finds a pair of six-jointed first antennæ projecting from the anterior margin of the cephalothorax which he says Kröyer "overlooked."

4. There are no traces of the two-jointed attachment organs described by Kröyer on the inner margin of the side lappets, and he thinks Kröyer was really looking at the thickened edge of the lappets themselves.

5. He finds the dorsal and ventral surfaces of the body, including the central portion of the cephalothorax, but not the lappets, covered with small conical "Warzen," which were not noticed by Kröyer.

None of these particulars were likely to have escaped Kröyer's attention, except possibly the last one. He certainly would not have

overlooked the prominent first antennæ if they had been projecting as Nordmann figures them.

6. Nordmann's specimens were obtained from a species of *Diodon* found on the west coast of Africa while Krøyer's came from *Diodon hystrix* found in the Danish West Indies.

Those described by the present author were taken from a *Chilomycterus* common in the Danish West Indies, and so closely related to *Diodon* that it was included under that genus until very recently.

Furthermore they agree with Krøyer's specimen and differ from those of Nordmann in every one of the above contrasted points.

It seems practically certain, therefore, that Nordmann was describing a new species, and we may give for it the following

SPECIES DIAGNOSIS.

Female.—Cephalothorax small and circular in outline, with emarginate lappets. Free thorax fused into a rectangular body one-half longer than wide, with rounded corners and straight sides. Genital segment and abdomen very narrow and cylindrical, with prominent anal laminae. Egg-cases spindle-shaped, shorter than the body and much widened at the center. First antennæ cylindrical, the same diameter throughout, and projecting for their entire length in front of the anterior margin of the cephalothorax.

Four pits on the dorsal surface of the free thorax, the two anterior much nearer the midline than the posterior. The entire body, including the dorsal surface of the cephalothorax, but not the side lappets, covered with small conical papillæ.

(*Verrucosus*, covered with papillæ.)

Genus ARTACOLAX Wilson.

First thorax segment united with the head to form the carapace which is much wider than it is long, and is squarely truncated posteriorly. Second thorax segment free and as wide as the carapace or nearly so; third and fourth segments fused and but little narrower than the second; third segment overlapping the fourth dorsally so as to entirely conceal it. In lateral and ventral views the groove between the two segments is still visible, but no motion is possible between them. Fifth segment free and abruptly narrowed to a half or even a third of the width of the preceding fused segments. Genital segment enlarged but little; abdomen narrow and linear. The copepod has thus a sort of tadpole shape, consisting of a much widened and inflated anterior portion and a suddenly contracted and caudiform posterior portion, quite different from the Cyclops form of the genus *Bomolochus*. First antennæ six-jointed, the fused basal joints enlarged and armed with stout setæ; second antennæ four-jointed. Mandibles with two joints in addition to the terminal cutting blade,

and a short claw-like palp at the base of the latter. Second maxillæ with a powerful basal joint and a long cutting blade which extends forward diagonally at an angle of about 120° with the basal joint.

Maxillipeds like those of *Bomolochus*, except that they are usually without setæ. First swimming legs with very wide rami, armed with large flattened setæ; endopod of the second and often of the third legs similarly widened and armed with flattened setæ; exopods of second third, and fourth legs with but three joints like the endopods.

Male like the female, but with the maxillipeds in normal position behind the other mouth-parts and armed with the usual terminal claw.

Type-species.—*Artacolax (Bomolochus) ardeolæ* (Kröyer).

(*Artacolax*, ἀρτάω, to hang on and κόλαξ, a parasite).

This genus is distinguished from *Bomolochus* by the great comparative width of the first four thorax segments, by the fusion and overlapping of the third and fourth segments, so that there are apparently but three free segments in front of the genital segment instead of four, by the abrupt narrowing of the fifth segment, by the increased width of the rami of the first and second swimming legs, and by peculiarities in the structure of each of the mouth-parts, especially the second maxillæ.

ARTIFICIAL KEY TO THE SPECIES.

- a. Basal portion of first antenna armed with a large chitin plate, split anteriorly into three spines b.
- a. Basal portion of first antenna armed only with setæ and tactile hairs, no chitin plate..... c.
- b. First antennæ reaching far beyond the lateral margins; fifth legs made up of two very unequal joints; maxillipeds without plumose setæ. *cornutus* (Claus), 1864.
- b. First antennæ reaching just beyond the lateral margins; fifth legs made up of two very unequal joints; maxillipeds armed with large plumose setæ.
sætiger, new species, p. 361.
- b. First antennæ scarcely reaching the lateral margin; fifth legs made up of three short joints of equal length; maxillipeds without plumose setæ.
scomberesocis (Kröyer), 1863.
- c. Exopod of first legs three-jointed; fused third and fourth joints as wide as the second joint; each anal lamina with three setæ of equal length and one much shorter..... *chatoessi* (Kröyer), 1863.
- c. Exopod of first legs one-jointed; fused third and fourth joints much narrower than the second joint; each anal lamina with but two setæ..... d.
- d. Cephalothorax widest at the center and narrowed posteriorly; first abdomen joint much longer than the others..... *unicirrus* (Brian), 1902.
- d. Cephalothorax widest at the posterior margin; the three abdomen joints about the same length..... *ardeolæ* (Kröyer), 1863, p. 363.

ARTACOLAX SÆTIGER, new species.

Plate 51.

Female.—Cephalothorax semielliptical in shape, but not evenly rounded anteriorly; squarely truncated posteriorly, one-third wider than long. Remaining thorax segments diminishing in width with

fair regularity; second segment very short and well rounded at the sides. Third and fourth segments about the same width as the second segment anteriorly but considerably narrowed posteriorly. The third segment covers dorsally the whole of the fourth and a part of the fifth segments; its contour can be well seen in side view (figs. 129 and 139). The fifth segment is nearly as wide as the fourth but much shorter; the genital segment is not enlarged and its sides are straight. The abdomen is three-jointed, the joints diminishing regularly in width, the terminal one the longest, with a deep anal incision on its posterior border. The anal laminae are rectangular, wider than long, each armed with two unequal setae, the inner one more than twice the length of the outer. The egg-cases are elliptical, the same width as the genital segment and about one-third the entire body length. The eggs are of medium size and arranged in six or seven longitudinal rows, about sixty or seventy-five in each case.

The first antennae are narrow and of medium length; the three terminal joints are distinctly marked, while the three basal ones are well fused. The terminal joints are sparingly armed with setae and there is no tuft at the tip. The basal joints are heavily armed with stout and coarse setae mixed with slender tactile hairs; attached to their ventral surface on each antenna is a narrow chitin plate, which points diagonally forward and is split into three flattened spines of about equal length.

The second antennae are two-jointed, the terminal joint roughened with rows of short spines and tipped with three curved claws.

The labrum is transversely elliptical, one-third wider than long and perfectly smooth. The mandibles have two stout basal joints besides the cutting blades; the proximal joint is considerably enlarged, the second joint is long and narrow, the terminal cutting blade is shorter than the second joint and is armed with a fringe of short hairs along both margins.

The first maxillae are knobs of large size, each armed with three widely divergent setae. The second maxillae have a powerful basal joint and a cutting blade, whose triangular base is as wide as the basal joint, but is abruptly narrowed into the slender cutting portion, which is half as long again as the basal joint, and is armed along its anterior border with a row of stout hairs. The shape of this cutting blade and its mode of attachment to the basal joint is totally different from that found in *Bomolochus* species, and illustrates one of the characteristics of the genus.

The maxillipeds are also peculiar; they are very large and the triangular basal portion is attached well forward so that its distal end is opposite the second antennae. From this end projects the terminal claw which is bent into an almost perfect S-shape, and does not show the abrupt curve found in *ardeolæ*. This claw is also perfectly smooth,

without tooth or branch, but is armed with two huge plumose setæ, which are attached to the outer curve close to the base of the claw.

First swimming legs with a one-jointed exopod and a three-jointed endopod. The former is armed with five plumose setæ; the two basal joints of the latter each carry one seta on their inner margin, the terminal joint carries five. The arrangement of the spines and setæ on the second, third, and fourth legs is as follows: Second exopod, I-1; II-1; III-5: endopod, 0-1; 0-2; II-3: third exopod, I-0; I-1; II-5: endopod, 0-1; 0-2; III-2: fourth exopod, I-0; I-1; II-5: endopod, 0-0; 0-0; II-1.

The arrangement of the spines and setæ as well as the contour of the leg itself makes it reasonably certain that the last joints of the exopods of these three pairs of legs is really a fusion of two joints, but there are no signs of any groove between them. The claws have the structure shown in figure 137, and are thus peculiar.

Total length, 2 mm. Cephalothorax 0.8 mm. long, 1 mm. wide. Length of second, third, and fourth segments, 0.75 mm. Length of egg-strings, 0.75 mm. Length of inner seta on the anal laminae, 0.6 mm.

Color a rich seal brown, uniform over the entire dorsal surface, lighter and somewhat yellowish on the ventral surface.

(*sætiger*, armed with setæ, alluding to the large ones on the maxillipeds).

The National Museum collection contains a single lot of this species, consisting of three females taken from the flying fish, *Exocætus volitans*, at Woods Hole, Massachusetts, which is numbered 38629, U.S.N.M. These are made the types of the new species.

ARTACOLAX ARDEOLÆ (Krøyer).

Plate 52; Plate 53, fig. 147.

Bomolochus ardeolæ, KRØYER, 1863, p. 220, pl. 11, fig. 3, *a* to *e*.

Artacolax ardeolæ, WILSON, 1908, p. 434.

Female.—Body tadpole-shaped, the cephalothorax more than four times the width of the posterior portion. Cephalothorax semi-elliptical in shape and almost twice as wide as long, the anterior margin evenly rounded, the posterior margin a straight line. Second (first free) segment considerably narrower than the carapace and tapered posteriorly; third and fourth segments rigidly fused, one-third narrower than the second segment, and together about equaling it in length. Fifth segment abruptly narrowed to one-third the width of the fused segments, and distinctly separated from the genital segment, its lateral margins slightly concave. Genital segment the same width anteriorly as the fifth segment, but somewhat narrowed posteriorly, the same length as the second segment and barrel shaped, with nearly straight sides.

Abdomen three-jointed, the first joint as wide as the posterior end of the genital segment, the other joints diminishing regularly. Anal laminae shorter than the last abdomen joint and less than half its width, each bearing three setae, of which the inner one is twice the length of the outer. There is also a short spine at the base of each lamina on the outer margin. Egg-cases elongate, about two-thirds the entire length and three times as long as wide.

First antennae very large, each one-fourth longer than the cephalothorax, probably six-jointed, but with the joints of the basal portion indistinctly separated. These basal joints are much enlarged and are attached to the front of the carapace some little distance apart, with a fringe of large flattened setae around their anterior margin. They are operated by a set of powerful muscles which extend diagonally backward and inward nearly to the posterior margin of the cephalothorax and which are plainly visible in dorsal view. On the dorsal surface of the third joint of each antenna are two long tactile hairs which point directly forward. The second antennae are two-jointed, the last joint with the usual roughened surfaces and terminal claws.

The mouth-parts agree with those of *Bomolochus* in the main particulars, but differ in details. The labrum is much broader than long and crescentic, projecting at the angles on either side. The mandibles are three-jointed, the basal joint much wider than the others, about one-third the entire length of the appendage, and evenly rounded at the distal end. The second joint is shorter and narrower, and bears at its distal end both a cutting blade and a palp. The former is longer than even the basal joint and quite narrow, with a fringe of short hairs along its posterior border.

The latter consists of a rounded knob terminated by a short curved claw, and is ventral to the cutting blade.

The first maxillae are elevated well above the surface of the head, and each is armed with three widely divergent setae. The second maxillae have a long and narrow basal joint, running back to the basal joint of the mandibles, and a slender cutting blade turned diagonally forward, a little more than half as long as the basal joint and entirely smooth.

The maxillipeds are comparatively small, the basal joint is triangular and armed with powerful muscles, while the terminal claw is bent completely back upon itself and then turned inward at a right angle like a sickle, with a large accessory tooth on the outer or convex side. Neither basal joint or claw shows any plumose setae, but the latter has a small smooth bristle on the ventral surface of the first bend.

The first legs have very broad and flattened rami, the exopod one-jointed and as long as the two-jointed endopod; the joints of

the latter are two or three times as wide as long, and both rami are armed with large and strongly flattened plumose setæ. The second, third, and fourth legs have three-jointed rami, the endopods wider and longer than the exopods, the spines and setæ arranged as follows: Second exopod, I-0; I-1; III-5: endopod, 0-0; 0-2; II-2: third exopod, I-0; I-1; III-6: endopod, 0-1; 0-2; III-2: fourth exopod, I-0; I-0; I-5: endopod, 0-1; 0-1; II-1.

The claws are large and toothed along their posterior margin; the fifth legs are two-jointed, the terminal joint much larger than the basal, spatulate in form and tipped with four spines of unequal length; there is also a short spine on the anterior border of the basal joint (fig. 145).

Color, a light yellowish cartilage gray, inclining to brown on the cephalothorax.

Total length, 2.4 mm. Cephalothorax, 1 mm. long, 1.7 mm. wide. Length of second, third, and fourth segments, 0.5 mm. Width of genital segment, 0.4 mm. Length of egg-strings, 1.6 mm.

(*ardeolæ*, from the name of the host, *Belone ardeola* Kröyer, which was probably *Tylosaurus marinus*, the silver gar.)

There is a single female of this species taken from the gills of the Little Garibaldi, *Hypsypops rubicundus*, at La Jolla, California, by Dr. J. C. McClendon, and is numbered 38597, U.S.N.M. When the present author endeavored to locate this specimen among the described species of *Bomolochus*, it was found to possess differences which could not consistently be included in the same genus. Accordingly a new genus was constructed for this and the species mentioned on p. 361. In the paper dealing with Doctor McClendon's fine lot of specimens nothing but the diagnosis of the new genus was given.^a In the present paper Kröyer's species, *ardeolæ*, which was taken as the genus type, has been redescribed and figured. This, with the description and figures of the new species, *sætiger*, will fix the genus definitely. It is worthy of note that Kröyer's type of the species, *ardeolæ*, was taken from the gills of a fish captured at New Orleans, and is hence North American.

Genus BOMOLOCHUS Nordmann.

Female.—Body with a general *Cyclops* shape, but usually with a widened cephalothorax and a narrowed abdomen. First thorax segment fused with the head, the others free and diminishing regularly in size; genital segment enlarged but little; abdomen narrow and tapering. First antennæ six-jointed, the three basal joints fused together, enlarged, flattened, bent at a right angle near the base, and fringed with a dense row of plumose setæ, with a few tactile hairs

^a Proc. U. S. Nat. Mus., vol. 35, p. 433.

and sometimes digitate chitinous processes. Second antennæ four-jointed, the two terminal joints with their entire surface roughened, and tipped with short processes and curved claws.

Mandible simple, sometimes with a short palp; first maxillæ, reduced to mere knobs armed with plumose setæ. Second maxillæ three-jointed and simple; maxillipeds also three-jointed, the basal joint directly behind that of the second maxilla, the second joint turned forward outside the other mouth-parts and fused to the surface of the head, the third joint in the form of a stout claw bent twice like the letter S and armed with plumose setæ.

First swimming legs strongly flattened and widened; second, third, and fourth exopods four-jointed; fifth legs rudimentary, two-jointed. Egg-cases cigar-shaped, narrowed posteriorly; eggs small and numerous.

Male.—About half the size of the female; general body form elongate and slender. Cephalothorax nearly circular in outline; free segments diminishing regularly in size; genital segment considerably enlarged and lobed at the posterior corners. Abdomen short and tapering; anal laminæ medium size but the setæ are usually half the entire length or more.

First antennæ cylindrical, not enlarged and flattened at the base, and armed with smaller and more slender setæ than in the female. Maxillipeds in normal position behind the other mouth-parts, three-jointed, the two basal joints stout, the terminal claw long and slender and toothed along its inner margin. Other appendages like those of the female, except that they are smaller.

Type-species.—*Bomolochus bellones* Burmeister.^a

(*Bomolochus*, βωμολόχος, the rabble that waited about the altars to beg or steal, veritable parasites.)

ARTIFICIAL KEY TO THE SPECIES.

In the following key certain species which have previously appeared under the genus *Bomolochus* have been eliminated because, after careful study, they are found to be so different from the type as to constitute separate genera:

Ardeolæ, *chatoessi*, and *scomberesocis* (Kröyer, 1863), *cornutus* (Claus, 1864), and *unicirrus* (Brian, 1902) belong under the genus *Artacolax* (Wilson, 1908) (see p. 361). *Gracilis* (Heller, 1865) and *tetrodontis* (Bassett-Smith, 1898) are placed as species of the new genus *Irodes* (see p. 390).

^a Nordmann who established the genus described but one species, *parvulus*, which ought ordinarily to become the genus type. But he had only a single specimen, his description is meager and lacking in most of the details, he published no figures, and his species has neither been described nor seen by any investigator since his day. It can not serve, therefore, as a type-species, but must give place to *Bomolochus bellones*, which was well described and figured by Burmeister in the following year (1833), and has been repeatedly found, described, and figured by subsequent investigators.

Murænæ (Brian, 1906) is made the type of the provisional new genus *Phagus* (see p. 391). *Ostracionis* (Richiardi, 1870) is transferred to Brian's genus *Anchistrotos*. Finally there are two species, *minimus* and *oblongus* (Richiardi, 1880) which have never been described, and hence can not be definitely located at the present time.

- a. Maxillipeds turned forward outside of the other mouth-parts, with the basal joint fused to the ventral surface of the head, females.....b.
- a. Maxillipeds in normal position behind the other mouth-parts, both joints free and of the usual shape, males.....l.
- b. Terminal claw on maxillipeds very stout, with one or more teeth or branches and turned backward along the central axis of the basal joint in a sigmoid curve.....c.
- b. Terminal claw on maxillipeds slender, without teeth or branches, and usually turned backward along the lateral margin of the basal joint, or even outside it, in a simple curve.....g.
- c. Exopod of first swimming leg with a single triangular joint, well armed with plumose setæ.....d.
- c. Exopod of first swimming leg with two joints, the terminal one only armed with plumose setæ.....c.
- c. Exopod of first swimming leg with three joints like the endopod, the two terminal ones with plumose setæ.....f.
- d. Basal joints of first antennæ close together; third joint only with tactile hairs; first abdomen joint as long as the other two.
eminens, new species, p. 368.
- d. Basal joints of first antennæ close together, each with one or two slender tactile hairs; three abdomen joints the same length.
bellones Burmeister, 1833.
- d. Basal joints of first antennæ widely separated, each with several stout spines; first abdomen joint as long as the other two.....*megaceros* Heller, 1865.
- e. Frontal margin well rounded, entirely covering the bases of the first antennæ and filling the space between them; mandible and second maxilla simple and smooth.....*concinus*, new species, p. 371.
- e. Frontal margin well rounded, entirely covering the bases of the first antennæ and filling the space between them; mandible with a secondary spine on the second joint; second maxilla bipartite, both appendages toothed.....*nitidus*, new species, p. 374.
- e. Frontal margin reentrant, showing the entire bases of the first antennæ in dorsal view; mandible and second maxilla simple and smooth.
soleæ Claus, 1864, p. 375.
- f. First three free thorax joints nearly as wide as the cephalothorax; fourth joint abruptly narrowed to one-third that width; maxillipeds with but a single plumose seta.....*glyphisodontis* Kröyer, 1863.
- f. Only the first free thorax joint as wide as the cephalothorax, the second narrowed to two-thirds, the third to one-third of that width; maxillipeds with three large plumose setæ.....*exilipes*, new species, p. 377.
- g. Frontal margin of carapace deeply notched; basal joints of first antennæ fully visible and heavily armed with stout spines and digitate processes.....h.
- g. Frontal margin of carapace protruding and covering the bases of the first antennæ; the latter distinctly jointed and armed with short setæ, without spines or processes.....k.
- h. Maxillipeds with but a single plumose seta; carapace much wider than free segments.....i.
- h. Maxillipeds with two large plumose setæ; carapace but little wider than the first free segment.....j.

- i. Exopod of first swimming leg with two joints, endopod with three; short digitate processes on the first antennæ.
denticulatus Bassett-Smith, 1898, *b*.
- i. Exopod of first swimming leg with one joint, endopod with two; processes on first antennæ with very long spines.
tricerus Bassett-Smith, 1898, *a*.
- j. Second free segment swollen and overlapping the third; fifth legs three-jointed; abdomen joints equal.
parvulus Nordmann, 1832.
- j. Second free segment not swollen; fifth legs two-jointed; first abdomen joint as long as the other two.
teres, new species, p. 379.
- k. Terminal abdomen joint much longer than either of the other two; the setæ on the claw of the maxillipeds widely separated.....*onosi* T. Scott, 1902.
- k. Basal abdomen joint considerably the longest; the setæ on the claw of the maxillipeds close together.
zeugopteri T. Scott, 1902.
- l. Exopod of first swimming leg two-jointed, endopod three-jointed.....*m*.
- l. Both rami of the first swimming legs three-jointed, neither ramus widened.....*n*.
- m. Second joint of maxillipeds very small, only one-eighth the length of the basal joint; terminal claw longer than both joints, and coarsely toothed along the entire inner margin.....*soleæ* Claus, 1864, p. 376.
- m. Second joint of the maxillipeds swollen to three or four times the size of the basal joint; terminal claw about the length of the second joint, slender and finely toothed along the inner margin.
concinus, new species, p. 371.
- n. Second joint of maxillipeds twice as long as wide, narrower than the basal joint; terminal claw coarsely toothed, with two stout spines at its base.
onosi T. Scott, 1902.
- n. Second joint of maxillipeds enlarged and flattened, much wider than the basal joint; terminal claw finely toothed, with a single bristle at its base.
megacerus Heller, 1865.

BOMOLOCHUS EMINENS, new species.

Plate 53, text figure 6.

Female.—General body form long and slender; cephalothorax transversely elliptical, three-fifths wider than long, with strongly projecting lateral margins. Anteriorly the carapace projects over the first antennæ so as to entirely conceal them in dorsal view, except the very tips of the setæ with which they are armed. From the center of the anterior margin an almost circular lamina projects like a rostrum.

Second, third, fourth, and fifth segments diminishing regularly in width, the fifth segment three-eighths the width of the carapace. The respective lengths of the carapace and the four free segments are rep-

sented by the figures 11, 5, 4, 6, and 2. Genital segment narrower than the fifth segment, with nearly straight sides and short evenly rounded lobes at the posterior corners. From the center of each lobe on the ventral surface projects a single short spine, while from the angle between the lobe and the first abdomen segment projects a short finger-like process, curved slightly outward. Abdomen three-jointed, tapering posteriorly, the first segment as long as the other two and twice the width of the terminal segment. Anal laminae as long as the last segment, inclined toward each other, and each armed with a single stout seta at the tip, twice as long as the entire abdomen, a very short seta on either side of it, and a slightly longer one on the outer margin near the base.

Egg-cases ellipsoidal, half as long as the entire body, and narrowed a little at either end; eggs arranged in six or eight longitudinal rows, about eighteen in the longest central rows.

First antennae showing the joints distinctly, the fused basal joints with a fringe of heavy setae around the anterior margin and running back on the dorsal surface of the third joint to the posterior margin, the last seta projecting diagonally backward from the posterior corner of the third joint and considerably longer than the others. From the anterior margin of the second joint project a pair of tactile hairs nearly three times the length of the setae (fig. 6).

Second antennae of the usual pattern, the terminal joint ending in two long curved claws of about the same size, and a finger-like process covered with short spines.

Labrum two-fifths wider than long, narrowed into a knob on either lateral margin. Mandible long, smooth, and slender, directed diagonally backward along the margin of the labrum.

First maxillae small, each armed with two short and nearly parallel setae. Second maxilla long and slender, the terminal joint simple, covered with short hairs and directed slightly forward, almost meeting the tip of the mandible.

Maxilliped very large, the basal joint distinctly visible, showing even the musculature, and extending laterally far outside of the other mouth-parts. Second joint turned forward and inward and about the same size as the basal joint, with a single large plumose seta at the tip on the ventral surface, alongside the terminal claw. The latter is stout but short, not reaching the middle of the second joint, and with a simple crescentic curve, the outer convex margin of which is broken at the center by an angular protuberance.

Swimming legs of the usual form, each ramus of the first pair two-jointed, the terminal joint of the exopod with ten setae, covering its entire margin, the basal joint unarmed. The terminal joint of the endopod carries six large setae, the basal joint one on the inner margin.

The second, third, and fourth legs each have a three-jointed endopod and a four-jointed exopod, the two terminal joints of the latter more or less fused. All the swimming legs stand out prominently in dorsal view; the tips of the rami of the first pair and the entire rami and most of the basal joints of the other pairs are plainly visible. The arrangement of the spines and setæ is as follows: Second exopod, I-0; I-1; I-1; II-3: endopod, 0-0; 0-1; I-3: third exopod, II-0; I-1; I-1; I-4: endopod, 0-1; 0-1; I-2: fourth exopod, I-0; I-1; I-2; II-2: endopod, 0-1; 0-1; I-2. Fifth legs composed of a single broad and spatulate joint, two-thirds as long as the genital segment and tipped with three setæ, the middle one longer than the other two.

Color (preserved material) a light gray, becoming thick and opaque on the dorsal surface.

Total length, 2.75 mm. Carapace, 0.85 mm. long, 1.25 mm. wide. Free thorax, 1.34 mm. long. Egg-strings, 1.75 mm. long, 0.50 mm. wide.

(*eminens*, eminent, notable, in the sense of being well distinguished from other species.)

There is a single lot of this species, numbered 38638, U.S.N.M., and consisting of two females, both of which carry fully formed egg-strings. They were taken from the gill cavity of the false Spanish sardine, *Clupanodon pseudohispanicus*, at the Tortuga Islands, by Dr. Edwin Linton.

In spite of the poverty of specimens the species stands out in marked contrast to all others in the following particulars:

1. General body form; the comparatively small size of the carapace and the length of the free thorax segments.
2. The prominence of the swimming legs; not merely the rami but the most of the basal joints are visible in dorsal view.
3. The peculiar fusion of the last two joints of the exopod in the second, third, and fourth legs.
4. The size of the maxillipeds, their position so far outside the other mouth-parts, and the fact that their basal joints are visible for their entire length.

This last characteristic is of great importance since, in connection with the developmental stage to be described later (see p. 373), it completely proves the identity of these appendages as maxillipeds.

In other species these basal joints are so thoroughly fused with the ventral surface of the head that they are indistinguishable, and only the second joint and terminal claw are visible. The position of these last two joints is not such as to suggest that they belong to the maxillipeds, and hence much confusion has arisen with reference to them. But here we have the entire appendage visible and there can be no question of its identity.

BOMOLOCHUS CONCINNUS, new species.

Plates 54 and 55.

Female.—General body form like that of *Cyclops*; cephalothorax one-half wider than long, with a rounded posterior margin and projecting sides. Free segments diminishing regularly in size; genital segment considerably enlarged, half as wide again as the fifth segment, and barrel shaped, with the sides strongly convex. Abdomen three-jointed, the basal joint considerably the largest; anal laminae oblong, three-quarters the length of the last abdomen joint and tapered posteriorly, each armed with four setæ, two short ones on the sides of the lamina and two long ones at its tip, the inner one longer than the outer. Egg cases about half the entire length, anteriorly the same width as the genital segment, but narrowed posteriorly; eggs in five or six longitudinal rows, about seventy or eighty in each case.

First antennæ slender and similar to those in *exilipes*, except that the basal joints are almost entirely covered by the carapace in dorsal view. Two long tactile hairs are inserted close together and near the center of the anterior margin of the fused basal portion, and there is an extra long plumose seta at the distal end of this portion on the dorsal surface. The three slender terminal joints carry these antennæ far beyond the lateral margins of the carapace. In the second antennæ the anterior surface of the second joint and a portion of the ventral surface of the basal joint are covered with transverse ridges. The anterior surface of the two terminal joints is covered with longitudinal rows of short spines; the terminal claws on the last joint are interspersed with spines and setæ, making a dense tuft.

The labrum is transversely elliptical, twice as wide as long, with a smooth surface. The mandibles have a smooth and slender cutting blade about the same length as the basal joint. The first maxillæ project moderately from the ventral surface, and are each armed with four widely divergent plumose setæ. The second maxillæ are simple, the terminal blade conical and covered with fine hairs. The maxillipeds are large, with a terminal claw long enough to reach the proximal end of the second joint. The tip is acute and there is a short curved accessory claw on the outer margin near the center. To the base of this claw on its outer side is attached a large plumose seta; another much smaller one is attached to the tip of the second joint inside the terminal claw; a third, and by far the largest of the three, is attached to the ventral surface of the second joint close to its inner margin and points backward.

The first legs have a two-jointed exopod, the basal joint unarmed, the terminal one with six large setæ. The endopod is three-jointed; each of the two basal joints carries a single huge seta on its inner

margin, while the terminal joint has five. The arrangement of the spines and setæ on the other legs is as follows: Second exopod, I-0; I-1; II-1; II-4: endopod, 0-1; 0-2; 0-3: third exopod, I-0; I-1; I-1; II-4: endopod, 0-1; I-1; II-2: fourth exopod, I-0; I-1; I-1; II-4: endopod, 0-1; 0-1; I-2. The fifth leg is two-jointed, the basal joint triangular, with a small spine on the outer distal corner; the terminal joint carries a spine at the center of the outer margin and three at the tip, the central one longer than the others.

Color, a uniform light cinnamon brown, deepening in preservatives.

Total length, 1.80 mm. Cephalothorax, 0.65 mm. long, 0.9 mm. wide. Length of free segments, 0.55 mm. Length of anal setæ, 0.5 mm. Length of egg cases, 0.85 mm. Width of genital segment, 0.3 mm.

Male.—General body form much longer and narrower than that of the female; cephalothorax nearly circular in outline, a little wider than long, with evenly rounded lateral and anterior margins, and a nearly squarely truncated posterior margin.

Second, third, and fourth segments about the same length and diminishing regularly in width, but with the bases of the swimming legs projecting at the sides, and so making them appear nearly as wide as the carapace. Fifth segment very short and hidden between the fourth and genital segments. The latter is the same width as the fourth segment, oblong, widened posteriorly, with straight sides and truncated corners.

Abdomen three-jointed, basal joint much shorter than the other two, the three about the same width; anal laminae as long as the last joint, twice as long as wide, evenly rounded posteriorly, and each armed with five nonplumose setæ, three short ones on the outer margin and two longer ones at the tip, the inner one of the latter being over half the entire length of the animal, the outer one a third as long.

First antennæ similar to those of the female, but the basal portion is not as heavily armed with setæ and the tactile hairs are shorter. The third joint of the second antennæ is considerably more swollen than in the female, and there is a similar tuft of claws and setæ at the tip of the last joint. The maxillipeds are in normal position behind the other mouth parts; each consists of a fairly stout basal joint with three or four short spines on its ventral surface, a very much stouter second joint furnished with powerful muscles, and a long slender terminal claw slightly curved and armed with fine sawteeth along its inner margin.

The swimming legs are similar to those of the female, except the first and fifth pairs; in the former a stout and flattened plumose seta, fully as long as either ramus, is attached to the outer margin of the basal joint; in the latter each leg has but a single slender joint, tipped with two nonplumose setæ. Color the same as that of the female.

Total length, 1 mm. Cephalothorax, 0.4 mm. long, 0.45 mm. wide. Length of free segments, 0.19 mm.; of genital segment, 0.22 mm.; of abdomen, 0.24 mm.; of anal setæ, 0.65 mm.

(*concinuus*, beautiful, elegant in appearance.)

Young female, a developmental stage. General body form long and narrow, similar to that of the male, but with marked differences in detail. Cephalothorax circular in outline, about as long as wide, narrowed and projecting a little between the antennæ, and squarely truncated posteriorly.

Free and genital segments all about the same length, but diminishing regularly in width. Each of the free segments carries a rounded projection on either margin, covering the base of the swimming leg. The genital segment is almost a perfect rectangle, and the abdomen contains but a single joint, which is deeply cut posteriorly by the anal fissure. Each anal lamina is armed with three setæ, one, short and slender, on the outer margin near the base, and two at the tip, the inner of which is nine times the length of the outer and more than half the length of the entire body.

The first antennæ are distinctly six-jointed, the three terminal joints much narrower than the basal and armed throughout with densely plumose setæ. The large seta given off from the distal end of the third joint is itself jointed near the base and thus forms a sort of ramus.

The mouth-parts are similar to those of the adult but with the following differences. The first maxillæ project well from the ventral surface and each carries four plumose setæ diverging but little.

The basal joints of the second maxillæ are considerably elongated and the cutting blade is covered with long bristles. The maxillipeds are distinctly three-jointed; the proximal joint is in normal position behind the second maxillæ, the second joint turns forward outside the base of the second maxillæ but is not long enough to reach their anterior margin, while the terminal claw is comparatively small and weak. Of the swimming legs each ramus of the fourth pair contains but two joints, while the fifth legs are represented by mere spines on the sides of the fifth segment like those in the adults of some *Ergasilus* species.

Total length, 0.5 mm. Cephalothorax, 0.2 mm. long, 0.21 mm. wide. Length of free segments, 0.18 mm.; of anal setæ, 0.28 mm.

This developmental stage helps to fix the anatomy of several appendages in this genus which have been heretofore somewhat in doubt. The first antennæ are really six-jointed and the three basal joints become fused in later development. The fifth thorax segment is at first of equal importance and corresponding size with the other segments, but it loses its size and importance as the sexual products

are developed within the segments in front of it, until finally in the fully mature adult it may almost disappear.

The maxillipeds are three-jointed appendages, with the basal joint in proper position behind the other mouth-parts. It is therefore only in the very last stage of development that they become abortive and the basal joint disappears to a greater or less degree. On the contrary, the first maxillæ are rudimentary from the very beginning and are never developed any more than we see in the adult.

This species is found occasionally upon the gills of the gar-fish or bill-fish, *Tylosaurus marinus*, and is never very common. The Museum collection includes a single lot obtained at Beaufort, North Carolina in 1905 and numbered 38622, U.S.N.M. There are a goodly number of specimens, and the lot includes both sexes and development stages.

BOMOLOCHUS NITIDUS, new species.

Plate 56; text-figure 8; plate 58, fig. 201.

Female.—Cephalothorax semielliptical, one-half wider than long and squarely truncated posteriorly; bases of the first antennæ widely separated, with a broad rectangular rostrum projecting between them. Free thorax segments diminishing regularly and rapidly in width, their lengths in the proportions expressed by the numbers 25, 35, 18, 9; genital segment not enlarged, as wide as the fifth segment, with strongly convex sides. Abdomen three-jointed, the joints diminishing slightly in width, the terminal one a little the longest and cut off obliquely at the posterior corners. Anal laminae as long as the last abdomen joint and somewhat tapered, each tipped with two large setæ, of which the inner one is considerably longer than the outer, and three shorter ones. Egg-cases large and cylindrical, half the entire length and nearly twice the diameter of the genital segment; eggs large, arranged in six or seven longitudinal rows, about seventy-five in each case.

First antennæ stout but rather short, scarcely reaching the lateral margin of the carapace, and very indistinctly segmented, even the terminal portion. These antennæ are sparsely armed with short setæ, large and flattened at the base, smaller and hair-like toward the tip. Second antennæ of the usual pattern for this genus.

Labrum almost circular, with evenly rounded margins and a smooth surface; mandibles small and weak, the cutting blade short and smooth.

First maxillæ large and swollen, each armed with three widely divergent setæ. Second maxillæ with a large and stout basal joint, the terminal cutting portion bipartite, each ramus acuminate and covered with short hairs. Maxillipeds of good size and placed well forward, the terminal claw smooth, without teeth or branches, and armed with a single medium sized plumose seta at its base.

First swimming legs with a one-jointed exopod, triangular in shape, and armed with six flattened plumose setæ along its posterior margin and a single spine on its anterior margin. Endopod made up of three joints, the first without spines or setæ, the second with a single large seta on its inner margin, the third with five setæ. Exopods of second, third, and fourth legs distinctly four-jointed, endopods three-jointed. Endopod of the second pair with the flattening of the joints and setæ carried to such a degree that it seems as if it must be abortive. And yet it is alike on the right and left sides and on the two specimens at command. Each joint is much widened and flattened, very similar to those of the first legs; the setæ with which they are armed are also widened and flattened like those on the first legs (see fig. 180). The arrangement of the spines and setæ is as follows: Second exopod, I-0; I-1; II-2; II-3: endopod, 0-1; 0-1; 0-2: third exopod, I-0; I-1; I-1; II-3: endopod, 0-1; 0-1; 0-4: fourth exopod, I-0; I-0; I-0; II-4: endopod, 0-1; 0-1; 0-3. Fifth legs two-jointed, the basal joint short and narrow, the terminal joint four times as long, enlarged into a spatulate form, and tipped with three nonplumose setæ, of which the central one is three times the length of the other two.

Total length, 2.2 mm. Cephalothorax, 0.77 mm. long, 1.18 mm. wide. Length of free segments, 0.87 mm.; of genital segment and abdomen, 0.55 mm.; of anal setæ, 0.55 mm.; of egg-cases, 1.1 mm.

Color a rich seal brown inclining to reddish, lighter on the ventral surface.

(*nitidus*, neat, tasty in appearance.)

The National Museum collection includes but a single lot of this species, obtained from the gills of the common mullet *Mugil cephalus*, at Beaufort, North Carolina, in 1905.

This lot is numbered 38611, U.S.N.M., and consists of two females which are made the types of the new species.

These parasites are not at all common, since the examination of several hundreds of fish yielded only the two specimens. They were found in company with *Ergasilus mugilis* Vogt.

BOMOLOCHUS SOLEÆ Claus.

Plate 57, text-figure 40.

Bomolochus solex, CLAUDIUS, 1864, p. 374, pl. 25, figs. 16-20.—T. SCOTT, 1902, p. 288, pl. 13, figs. 13-18.—A. SCOTT, 1904, p. 117.

Male.—General body form elongate and narrow; first thorax segment distinctly separated from the head; carapace (cephalon) circular, abruptly narrowed anteriorly between the bases of the first antennæ, elsewhere evenly rounded.

First and second free segments the same width, which is two-thirds that of the carapace, the second segment a little the longer. Remaining free segments diminishing regularly in width, the third and fourth the same length as the second, the fifth about half as long. Genital segment barrel-shaped, the same width as the fifth segment, a little longer than wide and contracted posteriorly in front of the abdomen.

Abdomen half the width of the genital segment, two-jointed, the segments equal in length, the terminal one somewhat narrower than the basal. Anal laminae large, covering together almost the entire width of the terminal segment and two-thirds as long, each armed with two terminal setae, of which the inner is twice the length of the outer, and three short spines, one at the outer distal corner, another on the ventral surface near the tip, and the third on the lateral margin nearer the base.

The terminal joint of the abdomen and the anal laminae have large patches of coarse hairs upon their ventral surface, arranged as shown in fig. 185.

First antennae distinctly six-jointed, the basal joint not enlarged nor projecting as much as in the female, but armed with the same fringe of broad plumose setae. No tactile hairs, however, could be found among these setae. Second antennae with the two terminal joints heavily corrugated and tipped with five curved claws, which diminish regularly in size from within outward.

Labrum shield-shaped, one-third longer than wide, with short rounded projections at the center of the anterior and posterior margins and a reentrant sinus on each lateral margin one-third of the distance from the anterior end (fig. 40).

Mandibles similar to those of the female, with a small secondary spine at the base of the larger terminal one on the inner side.

First maxillae with three long plumose setae, the central one the shortest; second pair with a single terminal spine and without the accessory ciliated spine found in the female.

Maxillipeds in normal position behind the other mouth-parts, consisting of a swollen basal joint and a slender terminal claw, the same length as the basal joint and curved near its tip so as to fit tightly against the posterior margin of the basal joint when flexed. The inside of the claw and the margin of the basal joint against which it fits are covered with short saw-teeth.

First swimming legs not widened nor fringed with broad plumose setae as in the female, but consisting of a broad basal portion and two narrow rami armed with spines and setae like the other legs (fig. 219).

Endopod of fourth legs two-jointed, the terminal joint twice the length of the basal and tipped with three setae. Above the base of each of the fifth legs there projects from the dorsal surface of the fifth thorax segment a single long nonplumose spine.

Color a clear cartilage gray without pigment markings.

Total length, 1.12 mm. Carapace, 0.40 mm. long and wide. Free thorax segments, 0.40 mm. long, the first and second 0.28 mm. wide. Genital segment 0.17 mm. long, 0.15 mm. wide.

A single lot of this species obtained from the nostrils of the cod off the coast of Scotland, and containing a male and three females, was sent to the author by A. Scott, esq., of the Fishery Board of Scotland. For this courtesy, as well as for permission to include a description of the hitherto unknown male in the present paper, the sincere thanks of the author are hereby tendered.

This lot of specimens has been placed in the National Museum and is numbered 38618, U. S. N. M.

BOMOLOCHUS EXILIPES, new species.

Plate 58; text-figure 10.

Female.—General body form small and slender; cephalothorax semielliptical, nearly twice as wide as long and slightly rounded posteriorly. First antennæ projecting so that nearly all the basal portion is visible in dorsal view; the bases of these antennæ are well separated with a rounded rostrum protruding a little between them. Second thorax segment nearly as wide as the carapace, but short; third segment longer and considerably narrower; fourth segment also much narrowed and partly concealed beneath the third segment; fifth segment the same width and length as the fourth, projecting strongly on either side at the bases of the fifth legs. Genital segment about as wide as the fifth segment, barrel-shaped, with strongly convex sides. Abdomen three-jointed, joints diminishing evenly in width, the first two the same length, the terminal one a little longer. Anal laminae oblong, about half the length of the last segment, each tipped with three unequal setæ, the inner and longest of which is as long as the genital segment and abdomen combined. Egg-cases long and narrow, two-thirds of the entire length, and two-thirds as wide as the genital segment; eggs in six or eight longitudinal rows, about 70 eggs in each case.

First antennæ distinctly six-jointed, slender, and not reaching far beyond the lateral margins; the base for insertion is rather long and narrow, causing the appendages to project well in front of the carapace. The basal joints are fringed along their anterior border with a dense row of flattened plumose setæ and a couple of tactile hairs. The terminal joints are only sparingly supplied with short setæ which are nonplumose. The second antennæ have the basal joint longer than the other two, the second joint very short, the terminal joint armed with the usual longitudinal rows of spines. The last joint terminates in five claws of different lengths and a

rounded process covered with short spines. In life the two terminal joints are carried folded back against the basal joint, and each antenna points forward and inward in front of the mouth-parts toward its fellow on the opposite side, the distal ends of the basal joints meeting at the mid-line. From each of these distal ends projects a long curved claw, the two crossing each other like the letter X. The labrum is ovoid, with an evenly rounded outline and a smooth surface; the mandibles are very slender and the terminal blade is smooth; each first maxilla is armed with three divergent setæ, of which the one in the center is much smaller than the others. The second maxillæ are as slender as the mandibles, and the spine-like terminal portions are covered with short hairs.

The maxillipeds are large and stout, and are placed well forward; the terminal claw is bent sharply at the angles, and has a large accessory spine or tooth on its outer margin; it also carries a single large plumose seta on its ventral surface, and there are two others on the inner margin of the second joint. The first four pairs of legs have three-jointed rami, all of which and especially those of the fourth pair are comparatively long and slender. The arrangement of the spines and setæ is as follows: First exopod, I-0; 0-2; 0-3: endopod, 0-1; 0-1; 0-5: second exopod, I-0; I-1; III-7: endopod, 0-1; 0-2; II-3: third exopod, I-0; I-1; I-6: endopod, 0-1; 0-1; II-2: fourth exopod, I-0; I-1; III-5: endopod, 0-1; 0-1; I-2. The fifth legs are two-jointed, the basal joint very short, the terminal one long and spatulate and squarely truncated at its distal end. It carries a seta on its outer margin and three at the end, of which the middle one is the longest. There is a pair of rudimentary sixth legs projecting from the genital segment just inside the openings of the oviducts; they are in the form of good-sized papillæ, each tipped with three long, cylindrical, nonplumose setæ (fig. 200).

Color a light yellowish brown, darkening to cinnamon brown in the thicker and more opaque parts of the body.

Total length, 1.55 mm. Cephalothorax, 0.5 mm. long, 0.8 mm. wide. Length of free segments, 0.55 mm.; of egg-cases, 1 mm.

(*exilipes*, *exilis*, slender and *pes*, foot.)

The National Museum collection contains a single lot of this species, consisting of 15 females taken from the gills of the sheepshead, *Archosargus probatocephalus*, at Beaufort, N. C., in 1905; it is numbered 38608, U.S.N.M.

The parasite is a fairly common one, the above number of specimens being obtained from half a dozen sheepsheads.

It may be distinguished from other species by the long claws at the distal ends of the basal joints of the second antennæ, and by the slender rami of the swimming legs, particularly those of the first and fourth legs.

BOMOLOCHUS TERES, new species.

Plate 59, text figure 39.

Female.—Cephalothorax semielliptical, one-half wider than long, and squarely truncated posteriorly. Anteriorly it does not cover the bases of the first antennæ at all, but leaves them wholly visible in dorsal view. The free segments diminish regularly in width; the second, third, and fourth about the same length, the fifth a little shorter. The latter segment is also widened considerably at the center through the bases of the fifth legs. The genital segment is narrower than the fifth segment, as long as wide, with nearly flat sides. The abdomen is very long and slender, and three-jointed, the joints diminishing one-third in length from the base toward the tip, but all about the same width.

The terminal joint is cut diagonally at the posterior corners; the anal laminae are narrow and cylindrical, a little more than twice as long as wide, and strongly divergent. Each is tipped with a stout inner seta, whose base is the same diameter as the tip of the lamina, and a much smaller outer seta.

The latter usually can hardly be seen because it is pressed close to the base of the larger one, but sometimes it gets away from the latter and becomes distinct. Both these setæ are nonplumose. Egg-cases somewhat wider than the genital segment, about the same diameter throughout, and only reaching to the center of the terminal setæ; about 100 eggs in each case.

First antennæ long and slender, reaching well beyond the lateral margins, basal portion not much enlarged, fused so that the joints are invisible, and bent so strongly that it forms an acute angle of 60° instead of a right angle. This angle is armed with a row of very large setæ around its entire margin; elsewhere the setæ are scattering except for a small tuft at the extreme tip. Second antennæ of the usual pattern, the terminal joint entirely covered on its ventral and posterior surfaces with dense rows of short spines. The terminal claws are rather short and are reenforced by a long, straight plumose seta at the inner distal corner of the terminal joint.

The mouth parts are well defined; the labrum is semielliptical, with the posterior corners enlarged, rounded, and projecting, and the posterior margin reentrant. Every portion of the surface of the labrum, even to its extreme margin, is densely covered with fine hairs. The mandibles are smooth and simple and are well concealed beneath the labrum.

The first maxillæ are of the usual pattern, each bearing three strongly divergent setæ. The second maxillæ are two-jointed, the basal joint considerably enlarged, the terminal joint in the shape of a large smooth spine five times as long as wide and acutely pointed.

The maxillipeds have small and weak terminal claws, each bearing two huge setæ, much larger than the claw itself. The second joint of these maxillipeds reaches well in front of all the other mouth parts, and overlaps the base of the second antennæ for half its length. The labium is large and is nearly a half circle in outline, extending back from about the center of the basal joint of the second maxilla, on either side.

The rami of the first swimming legs are each two-jointed and armed with extra large and flattened setæ, three on each exopod joint, one on the basal and six on the terminal joint of the endopod. The second, third, and fourth legs have each a four-jointed exopod and a three-jointed endopod, the latter being longer than the former. The arrangement of the spines and setæ is as follows: Second exopod, I-0; I-1; II-1; I-5: endopod, 0-1; 0-2; I-3: third exopod, I-0; I-1; I-1; I-5: endopod, 0-1; 0-2; I-3: fourth exopod, I-0; I-1; I-1; I-4: endopod, 0-1; 0-1; I-2. The fifth legs are each composed of a single two-jointed ramus, the basal joint short, the terminal one four times as long as wide, armed with a single seta on the outer margin near the center, and three of unequal length at the end, the inner one twice the length of the middle one and the latter twice the length of the outer one.

Color a light brown, inclining to green on the dorsal surface, paler and yellowish below.

Total length, 2.14 mm. Cephalothorax, 0.65 mm. long, 0.9 mm. wide. Length of free segments, 0.7 mm.; of abdomen, 0.7 mm.; of egg-strings, 1 mm.

(*teres*, graceful, slender.)

The National Museum collection contains two lots of this species, both obtained from the gills of the common menhaden, *Brevoortia tyrannus*, at Woods Hole, Massachusetts. The lots are numbered 38606 and 38607, U.S.N.M., and the former are made the types of the new species. The species is quite rare, the examination of many fish yielding but a few specimens.

Genus PSEUDOEUCANTHUS Brian.

Cephalothorax elliptical or somewhat ovate, with a continuous raised border around its margin. Second to the sixth (genital) segments all free and of about the same width, which is three-fifths that of the carapace. Abdomen suddenly contracted to one-third the width of the genital segment, three times as long as wide; anal laminae longer than the last segment; First antennæ cylindrical and four-jointed, the basal portion neither enlarged nor flattened nor bent at a right angle. The second antennæ three-jointed and like those of *Bomolochus*. Mandibles strongly curved, simple and smooth; first

maxillæ apparently lacking; second maxillæ stout and simple, the terminal joint covered with hairs; maxillipeds similar to those of *Bomolochus*, but without plumose setæ. First swimming legs with flattened rami; both rami of the second, third, and fourth legs three-jointed, the exopods not well supplied with setæ. Fifth legs uniramous, two-jointed; rudimentary sixth legs on the genital segment. Egg-cases short and narrow; eggs large, only about thirty in each case.

Type-species.—*Pseudocucanthus alosæ* Brian, 1906.

(*Pseudocucanthus*, *pseudo*, false and *Eucanthus*).

There are several points in the description of this genus that need confirmation or correction. In the first place, Brian himself places a question mark after the sex of his specimens. The only thing in the anatomy of the individual he has figured as a "male(?)" which suggests that sex is the lack of egg-strings. On the contrary, the genital segment is exactly the same as in the female and the maxillipeds are turned forward outside the other mouth-parts instead of being in normal position behind them.

Again, Brian has failed to discover any first maxillæ, although he found them in *Bomolochus* and *Anchistrotos*, described in the same paper, and he says nothing about them in the text. If this pair is really lacking that would constitute a generic distinction stronger than any he has advanced.

Finally, in the figure he has given there are only three free segments in front of the genital segment, but there are the usual four pairs of legs. From the arrangement of the latter it is impossible to tell which two of the segments are fused. Until these points of vital importance are settled the genus must be left as Brian has described it.

Subfamily TÆNIACANTHINÆ.

Body strongly flattened; head fused with the first thorax segment and the resultant cephalothorax reentrant on the ventral surface, so that its lateral margins with the basal joints of the first antennæ and the first legs form an effective prehensile disk as in the *Bomolochinæ*. All the other thorax segments are free; the genital segment is not enlarged; the abdomen is cylindrical and tapers gradually, producing a typical *Cyclops* form like that of the *Ergasilinæ*. First antennæ cylindrical, the basal joints enlarged but little, and usually not flattened; second antennæ similar to those in the *Bomolochinæ*. First swimming legs flattened, rami wide and with only one or two joints; the other legs of the usual pattern. Male considerably smaller than the female, with the ordinary sexual differences in the second antennæ and second maxillipeds. Species averaging somewhat larger than the *Bomolochinæ*, 2 to 2.5 mm. in length.

DESCRIPTION OF THE MOUTH-PARTS.

Female.—Mouth-parts close to the second antennæ; labrum much wider than long, not prominent, in *Tæniacanthus* reduced to a very small size; labium reduced to a mere ridge on the ventral surface of the head. Mandible three-jointed, the basal joint fused to the surface of the head, second and third joints free and turned backward; third joint consisting of one or two slender spines of equal length, shorter than the second joint. Maxillary hook in the form of a claw similar to those in the Caliginæ and attached to the ventral surface near the lateral margin and just behind the first antenna. In *Anchistrotos* it

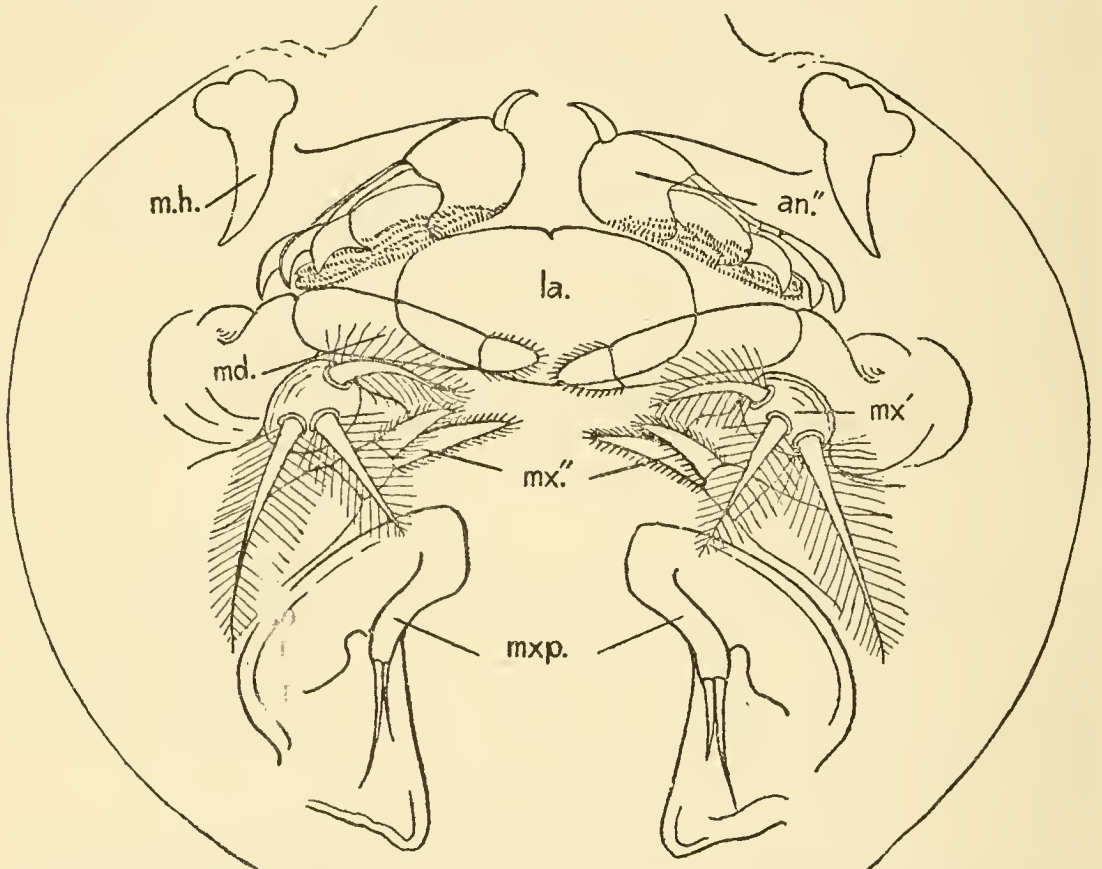


FIG. 41.—MOUTH-PARTS OF FEMALE *TÆNIACANTHUS ALBIDUS*. *an''*, SECOND ANTENNÆ; *la*, LABIUM; *md*, MANDIBLE; *m. h.*, MAXILLARY HOOK; *mx'*, FIRST MAXILLA; *mx''*, SECOND MAXILLA; *mxp*, MAXILLIPEDS.

is long and two-jointed, in *Irodes* and *Tæniacanthus* it has but a single joint, and in *Phagus* it is apparently wanting. First maxilla in the form of a knob armed with from two to four plumose setæ. Basal joints of the second maxillæ fused to the ventral surface, terminal joints slender and bipartite or simple in the different genera. Maxillipeds in their normal position but very rudimentary, the basal joint fused with the ventral surface close behind the other mouth-parts, and directed diagonally inwards and forwards. The terminal joint consists of a slender and weak claw bent in a simple curve (*Tæniacanthus*, *Anchistrotos*), or of two or more slender setæ (*Phagus*, *Irodes*).

Male.—Mouth-parts a little farther back than in the female, labrum more nearly circular in outline. Mandibles similar to those of the female; maxillary hook considerably enlarged, the terminal claw elongate, slender, and strongly curved. First and second maxillæ as in the female.

Maxilliped in the same position as in the female but much larger and not as rudimentary; basal joint inflated and armed with powerful muscles, not fused with the ventral surface of the head and armed with coarse teeth on the inner margin near the proximal end; terminal joint a stout claw, but in a simple curve, its tip shutting against the teeth on the basal joint.

ARTIFICIAL KEY TO THE GENERA.

- a. Each of the first three free segments as large as the cephalothorax, the four together fully four-fifths of the entire length.....*Tæniacanthus* Sumpf, 1871, p. 387.
- a. Each of the first three free segments much smaller than the cephalothorax, the four together about half the entire length.....*b*.
- b*. Maxillipeds little larger than the second maxillæ, their terminal joint seta-like, pointing inwards and forwards, and covered with hairs, with one or two accessory plumose setæ.....*Irodes*, new genus, p. 390.
- b*. Maxillipeds much larger than the second maxillæ, and armed with a curved claw, or with smooth spines folded back against the basal joint.....*c*.
- c*. Mandibles and second maxillæ bipartite; maxillary hooks wanting.
.....*Phagus*, new genus, p. 390.
- c*. Mandibles and second maxillæ simple; maxillary hooks large and often two-jointed.....*Anchistrostus* Brian, 1906, p. 391.

Of the seven species here included five have already been described under other genus names. For such a radical transposition the author feels that a full explanation is demanded. Accordingly the species are taken in chronological order, and the reasons are clearly stated for the changes that have been made. This subfamily closely resembles the Bomolochinæ; perhaps the most obvious differences are the presence of a part of the first maxillæ in the form of prehensile hooks on the ventral surface of the cephalothorax opposite the bases of the second antennæ, and the structure and position of the maxillipeds.

With reference to the latter nothing need be said beyond emphasizing the fact that both structure and position are more nearly normal than in either of the other subfamilies.

In regard to the former there has been considerable diversity of opinion, and this in connection with a corresponding diversity in the interpretation of the maxillipeds has occasioned the mislocation of four out of the five species.

The fifth is a case of simple preoccupation which chronologically comes first.

Eucanthus balistæ.—Claus established the new genus *Eucanthus* in 1864; in speaking of its distinguishing characters he says:

Unterscheidet sie sich von *Bomolochus* durch den Besitz von zwei kräftigen Kopfhaken, durch eine abweichende Form und Lage des untern Kieferfusses Nach den beide ausserhalb der untern Antennen befestigten Haken mag die Gattung *Eucanthus* heissen (p. 378).

He thus recognizes that the presence of these prehensile hooks is an important generic character, but he makes no attempt to explain them. In fact the above quotation is all that is said of them.

Unfortunately the name *Eucanthus* had been used in 1848 by Woodward for a genus of Coleoptera, and so can not stand for this genus of copepods. Brian, however, described in 1906 a new subgenus which he called *Anchistrotos*, and which seems to be identical with *Eucanthus*, and hence his name can be substituted for the one given by Claus.

Bomolochus gracilis.—In the following year (1865) Heller published in his account of the crustacea obtained during the Reise der *Novara* descriptions of *Ergasilus peregrinus*, *Bomolochus megaceros*, and a form which he called *Bomolochus gracilis*, all new species. In speaking of *B. megaceros*, which is a genuine *Bomolochus* species, he calls the large maxillipeds "Diese grossen seitlichen Hornhaken." After noting that they were found by Kröyer (1863) in most of the *Bomolochus* species which he investigated and were designated—

Als das vergrösserte zweite Fusspaar (zweites Kaufusspaar der Autoren)—

Heller goes on to say that he can not agree with this designation. He adds by way of explanation:

Man findet nämlich auch hier die gewöhnlichen zwei Kaufusspaare (das erste und zweite Fusspaar Kröyers) ganz in der Nähe des Mundes eingefügt. Sie sind zwar klein und zart, eber bei starker Vergrösserung ganz deutlich als solche wahrzunehmen. Die seitlichen Hornhaken sind dieselben Gebilde, welche wir bei den Geschlechtern *Caligus* und *Lepeophtheirus* fast constant an der Aussenseite der hintern Antennen bemerken, sie sind hier nur auf eine ausserordentliche Weise entwickelt und bilden jedenfalls ein ganz kräftiges Werkzeug, mit welchen das Schmarotzerthier sich an seinen Wirthe festsetzen kann (p. 155).

Then in speaking of *Bomolochus gracilis* he says:

Der seitliche Hornhaken is hier viel weniger entwickelt und mehr nach vorne hingerückt, so dass er wie ein Anhang der vor deren Antennen erscheint (p. 153).

Heller made several mistakes which, when clearly understood, go far to explain these apparently conflicting statements. In the first place he finds what he calls the mandibles of *B. megaceros* inside of the mouth instead of on the ventral surface of the head, where all other investigators have located them and where he himself locates them in *B. gracilis*. This leaves him free to designate the true mandibles as first maxillipeds and the second maxillæ as the second pair, and under these conditions the only thing he could do with the

true maxillipeds was to call them "seitlichen Hornhaken." But it would be manifestly impossible to have two species belonging to the same genus in one of which the mandibles were inclosed within the mouth-tube while in the other they were entirely free.

What Heller really saw inside the mouth can not even be surmised, but at all events it was not a pair of mandibles, for these are in their normal position at the side of the mouth.

Again Heller did not see the first maxillæ in any species of *Ergasilus* or *Bomolochus* which he described; they do not appear in his figures and are not mentioned in his text. If he had seen them he would never have placed one pair of "maxillipeds" in front of them. But his most serious error is the assumption that the prehensile hook in *gracilis* corresponds to the maxilliped in *megaceros*, when the two are entirely different in structure and position. The hook in *gracilis* corresponds to that found in *Caligus* and *Lepeophtheirus* in structure, function, and sex variation. But if so, the species *gracilis* can not belong to the genus *Bomolochus*, but must be made the type of a new genus, *Irodes* (see p. 390).

Bomolochus ostracionis.—Richiardi in 1870 established a new species which he referred to the genus *Bomolochus*, and which possessed similar prehensile hooks. He describes them as follows:

All' esterno dell' inserzione del primo articolo delle antenne del primo paio, si staccano dalla superficie del cefalo-torace due grossi uncini robusti, rigidi, i quali si prolungano indietro fino oltre le antenne del secondo paio quasi paralleli al margine laterale del corpo, curvi nella loro lunghezza, a punta molto acuta, sul margine interno verso la loro base anteriormente presentano una piccola appendice unciniforme, essi servono evidentemente all' animale a fissarsi sulle membrane sulle quali vive parassito (p. 53).

He thus recognizes their function, but makes no further attempt at an explanation of their presence.

In endeavoring to locate his species he states at the close of his paper that, from the presence of these two large hooks and from the form and position of the maxillipeds, it ought to belong to the genus *Eucanthus* of Claus. But in spite of this he places it under the genus *Bomolochus*, giving as his reasons for so doing the shape of the basal joint of the first antennæ, the form of the mandible and maxilla, the shape of the last joint of the endopod of the fourth legs, and the number of body segments. But variations in shape and form, especially within the narrow limits here described, are manifestly specific in value and not generic. Furthermore, the only difference in the number of body segments is found in the abdomen where variety is the rule among all the parasitic copepods. Such differences as these can not offset the presence of maxillary hooks and the structure and position of the maxillipeds. Hence the species mani-

festly belongs to the genus *Eucanthus* (*Anchistrotos*), where the present author has placed it.

Taeniacanthus carchariæ.—In the following year (1871) Sumpf described the new genus *Taeniacanthus*, on whose cephalothorax are found these same hooks which he calls "Klammerhaken" and says of them:

Letztere liegen seitlich über der Basis der hintern Antenne und erinnern durch ihre Gestalt auffallend an die Haken, mit denen das Rostellum der Taenien bewaffnet ist (p. 10).

He then adds in the next sentence:

An Gliedmassen sind am Cephalothorax folgende vorhanden.

This is the only hint given as to the nature of the hooks and he evidently does not regard them as appendages.

This genus stands as he described it and proves to be a most interesting and instructive one, since we find all the mouth-parts in their normal position beside and behind the mouth, and in addition the maxillary hooks opposite the bases of the second antennæ.

Bomolochus tetrodontis.—No more species bearing these maxillary hooks were discovered until 1898, when Bassett-Smith described *Bomolochus tricerus* and *B. tetrodontis*, both new species. He repeated Heller's errors, for his first species is a true *Bomolochus*, while the second is so different that it must be placed with Heller's *B. gracilis* in the new genus *Irodes* (see p. 390). Like Heller, Bassett-Smith has never found the first maxillæ in any species of either *Ergasilus* or *Bomolochus* which he has examined. And like the German investigator, he makes these maxillary hooks in *tetrodontis* the homologues of the true maxillipeds (which he calls hamuli) in *tricerus*.

Bomolochus murænæ.—In 1906 Brian described two new species belonging to this subfamily; one he made the type of a new genus to which he gave the name *Anchistrotos*; the other species which he called *murænæ*, was referred to the genus *Bomolochus*.

Brian's *Anchistrotos* is apparently identical with the *Eucanthus* of Claus, described forty years before, but Brian's genus name must be retained as already stated (p. 384).

The second species, *murænæ*, had been named by Richiardi in 1880, but had never been described. Brian identifies all his specimens as females; he does not find any maxillary hooks, and we may be reasonably sure he would have detected them if present, since he found them in *Anchistrotos*. But neither do they possess the characteristic maxillipeds of *Bomolochus* females; on the contrary their maxillipeds are very similar to those of *Anchistrotos*, and are in a normal position behind the other mouth-parts. This species, therefore, can not be referred to either *Bomolochus* or *Anchistrotos*, but must constitute a genus by itself, intermediate between the two,

for which the author would propose the name *Phagus*. At present, however, the genus must be regarded as more or less provisional, since the distinctions on which it is founded require confirmation by further study (see p. 391).

That the maxillary hooks found in this subfamily are not the homologs of the maxillipeds in *Bomolochus*, as some authors have described them, is self-evident when once the mandibles and maxillæ are correctly located. That they are homologous with the corresponding hooks in *Caligus* and *Lepeophtheirus*, as Heller and Brian suggest, is shown by their identity in structure, by their articulation directly to the ventral surface of the head, by their sex variation, being larger and longer in the male, and by their position. They appear relatively farther forward than in many *Caligus* species, but even there they are opposite the bases of the second antennæ and in front of the other mouth-parts, which is exactly their position here. And as their presence is one of the things that shows the Caliginæ to be the least degenerate family of the Caligidæ, so their presence here testifies that the Tæniacanthinæ is the subfamily showing least degeneration among the Ergasilidæ. This fact is still further attested by the presence of so degenerate a form as *Tucca* in one of the other subfamilies.

Genus TÆNIACANTHUS Sumpf.

Tæniacanthus carchariæ, SUMPFF, 1871, pp. 7-18, pls. 1 and 2.

Female.—Head joined with the first thorax segment; each of the three following free segments somewhat enlarged so that the four together make from one-half to four-fifths of the entire length. The lateral margins on these segments are turned over ventrally, and each of the four pairs of legs projects strongly from the ventral surface. Fifth and genital segments more or less abruptly narrowed. In *T. carchariæ* these two segments with the abdomen form a sort of diminutive tail, one-fifth of the entire length, tapering angularly backward, and inclined at an angle of about 30° to the anterior part of the body.

First antennæ probably six-jointed as in other genera; the three basal joints thoroughly fused and half the entire length. Second antennæ similar to those of *Bomolochus*. Mandibles bipartite. A portion of the first maxillæ in the form of prehensile hooks opposite the bases of the second antennæ, similar to those in *Caligus* and *Lepeophtheirus*. (Fig. 4.) First maxillæ of the usual pattern and armed with plumose setæ. Second maxillæ rudimentary; maxillipeds also rudimentary, the terminal claw the same length as the basal joint. Both rami of the first swimming legs widened, and well armed with broad plumose setæ. Egg-tubes narrow and elongate; eggs minute.

(*Tænia*, a genus of tapeworms, and ἄκανθα, a spine, the maxillary hooks being similar to the hooks on the rostellum of *Tænia*).

Type-species.—*Tæniacanthus carchariæ* Sumpf.

ARTIFICIAL KEY TO THE SPECIES.

- a. Free segments diminishing regularly in size; fourth segment but little wider than the fifth.....*albidus*, new species, p. 388.
 a. Second, third, and fourth segments fully as wide as the carapace; fifth segment abruptly narrowed to one-third that width.....*carchariæ* Sumpf, 1871.

TÆNIACANTHUS ALBIDUS, new species.

Plate 60, text fig. 41.

Female.—First thorax segment fused with the head; resultant cephalothorax semielliptical, one-half wider than long, with a slight incision between the antennæ and a squarely truncated posterior margin. Second and third thorax segments the same length and width, four-fifths as wide as the carapace. Fourth segment the same length but one-third narrower; fifth segment half as long and three-quarters as wide. Genital segment trapezoidal in outline, with rounded corners, the same width as the fifth segment and twice as long, widest at the anterior margin and tapering posteriorly. The genital orifices are on the upper surface of the segment and close to the anterior margin. Abdomen three-fourths as wide as the genital segment and four-jointed, the first two joints somewhat longer than the last two. Anal laminae narrow and widely divergent, two-thirds as long as the last joint, and each tipped with two setæ, of which the inner is two and a half times the length of the outer; there is also a short spine on the outer margin of each lamina near the center. Egg-cases of good size, tapered at each end, half the entire length and as wide as the genital segment. Eggs minute, arranged in fifteen or more longitudinal rows, about four hundred in each case.

First antenna presumably six-jointed, the three terminal joints distinct, the three basal ones thoroughly fused. This basal portion of the antenna is enlarged and turned outward at a right angle, as in *Bomolochus*. It carries along its anterior border a row of flattened plumose setæ, all of which are the same size and structure, and there are no tactile hairs or spines among them. The terminal joints are also well supplied with setæ, of which one at the distal end of the fourth joint is much larger than the others.

The second antennæ are three-jointed, the basal joint as long as the other two and serving for the attachment of the appendage, the second and third joints the same length and folded back against the basal joint. The ventral and posterior surfaces of these last two joints are roughened with rows of short spines, and the last joint terminates

in three large curved claws, graded in size, the outer one a little more than twice the length of the inner. Beneath them the joint sends out a rough and flattened process, which reaches the tip of the second claw. From the anterior proximal corner of the second joint a stout curved claw projects inward toward its fellow on the opposite antenna, and the two nearly meet at the mid-line.

The mouth-parts are close behind the antennæ; they consist of a well-defined upper lip, a pair of mandibles, two pairs of maxillæ, and one pair of maxillipeds (fig. 41). The upper lip is transversely elliptical, twice as long as wide, with a fairly regular outline. The mandibles are three-jointed, the joints diminishing regularly in size; the basal joint starts out perpendicularly from the surface of the head and is then bent over inward at a right angle, carrying the last two joints beneath the upper lip. The terminal joint is conical, twice as long as wide, and covered with fine hairs.

The maxillary hooks are attached to the raised edge of the disk which surrounds the other mouth-parts; each consists of a rounded base and a stout curved claw. The first maxillæ are in the form of knobs, each armed with three widely divergent setæ. Each second maxilla has two joints beside the terminal blades, the proximal one much longer and stouter than the distal. The terminal blades are attached side by side, the dorsal or superior one twice the length of the ventral, both entirely covered with short hairs.

The maxillipeds are immediately behind the maxillæ; the basal joint is elongate, triangular in outline, with the apex extending forward and inward, and is fused to the surface of the head. From the anterior apex the slender and cylindrical terminal joint is turned backward in an S curve, as in *Bomolochus*. This terminal joint is only about half the length of the basal and ends in two stout, non-plumose setæ of unequal length.

The first four pairs of legs are biramose, with three-jointed rami, the joints in the exopods of the first pair being thoroughly fused. The arrangement of the spines and setæ is as follows: First exopod, 0-0; I-0; I-5: endopod, 0-1; 0-2; 0-7: second exopod, I-0; I-1; III-6: endopod, 0-1; I-2; II-4: third exopod, I-0; I-1; I-7: endopod, 0-1; I-2; II-3: fourth exopod, I-0; I-0; II-2: endopod, I-0; II-0; II-6. The fifth legs are uniramous and two-jointed; the basal joint is very narrow and short and is armed with a small spine on its anterior border. The terminal joint is enlarged into a broad ovate lamina, tipped with four short spines.

Color a dull white throughout, the ovaries and oviducts a deeper shade than the rest of the body.

Total length, 2.64 mm. Cephalothorax, 0.6 mm. long, 0.88 mm. wide. Length of free segments, 1 mm.; of egg-strings, 1.53 mm.; of anal setæ, 0.6 mm.

(*albidus*, whitish, in allusion to the general color.)

Only a single lot of this species, consisting of two females, was obtained from the vent of a shovel-headed shark, *Sphyrna tiburo*, at Beaufort, N. C., in the summer of 1905. These are numbered 38587, U.S.N.M., and are made the types of the new species. They are readily distinguished from *carchariæ* by the fact that the free segments diminish regularly in size, leaving the fourth segment but little wider than the fifth. On closer examination all the appendages show specific differences, notably the first maxillæ, mandibles, and second maxillipeds.

IRODES, new genus.

Female.—Cephalothorax much larger than any of the free segments, which diminish regularly in size from in front backwards.

Genital segment but little enlarged; abdomen cylindrical, and four-jointed in the two species known; anal laminae small and armed with very short bristles. Egg-tubes also short and club shaped. First antennæ cylindrical, the basal joint but little enlarged and armed with short setæ, not flattened, and without tactile hairs or chitin processes. Second pair similar to those of *Bomolochus*. Mandibles three-jointed, the terminal joint bipartite and toothed; maxillary hooks like those of *Tæniacanthus*; first maxillæ probably of the usual pattern. Second maxillæ simple and three-jointed; maxillipeds behind these and only a trifle larger. They are also like the second maxillæ in structure and arrangement, except that they are tipped with two or three plumose setæ instead of one smooth spine. Each ramus of the first legs with a single widened joint; other legs as in *Bomolochus*.

Type-species.—*Irodes (Bomolochus) gracilis* Heller.

(*Irodes, Irus*, the well-known beggar of Ithaca, and εἶδος, similarity or likeness.)

Here belong the type species just mentioned and Bassett-Smith's "*Bomolochus tetrodontis*." The description of these two forms is complete, except that neither author discovered the first maxillæ. There is no reason to believe, however, that they differ from the type found in the other genera of the Ergasilidæ. If it should turn out that the authors are right and that these maxillæ are really lacking that would be a still stronger reason for creating the above new genus.

PHAGUS, new genus.

Female.—Cephalothorax much larger than any of the free segments, which diminish regularly in size. Genital segment considerably enlarged, nearly twice the diameter of the abdomen; the latter cylindrical and tapering; anal laminae short, each armed with three setæ, of which the inner one is more than half the entire length.

First antennæ cylindrical, basal joint moderately enlarged and flattened, with a right-angled curve similar to that in *Bomolochus*, and armed with a scraggy row of short setæ, interspersed with tactile hairs. Second pair distinctly three jointed, second joint nearly as long as the terminal; the latter roughened and tipped with two slender processes, nearly as long as the joint itself, and a tuft of spines.

First maxillary hooks wanting; mandibles and second maxillæ slender and two-jointed, the last joint bipartite; first maxillæ each armed with three short plumose setæ.

Maxillipeds behind the second maxillæ, each made up of a very large and flattened basal joint, bent inwards at a right angle near its center and bluntly rounded, and two smooth setæ or spines which arise from the posterior margin near the distal end and extend backward parallel with the body axis.

Each ramus of the first legs contains two widened joints.

Egg-tubes unknown.

Type-species.—*Phagus (Bomolochus) murænæ* Richiardi.

(*Phagus*, φάγος, a glutton.)

As already explained (p. 387), this new genus is provisionally proposed for *Bomolochus murænæ* Richiardi, as described and figured by Brian (1906). As will be seen from Brian's figures of the second antennæ and mouth-parts, the generic distinction is a valid one provided the maxillary hooks have not been overlooked and there has been no mistake in the sex of the specimens.

Genus ANCHISTROTOS Brian.

Anchistrotos gobii, BRIAN, 1906, p. 33; pl. 12, figs. 1-10.

Female.—General body form like that of *Cyclops*; cephalothorax much larger than any of the free segments; the latter diminishing regularly in size. Genital segment enlarged but little; abdomen tapering considerably; anal laminæ narrow and short, but well armed with setæ. First antennæ cylindrical and six-jointed, the basal portion enlarged hardly at all, not bent at a right angle, and armed with small setæ which are neither widened nor flattened; there are also no tactile hairs nor chitin processes. Second antennæ similar to those of *Bomolochus*, three-jointed, the second joint very short, the terminal claws large.

First maxillary hooks of good size, with a well developed basal joint and a short and curved terminal claw; mandibles and second maxillæ simple, with a smooth terminal joint; first maxillæ small, each armed with three short plumose setæ.

Maxillipeds in normal position behind the other mouth-parts, made up of a large basal joint and a curved terminal claw, sometimes bearing long setæ. Each ramus of the first swimming legs made up of a

single widened joint; other legs as in *Bomolochus*. Egg-strings wide and long; eggs of medium size, about one hundred in each string.

Male.—Body smaller than that of the female and similar to the males of the Corycæidæ. The two pairs of antennæ and the swimming legs are like those of the female; the first maxillary hooks are considerably enlarged and the terminal claw is elongated and strongly curved. The mandibles are stouter than those of the female, especially the basal joints; the first and second maxillæ are small and slender. The maxillipeds are large and strong and of the usual pattern for the male sex; the basal joint is furnished with powerful muscles and armed with a row of coarse teeth on the inner margin near the proximal end; the terminal claw is stout, bent in a half circle, so that the tip shuts against the teeth on the basal joint.

Type-species.—*Anchistrotos gobi* Brian.

(Ἀγκιστροπόδις, barbed or armed with hooks, alluding to the maxillary hooks.)

To this genus belong the type species, *gobii*, described by Brian in 1906, the species designated as *Bomolochus ostracionis* by Richiardi in 1870, and Claus's genus *Eucanthus*, with the species *balistæ* Claus, and probably *marchesetti* Della Valle, 1884. This last species has never been described to the author's knowledge, and hence we do not know its distinguishing characters. It is therefore omitted from the following key.

ARTIFICIAL KEY TO THE SPECIES.

- a. Exopod of fourth swimming legs without setæ, its terminal joint prolonged into a claw..... *balistæ* Claus, 1864.
- a. Both rami of fourth swimming legs of normal shape and well armed with plumose setæ..... b.
- b. Terminal claw of maxillipeds as long as the basal joint and without filaments; abdomen three-jointed, last joint the longest.. *ostracionis* Richiardi, 1870.
- b. Terminal claw of maxillipeds less than one-fourth the length of the basal joint and armed with two filaments longer than the entire appendage; abdomen four-jointed, joints equal..... *gobii* Brian, 1906.

Brian established *Anchistrotos* as a new subgenus under the genus *Bomolochus*, but there can be no question that it is entitled to be made a separate genus, when one considers the structure of the first antennæ, the maxillary hooks, and the maxillipeds. It is, however, very doubtful whether the specimen figured by Brian (Pl. 12, figs. 1, 2, and 7 to 10) is really a male. It looks much more like a young female without egg-strings, and it shows no sex distinctions from the female in the first maxillary hooks, the maxillipeds, or the genital segment. Certainly one or more of these parts ought to be modified in the true male.

Claus shows such differences clearly in his species, *balistæ*, and he certainly had both sexes. It is from the male which he describes and not from Brian's doubtful specimen that the sex distinctions of the present genus have been drawn.

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EXPLANATION OF PLATES.

PLATE 41.

Female of *Ergasilus labracis* Kröyer.

Fig. 42, dorsal view. Fig. 43, ventral view showing pigment pattern. Fig. 44, genital segment and abdomen, dorsal view. Fig. 45, second antenna. Fig. 46, mouth-parts; *lb.*, labium; *md.*, mandible; *mdp.*, mandibular palp; *mx'*, first maxilla; *mx''*, second maxilla. Figs. 47 to 49, first, third, and fourth swimming legs.

PLATE 42.

Female of *Ergasilus centrarchidarum* Wright.

Fig. 50, dorsal view. Fig. 51, dorsal surface of second (really the third) thorax segment. Fig. 52, side view of mouth-parts, showing protrusion of first maxillæ. Figs. 53 and 54, diagonal views of the mouth-parts. Figs. 55 to 58, first, second, third, and fourth swimming legs. Fig. 59, spermatozoan, highly magnified.

PLATE 43.

Female of *Ergasilus cæruleus*, new species.

Fig. 60, dorsal view. Fig. 61, ventral view, showing distribution of the deep blue pigment. Figs. 62 and 63, first and second antenna. Fig. 64, mouth-parts; *md.*, mandible; *mdp.*, mandibular palp; *mx'* and *mx''*, first and second maxillæ. Figs. 65 to 68, first, second, third, and fourth swimming legs.

PLATE 44.

Female of *Ergasilus manicatus*, new species.

Fig. 69, dorsal view. Fig. 70, genital segment and abdomen, dorsal view. Fig. 71, first antenna. Fig. 72, one of the peculiar second antennæ, furnished with large sleeves or hoods at the joints. Fig. 73, mouth-parts; *md.*, mandible; *mdp.*, mandibular palp; *mx'* and *mx''*, first and second maxillæ. Figs. 74 to 77, first, second, third, and fourth swimming legs. All the figures except 69 and 72 were drawn by Richard Rathbun.

PLATE 45.

Female of *Ergasilus versicolor*, new species.

Figs. 78 and 79, dorsal and ventral views, showing the distribution of pigment. Fig. 80, first antenna. Fig. 81, mouth-parts (see fig. 46). Figs. 82 to 85, first, second, third, and fourth swimming legs.

PLATE 46.

Male of *Ergasilus chautauquaënsis* Fellows.

Fig. 86, dorsal view. Fig. 87, ventral view of abdomen, showing armature of species. Fig. 88, second antenna. Fig. 89, mouth-parts (see fig. 46). Fig. 90, exopod of first swimming leg, left side. Fig. 91, endopod of first swimming leg, right side. Figs. 92 to 94, second, third, and fourth swimming legs.

PLATE 47.

Female of *Ergasilus mugilis* Vogt.

Fig. 95, dorsal view. Fig. 96, dorsal view of genital segment and abdomen, showing fusion of fifth and genital segments, fifth legs, and musculature of the oviduct openings. Fig. 97, second antenna. Figs. 98 to 101, first, second, third, and fourth swimming legs.

PLATE 48.

Female of *Tucca impressus* Kröyer.

Fig. 102, dorsal view. Fig. 103, ventral view, showing rudimentary third and fourth legs and muscles. Fig. 104, mouth-parts; *la.*, labrum; *md.*, mandible; *mx.*' and *mx.*'', first and second maxillæ. Fig. 105, second antenna. Figs. 106 to 108, second, third, and fourth swimming legs.

PLATE 49.

Male of *Tucca impressus* Kröyer.

Fig. 109, ventral view, showing rudimentary swimming legs and muscles connected with them. Fig. 110, side view of female, showing relative thickness of the body. Fig. 111, genital segment and abdomen of female, ventral view, showing anal laminae and openings of the oviducts. Fig. 112, chitin framework of the cephalothorax, after treatment with caustic potash. Fig. 113, cross section of egg-string of female. Fig. 114, second maxilla of male. Fig. 115, maxilliped. Figs. 116 and 117, first and second swimming legs of female of *Tucca corpulentus*. Figs. 118 to 120, third, fourth, and fifth swimming legs of male of *Tucca impressus*. Figs. 110 to 112 were drawn by Richard Rathbun.

PLATE 50.

Female of *Tucca corpulentus*, new species.

Fig. 121, dorsal view. Fig. 122, first antenna. Fig. 123, second antenna. Fig. 124, ventral view of cephalothorax, showing antennæ, mouth-parts, and first and second legs in natural position. Fig. 125, mouth-parts, except the maxillipeds, enlarged (see fig. 104). Figs. 126 and 127, third and fourth swimming legs.

PLATE 51.

Female of *Artacolax sætiger*, new species.

Fig. 128, dorsal view. Fig. 129, side view, showing fusion of third and fourth thorax segments. Fig. 130, second antenna. Fig. 131, mouth-parts: *la.* labrum; *md.*, mandible; *mx.*' and *mx.*'', first and second maxillæ; *p.*, paragnath. Fig. 132, maxilliped. Figs. 133 to 136, first, second, third, and fourth swimming legs. Fig. 137, one of the claws on the exopods of the swimming legs.

PLATE 52.

Female of *Artacolax ardeolæ* (Kröyer).

Fig. 138, dorsal view. Fig. 139, side view, showing fusion of third and fourth thorax segments. Fig. 140, mouth-parts (see fig. 131). Fig. 141, maxilliped. Figs. 142 to 145, first, second, fourth, and fifth swimming legs. Fig. 146, one of the claws on the exopods of the swimming legs.

PLATE 53.

Female of *Bomolochus eminens*, new species.

Fig. 147, third swimming leg of *Artacolax ardeolæ*. Fig. 148, dorsal view of *Bomolochus eminens*. Fig. 149, ventral view of genital segment and abdomen. Fig. 150,

second antenna. Fig. 151, mouth-parts: *la.*, labrum; *md.*, mandible; *mx.*' and *mx.*'', first and second maxillæ; *mxp.*, maxilliped, the single one being drawn in the right position and of the correct size with reference to the other mouth-parts. Figs. 152 to 155, first, second, third, and fourth swimming legs.

PLATE 54.

Female of *Bomolochus concinnus*, new species.

Fig. 156, dorsal view. Fig. 157, first antenna. Fig. 158, second antenna. Fig. 159, mouth-parts (see fig. 151) of young female. Fig. 160, maxilliped of adult, showing lengthening of the claw. Figs. 161 to 165, first, second, third, fourth, and fifth swimming legs.

PLATE 55.

Male of *Bomolochus concinnus*, new species.

Fig. 166, first antenna of young female, showing division into 6 segments. Fig. 167, fourth leg of young female. Fig. 168, fifth leg of young female; note resemblance to fig. 176 and compare with fig. 165. Fig. 169, dorsal view of adult male. Fig. 170, dorsal view of very young male less than half a millimeter in length. Fig. 171, second antenna. Fig. 172, mandible. Fig. 173, first maxilla. Fig. 174, maxilliped. Figs. 175 and 176, first and fifth swimming legs.

PLATE 56.

Female of *Bomolochus nitidus*, new species.

Fig. 177, dorsal view. Fig. 178, first antenna. Figs. 179 to 183, first, second, third, fourth, and fifth swimming legs. (Fig. 181 is the fourth pair.)

PLATE 57.

Male and female of *Bomolochus soleæ* Claus.

Fig. 184, dorsal view of male. Fig. 185, ventral view of abdomen, showing armature of stiff bristles. Fig. 186, second antenna. Fig. 187, mandible and first maxilla. Fig. 188, second maxilla and paragnath. Fig. 189, fourth swimming leg. Fig. 190, side view of female.

PLATE 58.

Female of *Bomolochus exilipes*, new species.

Fig. 191, dorsal view. Fig. 192, ventral view of genital segment and abdomen. Figs. 193 and 194, first and second antenna. Figs. 195 to 199, first, second, third, fourth, and fifth swimming legs. Fig. 200, rudimentary sixth leg at the opening of the oviduct on the genital segment. Fig. 201, mouth-parts of *Bomolochus nitidus* (see fig. 151).

PLATE 59.

Female of *Bomolochus teres*, new species.

Fig. 202, dorsal view. Fig. 203, first antenna. Fig. 204, second antenna. Figs. 205 to 209, first, second, third, fourth, and fifth swimming legs. Fig. 210, one of the claws on the exopods of the swimming legs.

PLATE 60.

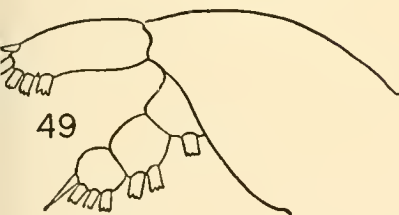
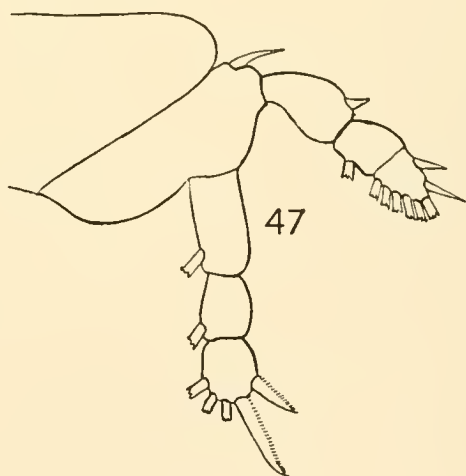
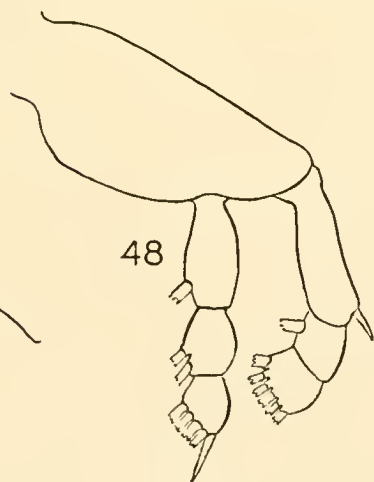
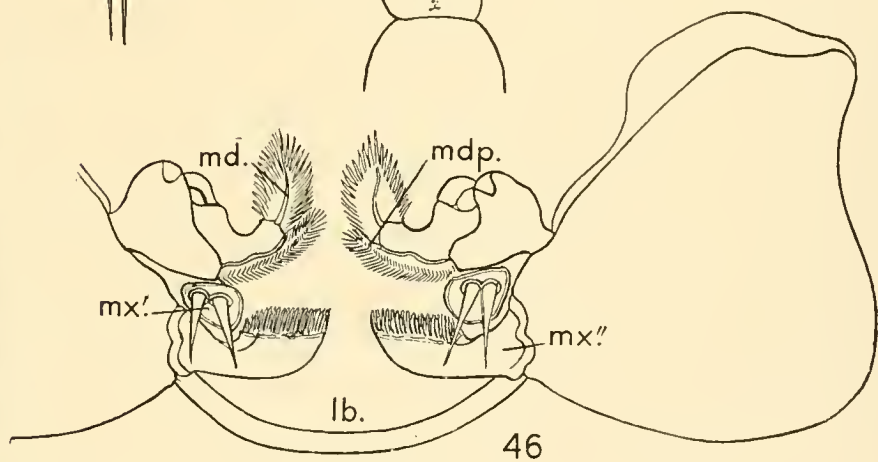
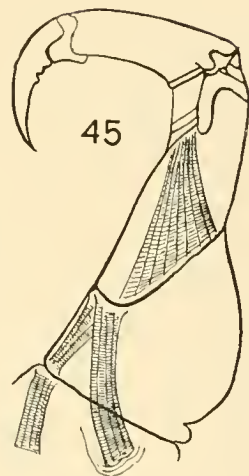
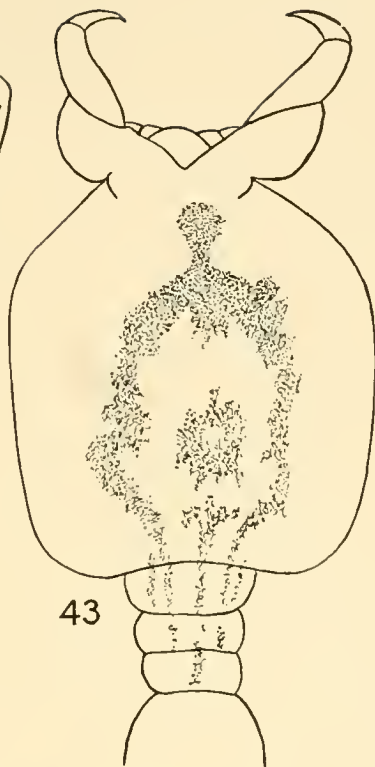
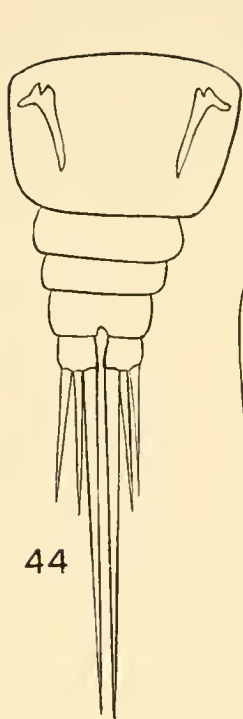
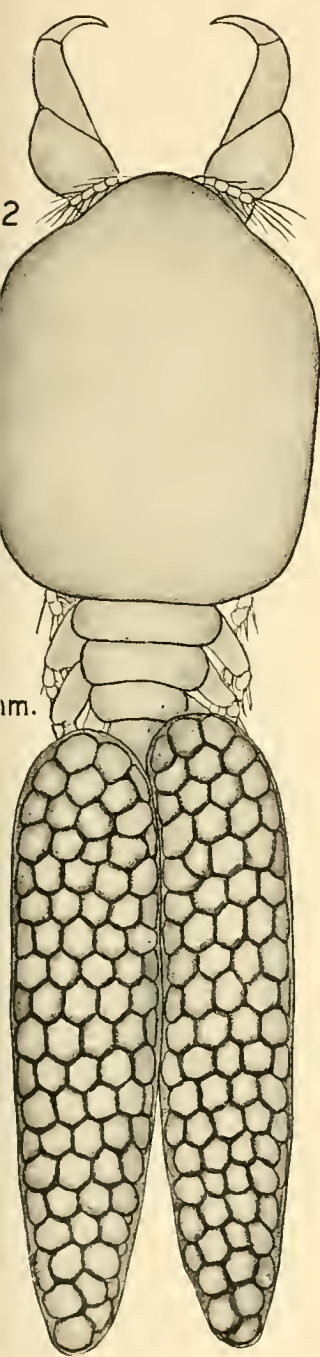
Female of *Tæniacanthus albidus*, new species.

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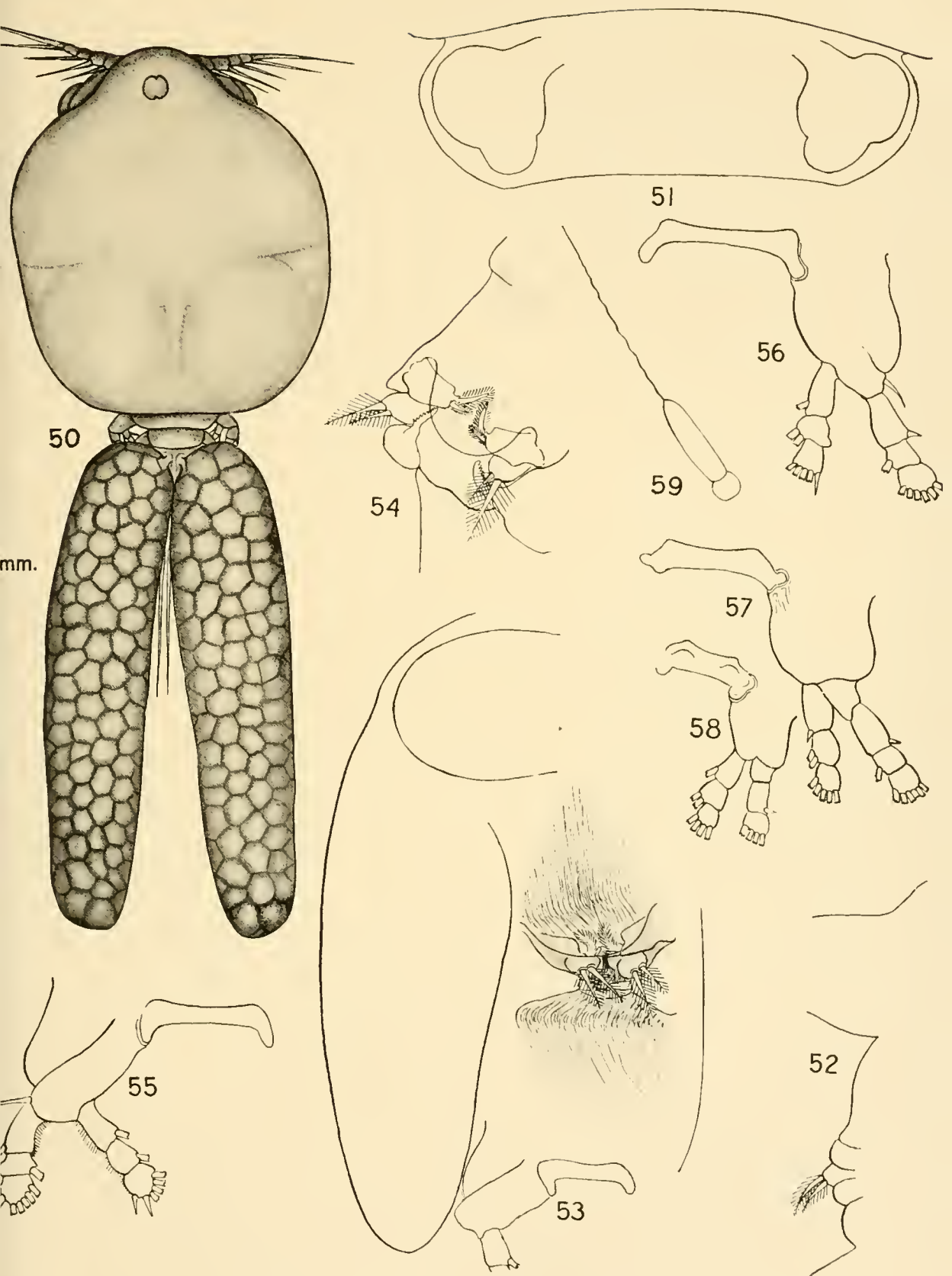
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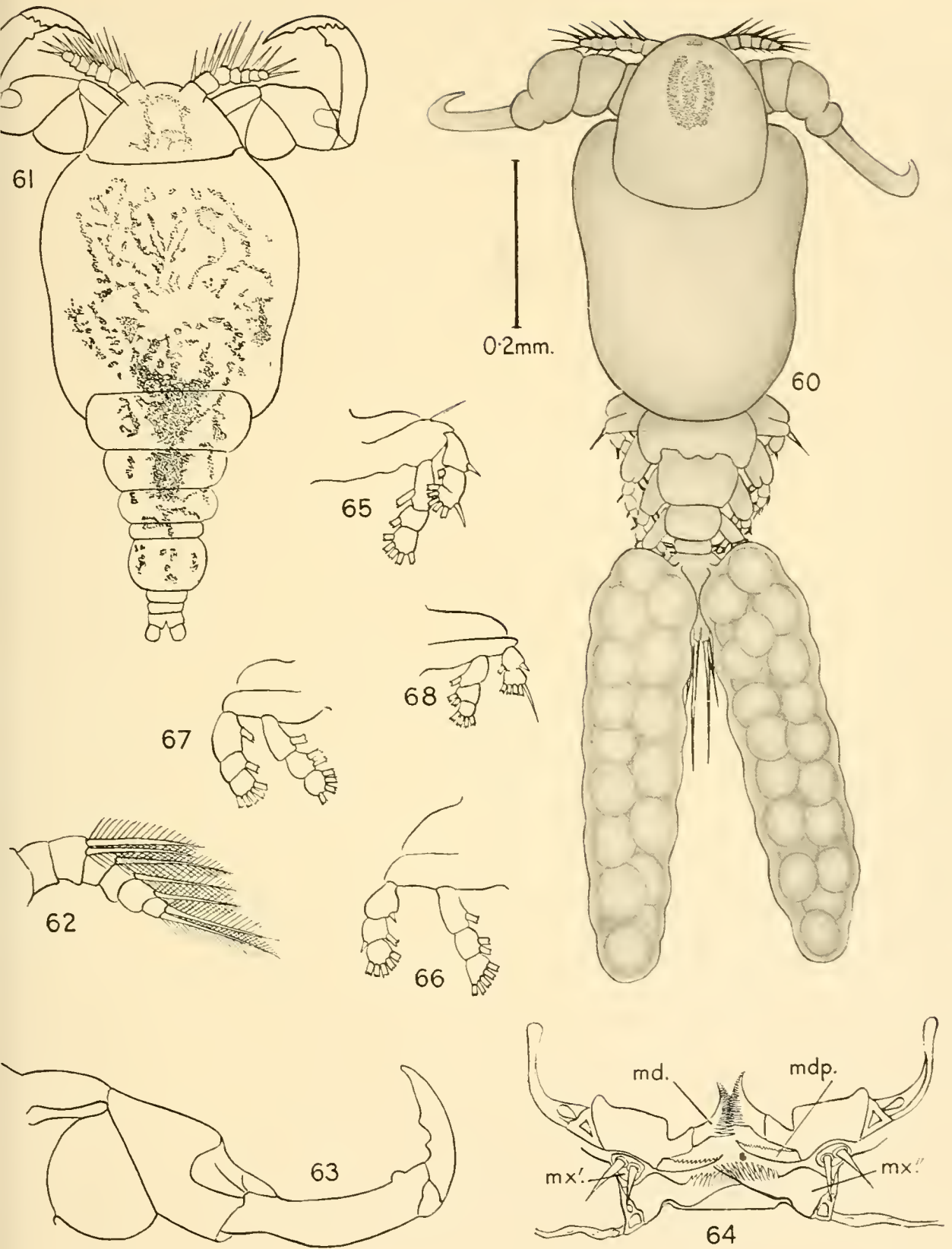
FEMALE OF *ERGASILUS LABRACIS*.

FOR EXPLANATION OF PLATE SEE PAGE 395.



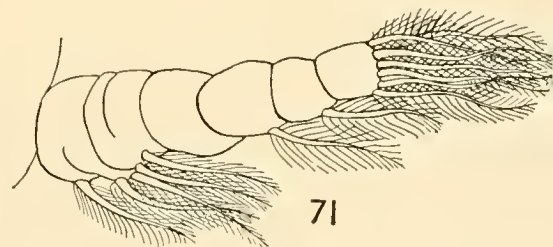
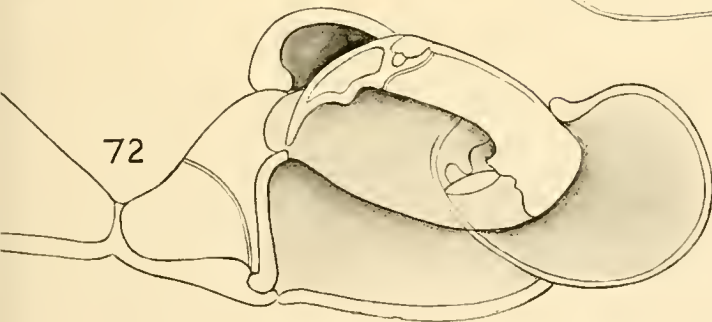
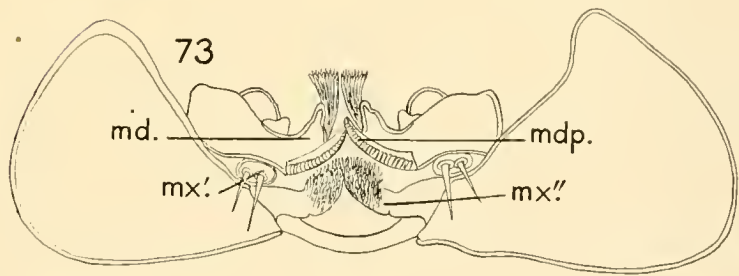
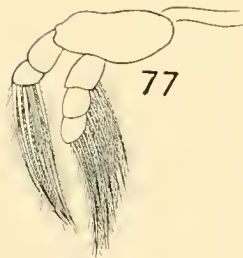
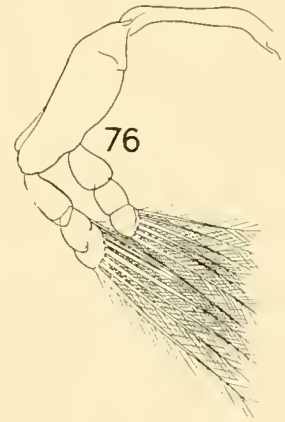
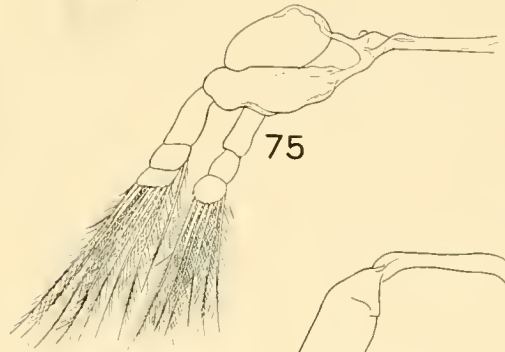
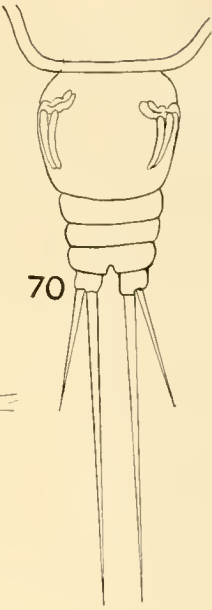
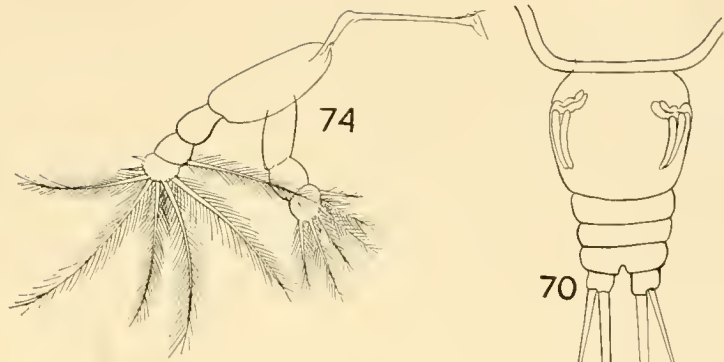
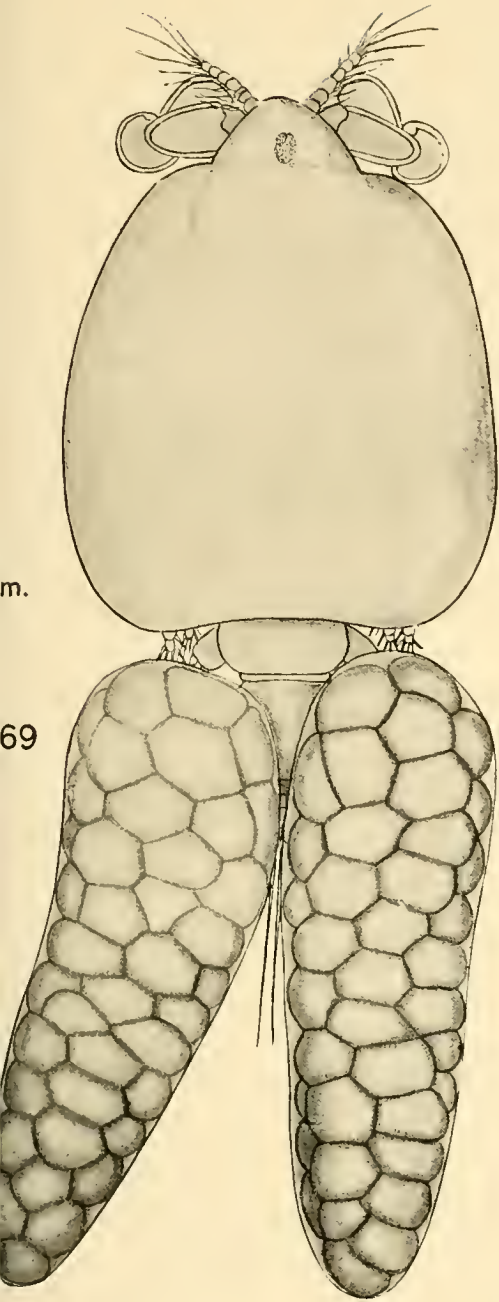
FEMALE OF *ERGASILUS CENTRARCHIDARUM*.

FOR EXPLANATION OF PLATE SEE PAGE 395.



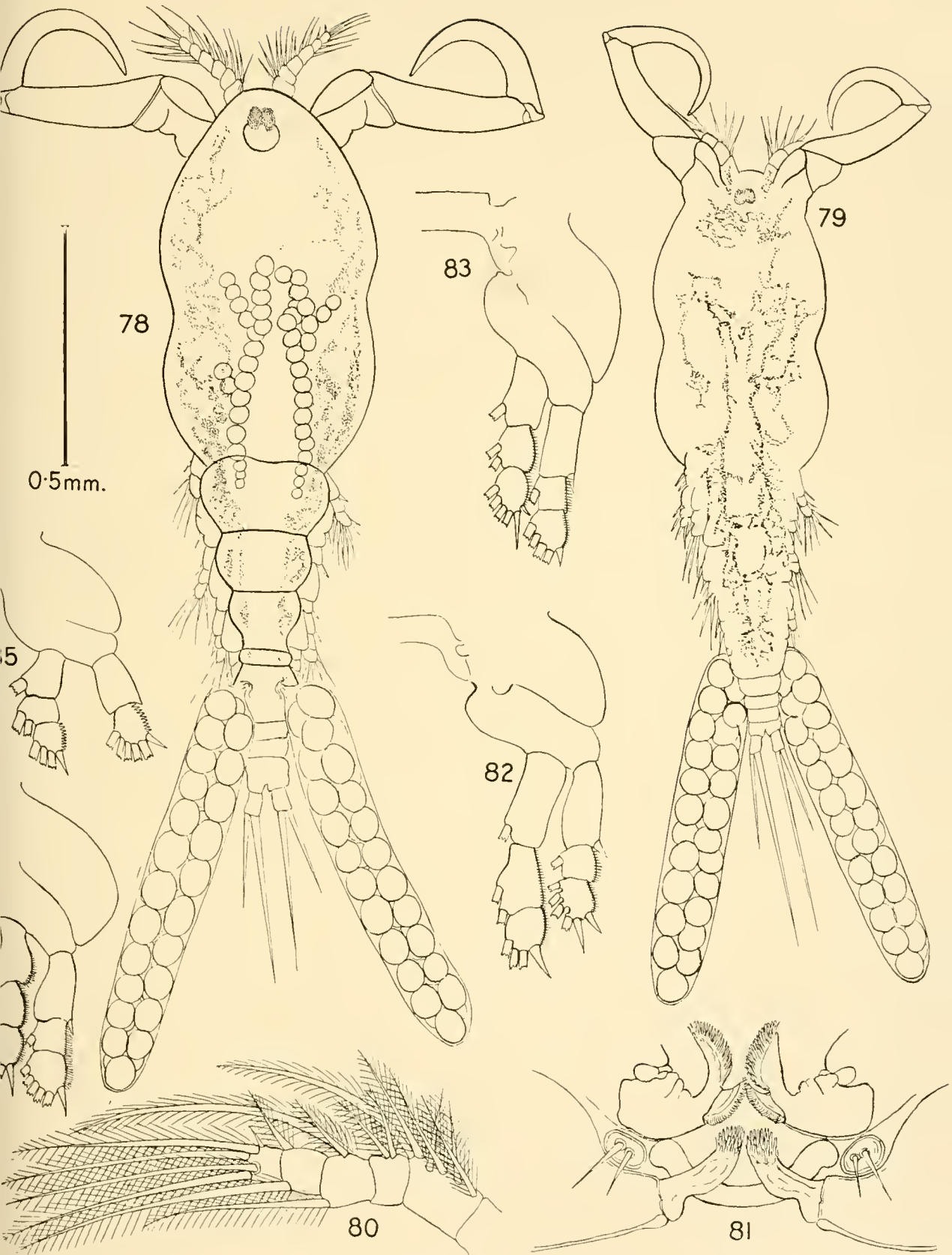
FEMALE OF *ERGASILUS CAERULEUS*.

FOR EXPLANATION OF PLATE SEE PAGE 395.



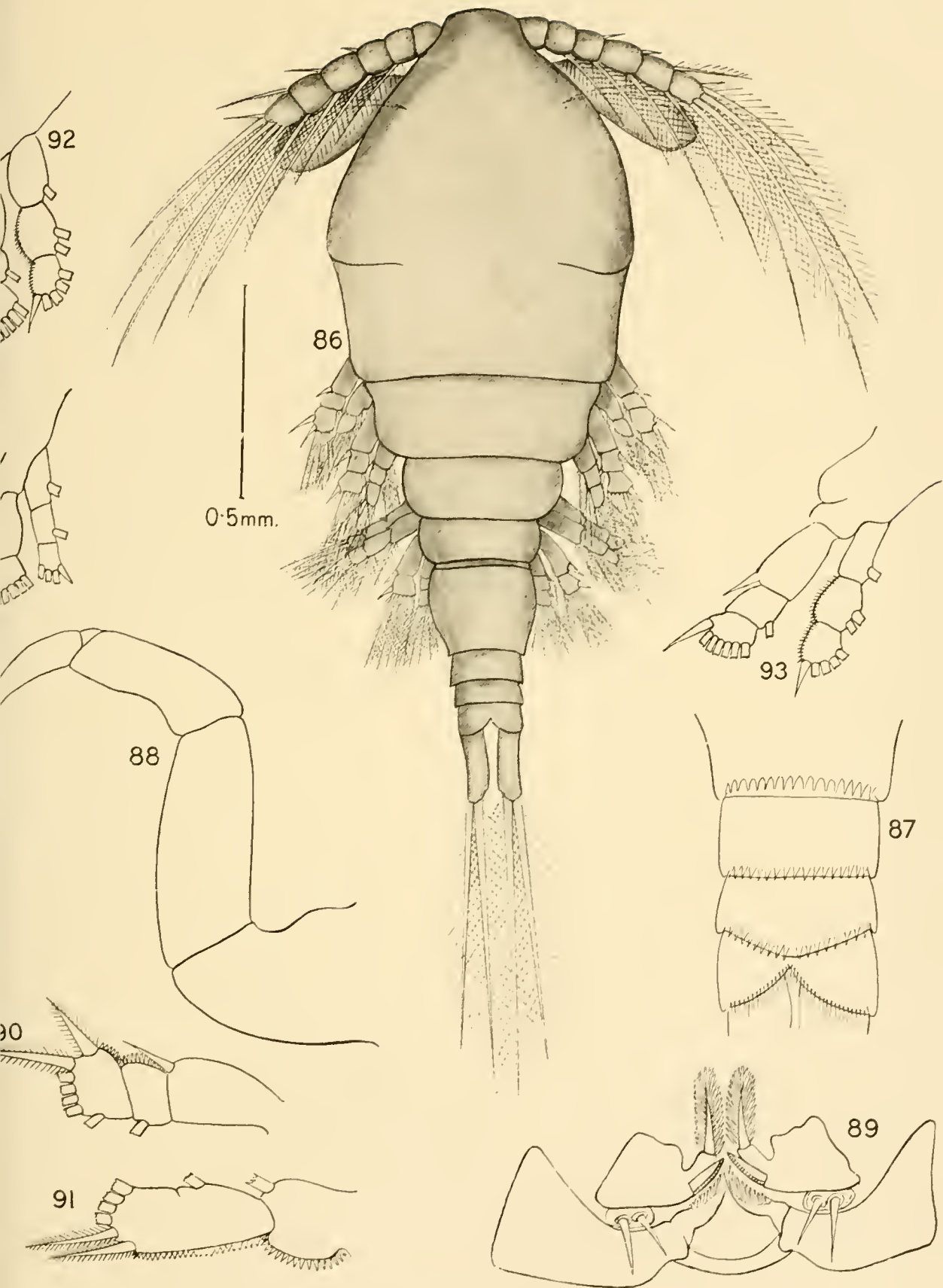
FEMALE OF ERGASILUS MANICATUS.

FOR EXPLANATION OF PLATE SEE PAGE 395.



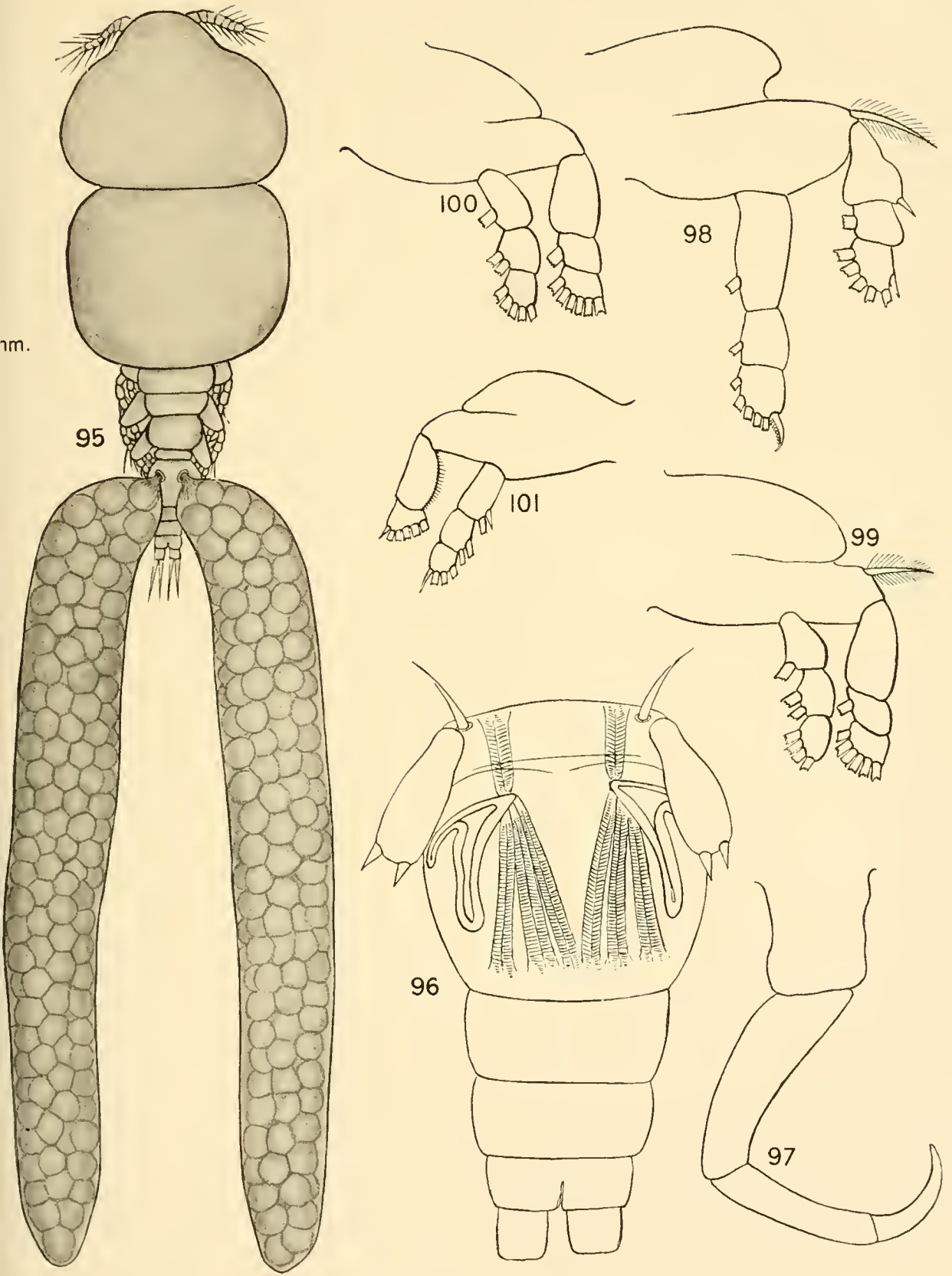
FEMALE OF *ERGASILUS VERSICOLOR*.

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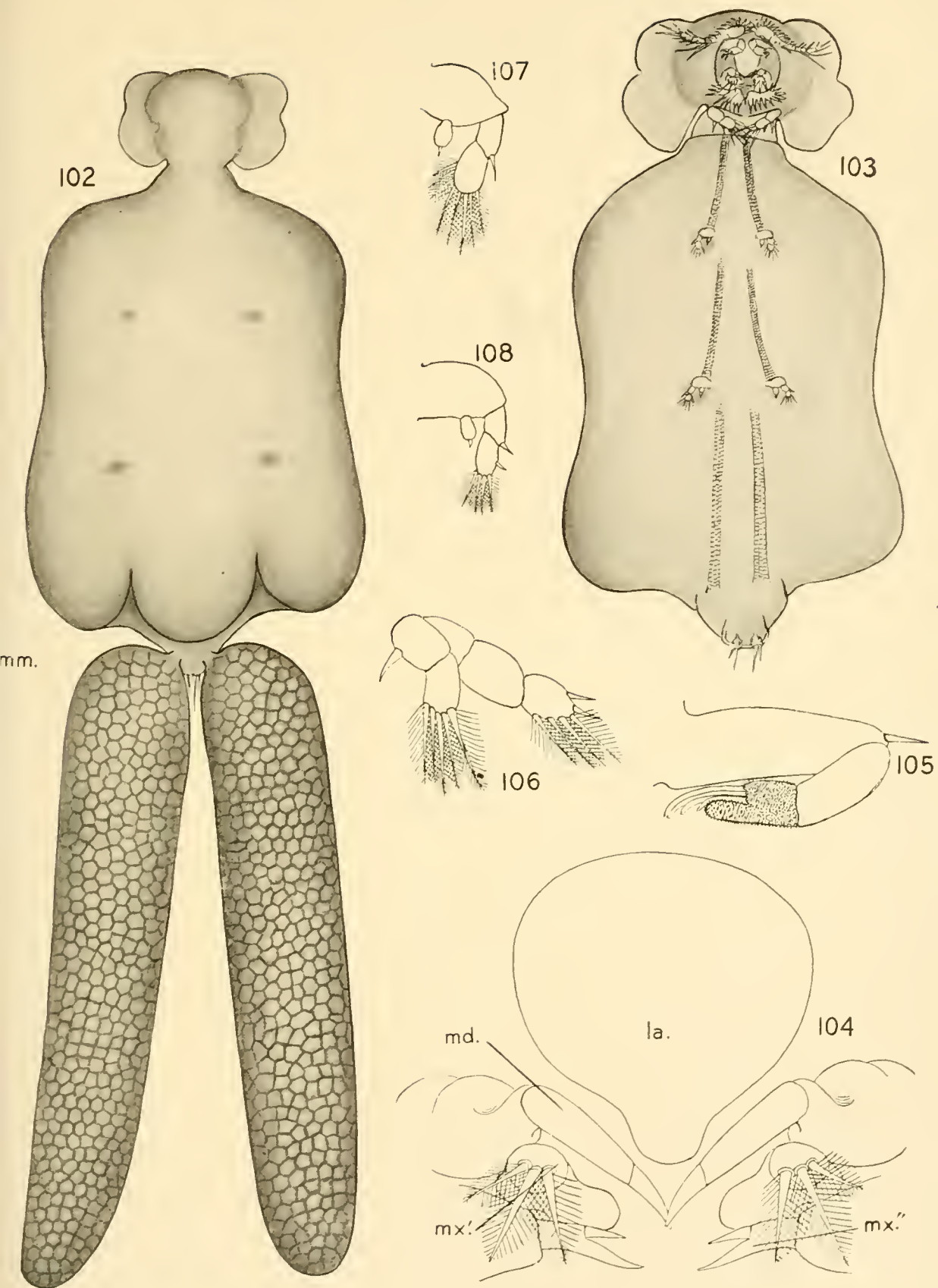
MALE OF *ERGASILUS CHAUTAUQUAENSIS*.

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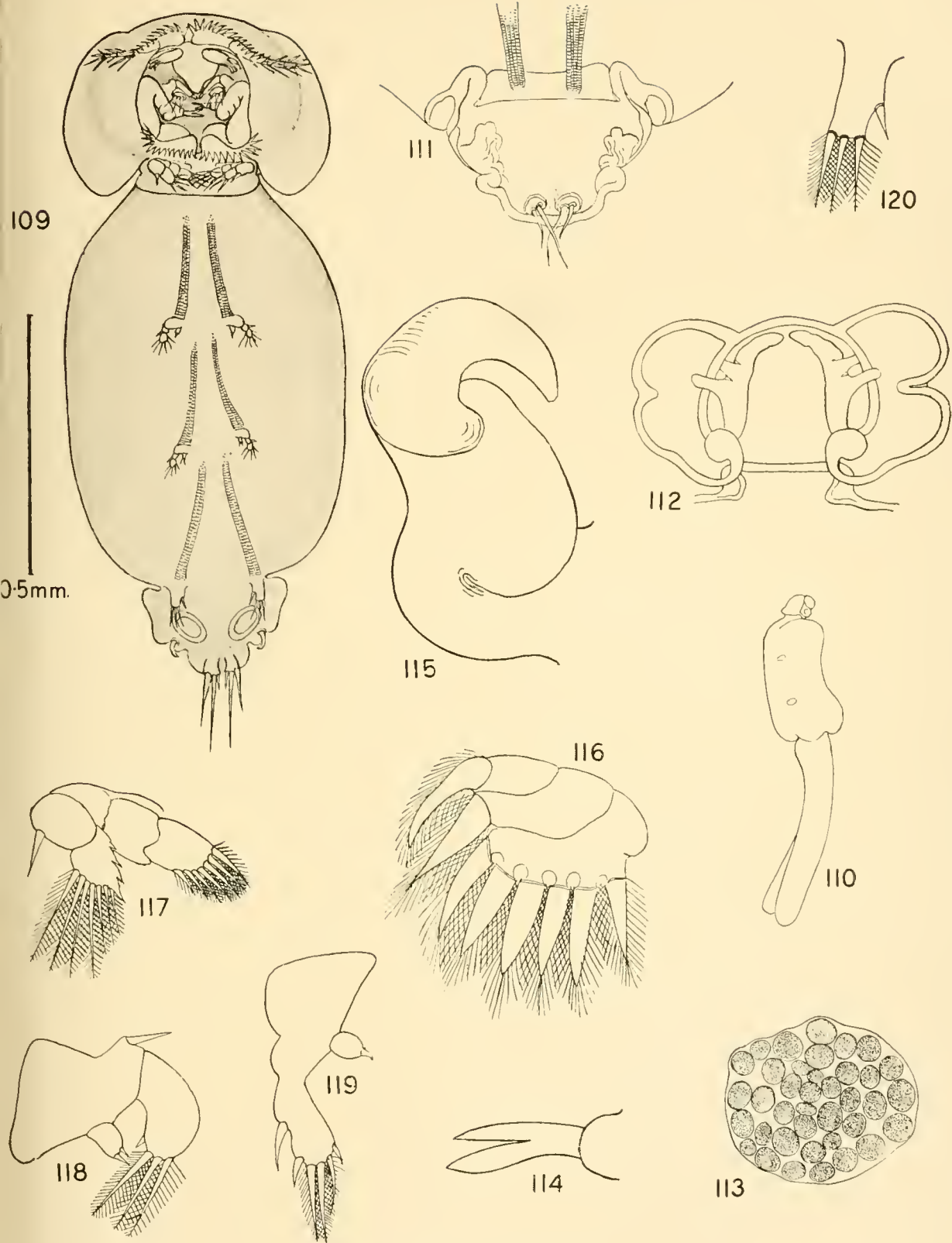
FEMALE OF *ERGASILUS MUGILIS*.

FOR EXPLANATION OF PLATE SEE PAGE 396.



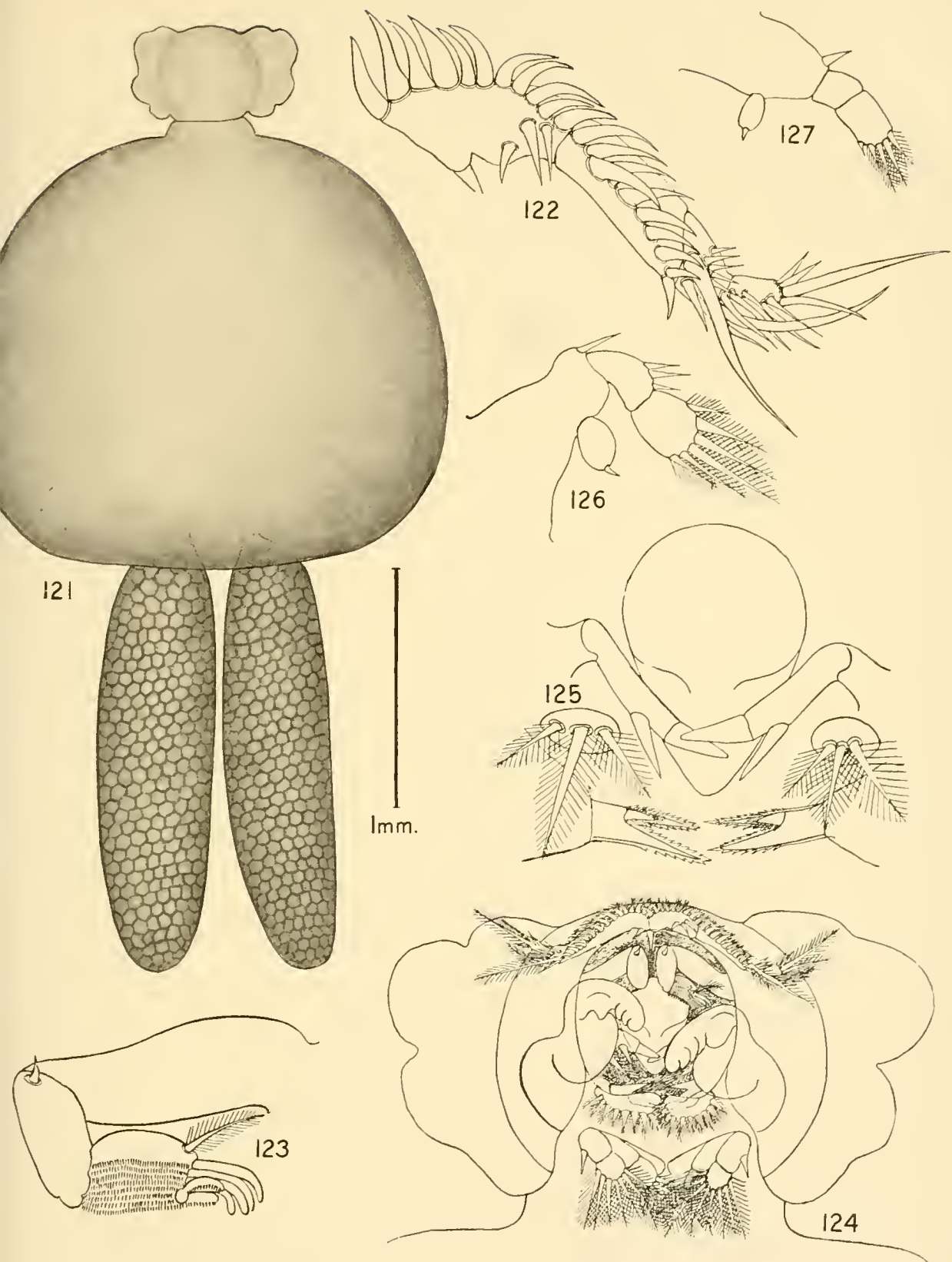
FEMALE OF TUCA IMPRESSUS.

FOR EXPLANATION OF PLATE SEE PAGE 396.



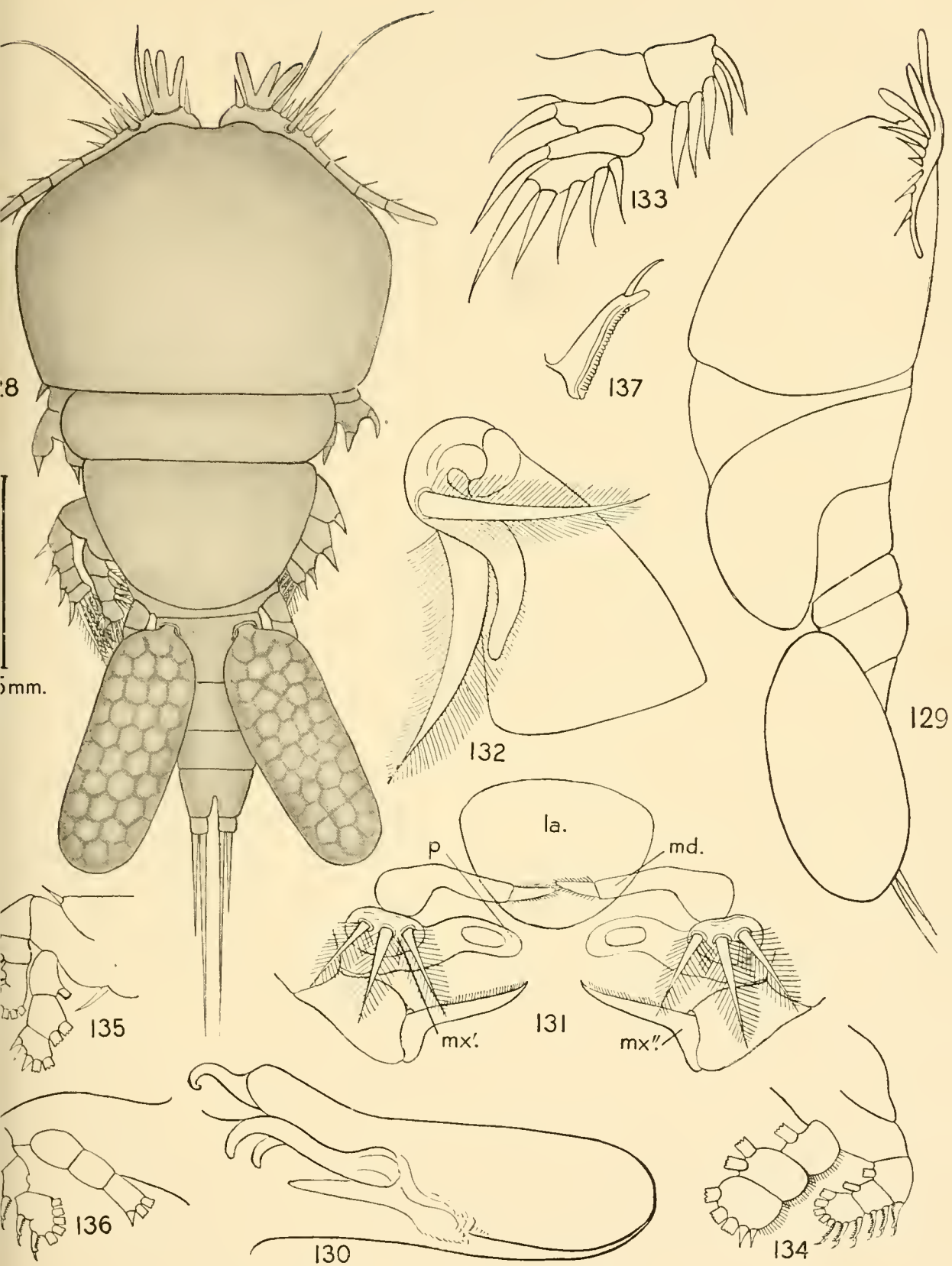
MALE OF TUCCA IMPRESSUS.

FOR EXPLANATION OF PLATE SEE PAGE 396.



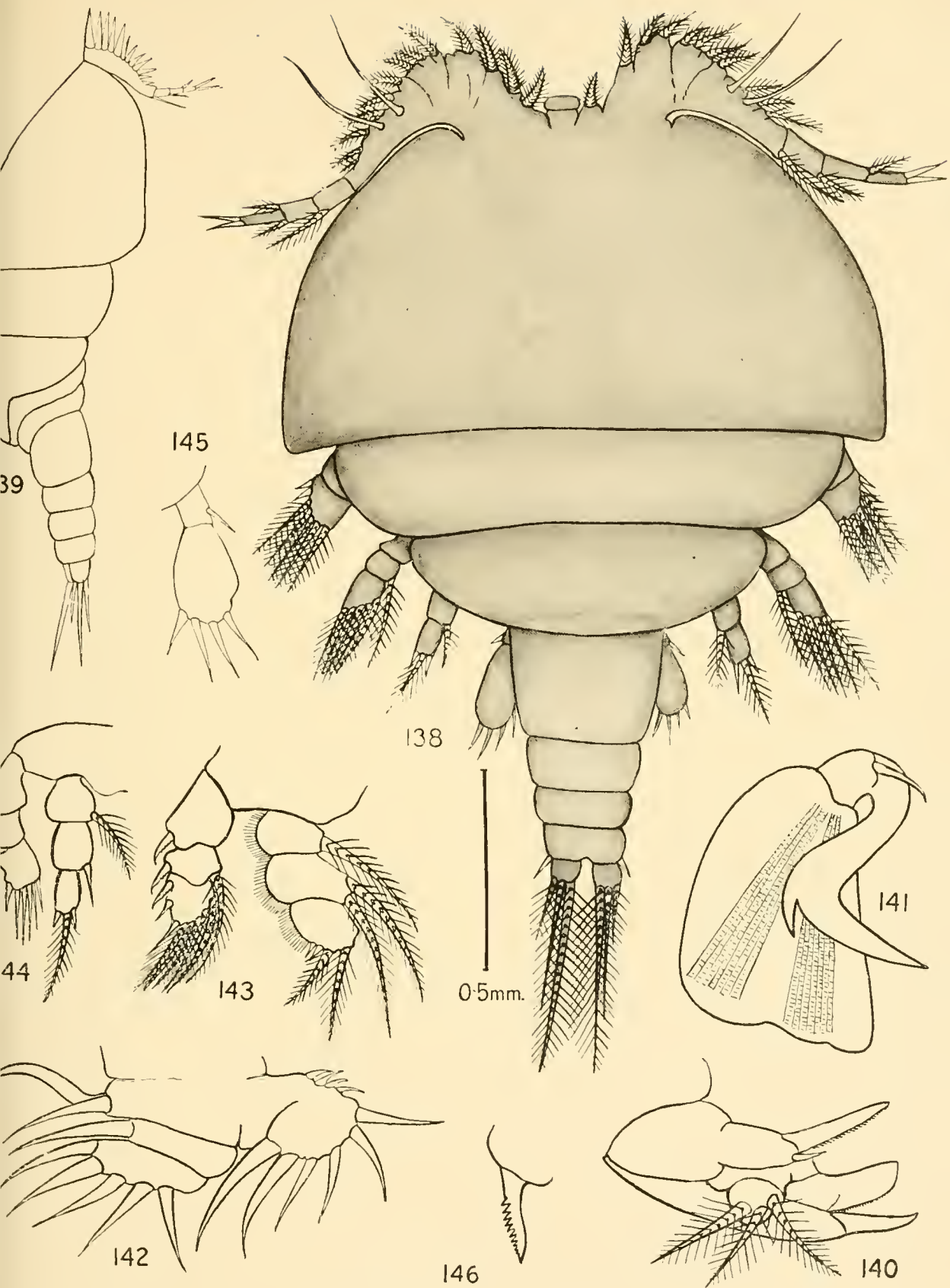
FEMALE OF *TUCCA CORPULENTUS*.

FOR EXPLANATION OF PLATE SEE PAGE 396.



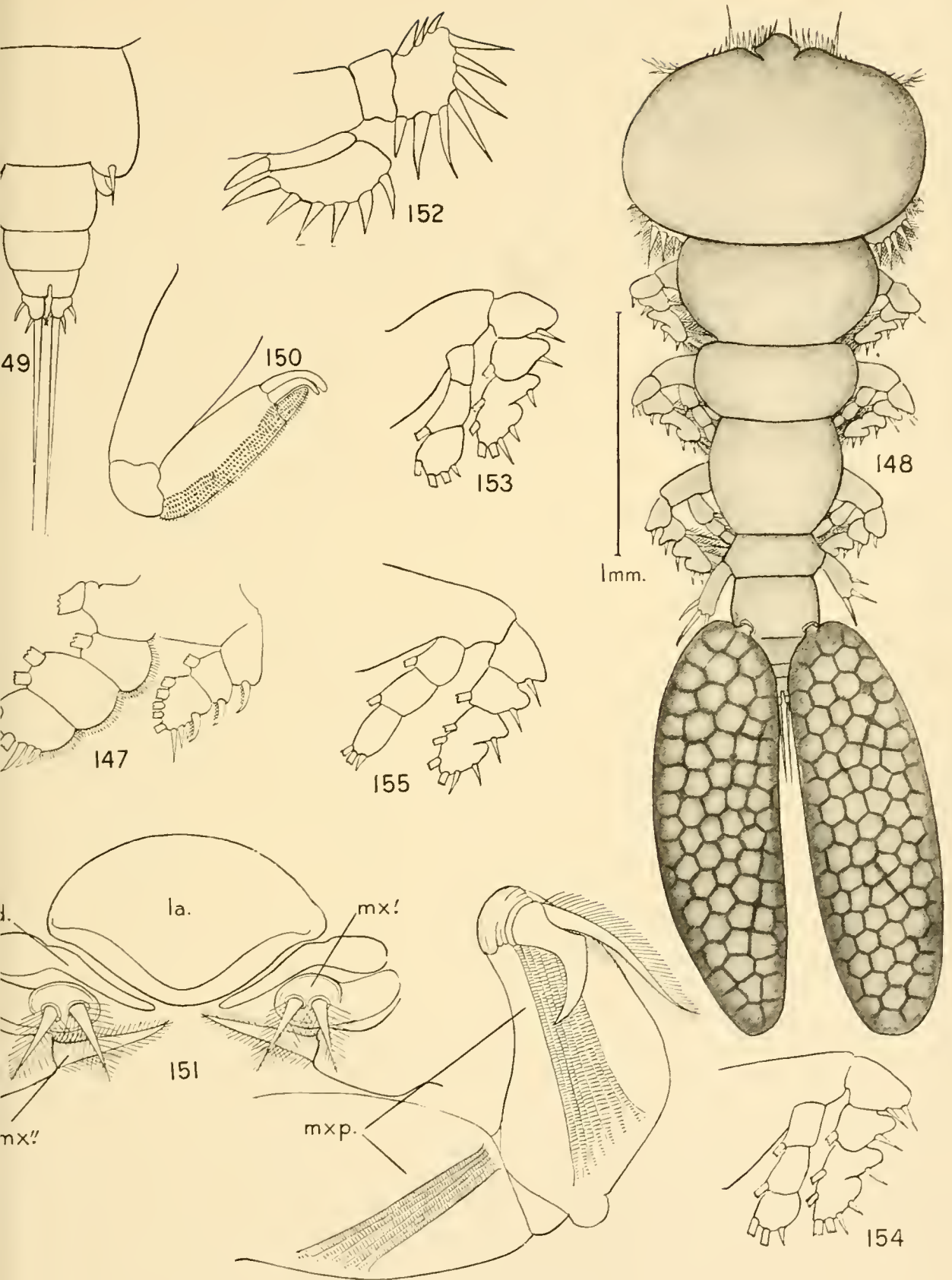
FEMALE OF ARTACOLAX SÆTIGER.

FOR EXPLANATION OF PLATE SEE PAGE 396.



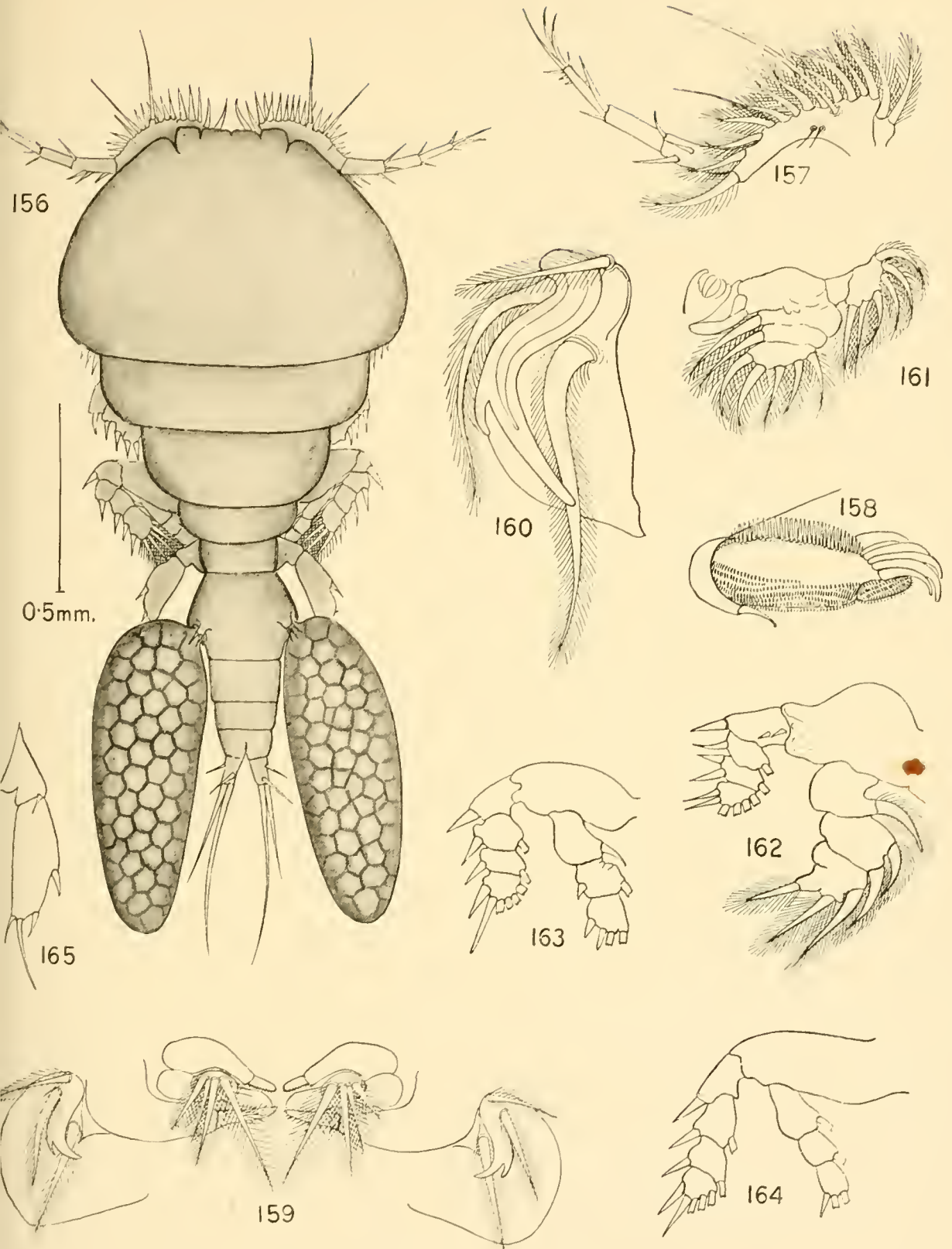
FEMALE OF *ARTACOLAX ARDEOLÆ*.

FOR EXPLANATION OF PLATE SEE PAGE 396.



FEMALE OF BOMOLOCHUS EMINENS.

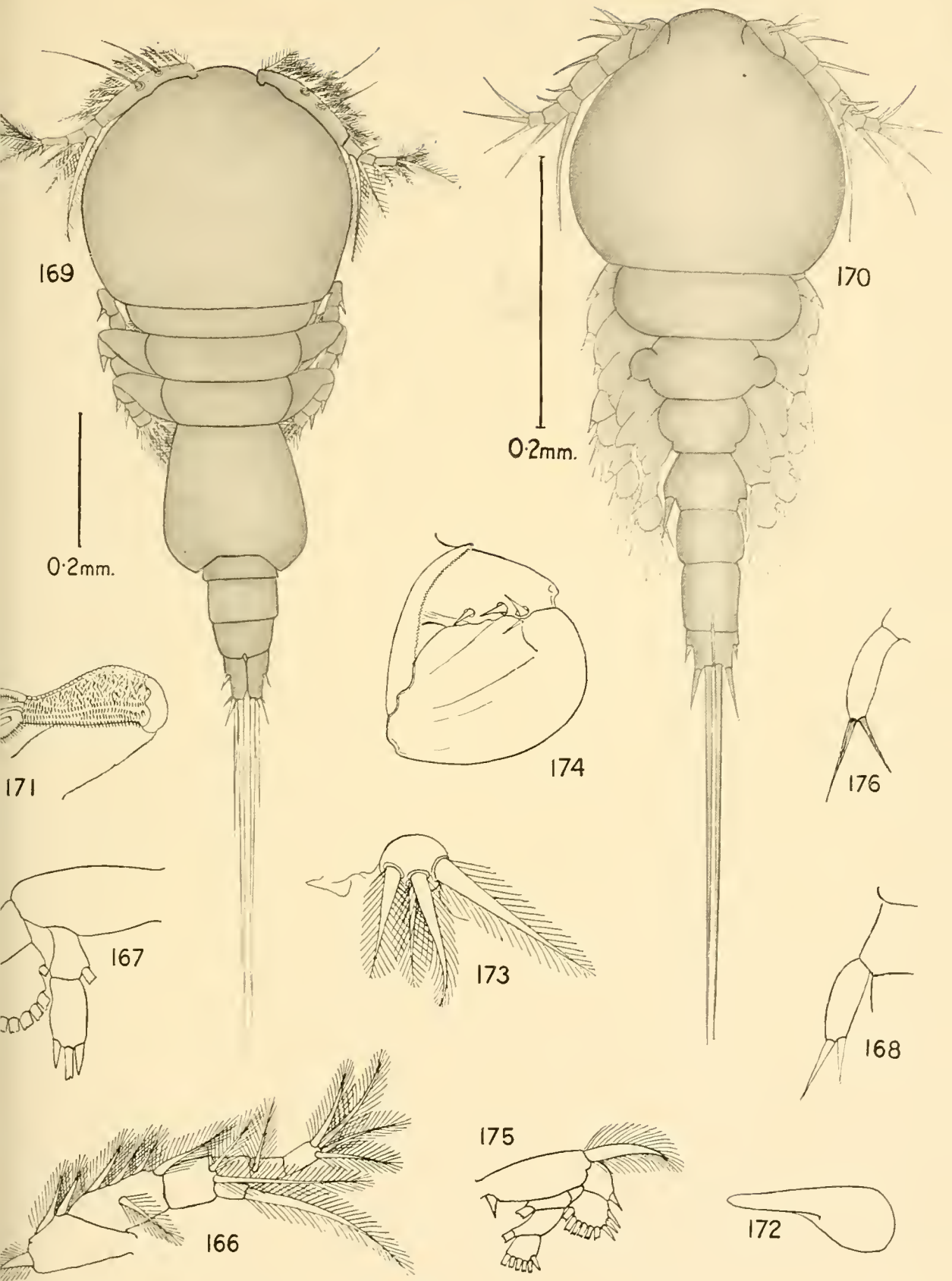
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FEMALE OF *BOMOLOCHUS CONCINNUS*.

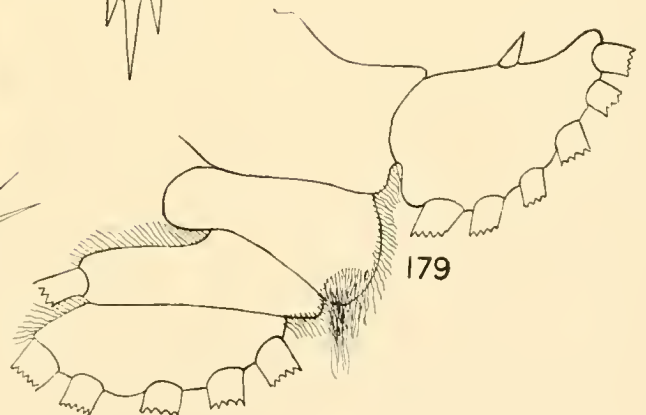
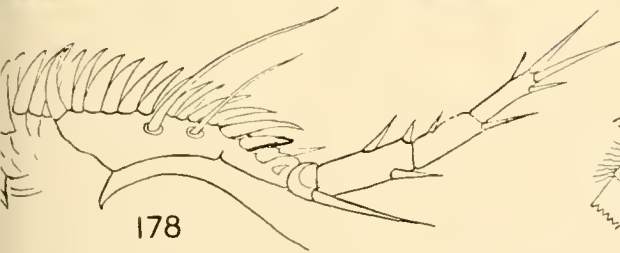
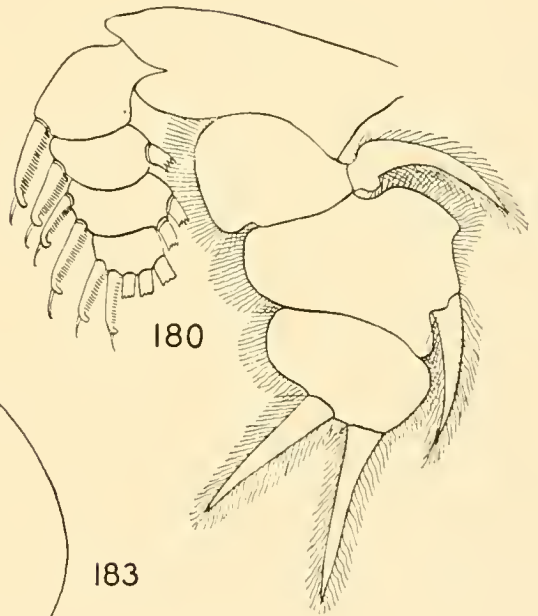
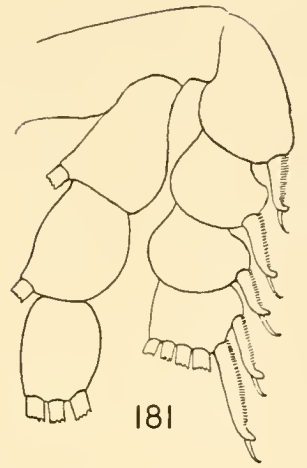
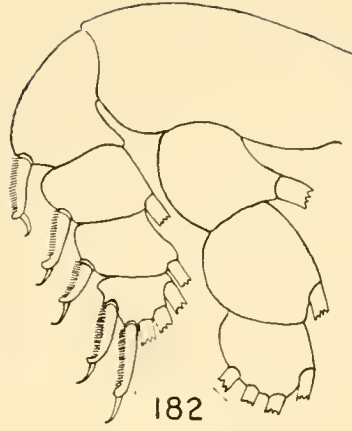
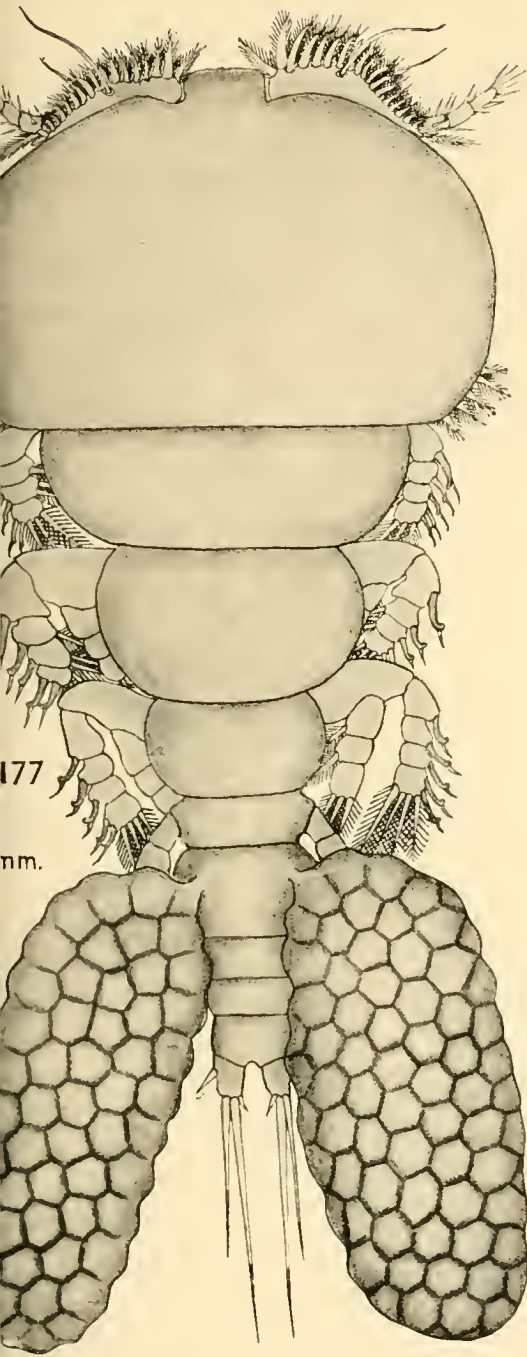
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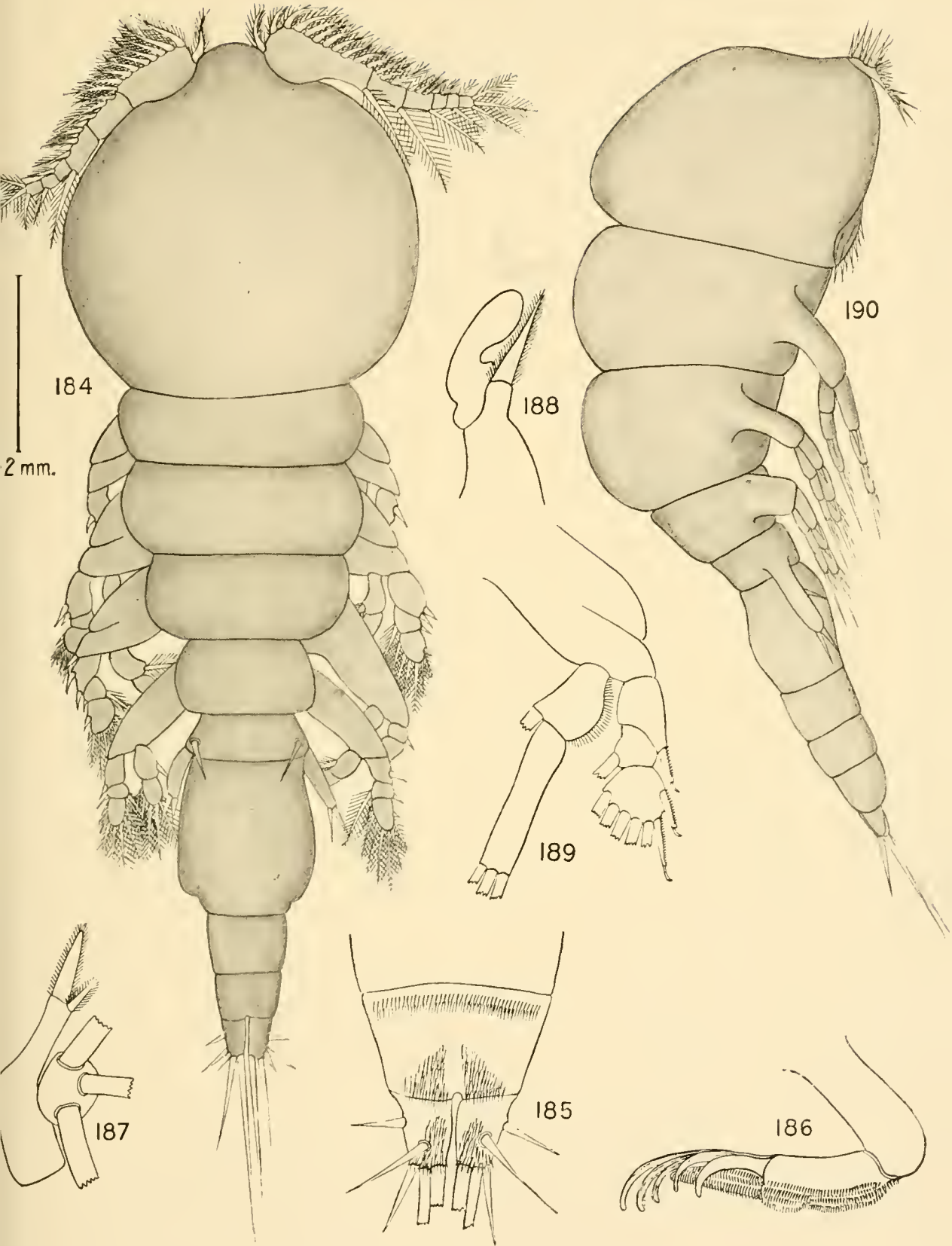
MALE OF BOMOLOCHUS CONCINNUS.

FOR EXPLANATION OF PLATE SEE PAGE 397.



FEMALE OF BOMOLOCHUS NITIDUS.

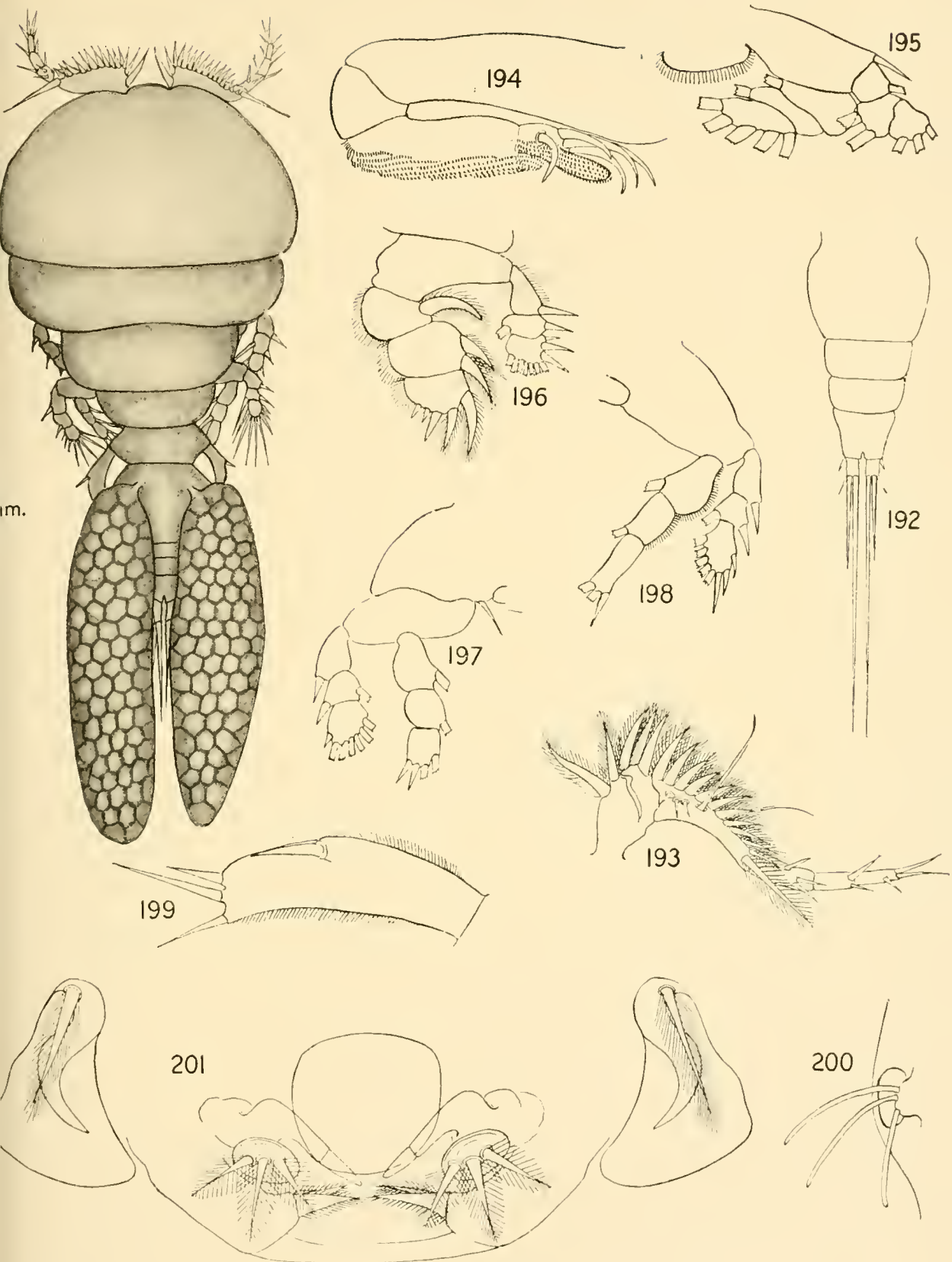
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MALE AND FEMALE OF *BOMOLOCHUS SOLEÆ*.

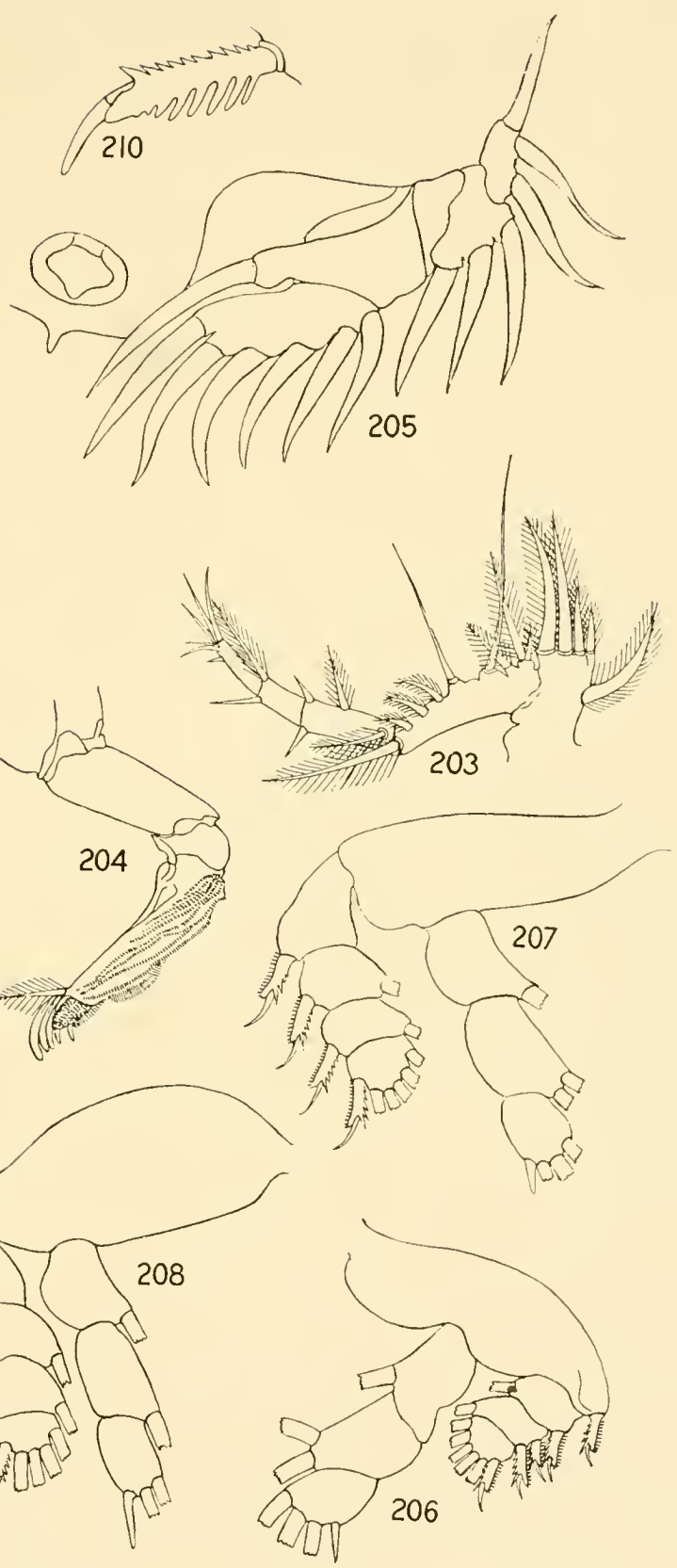
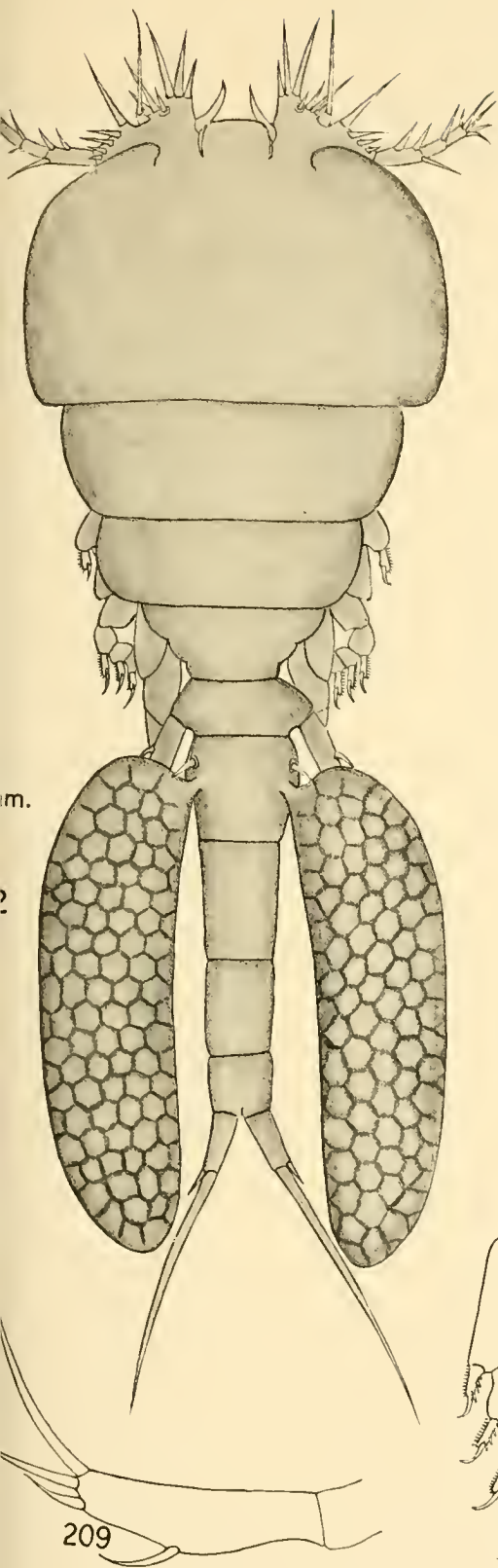
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FEMALE OF BOMOLOCHUS EXILIPES.

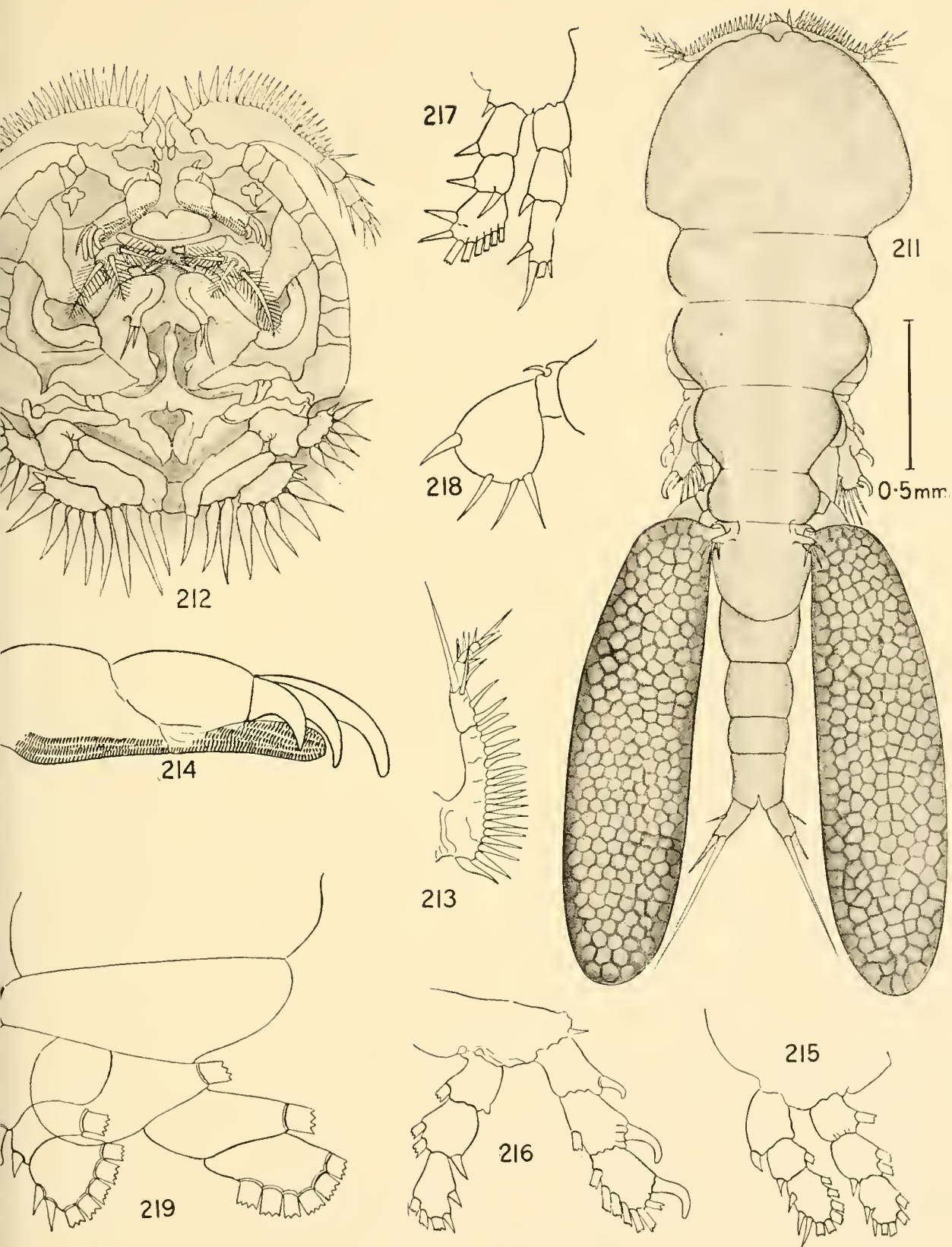
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FEMALE OF BOMOLOCHUS TERES.

FOR EXPLANATION OF PLATE SEE PAGE 397.



FEMALE OF TÆNIACANTHUS ALBIDUS.

FOR EXPLANATION OF PLATE SEE PAGE 397.

NEW SPECIES OF REARED ICHNEUMON-FLIES.

By H. L. VIERECK,

Of the Bureau of Entomology, Department of Agriculture, Washington, D. C.

Most of the species herein treated are the results of rearings of economic species of insects carried on by the Bureau of Entomology of the U. S. Department of Agriculture. Where the type of a genus herein treated has not yet been fixed I have designated the type.

Genus METEORUS Haliday.

Type.—*M. filator* Haliday.

METEORUS LOXOSTEGEI, new species.

Male.—Length 4 mm.; related to *Metorus pulchricornis* Wesmael and to *M. politus* Provancher. Differential points are the absence of the median longitudinal carina of the propodeum, striæ on first dorsal segment strongly converging toward the apex, boss between the fossæ on the first dorsal segment narrower than either fossa, spiracles of first segment not prominently projecting, striæ of this segment not coarse.

Type-locality.—Rocky Ford, Colorado.

Type.—Cat. No. 13338, U.S.N.M.

One specimen with the following additional data, "Bred from *Loxostege sticticalis*, April 14, 1910, H. O. Marsh collector, Chittenden No. 1565," received from the Bureau of Entomology, U. S. Department of Agriculture.

Genus SCHIZOPRYMNUS Foerster.

SCHIZOPRYMNUS PHILLIPSI, new species.

Female.—Length 2.5 mm. Closely resembles *S. texanus* (Cresson), from which it may be distinguished by the sculptured front and vertex. Abdomen reddish brown suffused with black.

Male.—Similar to the female, apex of abdomen hardly emarginate, abdomen mostly reddish.

Type-locality.—Richmond, Indiana.

Type.—Cat. No. 13339, U.S.N.M.

Webster No. 3363, bred from timothy, W. J. Phillips, collector, and No. 5103, same collector, Bureau of Entomology, U. S. Department of Agriculture.

Named for W. J. Phillips.

Genus CHELONUS (Jurine) Panzer.

CHELONUS SHOSHONEANORUM, new species.

Female.—Length 2.5 mm. Antennæ 16-jointed. Compared with the type of *C. lavernæ* Ashmead, its nearest or at least one of its closest relatives, it differs as follows: Reticulations of posterior half of dorsulum smaller than the foveæ at base of scutel, the latter without a row of foveæ or reticulations along the lateral margin, nearly smooth and polished; central area on dorsal aspect of propodeum nearly quadrate and with only one carina and this a median one extending from the anterior edge of the area to near the middle, posterior face of propodeum bounded above by a carina that is produced in four places into flattened tubercles much as in *Ascogaster carpocapsæ*, except that the median prolongations are nearer to each other than to the lateral prolongations; stigma fuscous, veins mostly infuscated, hind tibiæ almost entirely testaceous.

Type-locality.—Colorado Springs, Colorado.

Type.—Cat. No. 13340, U.S.N.M.

One specimen labeled Ex *Quercus*, April 2, 1910, E. Bethel, collector, and probably parasitic on *Argyresthia*, sp.

Genus APANTELES Foerster.

APANTELES (APANTELES) BETHELI, new species.

Female.—Length, 2.25 mm. Similar in many points to *A. canarsiæ* Ashmead, from the type of which it differs essentially as follows: Antennæ entirely black, palpi inclining to testaceous; tegulæ and wing base blackish, stigma and veins mostly more or less fuscous, mid legs mostly black or blackish, propodeum dullish, the septa forming the nearly complete areola supplemented on each side by an incomplete lateral longitudinal carina, which lies nearer the lateral edge of the propodeum than to the median carinæ; first dorsal plate twice or almost twice as long as wide in the middle, nearly as wide at apex as at base, gently arched, its apical two-thirds rugose throughout and dullish, its apical half divided longitudinally by an oval, shallow fossa that extends nearly to the apex, the greatest transverse width of this fossa is one-third or nearly one-third the width of the first dorsal plate at its apex, sides of the second plate forming a trapezoid that is twice as wide at base as long down the middle and nearly three times as wide at apex as long down the middle, second plate dullish rugulose and a little less than half as long as the next dorsal segment measured down the middle, third dorsal segment smooth, polished, and impunctate,

except for a few indistinct subapical punctures; abdomen almost entirely black, hypopygium buttress shaped, exerted portion of sheaths of the ovipositor linear, nearly parallel sided and as long as or nearly as long as the gaster above.

Male.—Answers the description of the opposite sex sufficiently well to be recognized thereby.

Type-locality.—Colorado Springs, Colorado.

Type.—Cat. No. 13341, U.S.N.M.

Presumably parasitic upon *Argyresthia*, sp. and labeled Ex *Quercus* April 2, 1910. E. Bethel, collector.

Three specimens, of which two are females. The female paratopotype has the lateral longitudinal carina apparently wanting, but replaced by an incomplete costula.

Named for the collector, E. Bethel.

Genus MICROGASTER Latreille.

MICROGASTER COMPTANÆ, new species.

Female.—2.5 mm. Clypeus not entirely separated from the face by a suture; propodeum coarsely rugose and with a distinct longitudinal median carina; second dorsal plate nearly parallel sided, almost four times as wide at apex as long down the middle, the latter distance one-half the similar distance on the first plate; these two plates uniformly and similarly irregularly reticulate and entirely black, the second plate uninterrupted longitudinally, but with an apical row of shallow foveæ; the succeeding plates or segments black, smooth, and polished; the third with a few punctures that are in most cases more than four or five puncture widths apart; the remaining segments apparently impunctate, ventral segments also black; coxæ black, rest of legs more or less stramineous to testaceous, the tarsi more or less fuscous.

Type-locality.—Rocky Ford, Colorado, "bred from *Ancylis comptana*, September 2, 1909, H. O. Marsh, collector, Chittenden No. 1537°," Bureau of Entomology, Washington, D. C.

Type.—Cat. No. 13342, U.S.N.M.

Genus HETEROSPILUS Haliday.

HETEROSPILUS MORDELLISTENÆ, new species.

Female.—2.5 mm. Related to (*Cænophanes*) *Heterospilus anthaxiæ* (Ashmead) from which it differs chiefly as follows: Head entirely black or blackish, head above distinctly transversely striate, in *anthaxiæ* there are striae, but these are so fine as to be easily overlooked with the aid of only a hand lens; pleuræ entirely dull, dorsulum with long conspicuous, whitish hairs along the notauli and where these meet; basal areas on propodeum dull, granular, collar and pleuræ

brownish in part; third dorsal segment completely fused with the second medially, its striæ extending nearer the posterior edge medially than laterally, striate portion of dorsal segments mostly brownish and dull, rest of dorsal segments polished and rather testaceous.

Male.—Similar to the female. Stigma in hind wings black.

Type-locality.—Wilmington, Ohio.

Type.—Cat. No. 13343, U.S.N.M.

The types bear the legends W. J. Phillips, collector, Webster, No. 6332, *Mordellistena ustulata* parasites 1910, and were received from the Bureau of Entomology, U. S. Department of Agriculture.

Genus HOROGENES Foerster.

LIMNERIUM (HOROGENES) DISCOOCELLELLÆ, new species.

Female.—Length, 4 mm. Agrees fairly well with the description of *Limnerium parva* Provancher, except as follows: The scape is brownish to yellow beneath, the pedicel is partly pale, the mandibles, fore coxæ, fore and mid trochanters and tegulæ are mostly yellow, mid coxæ mostly brown, hind tibiæ yellow except for a subbasal and an apical brown band, hind tarsi brown, more or less yellow at base, areolet sessile. The middle areolation in *L. discoocellellæ* consists of a basal area and an areopetiolarea.

Type-locality.—Washington, D. C., "bred Sept. 30, 1907, *Gelechia discoocellellæ*, Chittenden No. 154⁰¹, Chittenden collector, Bureau of Entomology, Washington, D. C."

Type.—Cat. No. 13344, U.S.N.M.

This species could also be referred to *Angitia* in Foerster's classification though there are no particulars given there as to the relative lengths of the hind tarsal joints in that genus.

Genus EXENTERUS Hartig.

Type.—*Exenterus oriolus* Hartig.

EXENTERUS LOPHYRI, new species.

Resembles *Picroscopus* as defined by Davis in wanting an areola.

Female.—Length 11 mm. Head mostly black ornamented with yellow as follows: Inner and outer orbital margin except above the eyes, the inner orbital margin produced below the antennal fossæ to near the middle line which latter is black as is the margin of the face adjoining the clypeus, the latter almost entirely yellow and nearly punctureless and polished, mandibles yellow except at base and apex where they are black, punctured, their punctures of unequal size and in some cases as many as four or five puncture widths apart palpi testaceous, the third and fifth joints of the *m. p.* subequal in length with each at least one and one-half times as long as the fourth joint,

pedicel entirely black; thorax black except for the following yellow ornaments: Anterior lateral edge of collar, anterior lateral edge of mesonotum and a transverse line on the mesopleura beneath the wings, yellow, posterior half of disk of scutel and disk of postscutel yellow, tegulae translucent brownish with a yellow spot, mesopleura with conspicuous nearly adjoining punctures with hardly any impunctate area above posteriorly, propodeum with the median longitudinal carinae represented but not quite attaining the middle of the sclerite, third lateral area more or less defined by carinae, fore and mid trochanters more or less black above, hind trochanters entirely black, hind femora mostly castaneous or reddish tipped with yellow and streaked with black, wings strongly brownish, region about the apex of the marginal cell darker than the rest of the wing, stigma and costa brownish, remaining veins appearing black or blackish except the submedian vein which is translucent, areolet nearly quadrate; dorsal segments with an apical yellow band of nearly equal width, the first segment with its yellow band undulate anteriorly, hypopygium yellow.

Type-locality.—Crawford, Nebraska.

Type.—Cat. No. 13345, U.S.N.M.

In describing this species comparison has been made with a specimen of *E. oriolus* Hartig in the U. S. National Museum and determined by O. Schmiedeknecht. In points not touched upon above this species is very similar to *E. oriolus* Hartig as represented by the specimen in question. In closing it needs only to be said that this new species was described from specimens reared June 10, 1910, by L. Bruner and M. H. Swenk from *Lophyrus townsendi* taken in the type-locality.

In the three paratypes there is additional yellow ornamentation, namely, an additional line on the collar and mesopleura, a spot beneath the hind wings and a spot on each side of the propodeum.

Genus PHYGADEUON Gravenhorst.

Type.—*Phygadeuon fumator* Gravenhorst.

PHYGADEUON (ÆNOPLEX) ARGEÆ, new species.

Female.—Length, 5.5 mm.; flagel 25-jointed, with each joint a little shorter than the one preceding, although beyond the middle they are more nearly equal to each other excepting the apical joint, which is nearly as long as the two preceding together, first joint nearly four times as long as wide at apex, antennae brownish throughout, head black, face dullish, indistinctly punctured, with whitish hairs, vertex, occiput and cheeks shining, punctured, clypeus transversely striated, impressed anteriorly, its middle third rather truncate or undulate truncate, mandibles mostly castaneous, their upper edge about half again as long as the width at base; palpi stramineous,

penultimate joint nearly two-thirds as long as the apical joint; thorax black, shining with more or less distinct punctures and inconspicuous whitish pubescence, furrow between scutellum and dorsulum traversed longitudinally by two rather distinct raised lines, notauli indistinct, almost wanting even anteriorly, propodeal spiracles perfectly round, third lateral area distinctly more than half as wide as long, not longitudinally divided by a carina, legs mostly brownish, the sutures and apical tarsal joints more or less testaceous; wings infuscated, transparent, stigma and most veins blackish, gaster mostly castaneous, base of petiole blackish, the latter with indistinct dorsal carinae, thyridia on second segment indistinct and nearly circular, exerted portion of sheaths of the ovipositor as long as or a little longer than the first segment.

Type-locality.—Marietta, Ohio.

Type.—Cat. No. 13346, U.S.N.M.

Reared from the cocoon of a species of (*Hylotoma*) *Arge* on elm, Hopk. U. S. 8635b. In describing this species numerous comparisons were made with the genotype of *Ænoplex*, namely, *Phygadeuon* (*Ænoplex*) *betulaecola* Ashmead.

Genus POLYTRIBAX Foerster.

PHYGADEUON (POLYTRIBAX) PALLESCENS, new species.

Male.—Length 10 mm. Shining, mostly pale fulvous, head and thorax beneath, palpi, and coxæ and trochanters of fore and mid legs more or less yellowish; antennæ 35-jointed, the joints of the flagel subequal, the first flagellar joint the longest and brown, the succeeding joints mostly or entirely black, scapes approximated so as to be faceted on the opposite sides, proportion of scape and pedicel normal; the basal area poorly separated from the areola by a more or less developed welt, the basal areas mostly open at base, just internal to the middle of the base of each first lateral area is a tubercle of about the same size as the tubercles on the anterior edge of the clypeus, tegulae yellowish, wings yellowish transparent, the veins and stigma brownish excepting the costa, which is mostly fulvous.

Type-locality.—Castle Rock, Pennsylvania, June 6, 1909, H. S. Harbeck, collector.

Type.—Cat. No. 13347, U.S.N.M.

A paratype from Montgomery County, Pennsylvania, May 30, 1897, C. W. Johnson collector, is but 7 mm. long and wants the welt between the basal area and the areola.

Since drawing up the above description I have received an additional male of this species reared from what appears to be a chrysalis

of *Hyphantria* and a female reared from the chrysalis of *Eudamus* (*Epargyreus*) *tityrus*, both from Enola, Pennsylvania, collected by H. Kirk and A. B. Champlain, March 27, 1909. The male emerged April 27, 1909, and the female May 5, 1909.

The female resembles the male. It is, however, noteworthy that in the female the sixth and twelfth joints of the flagel are either entirely or mostly yellow, the nipples on the anterior edge of the clypeus not so distinct, in fact quite rudimentary, and the areola is emarginate posteriorly. The sheaths of the ovipositor are approximately as long as the first dorsal segment of the abdomen.

Genus MESOCHORUS Gravenhorst.

MESOCHORUS PERNICIOSUS, new species.

Scutel typical in outline.

Female.—Length 5 mm.; face separated from the malar space as in the genotype, lower inner orbits not striate but punctured, the inner orbits with a yellow band extending nearly to the top of the eyes, malar space and most of mandibles yellow, clypeus yellowish, with a few punctures, rest of face translucent brownish as are the antennæ except beyond the middle where they are fuscous, tips of mandibles blackish, palpi ochreous, interocellar area and occiput blackish; pronotum without a median longitudinal carina, brownish, the posterior edge blackish and the tubercles yellowish, rest of thorax brownish variegated with black or blackish patches, tegulæ and base of wings yellowish, stigma mostly blackish, yellow at base, veins more or less brownish, transverse median vein almost interstitial, areolet petiolate, otherwise the venation is nearly as in the genotype, legs mostly brownish; median areas of propodeum separated from each other by distinct carinæ, basal area at least three times as long as wide at apex and nearly parallel sided, nearly half as long as the areola which is nearly as wide between the costulæ as from costulæ to base, costulæ joining the areola above the middle, petiolarea about twice as wide as the areola and nearly as wide as long, petiole nearly three times as long as at apex, gradually widened toward apex where it is nearly three times as wide as at base, smooth and polished, slightly depressed down the middle of the basal half of the region beyond an imaginary line drawn between the spiracles, first dorsal segment mostly blackish, second dorsal segment blackish except for the thyridia which are translucent brownish and apical margin which is more or less testaceous to yellowish, basal two-thirds of third dorsal segment translucent brownish, the rest of this segment and the remaining dorsal segments brownish stained with black, ventral fold more or less yellow, sheaths of the ovipositor not much longer than the hypopygium.

Type-locality.—Rocky Ford, Colorado.

Type.—Cat. No. 13348, U.S.N.M.

Additional data are: "Bred from *Loxostege sticticalis* April 29, 1910, H. O. Marsh, collector, Chittenden No. 1565." This is probably a hyperparasite of *Apanteles læviceps* Ashmead which was reared under the same conditions at the same time. The specimen was received from the Bureau of Entomology, U. S. Department of Agriculture.

THE RECENT AND FOSSIL MOLLUSKS OF THE GENUS ALABINA FROM THE WEST COAST OF AMERICA.

By PAUL BARTSCH,

Assistant Curator, Division of Mollusks, U. S. National Museum.

The first record that we find for *Alabina* on the west coast of America was made by Dr. P. P. Carpenter in the Report for the British Association for the Advancement of Science for 1863, published in 1864. Here he writes (page 612) that *Mesalia tenuisculpta*, n. s., occurs in shoal water at San Diego, and on page 655 of the same report he adds, "*Mesalia tenuisculpta*, n. s. Very small, slender, whorls rounded, lip waved, shoal water San Diego, Cp." (Cooper). This description is further supplemented by him in 1866 in the Proceedings of the California Academy of Natural Sciences, volume 3, page 216, where he gives a detailed description of the species and queries its position in the genus *Mesalia* by placing a question mark before it.

In the last paper (page 219) Doctor Carpenter also described *Styliferina turrita*, which is now referred to *Alabina*.

In 1894 Mr. Henry Hemphill published a description of *Eulimella occidentalis* in the fourth volume of *Zoe* (page 395). A fourth species was described by Doctor Dall and myself in the *Nautilus*, volume 15 (pages 58 and 59), in 1901 under the name of *Bittium (Elachista) californicum*.

Since the last was described a very large number of shell dredgings made by the U. S. Bureau of Fisheries steamer *Albatross* have been examined, which have yielded quite a number of additional species. Considerable work has also been done on the Tertiary faunas of the west coast, and these too have returned some interesting new forms, all of which are here described and figured.^a

^a In the preparation of the present diagnoses the following terminology is used:

"Axial sculpture," the markings which extend from the summit of the whorls toward the umbilicus.

The axial sculpture may be—

"Vertical," when the markings are in general parallelism with the axis of the shell.

"Protractive," when the markings slant forward from the preceding suture.

"Retractive," when the markings slant backward from the suture.

"Spiral sculpture," the markings following the directions of the coils of the whorls.

KEY TO THE GENUS ALABINA.

- Shell without sculpture.....*turrita*.
 Shell sculptured.
 Shell without axial sculpture (except lines of growth).
 Shell with a single spiral cord between the sutures.....*occidentalis*.
 Shell with five low, spiral cords between the sutures.....*barbarensis*.
 Shell with axial sculpture.
 Axial ribs strong.
 Spiral sculpture consisting of broad cords.
 Shell large; adult more than 6 mm. long.....*hamlini*.
 Shell small; adult less than 4 mm. long.....*phanea*.
 Spiral sculpture not consisting of broad cords.
 Spiral sculpture consisting of slender cords.
 Shell slender, conic.....*diomedea*.
 Shell stout, broadly conic.....*ignati*.
 Spiral sculpture consisting of incised lines.....*californica*.
 Axial ribs slender or obsolete.
 Axial ribs broad, but feebly developed.
 Spiral sculpture absent.....*io*.
 Spiral sculpture present.....*t. phalacra*.
 Axial ribs slender.
 Adult shell less than 5.5 mm. long.....*monicensis*.
 Adult shell more than 7 mm. long.
 Spiral sculpture obsolete between the sutures.....*tenuisculpta*.
 Spiral sculpture strong between the sutures.....*t. diegensis*.

ALABINA TURRITA Carpenter.

Plate 62, fig. 4.

Styliferina turrita CARPENTER, Proc. Cal. Acad. Nat. Sci., vol. 3, 1866, p. 219.

Shell small, elongate-conic, white. Nuclear whorls minute, apparently not differentiated from the remaining turns. Post-nuclear whorls strongly flattened, somewhat overhanging, separated by a deeply channeled suture, apparently without sculpture. Periphery and base of the last whorl well rounded. Aperture ovate, posterior angle acute, outer lip thin; columella short, moderately strong, slightly reflected.

Doctor Carpenter's type (Cat. no. 15566, U.S.N.M.), which has furnished this description and figure, has 8 whorls and measures: Length 1.7 mm., diameter 0.6 mm. It was collected by Doctor Cooper at San Pedro, California.

ALABINA OCCIDENTALIS Hemphill.

Plate 62, fig. 2.

Eulimella occidentalis HEMPHILL, Zoe, vol. 4, 1894, p. 395.

Shell elongate-conic, subdiaphanous. Nuclear whorls $1\frac{1}{2}$, small, well rounded, smooth. Post-nuclear whorls with a very strong, concavely sloping shoulder, which extends from the appressed summit over the posterior third of the whorls terminating there in a well

rounded keel. The shoulder is smooth, excepting fine lines of growth; the portion between the suture and the shoulder is well rounded, marked with lines of growth and 9 to 11 equal and equally spaced incised spiral lines. Sutures strongly constricted; periphery of the last whorl well rounded. Base moderately long, somewhat inflated, well rounded, narrowly umbilicated, marked by slender lines of growth and numerous fine spiral striations. Aperture very broadly ovate; posterior angle obtuse; outer lip thin, columella slender, slightly oblique, revolute.

The specimen described and figured (Cat. no. 127551, U.S.N.M.) is one of six which come from the Mud Flats, near San Diego, California. It has 9 whorls and measures: Length 3.1 mm., diameter 1 mm.

ALABINA BARBARENSIS, new species.

Plate 61, fig. 3.

Shell broadly conic, creamy yellow. (Nuclear whorls decollated.) Post-nuclear whorls flattened, appressed at the summit, marked by four slender, incised, spiral lines, which divide the space between the sutures into five equal, flat, cords; axial sculpture consisting of lines of growth only. Sutures strongly impressed. Periphery of the last whorl angulated. Base well rounded, marked by six spiral lines, which divide it into six cords, the posterior five of which are equal, the one about the umbilicus being wider than the rest. Aperture ovate, feebly channeled anteriorly. Posterior angle acute; outer lip thin at the edge; columella decidedly curved, oblique, strongly reflected over the reinforcing base; parietal wall covered with a thick callus.

The type (Cat. no. 203676, U.S.N.M.) and four specimens come from the Postpliocene of Santa Barbara, California. The type has 8 whorls and measures: Length 6.2 mm., diameter 2.8 mm.

ALABINA HAMLINI, new species.

Plate 61, fig. 2.

Shell elongate-conic, yellowish white. Greater part of the nuclear whorls decollated, the last turn only remaining, which is well rounded and smooth. The first two post-nuclear turns are strongly, slopingly shouldered, the remainder well rounded. All of them are marked between the sutures by four nodulose spiral cords, of which the third one below the summit is the largest, while the two posterior to it are of equal size, but smaller than the rest. The shoulder on the first two whorls extends from the third cord to the summit. In addition to the spiral cords, the whorls are marked by axial ribs, of which 14 occur upon the first and second, 16 upon the third, while upon the last they become somewhat irregular. The spaces inclosed

between the ribs and the spiral cords appear as squarish, well-impressed pits, while their intersections form low and well rounded nodules. Sutures strongly impressed; periphery of the last whorl marked by a shallow sulcus. Base well rounded, marked by a single low feeble cord immediately below the peripheral sulcus, which is almost as wide as the spiral cords between the sutures, and numerous lines of growth. Aperture ovate, slightly channeled anteriorly; posterior angle acute; outer lip thin at the edge; columella strong, decidedly curved and reflected over the reinforcing base; parietal wall covered with a thin callus.

The type and 19 specimens (Cat. no. 195216, U.S.N.M.) were collected in the Post-Pliocene deposits at Hallenbeck's Well, Los Angeles, California. The type has 6 post-nuclear whorls, and measures: Length 6.8 mm., diameter 2.5 mm.

Named for Mr. Homer Hamlin, the collector.

ALABINA PHANEA, new species.

Plate 62, fig. 6.

Shell elongate-conic, white excepting the nuclear whorls which are yellowish brown. Nuclear whorls small; the first one and one-half well rounded and smooth; the next two marked by two strong spiral keels, which divide the space between the sutures into three subequal parts. Post-nuclear whorls strongly, slopingly shouldered, ornamented with moderately strong, decidedly curved, axial ribs, of which 16 occur upon the first, 18 upon the second to fourth, 20 upon the fifth, 22 upon the sixth, and 18 upon the penultimate turn. In addition to these ribs, the whorls are marked by three broad, low, spiral cords, the weakest of which is at the summit, while the other two divide the space between the sutures into three equal portions. The intersections of the axial ribs and the spiral keels form strong tubercles which are truncated posteriorly and slope gently anteriorly. The two middle cords are much more strongly tuberculate than the one at the summit. The spaces inclosed between the axial ribs and the spiral cords are moderately impressed, squarish pits. Sutures strongly impressed. Periphery of the last whorl marked by a channel which is crossed by the continuations of the axial ribs that terminate at its anterior border. Base short, well rounded, ornamented with four rather broad, weak spiral cords. Aperture subquadrate, channeled anteriorly; posterior angle decidedly obtuse; outer lip thin, showing the external sculpture within; columella decidedly oblique, strongly revolute and somewhat twisted; parietal wall covered with a moderately thick callus.

The type and two specimens (Cat. no. 198924, U.S.N.M.) come from San Diego, California. The type has 8 post-nuclear whorls, and measures: Length 3.6 mm., diameter 1.1 mm.

ALABINA DIOMEDEÆ, new species.

Plate 62, fig. 1.

Shell elongate-conic, wax yellow. Nuclear whorls 3, small, decidedly rounded, smooth. Post-nuclear whorls well rounded with a slender sloping shoulder which extends from the summit to the middle of the whorls, where it is bounded by a strong, median spiral keel. There are two other keels upon the whorls between the sutures, one a little less strong and a little nearer the suture than the median, and another a little nearer the summit than the median; the latter being the weakest of the three. In addition to the spiral cords, the whorls are marked by numerous very fine, spiral striations and well rounded, slender, curved, axial riblets, of which 24 occur upon all but the last two turns, which have 26. In addition to the axial riblets there are numerous fine lines of growth. The intersections of the axial ribs and the spiral cords are slightly nodulose. The spaces inclosed between them are impressed rectangular pits. Periphery of the last whorl marked by a sulcus. Base moderately long, well rounded, marked by five spiral cords which are equally spaced, but grow successively weaker from the periphery to the umbilical area. Aperture broadly ovate, somewhat effuse anteriorly; posterior angle obtuse; outer lip thin, showing the external sculpture within; columella slender, decidedly curved, very slightly revolute; parietal wall glazed with a thin callus.

The type has 8 post-nuclear whorls, and measures: Length 4.7 mm., diameter 1.7 mm. It and 2,398 specimens were dredged at U. S. Bureau of Fisheries station 2823 in 26½ fathoms, on broken shell bottom off Cacachitas, Gulf of California. They are entered as Cat. no. 96705, U.S.N.M. Cat. no. 96710, U.S.N.M., contains 173 specimens dredged at station 2822 in 21 fathoms, on coral sand and broken shell bottom in the Gulf of California. Cat. no. 151950, U.S.N.M., contains 910 specimens dredged at U. S. Bureau of Fisheries stations 2826 to 2828 in 9½ to 10 fathoms, on shell bottom, near La Paz, Gulf of California.

ALABINA IGNATI, new species.

Plate 62, fig. 3.

Shell elongate conic. Early whorls bright, light chestnut brown, later wax yellow. Nuclear whorls 3, small, strongly rounded, smooth; post-nuclear whorls with a strong, sloping shoulder which extends from the summit to the middle of the whorl; marked by 4 spiral keels of which the strongest is on the middle of the whorl, the next stronger about half way between the suture and the median, and the next half between the median and the summit, the fourth remaining a slen-

der thread at the summit. In addition to these spiral cords, the whorls are marked by well-rounded, slender, somewhat retractive axial riblets, which, like the spiral sculpture, become obsolete on the last volution. Of these riblets, 22 appear upon the second and third, 24 upon the fourth and fifth, and about 40 upon the last volution. Sutures constricted; periphery of the last whorl marked by a broad, shallow sulcus. Base somewhat inflated, well rounded, marked by 6 low, rounded, subequal and subequally spaced spiral keels. Anterior portion of the base surrounding the umbilical area smooth, excepting slender lines of growth. Aperture broadly ovate, somewhat effuse anteriorly; posterior angle acute; outer lip thin, showing the external sculpture within; columella slender, strongly curved, and very slightly revolute.

The type (Cat. no. 105515, U.S.N.M.) has 7 post-nuclear whorls, and measures: Length 4 mm., diameter 1.7 mm. It comes from San Ignacio Lagoon, Lower California.

ALABINA CALIFORNICA Dall and Bartsch.

Plate 62, fig. 7.

Bittium (Elachista) californicum DALL and BARTSCH, Nautilus, vol. 15, 1901, pp. 58-59.

Shell elongate-conic, yellowish white. Nuclear whorls $2\frac{1}{10}$, moderately rounded, smooth. Post-nuclear whorls strongly rounded, somewhat inflated, appressed at the summit, marked by broad, low, strong, protractive axial ribs of which 14 occur upon the first to third, 16 upon the fourth, and 18 upon the penultimate whorl. In addition to the axial ribs, the whorls are marked on the spire by three feebly impressed, spiral lines which pass over the ribs as well as the broad, intercostal spaces. The middle one of these three lines is halfway between the sutures. The other two divide the space anterior and posterior to it into equal halves. Sutures strongly constricted. Periphery and base of the last whorl well rounded, smooth, excepting faint lines of growth. Aperture broadly ovate; posterior angle acute; outer lip thin; columella short, moderately strong, strongly curved and slightly reflected over the reinforcing base.

The type has 8 whorls and measures: Length 5.3 mm., diameter 2.2 mm. It is one of 7 specimens (Cat. no. 162548, U.S.N.M.) and came from Dead Man's Island, San Pedro, California. Cat. no. 162547, U.S.N.M., one specimen, came from the Lower San Pedro Series, Dead Man's Island, California; and Cat. no. 195215, U.S.N.M., 75 specimens, came from the same locality.

ALABINA IO, new species.

Plate 61, fig. 1.

Shell conic, white. Nuclear whorls small, well rounded. Post-nuclear whorls well rounded, appressed at the summit, marked by rather broad, low, obsolete, retractive ribs, of which 18 occur upon the fourth and fifth, and 20 upon the penultimate turn. Sutures strongly constricted. Periphery of the last whorl well rounded. Base moderately long, well rounded. Aperture oval; posterior angle obtuse; outer lip thin; columella short, slightly revolute, and reinforced by the base.

The type (Cat. no. 148669, U.S.N.M.) comes from the Post Pliocene beds of San Diego, California. It has 7 post-nuclear whorls and measures: Length 6 mm., diameter 2.3 mm.

ALABINA MONICENSIS, new species.

Plate 62, fig. 5.

Shell small, white. Nuclear whorls partly decollated, those remaining, well rounded, without apparent sculpture. Post-nuclear whorls well rounded, appressed at the summit, separated by constricted sutures, marked by numerous raised axial threads and 7 subequally spaced, low broad spiral cords between the sutures. Periphery of the last whorl well rounded. Base moderately long, well rounded, marked like the spire. Aperture broadly ovate; outer lip thin; columella slender, decidedly curved, reflected slightly over the base; parietal wall glazed with a thin callus.

The type (Cat. no. 195217, U.S.N.M.) has 8 whorls remaining and measures: Length 5 mm., diameter 1.7 mm. It comes from the Upper San Pedro Series at Santa Monica, California.

ALABINA TENUISCULPTA Carpenter.

Plate 61, fig. 6.

Mesalia tenuisculpta CARPENTER, Rep. Brit. Ass. Adv. Sci. for 1863, 1864, pp. 612 and 655.—? *Mesalia tenuisculpta* CARPENTER, Proc. Cal. Acad. Nat. Sci., vol. 3, 1866, p. 216.

Shell acicular, light chestnut brown. Nuclear whorls very small, $2\frac{1}{2}$, increasing regularly in size, well rounded. Post-nuclear whorls with a strong, very wide, sloping shoulder which extends over the posterior half of the whorls between the sutures; and is bounded at the summit by a slender spiral thread. The first five post-nuclear turns have a strong, median, spiral cord and a second as strong as the median, about halfway between the suture and the median cord. Midway between these two, a slender spiral thread can be seen on the third to the sixth whorl. On the last three

whorls the median cord is almost completely lost, while the one above the sutural line retains its strength. On these three whorls additional fine spiral lines make their appearance. The axial sculpture consists of fine lines of growth only. Sutures weakly channeled. Periphery and base of the last whorl well rounded, marked by eight subequal and subequally spaced, spiral keels and fine lines of growth. The space immediately surrounding the umbilical area has no spiral sculpture. Aperture broadly ovate; posterior angle obtuse; outer lip thin; columella slender, decidedly curved and slightly reflected over the narrow umbilicus; parietal wall glazed with a thin callus.

Doctor Carpenter's type (Cat. no. 40933, U.S.N.M.) was collected by Dr. J. G. Cooper at San Diego, California. It has 9 post-nuclear whorls and measures: Length 7.2 mm., diameter 2.4 mm. Two additional lots are in the U.S.N.M., Cat. no. 195218 (1 specimen) from San Pedro, California, and Cat. no. 160095a (1 specimen) from San Diego, California.

ALABINA TENUISCUPTA DIEGENSIS, new subspecies.

Plate 61, fig. 4.

Shell elongate-conic, chestnut brown, excepting the extreme apex and the last volution, which are paler. Nuclear, whorls 3, small, increasing regularly in size, well rounded, without sculpture. The early post-nuclear whorls have a decidedly sloping shoulder which extends from the middle to the whorls, between the sutures to the summit. This shoulder is marked on the first whorl by a single cord that limits it anteriorly, on the second by an additional cord, which divides the shoulder in two equal halves, while on the third, two additional cords a little less strong than the other two divide the space between the summit and the first cord, and the space between the next two cords into equal halves. The sculpture on the anterior half of the whorls between the suture consists of a single cord on the first and second, which is halfway between the median cord and the suture. On the third, an additional cord a little less strong appears between the two. This cord becomes equal in strength to the other two on the succeeding turns. The space between the suture and the first supra-sutural cord remains plain, barring exceedingly fine microscopic spiral striations and is as wide as the space between this cord and the median cord. In addition to the spiral sculpture, the whorls are marked by very many irregular decidedly curved and regularly distributed axial riblets, which render their intersections with the spiral cords very weakly nodulose. The summits of the whorls are roundly shouldered and make the sutures appear constricted. Periphery and base of the last whorl somewhat inflated, well rounded, the latter marked by seven equal and equally spaced, low, rounded, spiral cords and feeble axial threads. The space

immediately surrounding the umbilical area is free from all spiral sculpture. Aperture very broadly ovate; outer lip thin, showing the external sculpture within; columella slender, strongly curved and slightly revolute; parietal wall glazed with a thin callus.

The type (Cat. no. 195219, U.S.N.M.) comes from San Pedro, California, and has 8 post-nuclear whorls and measures: Length 7.5 mm., diameter 2.7 mm.

Specimens examined.

Catalogue number.	Locality.	Number of specimens.
195219	San Pedro Bay, California.....	2
191578	Terminal Island, California.....	41
32205	San Diego, California.....	26
56449	do.....	3
109368	do.....	1
160095	do.....	2
198585	do.....	1
198589	do.....	1
206667	United States Bureau of Fisheries, station 3568, San Diego Bay, California (4 fathoms, hard, broken shell bottom).....	1
213010	United States Bureau of Fisheries, station 3573, San Diego Bay, California (1½ fathoms, mud and sand bottom).....	24
213011	United States Bureau of Fisheries, station 3572, San Diego Bay, California (2 fathoms, mud and sand bottom).....	5
195220	Southern California.....	11
212035	United States Bureau of Fisheries, station 3564, San Diego Bay, California (5 fathoms, sand, mud, and shell bottom).....	3
212036	United States Bureau of Fisheries, station 3566, San Diego Bay, California (3 fathoms, sand and shell bottom).....	57

ALABINA TENUISCULPTA PHALACRA, new subspecies.

Plate 61, fig. 5.

Shell broadly elongate-conic, light chestnut brown. Nuclear whorls $2\frac{1}{2}$, small, increasing regularly in size, smooth. Post-nuclear whorls slightly shouldered at the summit, marked by slender, axial ribs, of which 18 occur upon the first to fourth, 20 upon the fifth and sixth, and 24 upon the penultimate turn. Upon the early whorls the ribs are almost vertical; on the last two they are decidedly retractive. Here also they are less regular. In addition to the axial ribs, the whorls are marked by three obsolete spiral cords, of which one is median, another a little nearer to the median cord than the summit, and the third about halfway between the median and the suture. Periphery and base of the last whorl inflated, the latter narrowly umbilical, marked by five subequal subobsolete cords. The space immediately about the umbilical area is smooth. Aperture very broadly ovate; posterior angle obtuse; outer lip thin, showing the external sculpture within; columella slender, curved, and slightly revolute; parietal wall glazed with a thin callus.

The type and another specimen (Cat. no. 32205a, U.S.N.M.) come from San Diego. The type has 8 post-nuclear whorls, and measures: Length, 7.5 mm.; diameter, 3 mm.

EXPLANATION OF PLATES.

PLATE 61.

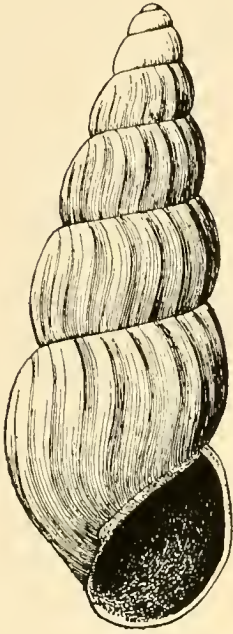
All figures on this plate are enlarged 10 times.

- FIG. 1. *Alabina io*.
2. *Alabina hamlini*.
3. *Alabina barbarentis*.
4. *Alabina tenuisculpta dicgensis*.
5. *Alabina tenuisculpta phalacra*.
6. *Alabina tenuisculpta*.

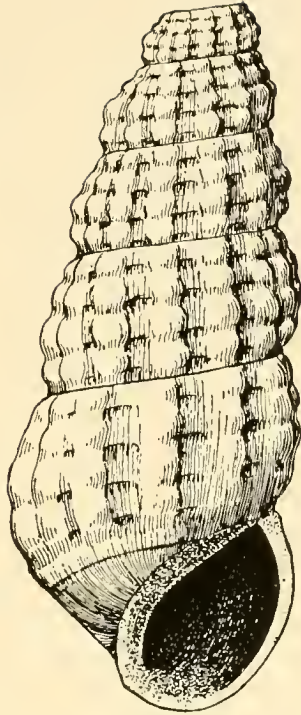
PLATE 62.

All figures on this plate excepting No. 4 are enlarged 12.5 times. No. 4 is enlarged 22.5 times.

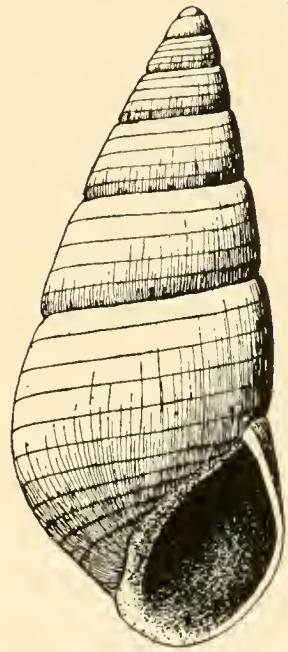
- FIG. 1. *Alabina diomedææ*.
2. *Alabina occidentalis*.
3. *Alabina ignati*.
4. *Alabina turrita*.
5. *Alabina monicensis*.
6. *Alabina phanca*.
7. *Alabina californica*.



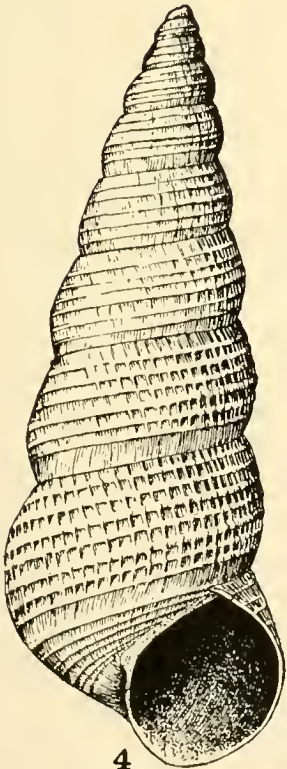
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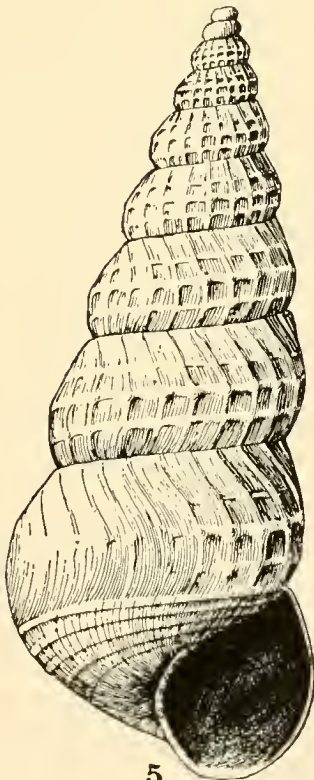
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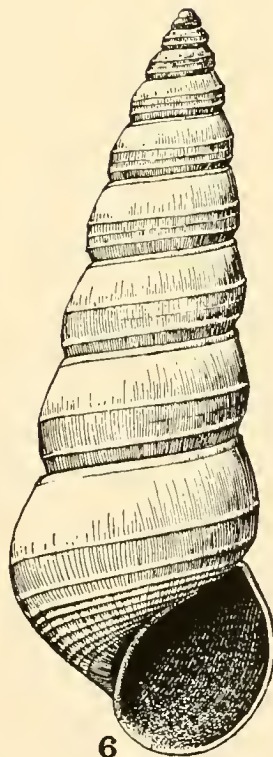
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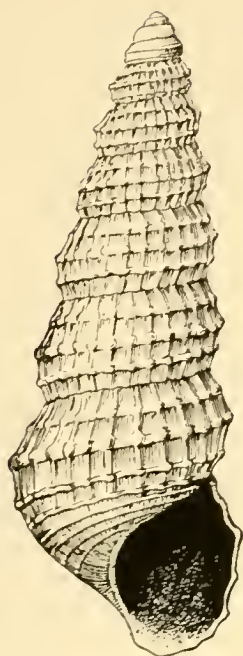
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ALABINA FROM THE WEST COAST OF AMERICA.

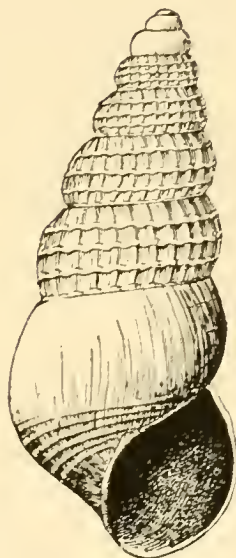
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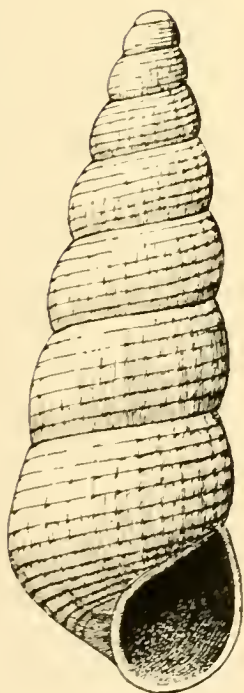
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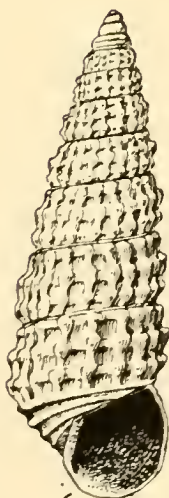
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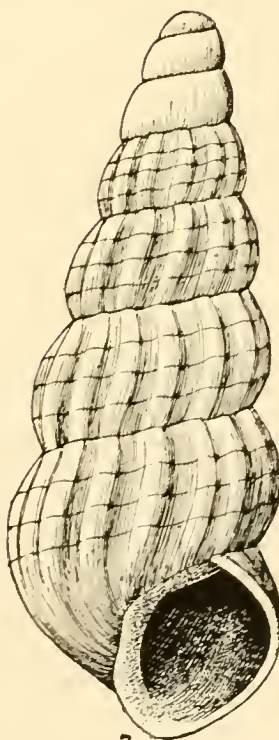
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ALABINA FROM THE WEST COAST OF AMERICA.

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SPERM TRANSFER IN CERTAIN DECAPODS.

By E. A. ANDREWS,

Of the Johns Hopkins University, Baltimore.

Among the Crustacea it is common for the sperm to emerge from the males enveloped in more or less secretion from the deferent ducts. Thus are formed sperm masses, which are enveloped by secreted coverings; these are transferred to the females by the aid of special appendages and constitute the "spermatophores." These spermatophores are received by the females chiefly in three ways—either the spermatophores are fastened merely upon the outside of the shell or they are directly introduced into the oviducts, or they are placed within some special spermatheca or receptacle not used for any other purpose. This latter case, the employment of a spermatheca, is rare, but it is especially deserving of study and explanation.

While the crayfish of the genus *Astacus* applies spermatophores over the surface of the shell of the female, the crayfish of the genus *Cambarus* fills a special receptacle within which the sperm may lie dormant for months. In the lobster there is a similar receptacle, but it is a space between elevations of the shell, while the receptacle in *Cambarus* is a pit within the shell.

A peculiar receptacle known as the "thelycum" is found in certain prawns, the Peneidæ. Outside these few decapods a receptacle is known in the remarkable mountain shrimp of that group of primitive Eumalacostraca, the Anaspidacea.

To Dr. W. T. Calman belongs the credit of pointing out the importance a comparative study of these organs may have in the proper classification of the Crustacea. Any additional cases of the occurrence of such median spermatheca would be welcome, but their great importance should make one very critical in asserting to their reality. In his recent account of the Anaspidacea, Geoffrey Smith has described a like receptacle in the deep-sea prawns of the group Eryonidea, and asserted the fundamental nature of this spermatheca as a decapod character.

It is the object of the present paper to describe the sperm receptacle in certain of the Peneidæ, and further to show how very doubtful is the existence of any spermatheca in the Eryonidea.

Just as the "annulus ventralis" of the female and the specialized pleopods of the male *Cambarus* were well known as specific characters before it was known that both these sets of organs were essential as sperm receptacles and organs to fill the receptacles, so also in the prawns of the family Peneidæ it was well known that the females possessed remarkable structures, called the thelyca, and the males peculiar united appendages, the petasma, before it was known that here also we have useful receptacles and transferers of sperm.

The following description will show what the thelycum is in three of these prawns, with reference to its use as a sperm receptacle.

In *Peneus setiferus* (Linnæus), *P. brasiliensis* (Latreille), and *Parapeneus constrictus* (Stimpson) the thelycum is found to be a more or less simple cavity on the ventral surface of the thorax between the fourth and the fifth pairs of legs, made by anterior and posterior scales or elevations of the shell that inclose the sperm-containing space. The posterior outgrowth from the sternum of the fifth legs is more or less divided into right and left lobes, and it grows forward to overlap the anterior outgrowth which extends back from the sternal region between the fourth legs.

In specimens of *Peneus setiferus* obtained in March at New Orleans, Louisiana, when small, as well as in large specimens up to 180 mm. in length obtained in April at Hampton, Virginia, and in the Baltimore markets in November, the thelycum is so simple as to suggest immaturity, yet the presence of mature sperm in the April males along with minute young eggs in the females suggests that the males may have been about ready to transfer the sperm to the thelycum, where it would await the maturing of the eggs.

Figure 1 shows part of the underside of a female with the third, fourth, and fifth left legs removed from the left side. The oval opening of the oviduct is represented upon the base of the third right leg. Between the fifth legs two scales (*Sc*) with a wide groove between them project forward over a depressed area. These scales may be regarded as arising from a common transverse plate some 3 mm. wide. Each scale is some 1.5 mm. long, and its anterior edge is very abrupt, as seen in the lengthwise section, fig. 2 (*Sc*).

The depressed area anterior to the scales is partly overhung by a wide shelf, figs. 1 and 2 (*S*), which is somewhat bilobed and has its posterior overhanging part decidedly bent toward the general shell of the sternal region, so that there is formed a concealed recess in which dirt frequently collects. Several specimens have dark, necrotic areas on the shelf, as if the results of injury (possibly in conjugation?). In the November specimens curious remains of minute organisms, apparently stalked protozoa, are found attached to the shell under the above-mentioned shelf. The shelf is depressed right and left, so that its middle stands up as a rounded boss, fig. 1 (*S*).

The depressed area between the scales and the shelf is especially hollowed out in a rounded area some 2 mm. wide on the median line under the shelf and continuing back from that; the shelf being 3 mm. wide, but overhanging only 1 mm. The posterior edge of this central pit or saucer is shown as a break in the shell line in fig. 2 between the

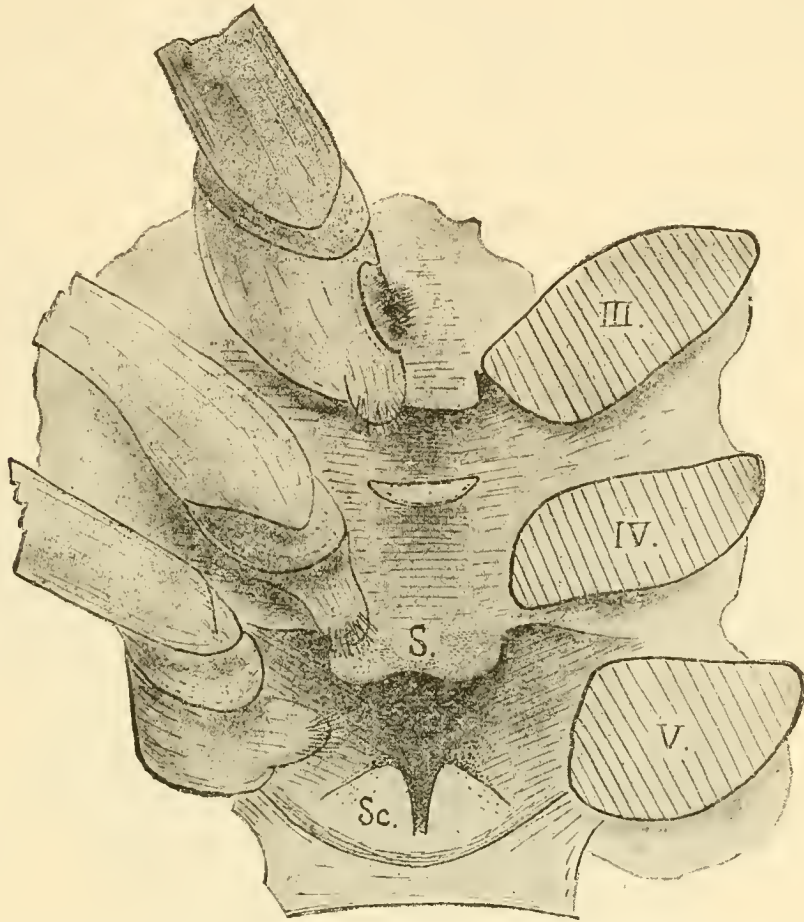


FIG. 1.—PART OF VENTRAL SIDE OF THORAX OF *PENEUS SETIFERUS* WITH BASES OF LEGS III, IV, V, S, SHELF; Sc, SCALES, FORMING BOUNDARIES OF THE SIMPLE THELYCUM.

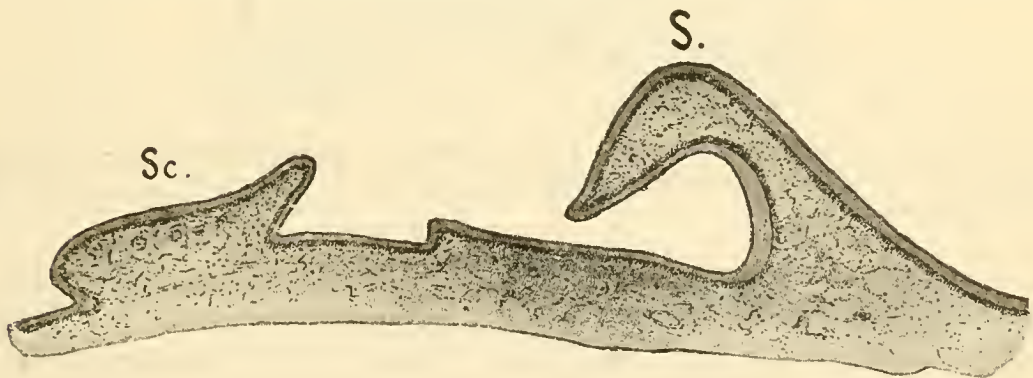


FIG. 2.—LONGITUDINAL MEDIAN SECTION OF THELYCUM OF *PENEUS SETIFERUS*, VENTRAL SURFACE ABOVE. S, SHELF; Sc, SCALE.

shelf (S) and the scales (Sc). The depressed saucer is bounded on the sides by faint ridges which tend to meet one another posteriorly as the rim of the saucer, causing the above change of level in the shell as seen in section.

In the males there is neither shelf nor scales, but there is a pronounced median keel along the area that is depressed in the female. Some faint suggestion of such a keel is seen in the female also.

If this thelycum is complete in this state, we may suppose the more important part is the overhanging shelf under which the sperm might be deposited, while the scales might have merely the value of hold-fasts for the petasma of the male. However, nothing was found out as to the mode of functioning in this species.

A second species, *Peneus brasiliensis*, has a similar thelycum with sperm within it.

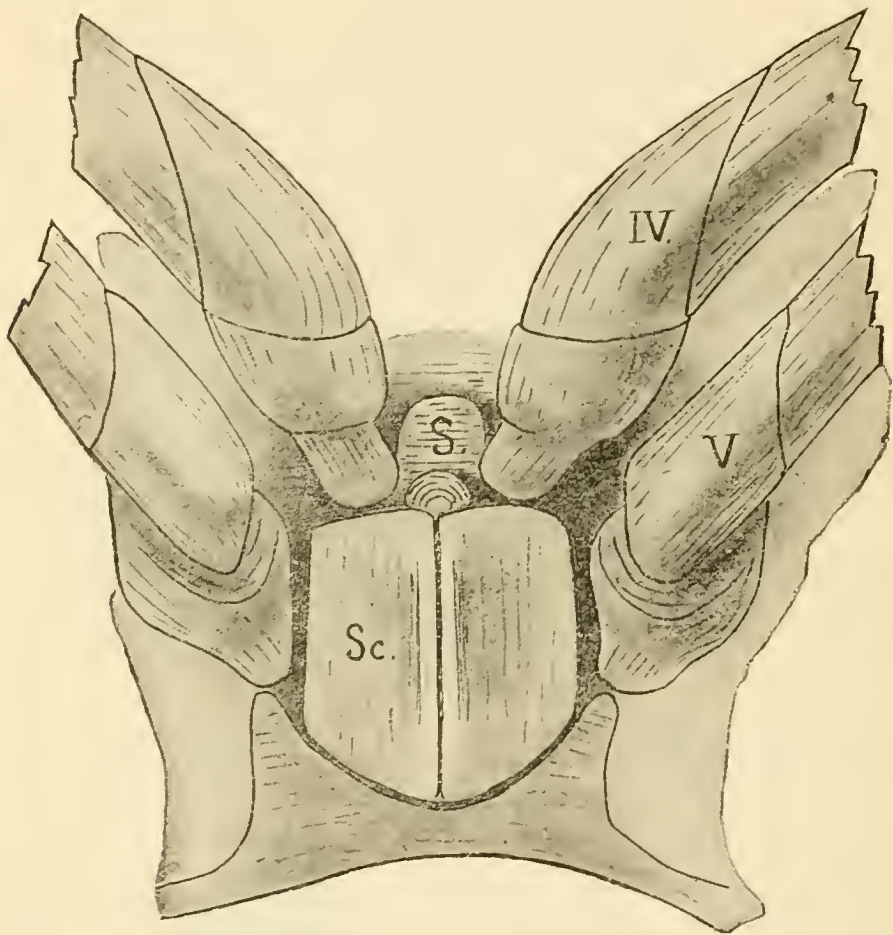


FIG. 3.—SURFACE VIEW OF THELYCUM AND ADJACENT PARTS OF THORAX OF *PENEUS BRASILIENSIS*. IV AND V BASES OF LEFT FOURTH AND FIFTH THORACIC LEGS; S, BASE OF SHELF-BEARING SPINE; Sc, CLOSED SCALE.

In large specimens, 110 mm. long, fig. 3, there is a shelf and two scales to form the thelycum, but the proportions are very different from what they are in *P. setiferus*. The shelf (S) is largely concealed by the scales (Sc) which run forward like two great doors, leaving only the median boss of the shelf showing between the fourth legs, while all the depressed region is overarched and concealed. However, in young specimens 60 mm. long the two scales are very widely separated along the median line, and anteriorly they cover the shelf only at its sides, so that the shelf appears not only as a high boss that runs back as a spine between the scales, but also as

two lateral lobes, one of which runs back under the anterior part of each scale.

A cross section between the fifth legs in one of the young females, fig. 4, shows the scales as thick outgrowths of the shell arising from the body at the sides and overarching a wide space, but not meeting one another at the middle line. The young individual is thus intermediate between the adults of *P. setiferus* and *P. brasiliensis* in having the scales much more extensive than in the former and much less so than the latter.

When the spermatophoral mass is present within the thelycum, the internal relations of the organ are more complex and less easy to understand, since parts of the sperm envelope may be mistaken for parts of the thelycum. When the scales were dissected off from museum specimens, the secreted mass that incloses the sperm was seen as a large flat bag-like mass stuck to the shelf as if a part of it. The scales themselves were thick fleshy plates, fig. 4, hollowed out

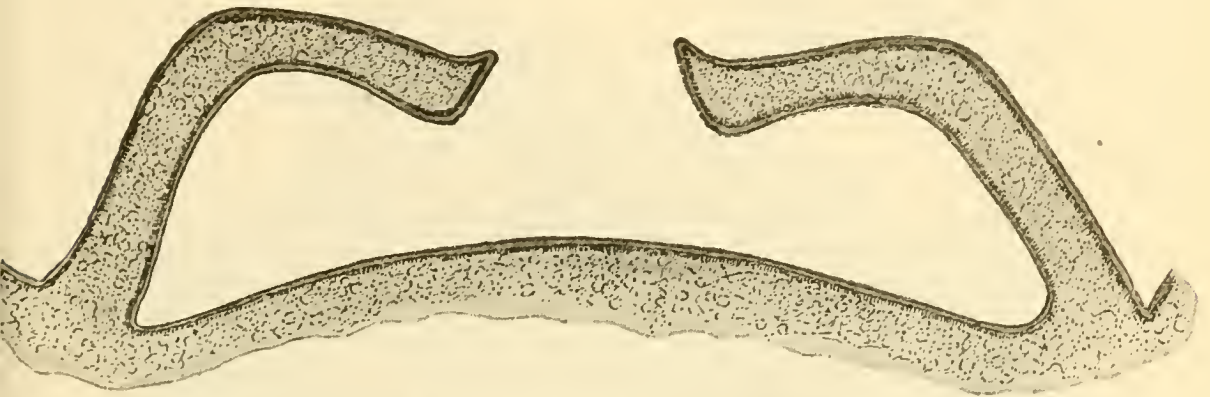


FIG. 4.—CROSS SECTION OF THELYCUM OF A YOUNG *PENEUS BRASILIENSIS*, SHOWING SCALES RIGHT AND LEFT.

on their dorsal faces to receive corresponding elevations of the spermatophoral mass. The edges of the plates are flattened where they join one another.

The entire shelf is somewhat Y-shaped; each lateral part has a deep groove to receive the downward bent anterior edge of the scale, so that the space inclosed by the scales is very tightly shut off from the external water. In the lengthwise section, fig. 5, this groove on the scale (*S*) is seen with the edge of the scale (*Sc*) resting in it. The space inclosed by the overarching shelf and the overgrown scales is filled by the spermatophoral mass. This consists of a secretion that breaks into thick lamellæ in the preserved specimen and which incloses the sperm, indicated by the dark central mass.

The entire spermatophoral mass has a marked median keel between the right and left scales and a large right and a left wing. The inclosed sperm is chalky white before staining and is completely enveloped by the secreted mass, so that it would be well cut off from the water as well as entirely concealed within the spermatheca or

space between the scales and shelf of this thelycum. The sperm consists of innumerable minute spheroidal cells, each showing a large refractive body.

The important fact is thus established that a large mass of spermatozoa is contained within the thelycum much as sperm is contained in the annulus ventralis of *Cambarus*. How this is introduced is at present conjectural, though the anatomy of the petasma of the male leaves little doubt that this compound organ transfers the sperm. The way the secreted mass fills the cavity of the thelycum indicates that it is run in when soft and subsequently "sets" more or less. The place of entry is doubtless the posterior part of the slit between the scales, for series of cross sections show that here the secreted mass comes to the surface as a fine narrow edge. In life there may have been a continuation of the spermatophoral mass through this cleft into the outside water, which might represent the mass described by Spence Bate in other species.

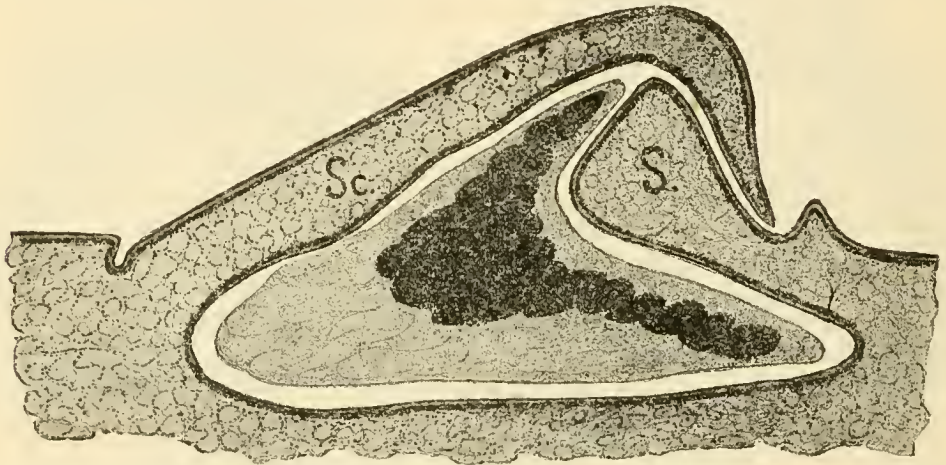


FIG. 5.—LONGITUDINAL SECTION OF THELYCUM OF A MATURE *PENEUS BRASILIENSIS*, SHOWING THE DARKLY STAINED SPERM ENVELOPED IN A LIGHT SECRETED MASS AND ENCLOSED BY THE SCALES (Sc) OVERLAPPING THE SHELF (S).

But this raises the question, how far are these sperm-containing secreted masses within the thelycum to be regarded as spermatophores?

If a spermatophore is a bag or receptacle of secreted matter that is fashioned by the male and then transferred with little change to the female, the mass that fills the thelycum in *P. brasiliensis* can scarcely be regarded as a true spermatophore, though it is doubtless of the same essential nature. As the mass is some 4 mm. wide, 6 mm. long, and 3 mm. deep in a female 110 mm. long, and as it fills all the cavity of the thelycum as if run in when essentially flowing or liquid, it would appear more like a secretion of the male deferent duct conducted by the petasma than a true preformed spermatophore formed and to some extent made firm within the male duct and then merely manipulated by the petasma. Better

preservation of material would be necessary to decide how far the mass about the sperm was run in against the shell as a liquid or in how far it existed outside the thelycum as a spermatophore with its walls already formed.^a

In a third prawn, *Parapenæus constrictus* Stimpson, specimens 65 mm. long present a thelycum as figured in figure 6. The scales are here evidently an anterior continuation of a transverse plate between the fifth legs. The shelf (*S*) passing back from between the fourth legs disappears under the scales.

In this figure of the female the right first pleopod is included to show the minute endopodite. In the male the region of the thelycum of the female is occupied by two ridges:

A transverse ridge between the fourth legs in place of the female shelf and a longitudinal ridge, expanding as a T-shaped mass, representing the scales of the female.

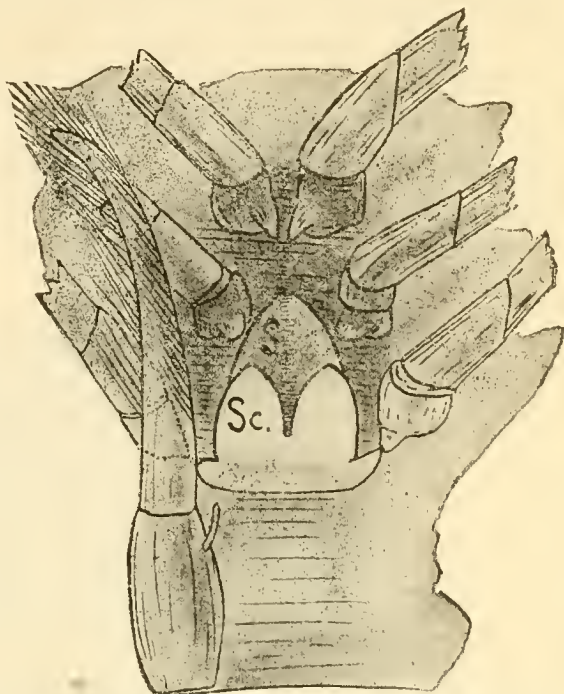


FIG. 6.—PART OF VENTRAL SIDE OF THORAX OF PARAPENÆUS CONSTRICTUS, SHOWING BASES OF LEGS, ONE OF THE FIRST PLEOPODS, AND THE SCALES (*Sc*) AND SHELF (*S*) OF THE THELYCUM.

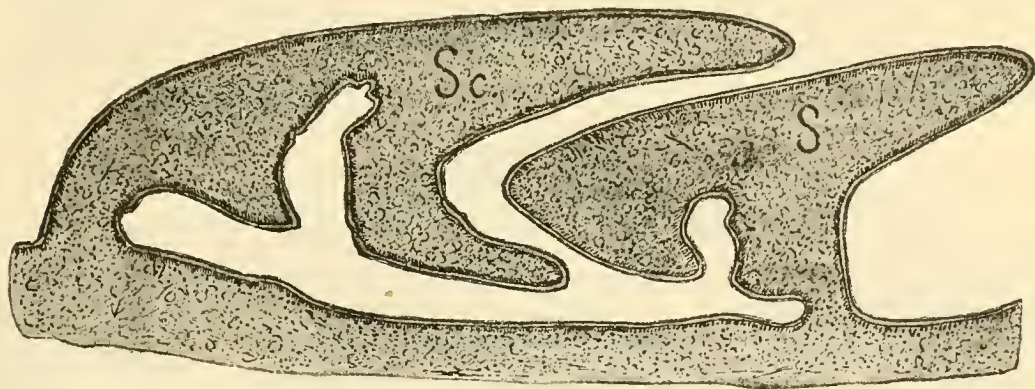


FIG. 7.—LONGITUDINAL, LATERAL SECTION OF THELYCUM OF PARAPENÆUS CONSTRICTUS. *S*, SHELF AND *Sc*, SCALE; OVERHANGING A BRANCHED CAVITY.

Returning to the female thelycum, it may be noted that the scales and the shelf are both sparsely covered with short bristle-like setæ.

^a Five specimens obtained alive at Montego Bay, Jamaica, Aug. 22, 1910, measured 90, 100, 120, 120, 160 mm., and each possessed a well-formed thelycum. The scales were translucent enough to show the curved sperm mass under each and soft enough to be readily separated by forceps so that the male might introduce a large spermatophore. When dissected the sperm was in a bag on each side which had a stiff lateral edge and might well be formed in the petasma. The shelf projected into the thelycum as a median and two lateral spines. The sperms were spheroidal, with one stiff process. In one specimen a soft gelatinous mass projected from under the scales forward over the shelf some distance into the water.

The internal anatomy of this seemingly simple thelycum is unexpectedly complex. While in a median longitudinal section the shelf is seen to pass down into the general level without overhanging and to be covered over by the scales with but a small simple cavity between, yet in a section to one side of the median line, fig. 7, we find the shelf overhangs posteriorly a space which is continued both forward and backward to end in branching chambers. In cross sections these chambers (figs. 8, 9, and 10) are repeated right and left. In

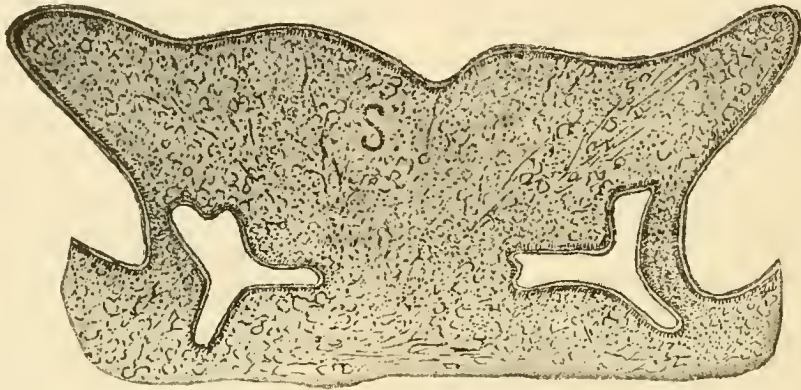


FIG. 8.—CROSS SECTION OF ANTERIOR PART OF THELYCUM OF *PARAPENEUS CONSTRICTUS*, SHOWING THE SHELF (*S*) PENETRATED BY LATERAL CAVITIES RIGHT AND LEFT.

fig. 8, which is across the anterior part of the shelf, the chambers are two large separate cavities in the substance of the shelf. Each has its horizontal and vertical portion, and each leads back in other sections to the common narrow cavity between the shelf and the scales. Again the section, fig. 9, through the posterior part of the scales shows two large cavities hollowed out in the substance of the scale plate and expanding as horizontal and vertical portions. These

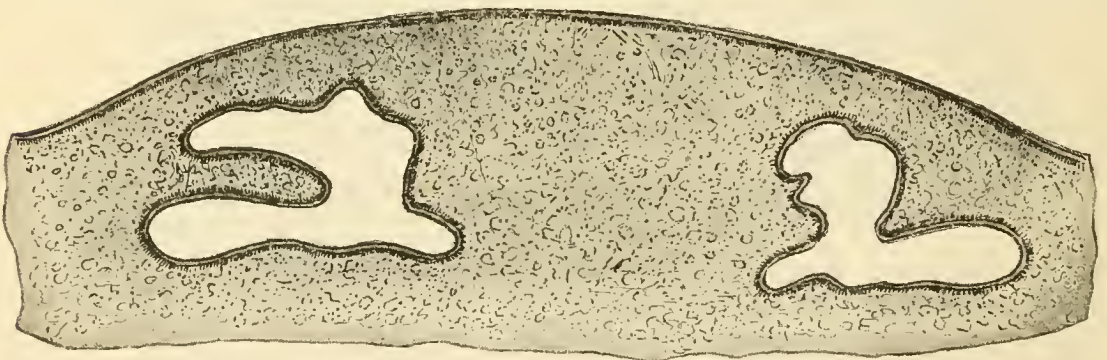


FIG. 9.—CROSS SECTION POSTERIOR TO THAT SHOWN IN FIG. 8.

chambers run forward to open into the common median cavity, as shown in fig. 10, which is cut across the middle of the thelycum and shows the two scales (*Sc*) overarching the shelf (*S*); the space between the shelf and scales passes on each side as a tube to expand as the chambers seen in fig. 9. The entire cavity into which the sperm mass might be thrust in under the scales is thus seen to be somewhat H-shaped, with the anterior horns converging and branched in the

substance of the shelf while its posterior horns diverge widely and branch in the substance of the scale plate. The middle of the H-shaped cavity is also somewhat prolonged posteriorly between the beginnings of the posterior horns.

No specimens were found with sperm in the thelycum, but its structure seems well adapted to hold sperm masses.

The above fragmentary observations suffice to show that in some of these prawns, the Peneidæ, the thelycum is used as a spermatheca and that it is morphologically a space inclosed more or less by outgrowths from the shell.

Turning now to another group of Decapods, the Eryonidea, in which a spermatheca is said to occur, we find in specimens in the collections of the U. S. National Museum no sign of a spermatheca,

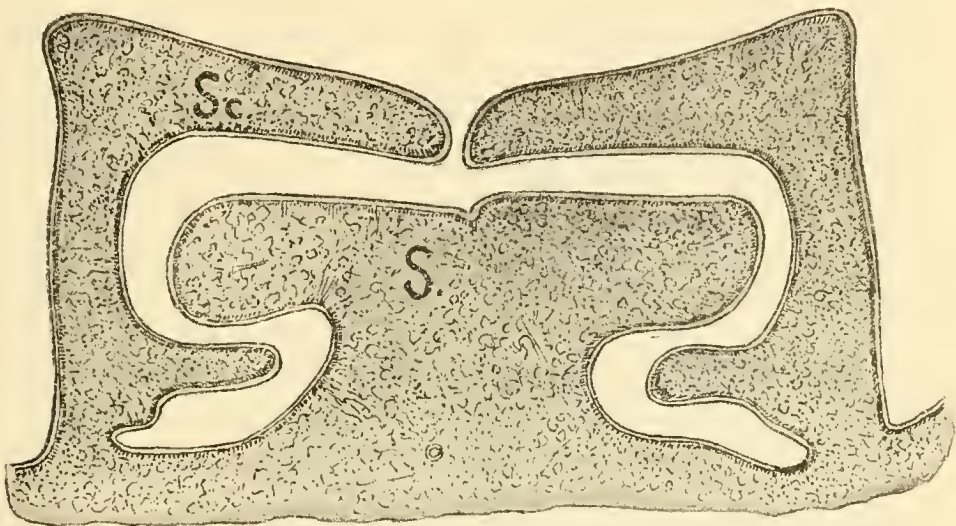


FIG. 10.—SECTION ACROSS THE MIDDLE OF THE THELYCUM, POSTERIOR TO THE SECTIONS SHOWN IN FIGS. 8 AND 9, WITH THE SHELF (S) OVERARCHED BY THE SCALES (Sc).

but, however, a well marked spermatophore mass applied to the surface of the sternum of the female in the region of the thelycum of the Peneidæ.

In *Polycheles granulatus* the sternum of the female is composed of three well-marked plates in the region to be studied, one between the fourth legs, one between the fifth, and a third somewhat posterior to the fifth legs. Laterally these plates are marked off from one another by grooves, but along the median region they form one continuous shell that is depressed so that the anterior part rises up markedly above the posterior part. There is no indication of any elevated ridges or plates at all comparable to the thelycum and no holes or cavities that could function as a sperm receptacle. The same general structure and absence of any receptacle was seen in specimens labeled *Willemoesia inornata*, *Eryoneicus indicus hawaiiensis*, and *Eryoneicus cæcus*.

In the young or smaller specimens of *Polycheles submi* and *P. sculptus* the same is true, but in older or larger specimens there are

some individuals with structures in this region that may have been mistaken for receptacles, though they are really only large spermatophores. Thus in *Polycheles suhmi* the depressed smooth shell between the fourth and fifth legs has fastened firmly to it a yellow brown flat mass which looks like two flattened tubes side by side. Each has a small opening near the anterior tip. They are fused into a common mass posteriorly and expanded laterally to make the entire outline rather triangular. This mass is really two spermatophores. The first pleopods of the female are here markedly differentiated as flat setose brushes which would seem well made to glide over the surface to which the spermatophores are attached and to keep it clean before they were attached. That the above masses are spermatophores is supported by the fact that in the males there is in some cases a similar dark brown mass, of flat form projecting far out of the opening of the deferent duct on the base of each fifth leg, like a hardened secretion which was in process of emergence to be transferred to the female to form the above spermatophoral mass.

In the males of *Polycheles granulatus*, *P. agassizii*, *P. sculptus*, and *P. sculptus pacificus* Faxon there are, in some specimens, similar colored projections from the male orifices. That these masses could be transferred from the male to the female seemed evident from applying the two sexes together when the projecting secretions of the male could be brought to the long, spoon-shaped male pleopods in such a way as to make it plausible that these spoons serve somewhat as do the homologous pleopods of the crayfish to conduct the sperm, or the spermatophores, from the male to the female.

The demonstration of the spermatophore nature of the masses found upon the female is, however, to be found in the following description of their structure and probable male origin as seen in specimens of *Polycheles sculptus*.

A female from *Albatross* station 2394, Gulf of Mexico, in 420 fathoms, has between the fourth and fifth legs, as represented in fig. 11, a large triangular or trefoil-shaped mass which proves to be not a spermatheca or female receptive organ, but a pair of fused spermatophores, or purely male products, applied to the outside of the shell of the female. While the female is 95 mm. long with claws 120 mm. long, the spermatophore mass is 9 mm. long and wide, with a maximum diagonal length of 10 mm., so that it takes up quite a portion of the sternal surface of the thorax, which is but 33 mm. wide.

This flat mass is somewhat irregular on the surface and its anterior half bends up at a wide angle with the posterior, since it is applied closely to the shell which is curved between the fourth and fifth legs. It is made up of a translucent yellow brown material through which a curved whitish content can be seen dimly on each side pass-

ing back from a terminal orifice, becoming bent posteriorly. The mass sticks so tightly to the shell that a knife point does not separate it. It cuts like hardened paste, cracking along the knife cut. It at once suggests a coagulated mass containing a tubular cavity more or less full of sperm on each side; that is, two more or less fused spermatophores stuck to the shell. The two do not have their anterior openings at the same level, as far as noted in several specimens, but one is in advance of the other, and posteriorly one side is not like the other. Moreover, the whole mass, though roughly of trefoil outline, quite lacks the exact bilateral symmetry which would be expected in any crustacean median organ, such as a real spermatheca.

On removing a piece of the spermatophore and teasing it it was found that the outermost indurated shell-like covering incloses a somewhat softer friable yellowish mass itself inclosing a white-yellow rod, or more or less coiled filament, quite different from the rest of the mass, being a granular aggregate of innumerable rounded agglutinated objects. Sufficiently magnified these are obviously sperm, rounded, with a dark staining central body and outer film of

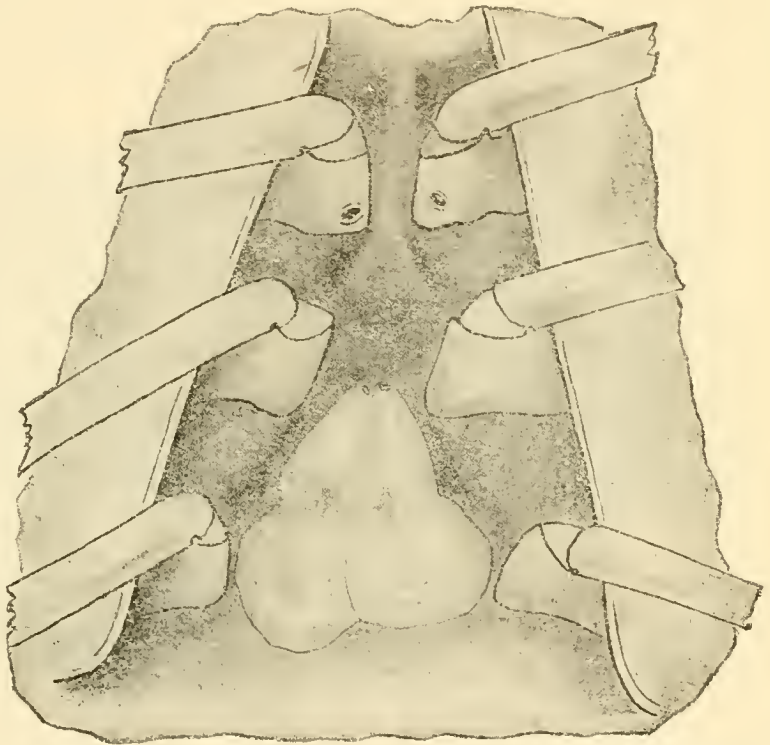


FIG. 11.—SURFACE VIEW OF UNDER SIDE OF THORAX OF A FEMALE *POLYCHELES SCULPTUS*, SHOWING BASES OF LEGS AND LARGE PAIR OF SPERMATOPHORES FUSED TOGETHER AND FASTENED TO THE SHELL BETWEEN THE LAST PAIRS OF LEGS.

protoplasm that presents various forms. In some it is projected as pseudopodia-like processes. On the surface of the mass especially these sperms send out clear films, as if actively amœboid leucocytes. Comparing these with the cells in the testes of the male we find that these are smaller, the testes now being inactive, apparently, but the cells in the deferent ducts are just like those in the spermatophores.

In this female the eggs in sections of the small H-shaped ovary are apparently immature, which suggests that the sperm must remain sometime in the spermatophore before the eggs are laid. Other females show the eggs already fastened to the pleopods, including the small first pair.

That these masses on the females are really spermatophores was again indicated by the observation that in one female *Polycheles sculptus* from *Albatross* station 2677, from off Cape Fear, in 478 fathoms, there were two in place of the usual single pair of the spermatophores. One pair was as in fig. 11, the other was similar but not so well made, that is less completely fused and more evidently complex. It was applied to the regular one so as to lie over its posterior half and thence project back freely without contact with the body wall of the female.

It was quite evident that this accessory pair of spermatophores was but a pair of tubes filled with a mass of white substance, presumably sperm. Probably after one male had applied the normal pair of spermatophores another male added a second pair.

Sectioning pieces of a spermatophore shows that it is but a secreted mass containing sperm and no other cellular elements whatever.

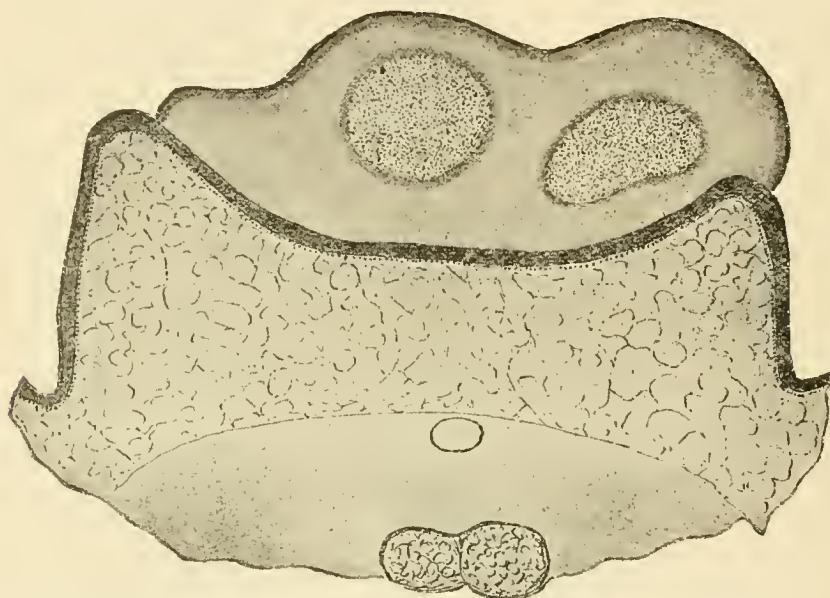


FIG. 12.—CROSS SECTION OF VENTRAL PART OF THORAX OF POLYCHELES SCULPTUS WITH NERVE CORD BELOW AND THE APPLIED SPERMATOPHORES ABOVE OUTSIDE THE SHELL WHICH IS INDICATED AS A DARK LAYER.

A cross section through the shell of the female represented in fig. 11, across the anterior part of the applied spermatophore mass, is represented in fig. 12. Below is the median nerve cord and blood vessel, connective tissue, and thick shell of the female. Above is the pair of spermatophores showing as a secreted mass containing a central rod of sperm, right and left. The secretion has become more dense where it is in contact with the water and the sperm, producing a sort of denser shell, but there is no special structure there, and moreover even this differentiation is absent where the secretion comes against the shell of the female to which it adheres so firmly. The asymmetry of the two combined spermatophores is seen in the section.

In sections farther back where the mass is wider, fig. 11 and fig. 13, the ventral nerve ganglion is much nearer the shell, since this region

of the female is not elevated as is the region toward the fourth legs, fig. 11. Here the spermatophoral mass seems more clearly a mere applied mass of secretion containing two sperm strands. In this posterior region the strands of sperm are bent, as dimly seen in fig. 11, and hence they appear elongated in cross section, fig. 13. The strand on the left of the figure shows that there the sperm does not completely fill out the tubular cavity in the secreted spermatophore, but that there is some other secreted material inserted here between the general walls of the spermatophore and the actual sperms. Probably there is a slight admixture of sperm and secretion such as occurs toward the end of the filling of the spermatheca in *Cambarus*.

In the main each spermatophore is a long bent rod of sperm inclosed in a thick envelope of some translucent secretion and stuck fast to the sternum of the female along with a like spermatophore.

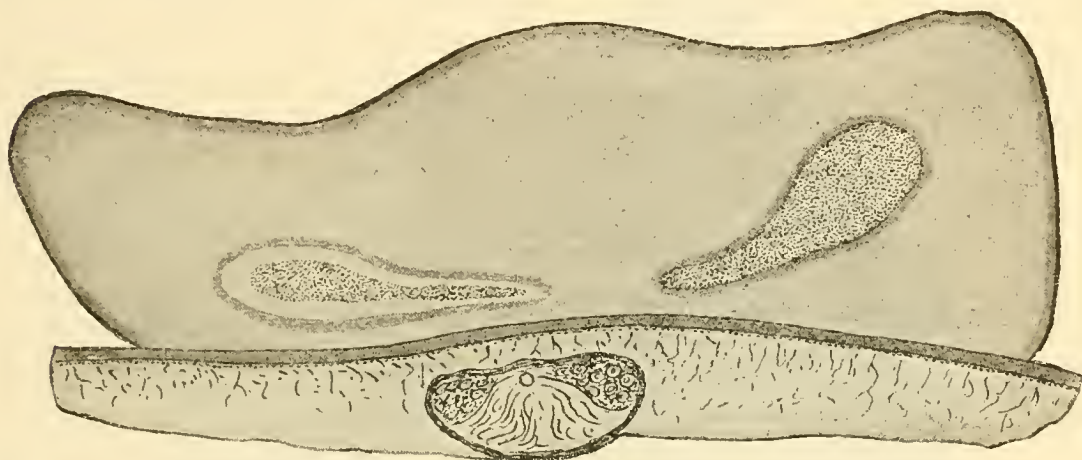


FIG. 13.—CROSS SECTION POSTERIOR TO THAT SHOWN IN FIG. 12.

That these two spermatophores arise from the deferent ducts of one male seems probable from the following observations on the male of this same species.

In a male from the last-mentioned locality the brown mass previously mentioned as proceeding from the orifice of the male duct, fig. 14, is found on cutting off the leg to run throughout the base of the leg as a large rounded cylinder up into the body of the male.

The part of this mass that projects into the water is seen in fig. 14 as the dark bent object above, while its continuation from the base of the leg into the body is represented as cut across below.^a Following this up into the body we find the colored cylinder continues as a cast of the deferent duct for a distance of 25 to 30 mm. and with a width of 2 mm. to end abruptly at the relatively small and delicate lobulated

^a The dark-colored protuberance is more than 2 mm. long, not the same exactly on the right as the left leg, of cylindrical form but flattened so that one diameter is 2 mm. and the other about 1.5 mm. It bends at the tip as if to coil, and is somewhat retort shaped. The white contents seen throughout the translucent colored part comes to the tip and is there closed off as if by the elasticity of the inclosing secretion.

testes. On each side the duct full of secretion and its central sperm core is differently bent. Apparently the sperm mass is long enough to supply spermatophores to two or three females.

The projecting mass shows plainly a central core, fig. 14, and this continues up through the leg. When the projecting mass is cut into sections it is found that it has the same structure as it has within the leg, as indicated in fig. 15. Here the rounded mass is a secretion filling the deferent duct completely. The protuberant mass is only

the secretion emerging from the deferent duct in which it is made about the central core of sperm.

In this section the shell of the basal segment of the leg is lined by epidermis and connective tissue surrounding the large muscles and the deferent duct. This duct has a thick muscular wall lined by epithelium and full of a clear secretion which in the preparations is shrunken so as to show conchoidal fractures. The central part of the contents of the duct is a rod of sperm exactly as in the spermatophore mass on the body of the female, but the sperm shows fewer protoplasmic processes.

The secretion inclosing the sperm seems not to have clotted more firmly about the sperm nor the walls of the duct than elsewhere, but otherwise the mass is like that of the spermatophore on the female.

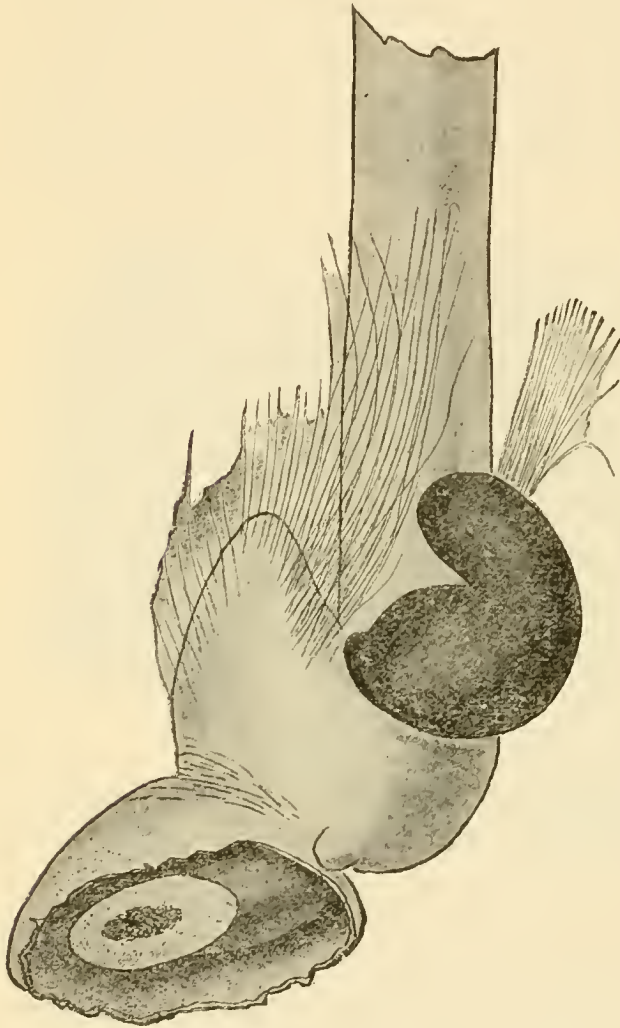


FIG. 14.—SURFACE VIEW OF BASE OF LAST THORACIC LEG OF MALE POLYCHELES SCULPTUS SHOWING BELOW THE DEFERENT DUCT AND CONTAINED SPERM CUT ACROSS AND ABOVE THE LARGE DARK SPERMATOPHORE EMERGING FROM THE ORIFICE.

That these projecting masses are the spermatophores fixed in process of emergence from the deferent ducts and about to be transferred to the female to form the united pair of spermatophores found upon the sternal surface of the female seems most evident. The occurrence of a minute mass of sperm in a minute string of secretion lying among the hairs on the base of the leg, fig. 14, near the orifice of the sperm duct suggests that the emerging mass may have portions of its

contents squeezed out of it as it is emerging and further strengthens the view that these masses are the spermatophores.

The only objection to the acceptance of this view is the statement of Geoffrey Smith in his paper above referred to.^a He states:

The presence of this spermatheca is of considerable taxonomic importance, as it appears to be entirely absent in the other Schizopods, viz, Mysidacea and Euphausiacea, but to be present in certain of the more primitive Decapods. In the lobster and certain prawns a similar spermatheca is present, and in the peculiar Eryonidea (*Polycheles*, *Willemasia*) the presence of a spermatheca in the same position was pointed out to me by Mr. Gray, of the Oxford University Museum. The investigation of this spermatheca in the female of *Polycheles* has revealed a structure identical with that of *Anaspides*. The spermatheca of *Polycheles* is a shield-shaped chitinous structure with a median opening leading into a tube which bifurcates exactly as in *Anaspides*. There can be no doubt that the structure in both cases is strictly homologous, and that we have in the spermatheca of Anaspidacea a Decapodan character, parallel to the presence of the otocyst on the first antennæ.

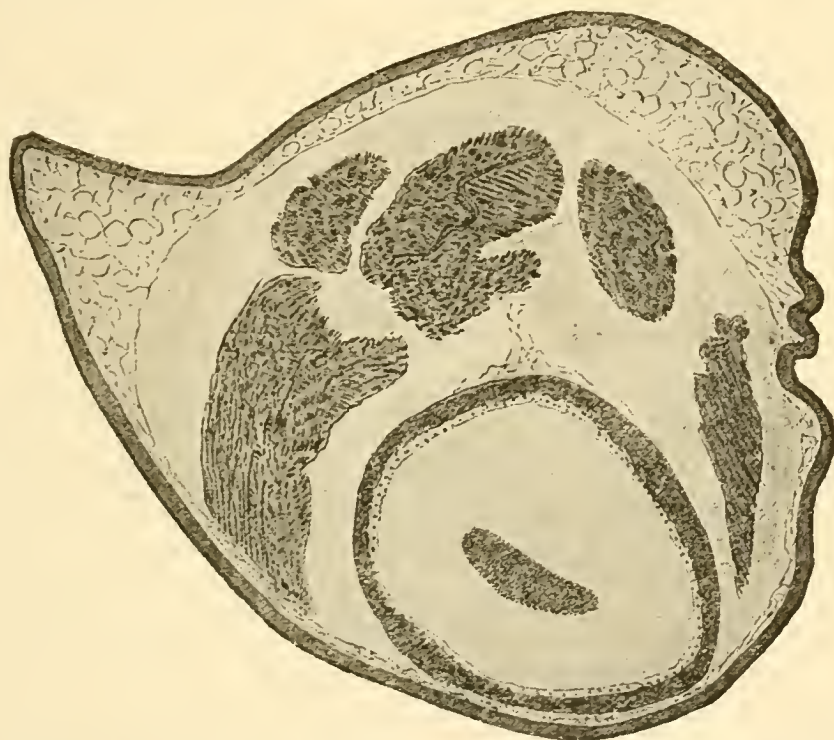


FIG. 15.—CROSS SECTION OF BASE OF LAST LEG OF MALE *POLYCHELES SCULPTUS*, NEAR THE EXTERNAL ORIFICE OF THE DEFERENT DUCT, SHOWING THE MUSCULAR WALL OF THE DUCT AS A DARK CIRCLE ENCLOSING THE CLEAR SPERMATOPHORE SECRETION AND A CENTRAL CORE OF SPERM.

As several authors have described the spermatheca of Anaspidacea as an actual cavity within the female shell within which a pair of spermatophores is found, we can not suppose this spermatheca comparable to what we have found in *Polycheles*. Hence to reconcile the present description of the spermatophores of *Polycheles* with the above statement of Smith that *Polycheles* has a spermatheca which is identical with that of Anaspidacea (that is, a female organ

^a Quart. Journ. Micr. Sci., 1909, pp. 517-518.

and not a male production), we seem to have only two alternatives. Either the different species of *Polycheles* differ so much that the one investigated by Smith has a spermatheca while several others do not, but have only spermatophores, or else we must assume that the interpretation of what was seen in *Polycheles* as a spermatheca is an error. The former assumption seems to be very improbable. An error may readily be ascribed to the examination of poorly preserved material, such as deep dredgings often supply. The seeing of a cavity that forks exactly as in *Anaspides* might arise from great familiarity with the latter form and a hasty investigation of *Polycheles* as subordinate material.

In conclusion we may express the hope that spermatheca may yet be found in other groups of crustacea that will throw light upon the relationships of these organs in the few groups in which they are now known.

A REVIEW OF THE FISHES OF THE FAMILIES LOBOTIDÆ AND LUTIANIDÆ, FOUND IN THE WATERS OF JAPAN.

By DAVID STARR JORDAN and WILLIAM FRANCIS THOMPSON,
Of Stanford University, California.

In the present paper an account is given of the Japanese species of percoid fishes constituting the family of Lobotidæ, or triple-tails, and the family of Lutianidæ, or snappers. It is based on material obtained in Japan in 1900, by Professors Jordan and Snyder, and now divided between the United States National Museum and the Museum of Stanford University.

The drawings for figures 2, 3, and 4 were made by Mr. Sekko Shimada.

Family LOBOTIDÆ.

The TRIPLE-TAILS.

Bass-like fishes, with an oblong, compressed body, equally developed above and below; a short snout and anterior eyes; edentulous palate; dorsal and anal with the soft portions equal and opposite, the former preceded by a much longer spinous portion, the latter with 3 spines; vertebræ 24, 12 abdominal and 12 caudal, the fifth to eleventh with short but gradually lengthening parapophyses projecting sideways and behind downward, and the twelfth with the parapophyses elongated, converging at their extremities, and fitting into a groove of the first hæmal spine, the costiferous pits excavated obliquely in the developed parapophyses, and gradually ascending forward on the vertebræ, and finally on the neurapophyses; the skull with its frontal portion broad, expanded forward and outward, and entering into the posterior borders of the orbits, which are advanced far forward; the post-frontals elongated forward and underlying the frontals; ethmoid short, decurved, and expanded sideways (Gill). This family contains but two species, large fishes closely allied to the Serranidæ, but lacking vomerine and palatine teeth, and with the fore part of the head very short. Its relations are decidedly with the Serranidæ and not with the Hæmulidæ with which group it agrees in the absence of teeth on the palate.

1. Genus *LOBOTES* Cuvier.

Lobotes CUVIER, Règne Animal, ed. 2, vol. 2, 1829, p. 177 (*erate*=*surinamensis*).

Body oblong, compressed and elevated, covered with moderate-sized, weakly ctenoid scales; profile of head concave, the snout prominent; mouth moderate, oblique, with thick lips; upper jaw very protractile, the lower the longer; maxillary without supplemental bone; jaws with narrow bands of villiform teeth, in front of which is a row of larger conical teeth directed backward; no teeth on vomer or palatines; preorbital narrower than eye; preopercle strongly serrate, the serræ becoming smaller with age. Branchiostegals 6. Dorsal fin continuous, with 12 spines which may be depressed in a shallow groove; soft rays of dorsal and anal fins elevated; anal spines graduated; bases of soft dorsal and anal thickened and scaly; caudal rounded. Air bladder present. Pyloric cæca 3.

(*λοβοτός* lobed; the soft parts of dorsal, anal, and caudal thought to resemble one three-lobed fin.)

1. *LOBOTES SURINAMENSIS* (Bloch).

Holocentrus surinamensis BLOCH, Ichthyologia, pt. 7, pl. 243, 1790 (Surinam).

Lobotes surinamensis CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 319 (after Bloch).—HOLBROOK, Ichth. South Carolina, 1860, p. 169, pl. 24, fig. 2 (South Carolina).—DAY, Fishes India, 1875, p. 84, pl. 21, fig. 5 (India).—POEY, Fauna Puerto Riqueña, 1881, p. 329 (Porto Rico).—JORDAN and EVERMANN, Fishes North and Middle America, vol. 1, 1896, p. 1235, pl. 194, fig. 510.—JORDAN and RUTTER, Proc. Acad. Nat. Sci. Phila., 1897, p. 112 (Kingston, Jamaica).—EVERMANN and MARSH, Bull. U. S. Fish Comm., 1900, p. 164, fig. 47 (San Juan, Porto Rico), and of authors generally.

Bodianus triurus MITCHILL, Trans. Amer. Philos. Soc., 1815, p. 418, pl. 3, fig. 10 (Powles Hook, New Jersey).

Lobotes erate CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 322 (Pondicherry).—BLEEKER, Verh. Bat. Gen. Kunst. Wet., vol. 23, Sciæn., 1849, p. 26; Atlas Ich., Perc., pl. 23, fig. 4 (Batavia, Samarang, Surabaya).—CANTOR, Cat. Malay Fish., 1850, p. 80 (Sea of Pinang, Malayan Peninsular coasts, Singapore).

Lobotes farkhari CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 324 (on a drawing), (Malacca).

Lobotes somnolentus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 5, 1830, p. 324, pl. 126 (Santo Domingo).

Lobotes incurvus RICHARDSON, Ich. China, 1846, p. 237. (Hong Kong.)

Lobotes auctorum GÜNTHER, Cat. Fish Brit. Mus., vol. 7, 1859, p. 338 (Cuba, Calcutta, China).

Habitat.—Atlantic coast of America from Cape Cod to Brazil, Madagascar, and East Indies, north to Japan.

Description.—Of a specimen from Misaki, 48 cm. in total length.

Head $2\frac{5}{8}$ in body, $3\frac{1}{2}$ in total; depth $2\frac{1}{6}$ in length; maxillary $2\frac{3}{4}$ in head; longitudinal diameter of eye 8; interorbital space (bone, above

pupils) 3; snout 4; D. XII, 15; A. III, 11; scales in longitudinal series above lateral line to last vertebra 45; in series below 40; on lateral line 42; in transverse series 10/16; gill rakers 6+13; length of longest one-half diameter of eye.

Body deep; dorsal and ventral profiles similar and symmetrical; compressed; caudal peduncle deep, $2\frac{1}{8}$ in head, its length from last anal rays to base of caudal 3 in head; head slightly concave in profile back of interorbital area, strongly convex from side to side; snout very much rounded, broad, its length less than its width; suborbitals very narrow, less than half width of the small eye; lower jaw longer; maxillary extending to below posterior border of eye; mouth cleft very oblique, at about 40° to body axis, its tip at lower level of eye, laterally fully the diameter of the eye below. Teeth in outer rows of both jaws conical, not at all compressed nor canine-like, rather closely set. Inner band of upper jaw broader anteriorly than that of lower, both becoming narrower posteriorly, those above being of five or six rows in front, those below three or four; outer row teeth stoutly conical, somewhat enlarged.

Preopercle set with bony teeth, projecting little beyond bony margin, making rather coarse serrations, stronger at the slightly projecting angle, small and pointing upward on dorsal half of posterior border; downward on lower border, but lacking on anterior half of latter, the remainder small. Portion of posterior border of interopercle and whole free edge of subopercle finely serrated, as is the clavicle and the posttemporal. These serrations are much larger in young examples.

Dorsal spines longest in fourth and fifth, about $2\frac{3}{4}$ times in head, stout and strong. Spinous dorsal base $2\frac{2}{5}$ in body to base of caudal, soft dorsal $3\frac{2}{3}$. Anal spines graduated, third and longest, about 4 times in head; soft anal rounded; anal base four in length to base of caudal.

Lateral line following line of back, arched strongly anteriorly, the tubes simple, large.

Scales thick and bony, rather large and coarse, slightly ctenoid; covering basal halves of soft dorsal and anal and basal third of caudal; those on head and cheeks much smaller; those on opercle in seven rows, of eight or nine scales along border, on subopercle in one lengthwise row of six or seven, on interopercle in one of ten or eleven, with two partial rows. Scales lacking on snout before nostrils, on lips and lower jaw.

Color dark olive, especially dark on head. Lining of gill cavity and peritoneum clear; distal part of caudal fin paler. In life, blackish above, silver gray below, often blotched or tinged with yellow.

Of this species of wide distribution in the warm seas, one specimen only is known from Japan. This was found dead on the beach at

Misaki, near the Zoological Station of the Imperial University, in August, 1900. This specimen, now before us, is typical of *Lobotes erate* Cuvier and Valenciennes. We are, however, wholly unable to separate this nominal species from the common *Lobotes surinamensis* of the western Atlantic.

On careful comparison of specimens and published plates, we can not find any difference which will hold. The denticulations on the preopercle are subject to much variation, and become much less distinct with age, being long and prominent in the young. Small specimens of *L. surinamensis* from Jamaica and Charleston, South Carolina, in the Museum of Stanford University, show a somewhat greater depth, but this character is not borne out by the observations of other authors on adults from the same localities, and it is very probable that the depth in this species grows less with age. These facts account for the differences held to exist between the species.

Lobotes pacificus Gilbert, from Panama (cotypes in the Stanford Museum), must be regarded as a distinct species, having much smaller preopercular spines, even in the young, and narrower suborbital bones. A specimen described by Sauvage from Madagascar as *L. surinamensis* has large preopercular spines, notwithstanding a total length of 2 feet, as shown by the indicated scale on the plate. If this is correct, it may be a different species.

2. Family LUTIANIDÆ.

THE SNAPPERS.

Body oblong or more or less elevated, covered with moderate-sized adherent scales, which are more or less strongly ctenoid or almost cycloid. Lateral line well developed, concurrent with the back, usually not extending on the caudal fin. Head large, the crests on the skull usually well developed. No suborbital stay. Mouth moderate or large, usually terminal, low and horizontal; premaxillaries moderately protractile, their spines not extending to the occiput; maxillary long, without supplemental bone (except in *Doderleinia* and *Glaucosoma*, genera allied to the Serranidæ), for most of its length slipping under the edge of the preorbital, which forms a distinct sheath (except in the genera just named); teeth various, usually unequal and sharp, never incisor-like, sometimes deciduous, some of them sometimes molar; vomer and palatines with villiform teeth (these deciduous or wanting in *Aphareus*), sometimes molar, sometimes very small, sometimes wanting, tongue usually with a band of teeth; lower pharyngeals separate; gills 4, a slit behind the fourth; pseudobranchiæ large; gill rakers moderate or long, slender; gill membranes separate, free from the isthmus. Preopercle serrate or entire;

opercle without spines (in typical species); sides of head scaly. Dorsal fin single, continuous, or deeply notched, sometimes divided into two fins, the spines usually strong, depressible in a groove, and heteracanthous, that is, alternating, the one stronger on the right side, the other on the left; the spines 10 to 12 in number. Anal fin similar to soft dorsal and with three spines; ventral fins thoracic, the rays I, 5, with a more or less distinct scale-like appendage at base; caudal fin usually more or less concave or forked. Air-bladder present, usually simple. Intestinal canal short. Pyloric cæca few. Vertebræ usually $10 + 14 = 24$. No distinct tubercles from the cranium for the articulation of the epipharyngeal bones; enlarged apophyses for the articulation of palatine and preorbital bones; anterior 4 vertebræ without parapophyses. The family comprises about 20 genera and some 250 species, chiefly inhabiting the shores of warm regions. All of them are valued as food, and all are active, carnivorous, and voracious. The group is closely related to the Serranidæ on the one hand and to the Hæmulidæ on the other.

We here exclude from the Lutianidæ the genus *Xenichthys* and its relatives, more nearly allied to the Hæmulidæ, and also the genera *Dentex*, *Nemipterus*, and *Gymnocranius*, which approach the Sparidæ. *Doderleinia* and *Glaucosoma* should doubtless also be excluded, as more nearly related to the Serranidæ.

In Japan the family is not largely represented, either in number of species or in number of individuals, but two species being abundant enough to have commercial value.

*a*¹. Maxillary broad, scaly, with a distinct supplemental bone; maxillary scarcely sheathed by the preorbital; gill rakers long and slender (genera allied to the Anthiinae among the Serranidæ).

*b*¹. GLAUCOSOMATINÆ. Teeth in bands, without distinct canines; supplementary maxillary narrow; preopercle coarsely toothed; pectoral fins short; caudal lunate; scales moderate; head entirely scaly; lateral line extending on caudal; dorsal continuous, with graduated spines; soft dorsal and anal scaly at base.

Glaucosoma, 2.

*b*². DODERLEINIINÆ. Teeth unequal, canines moderate, numerous; skull essentially as in *Etelis*, the supraoccipital not encroaching on the cranium; supplemental maxillary broad; dorsal deeply notched, with 10 spines; soft dorsal and anal scaleless; scales large; pectorals long but not falcate. *Doderleinia*, 3.

*a*². Maxillary without supplemental bone.

*c*¹. Vomer and palatines with teeth.

*d*¹. Nostrils near together, placed just before eye, the anterior not tubular; vomerine teeth villiform, the patch \wedge , \nearrow , or \diamond -shaped; no incisors nor molars.

*e*¹. LUTIANINÆ. Interorbital area not flat, the frontal region invaded by the occipital and temporal crests which extend forward about to the eye; jaws with canine teeth; dorsal fin continuous.

*f*¹. Soft dorsal and anal fins more or less scaly; last rays of dorsal and anal not produced; pectoral falcate; tongue usually with teeth.

*g*¹. Fronto-occipital crest, not reaching near to front of frontal; caudal fin lunate; gill rakers few, rather short. *Lutianus*, 4.

*e*². Interorbital area flat, separated by a transverse line of demarcation from the occipital, by which the median as well as the lateral crests are limited; frontals wide in front; tongue and pterygoids toothless; soft dorsal and anal scaleless (in Asiatic species); top of head naked; soft dorsal with 11 or 12 rays.

*h*¹. APRIONINÆ. Dorsal fin continuous; last ray of dorsal and anal more or less filamentous; jaws and front of head naked.

*i*¹. Jaws with well-developed teeth; teeth on vomer and palatines.

*j*¹. Pectoral fin long, falcate; body not fusiform, more or less compressed.....*Pristipomoides*, 5.

*h*². ETELINÆ. Dorsal fin deeply notched.

*k*¹. Cranium not cavernous; dorsal and anal naked; maxillary scaly; opercle without spine; caudal deeply and, in the adult, unequally forked.....*Etelis*, 6.

*c*². Vomer and palatines without teeth.

*l*¹. APHAREINÆ. Pectoral fin falcate, its lower rays also prolonged in the adult; dorsal and anal scaleless, the last rays produced; jaws with very small teeth which disappear with age; jaws heavy, the lower projecting.

Aphareus, 7.

2. Genus GLAUCOSOMA Temminck and Schlegel.

Glaucosoma TEMMINCK and SCHLEGEL, Fauna Japonica, Poiss., 1843, p. 62.

Body robust, compressed, covered with rather small, weakly ctenoid scales; lateral line nearly straight, extending on the caudal fin; head large, almost everywhere scaly; maxillary and mandible scaly; mouth large, the lower jaw projecting; maxillary very broad, with a narrow, supplemental bone, hardly slipping under preorbital; teeth in narrow bands, some of them canine-like; teeth on vomer and tongue, apparently none on palatines; preopercle with blunt teeth at the angle; gill rakers long and slender. Dorsal fin small, of 8 graduated spines and 12 soft rays, much higher than spines; bases of dorsal and anal scaly; anal with three short graduated spines; caudal lunate, with blunt lobes; pectoral short, blunt; ventrals inserted below them.

Large fishes of the Pacific, of doubtful relationship. They should probably be referred to the *Serranidæ* rather than to the *Lutianidæ*. (*υλαυκβς*, sea-blue; *σωμα*, body.)

2. GLAUCOSOMA BURGERI Richardson.

Glaucosoma TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 62, pl. 67 (Nagasaki).

Glaucosoma burgeri RICHARDSON, Voy. *Erebus* and *Terror*, Fishes, 1846, p. 27 (after Temminck and Schlegel).—GÜNTHER, Cat. Fish Brit. Mus., vol. 1, 1859, p. 211 (in part only, description from *G. hebraicum*).—JORDAN and EVERMANN, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 342, fig. 15 (Keerun, Formosa).—JORDAN and RICHARDSON, Mem. Carnegie Mus., vol. 4, 1910, no. 4, p. 185, fig. 13 (Takao, Formosa).

Habitat.—Formosa and southern Japan.

Description.—Of a specimen 17 inches long from Keerun, Formosa, after Jordan and Evermann.

Head $2\frac{3}{4}$ in body length; depth $2\frac{2}{5}$; eye $3\frac{1}{5}$ in head; snout $3\frac{4}{5}$; maxillary $1\frac{2}{5}$; mandible $1\frac{3}{5}$; interorbital space 5; preorbital width $7\frac{3}{10}$; D. VIII, 12; A. III, 10; scales 12-52-20.

Body rather short and deep, compressed; caudal peduncle compressed and deep, its least width 1.65 in eye, its least depth $2\frac{1}{2}$ in head; back gently and regularly arched from snout to caudal peduncle, somewhat depressed in front of eyes; head large and deep; eyes very large, rather high; nostrils close together, the posterior the larger; mouth very large, somewhat oblique, jaws subequal; maxillary very broad at tip, scarcely slipping under preorbital; teeth in a strong villiform band on upper jaw, composed of two rows, the outer in front canine-like; those of lower jaw in one series, except in front,

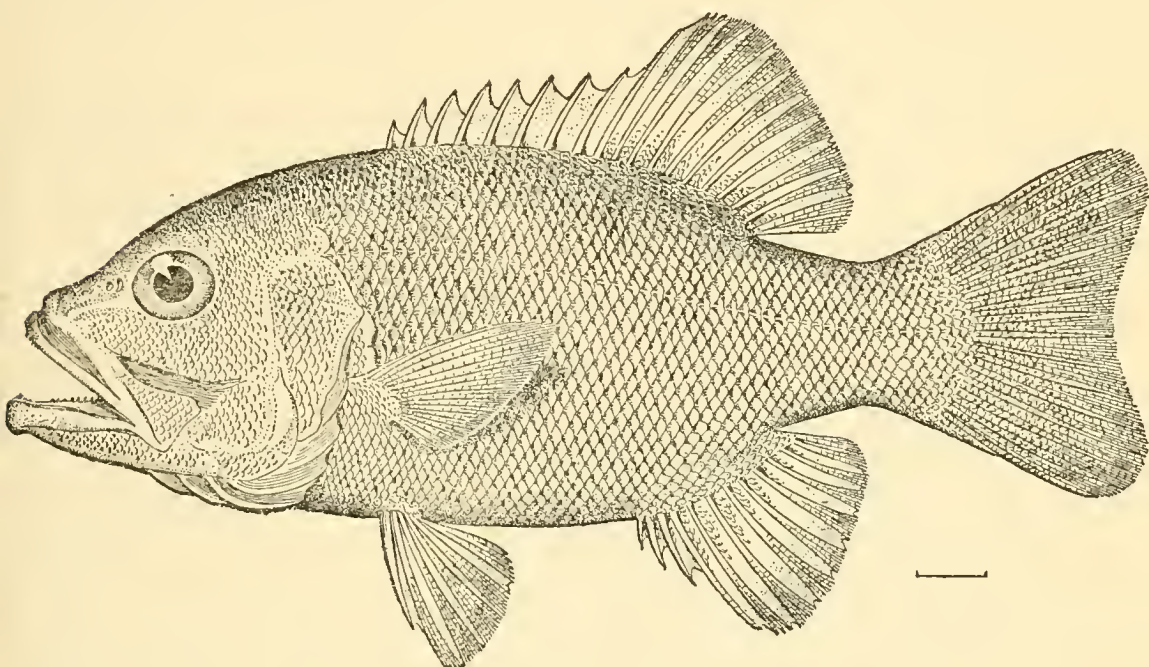


FIG. 1.—GLAUCOSOMA BURGERI.

where they are somewhat irregular; a large patch of villiform teeth on tongue and hyoid bone; a narrow V-shaped patch on vomer, apparently none on palatines. Angle of preopercle with coarse blunt teeth.

Fins moderate; dorsal spines rather short but strong, the soft part of dorsal somewhat elevated; longest dorsal spine $3\frac{1}{2}$ in head, longest ray $1\frac{9}{10}$; anal similar to soft dorsal, third spine considerably longest, 4 in head, longest ray 2; pectoral short and broad, $1\frac{2}{10}$ in head; ventrals scarcely reaching vent, 2 in head; caudal moderate, slightly lunate, the lobes rounded.

Scales moderate, weakly ctenoid, covering entire head, body, and bases of dorsal, caudal, and anal; maxillary densely scaled; base of pectoral scaled.

Color in alcohol, rusty silvery; head darker, somewhat purplish; edges of scales on side darkish, the bases brassy; dorsal, anal, and

caudal dusky; pectoral and ventral pale; a large brownish blotch on membrane below preorbital. Inside of mouth and peritoneum black.

This species seems to differ from *Glaucosoma hebraicum* Richardson, of Australia, in the absence of the elongation of the first soft rays of the dorsal, and in having 12 rows of scales above the lateral line, not 10. The absence of the palatine teeth needs confirmation, as these teeth may be deciduous. Doctor Günther remarks that Richardson's specimens of *Glaucosoma hebraicum* did not show the dorsal rays nearly as elongate as in his figure. A comparison of specimens, however, would be necessary before the characters separating the two species can be positively determined. The elongation of the dorsal rays is perhaps a character of age. The widely separated habitat of the Japanese species tends to render it probable that the Australian fish is different.

This species is probably rare in Japan. We have seen no specimen except the one described by Jordan and Evermann from Formosa.

(Named for Doctor Bürger, an artist naturalist, who made collections about Nagasaki for Siebold and Schlegel.)

3. Genus DODERLEINIA Steindachner.

Doderleinia STEINDACHNER, Fische Japans, I, Akad. Wiss. Wien, vol. 47, 1883, p. 129 (*orientalis*=young).

Acanthocephalus DODERLEIN, Ms. in Fische Japans, I, 1883, p. 129 (*orientalis*; name preoccupied).

Eteliscus JORDAN and SNYDER, Proc. U. S. Nat. Mus., vol. 23, 1900, p. 355 (*berycoides*; based on an error of Steindachner).

Corusculus JORDAN and SNYDER, Check List Fish. Ann. Zool. Jap. vol. 3, pts. 2 and 3, 1901, p. 75 (*berycoides*).

Body oblong, compressed, covered with large, firm scales; head scaly, except on snout; both jaws scaly; mouth large, oblique, the lower jaw projecting; maxillary broad, with a broad supplemental bone; teeth strong, some of them canine-like; teeth on vomer and palatines, none on tongue; preorbital very narrow, not sheathing the maxillary; preopercle finely serrate; supraoccipital crest scarcely encroaching on cranium, not extending to orbit; opercle ending in two spines. Dorsal fin short, deeply notched, of 9 spines and 10 soft rays; a few scales at base of soft dorsal; fourth spine highest; anal fin short, with three small, graduated spines; last rays of dorsal and anal not prolonged; pectorals long, but not falcate, the tip obtuse; ventrals below pectorals; caudal lunate.

Coasts of Japan. In spite of its resemblance to *Etelis*, the affinities of this genus seem rather with the *Anthiinae*, as indicated by Hilgendorf. It should doubtless be transferred to the Serranidæ, where it should form a distinct subfamily.

(Named for Prof. Ludwig Doderlein, who collected fishes in Japan for the Museum of Vienna.)

3. DODERLEINIA BERYCOIDES (Hilgendorf).

AKAMUTSU (Red Mutsu^a).

Anthias berycoides HILGENDORF, Sitzungsber. Ges. Naturf. Freunde, Berlin, 1879, p. 78 (Japan).

Etelis berycoides STEINDACHNER and DODERLEIN, Fische Japans, I, Akad. Wiss. Wien, vol. 47, 1883, p. 15, pl. 4; p. 91 (Tokyo).—ISHIKAWA, Prel. Cat., 1897, p. 57 (Kadzan).

Eteliscus berycoides JORDAN and SNYDER, Proc. U. S. Nat. Mus., vol. 23, 1900, p. 355 (Tokyo); Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 77 (after Steindachner).

Coruscus berycoides JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 75 (after Hilgendorf).

Doderleinia orientalis STEINDACHNER and DODERLEIN, Fische Japans, I, Acad. Wiss. Wien, vol. 47, 1883, p. 29 (Tokyo).

Acanthocephalus orientalis DODERLEIN, Ms. in Steindachner and Doderlein, Fische Japans, I, Acad. Wiss. Wien., vol. 47, 1883, p. 29 (Tokyo).

Habitat.—Deep waters off Tokyo.

Description.—Of a specimen 335 mm. in total length from off Tokyo, probably from Awa.

Interorbital space 5 in head; suborbital 7 in eye; D. VIII, I, 10; A. III, 8; scales in longitudinal series, above lateral line, 50, below 40, in transverse series from dorsal to anal 4/14; vertebræ 25 (Hilgendorf).

Body shaped much as in *Etelis*, fusiform, symmetrical, head conical, as wide as body, 2 in body depth; caudal peduncle rather deep, 3 in head. Profile of head continuous with that of body. Eyes large, circular. Snout shorter, $1\frac{1}{2}$ in eye, its tip at level of lower margin of pupil. Suborbital very narrow. Lower jaw projecting, its tip continuing profile of snout. Maxillary 2 in head, ending under posterior border of eye, its distal width one-half of eye, and sheathed but slightly by preorbitals. Premaxillaries produced to either side of tip of snout, leaving a deep emargination, into which fits a large symphyseal knob or production of the tip of mandible. Lower jaw contained in upper on sides. Teeth on vomer and palatines in a single row, stout, villiform, on vomer in an inverted V-shape; on premaxillaries in outer row small; outwardly projecting, stout canines anteriorly, becoming gradually smaller posteriorly, finally indistinguishable from inner villiform band, the latter extending along whole of premaxillaries, deepest at middle of extent, forming a low triangle; on inner edge of tip of premaxillaries a group of four to six strong canines, directed posteriorly; on mandible a loose row of stout canines, longest on the arched central portion of each mandible, but not much larger than those of anterior end of premaxillaries. Tongue toothless. Gill rakers as long as diameter of pupil, 8+15. Preopercle with rather widely set, flexible, indistinct radiating points, leaving

^a *Mutsu* is the Japanese name of *Scombrops boops*.

its margin slightly sinuate rather than dentate, but with one or two firm, spinous teeth of small size. Opercle with two sharp, spinous points, the upper smallest.

Dorsals deeply divided, but not separated; spines rather weak, fourth highest, $2\frac{3}{4}$ in head, the others graduated, the eighth $8\frac{1}{2}$ in head, last 4; base of spinous dorsal $3\frac{2}{3}$ in body; dorsal rays equal in length, $2\frac{1}{2}$ in head, soft dorsal base $5\frac{1}{2}$ in body; anal spines graduated, slender, last $3\frac{1}{2}$ in head; first and second rays longest, $2\frac{2}{3}$ in head, last $4\frac{1}{4}$. Pectorals not falcate, fourth to seventh nearly of equal length, the tip barely reaching anus, length $3\frac{1}{2}$ in body. Ventrals inserted almost directly beneath pectoral base, short, extending one-half way to anus. Caudal only slightly emarginate.

Lateral line parallel with dorsal profile of body, its tubes large, broad.

Scales on body parallel to lateral line above it, and to body axis below, those on body large and thin, finely ctenoid. Top of head posterior to center of eyes and temporal region thickly covered with very small scales. Preorbital below eyes, maxillary, cheeks and mandible scaled; scales on opercle largest, and those on mandible similar to those on dorsal surface of head. Bases of dorsals, anals, and ventrals scaleless. Pectorals with few scales only. Caudal scaled on basal half.

Color in life bright crimson. Color of an old alcoholic specimen uniform yellowish brown, bases of scales showing deeper. Slight margining of black on dorsals and caudal. Gill cavity, mouth, and peritoneum black.

This species is known from the deeper waters about Tokyo. Of our specimens, the largest, described above, is $33\frac{1}{2}$ cm. in length.

The species was first named *Anthias berycoides* by Hilgendorf, and afterwards described and very well figured as *Etelis berycoides* by Steindachner.

Later a young example was made the type of a genus, *Doderleinia*, by Steindachner. This specimen was $5\frac{1}{2}$ cm. in length. As usual with young fish of this type, the preopercle was more strongly serrate than in the adult, and the head appeared to be perhaps scaleless. Steindachner speaks of the second anal spine as "kaum länger als der dritte." In our specimen the second is two-thirds the length of the third. *Doderleinia orientalis* differs in no other way from the young of *Anthias berycoides*.

The species has been unfortunate in its generic denominations. The name *Doderleinia*, given to the young, has clear priority over the later names. *Acanthocephalus*, suggested by Doderlein, is preoccupied. The name *Eteliscus* was given by Jordan and Snyder, on account of the fin formula (D. XIV, I, 10), erroneously given by Steindachner to his *Etelis berycoides*. This formula is clearly a slip

in copying. Later the same writers gave the name *Corusculus* to the *berycoides* of Hilgendorf, which is the same species. The name *Doderleinia berycoides* replaces all others for this beautiful and interesting fish, which seems to be midway between *Anthias* and *Etelis*.

(βέρυξ, beryx; εἶδος, resemblance.)

4. Genus LUTIANUS Bloch.

Lutianus BLOCH, Ichthyologia, vol. 4, 1790, p. 107 (*lutianus*); the name first spelled *Lutianus*, but later changed, on the plates and elsewhere, to *Lutjanus*.

Diacope CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 410 (*sebæ*); name preoccupied in *Lepidoptera*.

Mesoprion CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 441 (*lutianus*, etc.).

Genyoroqe CANTOR, Cat. Malay. Fishes, 1850, p. 12 (*sebæ*); substitute for *Diacope*.

Evoplites GILL, Proc. Acad. Nat. Sci. Phila., 1862, p. 236 (*pomacanthus*=young of *kasmira*).

Neomænis GIRARD, U. S. Mex. Bound. Survey, Zool., Fishes, 1859, p. 18 (*emarginatus*=*griseus*).

Hypoplites GILL, Proc. Acad. Nat. Sci. Phila., 1862, p. 236 (*retrospinis*).

Proamblys GILL, Proc. Acad. Nat. Sci. Phila., 1862, p. 236 (*nigra*=*macolor*).

Macolor BLEEKER, Poiss. Amboina, Ned. Tyd. Dierk., 1867, p. 277 (*macolor*).

Raizero JORDAN and FESLER, Rept. U. S. Fish Comm., 1889 (1893), p. 438 (*aratus*).

Body oblong, compressed, the back somewhat elevated; head long, naked or scaly above, with a broad oblique band of scales at the nape; nostrils normally close together, neither with a tube; mouth large, the jaws with bands of villiform teeth, besides which is usually an outer series of larger teeth in each jaw, and 2 to 4 stronger teeth or canines in front of upper jaw; vomer with villiform teeth; villiform teeth on the palatines; usually one or more patches of teeth on the tongue in the adult; no molar teeth; no teeth on pterygoids; preopercle without notch (*Lutianus*) or with a shallow or deep emargination (*Genyoroqe*; *Evoplites*); posterior limb of preopercle finely serrate; gill rakers rather few, shortish; soft rays of dorsal and anal scaly at base; last rays of dorsal and anal not produced; dorsal spines 10 (rarely 11), continuous with the soft rays; anal rays 7 to 9. Interorbital area not flat nor separated from the occipital region, the median and lateral crests procurrent on it, and the frontal narrowed forward; fronto-occipital crest ceasing anteriorly far from front of frontal, usually behind eye; prefrontal with posterior areas impressed, long, and cribriform; prefrontal with the articular facets arising from diverging V-shaped ridges; basisphenoid with an anterior lobiform extension. Vertebrae 10 + 14 = 24.

In the old-world species of this genus, the fronto-occipital crest generally coalesces with the orbital rim, while in American forms (*Neomænis* Girard) the two are separate. We doubt, however, whether the latter group can be maintained as a distinct genus.

This genus is a very large one, showing much variation in form, dentition and scaling. At present we do not venture to subdivide it.

Species very numerous, chiefly of the East Indies and West Indies, active, predatory fishes, highly valued as food.

(Name from Ikan Lutjang, the Malay name of *Lutianus lutianus*.)

- a*¹. *EVOPLITES*.—Top of head scaly; notch in preopercle deep.
- b*¹. Sides with about 4 narrow sharply defined blue stripes; D. X, 15; A. III, 8; scales about 9-75-20; scales above lateral line in series not parallel with the lateral line *kasmira*, 4.
- a*². *LUTIANUS*.—Top of head naked; notch in preopercle shallow.
- c*¹. Vomerine teeth in a \wedge -shaped patch, with a posterior shaft; teeth on tongue in adults; a black bar or blotch on sides, young usually with 3 or 4 black longitudinal stripes; scales above lateral line in series not parallel with lateral line.
- d*¹. Sides with a broad black stripe from eye to middle of caudal, somewhat interrupted and widened below soft dorsal; scales 7-60-15..... *vitta*, 5.
- d*². Sides with a large black blotch below first rays of soft dorsal, its largest part above lateral line; no broad lateral stripe; young with 3 or 4 black lengthwise streaks. Scales 8-50-16 *russelli*, 6.
- c*². Vomerine teeth in a \wedge -shaped patch, without backward shaft; tongue toothless; no black lateral stripe or lateral blotch; scales about 50.
- e*¹. Caudal peduncle with a black saddle-like blotch at its base, bordered anteriorly and posteriorly by lighter spots; third anal spine not shorter than second. Scales about 11-50-20 *erythropterus*, 7.
- e*². Caudal peduncle without black saddle; third anal spine shorter than second; scales larger.
- f*¹. Head in adult with blue sinuous lines; young with dark bars; usually a milk-white blotch on lateral line below first dorsal rays. Scales 9-50-18..... *rivulatus*, 8.
- f*². Head without blue or dark stripes; fins narrowly margined with yellow, with black submarginal shades; no white blotch. Scales about 7-50-16 *vaigiensis*, 9.

4. *LUTIANUS KASMIRA* (Forskål.)

Sciæna kasmira FORSKÅL, Descr. Anim., 1775, p. 46 (Red Sea).

Mesoprion kasmira KLUNZINGER, Fische Rothen Meeres, 1884, p. 12, in part (Red Sea).

Lutianus kasmira DAY, Fishes India, 1888, p. 783 (India).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 76.

Evoplites kasmira JORDAN and EVERMANN, Fishes North and Middle America, vol. 2, 1898, p. 1246 (Swatow, China).

Holocentrus quinquelineatus (or *quinquelinearis*) BLOCH, Ichthyologia, 1790, pl. 239 (Japan) (not *Lutianus quinquelineatus* of most subsequent authors).

Holocentrus bengalensis BLOCH, Ichthyologia, 1790, pl. 246, fig. 2 (Bengal).

Genyoroge bengalensis GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 178, in part (Red Sea, India, Île de France, Amboyna, Fiji, Louisiades: China).

Lutianus bengalensis BLEEKER, Nat. Verh. Kon. Akad., vol. 13, Revision Lutjani, 1873, p. 34 (Sumatra, Java, Celebes, Timor, Ternate, Halmahera, Batjan, Buro, Ceram, Amboyna, Waigiu).—DAY, Fishes India, p. 33, 1875, pl. 10, fig. 4.—BLEEKER, Atlas Ichth., vol. 8, 1876, p. 55, pl. 333.—STEINDACHNER and DODERLEIN, Fische Japans I, Akad. Wiss. Wien., vol. 47, 1883, p. 28 (Kago-shima), and of various authors.

Perca polyzonias (Forster), BLOCH and SCHNEIDER, Syst. Ichth., 1801, p. 316 (South Seas).

Diacope octolineata RÜPPELL, Reise Nord. Afrika, Atlas, 1826, p. 75 (Red Sea).—CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 418 (Red Sea, etc.) in part.—TEMMINCK and SCHLEGEL, Fauna Japonica., 1843, p. 12, pl. 6, fig. 2 (Nagasaki) and of various authors.

Genyoroge octovittata GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 180 (Île de France).

Mesoprion etaape LESSON, Voyage Coquille, 1830, p. 229 (Matavia, Beula; from Tahiti to Borabora).

Mesoprion pomacanthus BLEEKER, Nat. Tyd. Ned. Ind., vol. 6, 1855, p. 407 (Amboina).

Evoplites pomacanthus GILL, Proc. Acad. Nat. Sci. Phila., 1862, p. 234, name only.

Habitat.—East Indies and neighboring seas, north to Nagasaki, and Kagoshima in southern Japan.

Description.—Of a specimen 180 mm. in total length, from Fuga Island, Philippine Archipelago.

Head $2\frac{2}{3}$ in length to base of caudal, $3\frac{2}{3}$ in total; depth equal to head; maxillary $2\frac{1}{2}$ in head; longitudinal diameter of eye 4; width of preorbitals 6; snout 3; D. X, 15; A. III, 8; scales above lateral line in longitudinal series (counting transverse rows) 78; below 66; between lateral line and dorsal 9; between lateral line and anal 20.

Dorsal and ventral profiles evenly arched, save for the straight dorsal profile of head. Upper jaw slightly longer, the lower included; maxillary ending below anterior half of eye; teeth in outer rows of both jaws conical, with two canines of larger size placed anteriorly in the upper, remainder small; in lower jaw those of outer row largest posteriorly, but much smaller than canines of upper. Inner bands in both jaws of minute, bristle-like teeth, absent posteriorly in the lower. Teeth on vomer in a \wedge -shaped band; on palatines in narrow bands; teeth absent on tongue; preopercle with a prominent angular notch on its posterior margin, which is finely toothed above and coarsely below and on the rounded angle. Interopercle with large, bluntly-spinous knob, fitting into preopercular notch. Opercle ending in two flat points.

Fourth dorsal spine highest, $2\frac{3}{4}$ in head, remainder diminishing gradually in length, the last shorter than penultimate; second anal spine much longer than third, $2\frac{1}{2}$ in head, the third 3. Soft dorsal height one-half its length. Pectorals long, reaching a trifle beyond anus, $1\frac{1}{4}$ in head. Ventrals short, not reaching anus, $1\frac{7}{8}$ in head. Caudal slightly emarginate.

Scales ctenoid, present on basal half of soft dorsal and anal, and on outer rays of caudal nearly to their tips. Occiput behind center of eyes densely scaled, as is temporal region and cheeks behind center of eyes; interopercle, subopercle, and lower limb of preopercle scaled; scales on opercle 10 or 11 rows, on preopercle 7. Rows on body above lateral line oblique, those below horizontal.

Color in spirits yellowish brown; head dark on scaleless parts; four longitudinal stripes of bright blue bordered with black on body, their width one-fourth eye diameter; first extending from a point above eye to insertion of soft dorsal, second from upper margin of eye to center of soft dorsal, third from lower margin of eye to upper part of caudal, and fourth from snout to middle caudal rays; below fourth on head, an indistinct stripe, not extending on body, and an indistinct, diffuse blotch of dusky equal to eye present under first soft rays of dorsal.

This species, very common in the East Indian region, has been twice recorded from southern Japan, although no specimens were taken by Jordan and Snyder. As Bloch records from Japan his *quinquelineatus* or *quinquelinearis* (the latter name on the plate, the former on the description), it is not impossible that he had in hand the present species. The figure of *quinquelinearis* resembles *L. kasmira*, but Day has examined the type of Bloch's description, which he finds identical with *Lutianus caeruleolineatus* of Klunzinger. The species we have hitherto called *quinquelinearis* is widely different from *Lutianus kasmira*.

(*kasmira*, an Arabic name.)

5. LUTIANUS VITTA (Quoy and Gaimard).

KINSEIISAKI (new-fashioned Porgy); TARUMI.

Serranus vitta QUOY and GAIMARD, Voy. *Uranie*, vol. 2, 1824, p. 315, pl. 58, fig. 3 (Waigiu).—RICHARDSON, Ichth. China, 1846, p. 234 (Hongkong).—CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 239, and vol. 6, 1830, p. 505 (after Quoy and Gaimard).

Diacope vitta TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 13, pl. 6, fig. 4, (Nagasaki).

Mesoprion vitta BLEEKER, Verh. Bat. Gen. Kunst. Wet., vol. 22, 1849, p. 44 (Batavia); Not. Ichth. Ternate, Ned. Tyd. Dierk., 1863, p. 233 (Ternate); Verh. Kon. Akad. Wet., XIII, Révision Lutjani, 1873, p. 25.—KNER, Reise Novara, 1860, p. 37 (Java).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 207 (Hongkong, Amboyna, Molucca, Louisades, Port Essington).

Lutjanus vitta DAY, Fishes India, 1875, p. 46, pl. 14, fig. 2.—BLEEKER, Atlas Ichth., vol. 8, 1876, p. 51, pl. 60, fig. 3 (Sumatra, Singapore, Bangka, Biliton, Java, Bali, Celebes, Ternate, Amboyna, Ceram, Waigiu, Bawak, New Guinea).—STEINDACHNER and DODERLEIN, Fische Japans, Akad. Wiss. Wien, vol. 47, 1883, p. 28 (Tokyo).

Lutianus vitta JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 76.

Mesoprion phaioteniatus BLEEKER, Verh. Bat. Gen. Kunst. Wet., vol. 22, Perc., 1849, p. 43 (Batavia).—ISHIKAWA, Prel. Cat., 1897, p. 56 (Tokyo).

Mesoprion ophuyseni BLEEKER, Act. Soc. Scient. Ind. Neerl., vol. 8, Achste Bijdt. Vischf., Sumatra, 1859, p. 74 (Sumatra).

Habitat.—East Indies, common northward to Tokyo, in southern Japan.

Description.—Of numerous specimens from Wakanoura, Nagasaki, and Kobe, from 135 to 260 mm. in length.

Head $2\frac{5}{8}$ in length, $3\frac{1}{2}$ with caudal; depth of body equal to length of head; maxillary $2\frac{1}{4}$ in head; eye 4; interorbital space $4\frac{1}{3}$; suborbital width 6; snout 3; D. X, 13; A. III, 8; scales 53 in lateral line to base of caudal, 70 above, counting transverse rows, 56 counting oblique series, and 55 to 60 below in longitudinal series, 7 or 8 between dorsal and lateral line, 16 between lateral line and ventrals; 6 or 7 series on preopercle, 8 or 9 on opercle. Gill-rakers, 4 rudiments and 1 fully developed on upper limb of arch; 4 rudiments and 9 fully developed on lower; longest one-third diameter of eye. Branchiostegals 7.

Dorsal and ventral body profiles similar, the outline straight over eyes. Caudal peduncle depth $2\frac{2}{3}$, length from last anal rays $1\frac{5}{8}$ in head. Snout long, $1\frac{1}{2}$ times eye, pointed and conical, its tip at level of lower border of eye. Jaws subequal; maxillary ending slightly before center of eye, cleft of mouth rather oblique. Teeth in both

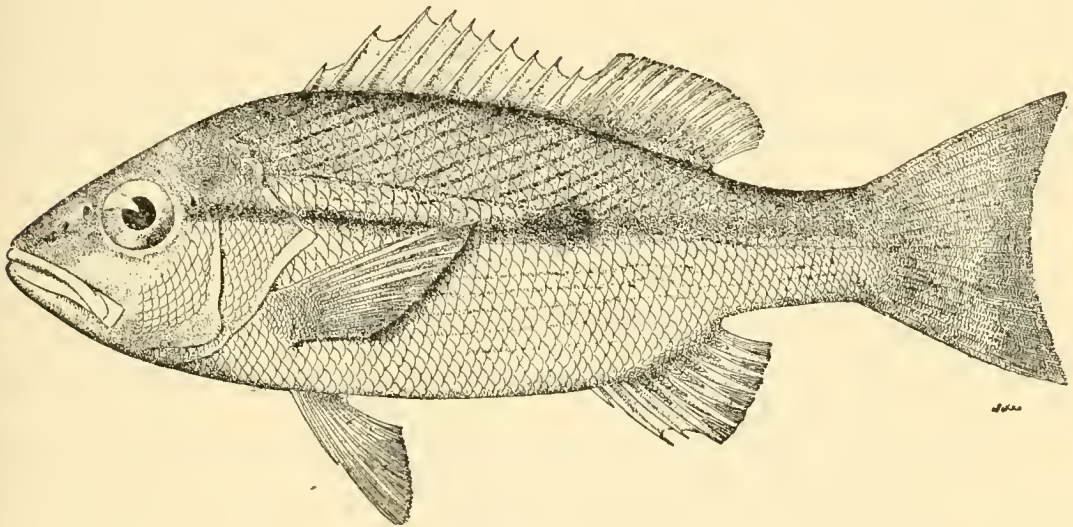


FIG. 2.—LUTIANUS VITTA.

jaws with larger external row, above with moderately large canine at either side, laterally much smaller conical teeth, below small anteriorly with canines on either side at middle of dentary; inner teeth in both jaws narrow, bristle-like bands, lacking posteriorly below; teeth on vomer in triangular patch with posteriorly projecting shaft; on palatines and tongue bands of similar, villiform teeth.

Preopercular margin notched, with slight knob on interopercle fitting into it, below more coarsely serrated than above. Opercle with two points, lower longer, upper short, triangular, rather stiff and pointed.

Dorsal spines longest in fourth and fifth, which are contained $2\frac{2}{3}$ in head. Longest dorsal rays $3\frac{1}{4}$ in head, fin margin rounded; second anal spine equal to or rather longer than third, the former contained $3\frac{1}{2}$ in head. Longest anal ray contained $2\frac{1}{2}$ in head. Pectorals and ventrals pointed, the former falcate, not reaching anus, contained $1\frac{1}{2}$ in head; latter $1\frac{2}{3}$ in head.

Scales ctenoid, present on posterior part of occiput and temporal region in continuation with those on posterior part of cheeks; interopercle and opercle scaled; snout, jaws, and interorbital space naked. Soft dorsal and anal scaled on basal two-fifths, caudal on basal half. Rows of scales above lateral line oblique, below horizontal.

Color in spirits darker above, silvery below, more or less red in life; a black lateral stripe running horizontally from snout to upper rays of caudal, less distinct before eyes and posterior to anus; below soft dorsal this stripe is widened to a diffuse blotch. No axillary blotch, a narrow streak following each row of scales, above level of pectoral, oblique above lateral line, and horizontal below. Fins colorless, dorsals and caudal darker than others. Peritoneum and lining of gill cavities pale.

This species is common in the markets of southern Japan. It was seen at Onomichi, Kawatana, Hakata, Kobe, Wakanoura, and Nagasaki, as well as at Tokyo and Misaki. It is known locally as Kinseiisaki, modern Isaki or porgy (as distinguished from the ancient or old-fashioned Koshiisaki, *Lutianus russelli*). Isaki is the name of the common *Parapristipoma trilineatum*. This species is also locally called *Tarumi*.

(*vitta*, stripe.)

6. LUTIANUS RUSSELLI Bleeker.

KOSHIISAKI (Ancient Porgy).

Lutjanus russelli BLEEKER, Verh. Bat. Gen. Kunst. Wet., vol. 22, Perc., 1849, p. 41 (Batavia).

Lutjanus notatus BLEEKER, Not. Ichth. Ternate, Ned. Tyd. Dierk., vol. 1, 1863, p. 233 (not of Cuvier and Valenciennes).

Lutianus russelli JORDAN and SEALE, Bull. U. S. Bur. Fish., vol. 26, 1906, p. 20 (Cavite, P. I.).

Lutjanus fulviflamma DAY, Fishes India, 1875, p. 41, pl. 12, fig. 5 (in part); (as var. *russelli*); Fishes India, Supplement, 1888, p. 783.—JORDAN and EVERMANN, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 343 (Keerun, Formosa); (not *Sciæna fulviflamma* of Forskål).

Mesoprion johnii ISHIKAWA, Prel. Cat., 1897, p. 56 (Kagoshima) (not of Bloch).

Lutianus quinquelineatus JORDAN and RICHARDSON, Bull. U. S. Bur. Fish., vol. 27, 1907, p. 258 (Manila, not of Bloch).

Lutianus fuscescens JORDAN and RICHARDSON, Mem. Carnegie Mus., vol. 4, 1910, no. 4, p. 184 (Takao, Formosa) (not of Cuvier and Valenciennes).

Lutianus nishikawæ SMITH and POPE, Proc. U. S. Nat. Mus., vol. 31, 1907, p. 474 (Hamashima).

Habitat.—East Indies, north to China and Japan. We have specimens from Kagoshima, Wakanoura, Tokyo, Misaki, Yokohama, and Shimezu (Suruga), Japan; Queensland, Australia; Cavite, Manila, and Puerta Princesa (Palawan), Philippine Islands; Takao and Keerun, Formosa; and from China, probably Shanghai.

Description.—Of adults and young, from 70 to 220 mm. in length.

Head $2\frac{2}{3}$ to $2\frac{5}{7}$ in body length, $3\frac{1}{2}$ in total; depth equal to head; maxillary $2\frac{1}{4}$ to $2\frac{1}{2}$ in head; eye $3\frac{1}{2}$ to $4\frac{1}{2}$; interorbital space $4\frac{1}{2}$; width of interorbital 5 to 6; snout $2\frac{1}{2}$ to 3; D. X, 14 or 15; A, III, 8 or 9; scales above lateral line 58 to 63, below 48 to 52; in transverse series from front of dorsal to anal $\frac{8}{16}$ or $\frac{9}{17}$.

Body rather deep, dorsal profile evenly and well arched, that of head straight or slightly concave. Snout somewhat pointed, not convex, its tip below lower margin of eye. Jaws subequal; maxillary ending below anterior half of eye. Teeth in both jaws larger externally, one or two moderately large canines on either side of upper jaw anteriorly, the remainder smaller; in lower jaw largest midway on either side; inner rows on both jaws rather narrow bands of bristle-like teeth, present only anteriorly in lower jaw; teeth on vomer in a rather anchor-shaped patch, on tongue in an oblong patch, on pala-

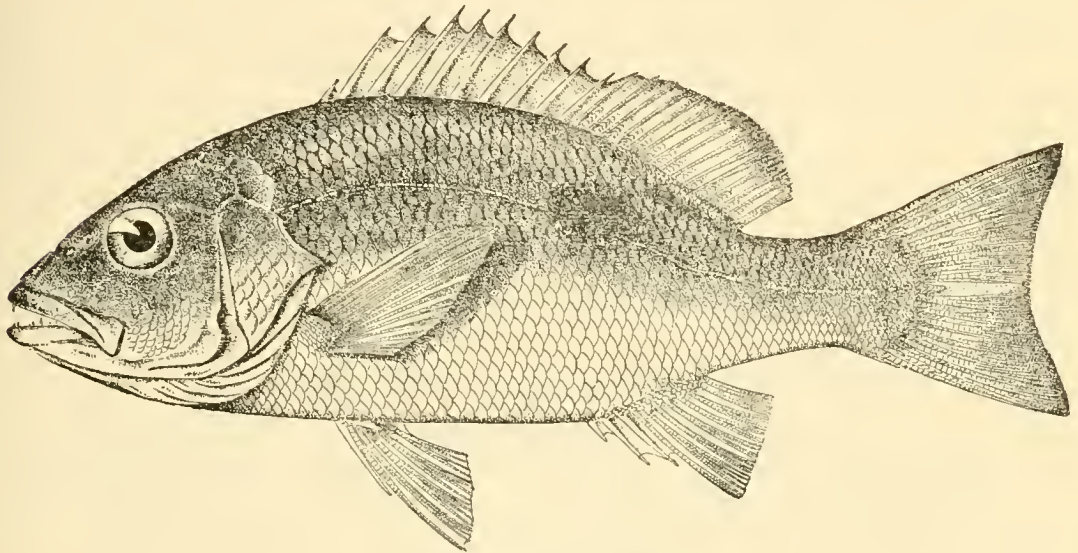


FIG. 3.—LUTIANUS RUSSELLI.

tines in narrow bands. Preopercular margin with moderately deep notch, its border finely serrated above, more coarsely below and on lower edge; interopercle with only indistinct prominence in the opercular notch.

Third and fourth dorsal spines longest, contained $2\frac{3}{4}$ in head, fifth only slightly shorter, last two subequal. Base of spinous dorsal $1\frac{1}{5}$ in head. Soft dorsal rounded, its base $1\frac{2}{3}$ in head, its rays not as long as dorsal spines. Pectorals $1\frac{1}{2}$ in head, not reaching anal. Ventrals acute, not reaching anus, half length of head. Anal spines strong, nearly equal in length, $3\frac{1}{2}$ in head; anal rays $1\frac{1}{3}$ times length of dorsal rays. Caudal slightly emarginate.

Scales less ctenoid on head than on body. Occiput scaleless posteriorly; temporal bands distinct, not connected with lateral, in 2 or 3 rows of about 10 each. Preopercle with 7 or 8 rows of scales, its lower limb scaleless; opercle with 6 or 7; interopercle with 1 or 2;

preorbitals scaleless. Soft dorsal and anal scaled on basal third, caudal nearly to tip on outer rays. Rows of scales above lateral line on body oblique, those below horizontal.

Body in spirits uniformly colored, olivaceous, lighter below; a large black blotch, its largest part above lateral line, below anterior part of soft dorsal, extending over eight scales longitudinally, and three or four transversely; around this an indistinct ocellation of lighter color. On axil of pectoral a small black spot. In young, four lateral longitudinal black stripes; first indistinct, near dorsal median line, ending at first dorsal spines; second distinct, from snout to middle of soft dorsal; third and fourth equally distinct, as broad as pupil and nearly twice as broad as second; third beginning at eye, passing through lateral blotch, and ending on upper half of base of caudal; fourth from below eye extending to lower half of base of caudal. These disappear with age, as shown conclusively by our series of specimens, and in adults are not to be seen. Color in life olive gray above, sides coppery red, axillary and lateral spots black; lower fins bright yellow, upper dark, tinged with red; upper scales with pearly spots. "Six or seven golden yellow streaks on body, upper four beginning at the orbit, first ending below dorsal spines, the rest below the dorsal rays, fifth from below the eye to the caudal, sixth and seventh from the maxillary to the caudal. These fading in spirits" (Bleeker).

Our young specimens are in all respects like those described by Smith and Pope as *Lutianus nishikawæ*, and these are undoubtedly the young of *L. russelli*. A careful comparison of measurements in hundredths of body length and of counts, as well as of shape and color, show no differences not due to age. The teeth on the tongue are apparently absent in very young specimens (of the size of the type of *L. nishikawæ*), but in slightly older specimens are barely distinct, as was noted by Bleeker.^a The lateral stripes gradually disappear with age, as remarked above. This species is obviously not that which Day described and figured as *L. chrysotænia*, as is shown by the smaller scales above the lateral line, 75, not 52, as quoted. Our specimens show less than 64 in every case.

Lutianus russelli is apparently distinct from *L. fulviflamma*, as shown by our numerous specimens of the latter from the Philippine Islands, differing in having a more arched back in the adult, a greater number of scales in transverse series, lower dorsal spines ($2\frac{1}{4}$ to 3 in body depth, not 2 to $2\frac{1}{2}$), 7 rows of scales on preopercle instead of 6, smaller eyes, and a greater part of the lateral blotch above the lateral line.

The specimens (in Stanford University) identified as *L. fulviflamma* by Jordan and Evermann from Keerun, Formosa, are undoubtedly

^aAtlas, vol. 8, p. 71.

L. russelli. The same is true of those identified as *L. fuscescens* by Jordan and Richardson from Takao, Formosa, and those identified by Jordan and Richardson as *L. quinquelineatus*, from Manila, Philippine Islands. That described as *L. russelli* by Jordan and Richardson from Cuyo, Philippine Islands,^a is undoubtedly *L. fulviflamma*, the identification apparently being based on the yellow stripes present in life, but which are found in *L. fulviflamma*, more as in the description given.^b All the above specimens are in Stanford University collections.

The specimen (cited by Day) in the British Museum from Amboyna as *Lutianus chrysotænia* is probably *L. russelli*, as it corresponds in most particulars with our young specimens.

Lutianus hoteen Richardson from Hongkong may be this species, in which case the name would have priority over *Lutianus russelli*. But it is more likely to be the same as *Lutianus fuscescens*, with which Günther, who has examined Richardson's specimens, has identified it.

This species is generally common in southern Japan and as far north as Tokyo, in company with *Lutianus vitta*.

(Named for Patrick Russell, the first student of the fishes of India.)

7. LUTIANUS ERYTHROPTERUS Bloch.

Lutianus erythropterus BLOCH, Ichthyologia, 1790, pl. 249 (Japan).—DAY, Fishes India, 1875, p. 32, pl. 10, figs. 1 and 2 (Japan, on Bloch's type; Red Sea; Pondicherry, on type of *Mesoprion rubellus* Cuvier and Valenciennes; not *L. erythropterus* of Bleeker).

Diacope sanguinea EHRENBERG in Cuvier and Valenciennes, Hist. Nat. Poiss., vol. 2, 1828, p. 437 (Massaua, Red Sea; types examined by Day).—BLEEKER, Verh. Bat. Gen. Kunst. Wet., vol. 22, Perc., 1849, p. 48 (East Indies).

Mesoprion rubellus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 475 (Pondicherry; types examined by Day).

Mesoprion annularis CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 484 (Java); vol. 3, p. 497.—GÜNTHER, Cat. Fish Brit. Mus., vol. 1, 1859, p. 204 (China, Australia).—KNER, Reise Novara, 1860, p. 33 (Java, Singapore).—GÜNTHER and PLAYFAIR, Fishes Zanzibar, 1866, p. 17 (Mozambique).—KLUNZINGER, Australian Fishes, 1879, p. 342.

Diacope annularis QUOY and GAIMARD, Voy. Astrolabe, 1834, p. 666, pl. 5, fig. 4 (Straits of Sunda).—RÜPPELL, Reise Nord. Afrika Atlas, 1828, p. 74 (Massaua, in Red Sea); Neue Wirbel., 1835, p. 91, pl. 24, fig. 2 (Massaua).

Lutjanus annularis BLEEKER, Ned. Tyd. Dierk. I. Deux. Not. Ichth., 1863, p. 240 (East Indies).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 76.

Mesoprion chirtah CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 488 (India, after *Chirtah* of Russell, 1803, pl. 93).

Mesoprion chirtah DAY, Proc. Zool. Soc., 1868, p. 150; 1869, p. 297.

Lutjanus chirtah BLEEKER, Nat. Verh. Kon. Akad., XIII, Révision Lutjani, 1873, p. 42 (Sumatra, Nias, Pinang, Singapore, Buitang, Bangka, Biliton, Java, Madura, Bali, Celebes, Batjan, Obi-major, Amboyna).—BLEEKER, Atlas Ichth., vol. 8, p. 58, Perc., 1876, pl. 23, figs. 1 and 2 (localities as above).

^aBull. U. S. Bur. Fish., vol. 27, 1907, p. 257.

^bBleeker's Atlas, pl. 344, fig. 3.

Lutjanus chriat BLEEKER (= *Mesoprion annularis* Cuvier and Valenciennes), Enum. Espèces Poiss. du Japon, 1879, p. 7 (Nagasaki) (misprint for *chirtah*).

Diacope erythrinus RÜPPELL, Neue Wirbel. 1835, p. 92, pl. 23, fig. 3 (Abyssinia).

Mesoprion erythrinus GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 199 (Red Sea, after Rüppell).—PLAYFAIR, Proc. Zool. Soc., 1867, p. 849 (types examined by Day).

Diacope metallicus (Kuhl and van Hasselt) BLEEKER, Nat. Gen. Arch. Ned. Ind., vol. 2, 1845, p. 525 (Batavia).

Habitat.—East Indian seas, recorded by Bloch and by Bleeker, from southern Japan. Both records must be regarded as doubtful.

Description.—Of three specimens from Sumatra and three from Manila, P. I., from 84 to 105 mm. in length.

Head $2\frac{1}{2}$ to $2\frac{2}{3}$ in body length to last vertebra, $3\frac{1}{2}$ in total; body depth $2\frac{1}{3}$ to $2\frac{1}{2}$ in body length, 3 in total; maxillary $2\frac{2}{3}$ in head; eye $3\frac{1}{2}$ to 4 (5 or 6 in adult, Day); interorbital space (bone), 5; suborbital width 5; snout 3; D. XI, 14; A. III, 8; scales in longitudinal series above lateral line 70 (56 oblique rows); in longitudinal series below 63; in lateral line 54; in transverse series, dorsal to insertion to ventrals 12/24; gill rakers 7 + 13; pyloric cæca 5 or 6.

Body compressed, deep; dorsal profile somewhat more convex than ventral; a slight concavity above orbit. Caudal peduncle from last anal rays to last vertebra $2\frac{1}{3}$ in head, its depth $2\frac{1}{2}$ to $2\frac{1}{3}$. Jaws subequal; maxillary ending under front margin of orbit or slightly before; on premaxillary one or two canines on either side, the inner pair if present, smaller; on both jaws an outer row of larger teeth, smallest on lower jaw; inner teeth of both jaws villiform or bristle-like, in narrow bands; on vomer an inverted V-shaped patch of villiform teeth; on palatines narrow bands, none on tongue. Gill rakers moderate in length, one-half diameter of eye in young. Preoperculum with shallow notch, margin finely serrated above, more coarsely below, and on horizontal border. No interopercular knob present. Subopercle broader than usual, one-third diameter of eye (in young).

Dorsal spines of moderate length and strength, fourth and longest $2\frac{2}{3}$ in head, remainder slightly less; tenth, the penultimate, being $2\frac{1}{2}$ in head. Dorsal rays longest in sixth and seventh, which are 2 in head. Longest anal spine third, contained $2\frac{2}{3}$ in head, but weaker than second; longest anal ray 2 in head. Pectoral and ventral length $1\frac{2}{5}$ in head, former reaching to and latter past anus. Spinous dorsal base 3 in body length to last vertebra, soft dorsal base $4\frac{1}{2}$, anal base 6. Caudal slightly emarginate.

Scales ctenoid. Bases of soft dorsal and anal scaled to a third of their height, on caudal over basal half. Rows on body oblique above and horizontal below lateral line. Occiput scaleless in posterior part, save for temporal rows, which are in 1 or 2 series of about 7 scales each. On preopercle 6 rows, on opercle and subopercle 9 rows, the lowermost with 10 scales.

Color in spirits dark, with indistinct lines on rows of scales, a broad, dark stripe through eye from snout to insertion of dorsal, a black spot on either side of caudal peduncle, merging on its upper surface, and bordered anteriorly and posteriorly with a lighter band. Dorsals and anal dusky, ventrals black at tip, pectorals and caudal clear.

Day, who saw Bloch's types, said to be from Japan, and who possessed a large series of the species from India, observes that the soft portion of the dorsal is more angular in adults than in young, and that the color also changes. The following is the substance of his description of the color in life: ^a Color crimson, with orange reflections; a broad blackish band passes from eye to insertion of dorsal, sometimes slightly apparent along whole base of fin; eight to twelve narrow and nearly horizontal black lines exist below the lateral line and several more above it, some being the continuations of those which commence below the lateral line; a black band crosses over back of free portion of tail, having a white one before it, a narrow pink one posterior; pectoral flesh colored; ventral either black, or stained black in its outer half or two-thirds; dorsal dark gray, in some specimens with a nearly black base and black edge; caudal pink, with narrow black border; anal darkest anteriorly. In adults (12 inches) black lines disappear, and each row of scales has a golden line; a trace exists of band from eye to dorsal fin, while that over the free portion of tail is somewhat indistinct.

(ἔρυθρός, red; πτερόν, fin.)

8. LUTIANUS RIVULATUS (Cuvier and Valenciennes).

FUYEDAI (Flute-player Porgy).

Diacope rivulata CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 414, pl. 38 (Coromandel, Pondicherry).—KLUNZINGER, Syn. Fische Rothen Meeres, Verh. Zool. Bot. Ges. Wien, vol. 2, 1870, p. 694 (Red Sea).—SAUVAGE, Poissons de Madagascar, 1891, p. 104 (Madagascar).

Genyoroge rivulata GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 182 (China, Amboyna, Red Sea).—GÜNTHER and PLAYFAIR, Fishes Zanzibar, 1866, p. 16 (Aden, Zanzibar).

Lutjanus rivulatus BLEEKER, Nat. Verh. Akad. Roy. Neer. Sci., XIII, Lutfani, 1873, p. 81.—BLEEKER, Atlas Ichth., vol. 8, 1877, p. 73, pl. 347, fig. 3 (Sumatra, Java, Bawean, Bali, Celebes, Timor, Batjan, Buro, Amboyna, Waigiu).—DAY, Fishes India, 1875, p. 37, pl. 11, fig. 4.—STEINDACHNER and DODERLEIN, Denkschr. Akad. Wiss. Wien, vol. 47, 1883, p. 28 (Japan).—JORDAN and RICHARDSON, Mem. Carnegie Museum, vol. 4, 1910, no. 4, p. 184 (Takao, Formosa).—JORDAN and SEALE, Bull. U. S. Bur. Fish., vol. 25, Fishes Samoa, 1905, p. 262 (Apia).

Mesoprion rivulatus KLUNZINGER, Fische Rothen Meeres, 1884, p. 12 (Red Sea).

Diacope cæruleopunctata CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 424 (after Russell, Balee-mace, pl. 96).

Mesoprion cæruleopunctatus BLEEKER, Percoid, Nat. Tyd., Ned. Ind., vol. 2, 1851, p. 169 (Padang).

Genyoroge cæruleopunctata GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 182 (Coromandel, Padang, Sumatra).—DAY, Fishes Malabar, pp. 7, 9.

Lutjanus ceruleopunctatus BLEEKER, Ned. Tyd. Dierk, vol. 2, 1863, p. 278 (Amboyna).

Diapocoe alboguttata CUVIER and VALENCIENNES, Hist. Nat. Poiss, vol. 7, 1831, p. 445 (Malabar).

Mesoprion myriaster LIÉNARD, Nat. Hist. Soc. Mauritius, 1839, p. 32 (according to Day and Bleeker).

Habitat.—East Indian seas, said to range northward to Japan.

Description.—Of two small specimens 70 and 85 mm. long from Naha, Okinawa, Riu Kiu Islands; specimens from Padang, Sumatra, and from Pago Pago, Samoa, the latter largest, 26 cm. in length.

Head $2\frac{1}{2}$ to $2\frac{2}{3}$ in body length, 3 to $3\frac{1}{3}$ in total; depth $2\frac{1}{3}$ to $2\frac{4}{7}$ in body; eye $3\frac{1}{2}$ to $4\frac{2}{3}$; maxillary $2\frac{1}{4}$ to $2\frac{1}{3}$; interorbital space (bone) 5; suborbital width 4 to 6 (narrowest in young); snout $2\frac{1}{2}$ to 3; D. X, 15; A. III, 8; scales above lateral line 55 to 60; below 50; in lateral line 50; in transverse series from insertion of dorsal to lateral line 8 or 9, from lateral line to anal insertion 18 or 19.

Body deep, back strongly arched, especially in adults. Dorsal profile of head straight, greatest curve of back at occiput and nape. Snout not very pointed, its tip much below lower border of eye in adult, not in young. Jaws subequal, maxillary ending below anterior half of eye; small canines present on either side of premaxillaries; outer rows of both jaws enlarged, inner villiform bands; vomerine teeth in \wedge -shaped patch; tongue toothless; palatine teeth in narrow bands. Lips thick, papillate on inner side. Preopercle with moderate narrow notch, and interopercle with knob fitting into it. Margin of preopercle finely serrate above, more coarsely below, especially in young. Opercle with two points, the upper very short.

Dorsal spines strong, third longest, $2\frac{1}{2}$ in head. Spinous base 3 in body. Dorsal rays $2\frac{1}{3}$ in head; soft dorsal base $4\frac{1}{2}$ in body; its margin rounded or slightly pointed; anal spines stout, second longer than third, $2\frac{1}{5}$ in head; anal fin angulate; third ray longest 2 to 3 in head, reaching beyond last vertebra. Pectoral long, $1\frac{1}{5}$ in head, somewhat falcate. Ventrals pointed, reaching the anus, but with filaments which extend beyond. Caudal somewhat emarginate.

Scales above lateral line parallel to it as far back as fifth spine of dorsal, then oblique until last of soft dorsal. Rows below horizontal. Scales on opercle in 9 rows; on preopercle 6, in a broad band on its anterior edge, the posterior and lower limbs scaleless. Interopercle with 1 or 2 series. Temporal scales in 2 or 3 series, unconnected dorsally, larger than those on opercles. Soft dorsal and anal scaled on basal thirds, spinous dorsal with a shallow sheath at base, and a series running up anterior edge of each spine as far as on soft dorsal.

Color of young specimens in spirits rather dark, paler ventrally; dorsal surface of head crossed by six narrow dark transverse lines, not visible on sides of head and cheeks, as they later become when adult; on body a transverse bar of black, as wide as pupil, running through point of opercle, fading out below, and fainter dorsally on

line of back; three pairs of indistinct narrow lines equidistantly placed between anterior line and base of caudal peduncle, those of each pair separated by width of pupil, and anterior ones less indistinct than posterior, but all fading out on ventral surface; a diffuse short line at last rays of dorsal; on lateral line, beneath first dorsal rays, a black blotch, half size of eye, with a narrow milk-white spot immediately behind, and a continuation of the black spot posteriorly, the whole covering ten scales of a longitudinal series; ventrals black on distal halves, other fins dusky. Steindachner and Doderlein give the following description of the color of an adult specimen 42 cm. long: Color of back brownish green, clearer ventrally; head dark violet dorsally, a blue, sinuous stripe under the eye; on scales of upper part of body only a very few blue spots; under base of first dorsal ray a slender, milk-white spot with a light stripe of pale red immediately over the lateral line.

The changes which apparently take place between the young and adult are disappearance of the transverse stripes, appearance of the numerous sinuous narrow lines on the cheeks, and of the spots on the scales above the lateral line, which Steindachner's specimen showed only in a few places, as well as a change in contour of head and depth of opercular notch. The band of scales on the preopercle apparently is less broad in adults.

This species of the South Seas is rare in southern Japan. It was first recorded by Steindachner and Doderlein without definite locality. We have before us numerous young examples collected at Tanegashima, off the coast of Kiusiu, by Professor Snyder. According to Doctor Ishikawa, the fish is known as Fuyedai; fuye, a flute player, and tai, a porgy.

(*rivulatus*, with winding streaks like rivulets.)

9. LUTIANUS VAIGIENSIS (Quoy and Gaimard).

DiaCOPE vaigiensis QUOY and GAIMARD, Voyage *Uranie*, 1824, p. 307 (Waigiou) (not *Mesoprion vaigiensis* Günther).

DiaCOPE marginata CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 425 (Pondicherry).—PETERS, Wieg. Arch., 1855, p. 238.

Mesoprion marginatus BLEEKER, Ichth. Amboyna, Tyd. Ned. Ind., vol. 5, 1852, p. 555.—KNER, *Novara* Fische, 1860, p. 31 (Tahiti, Sydney).—GÜNTHER, Fische Südsee, 1873, p. 13, pl. 14 (Polynesia).

Genyoroge marginata GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 181 (Ceylon, Amboyna, Louisades, Coast of Mozambique).

Lutjanus marginatus BLEEKER, Ichth. Halmaheira, Ned. Tydss. Dierk., vol. 1, 1863, p. 155; Nat. Verh. Acad. Roy. Neer. Sci., XIII, Revision Lutjani, 1873, p. 72; Atlas Ichth., vol. 8, 1876, p. 69 (Sumatra, Cocos, Java, Bali, Celebes, Sangi, Timor, Halmaheira, Ternate, Batjan, Obi-major, Buro, Ceram, Amboyna, Banda, Waigiou, New Guinea).—STEINDACHNER and DODERLEIN, Fische Japans, 1883, p. 28 (Kagoshima).

Lutianus marginatus JORDAN and SNYDER, Check-List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 76.—JORDAN and SEALE, Bull. U. S. Bur. Fish., vol. 25, 1905, p. 263 (Apia, Samoa).

DiaCOPE calveti TEMMINCK and SCHLEGEL, Fauna Japonica, Poiss., 1843, p. 14 (Nagasaki, not of Quoy and Gaimard).

Mesoprion gaimardi BLEEKER, Act. Soc. Sci. Ind. Neerl., vol. 6, 1859, p. 23 (Waigiou).

DiaCOPE xanthopus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 3, 1829, p. 495 (Trinquemali).

DiaCOPE axillaris CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 532 (Indian Seas).

Mesoprion kagoshimæ Doderlein Ms. in STEINDACHNER and DODERLEIN, Fische Japans, 1883, p. 28 (Kagoshima).

Habitat.—East Indian Seas, north to Kagoshima in southern Japan.

Description.—Of a specimen 14 mm. in total length, from Okinawa, Riu Kiu Islands, with numerous specimens from Apia, Samoa, and one from Keerun, Formosa.

Head $2\frac{1}{2}$ to $2\frac{3}{4}$ in body to last vertebra, $3\frac{1}{3}$ to 4 in total, depth $2\frac{1}{2}$ to $2\frac{3}{4}$ in body; maxillary $2\frac{1}{3}$ to $2\frac{2}{3}$ in head; longitudinal diameter of eye

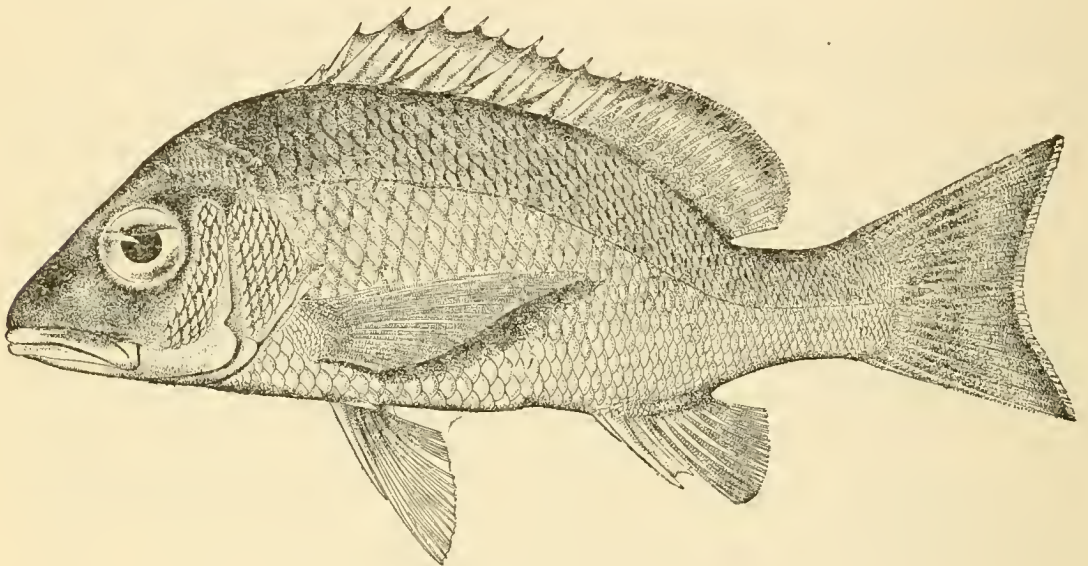


FIG. 4.—LUTIANUS VAIGIENSIS.

$3\frac{1}{2}$ to 4; interorbital space (bone) 5 or 6; width of preorbitals 5 to $5\frac{1}{2}$; snout $2\frac{1}{2}$ to $2\frac{3}{4}$ ($1\frac{1}{3}$ eye); D. X, 13 or 14; A. III, 8 or 9; scales above lateral line 58 to 65; below 49 or 50; in transverse series from insertion of dorsal to anal 8/15 or 16; pyloric caeca 7 (Kner).

Head somewhat conical; its dorsal profile straight or slightly convex. Jaws equal; maxillary ending below anterior half of eye or below pupil; tip of premaxillary below level of lower border of orbit. Teeth in both jaws larger externally, a small canine on either side of premaxillary, inner teeth in villiform bands, present anteriorly only in lower jaw. Vomerine teeth in a \wedge -shaped patch; palatine bands narrow; tongue without teeth; notch on preopercle moderately deep, with correspondingly strong knob on interopercle. Margin of preopercle finely serrated above, more coarsely and stronger below and on angle.

Dorsal spines strong, fourth longest, and contained $2\frac{1}{2}$ to $2\frac{3}{4}$ in head; base of spinous dorsal $3\frac{1}{3}$ in body length, soft dorsal base $4\frac{1}{2}$ or 5.

Second anal spine longest $2\frac{1}{2}$ or $2\frac{3}{4}$ in head, third 3 in head; margin of anal fin angulate, as is soft dorsal posteriorly to a less degree. Pectoral equal to head less one-third length of snout, not reaching past anal insertion. Ventrals extending to anus. Caudal emarginate.

Scales on body in oblique rows above lateral line, horizontal below, present on basal third of soft dorsal and anal. Dorsal surface of head scaleless, save for rather broad temporal bands, in four or five series, of which the posterior are very small, the anterior larger; temporal bands separated from lateral scales of head, but narrowly. Preopercle with 6 or 7 rows of scales, opercle with 8 or 9; limb of preopercle scaleless; interopercle with one or two rows; preorbitals scaleless.

Body in spirits dark, slightly paler below; dorsal and caudal very narrowly edged with yellowish white, with a submarginal band of black on dorsal; caudal nearly black, the margin pale; anal colored as is body; pectorals and ventrals colorless. The following is a translation of Bleeker's description of the life colors: The color of the body is reddish, paler below, each series of scales with a broad yellow or golden stripe, oblique above lateral line, horizontal below. Dorsal spines with a broad black or dusky margin. Margin of soft dorsal, anal and caudal yellow, with deep violet or black submarginal area, the remainder reddish. Day remarks that his specimens from the Malabar coast of India frequently have a black lateral blotch.

There seems to be no reason to doubt the pertinence of the name *vaigiensis* to this species. Quoy and Gaimard note the yellow fins with dark submarginal stripe, and the oblique streaks along the rows of scales of the body.

A stuffed skin from Nagasaki is recorded by Temminck and Schlegel, who identify it very doubtfully with *Diacope calveti* Cuvier and Valenciennes, which is *Lutianus timoriensis* of Quoy and Gaimard.

In all probability this specimen, which is compared with Quoy and Gaimard's rough figure, belonged to *Lutianus vaigiensis*, and *L. timoriensis* = *L. calveti* should be erased from the list of nominal species of Japan.

(*vaigiensis*, living about Waigiou.)

5. Genus PRISTIPOMOIDES Bleeker.

Chatopterus TEMMINCK and SCHLEGEL, Fauna Japonica, Poissons, 1843, p. 78 (not *Chatopterus* of Cuvier, 1830, a genus of worms).

Pristipomoides BLEEKER, Tyd. Ned. Ind., vol. 3, 1852, p. 574 (*typus*).

Platyinius GILL, Proc. Acad. Nat. Sci. Phila., 1863, p. 237 (*vorax* = *macrophthalmus*).

Bowersia JORDAN and EVERMANN, Bull. U. S. Fish Comm., vol. 22 (for 1902), 1903, p. 183 (*violescens*).

Ulaula JORDAN and THOMPSON; new subgenus; type, *Bowersia ulaula* Jordan and Evermann; substitute for *Chatopterus*, preoccupied.

Body oblong or rather elongate, compressed, covered with moderate sized scales. Skull as in *Aprion* and *Etelis*, the occipital crest

sharply set off from the cranium, on which it does not encroach; cranium broad and flattish above; mouth moderate, with canine teeth, which may be fairly large, or may be very small. Teeth on vomer and palatines and sometimes on tongue. Dorsal fin continuous; last soft ray of dorsal and anal produced; no scales on dorsal and anal; caudal forked; pectoral falcate, not shorter than head, the lower rays not produced.

This genus, as here understood, lies very close to *Aprion*, which differs mainly in the subcylindrical body, larger teeth, and especially in the very short and broad pectoral fin, which is about half head. In *Pristipomoides* the species with the deeper body have the pectoral fins most elongate.

In the closely allied genus, *Rooseveltia*, the cranium is narrower and with thickened ridges. *Apsilus* and *Tropidinius* have the skull of *Lutianus*, with the fins of *Pristipomoides*, the occipital crest being extended on the frontal region. These genera must be considered as allies of *Lutianus* rather than of *Aprion*.

The species of *Pristipomoides* differ considerably among themselves, and the group may admit of further generic subdivision. Bleeker unites all of these nominal genera to *Aprion*.

The recognizable subgenera may be thus compared:

Pristipomoides: Canine teeth strong; body elongate; pectoral falcate, but relatively short; no teeth on tongue (approaching *Aprion*).

Platyinius: Canine teeth moderate or strong; body compressed, not elongate; pectoral falcate, very long; no teeth on tongue.

Bowersia: Canine teeth weak; body compressed, elongate; pectoral long and falcate; no teeth on tongue.

Ulaula = *Chætopterus*, name preoccupied): Canine teeth very weak; body compressed, elongate; pectoral falcate; tongue with a patch of teeth.

(*Pristipoma* = *Pomadasis*, a genus of *Hæmulidæ*; εἶδος, resemblance.)

a¹. PLATYINIUS. Canine teeth rather strong, body compressed; pectoral long, falcate; no teeth on tongue;

b. Depth $2\frac{9}{10}$ in length; dorsal rays X, 11, anal III, 8; scales 10-50-15. .*sparus*, 10.

a². ULAULA. Canine teeth feeble; body elongate, compressed; pectoral elongate; tongue with a patch of teeth;

c. Depth $3\frac{1}{2}$ in length; dorsal rays X, 11; A. III, 8; scales 8-70-14. .*sieboldii*, 11.

10. PRISTIPOMOIDES SPARUS (Temminck and Schlegel).

Diacope sparus TEMMINCK and SCHLEGEL, Fauna Japonica, Poissons, 1843, p. 14 (Nagasaki).

Mesoprion sparus GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 188 (after Temminck and Schlegel).

Lutianus sparus BLEEKER, Enum. Espèces Poiss. du Japon., Acad. Roy. Neer. Sci., vol. 18, 1879, p. 7.

Platyinius sparus JORDAN and EVERMANN, Proc. U. S. Nat. Mus., vol. 25, 1903, p. 344, fig. 16 (Formosa).

Habitat.—Known from Formosa and southern Japan.

Description (after Jordan and Evermann).—Of a specimen from Formosa.

Head 3; depth 2.9; eye 3.2; snout 3.5; maxillary 2.25; mandible 1.9; interorbital 4; preorbital 6.25; D. X, 11; A. III, 8; scales 10–50–15; gill rakers $x + 12$.

Body rather short, deep and compressed; dorsal and ventral outlines gently arched, occipital region slightly depressed; head large; mouth large, somewhat oblique, the lower jaw slightly the longer; maxillary broad, slipping for its entire length under broad preorbital; eye large; nostrils very small; preopercle strongly serrate at angle, scarcely notched, with fine long cirri; preorbital not as broad as eye; two strong canine teeth in front of each jaw, besides smaller lateral

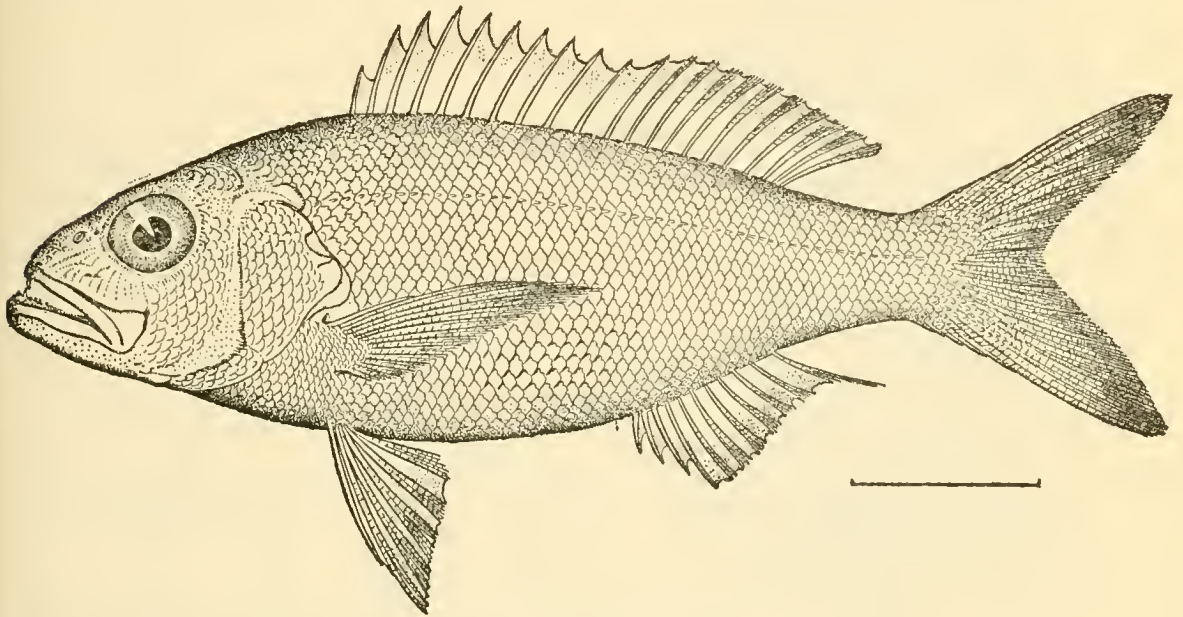


FIG. 5.—PRISTIPOMOIDES SPARUS.

canines; teeth on vomer in small V-shaped patch; no teeth on tongue. Gill rakers long.

Longest dorsal spine 2.75 in head, ray 2.75; last ray of dorsal and anal produced; pectoral length 1.25 in head; ventral 1.7; caudal deeply forked.

Scales small, nearly cycloid; cheek and opercle scaled, caudal fin scaled at base. No scales at base of dorsal or anal fins; bands of scales at the temples separated from those behind it; scales above lateral line in series parallel to it, six rows of scales on cheek.

Color, apparently bright red, now faded to silvery; cheeks bright silvery. This species is doubtless rare in Japan. We have seen no examples save this one from Formosa, now returned to the Imperial Fisheries School in Tokyo.

(*sparus*, a related genus, which this fish resembles.)

11. PRISTIPOMOIDES SIEBOLDII (Bleeker).

Chaetopterus TEMMINCK and SCHLEGEL, Fauna Japonica, 1843, p. 78, pl. 37, fig. 2 (Nagasaki).

Chaetopterus sieboldii BLEEKER, Nalez. Ich. Japan, 1857, p. 20, no. 146 (after Temminck and Schlegel).—REGAN, Ann. Mag. Nat. Hist., ser. 7, vol. 16, 1905, p. 18 (Inland Sea of Japan).

Aprion sieboldii BLEEKER, Enum. Espèces Poiss. du Japon, Acad. Roy. Neer. Sci., p. 7, 1879 (*Aprion sieboldii* Bleeker=*Chaetopterus sieboldii* Bleeker).—JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, pts. 2 and 3, 1901, p. 76 (Nagasaki, after Temminck and Schlegel).

Chaetopterus dubius GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 385 (after Temminck and Schlegel).—JORDAN and SNYDER, Bull. U. S. Bur. Fish., vol. 26, 1906, p. 213 (Honolulu, Fukaura, Japan).—JORDAN and SEALE, Bull. U. S. Bur. Fish., vol. 25, 1905, p. 269.

Aprion microdon STEINDACHNER, Ichth. Beitr., vol. 5, 1876, p. 158 (Hawaii).

Bowersia ulaula JORDAN and EVERMANN, Bull. U. S. Fish. Comm., vol. 23, 1903, p. 238, fig. 98 (Hilo, Hawaii).

Habitat.—Southern Japan; Hawaii.

This species is apparently rare in Japan. Jordan and Snyder obtained one example from Fukaura. This was compared carefully with the types of *Bowersia ulaula* from Hawaii, and no specific differences were noted.^a This specimen from Fukaura has been mislaid, and at present we have only Hawaiian examples for comparison. These are cotypes of *Bowersia ulaula*.

Regan described a specimen from the Inland Sea of Japan, 230 mm. in length. The following is the substance of his account:

Head $3\frac{3}{5}$ in length; depth $2\frac{4}{5}$; eye $3\frac{1}{4}$ in head; interorbital width $2\frac{2}{3}$; snout shorter than eye; D. X, 10; A. III, 8; scales in longitudinal series 72, in transverse 8/19. Gill rakers $x + 20$.

Body ovate, moderately compressed; mouth oblique; jaws equal anteriorly; maxillary exposed, without supplemental bone, extending to below anterior one-fourth of eye; width of its distal extremity two-fifths diameter of eye; premaxillaries protractile; preorbital narrow. Small villiform bands of teeth in jaws, vomer, and palatines; both jaws with a moderately enlarged outer series of teeth and with 2 or 3 moderate canines on each side anteriorly. Preopercle rounded and slightly produced at angle, with radiating ridges and crenulate margin; operculum with two spines. Pseudobranchiæ well developed; gill rakers as long as gill fringes.

Dorsal spines increasing in length to fourth, which is nearly one-half length of head, the last a little more than one-third length of head. Pectoral falcate, with 17 rays, longer than head, extending to above origin of anal. Ventrals commencing a little behind pectorals, extending to vent. Caudal deeply forked.

Lateral line concurrent with dorsal profile; scales lacking on interorbital region, snout, jaws, suborbitals, and preopercle; rest of head

^a Bull. U. S. Bur. Fish., vol. 23, p. 213.

scaly. Cheek with six series of scales; dorsal and anal fins scaleless. Caudal covered with scales except near posterior margin. Scales finely denticulated.

This description differs from our Hawaiian specimens in the shorter, wider head, and especially in the larger number of scales below the lateral line. It is, however, in all probability the same fish. If, however, it is shown that these distinctions are permanent, the Hawaiian fish, described below, will stand as *Pristipomoides microdon*.

Description.—Of a specimen 360 mm. in length, from Honolulu, Hawaii, co-type of *Bowersia ulaula*.

Head $3\frac{1}{2}$ in body; depth $3\frac{1}{2}$ in length; eyes $3\frac{1}{2}$ in head; snout $3\frac{1}{2}$; maxillary 3; mandible $2\frac{1}{4}$; interorbital $3\frac{1}{2}$; preorbital 9; D. X, 11; A. III, 8; scales 8-70-16 (to middle line of belly 10+); gill rakers 20.

Dorsal outline of body a low, gentle curve, ventral similar. Head bluntly conic; interorbital space broad and only slightly convex; preorbitals very narrow, ending before anterior margin of pupil; jaws equal; maxillary ending under anterior margin of eye, slipping for most of its length under preorbitals. Preopercular margin serrate, more coarsely at margin, its angle slightly produced; opercle ending in two obscure flat spines. Teeth in villiform bands on jaws, vomer, palatines, and tongue, those in outer series of jaws scarcely enlarged. Gill rakers $2\frac{1}{2}$ in eye, rather stout.

Dorsal fin continuous; spines flexible, fourth longest, $2\frac{1}{2}$ in head; first half length of fourth; last $3\frac{1}{2}$ in head; dorsal rays little higher than spines, last half again as long as remainder; anal spines short,

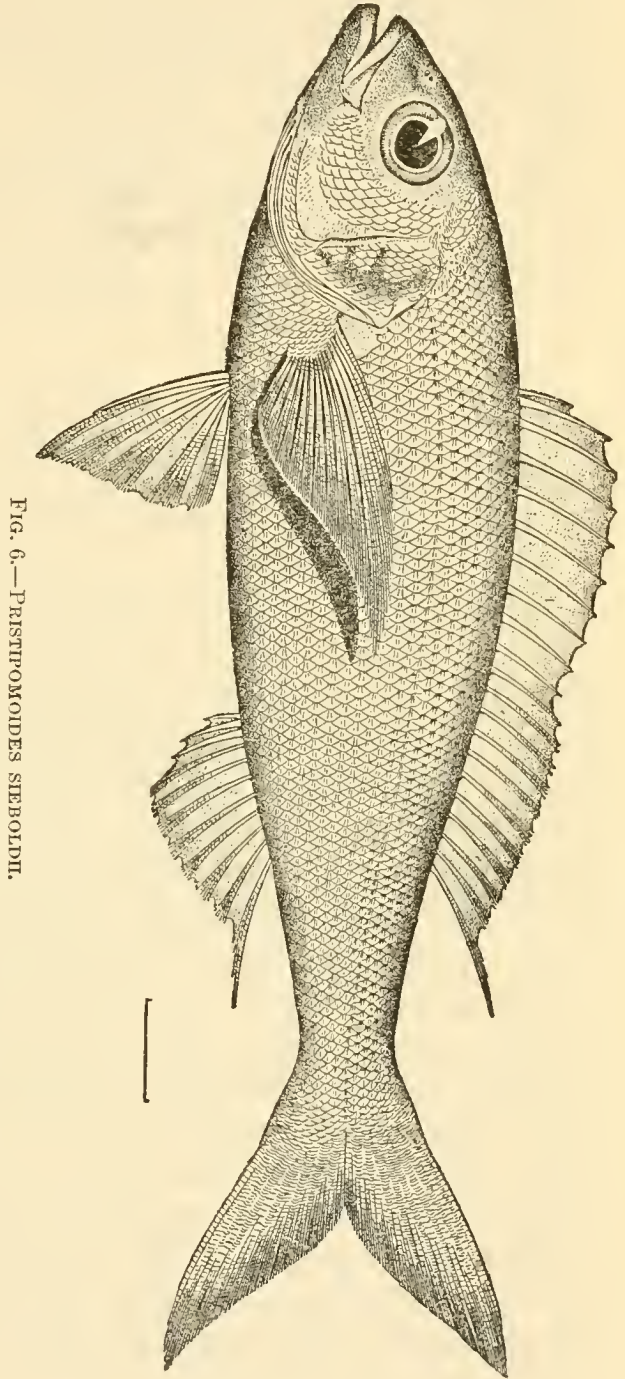


FIG. 6.—PRISTIPOMOIDES SIEBOLDII.

weak, second slightly shorter than third, which is $4\frac{1}{3}$ in head; soft anal similar to soft dorsal, its last ray similarly produced. Pectoral long, equal to head, falcate; ventrals reaching half way to insertion of anal, $1\frac{4}{5}$ in head. Caudal deeply forked, lobes equal.

Scales ctenoid, rows parallel above and below lateral line; present on opercles in 13 rows, on cheek in 6 rows, limbs of preopercle naked, as is preorbital ring, and head, save for temporal bands, when the scales are in four series of five or six each. Dorsals and anal naked, caudal densely scaled.

Color of an old alcoholic specimen uniform silvery, purplish in life; dark purplish, paler below; each scale on sides and back with a central darker spot, forming indistinct lines; fins pale.

(Named for Philipp Friedrich von Siebold, of Leyden, an associate of Professor Schlegel.)

6. Genus ETELIS Cuvier and Valenciennes.

Etelis CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 127 (*carbunculus*).

Elastoma SWAINSON, Nat. Hist. Fishes, vol. 2, 1839, pp. 168, 202 (*oculatus*).

Hesperanthias LOWE, Fishes of Madeira, 1843, p. 14 (*oculatus*).

Macrops DUMÉRIEUX, Ichth. Analytique, 1856, p. 279 (*oculatus*).

Body elongate, covered with large scales; eye very large; preorbital very narrow; mouth moderate, the lower jaw projecting; maxillary scaly; canines in upper jaw only; no teeth on tongue or pterygoids; gill rakers long and slender. Dorsal fin deeply notched, rather short, its spines 10 in number, its soft rays not scaly; caudal very deeply forked, the upper lobe produced in the adult; pectoral fin falcate, the lower rays not produced; last rays of dorsal and anal produced; head naked above; skull with the interorbital area flat, separated from the occipital area by a transverse line, limiting the median and also the lateral crests; frontals wide in front, not cavernous, simply normally perforate; supraorbital margins crenate; periotic region little convex and with the bones thick, unpolished; prefrontals behind, with funnel-shaped foramina. The relationships of this genus have been repeatedly misunderstood, but, as Gill has shown, it belongs in the Lutianidae and has no special affinity with *Anthias*, *Perca*, or *Serranus*. In spite of the difference in the form of its dorsal, the relations of *Etelis* with *Aprion* are very close. The skulls in the two are almost identical, as has already been noticed by Poey and Gill. The genus probably contains but one species, a brilliantly crimson fish, beautiful in form and color, and widely distributed in the warm seas.

(ἔτελις, *Etelis*, a name used by Aristotle for some fish not now recognized.)

NOTE ON ETELINUS, NEW GENUS.

Type—*Etelis marshi* Jenkins.

In the species called *Etelis marshi* Jenkins, from Hawaii, the caudal is simply forked, the lobes being relatively short. This species should be the type of a distinct genus, which may be called *Etelinus* Jordan, defined by the less elongate form and the simply lunate caudal fin.

Etelinus marshi bears a superficial resemblance to the genus *Doderleinia*, formerly called *Eteliseus*. *Etelinus*, like *Etelis*, lacks the supplemental maxillary and opercular spines. These are present in *Doderleinia*.

12. ETELIS CARBUNCULUS Cuvier and Valenciennes.

ONBUTSU (Male Mutsu.)

Etelis carbunculus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 127, pl. 18 (Seychelles).

Etelis carbunculus JORDAN and SNYDER, Check List, Ann. Zool. Jap., vol. 3, 1901, p. 77 (after *Serranus oculatus* Temminck and Schlegel).

Serranus oculatus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 2, 1828, p. 266, pl. 32 (Martinique).—TEMMINCK and SCHLEGEL, Fauna Japonica, Poissons, 1843, p. 5 (Nagasaki).

Hesperanthias oculatus LOWE, Fishes Madeira, 1843, p. 14 (Madeira).

Centropristis oculatus MÜLLER and TROSCHEL in Schomburgk, Hist. Barbados, 1848, p. 666 (Barbados).

Macrops oculatus DUMÉRIL, Ichth. Analytique, 1856, p. 279.

Anthias oculatus GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 92.

Etelis oculatus GILL, Proc. Acad. Nat. Sci. Phila., 1862, p. 447.—STEINDACHNER and DODERLEIN, Beitr. Fische Japans, I, Akad. Wiss. Wien, vol. 47, 1883, p. 15 (Tokyo).—JORDAN and SWAIN, Proc. U. S. Nat. Mus., 1884, p. 468 (Martinique, Madeira, Barbados, Jamaica, Cuba).—JORDAN and FESLER, Sparoid Fishes, p. 457.—JORDAN and EVERMANN, Fishes North and Middle America, vol. 2, 1898, p. 1282, pl. 201, fig. 524.

Etelis evurus JORDAN and EVERMANN, Bull. U. S. Fish Comm., vol. 23, p. 184, for 1902 (1903) (Hilo).—JORDAN and EVERMANN, Bull. U. S. Fish Comm., vol. 23, p. 242, for 1903 (July, 1905) (Hilo and Honolulu).—SNYDER, Bull. U. S. Fish Comm., vol. 22, p. 527, for 1902 (1904) (Honolulu).—JORDAN and SNYDER, Bull. U. S. Bur. Fish., vol. 26, p. 213, for 1906 (1907) (Hawaii).

Habitat.—West Indies to Madeira, and East Indies, north to Japan and Hawaii.

Description.—Of two specimens from Honolulu, Hawaiian Islands, cotypes of *Etelis evurus*, about 340 mm. in total length, and one from Havana, Cuba (typical of *Etelis oculatus*) between which no differences are discernible.

Head $3\frac{1}{5}$ in body length; depth $3\frac{4}{7}$; eye $3\frac{1}{3}$ in head; maxillary $2\frac{1}{7}$; snout $3\frac{1}{3}$; suborbital width 13; interorbital (bone) 4; D. X, 11; A. III, 8; scales in longitudinal series 53, in transverse 5 or 6/12, on checks in 7 rows. Gill-rakers 8 or 9 + 15 or 16.

Body elongate, fusiform, but tapering more posteriorly; somewhat compressed, its width $1\frac{3}{4}$ in depth. Head conical; interorbital space

broad and flat, straight in profile; snout rounded, blunt, arched somewhat from tip to above nostrils; preorbitals very narrow posteriorly under center of very large eye, broader anteriorly, its margin sinuate; lower jaw longer than upper; maxillary ending under middle of eye, its distal breadth $\frac{1}{3}$ diameter of eye, mouth cleft somewhat oblique. Teeth in the inner band in both jaws minute, in the outer row slightly enlarged; teeth larger and more widely set in upper jaw; a moderate canine on either side at tip of premaxillaries; villiform teeth on vomer, in a \wedge -shaped band; teeth on palatines in narrow bands; tongue without teeth. Gill-rakers equal to length of gill filaments, with several rudiments in each limb anteriorly. Preopercular margins finely serrated, angle rounded, vertical limb only slightly oblique. Opercle ending in two broad, flat, indistinct projections.

Dorsal spines moderately stout, second and third longest, 2 in head, remainder rapidly decreasing in height to last, which is 3 in second, leaving dorsal fin deeply notched; dorsal rays about equal, 3 in head, save last which is slightly elongate, $2\frac{1}{2}$ in head; anal similar to soft dorsal, its last ray produced, its first soft rays when depressed reaching little beyond base of last ray; anal spines slender and regularly graduated, third about 4 in head. Caudal very deeply forked, upper lobe longer, almost filamentous, its length 4 times that of middle rays, or $1\frac{1}{3}$ in head. Pectorals falciform, reaching almost to anal, $1\frac{1}{2}$ in head.

Scales moderate in size; rows on body all parallel to lateral line. Opercle with 8 or 9 rows of scales; subopercle 2; interopercle 4; on cheek 7; maxillary scaled on exposed surface. Temporal region with graduated band of scales, four rows of five each. Remainder of head naked save for few imbedded scales on lower jaw. Dorsals, ventrals, and anal naked; a few scales on base of pectoral; caudal scaled on membranes nearly to tip.

The young have the caudal lobes nearly equal, but later the upper lobe becomes much the longer.

Color in life brilliant rose red, sides from level of eye abruptly silver, with rosy shades; snout, jaws, eye, and inside of mouth red; fins all rose-color, dorsal and caudal bright; ventrals and anal pale, former washed with red on center; axil pink; pectoral pale rosy. Color in alcohol uniform pale yellowish, tips of caudal somewhat dark.

This species attains a length of 2 or 3 feet.

From comparison of specimens we can find no difference whatever between *Etelis oculatus* Cuvier and Valenciennes, and *Etelis evurus* Jordan and Evermann. The upper caudal lobe is the same in the two, as is the size of the scales and of the eye. Careful measurements in hundredths of body length show no differences in any detail more

than individual variation. *Etelis carbunculus* Cuvier and Valenciennes, of the Seychelles Archipelago, has, according to current descriptions, apparently no characteristic distinguishing it from *E. oculatus* except possibly in color. In the original description and figure given by Cuvier and Valenciennes, golden, longitudinal lines are shown, but the specimen was young, 11 inches in length, and these lines if ever existing, may vanish with age.

If these lines are characteristic of *Etelis carbunculus* at all ages, the species of the Seychelles may be different, in which case the common species may stand as *Etelis oculatus*.

We have seen no Japanese examples of this beautiful fish. It is common in rather deep water about Hawaii, as also about Cuba, from both of which regions we have ample material.

The species is known in Japan as Onbutsu; *on* meaning male, and Mutsu, the large eyed *Scombrops boops*, which it resembles. In Hawaii, it is called Ulaula, which means ultra red, "red-red." It is the Cachucho of the Cuban fishermen.

(*carbunculus*, a diamond.)

7. Genus APHAREUS Cuvier and Valenciennes.

Aphareus CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 485 (*cærulescens*=*furcatus*).

Body elongate, somewhat compressed, covered with moderate scales; skull essentially as in *Etelis*; preopercle entire; snout and jaws scaleless; mouth large, the teeth in jaws, minute or deciduous, without canines; no teeth on vomer or palatines; maxillary rather narrow; lower jaw strong; the chin prominent; dorsal low, continuous, the last soft ray produced; anal similar; both fins scaleless; pectoral long, its lower rays also produced in the adult; caudal deeply forked; ventrals inserted below pectorals. Probably but one species, widely distributed.

(ἀφάρεος, a word used by Aristotle, of unknown meaning, perhaps "une nageoire particulière à la femelle du Thon." Farés is an Arabic name of the fish, a fact which suggested the use of *Aphareus*, a Greek name of similar sound.)

13. APHAREUS FURCATUS (Lacépède).

Labrus furcatus LACÉPÈDE, Poiss., vol. 3, 1801, pp. 424, 477, pl. 21, fig. 1 (Île de France).

Aphareus furcatus GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 386 (after Cuvier and Valenciennes).—BLEEKER, Verh. Kon. Akad. Wet., XIII, Revision Lutjani, 1873, p. 99.—BLEEKER, Atlas Ichth., vol. 8, 1877, p. 80, pl. 299, fig. 2 (labeled *A. rutilans*) (Amboyna).—GÜNTHER, Fische Südsee, 1873, p. 17 (Tahiti).—SAUVAGE, Poissons Madagascar, 1891, p. 514 (Madagascar).—JORDAN and STARKS, Proc. U. S. Nat. Mus., vol. 23, 1901, p. 719, pl. 28 and 29 (Odawara) (skeletal characters).

- Aphareus furcatus* JORDAN and SEALE, Fishes Samoa, Bull. U. S. Bur. Fish., vol. 25, 1905, p. 265 (Hawaii).—JENKINS, Bull. U. S. Fish. Comm., vol. 22, 1902, p. 51 (Honolulu).
- Caranxomorus sacrestin* ("Sacré chien") LACÉPÈDE, Poiss., vol. 5, 1801, p. 682 (Île de France).
- Aphareus cœrulescens* CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 487, pl. 167 b. (Port Louis, Île de France).
- Aphareus rutilans* CUVIER and VALENCIENNES, Hist. Nat. Poiss., vol. 6, 1830, p. 490 (Red Sea).—BLEEKER, Act. Soc. Scient. Ind. Neerl., vol. 2, Achste Bijd. Vischf. Amb., 1856, p. 52 (Amboyna); Atlas Ichth., 1877, pl. 299, fig. 2 (Amboyna).—RÜPPELL, Neue Wirbel., Fische, 1835, p. 121 (Red Sea).—GÜNTHER, Cat. Fish. Brit. Mus., vol. 1, 1859, p. 386 (Red Sea, Amboyna).—KLUNZINGER, Syn. Fish. Roth. Meer., Verh. Zool-bot Ges. Wien, vol. 20, 1870, p. 768 (Red Sea); Fische Rothen Meeres, pt. 1, 1884, p. 45 (Red Sea, in deep water).—SAUVAGE, Poissons de Madagascar, 1891, p. 514 (Madagascar).—DAY, Fishes India, 1888, p. 782 (Ceylon).
- Aphareus flavivultus* JENKINS, Bull. U. S. Fish. Comm., vol. 19, 1901, p. 390, fig. (Honolulu).—JENKINS, Bull. U. S. Fish. Comm., vol. 22, 1902, p. 451 (Kona, Hawaii).—JORDAN and SEALE, Fishes Samoa, Bull. U. S. Bur. Fish., vol. 25, 1905, p. 265 (Hawaii).—JORDAN and EVERMANN, Fishes Hawaii, Bull. U. S. Fish. Comm., vol. 23, 1903, pt. 1, p. 235, fig. (Honolulu, Kailua, and Hilo).—JORDAN and DICKERSON, Proc. U. S. Nat. Mus., vol. 24, 1908, p. 611 (Honolulu).

Habitat.—East coast of Africa, Red Sea, Indian Ocean, East Indies, north to China, Japan, and Hawaii.

Description.—Of a specimen 580 mm. in total length, from Odawara, Sagami Bay, Japan.

Head $3\frac{1}{3}$ in body length; depth $3\frac{4}{5}$; eye $5\frac{1}{2}$ in head; maxillary $1\frac{5}{8}$; width of preorbitals $8\frac{1}{2}$; snout $2\frac{4}{5}$; D. X, 11; A. III, 8; scales in lateral line 72, between dorsal and lateral line 9, between ventrals and lateral line 18, between anal and lateral line 15; vertebræ 10 + 13 + hypural = 24. Branchiostegals 7.

Body fusiform and symmetrical, compressed, dorsal and ventral profiles similar; lower jaw projecting, its tip square and at right angles to cleft of mouth, which is somewhat oblique. Maxillary ending below posterior half of eye. Preorbital somewhat turgid, anteriorly produced slightly below edge of skin on snout. Nostrils small, close together, one-third of length of snout from eye. Teeth lacking save for slight roughening anteriorly in jaws. Preopercle with smooth margin, its angle produced somewhat posteriorly.

Dorsal spines weak and flexible, third, fourth, and fifth longest, $2\frac{2}{3}$ in head; last two-thirds length of fourth; first ray unbranched, but articulated, equal in length to last spine; last ray produced, probably 2 or 3 times length of penultimate. Pectoral falcate, contained $1\frac{1}{10}$ times in head, reaching anus; its lower rays produced, its margin therefore sharply incised; ventrals contained $1\frac{3}{4}$ times in head, extending half way to front of anal. Anal spines weak, first very short, second and third subequal, $5\frac{1}{2}$ times in head; anal rays equal in length to dorsal rays, last one produced similarly to that of dorsal; caudal deeply forked.

Rows of scales on body horizontal; equal in size above and below lateral line. Snout, upper surface of head, preorbitals, mandibles, and margins of preopercle naked; temporal patch with four transverse rows, six longitudinal; preopercle with six rows of scales, opercle, sub- and interopercle completely scaled; a small patch on base of pectorals, and densely crowded rows on interray membranes of caudal to tips, none on other fins.

Color of old alcoholic specimen silvery, slightly darker above. Naked parts of head dark brown, darker on upper edge of mandibles, and below end of maxillary. Fins pale. In life reddish brown, the forehead (*flavivultus*) sometimes bright yellow.

The synonymy of this species is very difficult to decide. *Aphareus rutilans*, as described by Cuvier and Valenciennes, differs from *Aphareus furcatus* in having the fourth, fifth, and sixth dorsal spines longest, and, according to Günther^a and also Klunzinger, the pectoral rays are produced below, the depth is less than the head, the snout is longer, and the eye smaller. The two last-mentioned authors had specimens 14 inches and 70 cm. in length, respectively, and some of the differences, as those in depth of body and size of eye can safely be attributed to age. The lower lobe of the pectoral becomes longer with age, as stated by

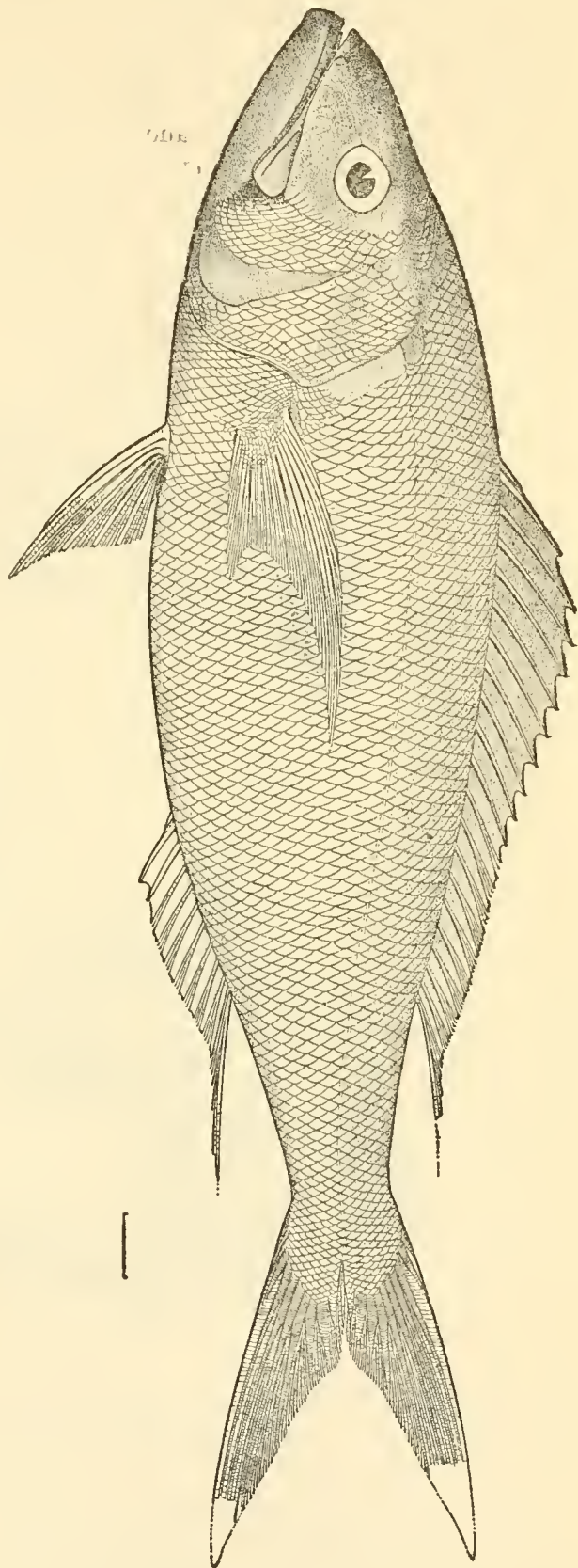


FIG. 7.—APHAREUS FURCATUS.

^a Südsee Fische.

Bleeker^a ("ætate provectoribus radiis sub inferis mediis longioribus"). As far as concerns the length of the dorsal rays, *A. furcatus* is said to have the third spine longest, thus differing from *A. rutilans*, but our specimen has the third, fourth, and fifth subequal. Should these nominal species prove distinct, our specimen would be *A. rutilans*, but the differences shown at present do not indicate any real distinction.

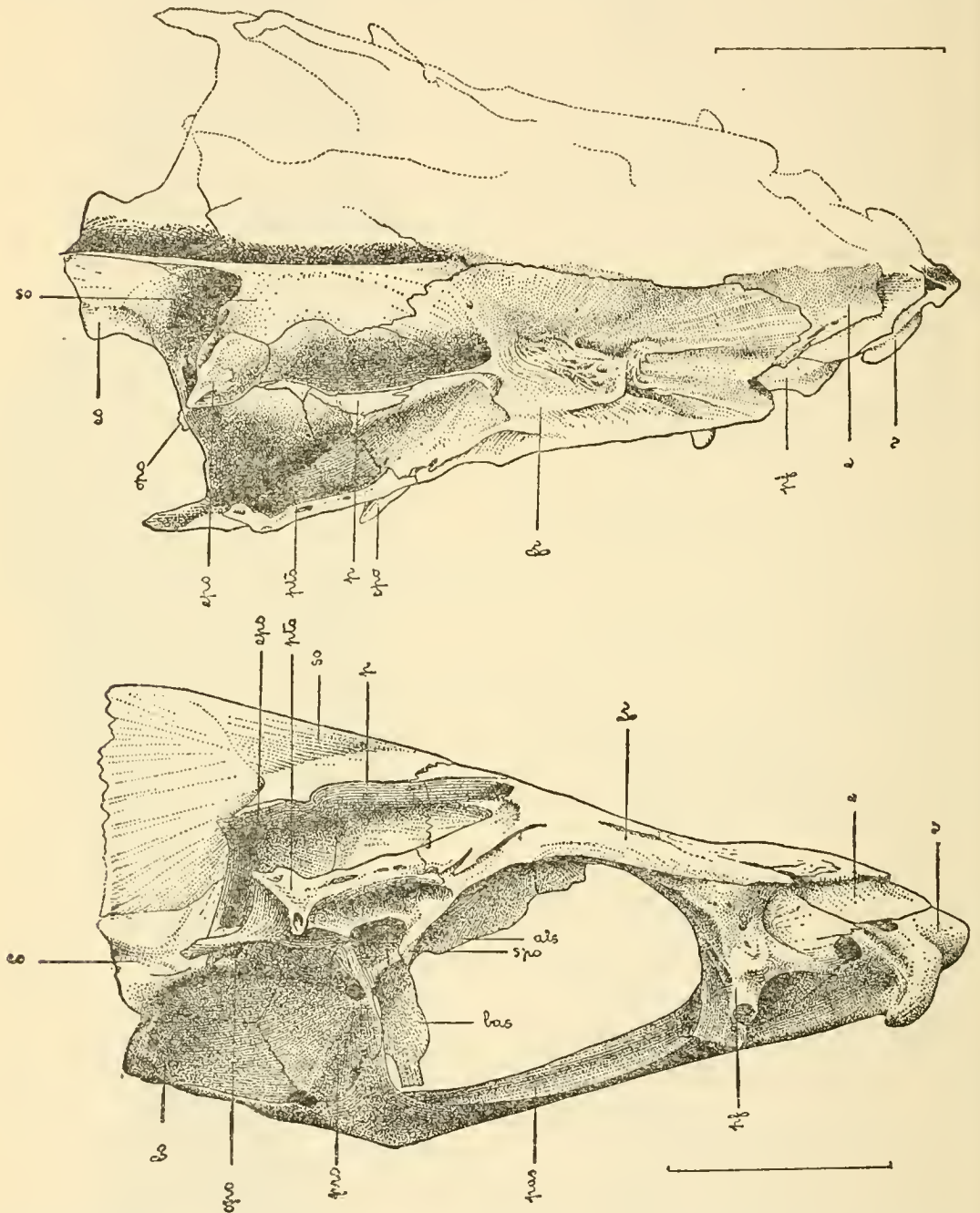


FIG. 8.—CRANIUM OF APHAREUS FURCATUS. *als*, ALISPHENOID; *bas*, BASISPHENOID; *bo*, BASIOCCIPITAL; *e*, ETHMOID; *co*, EXOCCIPITAL; *epo*, EPIOTIC; *fr*, FRONTAL; *opo*, OPISHTHOTIC; *p*, PARIETAL; *pas*, PARASPHE-
NOID; *pf*, PREFRONTAL; *pro*, PROOTIC; *pto*, PTEROTIC; *so*, SUPRAOCCIPITAL; *spo*, SPHENOTIC; *v*, VOMER.

Aphareus flavivultus Jenkins, from Honolulu, apparently differs from *A. furcatus* only in the presence of a bright yellow area on the dorsal surface of the head, agreeing in other respects with it. Klunzinger, in describing the color of a specimen of *A. rutilans* from the

^a Atlas, p. 80.

Red Sea, mentions yellow spots and lines on the upper surface of the head, and other authors give slightly differing color notes for the species, showing it variable to a certain degree. In two small specimens from Honolulu, in the Stanford collections, this color has faded away entirely in alcohol, leaving the dorsal surface of the head a dark brown in one case and much lighter in the other.

But one specimen of this fish has been recorded from Japan. This was presented to Jordan and Snyder by Professor Mitsukuri. It was kept for some time in the Imperial University collections under the name of the "Unknown Fish from Odawara." This specimen has been described in detail by Jordan and Starks, who have also given a full account of its osteology. Its affinities are plainly with *Etelis*.

(*furcatus*, forked.)

SUMMARY.

Family LOBOTIDÆ.

1. *Lobotes* Cuvier, 1829.

1. *surinamensis* (Bloch) 1790; Misaki.

Family LUTIANIDÆ.

2. *Glaucosoma* Temminck and Schlegel, 1843.

2. *burgeri* Richardson, 1846.

3. *Doderleinia* Steindachner, 1883.

3. *berycoides* (Hilgendorf), 1879; Awa.

4. *Lutianus* Bloch, 1790.

§ *Evoplites* Gill, 1862.

4. *kasmira* (Forskål), 1775.

§ *Lutianus* Bloch.

5. *vitta* (Quoy and Gaimard), 1824; Misaki, Tokyo, Yokohama, Wakanoura, Kobe Onomichi, Hakata, Kawatana, Nagasaki.

6. *russelli* Bleeker, 1849; Yokohama, Tokyo, Misaki, Shimezu, Wakanoura, Kagoshima.

7. *erythropterus* Bloch, 1790.

8. *rivulatus* (Cuvier and Valenciennes), 1828.

9. *vaigiensis* (Quoy and Gaimard), 1824; Tanegashima.

5. *Pristipomoides* Bleeker, 1852.

§ *Platyinius* Gill, 1863.

10. *sparus* (Temminck and Schlegel), 1843.

§ *Ulaula* Jordan and Thompson, 1910.

11. *sieboldii* (Bleeker), 1857; Fukaura.

6. *Etelis* Cuvier and Valenciennes, 1828.

12. *carbunculus* Cuvier and Valenciennes, 1828.

7. *Aphareus* Cuvier and Valenciennes, 1830.

13. *furcatus* (Lacépède), 1801; Odawara.



THALASSOCRINUS, A NEW GENUS OF STALKED CRINOIDS
FROM THE EAST INDIES.

By AUSTIN HOBART CLARK,

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During the course of her investigations among the East Indian islands, the United States Bureau of Fisheries steamer *Albatross* dredged a small stalked crinoid which in certain important respects is different from any hitherto known. It is evidently nearly related both to *Hyocrinus* and to *Gephyrocrinus*, and, with them, falls into the family Hyocrinidæ as redescribed by Kœhler and Bather. The affinities appear to be closer to *Gephyrocrinus* than to *Hyocrinus*, and I was at first inclined to consider it a new species of that genus. There is the same curious elevation of the disk ambulacra from which that genus derives its name, but the sides of this wall or bridge are completely covered with perisomic plates. The basals are proportionately considerably smaller than those of *Gephyrocrinus*, and their lower third is cylindrical as in *Hyocrinus*, but they are not so elongated as in that genus. They are three in number, the smaller being anterior and the two larger lateral. Each bears at its base two tubercles, which mark the angles of the stem; this latter is hexagonal proximally, becoming slowly cylindrical; the upper columnars bear six tubercles, marking the angles; on the lower cylindrical segments these tubercles persist as short, small spines, resembling the condition seen in certain species of *Millericrinus*. The arm bases do not occupy much more than one-third of the distal edge of the radial, this form being therefore intermediate between *Hyocrinus* and *Gephyrocrinus* in this feature. In *Hyocrinus* the first pinnule is on the sixth brachial (the epizygal of the third syzygial pair); in *Gephyrocrinus* the first pinnule is on the fourth brachial (usually the epizygal of the second syzygial pair); in this new form it is on the fifth brachial, the epizygal of the second syzygial pair, but the two first syzygial pairs are separated by a single brachial. The orals and interambulacral plates are pierced by about seventy water pores, which are not found, however, in the interambulacral plates of the anal area. The orals are very large, much larger than in either *Hyocrinus* or *Gephyrocrinus* and consist of a broad triangular apex and a posterior portion, concave laterally and posteriorly, which runs backward for some distance over the inter-

ambulacral areas. Beyond the third the brachials are united in syzygial pairs as in *Gephyrocrinus*, and the first two brachials are similarly united.

This new type may be known as

THALASSOCRINUS, new genus.

The characters of this genus are included in the description of the type-species.

Genotype.—*Thalassocrinus pontifer*, new species.

THALASSOCRINUS PONTIFER, new species.

Stem.—The stem is 151 mm. in length and is composed of 169 columnars; those immediately beneath the basals are discoidal, about 0.3 mm. in length and about 2.2 mm. in diameter, the diameter gradually decreasing, after the proximal eight or ten being about 1.8 mm.; after the sixth traces of intercalated columnars may be found between each two columnars, and after the fourteenth these intercalated columnars entirely separate those on either side; after the twenty-eighth there is no difference between the intercalated and the original columnars; both have increased so that they are now 0.7 mm. in height, remaining 1.7 mm. in diameter; at the fortieth they are about 0.8 mm. in height with the same diameter, but now they increase rather more rapidly in length, so that at the fifty-third they are 1.2 mm. long; after the proximal half of the stem they very gradually decrease in height, being distally about 0.8 mm. In the last 50 mm. of the stem there is an almost imperceptible increase in the diameter, which becomes rather more noticeable in the last 10 mm.; the diameter of the lowest columnar, the stem having been broken off at or near the root, is 2.3 mm.

At the top of the stem the columnars are hexagonal in outline, the angles of the hexagon being occupied by rather prominent tubercles, and these tubercles are practically alike on the succeeding columnars; after the eighth these tubercles become more prominent, for the reason that the original columnars are separated by intercalated columnars of lesser height, whose tubercles are only slightly developed; the tubercles on the second, fourth, eighth, fifteenth, and twenty-third columnars are slightly larger than those on the remainder; after the twenty-seventh segment these tubercles somewhat abruptly become much smaller and the columnars become nearly circular in outline, each bearing about its middle six minute moderately sharp tubercles which rise abruptly from the general surface; after the proximal third of the stem these show a tendency to become obsolete on alternate segments, and in the terminal third of the stem they have entirely disappeared, so that the columnars are perfectly smooth; after the proximal third of the stem the columnars appear to be quite circular in outline.

The joint faces in the upper middle portion of the stem (which is in two pieces) are marked with radial crenellæ, but there is a plane area about the central canal, equal in average width to half the diameter of the canal, which is produced into six angles whose apices reach halfway to the periphery of the joint face, or even somewhat farther.

One of the six angles of the stem is exactly in radius D.

On the topmost three or four columnars supplementary tubercles are formed between those occurring from radius A to radius C.

Basals.—The basals are three in number, but so closely united that the sutures are almost obsolete; one of the basals supports the anterior radial; the division between the two others coincides with the suture between the radials on either side of the anal interradius.

The basal cone is approximately 2 mm. high (radially), 3.5 mm. in distal and 2.5 in proximal diameter; in its proximal third its sides are parallel with the dorso-ventral axis, and bear six prominent though well-rounded tubercles, two to each basal; in the distal two-thirds the sides diverge at an angle of about 68° , and there are five shallow interrarial depressions.

Radials.—The radials are roughly pentagonal in shape; the sutures between them may be easily seen, though the union is very close; each radial is about 2.2 mm. wide at the base, 4 mm. wide distally, 3.7 mm. high interradially, and 3.5 mm. high to the base of the first brachial; the socket serving for the attachment of the first brachial is only about 1.7 mm. broad, so that not much more than one-third of the distal margin of the radial is occupied by the articulation; the free interrarial borders are turned upward and then slightly inward; in profile the sides of the radial circlet are seen to make an angle of about 68° with each other; the middle line of the radials is occupied by three nearly obsolete tubercles, a pair proximally (one on either side of the midradial line) and a single one just proximal to the articular socket. The border of the radials (and basals also) along the interrarial and basiradial sutures is usually narrowly depressed, so that these sutures appear in depressed bands.

Tegmen.—The tegmen is a rather high five-sided pyramid, the apex (the apices of the orals) being 5 mm. above the interrarial margin of the radials, or about as high as the base of the sixth brachial; each ambulacrum is raised high above the general surface of the tegmen upon a narrow wall, the crest of which at first runs outward horizontally from the base of the orals and then curves upward, merging into the ambulacrum of the arms at about the sixth brachial.

The orals are very large, reaching nearly two-thirds of the distance from the tip of the oral pyramid to the interrarial border of the radials; in their inner half they resemble the orals of *Hyocrinus*,

except that when the animal is viewed laterally their outline is more nearly triangular; the sides beyond this triangular inner half curve inward (around the bridge supporting the ambulacra) and then gradually outward again, so that their outermost diameter is slightly greater than that of the base of the triangular tip; the outermost border is more or less strongly concave (much more so than in *Hyocrinus*), so that the outer margin is rather strongly bilobate; there is a short spine in the center of each oral, and in the outer half there are, irregularly disposed, two or three low flattened tubercles, most of which are pierced by water pores.

The anal tube, which is small and conical, rises just beyond the bilobate outer margin of the oral; the whole anal area is covered with perisomic plates, smaller on the anal tube and between it and the oral than elsewhere, none of which are pierced by water pores. The remaining interradiial areas are completely covered by about a dozen perisomic plates, of which four or five are usually much larger than the others, irregular in shape and position, and bearing, collectively, from a dozen to nineteen irregularly placed tubercles, each pierced with a water pore. The sides of the wall or bridge which supports the disk ambulacra are entirely covered by numerous small subequal perisomic plates, entirely devoid of water pores.

Arms.—None of the arms are complete; their normal length appears to be between 55 mm. and 60 mm.; the brachials are united in syzygial pairs except the third, which has a muscular articulation at either end; the sides of the brachials are rather strongly concave, so that the articulations and the syzygial sutures are prominent.

The first pinnule (always on the fifth brachial) is 23 mm. long and is composed of thirty segments, which, in a lateral view, are about one-third longer than broad; the covering plates are large and rounded-triangular, resting upon a calcareous band which is not regularly differentiated into side plates, though in some cases the oblong side plates may be fairly well indicated; the pinnule is much compressed laterally, so that its lateral diameter is about half its dorso-ventral diameter; it is large and practically uniform throughout; in its middle part its diameter is about equal to that of the brachials at the same height; the following pinnules are similar, but apparently first increase and then decrease gradually in size; the second pinnule is 28 mm. long; the third pinnule is 26 mm. long, with thirty segments; the fourth is 25 mm., and the eighth is 23 mm. long, with twenty-three segments; the fifth pinnule on the right posterior ray is replaced by an arm.

Color (in life).—Pale sulphur yellow, the lower end of the stem becoming brownish (F. M. Chamberlain).

Type.—Cat. No. 27483, U.S.N.M., from *Albatross* station 5636.

ON SOME HYMENOPTEROUS INSECTS FROM THE ISLAND OF FORMOSA.

By S. A. ROHWER,

Of the Bureau of Entomology, Department of Agriculture, Washington, D. C.

The following is a list of the Tenthredinoidea, the Vespoidea, and the Sphecoidea belonging to a collection made by Mr. T. Fukai of Konosu, Saitama, Japan, and sent to the United States National Museum. The species were all collected at Horisha, Formosa, between April 20 and May 15, 1909. With the exception of the tenthredinoid genus *Athlophorus* Burmeister all of the genera are cosmopolitan.

Superfamily TENTHREDINOIDEA Ashmead.

Family TENTHREDINIDÆ.

ATHLOPHORUS FORMOSACOLA, new species.

Apparently nearest to *Athlophorus scurrilis* (Konow), but differs from that species in a number of ways.

Male.—Length 9 mm. Anterior margin of the labrum rounded; anterior margin of the clypeus arcuately emarginate, the angles acute; front with close, distinct punctures; vertex and posterior orbits shining, hardly punctured; middle fovea very shallow; ocellar basin very small, enclosing the ocellus above but not below; postocellar furrow wanting; postocellar area sharply defined laterally, the cephal-caudal length about half as long again as the width; ocelli in an equilateral triangle; antennæ thickened near the middle, the apical four joints ridged beneath; dorsulum with distinct, separate punctures; scutellum elevated in the middle into a strong sharp ridge; legs and venation normal; stigma slightly broadened apically; hypopygidium rounded at the apex; genitalia stipes rounded apically, broader basally. Black; labrum, clypeus, mandibles (except the piceous apices), scape, a narrow line surrounding the orbit (slightly interrupted above), line on posterior margin of pronotum, spot on propleuræ, two lines above the intermediate coxæ, narrow line on dorsal segments two and four, apical segments above and below,

and first two ventral segments white or yellowish-white; legs white or slightly yellowish, most of the posterior coxæ and the posterior femora above black. Wings dusky hyaline, darker in the radial cell, iridescent; venation dark brown, except the lower part of the stigma, which is yellowish.

Type-locality.—Horisha, Formosa. One male collected by Mr. T. Fukai.

Type.—Cat. no. 13372, U.S.N.M.

In the elevated scutellum this species differs from the genotype (*Athlophorus klugii* Burmeister), but there are no other differences of importance which can be found from the elaborate description of Burmeister. There is, however, a tendency to the elevation of the scutellum in some Nearctic *Strongylogasteroidæ* Ashmead.

Superfamily VESPOIDEA Ashmead.

Family CHRYSIDIDÆ.

CHRYSIS (*Chrysis*) FUKAI, new species.

Belongs near *Chrysis* (*Chrysis*) *principalis* (Smith), but the first joint of the flagellum is nearly as long as the two following (not but little longer than the second), the transverse facial carina is almost wanting (not distinctly present), the facial basin is sculptured as coarsely as the rest of the front, and the notauli are nearly parallel throughout and the anterior part between them is sculptured like the rest (not strongly diverging). The above comparison was made with specimens from Burmah. *Chrysis* (*Chrysis*) *schödtei* Dahlbom has the metanotum (postscutellum of authors) different, and teeth of the apical margin of the third abdominal segment are different.

Female.—Length 9 mm. Clypeus nearly truncate at the apex; malar space slightly less than the length of the pedicellum; facial basin sculptured similar to the rest of the head but more finely so; orbital carina strong, anterior ocellus distinctly hooded posteriorly; postocellar line slightly longer than the ocellocular line, but slightly shorter than the ocelloccipital line; third antennal joint nearly as long as the fourth and fifth combined; head and thorax with large, close, and in a few places confluent, punctures; pronotum about as long as the scutellum, distinctly shorter than the mesonotum, depressed in the anterior middle; notauli distinct and nearly parallel; metanotum convex, not depressed and separated from the propodeum by broad oblique furrows; first dorsal segment with large close punctures basally, fine scattered ones apically; second and third segments with distinct widely separate punctures, those on the second more widely separate than those on the first; lateral margin of the third segment nearly straight, the depressed apical groove with twelve well-defined pits; apical margins with six teeth, the distance

between the two middle ones somewhat less than the distance between the second and third. Bright metallic green with a few blue spots on head, thorax, and the basal segments; most of the flagellum and tarsi black. Wings dusky hyaline, venation dark brown. Almost without white hair.

Type-locality.—Horisha, Formosa. One female collected by Mr. T. Fukai, in whose honor the insect is named.

Type.—Cat. no. 13373, U.S.N.M.

CHRYSIS (Tetrachrysis) LUSCA (Fabricius).

One female of this species was collected by Mr. T. Fukai. It is a widely distributed species within the oriental region.

Family VESPIDÆ.

POLISTES STIGMA (Fabricius).

Represented by one small worker.

POLISTES HEBRÆUS (Fabricius).

Three workers of a pale variety.

POLISTES (Gyrostoma) SCHACH (Fabricius).

Both females and workers were collected.

VESPA DUCALIS Smith.

A single female of this species, which occurs both in India and China.

VESPA MANDARINIA Smith.

A female and worker of this large species, which is very common in Japan, occurring in China also.

Family EUMENIDÆ.

RHYGCHIUM FLAVOLINEATUM (Smith), variety.

Two females, which may represent a distinct species, were collected. They agree with the variety given by Bingham in the Fauna of British India, except that the pale spot at the emargination of the eyes is wanting.

RHYGCHIUM BRUNNEUM (Fabricius).

Males and a female were collected.

RHYGCHIUM METALLICUM Saussure.

Two males and a female are assigned to this species with some doubt. The clypeus of the male is entirely black. This is one of the border-line species between *Rhygchium* and *Odynerus*. The apical three joints of the maxillary palpi are distinctly longer than the third joint.

CAMPSOMERIS (*Campsomeris*) ALBOPILOSA, new species.

A distinct species which seems to be related to *Campsomeris* (*Campsomeris*) *grossa* (Fabricius) as defined by Col. L. T. Bingham in *The Hymenoptera of British India*.

Male.—Length a little over 12 mm.; length of antennæ 6 mm. Labrum rounded at the sides, very slightly arcuate on the anterior margin, the surface dull with fine scratches; clypeus with a narrow transverse furrow at the apex, the surface shining and impunctate except for the setigerous punctures; space between the eyes at the clypeus distinctly greater than the length of the scape and pedicellum; interocellar area parted by an indistinct furrow; postocellar line subequal with the ocellocular line; front with large punctures, in a few places confluent; vertex and occiput with widely scattered punctures; third and fourth antennal joints equal, apical joint longer than the preceding and sharply, obliquely truncate at the apex; mesothorax and scutellum shining, with scattered setigerous punctures; propodeum rather sharply truncate posteriorly, with setigerous punctures as on the mesonotum; inner spur of anterior tibiæ dilated at the apex, truncate; inner spur of posterior tibiæ more than half the length of the basitarsis; legs with numerous, weak spines; distance between the recurrent nervures subequal with the length of the second cubital on the radius; pygidium rather poorly margined, dulled. Black; clypeus except a large middle spot, pronotum broadly, two confluent spots on the scutellum, large spot on the metanotum (postscutellum of authors), line on femora beneath, a line on the four anterior tibiæ, and a band on first dorsal segments (broader on the first three, and dentate medianly on segments two and three) pale yellow; entire insect with long pale hair; wings dusky hyaline, slightly yellowish basally; venation dark brown.

Type-locality.—Horisha, Formosa. One male collected by Mr. T. Fukai.

Type.—Cat. no. 13374, U.S.N.M.

Family PSAMMOCHARIDÆ.

PALLOSOMA FULVOGNATHUS, new species.

Posterior part of thorax and abdomen black; head marked with fulvous; wings reddish-yellow; antennæ as long as body.

Male.—Length 15.5 mm.; length of antennæ 16 mm. Mandibles with an inner apical tooth; labrum hardly exerted, anterior margin rounded; clypeus rather large, lateral angles rounded; antennæ inserted above the clypeus; inner eye margins slightly converging to the clypeus, the upper part emarginate; ocelli in a low triangle, the lateral ones on the supraorbital line; postocellar line shorter than the

ocelloccipital or ocellocular line; occiput not emarginate, slightly margined; scape not especially large, cylindrical; pedicel longer than wide, constricted in the middle; flagellar joints very long and the apical ones gently arcuate, first slightly longer than second, apical one subequal with the preceding; pronotum with a broad cephal-caudad depression, arcuate posteriorly hardly half as long as the mesonotum; scutellum prominent, longer than wide; metanotum (postscutellum of authors) tuberculate in the middle; propodeum with transverse wrinkles, the spiricals narrow elongate, oblique, no longitudinal furrow, truncate posteriorly and the lower lateral angles when seen from the sides dentate; legs long, feebly spined, claws with a very long basal tooth; abdomen about the same length as the thorax, subcompressed, second dorsal segment longer than wide, apical segment with long hairs; submedian cell of the anterior wing distinctly longer than the median; cubital cells large, the third shorter on the radius than the second, and but little longer than the distance from the second transverse cubitus to the second recurrent nervure; submedian cell of the posterior wings distinctly shorter than the median. Black with a purple tinge to the abdomen; mandibles (apices piceous), clypeus, orbits (slightly interrupted above and nearly meeting on the occiput), pronotum, tegulae, and legs below middle of femora reddish-yellow; seven basal joints of the antennae reddish-yellow, the apical joints brown; mesonotum, pronotum, and head somewhat with reddish-yellow pile. Wings reddish-yellow, covered with hairs, the apical margin dusky and without hairs; venation reddish-yellow.

Paratype is slightly smaller and has the submedian cell of the hind wings subequal with the median.

Type-locality.—Horisha, Formosa (T. Fukai).

Type.—Cat. no. 13375, U.S.N.M.

PSAMMOCHARES (*Entypus*) FORMOSENSIS, new species.

In Colonel Bingham's table to the species of *Pompilus* of British India this species runs near to *ariadne* Cameron and *limbatus* Smith, but does not agree with the description of either. Entirely black with silvery bands on the abdomen; wings strongly dusky.

Male.—Length 12 mm. Labrum distinctly exerted, the exerted part about as long as the width of the mandibles at the base; clypeus very gently arcuate; a fine impressed line from the anterior ocellus to base of antennae; head, clypeus, labrum, and base of mandibles gently, irregularly scratched; postocellar line fully twice as long as the ocellocular line, and nearly twice as long as the ocelloccipital line; pedicel longer than wide, very indistinctly separated from the first joint of the flagellum; first joint of the flagellum slightly shorter than

the second, apical joint shorter than the preceding; emargination of the pronotum strongly arcuate; scutellum narrowed posteriorly, the cephal-caudad length distinctly greater than the width; propodeum obliquely truncate posteriorly, the spiricals elongate, arcuate; thorax dull, impunctate; venation and legs very like the genotype of *Entypus* (*Entypus ochraceus* Dahlbom), legs perhaps more strongly spined, inner claw tooth large, robust, obliquely truncate at the apex; abdomen dull, finely scratched. Entirely black; coxæ, and basal part of all the dorsal segments with silvery pile; wings strongly dusky, the apex and area basad of stigma darker; venation dark brown.

Type-locality.—Horisha, Formosa. One male collected by Mr. T. Fukai.

Type.—Cat. no. 13376, U.S.N.M.

Superfamily SPHECOIDEA Ashmead.

Family SPHECIDÆ.

PROTEROSPHEX NIGRIPES (Smith), variety.

Apparently a large specimen of variety *erythropoda* Cameron, being 22 mm. long. One male.

SCELIPHRON MADRASPATANUS (Fabricius).

One male.

Family PHILANTHIDÆ.

CERCERIS FUKAI, new species.

Perhaps closest to *Cerceris pentadonta* Cameron, but is much more coarsely sculptured than that species and hardly belongs to the same group. A yellow band on the third and sixth segments; femora black; tegulæ reddish yellow; with large, sometimes confluent, punctures.

Male.—Length 8.5 mm. Clypeus flat, the apical middle truncate; carina between the antennæ short, sharp, and pointed; inner eye margins nearly parallel; ocelli in a low triangle; postocellar line subequal with the ocelloccipital line, but distinctly longer than the ocellocular line; scape short and curved; first joint distinctly longer than the second, apical joint normal and subequal in length with the preceding; head with large, distinct punctures, below the antennæ the punctures are smaller and just above the antennæ they are confluent; thorax with punctures somewhat larger than those on the head, on the mesonotum confluent; mesosternum not spined; inclosure of the propodeum with a median channel, the sided with short oblique striæ; venation normal; legs very feebly spined, the post-basitarsis nearly as long as the following joints; first abdominal segment but little longer than wide; seventh dorsal segment distinctly margined laterally, apex truncate; seventh ventral segment arcuately

emarginate, the lobes narrow and acute; abdomen dorsally with large, distinct punctures, closer on the first two segments; abdomen ventrally with the apical and lateral margins punctured, the second with some punctures basally. Black; most of the scape, broad stripes on inner orbits to the antennæ, line on metanotum (postscutellum of authors), complete band on third segment, band on sixth dorsal segment, a small spot at the base of the second dorsal segment, four anterior tibiæ and tarsi, basal half of posterior tibiæ, and base of post-basitarsis yellow; tegulæ reddish yellow; wings dusky hyaline, radial cell strongly dusky; venation brown.

Type-locality.—Horisha, Formosa. One male collected by Mr. T. Fukai.

Type.—Cat. no. 13377, U.S.N.M.

Family LARRIDÆ.

LARRA SPARSA, new species.

Seems to be related to *Larra tisiphone* (Smith), but is not that species.

Male.—Length about 9 mm. Anterior margin of the clypeus rounded anteriorly, without teeth; middle facial fovea large, shining broader below; lateral facial ridges shining; depression from the anterior ocellus strong; depression behind lateral ocelli narrow and arcuate; space between the eyes at the vertex greater than the length of the scape; first joint of flagellum shorter than the second, second longer than third; frontal area with distinct, rather large, and mostly separate punctures, on the crest, however, the punctures are confluent; on the occiput the punctures are smaller and widely separate; mesonotum with distinct, separate punctures; scutellum with smaller punctures, not impressed; mesopleuræ more finely punctured than the mesonotum, the suture faintly foveolate; upper surface of the propodeum transversely reticulate; posterior face almost perpendicular, the furrow deep, striate medially, punctured laterally; sides with sparse, distinct punctures; legs very feebly spined; second cubital cell narrower on the radius than the third; abdomen dorsally with distinct, separate punctures, larger on the apical segment; last ventral segment entire; inner spur of the posterior tibiæ much longer than the outer. Black; apical half of the mandibles piceous; posterior part of the tegulæ pale brown; anterior tibiæ and tarsi brown. Wings distinctly dusky, hyaline, iridescent; venation dark brown to black. Face and thorax with sparse white hair.

Type-locality.—Horisha, Formosa. One male collected by Mr. T. Fukai.

Type.—Cat. no. 13378, U.S.N.M.

TACHYTES FUNDATUS, new species.

Wings fulvo-hyaline; pubescence of the head and thorax fulvous; hair of pygidium dark bronze-color; four posterior tibiæ reddish-brown.

Female.—Length 20 mm. Anterior margin of the clypeus gently rounded, with three obtuse teeth on each side of the median area; the notch on the exterior margin of the mandibles very distinct; no line from the anterior ocellus; front with small, irregular punctures, vertex with the punctures hardly as distinct as those on the front; space between the eyes at the vertex hardly as great as the length of the first flagellar joint; first flagellar joint but very little longer than the second; pedicel not twice as long as wide; mesonotum, scutellum, and propodeum with small, close, irregular punctures; scutellum, metanotum (postscutellum of authors) and the dorsal aspect of propodeum with an impressed longitudinal line, which broadens into a triangular fovea at the apex of the propodeum; legs rather strongly spined; third cubital cell a little longer than the second on the radius; dorsal segments dulled by fine longitudinal scratches; ventral segments shining basally, irregularly punctured apically; pygidium rounded at the apex. Black; tegulæ and legs below femora red or reddish-brown; head and thorax with long fulvous hair and pubescence; hair of pygidium bronzy. Wings fulvo-hyaline, venation reddish-yellow.

Male.—Length 16.5 mm. Anterior margin of the clypeus slightly produced in the middle, otherwise as in female; space between the eyes at the top not more than two-thirds the length of the first flagellar joint; emargination of the seventh ventral plate arcuate, lobes broad, obtuse; hair of the pygidium silvery; hair on thorax not so dense. Except where mentioned the male agrees with female.

Type-locality.—Horisha, Formosa. A male and female collected by Mr. T. Fukai.

Type.—Cat. no. 13379, U.S.N.M.

TACHYTES AUROPILOSUS, new species.

Head and thorax with bright golden pile, abdomen with silvery; scape and legs below the coxæ red; wings dark brown. Perhaps most closely related to *Tachytes proxima* Nurse (1903), but the scutellum and upper surface of the propodeum have an impressed line in that species and the wings are "flavo-hyaline."

Female.—Length 17 mm. Anterior margin of the clypeus gently rounded, without teeth; mandibles with the exterior notch almost wanting, the broad basal part rounded off gradually; space between the eyes at the vertex about the same as the length of the second and third antennal joints; a faint carina from the anterior ocellus to

between the antennæ; depression behind the lateral ocelli arcuate posteriorly; first joint of the flagellum a little longer than the second, apical joint subequal with the preceding; mesonotum closely, rather coarsely punctured, scutellum more sparsely punctured; propodeum very sharply truncate behind, dull, rather finely, transversely striatopunctate, a medium, longitudinal impressed, irregularly striate line which under low power looks like a longitudinal ridge; posterior aspect of the propodeum with an impressed line; lateral aspect of the propodeum with irregular striæ; dorsal segments impunctate, ventral basal segments impunctate but the apical segments with distinct punctures; pygidium truncate apically; third cubital cell on the radius distinctly narrower than the second; legs rather strongly spined. Black; base of mandibles, scape, tegulæ, legs below coxæ except tibiæ spurs red; head and thorax, especially the anterior part, with dense golden pile obscuring the sculpture; abdomen with the usual silver bands; hair of the pygidium bronzy. Wings dark brown, venation except the black costa and stigma, pale brown.

Type-locality.—Horisha, Formosa. One female collected by Mr. T. Fukai.

Type.—Cat. no. 13380, U.S.N.M.

Two females from Trong, Lower Siam, collected by Dr. W. L. Abbott, differ from the above only in having the dorsal aspect of the propodeum without the impressed, striate line.

ON THE INORGANIC CONSTITUENTS OF THE SKELETONS OF TWO RECENT CRINOIDS.

By AUSTIN HOBART CLARK,
Assistant Curator, Division of Marine Invertebrates.

Dr. Chase Palmer, of the U. S. Geological Survey, has recently been so kind as to make for me, under the direction of Prof. F. W. Clarke, analyses of the chief inorganic constituents of the skeletons of two recent crinoids, taken under very different conditions of temperature and light, but at nearly the same depth, and consequently at nearly the same pressure.

While there has been a considerable amount of work done in regard to the determination of the elements of the skeleton of many marine animals, more particularly corals and mollusks, there is only a single record to be found among the recent crinoids. In 1906 Mr. Henry W. Nichols^a analyzed some pinnulate arms from a specimen of *Metacrinus rotundus* from southern Japan (probably Sagami Bay), and he found that the skeleton contained 11 per cent of magnesium carbonate, a greater proportion than had been detected in the skeleton of any marine animal previously examined.

The material submitted to Doctor Palmer consisted of pinnulate arms of *Metacrinus rotundus* from the Eastern Sea and of *Helioметра maxima* from the Sea of Okhotsk. Both specimens were air dried from alcoholic examples collected by myself in 1906.

METACRINUS ROTUNDUS.

Metacrinus rotundus P. H. CARPENTER, Trans. Linn. Soc. (Zool.), (2), vol. 2, 1885, p. 436, pl. 50; pl. 52, figs. 1-7.

Locality.—Albatross station 4934; lat. 30° 58' 30'' N.; long. 130° 32' 00'' E. (Sata Misaki light bearing N. 77½° E., 7 miles distant), in the Eastern Sea off Kogoshima Gulf; depth, 152-103 fathoms; bottom temperature, about 56° F.; surface temperature, 84° F.; surface density, 1.02355.

This is the same species as that analyzed by Nichols. It is probable that the depth is somewhat greater and the temperature slightly less

^a Field Columbian Museum, Geol. Ser., vol. 3, 1906, p. 49.

than in the habitat of his specimen, which I suspect was a commercial specimen obtained through Mr. Alan Owston from Japanese fishermen living at Sagami Bay.

In the sample examined by him Doctor Palmer found the proportions of CaO and MgO to be as follows:

CaO = 49.95% (equivalent to CaCO₃ 89.19%);

MgO = 4.89% (equivalent to MgCO₃ 10.29%).

He notes, further, that "this specimen is white and quite free from extraneous material."

HELIOMETRA GLACIALIS var. MAXIMA.

Antedon eschrichtii var. *maxima* A. H. CLARK, Proc. U. S. Nat. Mus., vol. 33, 1907, p. 75.

Locality.—*Albatross* station 4986; lat. 43° 01' 40'' N.; long. 140° 22' 40'' E. (Benkei Mizaki light bearing N. 35° E., 15 miles distant), in Iwanai Bay, northeastern part of the Sea of Japan; depth, 172 fathoms; bottom temperature, 33.9° F.; surface temperature, 69° F.; surface density, 1.02405.

In this specimen Doctor Palmer found:

CaO = 40.03% (equivalent to CaCO₃ 71.48%);

MgO = 2.68% (equivalent to MgCO₃ 5.61%);

and he adds that "this specimen contains much foreign material, chiefly organic; on the basis of purity as found in the other specimen, the content of magnesium carbonate (MgCO₃) in this specimen may be accepted as 7 per cent."

This species is the largest crinoid known, measuring about three feet across its extended arms. It might be supposed that the comparative openness of its skeleton was due to this very large size as a result of the deposition of inorganic matter not keeping pace with the rapid increase in bodily size. It is noticeable, however, that the crinoids of the deep seas and from the colder regions have more delicate and more open skeletons than those from comparatively shallow water in the tropics, and it therefore seems most probable that cold has the effect of retarding the deposition of inorganic matter by the animals to a far greater degree than it retards the general body development. Probably in the deep-water forms the enormous pressure under which the animals live also tends in various ways to make the deposition of inorganic matter more difficult; but from the fact that among the crinoids the skeletal conditions found in the inhabitants of the deep sea are to almost or quite the same degree repeated or continued in those of the polar regions points to the conclusion that the chief factor involved is temperature rather than pressure.

A NEW LABYRINTHODONT FROM THE KANSAS COAL MEASURES.

By ROY L. MOODIE,
Of the University of Kansas.

The remains of labyrinthodonts in the coal measures of North America are very scanty. The specimens described from this horizon can be counted almost on the fingers of one hand.

The earliest discovery of labyrinthodont-like remains was made by Dawson, in 1850, in the coal measures of Nova Scotia. He secured from the coal mines near Albion an incomplete skull, which he sent to London, where it was described in 1854 by Sir Richard Owen as *Baphetes planiceps*. Its relations with the typical labyrinthodonts are somewhat uncertain, but it is more closely related to that group than to any other, so far as we may judge from the material preserved.

Hay^a places this form in his new suborder, Apœcospondyli and in the family Dendrepentidae. Hay includes also in this new suborder the Sauropleuridæ, Archegosauridæ, Cricotidæ, Anthracosauridæ, Eryopidæ, and Mastodonsauridæ, which is a very heterogeneous assemblage. *Baphetes* and *Dendrerpeton* may possibly belong in the same family, but they are still too imperfectly known to be sure of their relations. The Sauropleuridæ are typical microsaurs. Two orders and three suborders are represented by the other families included by Hay in his Apœcospondyli.

The discovery of *Baphetes* was followed in 1863 by the finding of typical labyrinthodont vertebræ in the coal measures of Nova Scotia, unless it be that the species of *Dendrerpeton* prove to be labyrinthodont, in which case their discovery would precede that just mentioned. The two vertebræ were described and named by Prof. O. C. Marsh, at that time a student of Agassiz's and an enthusiastic collector of minerals, as *Eosaurus canadensis* and the form was allied by him with the ichthyosaurs and plesiosaurs. The fallacy of this relationship was shown by Huxley in his description of *Anthracosaurus russelli* from the coal measures of Scotland,^b when he pointed out the marked relations of the two forms as exhibited by their vertebral structure.

^a Catalogue of Vertebrates, p. 418.

^b Quart. Journ. Geol. Soc., vol. 19, 1863, p. 66, and also p. 52.

Save for a few footprints discovered in 1849 by Lea in the coal measures of Pennsylvania the specimens above mentioned were the only evidences or suggestions of labyrinthodonts from the coal measures of North America until the year 1875, when Cope^a described a fragmentary skull from the coal measures of Linton, Ohio, as *Tuditonus huxleyi*. The present writer,^b in 1909, restudied the type of this species and placed it in a new genus, *Macrerpeton*, and suggested the labyrinthodont nature of the species, though the evidence was somewhat imperfect. Later in the same year he described and figured a large rib of undoubted labyrinthodont nature from the coal measures of Linton, Ohio, and located it tentatively with the fragmentary skull in the species *Macrerpeton huxleyi* (Cope).^c

No further discoveries were made in the coal measures for more than twenty years. In 1897 Doctor Williston described and figured a typical labyrinthodont tooth from the coal measures of Kansas. He compared this tooth, which had been found near Louisville, Kansas, by Herbert Bailey, with the teeth of *Mastodonsaurus* from the Trias of Germany, but was unable to detect characters in the tooth and few bone fragments he possessed which would distinguish the Kansas Carboniferous form from the European Triassic genus, so he located it tentatively in *Mastodonsaurus*.

The present specimens, described below as a new genus and species, represent the fifth or possibly the sixth discovery of labyrinthodont-like remains in the coal measures of this continent. The exact locality from which the specimens came is not known. They were secured some two or three years ago by the U. S. National Museum with the (Gustav) Hambach collection, so I am told by Mr. C. W. Gilmore, through whose courtesy the specimen was first called to my attention and subsequently loaned me for study. On a slip of paper accompanying the specimens was written in pencil, evidently by Mr. Hambach, "Coal Measures, Washington Co., Kansas."

In the recently published geological map of Kansas^d no coal-measure deposits are indicated in Washington County, but they outcrop at the fork of the Blue River in Marshall County near Marysville, and since the topography of the region is quite rough, as shown by the Washington and Marysville topographic sheets, and especially since there is an anticline reported to occur running northeast-southwest near Marysville, coal-measure deposits might very readily be expected to occur in the eastern edge of Washington County near the banks of the Little Blue River or its tributaries.

^a Geol. Surv. Ohio, vol. 2, pt. 2, p. 397, pl. 34, fig. 2.

^b Journ. Geol., vol. 7, no. 1, p. 72, fig. 17.

^c Proc. U. S. Nat. Mus., vol. 37, p. 28, pl. 8, fig. 4.

^d Geol. Surv. Kans., vol. 9, 1908.

ERPETOSUCHUS, new genus.

The genus is very readily distinguished by two prominent characters: The short uniform dentition and the presence of two elongate, oval, internal mandibular foramina on the inner side of the jaw. The genus may be further distinguished by the great depth of the posterior portion of the jaw and the slender anterior part as well as by the ornamentation, which is typically the rough tuberculated labyrinthodont sculpture on the anterior end of the mandible. This changes gradually to longitudinal grooves and ridges of a rather small size on the posterior portion, a very unusual arrangement for a labyrinthodont.

These characters are sustained by those of the skull fragment, in which the dentition is uniform and the sculpture very similar to that of the mandible. The ribs are long, curved, and solid as in other labyrinthodonts.

The genus receives its name from the similarity of the internal surface of the jaw to that of the crocodiles and alligators of the present day.

(ἔρπετόν = a creeping thing; σοῦχος = crocodile.)

ERPETOSUCHUS KANSENSIS, new species.

The species is represented in the collection of the U. S. National Museum by a fragment of a skull, with portions of two ribs (Cat. No. 6699, Vert. Pal. U.S.N.M.) and the larger part of the left ramus of the mandible (Cat. No. 6680, Vert. Pal. U.S.N.M.). The mandible was preserved in a large block of coal which contained the impression of the back portion of the mandible from which the bone had been weathered. It was possible to remove the bone and make a plaster cast of the impression. This shows in a very satisfactory manner all the characters of the external surface.

SKULL.

Only a portion of the left maxilla, with fourteen teeth, and a part of the nasal are preserved. The skull seems to have been flattened sideways and the right side of the skull has been crushed flat under the left. It has not seemed feasible to remove the skull from the matrix.

The teeth are uniform, rather short, bluntly conical, curved backward, and coarsely striate. They are somewhat crowded, the bases being separated from each other by only a fraction of a millimeter.

The maxilla and portion of the nasal are coarsely sculptured with elongate pits and ridges. A portion of the infraorbital lateral line canal is preserved. It is simply a rounded groove with three short branches. It lies near the middle of the maxilla (fig. 1).

MANDIBLE.

It has been possible to study both sides of the mandible. The left lamus was preserved in the coal with its inner face exposed. This face is broken by two large oval openings, the internal mandibular foramina. This is the term used by Reynolds^a for the openings on the inner surface of the alligator jaw. A drawing of the jaw of the crocodile is introduced in figure 4 for a direct comparison with the present mandible. So far as I can ascertain, no other known labyrinthodont mandible displays this character in such a marked degree. Doctor Branson has figured in *Anaschisma browni* from the Triassic of Wyoming the inner surface of the right ramus on which there are likewise two openings but differently situated.^b A

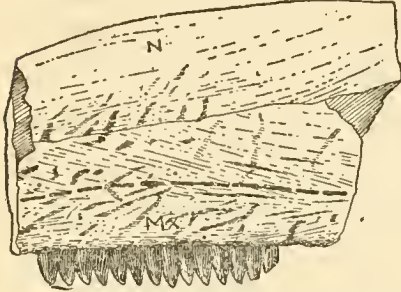


FIG. 1.—PORTION OF THE SKULL OF ERPETOSUCHUS KANSENSIS MOODIE. CAT. No. 6699, U. S. N. M. *Mx*=MAXILLA, *N*=NASAL. LATERAL LINE CANAL REPRESENTED BY HEAVY BROKEN LINE.

similarity between the two mandibles is observed in that the suture separating the prearticular and angular touches the posterior edge of the posterior foramen.

Several of the sutures are well preserved and they have been indicated in the drawing (fig. 2). The pillar separating the two foramina is cut by the suture separating the angular and prearticular very much as in *Anaschisma*, with the difference that in the latter form the angular and prearticular are not approximated. I believe

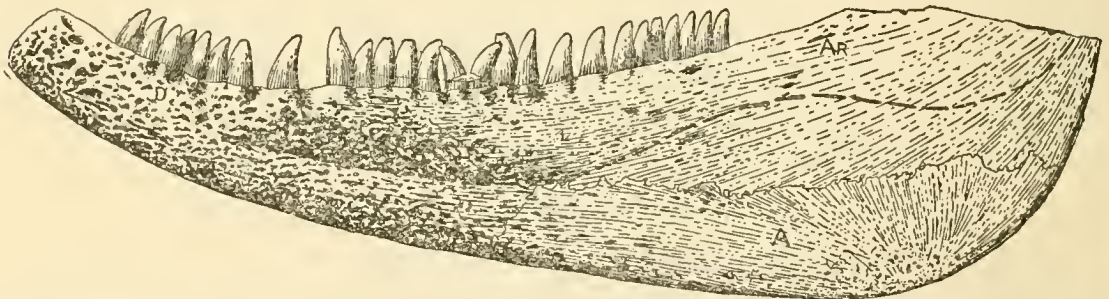


FIG. 2.—OUTER SURFACE OF LEFT MANDIBLE OF ERPETOSUCHUS KANSENSIS MOODIE. CAT. No. 6680, U.S.N.M. *A*=ANGULAR, *Ar*=ARTICULAR. OPERCULO-MANDIBULAR LATERAL LINE CANAL REPRESENTED BY HEAVY BROKEN LINE.

I detect the suture as represented separating the anterior end of the angular from the dentary and splenial. I am assured of the portion near the anterior foramen and also of the part near the tip of the ramus. This shows the angular to be a very elongate element, running very nearly the entire length of the mandible, much as in *Anaschisma* and other labyrinthodont genera. The splenial is a

^a Vertebrate Skeleton, p. 253.

^b Branson, Journ. Geol., vol. 13, no. 7, 1905, p. 589, fig. 10.

small, slender element located farther forward, where it has been shoved by the large sized internal mandibular foramina. The pre-articular is a rather long, broad element, of which only a portion is preserved. I am not sure as to the location of the suture for the dentary unless it is represented by the line bounding the roughened area near the teeth. If this is true, the dentary is a large element, since it extends well down upon the outer side of the jaw. The dentary possesses evidences of twenty-six teeth, a few of which are

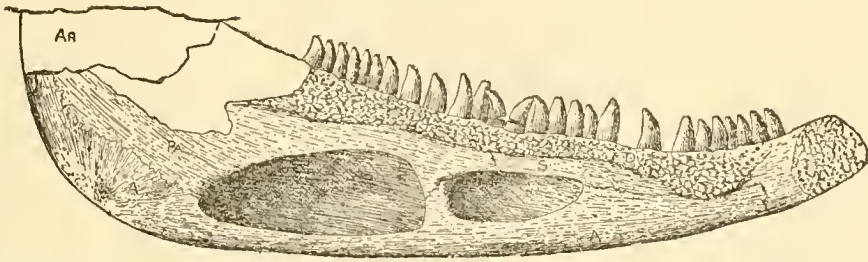


FIG. 3.—INNER SURFACE OF THE MANDIBLE OF ERPETOSUCHUS KANSENSIS MOODIE. A=ANGULAR, Ar=ARTICULAR, D=DENTARY, Pa=PREARTICULAR, S=SPLENIAL.

preserved completely. Most of them are, however, represented either by bases or by impressions in the coal. The teeth are very similar to those of the maxilla, though slightly larger. The characters given for the maxillary teeth will suffice for those of the dentary.

The markings of the inner surface are as indicated in the drawing (fig. 3). The back portion of the angular shows a few radiating lines. The dentary is roughened in two portions; one near the teeth, the other at the tip, where there is a cartilaginous roughening for union with its mate. The remainder of the inner surface is relatively smooth.

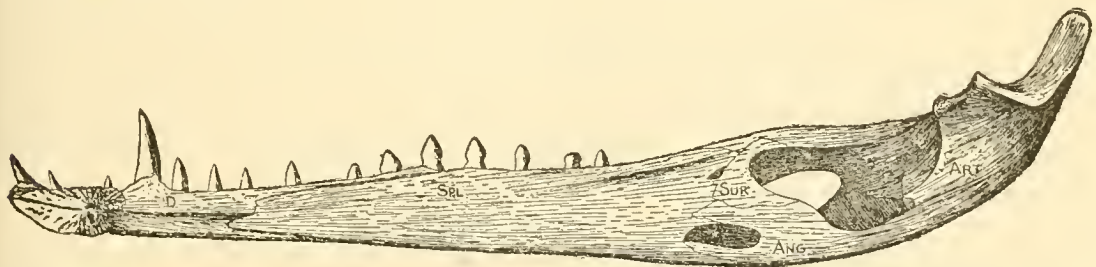


FIG. 4.—RIGHT RAMUS OF MANDIBLE OF CROCODILUS. Ang=ANGULAR, Art=ARTICULAR, D=DENTARY, Spl=SPLENIAL, Sur=CORONOID.

The outer surface shows at the anterior end the typical labyrinthodont sculpturing, which becomes slight grooves and ridges posteriorly. I detect evidences of the operculo-mandibular lateral line canal throughout the entire length of the mandible. Its location is indicated by the heavy broken line in the drawing (fig. 2). The suture between the dentary and angular is quite clear. The suture separating the dentary and splenial joins the angular suture about midway of the length of the jaw.

Measurements of the skull fragment of Erpetosuchus kansensis Moodie (Cat. no. 6699, U.S.N.M.).

	mm.
Length of portion preserved.....	109
Maximum width of maxilla.....	45
Thickness of maxilla.....	7
Length of tooth.....	10
Width of tooth at base.....	4

Measurements of the left ramus of the mandible of Erpetosuchus kansensis Moodie (Cat. no. 6680, U.S.N.M.).

	mm.
Total length of the jaw as preserved.....	305
Greatest width.....	79
Least width.....	24
Length of angular.....	132
Width of angular.....	45
Length of largest tooth.....	10
Width of largest tooth at base.....	6
Length of most posterior tooth.....	6
Width of most posterior tooth at base.....	4
Length of anterior internal mandibular foramen.....	56
Greatest width.....	15
Least width.....	7
Length of posterior internal mandibular foramen.....	77
Greatest width.....	28
Least width.....	14
Length of bridge.....	16
Width of bridge.....	8

RIBS.

There are portions of two dorsal ribs preserved on the block of coal with the skull. These show characters very similar to those exhibited by the rib ascribed to *Macrerpeton huxleyi* (Cope), and also those of *Metopias diagnosticus* von Meyer, and *Anaschisma*. The ribs are solid, heavy, curved, and have a longitudinal groove on the middle of each side. The heads of the ribs in the present specimen are obscured and nothing can be said of them except that they appear to be large.

Measurements of ribs of Erpetosuchus kansensis Moodie. (Cat. no. 6699, U.S.N.M.).

	mm.
Length of preserved portion.....	130
Width at distal end.....	18
Thickness of rib.....	5

RELATIONSHIPS.

The new form finds its nearest relationships with the members of the family Labyrinthodontidæ as used first by Hermann von Meyer in 1842,^a and by Zittel in 1887,^b and as correctly redefined and

^a N. J. Mineral., p. 301.

^b Handbuch Paleon., vol. 3, p. 401.

strengthened by Doctor Branson in 1905.^a The family as at present constituted undoubtedly represents a very heterogeneous assemblage, but it must serve as a scrap basket until we learn more of the characters of the forms described.

The following is a list of the labyrinthodont remains described from North America:

Carboniferous:

Baphetes planiceps Owen, 1854, Nova Scotia.

(?) *Dendrerpeton*, species Owen.

Eosaurus canadensis Marsh, 1862, Nova Scotia.

Mastodonsaurus, sp. indet. Williston, 1897, Kansas.

Erpetosuchus kansensis Moodie, 1910, Kansas. (Lower Permian?)

(?) *Macrerpeton huxleyi* (Cope), 1874, Ohio.

Permian. None known.

Triassic:

Dictyocephalus elegans, Leidy, 1856, North Carolina.

Eupelor durus Cope, 1866, Pennsylvania.

Pariostegus myops Cope, 1868, North Carolina.

Metoposaurus fraasi Lucas, 1904, Arizona.

Anaschisma browni Branson, 1905, Wyoming.

^a Journ. Geol., vol. 13, no. 7.

CORYNOTRYPA, A NEW GENUS OF TUBULIPOROID BRYOZOA.

By RAY S. BASSLER,

Curator of Invertebrate Paleontology, U. S. National Museum.

INTRODUCTION.

The present paper discusses all the known species of a supposed new genus of simple tubuliporoid Bryozoa, and may be said, therefore, to be monographic in its scope. However, the prime object of the article is the determination of the specific variation in a group of tubular organisms, which, on account of their minute size and extreme simplicity as well as alleged great variability of structure, have presented difficulties of classification.

In almost every class of natural history in which tubular organisms occur, the classification of these simpler types has proved more difficult than that of their more complicated allies. This is particularly true in the case of the Bryozoa where the simplest of such tubular forms are grouped under the family Tubuliporidae, in the order Cyclostomata. A wide difference of opinion has obtained even among the best students as to the classificatory value of the few and supposedly quite variable characters exhibited by these types, and their literature therefore presents varying degrees of exactness. For example, Waters, an excellent but very conservative student, considered the early Ordovician form *Mitoclema cinctosum* to be the same as the late Mesozoic *Spiropora verticillata*, while Haime included in one species specimens which d'Orbigny had divided among five genera. In spite of such extreme views there is a growing tendency among present-day students to recognize as genera in these simple bryozoans those groups, distinguished mainly by method of growth, around which the various species may be assembled. Gregory ^a has given an interesting discussion on the value of generic divisions in the Cyclostomata, arriving at the conclusion that the terms *Stomatopora*, *Proboscina*, and like names applied to the simple bryozoans, might be accepted, not as generic names in the sense in which this term is used in the higher groups of animals, but as designations for convenient groups not altogether artificial. He says: "They could

^a Cat. Foss. Bryozoa British Museum, The Jurassic Bryozoa, 1896, pp. 14-22.

be better described as circuli than as genera. A *circulus* was one of the small groups of individuals who clustered round speakers in the Roman forum. Most of the individuals in the forum were definitely attached to a particular group; the groups were less crowded around their margins, and between them people were irregularly scattered and crossed from circulus to circulus. They thus prevented any rigid division of the crowd into definite groups."

While Gregory's view of genera among the simple Cyclostomata is a very ingenious one, still it seems to me that no distinction need be made between the conception of a genus of Bryozoa and that of any other group of organisms. It must always be recognized that sharply outlined genera are impossible in any class, and that generic names are instituted for convenience in designating a series of organisms having certain characters in common, as well as to show natural affinity. The middle forms of such a series will have the most distinctive characters, while those at either end often show relationships to allied groups of species.

The simplest of the tubuliporoid bryozoans comprise the forms in which the zoëcia are adnate and arranged uniserially. To-day most writers restrict the genus *Stomatopora* Bronn to such unilinear species. More complex, adnate species have the zoëcia arranged in two or more rows and are generally referred to the genus *Proboscina* Audouin, while zoaria of incrusting circular or irregular patches, resulting from the union of numerous contiguous zoëcia, belong to Lamouroux's genus *Berenicea*. The present article deals only with simple, unilinear forms, which, as stated above, have hitherto been classed as *Stomatopora*.

My experience with *Stomatopora* began some years ago with the two very abundant Ordovician forms, *S. arachnoidea* and *S. inflata* Hall. These two species are so different that I could never reconcile their recognition as species of the same genus; but it is only recently that sufficient material has been accumulated in the collections of the U. S. National Museum to warrant a close study of the subject. Now all of the known Paleozoic and most of the Mesozoic and later forms of the genus are represented by specimens, and of many of them the material is abundant enough to fairly test their hitherto commonly supposed great instability in specific characters. The present paper is therefore based upon a study of thousands of specimens from widely separated localities and from many horizons in the geologic column.

The two Ordovician species mentioned above being the most numerously represented, received a correspondingly greater amount of study. *S. arachnoidea* is essentially like the Jurassic *S. dichotoma*, the genotype of *Stomatopora*, but the zoëcia of *S. inflata* are so different and its peculiarities are so constantly reproduced in a long line of descendants, that it seems desirable to establish a new genus

for them. Thus, while the typical forms of *Stomatopora* have zoecia with more or less parallel sides and no narrow, elongated, proximal portion, and large, open, exsert apertures, the new genus comprises the uniserial, adnate tubuliporoids in which the individual zoecia are contracted at their proximal end and rounded at the distal or apertural portion. The latter type of structure pertains to species ranging from the base of the Ordovician to the close of the Mesozoic, and the known representatives are divisible into no less than sixteen species. Considering these facts and also that the species are always easily distinguished from the typical forms of *Stomatopora*, I propose for them the new name *Corynotrypa*, in reference to the club-shaped

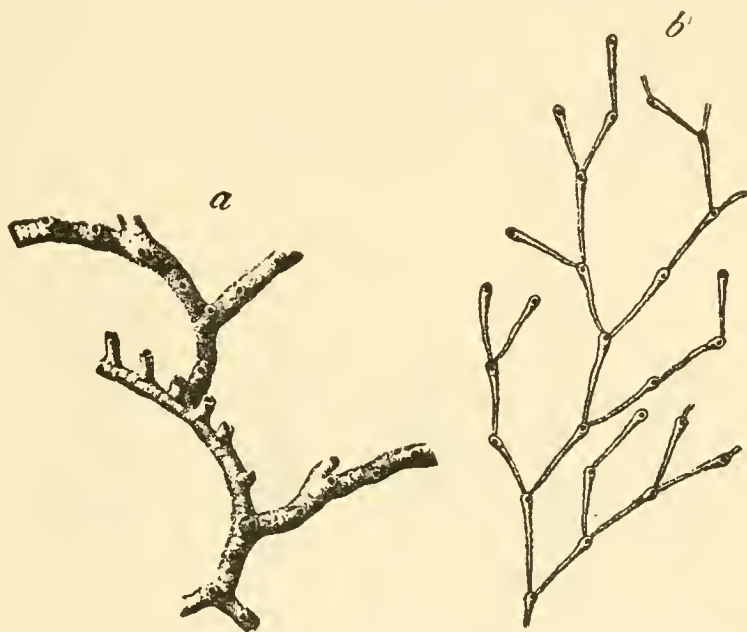


FIG. 1.—GENOTYPES OF STOMATOPORA AND CORYNOTRYPA, ILLUSTRATING GENERIC DIFFERENCES. *a*, STOMATOPORA DICHOTOMA. JURASSIC, HAMPTON CLIFFS, ENGLAND. (AFTER HAIME.) *b*, CORYNOTRYPA DELICATULA. UPPER ORDOVICIAN, CINCINNATI, OHIO. (AFTER ULRICH.)

zoecium with the perforation or zoecial aperture at its swollen end. The differences between the genus *Stomatopora* as thus restricted and the new genus *Corynotrypa* are brought out in figure 1.

TERMINOLOGY.

On account of the great simplicity of the clavate zoecia, and the constant difficulty in discriminating closely allied forms, it has been found useful to employ the following terms in their descriptions. The slender, proximal portion (*s*) of the zoecium (figure 2),^a is seen to vary

^a All of the original illustrations in this paper have been prepared by Miss Frances Wieser from camera lucida sketches drawn by the author. Great care has been taken to secure exactness of measurement, especially in the angle of divergence. Whenever a specimen did not show its characters clearly under the microscope, it was whitened by one of the several processes employed for this purpose. A thin coat of some white substance applied to apparently indistinct specimens often brings out their structure with astonishing clearness.

greatly in length, indeed a considerable variation exists in individual zoëcia of the same zoarium. For convenience this portion is called the stolon. The true zoëcial, and therefore specific characters can be expressed only in those portions of the zoarium lodging mature animals. Obviously the slender stolons of the typical species of *Corynotrypa* could not lodge normal polypides, and this portion is consequently deemed of subordinate specific value. The stolon may be said to correspond to the immature zone of a zoëcium in a trepostomatous bryozoan. The normal polypide undoubtedly was limited to the expanded portion of the zoëcium (z) which is here designated as the zoëcium proper or simply the zoëcium. This portion has several characteristics which are very constant within specific limits. First, and taxonomically most useful of such characters, is the size of the zoëcia, which, when the variable stolons are eliminated, is remarkably constant. The angle of divergence of a zoëcium (g), obtained by measuring the rate of expansion of its sides from the

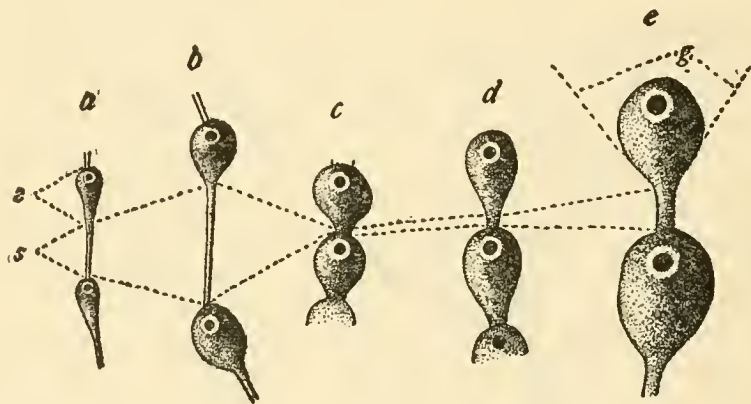


FIG. 2.—CHARACTERISTIC SPECIES OF *CORYNOTRYPA*, $\times 20$, ILLUSTRATING VARIATION IN STOLON (s) ZOËCIUM PROPER (z), AND ANGLE OF DIVERGENCE (g). a , *CORYNOTRYPA DELICATULA*; b , *C. ABRUPTA*; c , *C. CURTA*; d , *C. INFLATA*; e , *C. TURGIDA*.

distal end of the stolon, has likewise proved of much value in identifying the different types. Less useful criteria, and generic rather than specific in significance, are the position and relative size of the zoëcial aperture and its encircling peristome. As a rule the aperture is subterminal and has a diameter about one-third that of the zoëcium at its greatest width. The walls are similarly porous in this as well as in many other cyclostomatous genera, so that the minute structure of the walls offers little help in distinguishing either species or genera. However, one section of *Corynotrypa* contains species in which the walls are transversely wrinkled so that the character of the zoëcial surface is, therefore, not to be entirely ignored.

In brief, then, after determining from its uniserial growth and clavate zoëcia that a form belongs to this new genus, the species may be determined almost wholly by the size and general outline of the zoëcium proper, and, under the latter, especially by its angle of

divergence. The differences, while often very slight, hold so well that little difficulty is encountered in recognizing species the world over. For example, the genotype, *Corynotrypa delicatula*, and the well-known *C. inflata*, so common in numerous Ordovician horizons of America, have been recognized at several European localities. *C. abrupta*, *C. dissimilis*, *C. barberi*, and *C. elongata* are likewise nearly cosmopolitan forms.

With these points of terminology in mind, the genus may be defined as follows:

CORYNOTRYPA, new genus.

Zoarium adnate, consisting of simple, subtubular zoecia arranged in single-branched series; zoecia oval-pyriform to elongate clavate, the proximal end constricted and united with the preceding zoecium by a narrow, tubular stolon of variable length; the distal portion more or less expanded and bearing on its frontal side the aperture which is subterminal, circular, and inclosed by a more or less distinct, slightly elevated peristome; walls finely porous.

Genotype, *Stomatopora delicatula* James. Ordovician of America and Europe. Range of genus, base of Ordovician to close of Mesozoic; probably also Cenozoic.

The closest ally of *Corynotrypa* is undoubtedly the well-known and even more widely distributed and longer-lived *Stomatopora*. The two genera agree in having an incrusting zoarium composed of simple, porous, tubular zoecia arranged uniserially. *Corynotrypa* differs from *Stomatopora* most obviously in the constriction of the proximal end of the zoecium, giving it the characteristic clavate to pyriform shape which causes each to stand out as an individual. In *Stomatopora* the successive zoecia form a narrow branch with more or less parallel sides in which the individuals are scarcely delimitable except by their apertural openings.

Among the species referred to *Corynotrypa*, the proximal constriction is most evident in those assigned to the *C. inflata* and the *C. delicatula* groups discussed later, but becomes less marked in such forms as *C. canadensis* and *C. dissimilis*. The last two represent a third group in which the generic relationship to *Stomatopora* is much more obvious. In addition to the shape of the zoecium, the aperture in *Corynotrypa* likewise presents good generic characters. In typical *Stomatopora* the aperture is exsert, usually slightly tilted forward, and often almost equals the zoarial branch in diameter. *Corynotrypa*, in its two principal groups, has a small, neatly constricted aperture, never exsert, with a width about one-third that of the branch and surrounded by a low but distinctly marked peristome. In the third or *C. dissimilis* group of *Corynotrypa*, the nearer relation to *Stomatopora* is again expressed, in that the zoecial apertures are occasionally exsert and of unusual width. •

Altogether it is believed that the club-shaped zoëcia produced by the constriction of the proximal end, and the small, neatly constricted aperture with low peristomes, constitute sufficient characters to justify a new genus, although it is recognized that several intermediate forms exist between this genus and *Stomatopora*, as here restricted.

This new cyclostomatous genus, in its method of growth and general shape of the zoëcia is quite similar to genera of other orders, an occurrence which is not unusual in the Bryozoa. Such species as *Corynotrypa nitida* or *C. tenuichorda* are exceedingly like elongate, delicate forms of *Hippochoa*, and might readily be confused. The latter genus, however, a representative of the Chilostomata, has a sinus in the lower margin of the aperture and an occasional well-marked oëcium, as well as a very delicate surface ornamentation quite different, on close examination, from the simple punctate structure of *Corynotrypa*. Among the Ctenostomata such genera as the recent *Arachnidium* and the fossil *Rhopalonaria* are so similar in general shape to *Corynotrypa* that at least one species of the last genus was originally referred to the second.

GEOLOGIC DISTRIBUTION.

The geographic distribution of *Corynotrypa* has been briefly indicated in previous remarks, and is also shown in the description of the species. Regarding its geologic range, it is interesting to note that the two typical sections of the genus show a somewhat parallel specific development. Thus, in the Ordovician, the most abundant, *C. delicatula*, with a long geologic range, is accompanied through a considerable part of this time by the equally abundant *C. inflata*. During earliest Silurian, when the deposits of the Richmond group were being laid down, conditions seem to have been favorable for the development or introduction of new, somewhat bizarre species, which apparently did not survive for any great length of time. Among these are the unusually large, swollen form, *C. turgida*, another equally well marked species, *C. curta*, differing, however, in being exceptionally small and short, and, lastly, *C. abrupta*, with a long, slender stolon and short, greatly swollen zoëcium.

In the Silurian, succeeding Richmond time, no representative of the *C. inflata* section has been discovered so far, but the Devonian contains a delicate species of each section. The next known occurrence of the genus is in the Mesozoic, where, as shown in the table on page 504, again a single species of each section appears. The apparent absence of the genus in the known Mississippian, Pennsylvanian, and Permian rocks may be due to lack of systematic search, but it is nevertheless a curious fact that all of the simple cyclostomatous

bryozoans have a similar geologic distribution. *Stomatopora*, *Proboscina*, *Berenicea*, and other genera, although well developed before and after, have no known representative during Carboniferous time.

VARIATIONAL FORMULAS.

The extreme variability of these simple Cyclostomata has been recognized by many writers, with the result that the conception of a species has often changed with each author's study. Gregory has recognized this variation and has suggested the identification of species by means of variational formulæ. For the simple, incrusting forms, such as those discussed in this paper, he uses four main features, namely, the character of the peristome, the shape of the zoœcia, the length of the zoœcia, and, finally, the general aspect of the zoarium. Thus, for *Stomatopora*, the terms of his formula are as follows:

	Peristome.	Shape of zoœcia.	Length of zoœcia.	Zoarium.
	<i>p.</i>	<i>c.</i>	<i>l.</i>	<i>r.</i>
0	Flush.....	Cylindrical.....	Short.....	Uniserial; long thin series.
1	Slightly raised.....	Fusiform.....	Medium.....	Uniserial; branches tufted at ends.
2	Well raised.....	Pyriiform.....	Long.....	Uniserial; branches tend to become double at ends.
3	Highly raised.....	Hippothoiform....	Very long.....	Multiserial.

Applying his method to *Stomatopora dichotoma* (Lamouroux), illustrated on page 499, its formula would be as follows:

$$Stomatopora\ dichotoma\ (Lamouroux) = \frac{p.}{2} \frac{c.}{0} \frac{l.}{1} \frac{r.}{1}$$

However, a new scheme would be necessary for the species formerly assigned to *Stomatopora* but here described as *Corynotrypa*, since two of the terms—the length and outline of zoœcia, including the stolon—vary considerably in the same species, and the two remaining terms, the peristome and the zoarium, are practically always the same. For example, the formula for *Corynotrypa inflata*, as illustrated in figures 12 and 13, would be as below:

$$Corynotrypa\ inflata\ (Hall) = \frac{p.}{1} \frac{c.}{1-2-3} \frac{l.}{0-1-2-3} \frac{r.}{0}$$

Of course it is recognized that the latter is an extreme case and that the formula for this species should be based upon normal zoœcia only, as shown in figure 2*d*. The terms of the formula quoted above probably will serve very well for species of the genus *Stomatopora* as here restricted.

For *Corynotrypa*, it is believed that a division into three sections, based mainly upon the angle of divergence of the zoœcial walls, is preferable and of more value in the identification of species.

SUBDIVISIONS OF CORYNOTRYPA.

Three fairly distinct subdivisions of *Corynotrypa* may be recognized, with, however, one or more intermediate species connecting them. These, from their most characteristic species, may be known as (1) the *C. delicatula* section, with long, exceedingly slender zoëcia enlarging very slowly and always remaining quite narrow at the apertural portion; (2) the *C. inflata* section, in which the zoëcia enlarge rapidly after the slender, proximal stage is passed; and (3) the *C. dissimilis* section, with broad, stout, little constricted zoëcia and often distinguished in addition by a surface ornamentation of transverse lines. At least two quite dissimilar species, *C. schucherti* and *C. canadensis*, are known, connecting the second and third sections, while another well-marked form, *C. barberi*, appears to be intermediate between sections 1 and 2. Merely for convenience of classification, the difference in the angle of divergence of the apertural portion of each zoëcium is selected as the most distinctive character of the first and second sections. According to this scheme, the species of *Corynotrypa* are distributed among these sections as follows:

CORYNOTRYPA DELICATULA SECTION.

Angle of divergence small, proximal constriction well marked, aperture constricted and with peristome.

Species.	Angle of divergence.	Geologic range.
<i>C. delicatula</i> (James).....	15°	Ordovician and early Silurian.
<i>C. barberi</i> , new species.....	30°	Do.
<i>C. elongata</i> (Vine).....	25°	Silurian.
<i>C. nitida</i> , new species.....	20°	Devonian.
<i>C. tenuichorda</i> (Ulrich and Bassler) ^a	30°	Cretaceous.

^a Several of the Cretaceous species of *Stomatopora*, figured by d'Orbigny in the fifth volume of *Paleontologie Française*, appear to have the characters of *Corynotrypa*, but in view of that author's diagrammatic and frequently incorrect illustrations I have hesitated to refer them to the genus without a study of actual specimens.

CORYNOTRYPA INFLATA SECTION.

Angle of divergence great, proximal constriction well marked, aperture constricted and with peristome.

Species.	Angle of divergence.	Geologic range.
<i>C. inflata</i> (Hall).....	40°	Ordovician and early Silurian.
<i>C. abrupta</i> , new species.....	50°	Early Silurian.
<i>C. curta</i> , new species.....	70°	Do.
<i>C. medialis</i> , new species.....	50°	Do.
<i>C. turgida</i> (Ulrich).....	70°	Do.
<i>C. devonica</i> (Oehlert).....	40°	Devonian.
<i>C. smithi</i> (Phillips).....	40°	Jurassic.

CORYNOTRYPA DISSIMILIS SECTION.

Angle of divergence very small, proximal constriction less distinctly marked, aperture slightly exsert, little constricted, walls transversely wrinkled or smooth.

Species.	Geologic range.
<i>C. dissimilis</i> (Vine).....	Silurian.
<i>C. tennesseensis</i> , new species.....	Ordovician.
<i>C. schucherti</i> , new species.....	Do.
<i>C. canadensis</i> (Whiteaves).....	Do.

CORYNOTRYPA DELICATULA SECTION.

At least four species are known with characters so similar to the genotype that they may be grouped with it into a section of the genus as designated above. On account of their relations to *C. delicatula*, these five species naturally are the most typical forms of *Corynotrypa*, although the following *C. inflata* section comprises very similar, congeneric forms. In the present section the club-shaped zoecia are very delicate and usually greatly elongated, the slender stolon being almost always well developed. The angle of divergence in the zoecia proper is so slight that some care is required to determine the distal end of the stolon. This angle is about 15° in *C. delicatula*, and ranges from this to 30°

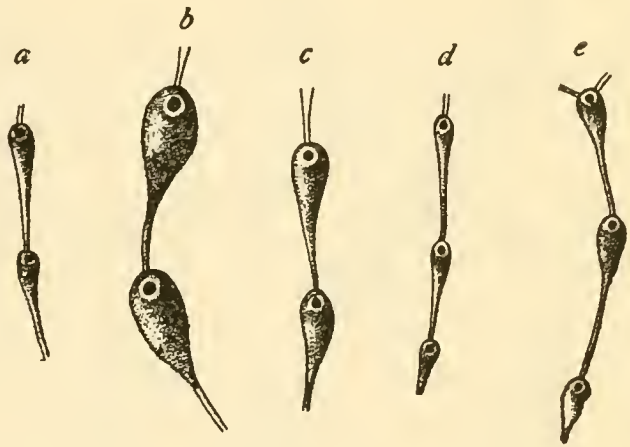


FIG. 3.—CORYNOTRYPA DELICATULA SECTION. GROUP OF ZOECIA, $\times 20$, SHOWING SPECIFIC DIFFERENCES. *a*, CORYNOTRYPA DELICATULA; *b*, *C. BARBERI*; *c*, *C. ELONGATA*; *d*, *C. NITIDA*; *e*, *C. TENUICHORDA*.

in other species of the section. The aperture in both this and the *C. inflata* section agrees in being constricted, with a diameter about one-third that of the zoecium, and in being surrounded by a distinct peristome. Views of average zoecia, equally magnified, of the five species referred to this section of the genus, are assembled in figure 3 for convenience of comparison.

Specific variation.—For reasons which will shortly be apparent, this section exhibits an astonishing amount of variation in the same species. This has been studied in only the type species on account of abundant material, but similar variation will no doubt be found in the other members of the section. Indeed, the variation is so great in *C. delicatula* that at least four distinct names have been applied to the species. The types, or typical specimens of these

four are in the collections of the U. S. National Museum, and their study, in connection with numerous other examples, soon revealed the fact that this extreme variation is due, not to the zoëcium proper, but to the stolon. Single zoaria were found exhibiting, in individual zoëcia, all the differences attributed to the supposed four distinct species. Such a zoarium is shown in figure 4, in which the usual relation between the length of the stolon and the zoëcium

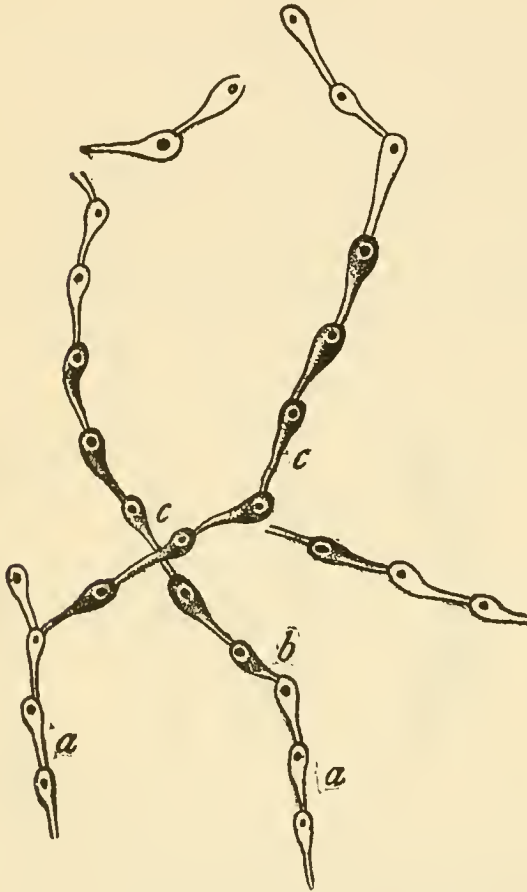


FIG. 4.—CORYNOTRYPA DELICATULA. ZOARIUM, $\times 12$ ILLUSTRATING VARIABLE LENGTH OF STOLON. ORDOVICIAN, CORRYVILLE BEDS OF McMILLAN FORMATION, CINCINNATI, OHIO. FOR LETTERING SEE TEXT.

proper is shown at *a*. At *b* the stolon is almost entirely absent, but the zoëcium has the normal shape, size, and angle of divergence. However, zoëcia in the same linear series, as at *c*, may develop stolons of considerable length. It will be observed in each of these cases that the size and shape of the zoëcium proper, and its angle of divergence, in addition to such characters as the position and size of the aperture, has remained constant. The stolon is obviously the variable character, and, eliminating it, one can not attribute such unusual variability to these simple types as has been done.

The cause of this variable development of the stolon seems to be a purely physical one, due almost entirely to the habitat of the species. For instance, again using the example figured above, the zoëcia at *a* are incrusting a smooth plane surface; at *b* there is a depression just wide enough to accommodate a short zoëcium, while at *c* the surface is slightly roughened, and the zoëcium, to avoid this unfavorable spot, develops a stolon of greater length.

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CORYNOTRYPA DELICATULA (James).

Hippothoa delicatula JAMES, Paleontologist, no. 1, 1878, p. 6.

Stomatopora delicatula NICKLES and BASSLER, Bull. U. S. Geol. Surv., no. 173, 1900, p. 419.—BASSLER, Proc. U. S. Nat. Mus., vol. 30, 1906, p. 55, pl. 3, figs. 4-7.

Stomatopora proutana MILLER, Journ. Cincinnati Soc. Nat. Hist., vol. 5, 1882, p. 39, pl. 1, figs. 4-4b.—ULRICH, Geol. and Nat. Hist. Surv. Minnesota, Final Rep., vol. 3, pt. 1, 1893, p. 117, pl. 1, figs. 8-12.

Rhopalonaria pertenuis ULRICH, Fourteenth Ann. Rep. Geol. and Nat. Hist. Surv. Minnesota, 1886, p. 59.

Stomatopora tenuissima ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 175, fig. 2; Geol. and Nat. Hist. Surv. Minnesota, Final Rep., vol. 3, pt. 1, 1893, p. 116, pl. 1, figs. 16, 17.

Stomatopora delicatula-tenuissima NICKLES and BASSLER, Bull. U. S. Geol. Surv., no. 173, 1900, p. 419.

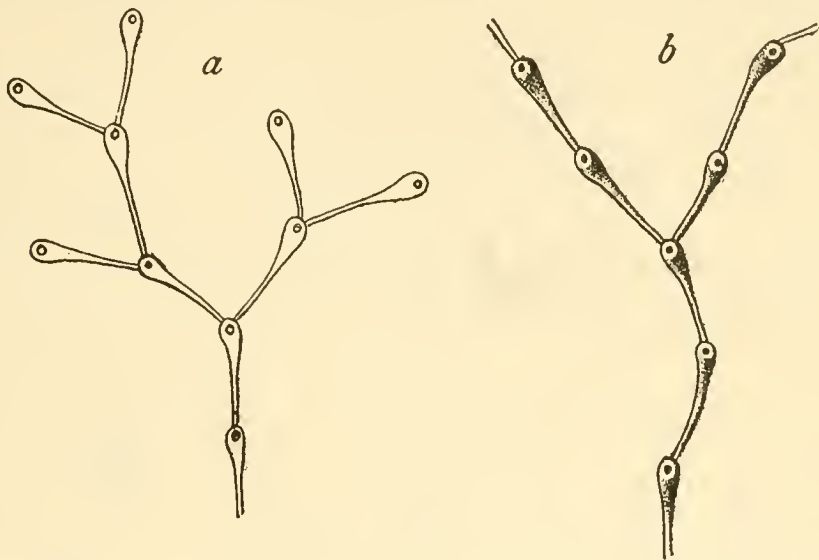


FIG. 5.—CORYNOTRYPA DELICATULA. *a*, VIEW OF AN AUTHENTIC SPECIMEN OF THE TYPICAL FORM $\times 12$, INCrustING A RAMOSE BRYOZOAN. ORDOVICIAN, ECONOMY BEDS OF EDEN FORMATION, CINCINNATI, OHIO; *b*, PART OF A ZOARIUM, $\times 12$, GROWING UPON THE EPITHECA OF AN EXPLANATE BRYOZOAN. ORDOVICIAN, OTTOSEE SHALE, KNOXVILLE, TENNESSEE.

Original description.—

“Polyzoary creeping, adnate, branching dichotomously, and sometimes anastomosing. Branches linear, about one-tenth of a line in diameter. Cells uniserial, each growing by a pointed base from the cell below, and expanding gradually to the mouth; two or three cells in the space of a line. Apertures terminal, elevated, and nearly or quite the diameter of the cells and placed on their front face.”

To James's original description the following remarks may be added. Strictly speaking, the zoecia do not gradually expand from a pointed

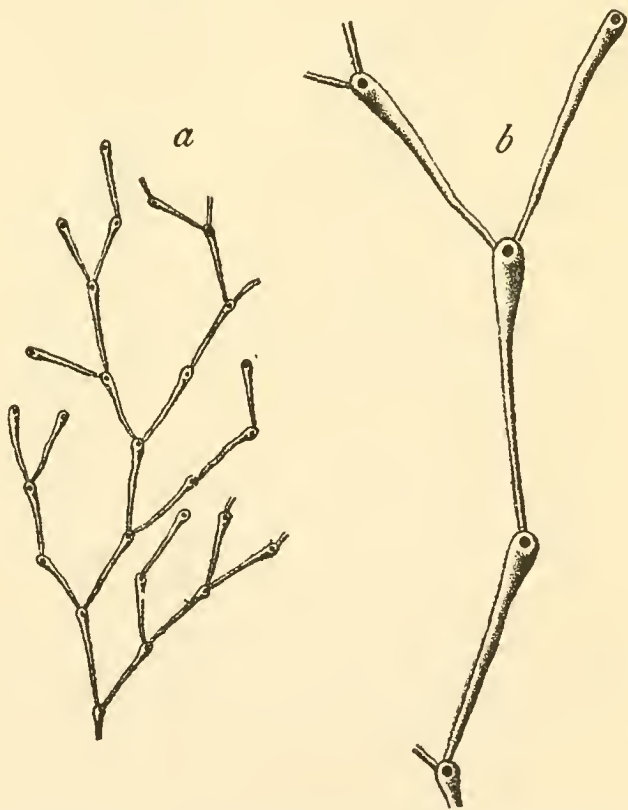


FIG. 6.—CORYNOTRYPA DELICATULA, *a* AND *b*, THE TYPE-SPECIMEN OF STOMATOPORA TENUISSIMA, $\times 9$ AND $\times 25$. ORDOVICIAN, ECONOMY BEDS OF EDEN FORMATION, CINCINNATI, OHIO. (AFTER ULRICH.)

base, but, as indicated in the several sets of figures illustrating this species, the slender part of the zoecium, here styled the

stolon, is of uniform diameter for some distance in the elongated forms. The gradual increase in diameter begins with the zoëcium proper. The dimensions for the various forms of the species are as follows: The zoëcia in the slender, elongate form shown in figure 6 average seven in 8 mm., while each, including the stolon, is from 1 mm. to 1.5 mm. long and from 0.11 mm. to 0.18 mm. at its greatest diameter. The slender proximal or stolonial portion in this form, as well as the others to be mentioned, is about 0.04 mm., while the aperture itself is slightly wider, averaging 0.05 mm. In figure 7 the short form of the species is illustrated. Here the measurements are practically the same as those given above, except that the zoëcia vary from 0.6 mm. to 0.8 mm.

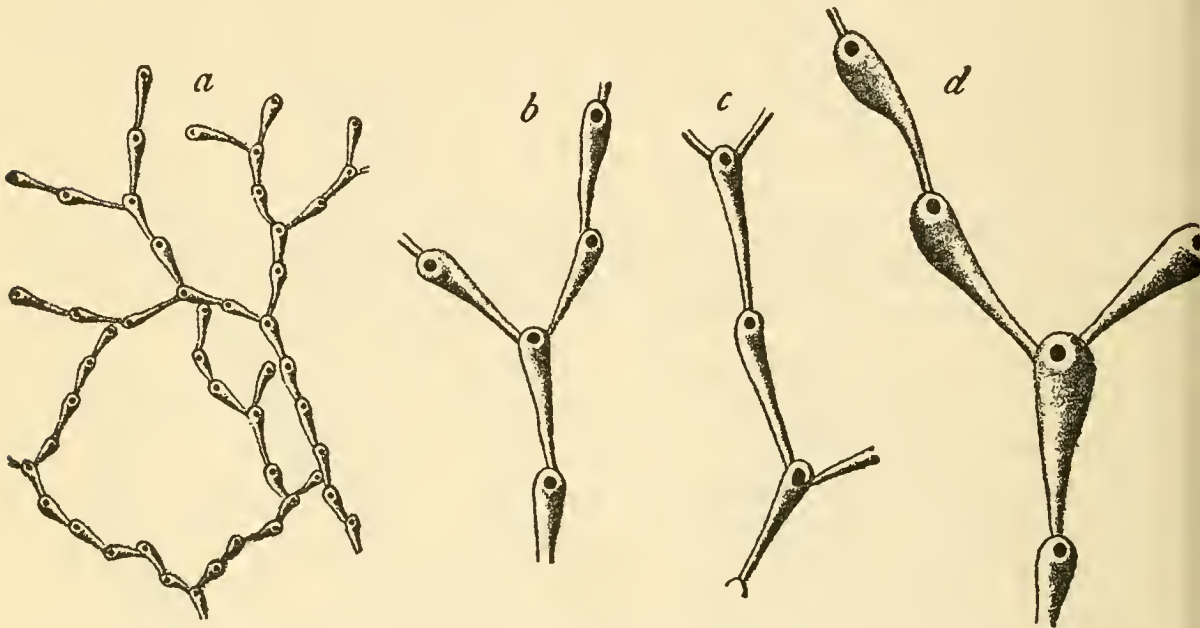


FIG. 7.—*CORYNOTRYPA DELICATULA*. SPECIMENS FIGURED BY ULRICH AS *STOMATOPORA PROUTANA*. *a*, FRAGMENT OF A ZOARIUM, $\times 9$; *b* AND *c*, TWO GROUPS OF ZOECIA, $\times 25$; *d*, SEVERAL ZOECIA OF UNUSUAL SIZE, $\times 25$. ORDOVICIAN, BLACK RIVER GROUP, ST. PAUL AND MINNEAPOLIS, MINNESOTA. (AFTER ULRICH.)

in length, and 8 to 10 occur in 5 mm. Several unusually large zoëcia are illustrated in figure 7*d*, but such specimens are of rare occurrence and even here the measurements are all in proportion to those of the typical specimens. In all of these various specimens the length of the zoëcium proper is approximately the same and its angle of divergence remains about 15° .

The considerable variation in the length of the stolon of this species has been discussed before and specific differences based upon this character have not been maintained, as noted in the synonymy above. At certain horizons, particularly in the McMillan formation at Cincinnati, Ohio, very luxuriant growths of *C. delicatula* are found and it is in such specimens that the greatest variation is exhibited.

Miller applied the name *Stomatopora proutana* to the very elongate form from the Corryville bed at Cincinnati, while specimens with the same characters but coming from the lower part of the Eden shale were described as *S. tenuissima* by Ulrich. The form with short zoëcia was named *Rhopalonaria pertenuis* by Ulrich, but later placed by him as a synonym of *S. proutana* Miller. Nickles and Bassler recognized James's name, but considered *S. tenuissima* of sufficient value to rank as a variety. The present study indicates that this last form has the zoëcium typical of the species and differs only in its greatly elongated stolon.

Occurrence.—An abundant fossil, beginning with the Stones River, in practically all of the Middle and Upper Ordovician and earliest Silurian (Richmond) formations of North America. In Europe the species is less abundantly represented, but is known from several of the Middle Ordovician formations of the Baltic provinces of Russia.

Plesiotypes.—Cat. nos. 13615, 43260, 43263, 54156, 54165, 54199, U.S.N.M.

CORYNOTRYPA BARBERI, new species.

At first sight this new species seems to be only an exceptionally large form of *C. delicatula*, but upon closer inspection other differences may be noted. These are, especially, the rapid swelling of

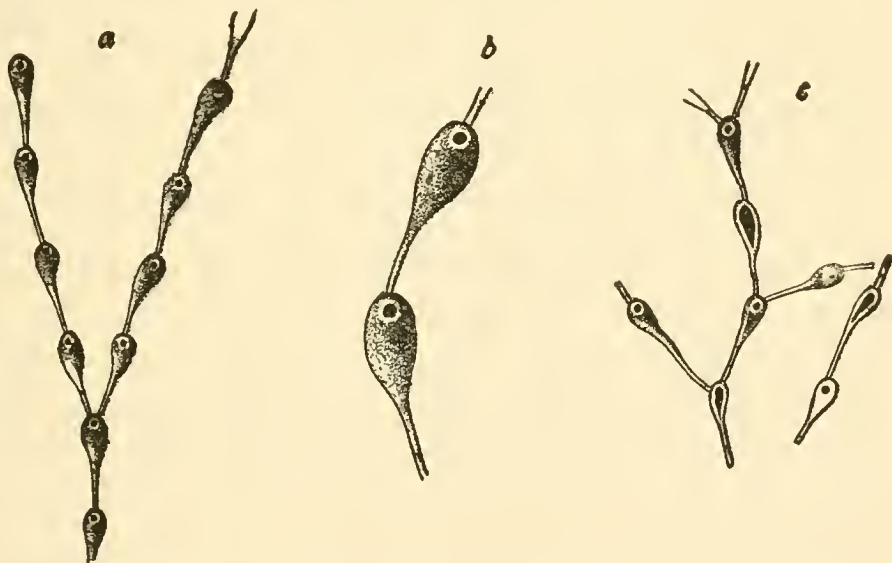


FIG. 8.—CORYNOTRYPA BARBERI. *a*, PORTION OF THE TYPE-SPECIMEN, $\times 9$, INCRUSTING A BIFOLIATE BRYOZOAN; *b*, SEVERAL ZOECIA, $\times 20$. ORDOVICIAN, OTTOSEE FORMATION, KNOXVILLE, TENNESSEE. *c*, PART OF A SMALL COLONY, $\times 9$, GROWING UPON A SPECIES OF HELIOLITES. EARLY SILURIAN, LYCKHOLM FORMATION, HOHENHOLM, ISLAND OF DAGO, BALTIC SEA.

the zoëcia after the stolonial portion has been left behind, and the marked difference between the stolon and the zoëcium proper. In *C. delicatula* the angle of divergence is so small (15°) and the increase in the zoëcial diameter so gradual that it is difficult to discriminate

between the stolon and the zoëcium proper. *C. barberi*, however, with equally slender and long stolons, has an angle of 30° , which is sufficient to cause the zoëcium to stand out prominently. Comparisons of equally magnified views of this and related species, as shown in figure 3, indicate the unusually large size of the zoëcium in *C. barberi*, although its stolon has practically the same dimensions as the more delicate forms. The dimensions of the species are as follows: An average zoëcium, including the stolon, is 1 mm. long and 0.23 mm. wide at its greatest diameter. The angle of divergence, as noted before, is 30° .

In growth, relative position and size of apertures, and height of peristome, *C. barberi* differs in no way from other members of the *C. delicatula* section, although, because of its large angle of divergence, it may be regarded as approaching the *C. inflata* section. The species often forms very luxuriant growths upon massive bryozoans, brachiopods, and other organisms. Such zoaria, with their prominent although delicate zoëcia, form striking cabinet specimens.

The specific name is in appreciation of the excellent collections made in the vicinity of his home city by Mr. Manly D. Barber, of Knoxville, Tennessee.

Occurrence.—Common in the shales of the Holston and Ottosee formations at Knoxville, Tennessee, and at many other places in that state and Virginia, where the same strata outcrop. Specimens indistinguishable from the types occur in the Lyckholm formation at Hohenholm, Island of Dago, Baltic Sea, in rocks equivalent to the Richmond group of America.

Holotype and paratype.—Cat. nos. 57105, 57106, U.S.N.M.

CORYNOTRYPA ELONGATA (Vine).

Stomatopora dissimilis, var. *elongata* VINE, Quart. Journ. Geol. Soc. London, vol. 38, 1882, p. 50.

Stomatopora elongata VINE, Ann. and Mag. Nat. Hist., ser. 5, vol. 14, 1884, p. 85, fig. IV, 2.—BASSLER, Bull. U. S. Geol. Surv., no. 292, 1906, p. 14, pl. 4, figs. 10–14.

Stomatopora parva RINGUEBERG, Bull. Buffalo Soc. Nat. Hist., vol. 5, 1886, p. 20, pl. 2, fig. 16.

Original description.—“*Stomatopora dissimilis* Vine, var. a. *elongata*. Zoarium very irregular, clustering. Zoëcia elongated, with, at times, long stoloniferous processes which intermingle with the cells. When colonial growth is distinct, arrangement of cells is linear and uniserial. Measured under favorable circumstances, about three cells occupy the space of one line.”

The present species has been treated by me at some length in the article cited above, and the following notes are mainly from that

work. The identity of the American form with Vine's species has been determined by the study of an authentic example from the original Wenlock shales material studied by Vine. A few zoecia of this example are shown in figure 9a, and comparison of this with the remaining figures of the American form indicates the specific identity. The long stoloniferous processes mentioned by Vine as intermingling with the cells are the stolons of ctenostomatous bryozoans such as *Vinella* or *Ascodictyon*, having no connection at all, of course, with *Corynotrypa*. Such widely diverse incrusting species are often found with their zoaria intermingled, but it usually requires little care to determine that one is merely growing over the other. The following description brings out the characters of *C. elongata* as observed in the present study.

Zoarium incrusting foreign objects, the smooth epitheca of corals or bryozoans being most frequently selected in the American examples. Zoecia uniserial, branching at irregular intervals, slender, fusiform, increasing slowly in size from a diameter of 0.03 mm. to 0.04 mm. at the proximal end, to one

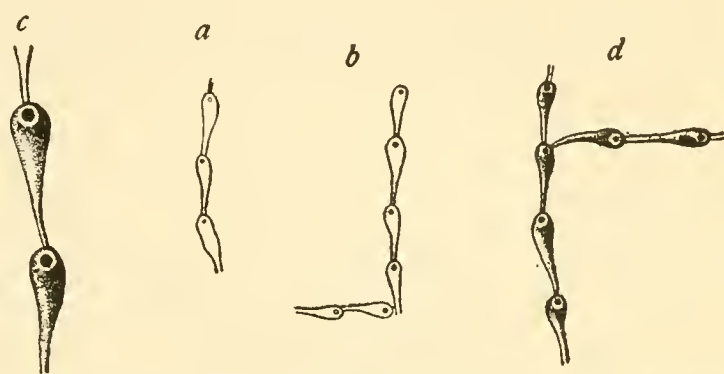


FIG. 9.—*CORYNOTRYPA ELONGATA*. *a*, SKETCH OF AN AUTHENTIC SPECIMEN, $\times 9$. SILURIAN (WENLOCK), ENGLAND; *b*, OUTLINE VIEW, $\times 9$, OF AN AMERICAN EXAMPLE INCRUSTING THE EPITHECAL SIDE OF A BRYOZOAN; *c*, TWO ZOECIA OF THE SAME, $\times 20$. SILURIAN, ROCHESTER SHALE, ROCHESTER, NEW YORK. *d*, PORTION OF A ZOARIUM, $\times 12$, INCRUSTING A BRACHIPOD. SILURIAN, WALDRON SHALES. WALDRON, INDIANA.

of 0.15 mm. to 0.18 mm. at the distal or anterior end, which, although normally rounded, is sometimes slightly drawn out. An average zoecium is 0.60 mm. in length; when arranged in a straight line, seven zoecia may be counted in the space of 4 mm.; angle of divergence about 25° . Aperture small, rounded, subterminal, with a slightly elevated border and less than half the greatest width of the zoecium in diameter. Surface of the zoecia smooth, probably finely porous.

Corynotrypa elongata is most certainly the Silurian representative of the abundant Ordovician *C. delicatula*, from which it differs mainly in its increased angle of divergence.

Occurrence.—Somewhat rare in the Buildwas beds of the Wenlock shales, Shropshire, England; Clinton formation, Seven Mile Creek, near Eaton, Ohio; Rochester shale, Rochester and Lockport, New York; Waldron shale, Newsom, Tennessee, and Waldron, Indiana.

Plesiotypes.—Cat. nos. 35475, 57107, U.S.N.M.

CORYNOTRYPA NITIDA, new species.

This very delicate, dainty species is clearly a descendant of the Ordovician type of the genus, *C. delicatula* (James), and of the widespread Silurian form, *C. elongata* (Vine). Indeed, these three forms are so similar that it is difficult if not impossible to point out striking differences. Very conservative students would probably regard the three as merely varieties, if not the same species, but, in view of their different geologic ages, and of the fact that some differences, however slight, may be observed, it is believed that the retention of separate specific names is preferable.

The incrusting zoarium of *C. nitida* has so far been noted only on corals, the two type-specimens growing upon *Pachypora fischeri* and *Cystiphyllum americanum*, respectively. The zoecia are very slender and much elongated, the angle of divergence being about 20° . An

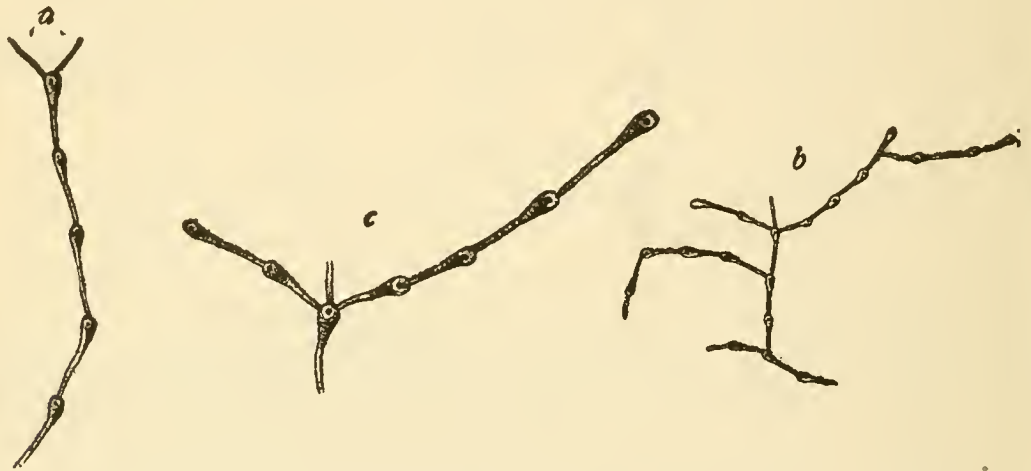


FIG. 10.—CORYNOTRYPA NITIDA. *a*, PORTION OF A ZOARIUM, $\times 20$, GROWING UPON THE CORAL *PACHYPORA FRONDOSA*. DEVONIAN, HAMILTON GROUP, ARKONA, ONTARIO. *b*, SKETCH OF A ZOARIUM, $\times 9$, INCrustING A CUP CORAL; *c*, SEVERAL ZOECIA OF THE SAME, $\times 20$. SAME HORIZON AT THEDFORD, ONTARIO.

average zoecium, including the stolon, is 0.5 mm. long and 0.07 mm. across at its widest part, and 6 to 7 zoecia may be counted in 3 mm. The aperture is subterminal and constricted, about one-third the diameter of the zoecium, and bears a low rim.

Compared with its Silurian progenitor, *C. elongata*, the present form is found to be decidedly smaller and more delicate and to have a less rapid angle of divergence. In general shape *C. delicatula* is probably more closely related, but here again the zoecia, although delicate, are coarser in every measurement than in *C. nitida*.

Occurrence.—Apparently rare in the shales of the Hamilton group at Thedford and Arkona, Canada.

Cotypes.—Cat. nos. 54180, 54181, U.S.N.M.

CORYNOTRYPA TENUICHORDA (Ulrich and Bassler).

Stomatopora tenuichorda (*temnichorda* in error) ULRICH and BASSLER, Geol. Surv. New Jersey, Paleontology, vol. 4, 1907, p. 314, pl. 20, figs. 5, 6.

Original description.—"Zoarium adnate, frequently branching, consisting of uniseriably arranged zoecia. Zoecia elongate-pyriform, or club-shaped, 0.45 mm. to 0.75 mm. in length, about 0.02 mm. in width at the posterior extremity, increasing very gradually in size through about one-half their length, and then somewhat abruptly to about 0.15 mm. at the rounded anterior end. Zoecial aperture nearly terminal, small, circular, with a slightly elevated, rim-like border, from 0.035 mm. to 0.05 mm. in diameter."

This delicate species is represented in the collections of the National Museum by a number of specimens, a portion of the best preserved one of which is shown in figure 11. While the general aspect of the species is precisely the same as in others of the *C. delicatula* group, a slight constriction in the middle portion of the zoecium proper causes a noticeable swelling in its proximal portion, giving an appearance somewhat similar to that often seen in certain forms of *Hippothoa*. None of the specimens shows any other features characteristic of *Hippothoa*, and all agree with *Corynotrypa* in every respect save the one character mentioned. Until more evidence is at hand, the species may be regarded as a typical *Corynotrypa*, differing from the other narrow, elongate species in having a greater angle of divergence (30°), and in the proximal swelling of the zoecia mentioned above.

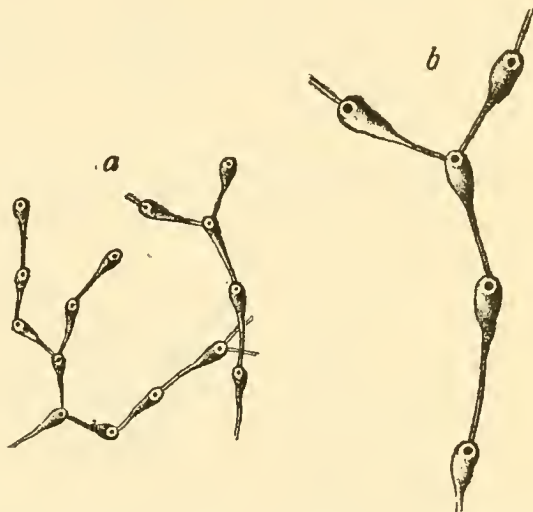


FIG. 11.—CORYNOTRYPA TENUICHORDA. *a*, PORTION OF A WELL PRESERVED ZOARIUM, $\times 9$, INCRUSTING THE INTERIOR OF A PELECYPOD; *b*, ZOECIA OF THE SAME ZOARIUM, $\times 20$. CRETACEOUS, VINCENTOWN SAND, VINCENTOWN, NEW JERSEY.

Occurrence.—Not uncommon in the Vincentown sand of the Cretaceous, at Vincentown, New Jersey.

Holotype.—Cat. no. 52618, U.S.N.M.

CORYNOTRYPA INFLATA SECTION.

The angle of divergence obtaining in species assigned to the *C. delicatula* section is usually so small that the stolon and the expanded part of the zoecium blend together to produce a structure which varies only in length. The variability in this section, therefore, although just as great, is not so conspicuous as in the *C. inflata*

section, where a wider angle of divergence results in a more expanded zoecium, contrasting sharply with the narrow, tubular stolon.

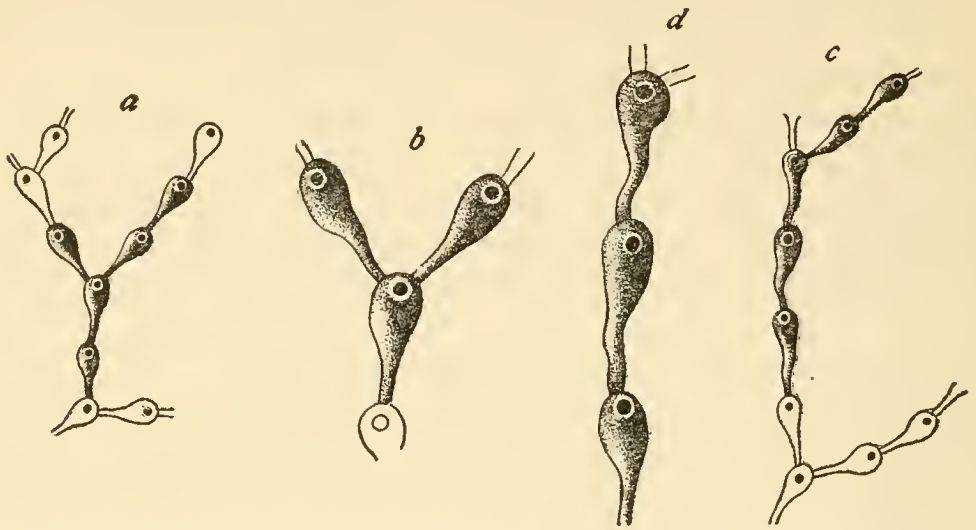


FIG. 12.—*CORYNOTRYPA INFLATA*, ILLUSTRATING DEVELOPMENT OF UNUSUALLY LONG STOLONS. *a* AND *b*, PORTIONS OF A ZOARIUM, $\times 9$ AND $\times 20$, INCrustING THE BRACHIOPOD *RAFINESQUINA SQUAMULA*. ORDOVICIAN, ECONOMY BEDS OF EDEN FORMATION, FORT THOMAS, KENTUCKY. *c* AND *d*, ANOTHER ZOARIUM, $\times 9$ AND $\times 20$, INCrustING A RAMOSE BRYOZOAN. SAME HORIZON AT WEST COVINGTON KENTUCKY.

Comparing the normal examples of *C. inflata*, for instance, as shown in figure 15, with specimens of the same species possessing elongated

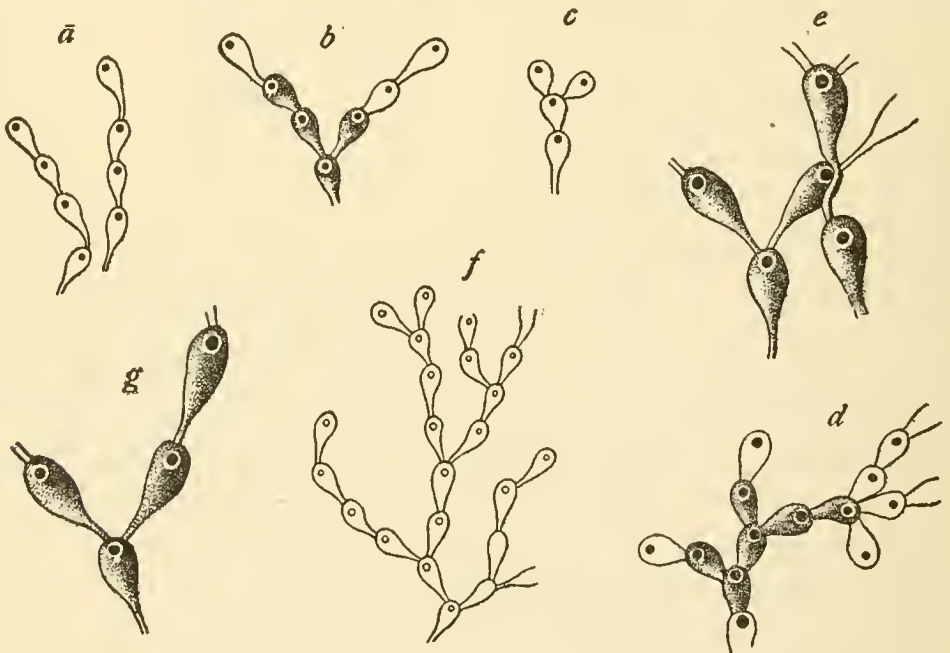


FIG. 13.—*CORYNOTRYPA INFLATA*, ILLUSTRATING VARIABLE LENGTH OF STOLONS. *a*, *b*, AND *c*, THREE PORTIONS OF THE SAME ZOARIUM, $\times 9$, INCrustING THE PEDICLE VALVE OF *STROPHOMENA TRENTONENSIS*. ORDOVICIAN, TRENTON FORMATION, ZYGOSPIRA BEDS, ST. PAUL, MINNESOTA. *d*, ANOTHER ZOARIUM, $\times 9$, WITH UNUSUALLY SHORT STOLONS, BLACK RIVER GROUP, PHYLLOPORINA BED, NEAR CANNON FALLS, MINNESOTA. *e*, ZOECIA, $\times 20$, WITH UNUSUALLY LONG STOLONS, GROWING UPON A FRAGMENT OF A TRILOBITE. ECONOMY BEDS OF EDEN FORMATION, NEWPORT, KENTUCKY. *f* AND *g*, A ZOARIUM, $\times 9$, AND A PORTION, $\times 20$, INCrustING *RAFINESQUINA ALTERNATA*. UPPER BEDS OF THE EDEN FORMATION, CINCINNATI, OHIO.

stolons (fig. 12), one might, without a study of this individual variation, refer the two sets to separate species. In the typical forms of

C. inflata, the stolon is quite short, in fact, often practically absent. The numerous examples before me show that this condition may prevail as long as the surface incrustated by the delicate zoaria is fairly even and smooth. Such a surface is afforded by the brachiopods incrustated by the originals of figure 15. The coarse striations of the brachiopod *Rafinesquina squamula*, incrustated by the originals of figs. 12*a*, *b*, produce a more uneven surface, and a similar surface is caused by the zoœcial apertures and acanthopores of the ramose bryozoan bearing the zoarium figured in 12*c*, *d*. The effect upon the length of the stolon is shown in the illustrations.

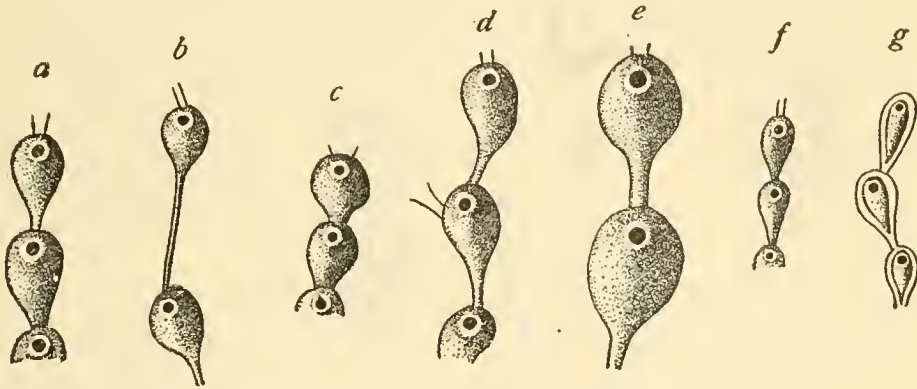


FIG. 14.—CORYNOTRYPA INFLATA SECTION. A GROUP OF ZOECIA, ALL $\times 20$, EXCEPT POSSIBLY *g*, SHOWING SPECIFIC DIFFERENCES. *a*, CORYNOTRYPA INFLATA; *b*, *C. ABRUPTA*; *c*, *C. CURTA*; *d*, *C. MEDIALIS*; *e*, *C. TURGHIDA*; *f*, *C. DEVONICA*; *g*, *C. SMITHI*.

In each of the examples compared above, either long or short stolons have been uniformly developed in the portions used for illustration. Such uniformity is not the rule, however, for both extremes and all intermediate lengths may be found in the same zoarium. This is shown in a zoarium incrusting a pedicle valve of *Strophomena trentonensis*, portions of which are smooth and other parts rough (figs. 13*a*–*c*). In another colony (fig. 13*d*), incrusting the nearly smooth base of a *Prasopora*, the stolon is wanting practically throughout the entire growth. Figure 13*e* illustrates the length of stolon attained when one zoœcium grows over another. Another zoarium bearing zoœcia with stolons of variable length is illustrated in figures 13*f* and *g*.

Normal zoœcia of each of the species referred to the *C. inflata* section of *Corynotrypa* have been assembled in figure 14.

CORYNOTRYPA INFLATA (Hall).

Alecto inflata HALL, Nat. Hist. New York, Pal., vol. 1, 1847, p. 77, pl. 26, figs. 7*a*, *b*.

Hippothoa inflata NICHOLSON, Pal. Ohio, vol. 2, 1875, p. 268, pl. 25, figs. 1–1*b*.

Stomatopora inflata VINE, Quar. Journ. Geol. Soc. London, vol. 37, 1881, p. 615.—

ULRICH Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 176, fig. 3*c*; Geol. and Nat. Hist. Surv. Minnesota, Final Rep., vol. 3, pt. 1, 1893, p. 117, pl. 1, figs. 13–21; Zittel's Textb. Pal. (Eng. ed.), p. 261, fig. 412*B*.—SIMPSON, Fourteenth Ann. Rep. State Geol. New York for the year 1894, 1897, p. 597, figs. 202–204.—RUEDEMANN, Bull. New York State Mus., no. 49, 1901 [1902], p. 12, pl. 1, figs. 2, 3.—CUMINGS, Thirty-second Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1907, p. 886, pl. 32, figs. 1, 1*a*

Zorium adnate, usually upon ramose or solid bryozoans or brachiopods; zoëcia typically short, pyriform, with the stolon but slightly developed; eight or nine zoëcia in 5 mm.; angle of divergence averaging 40° . Exclusive of the stolon a single specimen is 0.4 mm. long and 0.26 mm. wide. The aperture has a distinct peristome, is direct, circular, about 0.09 mm. in diameter, and situated near the anterior end.

The variability of this species has been noted in the previous remarks upon the section. Reference to the illustrations (figs. 12

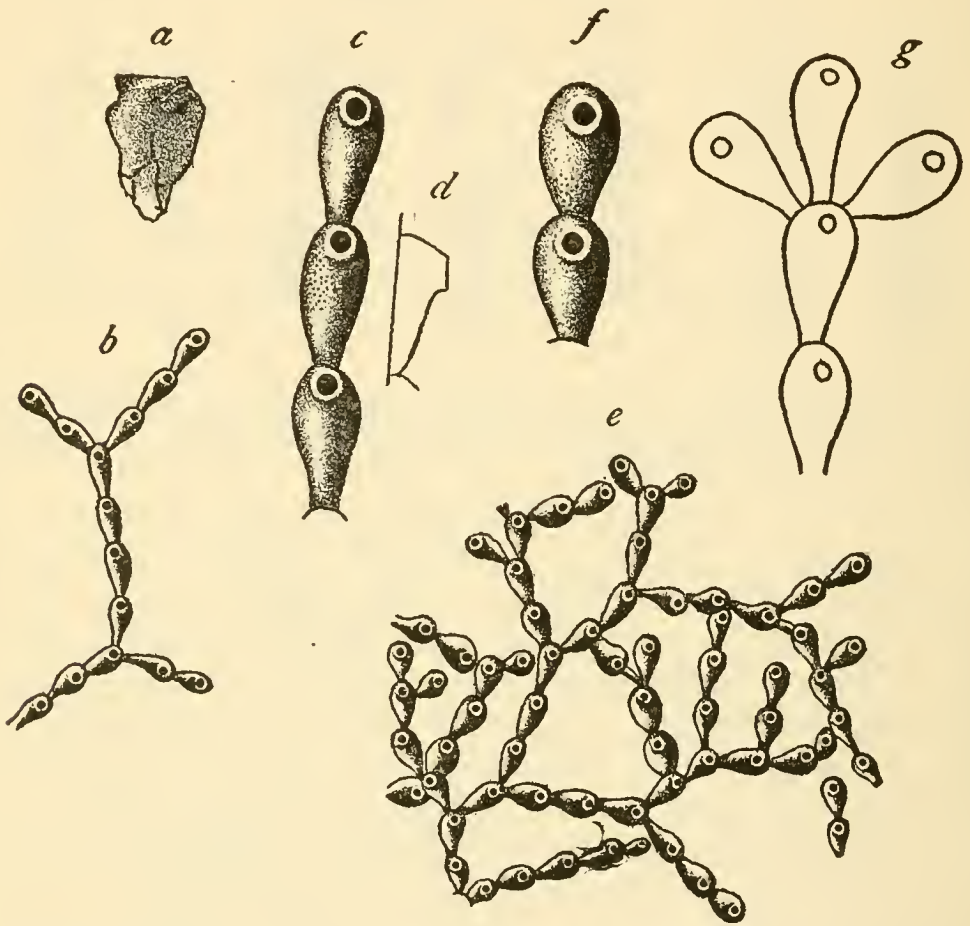


FIG. 15.—*CORYNOTRYPA INFLATA*. *a* and *b*, ZOARIUM NATURAL SIZE, AND A PORTION, $\times 9$; *c*, THREE ZOËCIA OF SAME, $\times 18$, SHOWING THE POROUS WALL; *d*, A VERTICAL SECTION OF A ZOËCIUM, $\times 18$. UPPER THIRD OF THE TRENTON SHALES AT CANNON FALLS, MINNESOTA. *e* and *f*, SMALL PORTION OF A COLONY INCRUSTING *RAFINESQUINA ALTERNATA*, $\times 9$ AND $\times 18$; *g*, OUTLINE OF ZOËCIA, $\times 18$, SHOWING THREE "GEMS" SPRINGING FROM ONE PARENT CELL. CORRYVILLE BEDS OF McMILLAN FORMATION, CINCINNATI, OHIO. (AFTER ULRICH.)

and 13) will show that the zoëcia of such variable zoaria are normal if the stolon is eliminated.

The pyriform shape and the size of the zoarium combined with its rather considerable angle of divergence, will distinguish *C. inflata* from related members of the section. The Devonian and Jurassic species, *C. devonica* and *C. smithi*, have a very similar zoarium, but in each instance their zoëcia, so far as present knowledge goes, are much smaller. The other members of the *C. inflata* section have

greater angles of divergence and their zoëcia are therefore correspondingly more swollen.

Occurrence.—Specimens of *C. inflata* are generally abundant in all of the middle and upper Ordovician and earliest Silurian (Richmond) formations of North America. Recently its geographic range has been extended by the discovery of typical examples in the middle Ordovician (Wesenberg) limestone, at Wesenberg, Esthonia, Russia. The original types came from the Trenton rocks of New York, where the zoarium is of more delicate growth than in the higher formations. The forms from the several Cincinnati formations have a very luxuriant growth, one network of zoëcia covering another until dense clusters result.

Plesiotypes.—Cat. nos. 43261, 43262, 54146, 54149, 54162, 54169, 54202, 57108, U.S.N.M.

CORYNOTRYPA ABRUPTA, new species.

Zoarium adnate, consisting of frequently branching, elongated, rather large, clavate zoëcia, much swollen at the anterior end. The

tubular proximal stolonial portion is almost thread-like, being not more than 0.04 mm. in width. This diameter is retained until the anterior third or fourth is reached, when the zoëcium abruptly swells, with an angle of divergence of 50° , and becomes rounded, with a diameter of 0.20 to

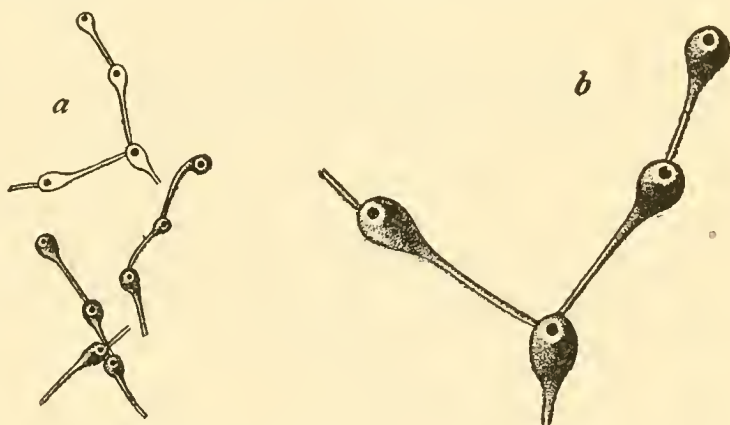


FIG. 16.—CORYNOTRYPA ABRUPTA. *a* AND *b*, PORTIONS OF THE TYPE-SPECIMEN, $\times 9$ AND $\times 20$, INCRUSTING A FRAGMENT OF RHYNCHOTREMA CAPAX. RICHMOND GROUP, IRON RIDGE, WISCONSIN.

0.25 mm. An average zoëcium and its stolon is 1.0 mm. long, but in individual zoëcia of the same zoarium the thread-like proximal portion may range in length from less than 0.10 mm. to 1 mm. The swollen anterior zoëcial portion, however, is fairly constant in its measurements, as no deviation from a width ranging between 0.20 mm. and 0.25 mm., and a length of 0.32 mm. to 0.40 mm. has been observed. The apertures are round, subterminal, bordered by a slightly elevated rim, and small, averaging only about 0.09 mm. in diameter.

Corynotrypa abrupta is easily distinguished from all other species of the genus by the extremely narrow proximal portion and the very abrupt swelling of the anterior end of the zoëcium. In related species such as *C. inflata* (Hall) and *C. medialis*, new species, the change from the proximal to the anterior end is less abrupt, but in

the present form the two portions are most distinctly marked. The extreme variation in the length of the narrow proximal portion is noted above, and is indicative of the fact that this part of the zoecium is the least stable in simple species of Cyclostomata.

Occurrence.—The American specimen illustrated in figure 16, upon which the species is based, incrusts a fragment of *Rhynchotrema capax* and was found in the highest beds of the Maquoketa shale division of the Richmond group at Iron Ridge, Wisconsin. The Russian example assigned to the species (fig. 17) was found at Kertel, Island of Dago, in the Lyckholm limestone, associated with *Calapoecia cribriformis* Nicholson,

Halysites sp., *Streptelasma*, and other fossils known to occur in certain strata of the Richmond group in America.

Holotype and *paratype.*—Cat. nos. 54173, 57109, U.S.N.M.

CORYNOTRYPA CURTA, new species.

This rather unique species grows usually in crowded little masses of zoecia, which, at first glance, show slight resemblance to the

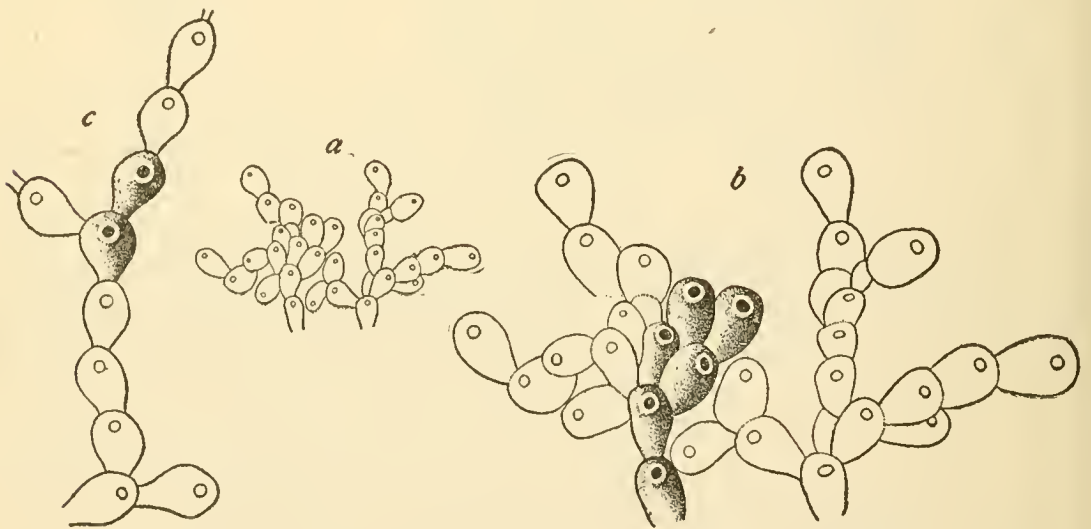


FIG. 17.—CORYNOTRYPA ABRUPTA. *a* AND *b*, PORTION OF A ZOARIUM, $\times 9$ AND $\times 20$, INCRUSTING A CRINOID COLUMN. EARLY SILURIAN, LYCKHOLM FORMATION, KERTEL, ISLAND OF DAGO, BALTIC SEA.

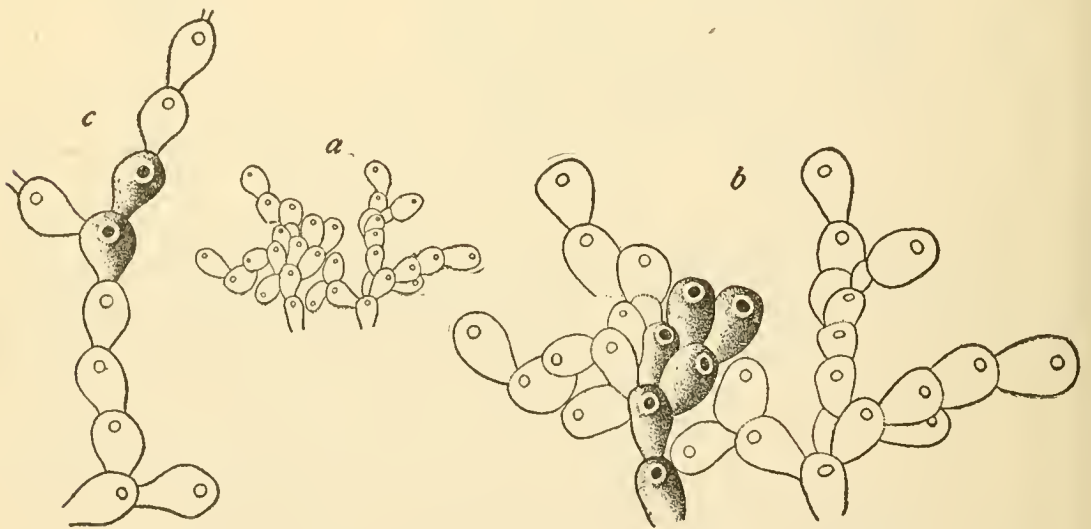


FIG. 18.—CORYNOTRYPA CURTA. *a* AND *b*, PORTION OF A CROWDED ZOARIUM, $\times 9$ AND $\times 20$, INCRUSTING THE BRYOZOAN *LIOCLEMELLA SOLIDISSIMA*; *c*, FRAGMENT OF A ZOARIUM GROWING MORE NORMALLY, $\times 20$. RICHMOND GROUP, SAVANNAH, ILLINOIS.

delicate, graceful colonies of other members of the genus. Upon resolving these small zoaria into their component zoecia, it becomes

evident that the crowded effect is produced by frequent budding of the short, almost rounded cells. A portion of such a dense growth is illustrated in figures 18*a*, *b*. Occasionally specimens with simple strings of zoëcia are found, and these show the intimate relationship of *C. curta* to the more common *C. inflata*.

Further comparisons with *C. inflata* will show the following differences: In *C. curta* the stolon is practically entirely absent, the zoëcium is small, but its angle of divergence is so great (70°) that the outline is subcircular or broadly oval. *C. inflata* has a larger and more pyriform zoëcium, a distinct although short stolon, and a much smaller angle of divergence (40°). The other species of the genus are less closely related and will not need detailed comparison.

The measurements of a normal zoëcium in *C. curta* are: Length, 0.33 mm.; greatest width, 0.26 mm.; angle of divergence, 70° ; six zoëcia in 2 mm.

Occurrence.—Not uncommon in the upper beds of the Maquoketa shale division of the Richmond group at Savannah, Illinois.

Cotypes.—Cat. no. 54171, U.S.N.M.

CORYNOTRYPA MEDIALIS, new species.

The specimens upon which this species is based occur in the Richmond formation, associated with typical examples of *Corynotrypa turgida* and *C. inflata*. This association, in connection with the fact that the characters of *C. medialis* are intermediate between the other two forms, might give rise to the idea that the three are merely mutations of a single species. Such an idea is disproved, first by the constancy in the size of the zoëcium proper in each species, and second by the practical identity of the angle of divergence in separate individuals of the same species. The zoëcium of *C. turgida* is so much larger than that of *C. inflata* that one of intermediate size is still distinct enough to be easily recognized as different from each with even a low power hand lens. Normal zoëcia of these three species are contrasted in figure 14, while a portion of the specimen selected as the holotype is figured above. The variable length of the stolon is shown in figure 19*a*, although a greater variation may be expected on other examples.

The dimensions of the usual zoëcium of *C. medialis* are as follows: Length of expanded portion, 0.50 mm.; greatest width, 0.26 mm.;

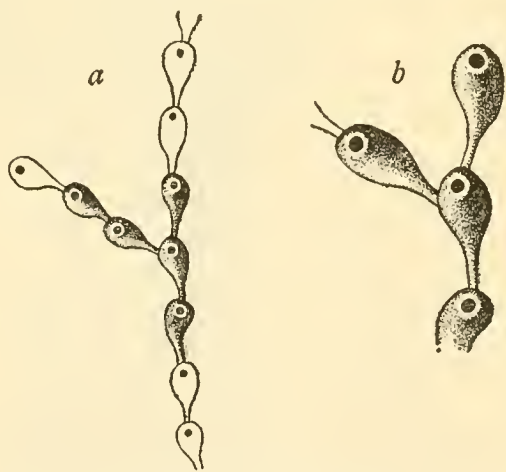


FIG. 19.—CORYNOTRYPA MEDIALIS. *a*, A PART OF THE TYPE-SPECIMEN, $\times 9$, INCRUSTING A CYSTID PLATE; *b*, SEVERAL ZOECIA OF SAME, $\times 20$. RICHMOND GROUP, THREE MILES NORTH OF SPRING VALLEY, MINNESOTA.

average length of stolon, 0.17 mm.; four to four and one-half zoëcia in 3 mm.; angle of divergence about 50° .

Occurrence.—Apparently rare in the Richmond group, 3 miles north of Spring Valley, Minnesota.

Holotype.—Cat. no. 57110, U.S.N.M.

CORYNOTRYPA TURGIDA (Ulrich).

Stomatopora turgida ULRICH, Journ. Cincinnati Soc. Nat. Hist., vol. 12, 1890, p. 176, fig. 3; Geol. and Nat. Hist. Surv. Minnesota, Final Rep., vol. 3, pt. 1, 1893, p. 118, pl. 1, figs. 22, 23.

Original description.—“Zoarium adnate, consisting of a single branching series of zoëcia. Zoëcia comparatively very large, the

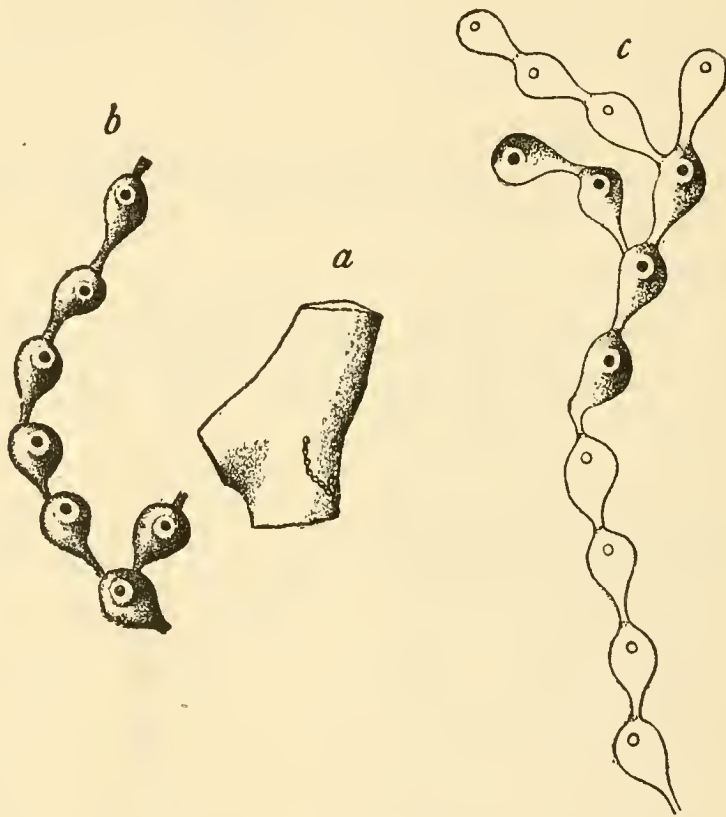


FIG. 20.—CORYNOTRYPA TURGIDA. *a* AND *b*, THE TYPE-SPECIMEN, NATURAL SIZE AND $\times 9$. RICHMOND GROUP (FERNVALE FORMATION), WILMINGTON, ILLINOIS. (AFTER ULRICH.) *c*, A SPECIMEN, $\times 9$, FROM THE RICHMOND GROUP, 3 MILES NORTH OF SPRING VALLEY, MINNESOTA.

anterior half much swollen, rapidly tapering posteriorly, with the slender, tubular proximal end inserted beneath the turgid anterior end of the preceding zoëcium. Five zoëcia in 5 mm.; length of each zoëcium varying from 0.85 to 1.30 mm.; the greatest diameter of the anterior half from 0.4 to 0.6 mm. The longest cells are the least turgid, while the shortest are the most. Apertures round, bordered by an elevated margin, small, 0.1 mm. in diameter, and situated about one-fourth of the length of the zoëcium from its anterior end.”

This species is represented in the collections of the U. S. National Museum by two excellent specimens from the type-locality, and by a third form from Minnesota, all of which agree with the description and measurements given above. The exceptionally large swelling of the zoëcia, and the very short and narrow stolonal portion are in such contrast that little difficulty should be experienced in recognizing the species. The amount of divergence of the zoëcium proper is about 50° . A similar abrupt swelling of the same region is present in *C. curta* and *C. abrupta* from the Richmond group, but each of these has zoëcia only one-third the size of those of *C. turgida*.

Occurrence.—Rare in the Richmond group (Fernvale shale) at Wilmington, Illinois, and in the same group at a locality 3 miles north of Spring Valley, Minnesota.

Plesiotype.—Cat. no. 54155, U.S.N.M.

CORYNOTRYPA DEVONICA (Oehlert).

Hypothoa devonica OEHLERT, Bull. Soc. d'Etudes Scientifiques d'Angers, vol. 17, 1888, p. 104, pl. 10, figs. 2-2c.

This species is known to me only from Oehlert's illustrations, which are here reproduced. Judging from these figures and from the magnifications ascribed to them, *C. devonica* belongs to the *C. inflata* section of *Corynotrypa*, but differs in its conspicuously smaller size. *C. inflata* has eight or more zoëcia in 5 mm., while fourteen to fifteen occur in the same diameter in *C. devonica*. It is probable that more careful study and illustrations of Oehlert's species will reveal other differences, although present knowledge is sufficient to place the form generically and to point out its specific relationships.

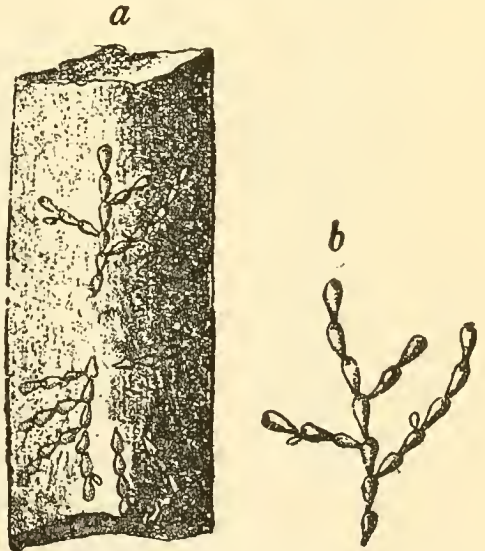


FIG. 21.—CORYNOTRYPA DEVONICA. *a*, ONE OF THE TYPE-SPECIMENS, $\times 7$; *b*, PORTION OF THE SAME, $\times 12$. DEVONIAN, DEPARTMENT DE LA MAYENNE, FRANCE. (AFTER OEHLERT.)

Occurrence.—Devonian, La Baconniere, Department de la Mayenne, France.

CORYNOTRYPA SMITHI (Phillips).

Cellaria smithi PHILLIPS, Geol. Yorkshire, pt. 1, Yorkshire Coast, 1829, p. 143, pl. 7, fig. 8.—BEAN, Mag. Nat. Hist., ser. 2, vol. 3, 1839, p. 58.—WRIGHT, Quart. Journ. Geol. Soc. London, vol. 16, 1860, p. 28.

Hypothoa smithi MORRIS, Cat. Brit. Foss., 1843, p. 39; ed. 2, 1854, p. 125.—HAIME, Mem. Soc. Geol. France, ser. 2, vol. 5, 1854, p. 217.—PICTET, Traite Pal., ed. 2, vol. 4, 1857, p. 103.

Alecto smithi D'ORBIGNY, Prodr. Pal., vol. 1, 1849, p. 317.

Stomatopora smithi GREGORY, Rep. Yorkshire Philos. Soc., 1894, p. 58, fig. 1; Ann. and Mag. Nat. Hist., ser. 6, vol. 15, 1895, p. 226; Cat. Foss. Bryozoa, The Jurassic Bryozoa, 1896, p. 56, fig. 8.

Gregory's description of this species follows:

Zoarium hippothoiform, uniserial; branches crowded and irregular; entirely adherent.

Zoecia pyriform; long, slender, proximal ends; front wall well raised, rounded, and punctate; orifice small, circular, surrounded by a low rim.

Peristomes slightly raised. Flat, regular rims surround each of the zoecia.

On account of the imperfection of Phillips's figures this species was not understood until Gregory described and refigured the type-specimen. As remarked by this author, the front walls of many zoecia in this specimen are often broken away, giving it a schizoporellidan aspect. Gregory, however, fails to mention a most

important matter, namely, the magnification of his figure. Judging from other magnifications in his volume, the figure, which is herewith reproduced, is enlarged about 25 diameters, but until this point is accurately determined the species can not be considered as fully described. *Stomatopora smithi* is undoubtedly a member of *Corynotrypa*, and, judging from its angle of divergence (40°), is quite similar to the Ordovician *C. inflata* (Hall). Gregory has given its formula as $p, c, l, r = 1, 3, 2, 0$, but from the variation noted in other species, more numerous specimens of *C. smithi* would show only the first and fourth terms to remain constant.

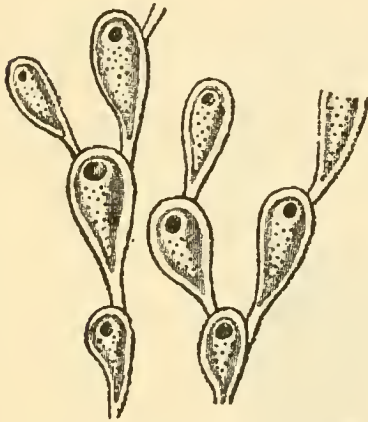


FIG. 22.—CORYNOTRYPA SMITHI. PART OF THE TYPE-SPECIMEN, INCRUSTING A CARDIUM. JURASSIC, BATHONIAN, NEAR SCARBOROUGH, ENGLAND. (AFTER GREGORY.)

Occurrence.—The type-specimen is incrusting *Cardium citrinoidum* and was found in the Bathonian (Cornbrash) division of the Jurassic, near Scarborough, England.

CORYNOTRYPA DISSIMILIS SECTION.

The four species assigned to this section form a less natural assemblage than those of the other two sections for the reason that they are either intermediate, in some of their characters, between *Corynotrypa* and *Stomatopora*, or show relationship to the other sections of *Corynotrypa*. The species selected as typical for the section has well-marked characters which are shared by only one other species, *C. tennesseensis*. These two forms constitute a small subsection characterized (1) by a slight proximal constriction of the zoecium, giving a small angle of divergence, and (2) by an aperture which, in addition

to being practically unconstricted, as in *Stomatopora*, tends also to be exsert, as in that genus. The proximal constriction of the zoecium, although slight, allies the species to *Corynotrypa*, but the remaining characters are the same as in *Stomatopora*. The two remaining species of the section, *C. schucherti* and *C. canadensis*, are more nearly related to *Corynotrypa*, since they have more constricted apertures surrounded by a peristome. Their proximal constriction, however, is much as in *C. dissimilis*, so that they must be considered as intermediate forms.

CORYNOTRYPA DISSIMILIS (Vine).

Stomatopora dissimilis VINE, Quart. Journ. Geol. Soc. London, vol. 37, 1881, pp. 615, 616, figs. 1-8; vol. 38, 1882, p. 50.—BASSLER, Bull. U. S. Geol. Surv., no. 292, 1906, p. 15, pl. 4, figs. 15-19.

Stomatopora recta RINGUEBERG, Bull. Buffalo Soc. Nat Hist., vol. 5, 1886, p. 20, pl. 2, figs. 15, 15a.

Stomatopora minor HENNIG, Arkiv für Zool., Kong. Sven. Vet.-Akad. Stockholm, vol. 3, no. 10, 1906, p. 24, pl. 3, fig. 6.

Aulopora, species, HALL, Nat. Hist. New York, Pal., vol. 2, 1852, pl. 50, figs. 27, 29.

Original description.—"Zoarium adnate, branching, generally attached to stems of Crinoidea, very rarely to broken shells; branches

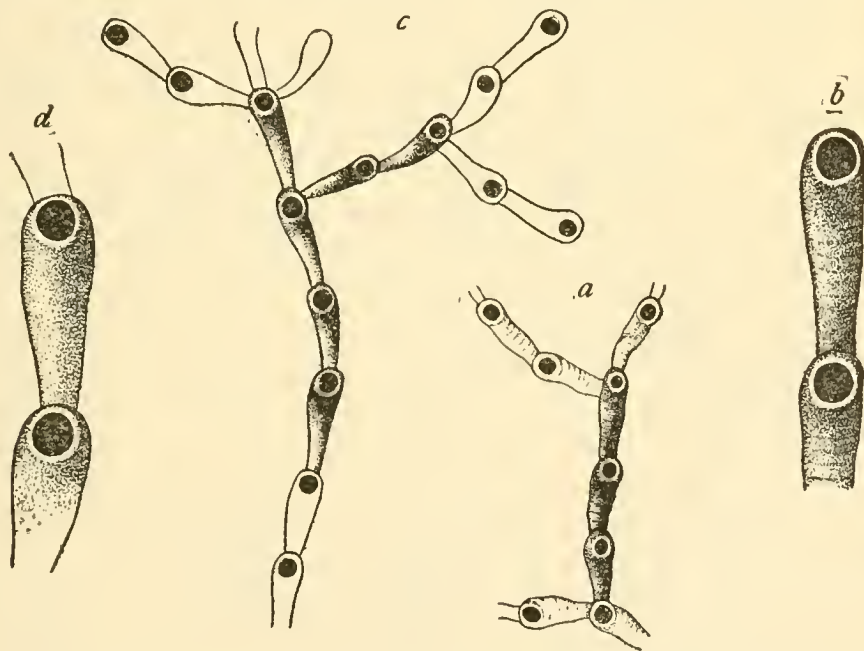


FIG. 23.—CORYNOTRYPA DISSIMILIS. *a* and *b*, A TYPICAL EXAMPLE OF THE SPECIES, $\times 9$ AND $\times 20$, INCRUSTING THE EPITHECA OF THE BRYOZOAN DIPLOTRYPA NUMMIFORMIS. SILURIAN, ROCHESTER SHALE, LOCKPORT, NEW YORK. *c* AND *d*, A POORLY PRESERVED SPECIMEN OF THE SPECIES, $\times 9$ AND $\times 20$, GROWING UPON A SPECIMEN OF HELIOLITES. EARLY SILURIAN, LYCKHOLM FORMATION, KERTEL, ISLAND OF DAGO, BALTIC SEA.

linear, sometimes wavy and anastomosing. Zoecia invariably uniserial, and, in the best preserved, very finely ribbed transversely; the oral extremity slightly raised; orifice circular or subcircular. Oöcial cells rather ventricose and strongly ribbed (?). Each normal zoecium about half a line; average about 6 to $3\frac{1}{2}$ lines."

A series of specimens from the Silurian rocks of various localities in Europe and America shows that the Wenlock shales species described by Vine as *Stomatopora dissimilis* has as wide a geographic distribution as certain Ordovician species of *Corynotrypa*. As indicated in the above synonymy, the American form was figured by Hall in 1852 without a specific designation, and later was figured and described by Ringueberg as *Stomatopora recta*.

The zoarium of *C. dissimilis* is parasitic, other bryozoans, brachiopods, and crinoid columns or plates being usually selected; uniserial, with lateral series branching usually irregularly, but sometimes very regularly and at right angles to the main series, as shown in figure 24. Zoecia subcylindrical rather than club-shaped, about 0.10 mm. in diameter at the proximal end and increasing to 0.35 mm. at the rounded distal portion; an average zoecium is 1.15 mm. in length. Apertures large, subterminal, slightly exsert. Zoecia marked transversely by fine wrinkles or striations.

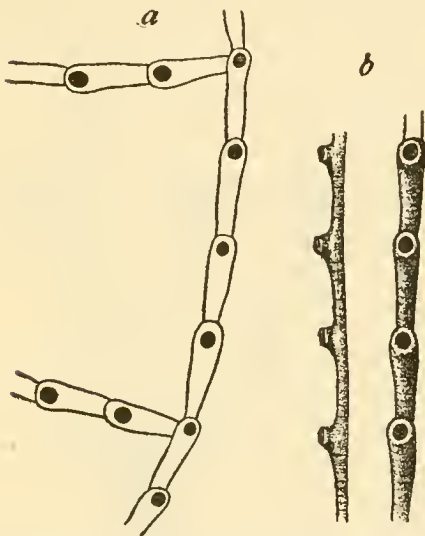


FIG. 24.—*CORYNOTRYPA DISSIMILIS*. *a* AND *b*, PORTIONS OF A ZOARIUM, $\times 9$, PARASITIC UPON A FRAGMENT OF A *SPIRIFER*. SILURIAN, ROCHESTER SHALE, LOCKPORT, NEW YORK. THIS SPECIMEN ILLUSTRATES BRANCHING AT RIGHT ANGLES.

(see figs. 23*c* and *d*) differ only in lacking the transversely wrinkled surface, a condition due probably to their somewhat imperfect preservation. The types are from the Buildwas beds of the Wenlock shales, Shropshire, England. The species occurs also in the Silurian beds, Island of Gotland, where it has been given the name *Stomatopora minor* by Hennig. It is abundant in the Rochester shale at Lockport and other localities in western New York, and at Grimsby, Ontario, and in the Osgood beds at Osgood, Indiana.

Plesiotypes.—Cat. nos. 35473, 57112, U.S.N.M.

***CORYNOTRYPA TENNESSEENSIS*, new species.**

The two well-preserved specimens upon which this new species is based present a combination of characters so similar to those of *C. dissimilis* that the same description, with slight emendations, will

The large zoecia with their transverse striations or wrinkles particularly characterize *C. dissimilis* and serve to distinguish it from all other Paleozoic species of the genus. The relations of the species to *Stomatopora* have been discussed in the remarks upon the *C. dissimilis* section (p. 522).

Occurrence.—The earliest appearance of *C. dissimilis* is in the Lyckholm limestone of Baltic Russia, in strata equivalent to the Richmond group of America. These specimens

apply to both. The characters in common are (1) rather large zoecia with a slight angle of divergence and transversely lined or wrinkled walls, and (2) zoecial apertures exert as in *Stomatopora* and much larger than in typical *Corynotrypa*. Comparing the two closely, the average zoecium of *C. tennesseensis* has a length of 0.75 mm. and a width of 0.30 mm. at its greatest diameter, and is therefore of less size than that obtaining in *C. dissimilis*.

The proximal constriction is also more pronounced in the older species, so that altogether it may be considered as representing an intermediate stage between the typical sections of *Corynotrypa* and the divergent group typified by *C. dissimilis*.

Occurrence.—Pierce limestone division of the Stones River group, 1½ miles south of Murfreesboro, Tennessee.

Cotypes.—Cat. no. 54177, U.S.N.M.

CORYNOTRYPA SCHUCHERTI, new species.

Zoarium frequently branching, uniserial, incrusting, in the case of the type-specimen, an example of *Streptelasma*. Zoecium compara-

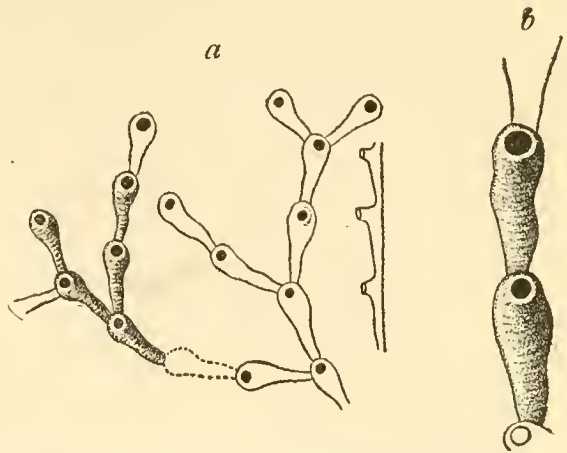


FIG. 25.—CORYNOTRYPA TENNESSEENSIS. *a*, THE TYPE-SPECIMEN, $\times 9$, WITH A LONGITUDINAL SECTION OF SEVERAL ZOECIA; *b*, SEVERAL ZOECIA, $\times 20$, INCrustING A FRAGMENT OF A STROPHOMENA. ORDOVICIAN, STONES RIVER GROUP, PIERCE LIMESTONE, ONE-HALF MILE SOUTH OF MURFREESBORO, TENNESSEE.

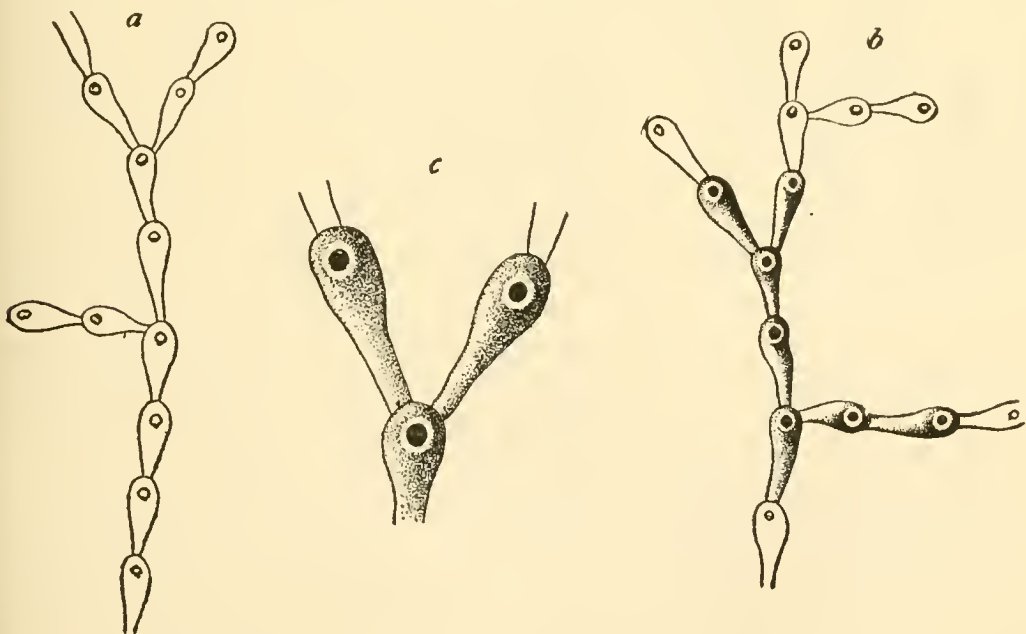


FIG. 26.—CORYNOTRYPA SCHUCHERTI. *a* AND *b*, PORTIONS OF THE TYPE-SPECIMEN, INCrustING A STREPTELASMA, $\times 9$; *c*, SEVERAL ZOECIA OF THE SAME, $\times 20$. MIDDLE ORDOVICIAN, WESENBERG FORMATION, WESENBERG, ESTHONIA, RUSSIA.

tively large, averaging 1 mm. in length, irregularly club-shaped, the anterior half swollen, with a maximum diameter of 0.40 mm., tapering gradually in the posterior half to the narrowest part with a width of 0.15 mm., where it joins the distal end of the preceding one. Apertures subterminal, surrounded by a slight border, and with a diameter slightly more than one-third that of the zoëcium.

This species, which is named in honor of Prof. Charles Schuchert, who collected the type-specimen, is related most closely to the common American form *C. inflata*, but differs conspicuously, however, in having larger, less regular, more elongate and less rapidly tapering zoëcia. From other members of the *C. dissimilis* group it is distinguished by its constricted aperture.

Occurrence.—Rare in the Wesenberg limestone at Wesenberg, Esthonia, Russia.

Holotype.—Cat. no. 57111, U.S.N.M.

CORYNOTRYPA CANADENSIS (Whiteaves).

Stomatopora canadensis WHITEAVES, Pal. Foss., vol. 3, 1897, p. 161, pl. 18, figs. 4, 4a.

Through the courtesy of the Director of the Geological Survey of Canada, I am able to refigure the type of this species, which was well

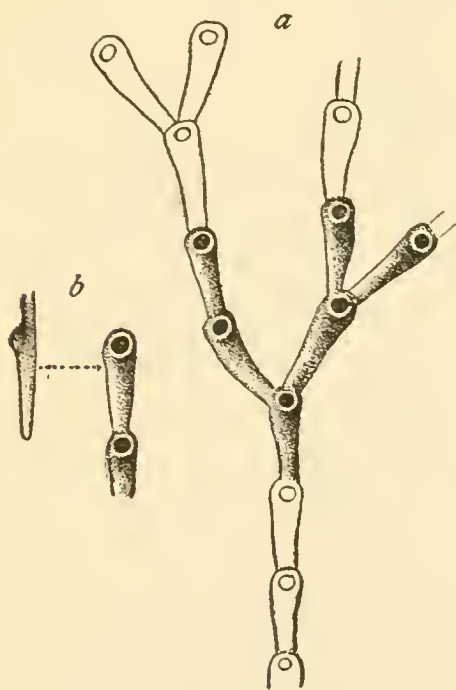


FIG. 27.—CORYNOTRYPA CANADENSIS. *a*, PORTION OF TYPE-SPECIMEN, $\times 9$; *b*, FRONT AND SIDE VIEWS OF A ZOËCIUM, $\times 9$. MIDDLE ORDOVICIAN, SWAMPY ISLAND, LAKE WINNIPEG, CANADA.

described by Professor Whiteaves, although his illustrations are inadequate for careful discrimination. Comparing figure 27 with figures 23 to 26, the close relationship of these four species can not fail to be apparent. With one exception, *C. tennesseensis*, the zoëcia are of equal size. The specific distinctions must, therefore, be based on differences in the aperture, surface ornamentation, and angle of divergence. *C. schucherti* has the most constricted aperture and in this respect is more closely related to the *C. inflata* section than to the present group of species. This relationship is further indicated by the constricted proximal portion of the zoëcium. *C. canadensis*, although of exactly the same size, is less constricted in the proximal area and also has a wider aperture,

which, in addition, is slightly exsert. While *C. schucherti* may be considered as intermediate between *C. canadensis* and *C. inflata*, *C. canadensis* likewise represents a stage between *C. schucherti* and *C.*

dissimilis. *C. tennesseensis*, with its exsert aperture and transversely rounded zoëcia, is probably an early expression of the Silurian *C. dissimilis*.

The dimensions for *C. canadensis* are as follows: Average length of zoarium, 0.80 mm.; width at constricted proximal portion, 0.22 mm.; diameter at most expanded part, 0.37 mm.; diameter of aperture, 0.20 mm.

Occurrence.—Middle Ordovician, Swampy Island, Lake Winnipeg, Canada.

ON A COLLECTION OF UNSTALKED CRINOIDS MADE BY
THE UNITED STATES FISHERIES STEAMER "ALBA-
TROSS" IN THE VICINITY OF THE PHILIPPINE ISLANDS.

BY AUSTIN HOBART CLARK,

Assistant Curator, Division of Marine Invertebrates, U. S. National Museum.

The third consignment of crinoids received from the U. S. Fisheries steamer *Albatross*, collected during her cruise among the Philippine and neighboring islands, proves to be much more interesting than either of the two previously received. In the first place it is very rich both in individuals and in species, being much the largest collection ever received from any single area; secondly, it contains a remarkable proportion of hitherto unknown forms.

Altogether fifty-nine species are represented, of which twenty-four are new; five have been rediscovered for the first time since the *Challenger* collected them between October, 1874, and January, 1875, and one has been found which has not been collected in the Philippines, from which locality the type was described, since 1866. Numerous species of which I gave preliminary diagnoses from material obtained by the Royal Indian Marine Surveying Ship *Investigator* have again come to light, and one of them, known previously from only a single example, proves to be abundant.

On the other hand, forty species previously secured by the *Albatross* in this region are not represented, and six species originally described from the Philippines by Carpenter yet remain to be rediscovered.

As we know it to-day the comatulid fauna of the Philippine Archipelago comprises about one hundred and five species, while the facts known in regard to the adjacent seas indicate the occurrence there of two or three score more.

Suborder OLIGOPHREATA.

Family COMASTERIDÆ.

Subfamily CAPILLASTERINÆ.

Genus CAPILLASTER.

CAPILLASTER SENTOSA (P. H. Carpenter).

Station 5355.—One small specimen.

Station 5481.—One specimen with fifty arms 90 mm. long and cirri XX, 27–35, 25 mm. to 30 mm. (usually 27 mm.) long.

Station 5482.—One specimen with forty-one arms 120 mm. long and cirri XXI, 27–30 (usually 28) 25 mm. to 30 mm. (usually 27 mm.) long.

Station 5483.—One specimen with thirty-seven arms 110 mm. long and cirri XXVIII, 27–31, 25 mm. to 30 mm. (usually 27 mm.) long.

CAPILLASTER MULTIRADIATA (Linnæus).

Station 5249.—One small specimen.

Station 5276.—Two specimens, one with thirteen, the other with about twenty arms; the brachials are very short with almost perfectly straight borders.

Station 5355.—One small specimen with arms about 70 mm. long; the right anterior radial is axillary, giving rise to two IBr series, one with one IIBr series and three arms, the other with two IIBr series and four arms. The IBr series arising from the axillary radial are spread out laterally exactly as IIBr series diverge from a IBr axillary, so that the anterior and the right posterior rays are much crowded. The left anterior ray is nearly twice the normal size, but of the five arms which it bears only one, which springs undivided from the IIBr axillary, is enlarged; the others, however, have just finished undergoing adolescent autotomy and may not have reached their full size.

Station 5482.—One specimen with about thirty arms.

Genus COMATELLA.

COMATELLA NIGRA (P. H. Carpenter).

Station 5356.—One specimen with twenty-nine arms 170 mm. long and cirri XXIII, 29–36, 30 mm. to 42 mm. long. The IIBr series bear a IIIBr series externally and an undivided arm internally except in one case where a IIBr series bears merely two undivided arms.

Station 5413.—One fine specimen with forty arms 170 mm. long and cirri XXI, 30–32, 30 mm. to 33 mm. long.

In the number of arms and in the arrangement of the arm divisions these specimens resemble typical *stelligera* instead of typical *nigra*; but in the structure of the cirri and pinnules and in all other points

they agree with *nigra*. It would thus appear that, while the frequency of the arm division can usually be relied upon to separate these two species, it is not so diagnostic as the characters presented by the centrodorsal and the cirri.

Genus COMISSIA.

COMISSIA LÜTKENI (A. H. Clark).

Station 5483.—Two specimens, closely resembling the type and cotype, but darker in color. The arms are dark greenish yellow, the pinnules chrome yellow, the cirri dull greenish yellow with dusky bands. One of the specimens has the mouth central and the anal tube marginal; the disk of the other is lacking.

COMISSIA DUMETUM, new species.

This new form is in general similar to *C. lütkeni*. The cirri, however, are more slender, the longer proximal segments somewhat more strongly constricted centrally, the distal with the dorsal processes slightly more pronounced; the cirri of the type are XV, 26–27, 15 mm. to 17 mm. long.

The ten arms of the type resemble those of *C. lütkeni* and are about 100 mm. long.

The pinnules are as in *C. lütkeni*, but the distal ends of the segments are more prominent and more spinous, and the dorsal surface is much more spinous. The spine at the ventral distal angles of the segments of the middle and distal pinnules is much longer than in *C. lütkeni* and somewhat more slender; on the outer segments its length is equal to the transverse diameter of the segment bearing it; it may be more or less branched, especially at the tip.

The color is olive green, the cirri blotched with lighter.

Type.—Cat. No. 27484, U.S.N.M., from station 5356.

Ten additional specimens were secured at this station.

COMISSIA HISPIDA, new species.

Centrodorsal thin-discoidal, the dorsal pole flat, 3.5 mm. in diameter; cirrus sockets in a single fairly regular marginal row.

Cirri XXII, 9–10, 8 mm. long; first segment very short, second about twice as broad as long, third the longest, about four times as long as the proximal diameter, a transition segment; next segment about twice as long as broad, the remainder about as long as broad; the second segment has both ends somewhat expanded; the third has the distal end somewhat expanded, this character dying away on the succeeding segments; the segments as far as the third are rounded in cross section, the remainder laterally flattened so that they appear considerably broader in lateral view; the fourth and following have small subterminal median dorsal tubercles; opposing spine small, median in position.

Mouth subcentral, anal tube submarginal.

Ends of the basal rays visible as small tubercles in the angles of the calyx; radials concealed in the median line but visible interradially as broad low triangles; IBr_1 exceedingly short, six to eight times as broad as long; IBr_2 triangular, not greatly broader than long, the anterior angle acute and somewhat produced.

Ten arms probably about 60 mm. long, resembling those of *Comissia lütkeni*; the lower brachials are triangular, about as long as broad; the arm increases slightly in diameter up to the twelfth or fourteenth brachial, then gradually tapers distally; the distal intersyzygial interval is three oblique muscular articulations.

P_1 12 mm. to 14 mm. long, very slender, with forty segments; terminal comb composed of from fifteen to seventeen long curved teeth set very closely together basally; P_2 12 mm. long resembling P_1 with a comb of fourteen teeth; P_3 9 mm. long resembling P_2 ; P_4 8 mm. long with a comb of fourteen teeth; P_5 7.5 mm. long with a similar comb; P_6 somewhat stouter than the preceding pinnules, 5 mm. long, with a rudimentary comb; following pinnules resembling P_6 , but without combs; the distal pinnules are slender, 9 mm. long.

Color, yellow.

Type.—Cat. No. 27485, U.S.N.M., from station 5431.

Subfamily COMACTINIINÆ.

Genus COMATULA.

COMATULA PECTINATA (Linnæus).

Station 5276.—One fine specimen with only six rather short and slender cirri; these are irregular in position, not being segregated in the interradiial angles like the cirri of *C. purpurea*.

Station 5358.—One fine specimen with the cirri XIV, 13, 13 mm. to 15 mm. long, rather stout.

Subfamily COMASTERINÆ.

Genus COMASTER.

COMASTER FRUTICOSUS, new species.

Centrodorsal discoidal with a broad flat bare polar area 2 mm. to 2.5 mm. in diameter.

Cirri slender, XXVII–XXX, 8–10 (usually 9) 7 mm. to 9 mm. long; the first segment is much broader than long, the second is about twice as long as its median breadth, and the third is the longest, three times as long as the median breadth; the fourth is somewhat shorter than the third, a transition segment; the following segments gradually become shorter, the antepenultimate being about as long as broad and the penultimate slightly broader than long; the transition and following segments have slight dorsal processes, as in the other small species of the genus.

IIBr 4 (3 + 4); IIIBr 2; IVBr 2, but rarely developed; thirty-seven to sixty-three very slender arms 90 mm. in length, resembling, with the division series, those of the related species; the projection of the distal edges of the brachials is very marked.

The color is brownish yellow.

Type.—Cat No. 27486, U.S.N.M., from station 5356.

Three additional specimens were secured at this station.

COMASTER DISTINCTA (P. H. Carpenter).

Station 5356.—One specimen with thirty arms 80 mm. long and cirri VIII, 10.

Station 5401.—Three specimens; one has thirty-three arms about 75 mm. long and cirri XXIII, 11; the two others are immature.

Station 5414.—One specimen with thirty arms 80 mm. long and cirri XV, 11, 7 mm. to 8 mm. long.

Station 5477.—Two specimens; one has thirty-one arms 100 mm. long and cirri XI, 11–12; the other is small with twenty arms 85 mm. long.

This species is nearest to *C. serrata* of southern Japan; but in *C. serrata* the third and fourth cirrus segments are much elongated, three times as long as broad, and the other segments are proportionately long; although *C. serrata* is a considerably smaller species, its cirri are actually longer, about 10 mm. in length.

Comaster parvus also bears a close resemblance to this species in many ways, but is easily distinguished by its more numerous arms and longer cirrus segments. The longest cirrus segment of *C. distincta*, the fourth, is about twice as long as broad.

In my report upon the comatulids collected by Mr. Alan Owston along the southern Japanese coast^a the two examples listed under "*Comaster parvicirra*" (p. 306) should have been referred to *Comaster serrata*.

COMASTER (?) HORRIDUS, new species.

Centrodorsal thin discoidal, the bare polar area 1 mm. in diameter; cirri in a single closely crowded irregularly alternating marginal row.

Cirri XVII, 14–15, 10 mm. long; first joint short, second somewhat longer than broad, third twice as long as its expanded ends, fourth or fifth the longest, two and one-half or three times as long as its expanded distal end; next very slightly shorter, usually a transition segment; following segments decreasing in length, the distal three or four being about as long as broad and the penultimate somewhat broader than long; transition and following segments with minute median subterminal dorsal tubercles; terminal claw half again as long as the penultimate segment, slender, moderately curved;

^a Proc. U. S. Nat. Mus., vol. 34, pp. 305–319.

second and following segments with expanded ends and rounded in section becoming after the fifth flattened laterally and much broader in lateral view.

Radials even with the edge of the centrodorsal in the median line, but extending well up into the interradiial angles and entirely separating the bases of the IBr_1 ; IBr_1 oblong or slightly trapezoidal, twice as broad as long, widely separated laterally; IBr_2 pentagonal, about as broad as long, the lateral edges slightly shorter than those of the IBr_1 and making with them a broadly obtuse angle.

Ten arms about 55 mm. long; first brachial nearly oblong, about twice as broad as long externally, interiorly in contact basally; second brachial about the same size but longer externally and shorter internally; third and fourth brachials (syzygial pair) about as long as broad; next two brachials approximately oblong, half again as long as broad, the following becoming obliquely wedge-shaped, somewhat longer than broad, and gradually increasing in length distally, the terminal brachials being twice as long as broad. The division series have slightly prominent and finely spinous distal ends; after the sixth the brachials develop strongly overlapping and very spinous distal edges.

P_1 10 mm. long with about thirty-nine segments, those after the fourth being about as long as broad; the long terminal comb consists of about twenty-five long curved teeth set closely together; P_2 6 mm. long, with a similar comb; P_3 6 mm. long, with a comb consisting of eighteen teeth; P_4 very slender, 6 mm. long, with a comb of twenty-one teeth, occupying rather more than its distal half; P_5 very slender and delicate, 4 mm. long, without a comb; following pinnules gradually increasing in length, the distal pinnules, which are very slender with greatly elongated segments, being 6 mm. long.

The color is yellowish brown.

Type.—Cat. No. 27487, U.S.N.M., from station 5356.

COMASTER (?) SCITULUS, new species.

Centrodorsal thin discoidal, the dorsal pole flat, 1.5 mm. in diameter.

Cirri XIX, 10–12, 5 mm. to 6 mm. long; first segment short, second somewhat longer than the diameter of its expanded ends, third two to two and one-half times as long as its expanded ends, fourth the longest, about four times as long as the diameter of its proximal end, a transition segment; following segments becoming very rapidly shorter, and at the same time becoming laterally compressed and increasing in lateral diameter, the penultimate segment being twice as broad as long; fourth and following with thickened distal dorsal edges and small sharp subterminal dorsal tubercles, which become central on the antepenultimate; opposing spine prominent but small, terminal, erect, or nearly erect, in height equal to about one-

third the lateral diameter of the penultimate segment; second and third segment with considerably expanded ends; fourth with the distal end much expanded, this character gradually dying away distally; terminal claw nearly twice as long as the penultimate segment, rather slender, and moderately curved.

Radials concealed; IBr_1 very short, oblong, about four times as broad as long, in apposition laterally; IBr_2 nearly triangular, twice as broad as long, with a shallow groove on the dorsal side at the anterior angle as in *Comatula pectinata*.

Ten arms about 60 mm. long; first brachial wedge shaped, about three times as broad as long exteriorly, basally united interiorly; second brachial more obliquely wedge shaped, about twice as broad as long exteriorly; third and fourth brachials (syzygial pair) nearly twice as broad as long; next two nearly oblong, about twice as broad as long, the following becoming very obliquely wedge shaped, nearly triangular and nearly as long as broad, and further out less obliquely wedge shaped, as long as broad, and longer than broad terminally. The IBr series and first two brachials have everted and spinous distal ends; the following brachials have strongly produced and overlapping coarsely spinous distal ends. Syzygies occur between the third and fourth brachials, again between the tenth and eleventh to thirteenth and fourteenth (usually in the latter position) and distally at intervals of three oblique muscular articulations.

P_1 7 mm. long with about twenty-five segments, all about as long as broad; their dorsal surface is excessively spinous, and frills of long spines fringe their distal edges; the terminal comb consists of seven or eight small and well-separated teeth, which are repeated, somewhat smaller, on the inner side of the pinnule; P_2 4 mm. long, with sixteen to twenty segments, similar to P_1 ; P_3 somewhat larger, 5 mm. long, with eighteen to twenty segments, the third-seventh or third-eighth with a genital gland, and a terminal comb; P_4 and following pinnules 4 mm. long, somewhat stouter than P_3 , without terminal combs, composed of about twelve very spiny segments; the distal pinnules are very slender, about 5 mm. long.

The color is greenish.

Type.—Cat. No. 27488, U.S.N.M., from station 5356.

Genus COMANTHUS.

Subgenus COMANTHERIA.

COMANTHUS (COMANTHERIA) BRIAREUS (Bell).

Station 5321.—One specimen.

Mahinog, Caunguin Island.—One specimen with about sixty-five arms.

Subgenus COMANTHINA.

COMANTHUS (COMANTHINA) SCHLEGELII (P. H. Carpenter).

Ulugan Bay, Palawan.—One fine large specimen, with about one hundred arms 155 mm. long; seven large functional cirri 13 mm. in length remain, all on the anterior semicircumference of the centrodorsal.

Examination of the type of Carpenter's *Actinometra schlegelii* at the Leyden Museum has disclosed the fact that it is exactly the same thing as the *Actinometra nobilis* and *Act. regalis* described in the *Challenger* report, Carpenter having overlooked at the time the characteristic arm structure which he described later in *Act. nobilis*.

Subgenus COMANTHUS.

Specific Group VALIDIA.

COMANTHUS (COMANTHUS) ANNULATA (Bell).

Station 5321.—One specimen with forty arms; one of the III Br series is 2.

Station 5599.—One specimen with forty-two arms; two of the III Br series are 2. Neither of these specimens have any cirri.

Tulayan Island.—One specimen with forty-six arms 100 mm. long; the brachials are rather strongly overlapping; one of the III Br series is 2, another is 8 (3 + 4; 7 + 8); there are three cirri remaining.

Thanks to the kindness and courtesy of Prof. Jeffrey Bell I have recently been able to examine the type of his *Actinometra annulata* at the British Museum, and I find that it is the same species as that later described in the *Challenger* report as *Actinometra valida*.

COMANTHUS (COMANTHUS) PARVICIRRA (J. Müller).

Station 5413.—One specimen with nineteen arms 95 mm. long; one of the II Br series bears two III Br series; twelve cirri are present in a partially deficient row.

Station 5414.—One specimen with fifteen arms 95 mm. long; there are five II Br series present, three 2, two 4 (3 + 4); the arms are long and slender with the brachials more strongly overlapping than usual; two small cirri 5 mm. long remain on a centrodorsal barely raised above the radials.

On the basis of Carpenter's statements in the *Challenger* report I have hitherto called this species *rotalaria*, but upon examining the types of *rotalaria* at Paris I find that it is the same thing as the form called *jukesii* by Carpenter and *paucicirra* by Bell. *Parvicirra* is the next available name.

Family ZYGOMETRIDÆ.

Genus ZYGOMETRA.

ZYGOMETRA COMATA (A. H. Clark).

Station 5358.—One specimen with twenty-eight arms 110 mm. long, resembling others from Singapore in the collection of the University of Copenhagen.

ZYGOMETRA PRISTINA, new species.

Centrodorsal low hemispherical, the bare polar area papillose, 1 mm. in diameter; cirrus sockets in a single irregular not especially crowded row.

Cirri moderately slender, XII, 20–21, 12 mm. long; first segment short, the following gradually increasing in length and becoming about one-third longer than broad on the fourth; next two similar; following slowly decreasing in length, the segments in the outer part of the cirri being about as long as broad; sixth and seventh and following segments with long sharp dorsal spines; opposing spine nearly as long as the diameter of the penultimate segment, slender, sharp, erect; terminal claw twice as long as the penultimate segment, strongly curved proximally, becoming straighter distally. The cirrus segments are somewhat constricted centrally with slightly expanded and overlapping distal ends.

Disk covered with rounded isolated flat plates, and thickly plated along the ambulacra and on the anal tube.

Radials short, about four times as broad as long, sometimes with a faintly marked row of small tubercles along the distal border; IBr_1 about as long as the radials, four times as broad as long, oblong; IBr_1 and $_2$ united by a pseudo-syzygy in which the outer part of the joint face for about one-half the distance from the periphery to the rim of the central canal is marked with radiating ridges, the space within this border being smooth and flat except for the low and narrow synarthrial longitudinal ridge; IBr_2 pentagonal, twice as broad as long.

Ten arms 50 mm. long; first two brachials subequal, slightly wedge-shaped, twice as broad as long exteriorly; third and fourth brachials (syzygial pair) slightly longer interiorly than exteriorly, twice as broad as the exterior length; next four brachials oblong, slightly over twice as broad as long, then becoming obliquely wedge-shaped, about as long as broad, after the proximal third of the arm less obliquely wedge-shaped, about as long as broad, and terminally slightly longer than broad; the brachials after the tenth have somewhat produced distal ends. Syzygies occur between the third and fourth brachials, again most commonly between the thirteenth and fourteenth, and distally at intervals of from six to ten (usually eight or nine) oblique muscular articulations.

P_1 8 mm. long, moderately stout basally, but tapering rapidly in the proximal half and becoming very slender and thread-like distally, with about twenty-five segments, the first about twice as broad as long, the following gradually increasing in length, becoming squarish on the fifth and following and slightly longer than broad terminally; the first three to five segments are slightly carinate and rounded-prismatic; P_2 about 10 mm. long, stouter than P_1 but similar to it, with about thirty segments; P_3 3.5 mm. long, small, weak, and slender, exceedingly slender in its distal half; P_4 similar, 3 mm. long; P_5 2 mm. long with ten segments not tapering so rapidly as the preceding, and therefore appearing somewhat stouter; following pinnules similar, soon increasing slowly in length and slenderness; distal pinnules very slender, 6 mm. long, with fifteen or sixteen segments.

The color is deep violet, the cirri white.

Type.—Cat. No. 27489, U.S.N.M., from station 5276.

My studies upon the origin and significance of the nonmuscular articulations in the crinoid arm ^a have shown that the occurrence of a true syzygy proximal to the syzygy between the third and fourth brachials of the free undivided arm is a very anomalous condition. Such a state of affairs has been supposed to exist in the comasterid genera *Comaster* and *Comatula*, and in the Zygometridæ. In the first two genera I have been able to prove that the supposed syzygies are in reality derived secondarily from the normal synarthries ^b and have nothing to do with true syzygies at all. I had never seen anything among the Zygometridæ which would warrant the statement that the syzygy found between the two elements of their IBr series is derived from a synarthry until the specimen just described came to hand. In this the primitive synarthry is in process of transformation into a pseudo-syzygy through the development of radiating ridges along the periphery of the joint face, which are apparently extending inward toward the central canal.

I now think that there can be no doubt that the "syzygy" between the two elements of the IBr series in the Zygometridæ is in reality nothing more than a remarkably perfect pseudo-syzygy derived secondarily from the synarthry, a condition called for by my interpretation of the brachial homologies as explained in previous papers.

^a Amer. Nat., vol. 43, 1909, pp. 577-587; Proc. U. S. Nat. Mus., vol. 35, 1908, pp. 113-131.

^b Proc. Biol. Soc. Washington, vol. 22, pp. 173, 174.

Genus CATOPTOMETRA.

CATOPTOMETRA OPHIURA, new species.

Centrodorsal thin-discoidal with a broad moderately concave polar area 5 mm. to 8 mm. in diameter marked in the center by a shallow rounded pit; cirrus sockets in two closely crowded irregular marginal rows.

Cirri XXVII, 15–18 (usually 17), 22 mm. long; first segment about twice as broad as long, second not quite so long as broad, third half again as long as the median diameter, fourth and fifth twice as long as the median diameter, the following gradually becoming very slightly shorter so that the terminal segments are half again as long as broad; dorsal and ventral edge of the longer proximal segments, especially the former, rather strongly concave, this feature gradually dying away distally; lateral edges of these longer proximal segments very strongly concave, this character gradually becoming less marked but persisting to the end of the cirrus; penultimate segment about one-third longer than broad; opposing spine terminal, small and inconspicuous; terminal claw half again as long as the penultimate segment, slender and slightly curved.

Radials barely visible in the angles of the calyx; IBr₁ very short and bandlike, oblong; IBr₂ triangular, nearly three times as broad as long; IBr₁ and ₂ well separated laterally; IIBr 4 (3+4); IIBr₁ interiorly united for the proximal half or two-thirds, diverging so as to make right angles with each other distally; IIIBr (when present) 2 always developed interiorly in 1, 2, 2, 1 order; synarthrial tubercles sharp and prominent.

Twenty to twenty-seven arms 180 mm. long; first brachial wedge-shaped, about twice as broad as long exteriorly, interiorly united for about the proximal two-thirds; second brachial about the same size but more obliquely wedge-shaped; third and fourth brachials (syzygial pair) slightly longer interiorly than exteriorly, about twice as broad as the median length; following five brachials oblong or slightly wedge-shaped, two to three times as broad as long, then becoming triangular, nearly as long as broad, then triangular and as long as broad, and distally obliquely wedge-shaped, becoming terminally longer than broad; distal edges of the tenth and following brachials moderately overlapping and finely spinous. Syzygies occur between the third and fourth brachials, again between the nineteenth and twentieth to thirty-sixth and thirty-seventh (usually about the twenty-seventh and twenty-eighth) and distally at intervals of eight to sixteen (usually ten or eleven) oblique muscular articulations.

P_d small and slender, 6 mm. long, with twenty-five to thirty segments, most of which are about as long as broad; the second to the fifth bear strong dorsal projections; P₁ 7 mm. to 8 mm. long, slender, the second to the fourth segments with dorsal projections which are

not so large as those on the basal segments of P_D ; P_2 resembling P_1 but 15 mm. long with forty to forty-two squarish segments, the first to the fourth with slight dorsal projections; P_3 similar, 12 mm. long; P_4 similar, 11 mm. long; P_5 similar, 11 mm. long; the following pinnules gradually decrease in length to 7 mm., then slowly increase to 10 mm. distally; the carination of the proximal segments of the lower pinnules becomes progressively less and less, disappearing entirely after P_{10} or P_{12} .

Color dull olive green, the disk ambulacra and the perisome of the pinnules dark brown.

Type.—Cat. No. 27490, U.S.N.M., from station 5356.

This species is nearest to *C. hartlaubi* of Japan, but the cirri are longer, much stouter, with more and shorter segments, which have strongly swollen articulations. The division series and arm bases lack the strongly everted and spinous distal edges so characteristic of those of *C. hartlaubi*.

Station 5356.—Four specimens, one with twenty, two with twenty-six, and one with twenty-seven arms.

Station 5414.—One small specimen with eleven arms about 90 mm. long.

Genus **EUDIOCRINUS**.

EUDIOCRINUS INDIVISUS (Semper).

Station 5356.—Five specimens, each with arms about 85 mm. long.

Family **HIMEROMETRIDÆ**.

Subfamily **HIMEROMETRINÆ**.

Genus **AMPHIMETRA**.

AMPHIMETRA MILBERTI (J. Müller).

Limborres Cave.—One specimen.

AMPHIMETRA VARIIPINNA (P. H. Carpenter).

Station 5358.—One specimen with eleven arms 150 mm. long and cirri XI, 34–41, 35 mm. to 37 mm. long. The cirri are rather more slender than usual, the processes on the segments of the proximal pinnules are less developed, and the general appearance is not so rugged as is commonly the case. The animal is probably not quite mature.

Station 5481.—One small specimen with twelve arms.

Genus **HIMEROMETRA**.

HIMEROMETRA MAGNIPINNA A. H. Clark.

Ulugan Bay, Palawan.—One magnificent specimen with forty-two arms 184 mm. long and cirri XXXIII, 29–35, 30 mm. long; the color is a uniform deep violet.

Genus CRASPEDOMETRA.

CRASPEDOMETRA ANCEPS (P. H. Carpenter).

Station 5355.—One small specimen with eighteen arms about 80 mm. long and cirri 20 mm. to 22 mm. long.

An examination of the *Challenger* types in London has shown me that Carpenter's *Antedon clemens* is the same thing as his *Antedon anceps* and as my *Craspedometra aliena*.

Subfamily STEPHANOMETRINÆ.

Genus STEPHANOMETRA.

STEPHANOMETRA CORONATA A. H. Clark.

Port Busin, Barias Island.—One fine specimen closely resembling the type in the Indian Museum at Calcutta; it has thirty-four arms about 150 mm. long; four of the post-radial series bear seven arms and one bears six; as in the type the division series omitted are always internal; the cirri are XVIII, 27–29, 26 mm. to 28 mm. long.

The color is dark purple.

This species was previously only known from "India."

Subfamily MARIAMETRINÆ.

SELENOMETRA, new genus.

Centrodorsal large, hemispherical, bearing numerous cirri which are long, moderately slender, with very numerous (45 or more) segments, of which the outer are short and bear sharp dorsal spines; radials long, their outer sides parallel to the dorso-ventral axis of the animal appearing when the animal is spread out as a short thick column; IBr and division series in close apposition and sharply flattened laterally; arms forty in number; proximal pinnules very slender, with about twenty segments, evenly tapering distally, slightly stiffened.

Genotype.—*Antedon finschii* Hartlaub, 1890.

SELENOMETRA VIRIDIS, new species.

Cirri XXXIII, 47–57, 30 mm. to 35 mm. long, rather slender; sharp dorsal spines are developed from the tenth or twelfth, which is a more or less marked transition segment, onward.

Calyx and arm bases as in *S. gracilipes*,^a but the division series and proximal ten brachials are sharply flattened laterally.

Forty arms 90 mm. long.

P₁ 10 mm. long, slender, with nineteen segments, which become twice as long as broad distally; P₂ and P₃ similar, 12 mm. long with twenty-one segments, slightly stiffer than P₁, and proportionately

^a *Himerometra gracilipes* A. H. Clark, *Smiths. Misc. Coll. (Quarterly Issue)*, vol. 52, 1908, p. 219.

stouter; P_4 9 mm. long with eighteen segments as slender as P_1 but slightly stiffer; P_5 7 mm. long, resembling P_4 ; P_6 5.5 mm. long resembling P_5 but less stiffened; P_7 and following pinnules 5 mm. long, the component segments slightly shorter than in the preceding pinnules; distal pinnules very slender, 7 mm. long.

The color is greenish yellow.

Type.—Cat. No. 27491, U.S.N.M., from station 5413.

Family PONTIOMETRIDÆ.

EPIMETRA, new genus.

Centrodorsal small, hemispherical, the dorsal pole convex.

Cirri long and rather stout, moderate in number, with between thirty and forty segments, the ninth and following short and strongly carinate dorsally with swollen distal ends; opposing spine V-shaped in dorsal view, crescentic in end view.

Structure of calyx and arms as in *Pontiometra*.

On the outer arms P_a is absent; on the inner arms P_a and P_1 are absent. The enlarged proximal pinnules are very slender, but much stiffened and not flagellate distally; on the outer arms P_2 is the longest; on the inner, P_b ; P_1 is shorter than P_2 ; P_3 is as long as P_1 , but resembles P_2 ; P_4 and the following pinnules are very short.

Genotype.—*Epimetra nympa*, new species.

EPIMETRA NYMPHA, new species.

Centrodorsal small, hemispherical, the dorsal pole convex, 1 mm. in diameter.

Cirri XIII (deficient in two interradii) 37–39, 12 mm. long; first segment short, the following gradually increasing in length and becoming about as long as broad on the fifth; following four to six slightly longer than broad, then gradually decreasing in length, the segments in the outer half of the cirri being nearly twice as broad as long; the eighth segment is a transition segment; the following segments have the distal dorsal edge slightly thickened and produced and the dorsal surface developing a low narrow median keel, becoming more prominent in the outer part of the cirrus, so that the dorsal profile of the outer part of the cirri is scalloped; opposing spine in dorsal view a thick V-shaped production of the distal half of the penultimate segment; the two limbs of the V are thick distally, tapering to a fine point at the apex; in end view this opposing spine is seen as a strong, high crescent.

Radials strongly produced interradially, separating the bases of the IBr_1 for a distance equal to about one-half of their dorsal transverse diameter; IBr , $IIBr$, and $IIIBr$ resembling the corresponding series in *Pontiometra andersoni*, but the component segments are somewhat longer and the synarthrial tubercles are more pronounced.

Thirty-nine arms, about 50 mm. long, resembling those of *Pontio-metra andersoni*, but the brachials are slightly constricted centrally and have rather prominent ends.

On the outer arms P_a is absent; on the inner arms P_a and usually also P_1 are absent.

P_1 on the outer arms 6 mm. long with twelve segments, exceedingly slender, the component segments not quite so long as those of the next pinnule; P_2 8.5 mm. long with ten segments, resembling P_1 , but slightly larger and stouter and much stiffer; P_3 6 mm. long, stiffer than P_1 , with nine segments, resembling those of P_2 ; P_4 4.3 mm. long, very slender, with eight segments, all but the first two of which are greatly elongated; following pinnules gradually increasing in length, the distal pinnules being 7 mm. long with twelve segments.

P_b on the inner arms is 9 mm. long with eleven segments, the first not so long as broad, the second half again as long as broad, the third three times as long as broad, and the following greatly elongated with swollen articulations; the last two or three have long and very slender spines upon their distal ends; the terminal segment, as usual, is short; the pinnule is exceedingly slender, stiff, but not flagellate.

Type.—Cat. No. 27492, U.S.N.M., from station 5356.

Family COLOBOMETRIDÆ.

Genus CENOMETRA.

CENOMETRA BELLA (Hartlaub).

Station 5401.—One specimen with twenty-three arms 120 mm. long; the cirri have 36–39 segments.

Genus COLOBOMETRA.

COLOBOMETRA DISCOLOR A. H. Clark.

Station 5355.—One small specimen with arms 60 mm. long.

Station 5356.—Two specimens; one has the arms 95 mm. long and cirri XIV, 30–40, 25 mm. long; the other is smaller.

These three specimens were compared directly with the type in the Indian Museum, Calcutta, and no differences were found.

Genus CYLLOMETRA.

CYLLOMETRA MANCA (P. H. Carpenter).

Station 5356.—Three small specimens; one has twenty-three arms 45 mm. long, and is entirely deep purple in color; another has fifteen arms about 40 mm. long; the third has ten arms 40 mm. long and cirri with 26–28 segments, 12 mm. long.

Station 5369.—One specimen.

Genus OLIGOMETRA.

OLIGOMETRA JAPONICA (Hartlaub).

Station 5356.—Two specimens.

OLIGOMETRA GRACILICIRRA, var. ORNATA, new variety.

In general similar to typical *O. gracilicirra*; but the broad IBr and first two brachials, instead of just coming into apposition laterally and showing only a trace of lateral flattening, are sharply flattened against their neighbors, their outer edges along the line of union being strongly everted and strongly denticulate; the radials bear an abrupt rounded dorso-ventrally elongate median tubercle; the IBr series have an abrupt more or less tuberculated median ridge which is continued on to the arm bases, becoming less noticeable as the brachials become triangular, but traceable to the distal portion of the arm; there is only a slight suggestion of this in typical *O. gracilicirra*. The color pattern is as in the specimens of *O. gracilicirra* at hand, but the color is much deeper.

Type.—Cat. No. 27493, U.S.N.M., from station 5355.

Two additional specimens were secured at this station.

Station 5356.—Two similar specimens.

Family TROPIOMETRIDÆ.

Genus CALOMETRA.

CALOMETRA ALECTO, new species.

This new form belongs to that group of the genus including *Calometra multicolor*, *C. acanthaster*, and *C. spinossima*.

Centrodorsal discoidal, moderately thick, the bare polar area flat, 4 mm. in diameter; cirrus sockets in a single slightly irregular marginal row.

Cirri IX–XV, 39–46, 25 mm. to 30 mm. long, resembling those of *S. spinossima* but somewhat more slender, especially distally; there is no ventral carination as in *C. acanthaster*. The first segment is very short, the following gradually increasing in length to the fifth, which is nearly or quite as long as broad; following to the twelfth similar, then gradually decreasing in length, those in the terminal third of the cirri being twice as broad as long; after the fifth or sixth the distal dorsal edge becomes prominent, distally gradually narrowing and becoming higher and moving anteriorly, the dorsal surface of the segments at the same time becoming strongly carinate so that the short distal segments possess prominent, though small and broadly rounded, dorsal spines which scarcely reach in height one-quarter of the lateral diameter of the segments which bear them; in the longer proximal segments there is more or less eversion of the

ventral distal edge. The cirri are moderately stout basally, but taper slightly, becoming rather slender distally.

Disk, calyx, and arm bases as in *C. multicolor*; the division series and first two brachials have a slight rounded median carination.

Fifteen to twenty arms 60 mm. to 70 mm. long, resembling those of *C. multicolor*; the brachials have moderately produced distal dorsal ends.

P_1 7 mm. long with twenty-five segments, slender and weak, with the first segment greatly enlarged; P_2 stiff and spinelike, 10 mm. long; P_3 similar, 12 mm. long; P_4 similar, 10 mm. long; P_5 9 mm. long; P_6 8 mm. long; P_7 and following pinnules 6 mm. long; distal pinnules 8 mm. long.

Type.—Cat. No. 27494, U.S.N.M., from station 5414.

There were also obtained at this station eighteen additional specimens, two with thirteen arms, one with fifteen, two with sixteen, three with seventeen, one with eighteen, three with nineteen, and five with twenty; one of the specimens was small and much mutilated; the two thirteen-armed specimens are young.

Station 5356.—One specimen with nineteen arms.

Station 5413.—Two specimens, one with seventeen the other with eighteen arms.

CALOMETRA DISCOIDEA (P. H. Carpenter).

Station 5577.—One specimen with ten arms 110 mm. long and cirri XVIII, 43–49, 27 mm. long.

This species is easily distinguished from *Calometra callista* by its longer and stouter cirri, which have much longer segments proximally. The radials are produced interradially into a narrow process which entirely separates the IBr_1 ; the IBr_1 and $_2$ have irregular thin and broad lateral extensions which are just in apposition beyond the interradial processes of the radials, thus forming, with the latter, a complete interradial plating. The disk is covered with a solid pavement of small subequal plates which become elongated on the anal tube. There are five small but well formed orals, resembling those of *Hyocrinus*.

Genus PTEROMETRA.

PTEROMETRA TRICHOPODA (A. H. Clark).

Station 5356.—One small specimen with sixteen arms.

Station 5413.—Two specimens; one has twenty arms 75 mm. long and cirri 80 mm. long, the other has twenty-one arms 70 mm. long and cirri 75 mm. long.

Station 5414.—Sixteen specimens; one has thirty arms 60 mm. long and cirri 50 mm. long, with 70–87 segments; another has twenty arms 73 mm. long and cirri 77 mm. long, the longest with 100 seg-

ments; the cirri of this specimen are rather stouter than those of the preceding; another has twenty arms 60 mm. long and cirri 60 mm. long; another has twenty-one arms 65 mm. long, the longest cirrus 75 mm. long, with 106 segments; another has nineteen arms; another has twenty-two arms 75 mm. long, the longest cirrus 80 mm. long; another has twenty-three arms 65 mm. long and cirri 70 mm. long; another has twenty-nine arms; another has twenty arms; one IIBr series is lacking, but a IIIBr series is developed on one ray; seven specimens have from twenty to twenty-five arms.

Station 5593.—One specimen with twenty-three arms and the longest cirrus 80 mm. in length, with 108 segments.

As a general rule the cirri average about 5 mm. shorter than the arms, though they are often the same length and may be even longer.

IIIBr series are always external in position (2, 1, 1, 2) as in all the Tropiometridæ in which they occur.

Genus ASTEROMETRA.

ASTEROMETRA MAGNIPEDA, new species.

Centrodorsal columnar, 5 mm. high and 6 mm. in diameter at the base, the dorsal pole elevated into a high truncated conical process about 3 mm. high, surmounted by a rosette of five small radial tubercles; cirrus sockets in ten columns of three each, the two columns in each radial area interiorly separated by about twice the distance separating the columns of adjacent areas.

Cirri XXX, 109–122, 100 mm. to 118 mm. long; first segment short, the following gradually increasing in length and becoming about as long as broad on the sixth; following segments similar or slightly longer (rarely so much as half again as long as broad), in the distal third of the cirrus very slowly becoming shorter, in the terminal portion being somewhat over twice as broad as long; beyond the proximal half of the cirri the segments very slowly become carinate and develop a projecting distal dorsal edge which is centrally elevated into a small spine; this slowly increases in height, involving more and more of the dorsal surface of the segment until in the very short terminal segments a high carinate spine is found reaching nearly one-half the lateral diameter of the segments in height, resembling the same structure found in the other species of the genus; last few segments rapidly tapering as in related species; a more or less marked transition segment occurs between the sixteenth and twenty-second (usually between the eighteenth and twentieth); ventral distal edge of the proximal segments slightly everted.

Twenty arms 90 mm. long resembling, with the IIBr series, those of *Asterometra macropoda*, though somewhat more slender basally; the dorsal surface of the division series and lower brachials is evenly and broadly rounded.

P_1 8 mm. long, small, slender, and evenly tapering, stiff, with sixteen segments; P_2 13 mm. long, stouter than P_1 with seventeen segments, the outer with produced and spinous distal ends; P_3 15 mm. long, with sixteen segments, slightly stouter than P_2 ; P_4 16 mm. long, resembling P_3 ; P_5 14 mm. long; P_7 13 mm. long; following pinnules similar, becoming gradually more slender distally and increasing in length to 14 mm.; the terminal four or five pinnulars have no ambulacral structures and are abruptly smaller and more slender than those preceding, with very spinous distal ends.

The color is brownish yellow.

Type.—Cat. No. 27495, U.S.N.M., from station 5413.

Another specimen was secured at this station which has twenty arms 90 mm. to 95 mm. long and cirri 100 mm. to 110 mm. long, with 99–105 segments; the longer cirri, however, are broken at the tip.

Station 5414.—Nine specimens; one has twenty-one arms 95 mm. long, cirri XXV, 99–112, 90 mm. to 105 mm. long; the IIIBr series is developed externally; another has twenty arms 100 mm. long, the cirri 95 mm. to 105 mm. in length; another has twenty arms 95 mm. long and cirri 90 mm. to 95 mm. long; of the remaining specimens one (small) has thirteen arms, one (small) sixteen, one eighteen, two nineteen, and one twenty.

This species is most nearly related to *Asterometra pulcherrima*,^a but it differs markedly in the much greater development of the cirri.

ASTEROMETRA CRISTATA, new species.

In general similar to *Asterometra longicirra* from the Ki Islands, and to *A. mirifica* from the Sahul Bank.

The IBr series and first two brachials bear a narrow, sharp, very prominent median keel of uniform height, which is not nearly so high nor so sharp as that of *A. mirifica*. In this latter the keels are seen in profile to be rather strongly convex along the apex, giving a characteristic scalloped appearance to the lower part of the animal; in the present species the crest is straight, so that the profile view of the animal is not altered.

The cirri in the type are XX, 77–86, 60 mm. to 65 mm. long, rather short, moderately stout, especially basally, ventrally rounded-carinate in the proximal half, the distal ventral edge of the short proximal segments being rather strongly produced, this character gradually dying away as the segments become longer.

The ten arms are 100 mm. long, proportionately more slender than in the other related ten-armed species.

The centrodorsal is conical, with the cirrus sockets in ten columns close together, two, more rarely three, sockets to a column.

Type.—Cat. No. 27496, U.S.N.M., from station 5483.

^a *Ptilometra pulcherrima* A. H. Clark, Proc. U. S. Nat. Mus., vol. 36, 1909, p 400.

Station 5482.—Five specimens; one has ten arms 90 mm. long and cirri 77–82, 55 mm. to 60 mm. long; another has ten arms 100 mm. long and cirri 82–107, 75 mm. to 80 mm. long, and a third is similar; one specimen has eleven arms 100 mm. long and cirri 85–94, 60 mm. to 70 mm. long; the single IIBr series is 2 as in *A. macropoda*; the last specimen also has eleven arms, one of the IBr axillaries bearing three equal arms instead of the usual two.

Family THALASSOMETRIDÆ.

Subfamily THALASSOMETRINÆ.

Genus COSMIOMETRA.

COSMIOMETRA PHILIPPINENSIS, new species.

Centrodorsal conical, about 4 mm. broad at the base and 4 mm. long; cirrus sockets arranged in ten columns, two to each radial area, two or three sockets to a column; the columns of each radial area are separated in the mid-radial line by a broad, bare, more or less finely spinous area about equal in width to a column of cirrus sockets; outwardly the columns of cirrus sockets are in close apposition with those of the adjacent radial areas.

Cirri stout, XX, 45–54 (the longer 49–54), 35 mm. to 42 mm. long; first segment short, the following gradually increasing in length to the fourth, which is about twice as broad as long, and the fifth, which is about half again as broad as long; sixth a transition segment, half again to twice as long as broad; following segments gradually decreasing in length, becoming squarish about the eleventh and twice as broad as long after the fifteenth; after the eighth or ninth the distal dorsal edge of the segments becomes slowly prominent so that the segments after the fifteenth or sixteenth are provided with a high and prominent dorsal spine as in the other species of the genus.

Ends of the basal rays visible as small but prominent tubercles in the angles of the calyx; radials concealed, or just visible in the mid-radial line; IBr₁ more or less crescentic, convex proximally, about four times as broad as long, with finely serrate edges and with the lateral thirds of the dorsal surface finely spinous; IBr₂ broadly pentagonal or rhombic, with blunted lateral angles, twice as broad as long, the edges finely serrate, the dorsolateral edge with a few small spines; division series and first brachial sharply flattened laterally; IIBr 2.

Nineteen arms 130 mm. long; first brachial slightly wedge-shaped, about twice as broad as long exteriorly; second brachial similar, but nearly twice as large; third and fourth brachials (syzygial pair) oblong, half again as broad as long; following six brachials approximately oblong, about two and one-half times as broad as long, then

becoming very obliquely wedge-shaped, half again as broad as long, toward the middle of the arm as long as broad, becoming distally less obliquely wedge-shaped, and terminally longer than broad. The arms increase slightly in diameter to the twelfth or fourteenth brachials, then slowly taper distally; the proximal third of the arm is very deep and strongly compressed laterally; the outer two-thirds is rather sharply rounded dorsally. After the oblong proximal brachials, the distal ends of the brachials begin to project as a serrate overlap which in the outer half of the arms becomes very pronounced and is accompanied by a fine spinosity of the dorsal (but not lateral) surface of the ossicles as in *C. komachi*.

The pinnules are essentially as in *C. komachi*.

The color is bright yellow.

Type.—Cat. No. 27497, U.S.N.M., from station 5523.

This new species is most closely related to *C. komachi* from southern Japan, but the division series and oblong lower brachials are smooth, without the broadly everted and roughened edges and the rounded median linear tubercles of the latter, and the bare mid-radial areas on the centrodorsal are much broader.

Both these species are related to *C. woodmasoni* which, however, appears to differ in the greater compression of the division series and consequent apparent narrowness of the lower part of the animal, and in the shortness of its cirri, which are said to have 35–45 segments, though figured with 35 (fig. 1) and 50 (figs. 2, 3).

Station 5424.—Three specimens, two with nineteen and one with twenty arms 100 mm. to 110 mm. long and cirri 35 mm. to 40 mm. long. These are somewhat smaller and more delicate than the type specimen described, with slightly more projecting edges to the division series and proximal brachials.

Genus CROTALOMETRA.

CROTALOMETRA PROPINQUA, new species.

Centrodorsal moderate in size, conical, the sides slightly convex, 5.5 mm. broad at the base and 4.5 mm. high, to 4.5 mm. broad at the base and 3.5 mm. high, the tip somewhat truncated; cirrus sockets in ten columns, two or three to a column, the columns slightly separated in the mid-radial line, in close apposition interradially.

Cirri XX, 59–64, 45 mm. to 55 mm. long, moderately stout (though not nearly so stout as those of *C. eupedata*); first three segments short, becoming as long as broad on the fourth or fifth; fifth–seventh (usually the sixth) a transition segment, half again as long as broad; following segments gradually decreasing in length, becoming about as long as broad on the fourteenth–sixteenth, and distally twice as broad as long; shortly after the transition segment the distal dorsal edge of the segments begins to become produced, rising up to

form a sort of gable, which leans somewhat inward, with serrate sides, and a blunt tubercle at the apex; but the dorsal surface of the segments does not become generally carinate, as is usually the case.

Ends of the basal rays visible or prominent, though small, tubercles in the angles of the calyx; radials just visible beyond the edge of the centrodorsal, more or less covered with fine spines and with a finely serrate distal border; IBr_1 very short, about four times as broad as long, convex proximally, concave distally; IBr_2 rhombic with the sides concave, twice as broad as long, the lateral edges shorter than those of the IBr_1 ; elements of the IBr series and first two brachials with somewhat everted, finely spinous edges, sometimes with scattered fine spines on the dorsal surface and a thick development of fine spines along the lateral margins, which are somewhat produced.

Ten arms 130 mm. long; first brachial short, twice as broad as long exteriorly, incised somewhat on its distal margin; the synarthrial tubercles are moderately prominent, broadly rounded; second brachial larger, with a rounded posterior process incising the first; third and fourth brachials (syzygial pair) one-third to one-half again as broad as long, oblong; next four brachials oblong, about two and one-half times as broad as long, the following becoming obliquely wedge-shaped and then triangular, as long as broad, and wedge-shaped again distally; the earlier brachials with everted and finely spinous distal ends; fourth and following with the dorsal (but not the lateral) surface thickly covered with fine spines, which on the outer brachials become somewhat coarser and are directed anteriorly; proximally as the brachials become wedge shaped the distal edge begins to overlap and the proximal to lose its eversion so that the later brachials assume strongly produced and very spinous distal ends.

In *C. eupedata* the second and following brachials are thickly covered with minute spines, but they are evenly distributed over the entire exposed surface, lateral as well as dorsal, and they are neither so large nor so long as in this species.

The color is yellow.

Type.—Cat. No. 27498, U.S.N.M., from station 5424.

A second similar specimen was secured at this station.

Station 5274.—One specimen, somewhat larger than the two preceding, the arms being about 150 mm. in length.

Station 5445.—One specimen, resembling the type.

CROTALOMETRA INFELIX, new species.

Centrodorsal low-conical, with the apex abruptly prolonged; cirrus sockets in ten closely crowded columns.

Cirri XX, 38–44, 25 mm. to 30 mm. long; first segment short, the following gradually increasing in length, becoming about as long as broad on the fifth and half again as long as broad on the seventh; following segments gradually decreasing in length becom-

ing about as long as broad on the eleventh, and half again to twice as broad as long distally; eighth and following with produced distal dorsal edges which soon become prominent dorsal spines.

Disk completely plated.

Ends of the basal rays visible in the angles of the calyx as dorso-ventrally elongate tubercles; radials short, about four times as broad as long, with a prominent median tubercle; IBr₁ decreasing slightly in width distally, about twice as broad distally as long in the median line; it bears a low broadly rounded median carination, most prominent posteriorly; IBr₂ rhombic, half again as broad as long, the proximal two-thirds of the median dorsal line raised into a low broad tubercle; IIBr 4 (3 + 4).

Thirteen arms 90 mm. long; after the proximal third the brachials gradually develop produced and overlapping spinous distal edges, at the same time becoming laterally compressed; after the proximal half this production of the distal edge becomes very prominent, especially in the median line.

Type.—Cat. No. 27499, U.S.N.M., from station 5317.

This species is nearest to *C. sentifera*; but the centrodorsal is proportionately much smaller and bears closely crowded columns of cirrus sockets without bare mid-radial areas, the edges of the elements of the IBr series are smooth instead of finely dentate, the IBr₁ has a distinct, though low, rounded median carination, and the distal overlap of the brachials, though very prominent, is not produced into the long overlapping spine characteristic of *C. sentifera*.

The type of *C. infelix*, however, is a small specimen; larger specimens may prove to approach *C. sentifera*, though it seems most probable that the two forms are quite distinct.

Genus THALASSOMETRA.

THALASSOMETRA ANNANDALEI (A. H. Clark).

This species was originally described in the genus *Crotalometra*, but I believe that it had better be referred to the genus *Thalassometra*, in which it would occupy a position near *T. gigantea*.

Station 5116.—A small thalassometrid with eleven arms 60 mm. long from this station I originally referred to *Crotalometra eupedata*,^a though with considerable hesitation. At that time the present species was not known. Comparison with the specimens at hand shows that it is without doubt an example of *Thalassometra annandalei*.

Station 5280.—One specimen with twenty-one arms 130 mm. long and cirri 50 mm. to 60 mm. long; there are four IIBr 2 series; two of these bear (externally) IIIIBr 4 (3 + 4) series.

^aProc. U. S. Nat. Mus., vol. 36, 1909, p. 406.

Station 5367.—Five specimens; one has twenty arms 85 mm. long and cirri 40 mm. to 47 mm. long; all the IIBr series are 4 (3+4); another has nineteen arms 115 mm. long and cirri 40 mm. to 45 mm. long; seven of the IIBr series are 4 (3+4), two are 2; another has twenty-three arms 110 mm. long, the cirri being 40 mm. to 45 mm. long; the ten IIBr series and the three IIIBr series are 4 (3+4); another has nineteen arms; three of the IIBr series are 2, six are 4 (3+4); the fifth specimen has twenty arms, the ten IIBr series being all 4 (3+4).

Station 5503.—Three specimens with twenty arms 120 mm. long; twenty arms 115 mm. long; and nineteen arms 130 mm. long, respectively.

Station 5504.—Two specimens.

Station 5506.—Two specimens, one with nineteen arms 90 mm. long, the other small, with fifteen arms.

Station 5536.—One specimen with twenty-two arms 160 mm. long and cirri 40 mm. to 50 mm. long; one of the IIBr series is 2, the remaining eight 4 (3+4); the axillary of one of the IIBr 2 series bears on its inner face another axillary and on its outer the first element of a IIIBr 2 series which is supported equally by the IIBr axillary and by the outer side of the IIIBr axillary.

All these specimens are somewhat smaller and more slender than the type in the Indian Museum, with which they were directly compared. The division series and lowest brachials are usually also slightly more spinous, and thus more nearly like the brachials just succeeding; there is, however, considerable variation in this character.

THALASSOMETRA HIRSUTA, new species.

Centrodorsal low conical, the dorsal pole finely papillose; cirrus sockets arranged in ten columns of two or three each, the two columns of each radial area being slightly separated proximally by a narrowly linear or wedge-shaped papillose area.

Cirri slender, XV–XXV, 48–66 (usually 54–66), 30 mm. to 50 mm. long; first segment short, the following increasing in length and becoming squarish or slightly longer than broad on the fourth; fifth or sixth a transition segment, about three times as long as broad; following segment nearly as long, the succeeding gradually decreasing in length, those in the distal part of the cirrus being somewhat broader than long; after the transition segment the distal dorsal edge slowly becomes produced, the short outer segments bearing rather low blunt spines.

Radials concealed; IBr₁ very narrow, crescentic, the edges all around strongly everted and coarsely spinous, with a coarsely spinous median carination and a few coarse spines scattered over the dorsal

surface; IBr₂ rhombic, twice as broad as long, the edges all around strongly everted and coarsely spinous, with a coarsely spinous median carination in the proximal two-thirds, and with coarse spines scattered irregularly over the dorsal surface.

Ten arms; first brachial short, slightly wedge-shaped, three or four times as broad as long exteriorly, the edges all around strongly everted and coarsely spinous, the dorsal surface more or less covered with rather long spines, and with a coarsely spinous median keel; second brachial slightly larger and more obliquely wedge-shaped; third and fourth brachials (syzygial pair) oblong, half again to nearly twice as broad as long; following four brachials approximately oblong, twice as broad as long, then becoming triangular, as long as broad, and further out wedge-shaped, somewhat longer than broad, and elongate terminally; the third-eighth brachials have strongly everted and spinous ends, and have the dorsal surface very thickly covered with rather long fine spines; the median carination seen on the elements of the IBr series and on the first two brachials may be faintly suggested on the third and fourth, but extends no farther; as the brachials become triangular the dorsal spinosity becomes shorter and finer and less evident, the proximal ends of the brachials become less everted and the distal more so, this distal eversion leaning gradually forward, becoming a spinous overlap which is fairly prominent distally; at the same time the dorsal surface of the brachials becomes marked by numerous fine sharp longitudinal ridges, most prominent distally; in the outer part of the arm the distal part of these ridges breaks up into numerous thickly set anteriorly directed spines.

Type.—Cat. No. 27500, U.S.N.M., from station 5445.

Three other specimens were secured at this station.

Station 5275.—One specimen.

Station 5474.—One specimen.

This form is nearest to *Thalassometra attenuata*, but it is stouter than that species, with shorter and somewhat stouter cirri, which have usually fewer segments. It differs greatly, however, in the great development of spines on the division series and arm bases, these parts in *T. attenuata* being comparatively smooth.

Genus STENOMETRA.

STENOMETRA CRISTATA, new species.

This new species is nearest to *Stenometra dorsata* from southern Japan, but is a smaller and more slender form; the centrodorsal is proportionately smaller, more conical, and less columnar, with a rounded conical tip, finely papillose; the arms are 85 mm. long in the type, and the cirri are about 40 mm. long; the fifth or sixth cirrus segment, which is the longest, is twice as long as broad, or even somewhat

longer, this being but little longer than broad in *S. dorsata*; the carination of the elements of the IBr series and the lower brachials is not quite so high as in *S. dorsata* and is more regular, with a more even crest; it is irregular and serrate in profile in *S. dorsata*.

S. quinquecostata resembles *S. dorsata* in having short cirrus segments, but it differs in having a considerably larger number.

Type.—Cat. No. 27501, U.S.N.M., from station 5275.

The type has twenty arms; at the same station four smaller specimens were secured, with eighteen, seventeen, fourteen, and thirteen arms, the two last being immature.

Genus PARAMETRA.

PARAMETRA COMPRESSA (P. H. Carpenter).

Station 5279.—Two specimens.

Station 5325.—One specimen with twenty arms 170 mm. long.

Station 5367.—Five specimens; one has twelve, one thirteen, one sixteen, and two nineteen arms, in the largest 115 mm. long.

Station 5411.—One specimen with fourteen arms 145 mm. long.

Station 5519.—Two specimens with arms about 160 mm. long.

Station 5523.—One specimen.

Station 5536.—Six specimens, all with arms about 150 mm. long.

In this species the sides of the division series and lower brachials are more or less covered with fine tubercles, and each segment bears a narrow and low, but distinct, carination.

PARAMETRA ORION (A. H. Clark).

Between Pracas Reef and Formosa.—Three specimens, all bright yellow.

This species has the division series invariably smooth laterally and without any median carination. It possesses rather fewer arms than *P. compressa* and does not reach so large a size.

Subfamily CHARITOMETRINÆ.

Genus PACHYLOMETRA.

PACHYLOMETRA SEPTENTRIONALIS, new species.

A much greater familiarity with the numerous species of this very difficult genus, and especially the acquisition of a fine adult unquestionably referable to *Pachylometra distincta*, has shown me that I was in error in referring to that species the Japanese *Pachylometra* found by Mr. Alan Owston in Sagami Bay.^a In reality it represents a well-marked new species, which may be described as follows:

Centrodorsal very rounded, conical, broader than high, the bare polar area very small, 1 mm. in diameter, surrounded by five small radial tubercles; cirrus sockets arranged in ten closely crowded columns of two or three each.

^aProc. U. S. Nat. Mus., vol. 34, p. 312.

Cirri XX, 19–23, about 35 mm. long, very stout, in lateral view increasing considerably in diameter in the outer portion; first segment short, twice as broad as long, the following gradually increasing in length to the fourth, which is about as broad as long; following similar, the terminal becoming slightly broader than long; the penultimate segment is of less diameter than those immediately preceding, half again as long as broad; on the fourth or fifth segment the dorsal surface becomes rounded carinate, this carination slowly becoming higher and sharper, on the distal ten or twelve standing out as a high narrow sharp keel, the distal apex of which, in lateral view, is seen to be parallel to the axes of the segments; the opposing spine is small, but prominent, terminal in position.

Ends of the basal rays very prominent in the interradian angles; radials concealed; IBr_1 very short, crescentic, the lateral ends thickened and more or less everted, the proximal edge thickened and more or less tubercular or crenulate; a rather high, strongly rounded, dorsoventrally elongate tubercle occupies the median dorsal line; IBr_2 triangular, twice as broad as long, with a high median tubercle resembling that on the IBr_1 , the anterior (distal) portion of which bends to one side or the other, reaching almost or quite to the base of the $IIBr_1$; nine of the $IIBr$ series 4 (3+4), one 2, strongly and evenly convex dorsally; the two distal components are slightly separated interradianly by the carinate basal segments of P_D ; the ossicles of the $IIBr$ series bear rounded median tubercles similar to those on the IBr series, but somewhat less high; $IIIBr$ 2 (1+2), developed internally in 1, 2, 2, 1 order; two $IVBr$ 2 (1+2) series are present, one internal in reference to the preceding $IIIBr$ series, the other internal in reference to the preceding $IIBr$ series. The lower part of the animal is broad and stout and broadly rounded, so that the profile resembles in general that of the larger species of *Crinometra*.

Thirty-three arms 130 mm. long; the proximal oblong brachials have a slight trace of a low median tubercle; the outer brachials overlap slightly.

Type.—Cat. No. 27502, U.S.N.M., from southern Japan, the original label reading "Sagami Bay."

PACHYLOMETRA DISTINCTA (P. H. Carpenter).

Station 5510.—Four specimens; one has twenty-one arms 130 mm. long and cirri 20 mm. to 25 mm. long; another has twenty-nine arms, the $IIIBr$ series being 2 (1+2), internally developed; the third has twenty-four arms.

Station 5536.—One fine specimen with twenty-three arms 160 mm. long and cirri XXVI, 19–24, 23 mm. to 25 mm. long; all the $IIBr$ series are 4 (3+4); the three $IIIBr$ series are 2 (1+2), developed internally. The genital pinnules bear eggs.

The most striking characteristic of this species is its slenderness, especially the slenderness of the cirri, the long proximal segments of which are twice as long as broad.

PACHYLOMETRA LUNA, new species.

Centrodorsal as in *P. investigatoris*, but proportionately shorter; the cirrus sockets are arranged in ten columns of two or three each.

Cirri XXV, 23–25, 30 mm. to 40 mm. long, stout, resembling those of *P. investigatoris*.

Division series and arm bases essentially as in *P. investigatoris*; but the basal rays are much larger, rhombic, entirely concealing the radials in the interradial angles of the calyx; the division series and arm bases make a slightly greater angle with the dorso-ventral axis than in *P. investigatoris*, though in general the shape and proportions are the same; the division series are more convex dorsally than those of *P. investigatoris*, and the center of each in the median dorsal line rises into a broadly rounded tubercle instead of being obscurely carinate, as in *P. investigatoris*; similarly, indistinct broad tubercles occur on the oblong proximal brachials; the interradial angles are slightly more deeply excavated than are those of *P. investigatoris*. All the IIBr series are 4 (3+4) and all the IIIBr series are 2 (1+2), all but a single one of the latter being developed internally.

The twenty-nine arms of the type are 150 mm. long.

Type.—Cat. No. 27503, U.S.N.M., from station 5325.

PACHYLOMETRA SELENE, new species.

This new species is most closely related to *P. investigatoris* and *P. luna*.

Centrodorsal resembling that of *P. investigatoris*.

Cirri XXX, 17–19, 25 mm. to 30 mm. long, much shorter and with fewer segments than those of the two species mentioned; the segments in the outer half have rather strongly produced distal dorsal edges, which bear a rounded tubercle in the median line, so that the dorsal profile of the cirri is strongly serrate.

The division series and arm bases diverge, as in *P. investigatoris*, and are only slightly convex dorsally, not so much so even as in that species; each ossicle is smooth and even dorsally, but bears in its center a very prominent high rounded tubercle; these tubercles gradually become obsolete after the proximal quarter of the arms, but may be traced as far as the beginning of the distal half; two of the IIBr series are 4 (3+4) and two 2; there are no IIIBr series present.

The fourteen arms are 205 mm. long.

Type.—Cat. No. 27504, U.S.N.M., from station 5523.

Another specimen was taken at this station which has twenty arms 195 mm. long; nine IIBr 4 (3+4) and one IIBr 2 series are

present; the cirri are XXX, 17–21 (usually 18–19); the tubercles on the division series and lower brachials are not quite so prominent as in the type.

PACHYLOMETRA SMITHI (A. H. Clark).

Station 5282.—Three specimens; one has twenty-five arms 150 mm. long; another has thirty arms 140 mm. long, one IIBr series dividing both internally and externally and another not dividing at all; the third has thirty-three arms 110 mm. long, three of the (internally developed) IIIBr series bearing on the innermost side IVBr series of 2 (1+2).

Station 5348.—Twenty-two specimens, medium sized or small, with from nineteen to twenty-two arms, in the larger from 125 mm. to 135 mm. in length.

In the original description of this species^a the arm length is given as "60 mm.;" this is an error for 160 mm.

PACHYLOMETRA PATULA (P. H. Carpenter).

Station 5356.—Three specimens; one has fourteen arms about 170 mm. long and cirri XXII, 19–22, about 30 mm. long; the opposing spine is single, large and prominent; another has sixteen arms about 170 mm. long and cirri XX, 18–20, 30–33 mm. long, the opposing spine large, and prominent, usually forked at the tip; the third has twenty arms, the cirri XXV, 17–22, 30 mm. to 37 mm. long; the opposing spine is single.

PACHYLOMETRA FLEXILIS (P. H. Carpenter).

In the original description of this species^b the spread is given as "55 cm.;" this is an error for 35 cm.

Genus *GLYPTOMETRA*.

GLYPTOMETRA TUBEROSA (P. H. Carpenter).

Station 5367.—One specimen with eighteen arms; six of the IIBr series are 4 (3+4), and one is 2, the last bearing (externally) a IIIBr 4 (3+4) series.

Station 5406.—One specimen with twelve arms resembling the preceding, but the dorsal carination of the arm bases is slightly more prominent; the two IIBr series are 2.

Station 5431.—Twenty-two specimens; seventeen of these are ten armed, the arms being usually between 100 mm. and 115 mm. in length; the arms of the largest are 140 mm. long; three are eleven armed, the IIBr series being 2; one is twelve armed, the two IIBr series being 2; the last is a large six-rayed specimen.

^a *Charitometra smithi* A. H. Clark, *Smiths. Misc. Coll. (Quarterly Issue)*, vol. 52, pt. 2, p. 227 (229).

^b *Challenger Reports*, vol. 26, Zoology, p. 218.

Station 5510.—Two specimens, each with ten arms 100 mm. long.

Station 5536.—Two specimens; one has ten arms 125 mm. long; the other is of the same size, but has twelve arms, the two IIBr series being 2.

Station 5537.—Two nearly perfect specimens, both with arms 140 mm. long; both have regenerating disks; one has twelve arms, both IIBr series being 2; the other has eleven arms, two IIBr 2 series being present, but one post-radial series not dividing at all, the IBr₂ merely bearing a pinnule instead of being axillary.

Genus CHLOROMETRA.

CHLOROMETRA ROBUSTA, new species.

Centrodorsal long, conical, about 6 mm. wide at the base and 6 mm. high, the cirrus sockets confined to the mid-radial region, as in *C. aculeata*, where they are arranged in two very closely crowded converging alternating columns, which merge and become a single column distally; four or five cirrus sockets in each radial area.

Cirri stout and very long, XX–XXV, the peripheral 26–28, 55 mm. to 60 mm. long, becoming apically 21, 35 mm. to 40 mm. long; first segment short, the following increasing in length, becoming approximately as long as broad on the sixth, and from the eighth onward about twice as long as broad; distal dorsal edges of the segments somewhat thickened, especially in the outer half of the cirri; penultimate segment slightly less in diameter than those preceding; opposing spine very small, terminal; terminal claw about as long as the penultimate segment, slender, slightly curved; cirri moderately compressed laterally.

Ten arms 211 mm. long; arm bases and arms essentially as in *C. aculeata*, but much more rugged; IBr₂ with a prominent dorso-ventrally elongate well-rounded tubercle; second brachial similar; following brachials, to the fourteenth, with prominent rounded median tubercles as long as the segments; after the fourteenth these tubercles become high thick overlapping spines, whose bases occupy the entire dorsal median line of the segments; terminally these spines gradually decrease in height and eventually disappear.

The genital pinnules are expanded as in *Glyptometra*.

Type.—Cat. No. 27505, U.S.N.M., from station 5348.

Two smaller specimens were also secured at this station; one of these is about the size of the type of *C. aculeata*; it is easily distinguished by the much longer and more sharply conical centrodorsal and by the dorsal ornamentation of the arms which, though not so developed as in the adult, is yet prominently marked; the cirrus segments are longer than those of *C. aculeata*; the other specimen has arms only 55 mm. long; the dorsal ornamentation is only just beginning to appear, but is already of the type characteristic of

the adult; the peripheral cirri are XIV, 19–20, 21 mm. long; the centrodorsal is of the characteristic shape.

Station 5349.—One large specimen resembling the type.

Suborder MACROPHREATA.

Family ANTEDONIDÆ.

Subfamily ANTEDONINÆ.

Genus IRIDOMETRA.

IRIDOMETRA EXQUISITA A. H. Clark.

Station 5483.—One specimen with arms about 50 mm. long and cirri 11 mm. long, somewhat more robust than the type.

IRIDOMETRA PARVICIRRA (P. H. Carpenter).

Station 5355.—One specimen.

IRIDOMETRA MELPOMENE, new species.

Centrodorsal low, hemispherical, the small dorsal pole papillose; cirrus sockets arranged in three or four closely crowded alternating rows, the proximal with four sockets in each radial area.

Cirri XXX–L, 15–19 (usually 16–18) 10 mm. to 14 mm. (usually 12 mm. to 14 mm.) long, very slender, and strongly compressed laterally; first two segments about twice as broad as long, third slightly longer than broad, fourth or fifth to sixth or eighth three to four times as long as broad, the following gradually decreasing in length, the four to six outermost segments being about half again as long as their distal diameter; both ends of the long lower segments and the distal end of the shorter outer segments somewhat enlarged; no dorsal spines; opposing spine prominent, terminal directed slightly anteriorly.

The calyx and arms resemble those of *I. adrestine*, to which species this new form is most closely allied.

P₁ 7.5 mm. long, moderately slender, with sixteen segments, the more distal somewhat over twice as long as broad; P₂ similar, 8 mm. long with sixteen segments; P₃ 6 mm. long with thirteen segments; P₄ 5 mm. long; following pinnules similar, gradually becoming longer, reaching a length of 9 mm. distally.

The color is a light yellow brown, the sides of the arms and of the division series, and the cirri, white; the perisome is dark purple.

Type.—Cat. No. 27506, U.S.N.M., from station 5311.

Five other specimens were obtained at this station.

TOXOMETRA, new genus.

Centrodorsal small, the cirrus sockets in three closely crowded alternating rows.

Cirri XVII-XXIX, 9-12, in general resembling those of *Antedon*.

Calyx and brachial structure essentially as in *Antedon*, but the ossicles have very strongly produced and serrate distal ends.

Lower pinnules somewhat stiffened; P_3 is the longest, and P_1 is shorter than P_2 ; P_4 is slightly longer than P_2 , and P_5 is slightly longer than P_1 ; the distal pinnules are about as long as P_2 .

Genotype.—*Toxometra paupera*, new species.

TOXOMETRA PAUPERA, new species.

Centrodorsal small, low hemispherical or thin discoidal, the bare dorsal pole about 1 mm. in diameter; cirrus sockets arranged in three closely crowded alternating rows.

Cirri XXII, 11-12 (usually 11), 7 mm. long; first segment short, second twice as broad as long, third one-third to one-half again as long as broad, fourth about twice as long as the median diameter; fifth not quite so long as the fourth; following segments gradually decreasing in length, the antepenultimate being about one-third longer than broad and the penultimate only slightly if at all longer than broad; third and following segments slightly constricted centrally with rather prominent ends, this character gradually dying away distally; fourth and following with a slight serrate production of the distal dorsal edge, but not sufficient to appear in lateral view as a definite process; opposing spine prominent, though small, terminal or subterminal, slightly longer than the penultimate segment, rather slender, moderately and evenly curved.

Radials even with the edge of the centrodorsal; IBr_1 short, oblong, three times as broad as long, just in contact basally, the anterior border rather prominently everted, and with a prominent dorso-ventrally elongated tubercle occupying the outer half or two-thirds of the median line; IBr_2 almost triangular, about twice as broad as long, the lateral edges about one-half as long as those of the IBr_1 , the anterior edges, like those of the IBr_1 , strongly everted and very finely serrate, and with a very prominent dorso-ventrally elongate tubercle in the proximal two-thirds.

Ten slender arms 80 mm. long; first brachial slightly wedge-shaped, twice as broad as the median length, interiorly united for the basal half, the inner sides diverging at a right angle beyond the farthest point of union; the distal edge is everted and there is a median tubercle in the distal half as on the IBr_1 ; second brachial about the same size, but much more obliquely wedge-shaped; the distal edge is strongly everted and there is a median tubercle in the proximal half; third and fourth brachials (syzygial pair) slightly longer interiorly

than exteriorly, about as broad as the median length, with the distal edge very strongly everted and the syzygial line raised into a sharp ridge; next three brachials slightly wedge-shaped, twice as broad as the median length, the distal edges very strongly everted, then becoming very obliquely wedge-shaped, almost triangular, about as long as broad, with the distal edges strongly produced and serrate, and after the second syzygy longer than broad, gradually decreasing in obliquity and increasing in length distally so that the outer brachials are twice as long as broad; the production of the distal edges of the brachials becomes rather less marked after the proximal fourth of the arm. but persists to the tip.

Syzygies occur between the third and fourth brachials, again between the ninth and tenth and fourteenth and fifteenth, and distally at intervals of three oblique muscular articulations.

P_1 4.5 mm. long, slender, rather stiff, evenly tapering to a pointed tip, with twelve segments, the first about twice as broad as long, the second and third about as broad as long or slightly longer, the following increasing in length, the distal being about three times as long as broad; P_2 6 mm. long, similar to P_1 but proportionately stouter, with about fourteen segments, the distal rather more elongated than those of P_1 ; P_3 7 mm. to 7.5 mm. long, similar to P_2 , but proportionately stouter, with seventeen segments, the outer with slightly produced distal ends; P_4 6.5 mm. long, about as stout basally as P_3 but more slender distally, the outer segments with more prominent distal ends; P_5 5 mm. long, nearly as stout basally as P_4 , but more slender distally and with longer segments; following pinnules similar to P_5 , gradually becoming longer and more slender; the distal pinnules are 6 mm. long.

The color is brownish yellow, with the perisome dark brown.

Type.—Cat. No. 27507, U.S.N.M., from station 5519.

Three additional specimens were secured at this station; one has the arms 70 mm. long and the cirri XVII, 9–10, 6 mm. long; another has the arms 75 mm. long and the cirri XIX, 9–12, 7 mm. long; and the third has the arms 65 mm. long and the cirri XIX, 10–11.

Station 5536.—One specimen with arms 55 mm. long and cirri XXIX, 10–12, 5 mm. long.

Subfamily PEROMETRINÆ.

Genus PEROMETRA.

PEROMETRA PUSILLA (P. H. Carpenter).

In the *Challenger* report Carpenter described, under the name of *Antedon pusilla*, a small comatulid from near the Ki Islands; he referred this species to his "*Basicurva* group," of which, together with his *Antedon denticulata*, it formed a section distinguished by the absence of ambulacral plating from all the other species.

Recent consideration of this form in connection with the present collection led me to suspect that it was related to *Antedon diomedæ*, which I described from southern Japan and subsequently made the type of the genus *Perometra*. Now *Perometra* belongs to a subfamily of Antedonidæ, all the species of which are remarkable for their deficient pinnulation; in *Perometra diomedæ* the first inner pinnule, P_a (the "pinnule on the third brachial") is always absent. Carpenter says nothing about the absence of any pinnules in *Antedon pusilla*, but as he had overlooked the absence of P_a in describing his *Antedon perspinosa*, I thought that perhaps a similar oversight had occurred here. I therefore wrote to Professor Bell asking him to investigate the point for me. With his usual kindness he has done this, and he writes, "I have, as you requested, made an examination of the type of Carpenter's *Antedon pusilla* and, so far as I can see, there is no pinnule on the third brachial."^a

As in all other ways *Antedon pusilla* shows a general agreement with *A. diomedæ*, the type of the genus *Perometra*, it must also be placed in that genus.

Professor Bell adds that the type of *Antedon pusilla* is obviously immature and regrets that it was described as a new species. I agree with him and share his regret in regard to the species, though it is of considerable interest to know that the genus *Perometra* occurs in the Ki Islands.

Plenty of material of *Perometra diomedæ* is available, showing all stages, from the very young to the adult; but the true status of *P. pusilla* can not be ascertained until more specimens have been secured.

Subfamily ZENOMETRINÆ.

Genus PSATHYROMETRA.

PSATHYROMETRA PARVA, new species.

Nearest to *P. mira*; the centrodorsal is as high as in that species, but is much narrower basally (4 mm. in length by 3.2 mm. broad at the base), so that it is considerably more pointed; the cirrus sockets are in two converging columns in each radial area, two or three to a column; there is no cirrus sockets between the proximal ends of the two columns as in *P. mira*, but sometimes one of the proximal cirrus sockets of a column may be displaced more or less inwardly; the bare interradsial areas are as broad as in *P. mira*, but somewhat less concave. The calyx and arms resemble, in so far as they are preserved, those of *P. mira*.

Type.—Cat. No. 27508, U.S.N.M., from station 5284.

^aSince the above was written I have personally examined the type of this species in London, and I find it to be undoubtedly referable to *Perometra*, though the first inner pinnule is present in all cases.

Subfamily HELIOMETRINÆ.

Genus TRICHOMETRA.

TRICHOMETRA EXPLICATA A. H. Clark.

Station 5349.—One small mutilated specimen, agreeing fairly well with the type.

Subfamily THYSANOMETRINÆ.

Genus EUMETRA.

EUMETRA CHAMBERLAINI A. H. Clark.

Station 5277.—One specimen with cirri 30 mm. to 40 mm. long composed of from 26–33 (usually 26) segments; the long peripheral cirri are lacking in the two specimens previously known.

The color is brownish yellow, the cirri and pinnules blotched with purple; the lower pinnules are slightly stouter than in the type, with slightly shorter segments, but the relative proportions are the same. The whole animal is throughout slightly stouter than the type.

THE WEST AMERICAN MOLLUSKS OF THE GENUS
EUMETA.

By PAUL BARTSCH,
Assistant Curator, Division of Mollusks, U. S. National Museum.

Three species only of the genus *Eumeta* are known from the west coast of America. They are all southern. *E. intercalaris* Carpenter comes from the Mazatlanic area; *E. bimarginata* C. B. Adams has been seen from the Gulf of California and Panama; while the third, *E. eucosmia* Bartsch, comes from the Galapagos Islands.^a

The drawings accompanying this paper were made by Miss Evelyn G. Mitchell.

EUMETA INTERCALARIS Carpenter.

Cerithiopsis intercalaris CARPENTER Proc. Zool. Soc. London, 1865, p. 281.

Shell regularly conic, wax-yellow, with the posterior line of tubercles on each whorl light brown. (Nuclear whorls decollated.) Post-nuclear whorls concave in the middle, marked by a double spiral series of tubercles. The posterior of these two rows is a little below the summit, leaving a very narrow, plain cord at the summit; the anterior row being immediately above the suture. These tubercles are joined spirally and axially by slender riblets, which inclose well-impressed, squarish pits. On the last two turns a third slender spiral cord occurs between the other two, a little nearer to the posterior

^a In the preparation of the present diagnoses the following terminology is used:

“Axial sculpture,” the markings which extend from the summit of the whorls toward the umbilicus.

The axial sculpture may be—

“Vertical,” when the markings are in general parallelism with the axis of the shell.

“Protractive,” when the markings slant forward from the preceding suture.

“Retractive,” when the markings slant backward from the suture.

“Spiral sculpture,” the markings following the directions of the coils of the whorls.

than its fellow, forming weak nodules at its junctions with the axial ribs. Suture strongly impressed. Periphery of the last whorl marked by a slender, plain cord, which is covered by the summit of the succeeding turn. The groove between this cord and the anterior series of tubercles is crossed by the extensions of the axial riblets. Base very short, marked by a slender, shallow, spiral groove, which bounds the peripheral cord anteriorly. The space between the groove and the insertion of the columella is slightly concave, marked only by lines of growth. Aperture rhomboidal, decidedly channeled anteriorly; posterior angle obtuse; outer lip sinuous; columella strong, short, twisted and provided with a strong, oblique fold at its anterior margin; parietal wall covered with a thin callus.

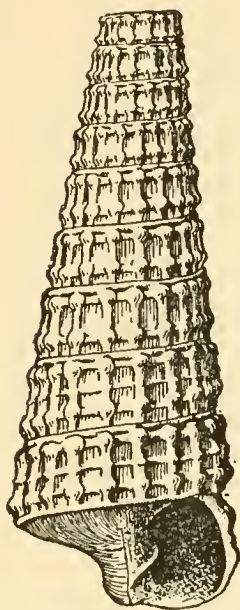


FIG. 1.—EUMETA INTERCALARIS CARPENTER.

The type (Cat. No. 15342, U.S.N.M.) has ten post-nuclear whorls and measures: Length, 5.7 mm., diameter 2 mm. It comes from Guacomayo, Mexico. Another specimen (Cat. No. 32286, U.S.N.M.) comes from the Gulf of California.

EUMETA BIMARGINATA C. B. Adams.

Cerithium bimarginatum C. B. ADAMS, Ann. Lyc. Nat. Hist. New York, 1852, pp. 375-376.

Shell elongate-conic, wax-yellow, except the posterior row of tubercles, which are light brown. Nuclear whorls four and one-half; the first half turn smooth; the remainder well rounded, separated by a constricted suture, marked by curved, quite regular, slender, distantly spaced, axial riblets, of which 16 occur upon the second, 18 upon the third, and 20 upon the last turn. Post-nuclear whorls concave in the middle, marked by two spiral cords, the first of which is at some little distance anterior to the summit, leaving a narrow, plain band at the summit, while the other is equally remote from the suture, the space between the two being about double the width of the spiral cord and the plain space at the summit. In addition to the spiral cords, the whorls are marked by well-rounded axial ribs which are very feeble posterior to the spiral cord at the summit. Of these ribs, 18 occur upon the first to third, 20 upon the fourth and fifth, 22 upon the sixth and seventh, and 24 upon the penultimate turn. These ribs are expanded where they meet the spiral cords, forming well developed tubercles at their junction. The spaces inclosed between the spiral



FIG. 2.—EUMETA BIMARGINATA C. B. ADAMS.

cords and the axial ribs are elongated pits, having their long axes parallel with the spiral sculpture. Suture strongly constricted. Periphery of the last whorl marked by a sulcus about half as wide as that which separates the two spiral cords on the spire, and, like these, crossed by the continuations of the axial ribs, which terminate at the posterior border of the basal cord. Base very short, concave between the columella and the periphery, marked by strong lines of growth and two slender, spiral cords which are near the periphery. Aperture subquadrate, very strongly channeled anteriorly; posterior angle obtuse; outer lip rendered decidedly sinuous by the external sculpture; columella very stout, light brown, curved and twisted, provided with a moderately strong fold at its anterior border; parietal wall glazed with a thin callus.

The specimen described (Cat. No. 195212, U.S.N.M.) was dredged at U. S. Bureau of Fisheries station 2799 in 29.5 fathoms, in the Bay of Panama. It has 8 post-nuclear whorls and measures: Length, 4.3 mm., diameter, 1.3 mm. Another specimen (Cat. No. 96409, U.S.N.M.) was dredged at U. S. Bureau of Fisheries station 2823 in 26 fathoms, on sandy bottom, off La Paz, in the Gulf of California. Prof. C. B. Adams's type came from Panama.

EUMETA EUCOSMIA, new species.

Shell elongate-conic, white. Nuclear whorls two and one-half, large, projecting beyond the outline of the first post-nuclear turn. The first half nuclear turn is smooth, the next turn is marked by sixteen strong, somewhat retractive, axial ribs, while the last turn has twenty axial ribs which are almost vertical and about twice as wide as the intercostal spaces. The middle of the intercostal spaces on the latter half of this whorl, also the ribs, are crossed by a broad, incised, spiral line which separates this whorl into an upper and lower half. This incised line develops into a broad sulcus, that separates the posterior from the anterior row of tubercles on the post-nuclear turns. The first one and one-half nuclear whorls are well rounded, the last inflated, separated by a well-impressed suture. Post-nuclear whorls somewhat flattened, the early ones marked by two nodulose, spiral cords, the first of which is at some little distance anterior to the summit, while the second is at even a greater distance posterior to the suture. Beginning with the fourth post-nuclear turn, the summit of the whorls develops into a slender, spiral cord which grows stronger on the succeeding turns. Beginning with the sixth post-nuclear whorl, a slender, spiral cord makes its appearance halfway between the two strong spiral cords; this also increases steadily in size, but at no time attains the strength of the stronger cords. In addition to the spiral sculpture, the whorls are marked by broad, low, slightly

protractive, axial ribs, which extend from the summit of the whorls to the suture. Of these ribs, about twenty occur upon each of the whorls. The junctions of these ribs with the strong, spiral cords

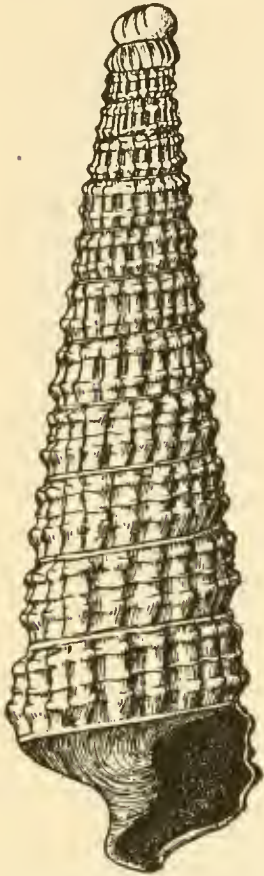


FIG. 3.—EUMETA EUCOS-
MIA BARTSCH.

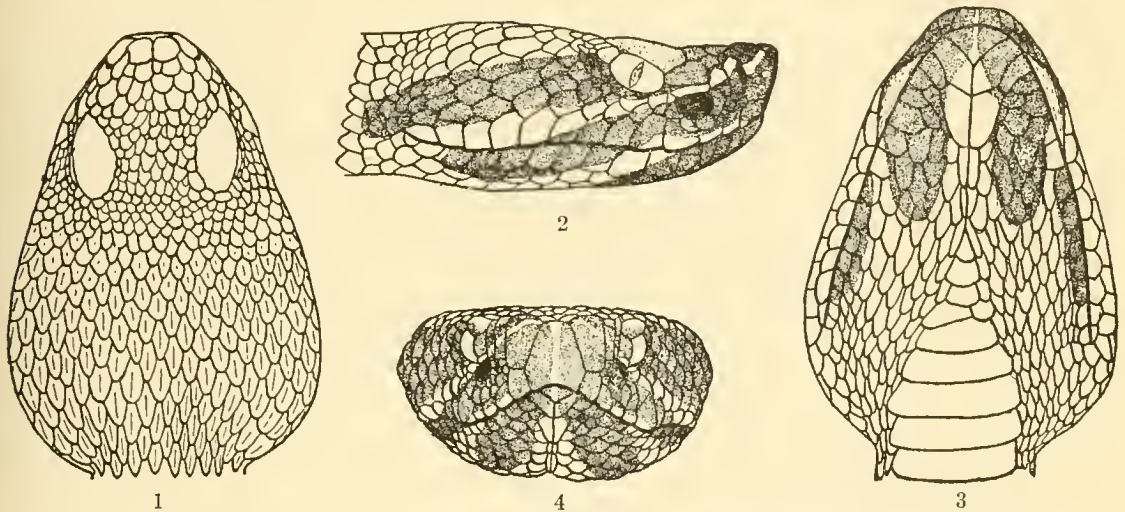
form tubercles, while their junctions with the two slender cords appear as mere deflections of these cords. The tubercles on the posterior of the two strong cords are elongate-oval, having their long axes parallel with the spiral sculpture, while those on the supra-sutural cord are truncated posteriorly and slope gently anteriorly. Suture strongly impressed, showing the posterior edge of the first basal cord on all the turns. Periphery of the last whorl marked by a rather broad channel, which is crossed by the continuations of the axial ribs. Base short, smooth, excepting the single, spiral cord which bounds the peripheral sulcus. Aperture irregular, strongly channeled anteriorly; posterior angle obtuse; outer lip thin, rendered wavy at the edge by the external sculpture, which is apparent within the aperture; columella stout, curved and strongly twisted; parietal wall glazed with a thin callus.

The type (Cat. No. 195213, U.S.N.M.) has eleven post-nuclear whorls and measures: Length 8.3 mm., diameter 2.1 mm. It was dredged at the U. S. Bureau of Fisheries station 2808 in 634 fathoms, on coral sand bottom, bottom temperature 39.9°, near the Galapagos Islands.

DESCRIPTION OF A LITTLE-KNOWN RATTLESNAKE,
CROTALUS WILLARDI, FROM ARIZONA.

By FRANK A. HARTMAN,
Of the Queen Anne High School, Seattle, Washington.

About four years ago Dr. S. E. Meek described^a a new species of rattlesnake as *Crotalus willardi* from a single specimen collected at Tombstone, Arizona. During the University of Kansas Expedition of 1907 a second specimen of this distinct and interesting species



FIGS. 1-4.—*CROTALUS WILLARDI*. $1\frac{1}{2} \times$ NAT. SIZE. 1, TOP OF HEAD; 2, SIDE OF HEAD; 3, UNDERSIDE OF HEAD; 4, HEAD FROM FRONT. NO. 39896, U.S.N.M.

was collected in the region of the Santa Rita Mountain, Arizona, and has been donated to the United States National Museum.

In view of the rarity of the species it has been considered desirable to publish a somewhat detailed description of the latter specimen.

CROTALUS WILLARDI Meek.

Description.—Cat. No. 39896, U.S.N.M., Santa Rita Mountain, Arizona (figs. 1-4). Head long; muzzle narrow, somewhat recurved; rostral higher than wide; anterior nasal in contact with rostral; upper preocular not divided vertically; internasals as long as wide and turned up anteriorly into the canthus rostralis, which is very prominent; seven or eight scales in a line between supraoculars; two rows of scales between eye and supralabials; 14 supralabials on

^a Field Columb. Mus., Zool. Ser., vol. 7, No. 1, January, 1906, p. 18, pl. 3.

left side, 13 on right; 13 lower labials on left side, 15 on right; 25 rows of scales, all keeled except first two, which are smooth; 153 ventrals; anal single; subcaudals 28, first one and last three divided. General color chocolate (the specimen was changed from alcohol to formalin which caused the epidermis to peel off, leaving the snake of a grayish cast), dorsally marked with short crossbars of dark shading into a black line posteriorly or anteriorly, these bars sometimes occurring in pairs and then separated by one or two scales width of ground color; tail with three distinct brown half rings on anterior part, remainder uniform brown dorsally; brown spots covering parts or all of from one to four scales laterally; whole body more or less speckled with black or brown; lateral scales covered with fine specks; ventrals of anterior portion almost white, posteriorly becoming slightly speckled with dark, the specks farther back becoming so numerous as to merge into spots or blotches until the posterior half of the ventral surface is almost entirely dark brown; a white median line on rostral continuing onto lower jaw and expanding between two wide dark bars, which extend about halfway back on the jaw; a light line bordering the second, third, fourth, and fifth labials continuing onto the lower jaw; a light band extending obliquely from the nasals, under the eye to the last four labials, covering them almost completely; below this, running across the pit, a dark band spreading out onto five or six lower labials; a prominent dark postocular band, about three scales wide, not bordered by white above.

Dimensions.

	<i>mm.</i>
Total length.....	495
Tail, from vent.....	51
Rattle.....	28

Remarks.—This specimen shows but few differences from Doctor Meek's brief description of the type. The latter, which has a body length of 380 mm. and a tail of 35 mm., has 160 ventrals and 24 subcaudals, and Doctor Meek describes its color as "light olive-brown, more or less irregularly blotched with white."

Doctor Meek says: "In general, this species bears some resemblance to *Crotalus lepidus* Kennicott. It differs in being light brown instead of greenish gray, and in having shorter transverse dorsal bars, which are much lighter than the ground color, instead of black crossbars, which are so characteristic of *C. lepidus*." I have made a careful study of *Crotalus willardi* and can find no resemblance to *C. lepidus*. The snout is elevated and not depressed, the head is triangular instead of oval; dorsal scale rows 25 instead of 23; the ground color is brown instead of greenish gray; there are no stripes on the side of the head of *C. lepidus*. In fact, instead of resemblances there seems to be considerable contrast between the two species.

ON CALAMINE CRYSTALS FROM MEXICO, RUTILE-MICA INTERGROWTH FROM CANADA, AND PSEUDOMORPHS OF MARCASITE AFTER PYRRHOTITE FROM PRUSSIA.

By JOSEPH E. POGUE,

Assistant Curator, Division of Mineralogy, U. S. National Museum.

1. CALAMINE CRYSTALS FROM CHIHUAHUA, MEXICO.

Calamine crystals of unusual perfection from Chihuahua, Mexico, acquired in April, 1910, by the United States National Museum (Catalogue No. 86662), show the following faces: $c(001)$, $b(010)$, $m(110)$, $e(011)$, $i(031)$, $s(101)$, $t(301)$, $u(211)$, and $v(121)$, the last appearing only on the antipodal pole. The crystals are clear and colorless, with tabular development parallel to $b(010)$, and vary in size up to 11 by 4 by 1 mm. for their greatest dimensions. Figures 1, 2, and 3, plate 63, show the actual development of three individuals, at the same time representing the three phases or habits to which all the crystals may be referred. Phase 1, of which figure 1 is typical, often lacks the base $c(001)$ and is chiefly characterized by a symmetrical development, the presence of $u(211)$, and a wedge-like top elongated parallel to the a -axis owing to a prominent development of the brachydomes. Crystals from the Organ Mountains, Dona Ana County, New Mexico,^a and from Altenberg, Belgium,^b resemble this phase. Occasionally the two pairs of domes are almost equally developed, a resulting squarish cast being then given the crystal. Phase 2, represented by figure 2, is terminated at its lower end in only one instance; aside from this, its chief characteristics are the pointed character of its apex, its rather unsymmetrical development, and relatively great length. Phase 3, as shown in figure 3, has a wedge-like upper termination, formed by the prominent development of the macrodomes $s(101)$ and $t(301)$, to the almost

^aW. E. Ford and F. Ward. Calamine crystals from the Organ Mountains, Dona Ana County, New Mexico. [*In Mineral Notes.*] Amer. Jour. Sci., vol. 28, 1909, pp. 185, 186.

^bC. Hintze. *Handbuch der Mineralogie*, vol. 2, 1897, pp. 1317-1319.

complete repression of the brachydomes $e(011)$ and $i(031)$. This phase, too, shows what appears to a less extent among most all the crystals, namely, striated side pinacoid faces, due to oscillatory combination of $b(010)$ and $m(110)$. The $t(301)$ faces in all three phases are frequently lightly striated horizontally.

2. A BIOTITE-PHLOGOPITE-RUTILE INTERGROWTH SHOWING ASTERISM FROM OTTAWA, CANADA.

The regular growth of one mica within another is a not infrequent occurrence. Inclusions of biotite in muscovite, and muscovite in biotite, of lepidolite in muscovite and the reverse, and of biotite in phlogopite, are known from a number of localities. For example, biotite in muscovite from Alstead, New Hampshire, and biotite inclosed in phlogopite from South Burgess and Grenville, Canada, and West Chester, Pennsylvania, have been described by Rose.^a Lasaulx^b has given a full account of intergrowths of muscovite and biotite occurring at Middletown, Connecticut. Lewis^c has discussed the inclosures of biotite in muscovite among the micas of West Philadelphia. Sheets of muscovite containing hexagonal plates of biotite have been noted by Leidy^d from Macon County, North Carolina. Kunz^e has mentioned that slender crystals of biotite were found inclosed in muscovite at Stoneham, Maine. Bowman^f has discussed in detail the intergrowths of muscovite and lepidolite occurring at Haddam Neck in Connecticut. Of these and additional examples, specimens from Middletown, Connecticut; hexagonal sheets of biotite included in muscovite from Buck Creek, Macon County, North Carolina; rhombic plates of muscovite in biotite from Custer County, South Dakota; and intergrowths of muscovite and lepidolite from Mount Apatite, Auburn, Maine, are represented in the U. S. National Museum collections.^g The various inclusions vary from several inches in diameter to those of microscopic dimensions, and appear mostly as thin plates within larger sheets, with mutual regularity of

^a G. Rose. Ueber die regelmässigen Verwachsungen der verschiedenen Glimmerarten unter einander sowie mit Pennin und Eisenglanz. Monatsb. kon. preuss. Acad., Berlin, 1869, pp. 339-362.

^b A. v. Lasaulx. Ueber eine Verwachsung zweier Glimmer von Middletown, Connecticut. Neues Jahrb. Min. Geol. Pal., 1878, pp. 630-635.

^c H. C. Lewis. On some inclosures in muscovite. Proc. Acad. Nat. Sci. Phila., 1882, pp. 311-315.

^d J. Leidy. On topaz and biotite. Proc. Acad. Nat. Sci. Phila., vol. 34, 1882, p. 261.

^e G. F. Kunz. Minerals from Stoneham, Maine. Amer. Jour. Sci., vol. 27, 1884, pp. 212-216.

^f H. L. Bowman. On an occurrence of minerals at Haddam Neck, Connecticut, U. S. A. Mineral Mag., vol. 13, 1902, pp. 77-121; Zeitschr. f. Kryst., vol. 37, 1903, pp. 97-119.

^g Catalogue numbers 14349, 13699, 83775, and 80230, respectively.

orientation, as shown by crystal outline, position of optic axes, and direction of the three rays of a percussion figure produced when a cleavage plate is struck by a sharp-pointed instrument.

Thick crystals of intergrown micas are much rarer than the intergrown sheets, with which the above citations have chiefly to do. Of such a kind is an example from Ottawa, Canada, in the Shepard collection of the U. S. National Museum (Cat. No. 195). Figure 4, plate 63, is a clinographic projection of this crystal in natural size and development, accompanied by a plan of both its upper and lower basal planes. The stippled portion is biotite; the white, phlogopite. The form is that of biotite and the faces $c(001)$, $O(112)$, $\mu(111)$, and $b(010)$ are well developed and easily identifiable by contact measurement. The angles for phlogopite are so nearly identical with biotite that probably the same faces are represented on the included phlogopite crystal. It is notable that of the comparatively large number of faces capable of occurring on biotite, only those are found which are included among the much fewer known forms of phlogopite. The biotite has a very small optic angle; the phlogopite a still smaller one, appearing almost uniaxial. The two optic planes, however, may be seen to be parallel, both lying in the plane of symmetry (010) and parallel to the b faces.

Chiefly within the phlogopite, but to a less extent running irregularly out into the biotite, there are visible under the microscope multitudinous inclusions of minute needles, most of which cross at angles of 60° , forming a triangular pattern. A less number, however, are arranged at right angles to the three main sets, and others are at random. These needles are of extreme thinness and so interleaved in the basal cleavage of the mica that successive ones may be brought into focus through the vertical extent of the thinnest obtainable cleavage sheet.

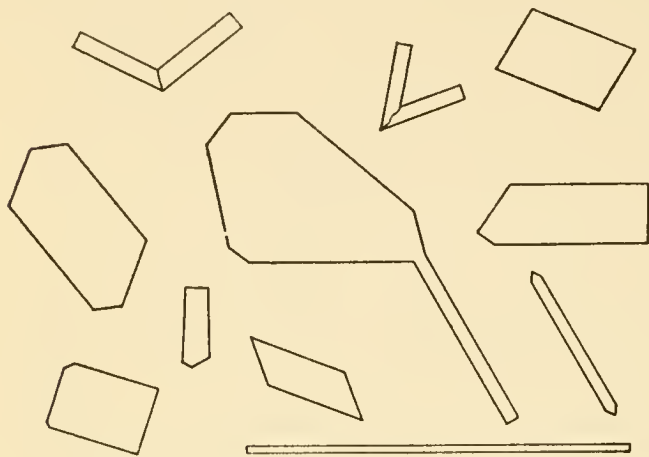
For their optical study and determination they were isolated from the mica by attacking the latter with hydrofluoric and heating the partly decomposed residue with strong nitric acid, whereby the needles were obtained floating in the liquid, completely freed from their host, and could be transferred by proper manipulation to a slide.

The inclusions were themselves unaffected by such violent treatment,^a and when in suspension their uncorroded faces reflected the light in prismatic colors, due to the excessive thinness of the reflecting surfaces.

Viewed under high magnification, the needles are seen to have a varied habit, occurring principally as long, slender laths with square or pointed terminations; but also in the form of rhombs, rectangles, distorted six-sided plates, wedges, knee-shaped twins, and so on (see

^a These were resistant likewise to the action of sulphuric acid.

accompanying figure). Numerous angular measurements were made, but the values were not constant, due doubtless to the restricted quarters of growth, so that the form is no absolute criterion for identification.



CHARACTERISTIC SHAPES OF THE RUTILE INCLUSIONS IN MICA.
GREATLY MAGNIFIED.

The mineral is brightly and delicately colored, showing shades of green, purple, blue, red, and yellow, with often a gradation in colors along the length of a single crystal. The pleochroism is usually weak, but occasionally strong: c = dark green to brown; a = pale gray. The extinction is parallel and the crystals positively elongated. Absorption is $c > a$, which corresponds to $\epsilon > \omega$; birefringence high. The index of refraction, determined by immersion,^a is considerably greater than 1.82.

These features and the resistance to chemical attack eliminate other possibilities and concur in identifying the mineral as rutile.

Analogous inclusions in mica have been described from several localities, but the conclusions regarding their nature are diverse. The much discussed inclusions causing asterism in mica from South Burgess, Canada, were described and figured in detail by Rose,^b who originally considered these to be cyanite, but later concurred in the opinion of De Cloizeaux that they represented an uniaxial mica. An examination of specimens from this locality, and a consideration of Rose's abundant figures, leaves no doubt that his inclusions are also rutile.

Tschermak,^c in 1878, studied the needles causing asterism in phlogopite from Perth, Canada, and from their refraction and form concluded that they could not be a mica, but was unable to determine their real nature.

Sanberger^d in 1881 noted rutile needles in a dark mica, altering to chlorite, from Bordenmais, and in the following year^e described a

^a The writer is indebted to Dr. F. E. Wright, of the Carnegie Geophysical Laboratory, for kindly making this determination.

^b G. Rose. Ueber die regelmässigen Verwachsungen der verschiedenen Glimmerarten unter einander sowie mit Pennin und Eisenglanz. Monatsb. kon. preuss. Acad. Berlin, 1869, pp. 339-362.

^c G. Tschermak. Die Glimmergruppe. Sitzungb. Akad. Wiss. Wien, vol. 76, 1877, p. 125; Zeitschr. f. Kryst., vol. 2, 1878, pp. 14, 15.

^d F. Sanberger. [Note.] Neues Jahrb. Min. Geol. Pal., vol. 1, 1881, pp. 258, 259.

^e F. Sanberger. Ueber Rutile in Phlogopite, etc. Neues Jahrb. Min. Geol. Pal., vol. 2, 1882, pp. 192, 193.

phlogopite from Ontario, Canada, containing a network of colorless crystals, crossing at angles of 60° , which he proved chemically to be pure titanium dioxide. He thought this rutile to be a product of decomposition, because it increased in abundance with the degree of alteration of the mica.

Rosenbusch^a in 1885 attributed the asterism of the Canadian micas chiefly to the presence of tourmalines of microscopic dimensions, though adding that in some instances rutile is present, causing asterism.

Lacroix^b the same year made a study of the inclusions in phlogopite from Templeton, Canada. These he succeeded in isolating by treatment with hydrochloric acid in a closed vessel heated to 250° , and obtained with them a strong qualitative test for titanium. In 1889^c he noted similar inclusions in a phlogopite from Ceylon.

In 1890 Clarke and Schneider^d submitted a sample of Burgess phlogopite to W. Lindgren for microscopic examination of its inclusions. It was concluded that the needles corresponded well in their optical properties with tourmaline, but no boron could be found in the mica to prove its presence.

Osann^e in 1899 became interested in the inclusions in phlogopite from Ottawa. He found these to occur as laths and variously shaped plates, with parallel extinction and positive elongation, which were unattacked by hydrofluoric acid and would scratch glass. These data being insufficient for identification, he submitted 0.0466 grain for chemical determination to Professor Jannasch, of Heidelberg, who reported ZrO_2 (?), TiO_2 (yellow coloration with H_2O_2), K, Na, traces of Fe, and H_2O (?), and thought that the mineral could not be rutile because the H_2O_2 reaction was "much too weak." No definite conclusion was therefore reached.

Canaval^f in 1901 mentioned the occurrence of sagenetic rutile needles within the biotite of a garnet and graphite gneiss from Lading, Carinthia, but did not give the data upon which he based his determination.

The writer has examined a number of Canadian phlogopites showing asterism, and has found in each instance inclusions identical with

^a H. Rosenbusch. *Microscopische Physiographie*, 1885, p. 487.

^b A. Lacroix. *Sur les inclusions de la phlogopite de Templeton (Canada)*. Bull. Soc. Min. France, vol. 8, 1885, pp. 99-102.

^c A. Lacroix. *Contributions a l'etude des gneiss a pyroxene et des roches a wernerite*. Bull. Soc. Min. France, vol. 12, 1889, pp. 341, 342.

^d F. W. Clarke and E. A. Schneider. *Experiments upon the constitution of the natural silicates*. Pt. 5, *The Micas*. Amer. Journ. Sci., vol. 40, 1890, pp. 411, 412.

^e A. Osann. *Notes on certain Archaean rocks of the Ottawa Valley*. Geol. Surv. Canada, vol. 12, 1899, pt. O, pp. 1-84.

^f R. Canaval. *Bemerkungen über das Kiesvorkommen von Lading*. Jahrb. naturh. Mus. von Kärnten, vol. 26, 1901, pp. 1-9.

those in the specimen here described, which itself shows marked asterism.^a The conclusion therefore seems warranted that *asterism is generally due to the inclusion of regularly arranged rutile laths.*

3. PSEUDOMORPHS OF MARCASITE AFTER PYRRHOTITE FROM OSNABRÜCK, PRUSSIA.

In November, 1909, the specimens here described were given to the U. S. National Museum (Catalogue No. 86666) by Mr. Werthmann, of Osnabrück, who called them "pseudomorphs of marcasite after an unknown mineral," and requested their more accurate determination. A careful study revealed the original mineral to be pyrrhotite, and this conclusion was made known to Mr. Werthmann. In the meantime Messrs. F. Schöndorf and R. Schroeder had reached the same conclusion regarding similar specimens, having published their results under the title *Ueber Markasit von Hannover und Osnabrück* in the *Zweiter Jahresbericht des Niedersächsischen geologischen Vereins, Hannover*, for 1909, pages 132 to 139, a copy of which was kindly sent to the present writer by Mr. Werthmann. Inasmuch, however, as this publication is one not readily accessible to English readers, and owing to the theoretical interest that pertains to the rare change of one iron sulphide into another, it is ventured to give the present account, even at the risk of some degree of repetition.

Plate 64 illustrates very completely the appearance and form of the marcasite. It may there be seen that this mineral occurs in single hexagonal pyramids, occasionally terminated by basal planes, and in larger, irregular masses and groups of crystals. The pyramidal faces are dull, usually rough, and frequently striated horizontally from repeated oscillatory combinations of the upper and lower pyramids. The basal planes are smooth, though almost without luster. In size the specimens range from 4 to 21 mm. in greatest length.

The mineral is sharply differentiated from pyrrhotite and established as a form of iron disulphide by its color, hardness, density of 4.80–4.86, chemical composition,^b lack of magnetism, and ability to yield much sulphur in the closed tube. Its identification as marcasite instead of pyrite, however, is not absolutely without question. Its density and the fact that much free sulphur is left when its powder is dissolved in strong nitric acid are indicative of marcasite. Several crystals were sliced and a polished surface studied under the micro-

^a When a small flame was viewed through a fairly thin sheet, a well-marked six-rayed star was visible, with a secondary similar but less prominent star intermediate in position.

^b Fe= 47.22%. M. Dittrich, analyst; quoted by Schöndorf and Schroeder;
S= 52.61% Ueber Markasit von Hannover und Osnabrück. Zweiter
Gangue= .30 Jahrb. Niedersächsischen geol. Vereins, Hannover,
1909, pp. 132–139.

scope alongside of similarly prepared specimens of known marcasite and pyrite. The pseudomorphs are compact and homogeneous, with no perceptible core of pyrrhotite. The structure is similar to that of the marcasite examined, but the color was found to be intermediate between the two standard specimens, but on the whole inclining more to white than to yellow, and distinctly white in the case of the smaller crystals. The comparisons were, of course, made after cleaning with hydrochloric acid. The color, therefore, is the only doubtful point in the sure determination of the mineral as marcasite; but a careful weighing of the evidence and consideration of the work of Julien,^a Stokes,^b and others renders the identification as marcasite reasonably conclusive.

The determination of the crystal form as that of pyrrhotite is based upon the identification of the faces $c(0001)$ and $z(20\bar{2}1)$ (see figs. 5 and 6, pl. 63) according to the following data:

	Average of 8 measurements. Reflection goniometer.	Average of 5 measurements. Reflection goniometer.	Average of 7 measurements. Contact.	Average of 5 measurements. Contact.	Theoretical for pyrrhotite.
$c : z$	63° 52'	.....	64°	.....	63° 32'
$z : z$.....	.....	52° 46'	.....	53°	53° 11'

The measurements were obtained with difficulty, as the crystals were poorly adapted for giving reflections. The signals for the smoothest faces were blurred and the centers had to be approximated. In some instances the reflection was aided by the application of a thin coat of shellac to the faces to be measured; in other instances signals were obtained from minute pieces of glass cemented to the faces; but such measurements were only used when checked around the entire crystal. A general coincidence from the several methods and agreement with results obtained by contact offset the unreliability of any individual measurement. The possibility that the crystal form is orthorhombic, with faces new for marcasite, was considered. A combination of a new brachydome (021), with a new pyramid (433), gives an approximate hexagonal girdle; but the calculated angles^c for such forms are not in close agreement with the measured values.

The specimens were obtained from the oxidized zone of an iron mine in the Carboniferous Mountains of the Teutoburger Wald, near

^a A. A. Julien. On the variation of decomposition in the iron pyrites; its cause and its relation to density. *Annals N. Y. Acad. Sci.*, vol. 3, 1884, pp. 365-404; also, vol. 4, 1888, pp. 133-223.

^b H. N. Stokes. On pyrite and marcasite. *Bull.* 186, U. S. Geol. Surv., 1901.

^c (001):(021)=67° 57'.

(001):(433)=68° 20'.

(021):(433)=55° 19'.

(433):(433)=55° 1'.

Osnabrück, Hanover, Prussia. Their immediate associate is limonite, resulting from the alteration of siderite, which is regarded by Haarmann,^a who studied the geology of the region, as a metasomatic replacement of Permian limestone.

Pseudomorphs of marcasite, after pyrrhotite, have been noted in only a few instances, and chiefly at German localities that have been studied in the utmost detail. From Freiberg, Saxony, such pseudomorphs have been known for a long time. In 1849 marcasite, having the hexagonal prismatic form of pyrrhotite, was described by Breithaupt^b as occurring with other sulphides in the "Neuglück," "Drei Eichen," "Alte Elizabeth," "Segen Gottes," "Herzog August," "Besheert Glück," and other mines of this district. Breithaupt's description was quoted by Blum^c in 1852; the occurrence noted by Frenzel^d in 1874; the faces stated by Groth^e in 1878 to be (0001) and (10 $\bar{1}$ 0), with an occasional steep hexagonal pyramid; and, finally, the various accounts summarized by Hintze^f in 1904. At Nagyag, Siebenburgen, Prussia, according to Blum,^g marcasite has been found on dolomite in hexagonal tablets, consisting of base, prism, and pyramid, with the side faces horizontally striated, and coinciding in habit with the pyrrhotite occurring at the same locality.

Rumpf,^h in 1870, described pseudomorphs of marcasite after pyrrhotite from one of the iron mines at Loben, near St. Leonhard, Carinthia, Austria, found, according to Weinek,ⁱ in a druse at the contact between siderite and limestone. These are rosettes of thin tabular crystals with smooth, regular, lusterless faces, comprising a base, hexagonal prism, and occasional fairly steep pyramid, and were mistaken by Reuss^j and Weinekⁱ for pseudomorphs after hematite. Döll,^k in 1874, briefly mentioned tabular pseudomorphs occurring on

^a E. Haarmann. Die Eisenerze des Hügels bei Osnabrück. Zeitschr. für prakt. Geol., vol. 17, 1909, pp. 343-353. See also Stockfloth. das Eisenerzvorkommen am Hügel bei Osnabrück., Glückauf, 1894.

^b A. Breithaupt. Paragenesis, 1849, pp. 130, 161-164, 170, 253.

^c J. R. Blum. Pseudomorphosen des Mineralreichs, 2 Nachtrag, 1853, p. 74.

^d A. Frenzel. Mineralogisches Lexicon für das Königreich Sachsen. Leipzig, 1874, p. 201.

^e P. Groth. Die Mineraliensammlung. Strassburg, 1878, p. 45.

^f C. Hintze. Handbuch der Mineralogie. Leipzig, vol. 1, 1904, p. 637.

^g J. R. Blum. Pseudomorphosen des Mineralreichs, 3 Nachtrag, 1863, pp. 192-193. This locality was noted by V. R. v. Zepharovich, Mineralogische Lexicon für das Kaiserthum Oesterreich, Vienna, 1873, p. 202.

^h J. Rumpf. Ueber den Magnetkies von Loben bei St. Leonhard in Karnten. Verh. k. k. geol. Reichsanst., Wien, 1870, pp. 2, 3.

ⁱ F. Weinek. Markasit nach Eisenglanz von Loben. Verh. k. k. geol. Reichsanst., Wien, 1867, p. 285.

^j A. E. Reuss. Markasit, pseudomorph nach Eisenglanz. Verh. k. k. geol. Reichsanst., Wien, 1867, pp. 218, 219.

^k E. Döll. Neue Pseudomorphosen. Tschermak's Min. Mitth., 1874, pp. 85-88.

blende at Dognacska, Hungary. In 1878 Ain Barber, Algiers, was cited by Groth^a as an additional locality, and the accounts of Rumpf, Reuss, and Weinek were summarized by Blum.^b Lacroix,^c in 1897, gave an account of marcasite from Pontpéan, near Rennes, Ille-et-Vilaine, France, describing thin hexagonal plates, with occasional pyramidal habit, as pseudomorphs after pyrrhotite. The same year Miers^d mentioned a specimen from Cornwall, England, comprising a low hexagonal pyramid, the material of which "appeared to be marcasite." And, finally, Pojana, Siebenburgen, was added by Hintze^e as a further locality.

EXPLANATIONS OF PLATES.

PLATE 63.

Figs. 1-3.—Crystals of calamine from Chihuahua, Mexico. Orthographic and clinographic projections. Enlarged.

4.—Biotite-phlogopite intergrowth from Ottawa, Canada. Natural size. Clinographic projection, with orthographic plan of upper and lower basal planes. The stippled portion is biotite; the white, phlogopite.

5-6.—Pseudomorphs of marcasite after pyrrhotite from Osnabrück, Prussia. Clinographic projection. Enlarged.

For the significance of the lettering on the figures see text.

PLATE 64.

Pseudomorphs of marcasite after pyrrhotite from Osnabrück, Prussia. About twice natural size.

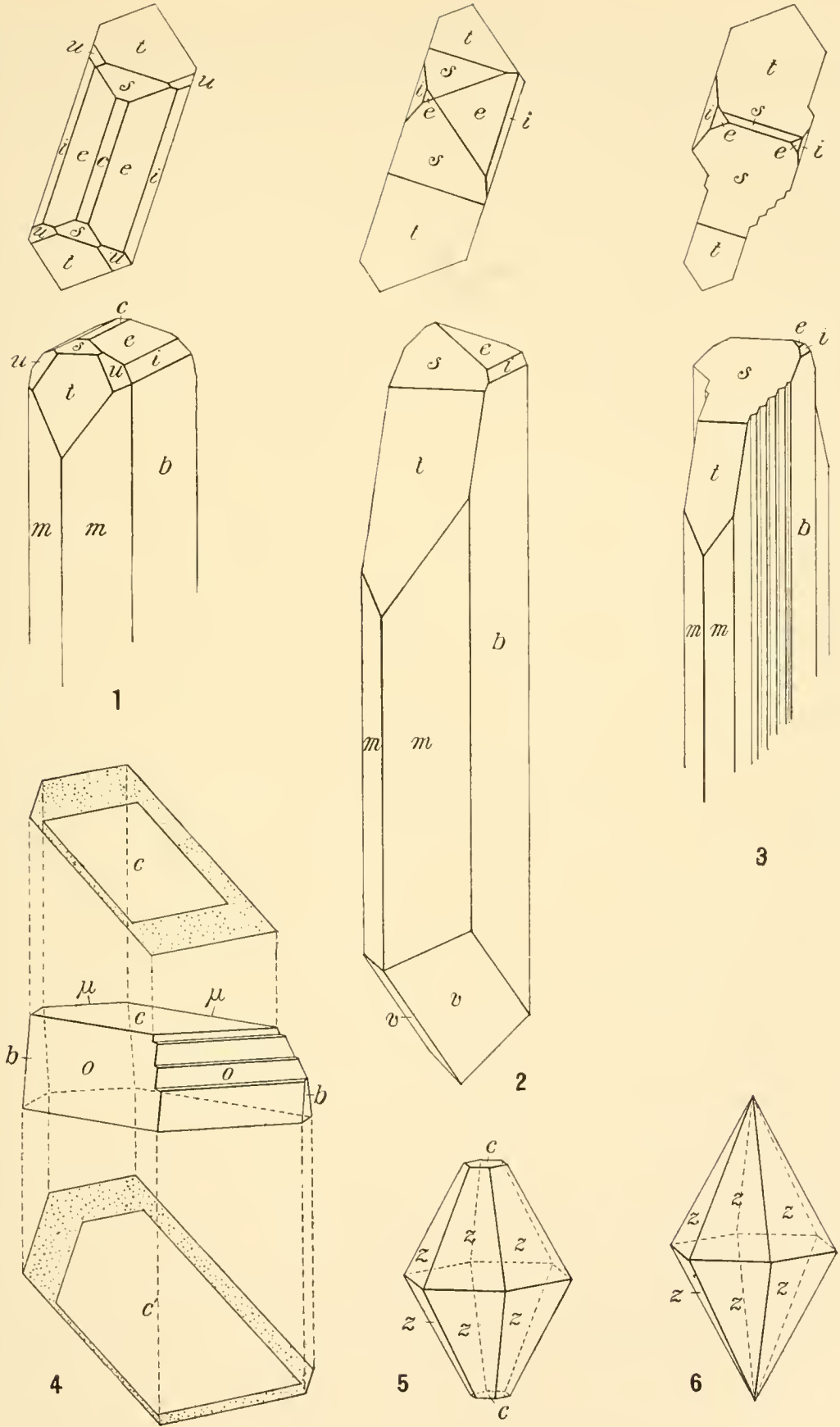
^a P. Groth. Die Mineraliensammlung. Strassburg, 1878, p. 45.

^b J. R. Blum. Pseudomorphosen des Mineralreichs. 4 Nachtrag, 1879, p. 105.

^c A. Lacroix. Sur la marcasite de Pontpéan (Ille-et-Vilaine) et sur les pseudomorphes qu'elle constitue. Compt. rend., vol. 125, 1897, pp. 265, 267; Bull. Soc. Min. France, vol. 20, 1897, pp. 223-232.

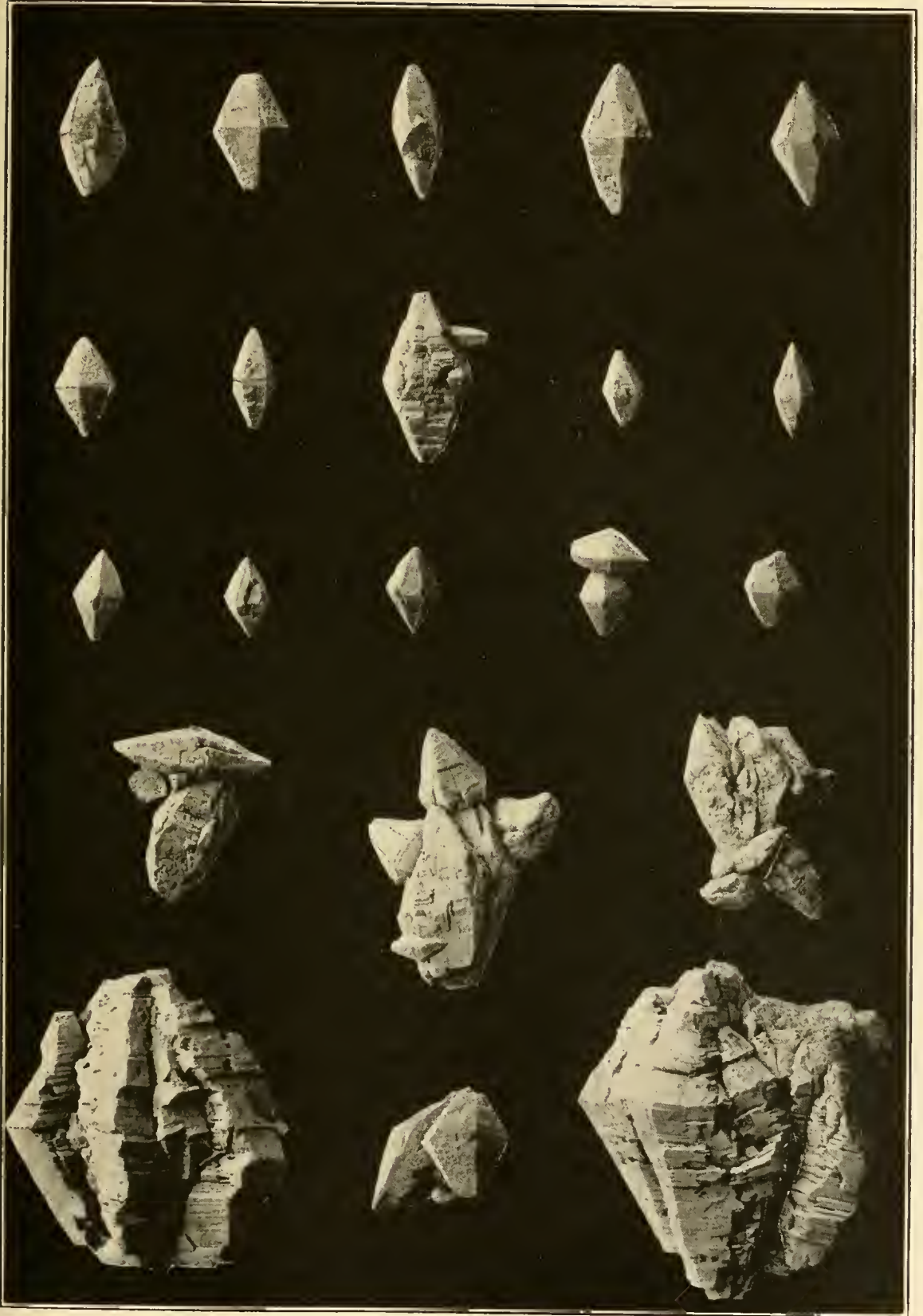
^d H. A. Miers. On some British pseudomorphs. Min. Mag., vol. 11, 1897, pp. 263-285.

^e C. Hintze. Handbuch der Mineralogie. Leipzig, vol. 1, 1904, p. 827.



CRYSTALS OF CALAMINE, BIOTITE, AND MARCASITE.

FOR EXPLANATION OF PLATE SEE PAGE 579.



PSEUDOMORPHS OF MARCASITE AFTER PYRRHOTITE.

FOR EXPLANATION OF PLATE SEE PAGE 579.



THE RECENT AND FOSSIL MOLLUSKS OF THE GENUS
DISASTOMA FROM THE WEST COAST OF AMERICA.

By PAUL BARTSCH.

Assistant Curator, Division of Mollusks, U. S. National Museum.

Of this genus only a single species has been reported from the west coast of America, *Bittium fastigiatum* Carpenter. This was tersely diagnosed by Dr. P. P. Carpenter in his report on the Mollusks of the West Coast of America, made to the British Association for the Advancement of Science in 1863, and published in their report on page 655 in 1864. Later, in 1865, it was more fully described in the Annals and Magazine of Natural History, page 181. This species was collected by Col. E. Jewett in the Lower Pleistocene deposits at Santa Barbara, California.

To this I now add three additional species, *Diastoma chrysalloidea* Bartsch, from the Gulf of California; *Diastoma oldroydæ* Bartsch, from San Pedro, California, and *Diastoma stearnsi* Bartsch, from San Diego, California.^a

DIASTOMA FASTIGIATA Carpenter.

Bittium fastigiatum CARPENTER, Rep. Brit. Ass. Adv. Sci. for 1863, 1864, p. 655; Ann. Mag. Nat. Hist., ser. 3, vol. 15, 1865, p. 181.

Shell elongate-conic, yellowish white. Nuclear whorls two, well rounded, smooth. Post-nuclear whorls flattened, much wider at the periphery than at the summit, overhanging, ornamented on the first seven whorls by four equal and equally spaced spiral cords, of which the posterior is at the summit and the anterior at some little distance

^a In the preparation of the present diagnoses the following terminology is used:

"Axial sculpture," the markings which extend from the summit of the whorls toward the umbilicus.

The axial sculpture may be—

"Vertical," when the markings are in general parallelism with the axis of the shell.

"Protractive," when the markings slant forward from the preceding suture.

"Retractive," when the markings slant backward from the suture.

"Spiral sculpture," the markings following the directions of the coils of the whorls.

above the suture; on the last whorl an additional slender cord appears between that on the summit and its neighbor. In addition to these spiral cords, the whorls are marked by strong, broad, low, axial ribs, of which twelve occur upon the first and second, fourteen upon the third and fourth, and sixteen upon each of the remaining whorls. The intersections of the spiral cords and axial ribs are nodulose. In addition to these cords and ribs, the entire surface of the shell is marked by numerous, very fine, spiral striations and slender lines of growth. Periphery of the last whorl marked by a sulcus which is as wide as the space between the cords on the spire and is crossed by the slender continuations of the axial ribs. Base well rounded, marked by eight equal and subequally spaced, rounded, spiral cords. Aperture elongate, decidedly effuse at the junction of the outer and basal lips, channeled anteriorly and subchanneled at the posterior angle; outer lip thin, rendered somewhat sinuous by the external sculpture; columella short and twisted; parietal wall covered with a thick callus, which extends over the edge of the columella and renders the peritreme complete. In the two specimens before me a strong varix is present a fourth of a turn behind the lip.

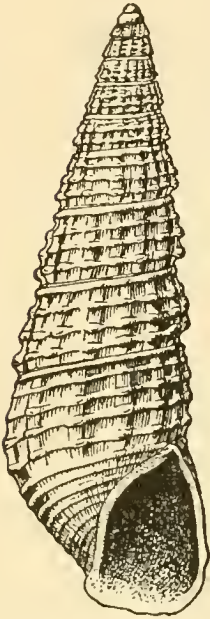


FIG. 1.—*DIASTOMA FASTIGIATA* CARPENTER.

The description and figure are based upon two specimens (Cat. No. 162561, U.S.N.M.) collected by Colonel Jewett in the Lower Pleistocene beds at Santa Barbara, California. One, a young individual of eight post-nuclear whorls, has furnished the description of the nucleus. The other, which has lost the nucleus and probably the first post-nuclear whorl, having eight post-nuclear whorls remaining, has furnished the remainder of the description. The two specimens mentioned measure: Length, 4.7 mm.; diameter, 1.5 mm.; and length, 6.5 mm.; diameter 2.1 mm., respectively.

DIASTOMA CHRYSALLOIDEA, new species.

Shell elongate-conic, pinkish white. Nuclear whorls partly decollated, the one remaining, smooth. Post-nuclear whorls appressed at the summit, sloping evenly from the posterior three-quarters between the sutures posteriorly, falling off rapidly between the sutures on the anterior fourth; marked by broad, low, rounded, distinct axial ribs, of which sixteen occur upon all the whorls. In addition to these ribs the whorls are marked by spiral bands, which are about as wide as the spaces that separate them. Of these bands, four occur upon the second turn; the fourth, marking the anterior termination of the sloping shoulder, is a little stronger than the rest and a little wider spaced.

The same number and disposition of bands occurs upon the third turn, but here the first subperipheral band becomes apparent in the suture. This arrangement holds good on the next turn. On the fifth post-nuclear whorl an additional slender cord appears between the first and second and another between the second and third cords, which on the penultimate turn assume the strength of the adjacent members. The intersections of the spiral cords and the axial ribs form ill-defined tubercles. Sutures strongly impressed; periphery and base of the last whorl well rounded, the latter marked by seven equal and equally spaced, low, spiral cords, which are almost as wide as the spaces that separate them. In the intervening grooves many slender, axial threads are present. Aperture irregularly ovate, large, decidedly expanded at the junction of the outer and basal lips, channeled anteriorly; posterior angle acute; outer lip thin at the edge where the spiral cords appear as brown spots on a yellowish, white background; columella short, moderately strong; appressed to and reflected over the attenuated base; parietal wall covered with a very thick callus which merges into the columellar edge and renders the peritreme complete. A strong varix is present about one-fourth of a turn behind the aperture.

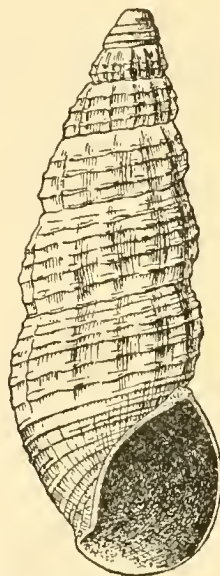


FIG. 2.—*DIASTOMA CHRYSSALLOIDEA* BARTSCH.

The type (Cat. No. 73996, U.S.N.M.) has seven post-nuclear whorls and measures: Length, 6.3 mm.; diameter, 2.4 mm. It comes from the Gulf of California.

DIASTOMA OLDROYDÆ, new species.

Shell broadly conic, light brown. Nuclear whorls decollated, postnuclear whorls slightly rounded, shouldered at the summit, marked by weak, axial ribs, of which sixteen occur upon the fourth and fifth, eighteen upon the sixth and the penultimate turn. Intercostal spaces about twice as wide as the ribs. In addition to the axial ribs the whorls are crossed by four slender, poorly developed, spiral cords, the intersection of which, with the ribs, renders them feebly nodulose. On the last whorl a slender, additional thread appears between the cord at the summit and the one adjacent to it. The spaces inclosed between the ribs and the spiral cords are rectangular, depressed areas, having their long axes parallel with their spiral sculpture. Periphery of the last whorl marked by a shallow sulcus. Base moderately long, well rounded, marked by six equal and equally spaced, spiral cords, the axial sculpture being represented by incre-



FIG. 3.—*DIASTOMA OLDROYDÆ* BARTSCH.

mental lines only. Sutures channeled. Aperture irregular, large, decidedly channeled and somewhat twisted anteriorly; posterior angle obtuse; outer lip moderately thin, showing the external sculpture within by transmitted light; columella very strongly curved and revolute; parietal wall covered with a thick callus which renders the peritreme complete. A strong, white varix is present about a quarter turn behind the lip.

The type (Cat. No. 213024, U.S.N.M.) was collected by Mrs. T. S. Oldroyd at San Pedro, California. It has eight postnuclear whorls and measures: Length, 3.8 mm.; diameter, 1.6 mm. Another specimen from the same locality is in Mrs. Oldroyd's collection.

DIASTOMA STEARNSI, new species.

Shell elongate-conic. Early whorls and columella light chestnut brown, the remaining creamy white. Nuclear whorls decollated, only the last two volutions remaining, which are well rounded and smooth. Postnuclear whorls strongly rounded, marked by low, well-

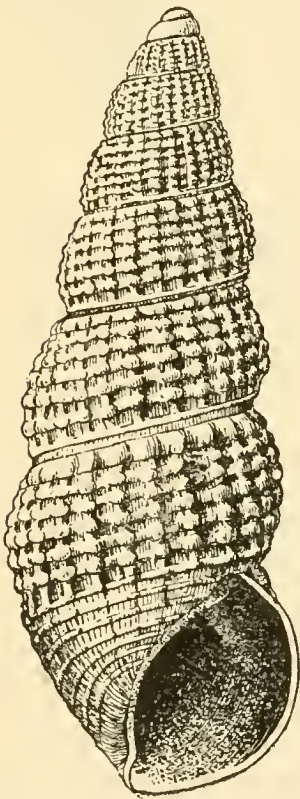


FIG. 4.—*DIASTOMA STEARNSI* BARTSCH.

rounded, vertical axial ribs which are about as wide as the intercostal spaces; of these ribs sixteen occur upon the first, and twenty-four upon the remaining whorls. In addition to these ribs, the whorls are marked by seven spiral cords, which are about as wide as the spaces that separate them and render the axial ribs nodulose. The cord at the summit is a little wider than the rest, likewise the space that separates it from the adjacent cord and this renders the summit of the whorls crenulated. The first subperipheral cord is apparent on all the whorls and forms the seventh one, between the sutures. The axial ribs usually encroach upon this only feebly, the nodulations therefore being less marked than on the spiral cords posterior to it. Sutures strongly constricted; periphery of the last whorl and base well rounded, the latter marked by six equal and equally spaced spiral cords which are a little less wide than the spaces that separate them. Aperture not quite complete in our specimen, broadly ovate, chan-

neled anteriorly; posterior angle acute; outer lip thin, showing the external markings within; columella moderately strong, somewhat twisted, curved, decidedly reflected; parietal wall glazed with a thick callus.

The type (Cat. No. 32212, U.S.N.M.) has seven postnuclear whorls and measures: Length, 9 mm.; diameter, 3 mm. It comes from San Diego and is named for the late Dr. R. E. C. Stearns.

A MONOGRAPH OF THE FLYCATCHER GENERA HYPOTHYMIS AND CYANONYMPHA.

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

Among the many East Indian birds of Dr. W. L. Abbott's collecting, now in the U. S. National Museum, that Mr. Ridgway, the curator of birds, has referred to the writer for determination, are a considerable number of blue flycatchers of the genus *Hypothymis*. These specimens are largely of forms more or less nearly related to *Hypothymis azurea*; and in order satisfactorily to work out their relationships it has been necessary to make as thorough an examination as possible of all the species of the genus.

The genus *Hypothymis* at present consists nominally of 11 species and subspecies. Of these, *Hypothymis superciliaris* and its close ally, *H. samarensis*, are clearly out of place in *Hypothymis*, but even more so in *Rhipidura*, where some recent authors have placed them. It seems necessary, therefore, to create for them a new genus, which I hereinafter accordingly do. Nor am I fully satisfied regarding the correct position of *Hypothymis rowleyi*, but leave it here pending further investigation. The bird from Celebes, *Hypothymis puella puella*, and its subspecies from the Sula Islands, *Hypothymis puella blasii*, are very distinct from the other members of the genus, as is also *Hypothymis abbotti* Richmond.

All the other forms, including several new ones, are clearly geographical races of *Hypothymis azurea*, though some of them pass for species. We are now able to distinguish sixteen forms of *Hypothymis azurea*, most of them island races, and, with two exceptions, of comparatively limited distribution. Each intergrades with some other, either through individual variation or (in one instance) continuity of range, so that there is just cause for considering them all subspecies. Most of the color characters exist only in the males, the females in nearly every case being separable, if at all, only by size, so that in the following pages the diagnoses apply to the

males alone unless otherwise specified. Individual variation in the group is not excessive, although there is usually some difference in the shade and extent of the blue; so that the characters are preserved with fair uniformity. Newly molted birds are usually of brighter, sometimes slightly more purplish, blue, than when much worn, but this color does not appear otherwise to undergo any material change.

Like so many other birds of the same general region, some of the forms of *Hypothymis* are peculiar in their geographical distribution. The race of *Hypothymis azurea* occurring on the Tambelan Islands, off the western coast of Borneo, is *H. a. opisthocyanea*^a of the Anamba Islands, instead of the Borneo-Malay Peninsula form. The subspecies found on the island of Car Nicobar, Nicobar Islands, *Hypothymis azurea idiochroa*,^b is much more like *Hypothymis azurea prophata*^c from the Malay Peninsula than like *Hypothymis azurea calocara*^d from the other Nicobar Islands. Still more remarkable, and showing again the apparent kinship or parallel development of forms from the western coast islands of Sumatra with forms from the Andaman Islands that exists in birds of other genera, is the close similarity of *Hypothymis azurea consobrina*, from Simalur Island, and *Hypothymis azurea richmondi*,^e from Engano Island, to *Hypothymis azurea tytleri*, from the Andaman Islands, and their great difference from both *Hypothymis azurea prophata*,^f of the Sumatra mainland, and all the island races that geographically intervene between Engano and Simalur islands. Furthermore, the bird from the Pagi Islands, *Hypothymis azurea leucophila*,^g which is the one of these island races geographically nearest *Hypothymis azurea richmondi*,^h from Engano, is, in appearance, the most different; while between *Hypothymis azurea amelis*,ⁱ from Nias, and *Hypothymis azurea consobrina*, from Simalur Island, there comes in the totally distinct species *Hypothymis abbotti*, on Pulo Babi and Pulo Lasia.

The literature relating to this group of very beautiful little flycatchers is to be found mostly as scattered notes on individual species in systematic and faunal papers; and the only complete recent account of the genus is that of Dr. R. B. Sharpe, in the Catalogue of Birds in the British Museum, volume 4, 1879, pages 273 to 279.

The material which has been available as the basis of this review of *Hypothymis* consists of 205 specimens, in large part of the fortunately excellent series (180 specimens) in the U. S. National Museum. Aside from this we are indebted for altogether 25 specimens to Mr. J. H. Fleming, and to the Academy of Natural Sciences of Philadelphia, through the kindness of Mr. Witmer Stone.

^a See p. 602.

^b See p. 604.

^c See p. 597.

^d See p. 610.

^e See p. 613.

^f See p. 597.

^g See p. 607.

^h See p. 613.

ⁱ See p. 608.

CYANONYMPHA,^a new genus.

Chars. gen.—Similar to *Hypothymis* Boie, but bill more slender; rictal bristles much longer, reaching nearly or quite to end of bill; feathers of crown not stiffened; tarsus much less distinctly scutellate. Similar to *Rhipidura* Vigors and Horsfield, but tail not decidedly longer than wing, and only rounded, not strongly graduated; tarsus less distinctly scutellate; rictal bristles relatively shorter, not reaching appreciably beyond tip of bill.

Type of the genus.—*Hypothymis superciliaris* Sharpe.

Geographical distribution.—Southern Philippine Islands.

KEY TO THE FORMS OF CYANONYMPHA, BASED ON ADULT MALES.

- a.* Pileum lighter, brighter, more bluish; light-blue eyebrow and frontal line broader.
Cyanonympha superciliaris superciliaris.
- a*¹. Pileum darker, duller, less bluish; light-blue eyebrow and frontal line more narrow.
Cyanonympha superciliaris samarensis.

CYANONYMPHA SUPERCILIARIS SUPERCILIARIS (Sharpe).

Hypothymis superciliaris SHARPE, Trans. Linn. Soc. Lond., ser. 2, vol. 1, pt. 6, 1877, p. 326 (Isabella de Basilan, Basilan Island, Philippine Islands).

Chars. sp.—Upper parts of male deep verditer blue, the pileum indigo blue, the forehead and a supraloral line bright azure blue; wings and tail fuscous, margined with cobalt or purplish indigo blue; throat and breast purplish china blue; posterior lower parts white washed with blue. Female similar to male, but of a rather lighter, slightly more greenish blue.

Measurements.—Seven males: Wing, 73–81 (average, 78.1); tail, 75.5–83.5 (average, 77.9); exposed culmen, 11–12 (average, 11.6); tarsus, 15.5–16.5 (average, 15.9) mm. Six females: Wing, 72–78.5 (average, 74.9); tail, 73.5–79 (average, 76.5); exposed culmen, 11–12 (average, 11.6); tarsus, 15–16 (average, 15.5) mm.

Type-locality.—Isabella de Basilan, Basilan Island, Philippine Islands.

Geographical distribution.—Islands of Basilan and Mindanao, Philippine Archipelago.

Specimens from the island of Basilan seem to average somewhat lighter, more greenish blue above than those from Mindanao, but this is not sufficient to warrant any subspecific separation, at least with the material at our present disposal. There is apparently very little sexual difference in this species, aside from the inferior size of the female.

^a κύανος, cyanos; νύμφη, nymphe.

Detailed millimeter measurements of the specimens examined are as follows:

Measurements of specimens of Cyanonympha superciliaris superciliaris examined.

Museum and No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Ex-posed cul-men.	Tar-sus.
U.S.N.M. 190250..	Male....	Pantar, Minda-nao, Philip-pine Islands.	Aug. 26, 1903	Dr. E. A. Mearns	79	79	11.5	15.5
U.S.N.M. 202321..	...do....	Catagan, Min-danao, Philip-pine Islands.	May 12, 1906	.....do.....	81	83.5	12	15.5
U.S.N.M. 202322..	...do....	.....do.....	.....do.....	.....do.....	75	76.5	11.5	16
U.S.N.M. 202524..	...do....	.....do.....	June 9, 1906	Robert A. Schroder.	73	75.5	12	16
J. H. Fleming 10415.	...do....	Isabella, Basi-lan, Philip-pine Islands.	Nov. 15, 1887	E. L. Moseley ..	79	77	11.5	16
U.S.N.M. 201267..	...do....	.....do.....	Feb. 1, 1906	Dr. E. A. Mearns	80	76	11	16.5
U.S.N.M. 191849..	...do....	.....do.....	Jan. 26, 1904	.....do.....	79.5	78	12	16
U.S.N.M. 202525..	Female	Catagan, Min-danao, Philip-pine Islands.	June 9, 1906	Robert A. Schroder.	78.5	79	12	15.5
U.S.N.M. 202523..	...do....	.....do.....	May 21, 1906	.....do.....	77	78	11.5	15.5
U.S.N.M. 202320..	...do....	.....do.....	May 12, 1906	Dr. E. A. Mearns	72	76.5	11	15
U.S.N.M. 190251..	...do....	Pantar, Minda-nao, Philip-pine Islands.	Sept. 3, 1903	.....do.....	75	78.5	11.5	15.5
U.S.N.M. 191850..	...do....	Basilan, Phil-ippine Is-lands.	Jan. 26, 1904	.....do.....	74	73.5	11.5	15.5
U.S.N.M. 201266..	...do....	.....do.....	Feb. 20, 1906	.....do.....	73	73.5	12	16

CYANONYMPHA SUPERCILIARIS SAMARENSIS (Steere).

Hypothymis samtrensis STEERE, List Birds and Mammals Steere Expedition Philippines, 1890, p. 16 (Samar Island, Philippine Islands).

Chars. subsp.—Similar to *Cyanonympha superciliaris superciliaris*, but pileum darker, more dusky (less bluish), and thus more contrasted with the back; remaining upper parts more greenish blue; the bright azure forehead and supraloral lines more narrow.

Measurements.—One male: Wing, 80; tail, 80; exposed culmen, 12; tarsus, 16 mm.

Type-locality.—Samar Island, Philippine Islands.

Geographical distribution.—Islands of Samar, Leyte, and Bohol, Philippine Islands.

The only specimen examined is an adult male (U.S.N.M. No. 211005) from Servilla, Bohol Island, collected April 18, 1906, by A. Celestino and M. Canton. It is very much like some specimens of *Cyanonympha superciliaris superciliaris*, and indicates that *C. s. samarensis* is only a subspecies.

Genus HYPOTHYMIS Boie.

Hypothymis BOIE, Isis, 1826, p. 973.

Chars. gen.—Similar to *Rhipidura*, but bill stouter; nostrils within basal half of bill, measured from rictus; rictal bristles much shorter,

reaching barely beyond middle of bill; feathers of crown stiffened; tail not decidedly longer than the wing, and not so strongly rounded or graduated.

Type.—"Musc. caerulea Vaill. Afr. pl. 153" (= *Muscicapa azurea* Boddaert).

Geographical distribution.—Philippine Islands, Formosa, Hainan, Cochin China, Burmah, Malay Peninsula, and India; south to Ceylon, Sumatra and its islands, Java, Lombok, Sumbawa, and Flores; east to Celebes and the Sula Islands.

KEY TO THE SPECIES AND SUBSPECIES OF HYPOTHYMIS, BASED ON ADULT MALES.

- A. No blackish occipital patch.
 - a. Upper parts deep pure blue.....*Hypothymis abbotti*.
 - a¹. Upper parts lighter, grayish blue.
 - b. Size averaging smaller; lower parts not decidedly paler than upper surface.
 - c. Blue above and below paler.....*Hypothymis puella puella*.
 - c¹. Blue above and below darker.....*Hypothymis puella blasii*.
 - b¹. Size larger; lower parts decidedly paler than upper surface..*Hypothymis rowleyi*.
- B. A black or blackish occipital patch.
 - a. Flanks and crissum pure white.
 - b. No black collar on foreneck; black occipital spot indistinct.
 - Hypothymis azurea ceylonensis*.
 - b¹. A black collar on foreneck; black occipital spot distinct.
 - c. Larger (wing 75 mm. or more); upper parts darker.
 - Hypothymis azurea forrestia*.
 - c¹. Smaller (wing less than 75 mm.); upper parts lighter.
 - d. Blue of upper surface more purplish; wing averaging less than 70 mm.
 - Hypothymis azurea azurea*.
 - d¹. Blue of upper surface less purplish; wing averaging more than 70 mm.
 - e. Crown much paler than back.....*Hypothymis azurea coeruleocephala*.
 - e¹. Crown not much paler than back.....*Hypothymis azurea leucophila*.
 - a¹. Flanks and crissum grayish or tinged with blue.
 - b. Crown decidedly paler than the back.
 - c. Wing less than 73 mm.
 - d. Back lighter, less purplish; pileum less strongly contrasted with back.
 - Hypothymis azurea ponera*.
 - d¹. Back darker, more purplish blue; pileum more strongly contrasted with back.....*Hypothymis azurea prophata*.
 - c¹. Wing 73 mm. or more.
 - d. Upper parts paler, less purplish blue.....*Hypothymis azurea idiochroa*.
 - d¹. Upper parts deeper, more purplish blue.
 - e. Larger (wing averaging 77.7 mm.); posterior lower parts usually more bluish.....*Hypothymis azurea opisthocyanea*.
 - e¹. Smaller (wing averaging 74 mm.); posterior lower parts usually less bluish.....*Hypothymis azurea gigantoptera*.
 - b¹. Crown not decidedly paler than the back.
 - c. Posterior lower parts less heavily overlaid with blue, the white of median abdomen more extended, never nearly absent.
 - d. Larger (wing over 70 mm.); blue less purplish..*Hypothymis azurea isocara*.
 - d¹. Smaller (wing under 70 mm.); blue more purplish.
 - Hypothymis azurea calocara*.

c¹. Posterior lower parts more heavily overlaid with blue, the white of median abdomen more restricted, sometimes absent.

d. Wing averaging less than 70 mm.

e. Pileum paler, and appreciably contrasted with back; posterior lower parts more whitish; axillars more whitish, less washed with blue.

Hypothymis azurea amclis.

e¹. Pileum darker, and not appreciably contrasted with back; posterior lower parts more bluish; axillars more grayish and more washed with blue.

Hypothymis azurea consobrina.

d¹. Wing averaging more than 70 mm.

e. Blue of upper and lower surfaces lighter; posterior lower parts more whitish and less overlaid with blue. *Hypothymis azurea tytleri.*

e¹. Blue of upper and lower surfaces darker; posterior lower parts more grayish and more overlaid with blue. . . *Hypothymis azurea richmondi.*

HYPOTHYMIS ROWLEYI (Meyer).

Zeocephus rowleyi MEYER, Rowley's Ornith. Misc., vol. 3, 1878, p. 163.

Chars. sp.—Similar to *Hypothymis puella puella*, but much larger; upper surface darker, and contrasted strongly with the paler lower parts.

Description of adult male.^a—“Upper parts bluish, brighter on the back; wing-feathers blackish grey, margins of the outer webs greyish blue, of the inner whitish. Underparts light pale blue, somewhat whitish on the belly; wing-feathers beneath grey, margins of the outer webs and under wing-coverts white. Rectrices bluish grey above, outer webs blue, of the same colour as the back; beneath grey. Bill blackish, under mandible paler. Bristles very long, some reaching the tip of the bill. Feet and claws greyish.”

Measurements (of type).—“Total length 180 millims., bill 13, wing 96, tail 92, tarsus 21.”^b

Type-locality.—Tabukan, Great Sangi Island, Sangi Islands.

Geographical distribution.—Sangi Islands.

The type of this pretty flycatcher is in the Dresden Museum, and apparently still remains unique. From what Meyer and Wigglesworth say,^c the species appears to be doubtfully placed in *Hypothymis*; but, not having seen a specimen, I am, of course, not able to make any change in its currently accepted generic position.

HYPOTHYMIS PUELLA PUELLA (Wallace).

Myiagra puella WALLACE, Proc. Zool. Soc. Lond., 1862, p. 340.

Chars. sp.—Upper and lower parts nearly uniform campanula blue, the abdomen paler; wings and tail fuscous, margined with campanula blue; a narrow blackish line around the base of the maxilla; iris gray; bill, legs, and feet black.

Measurements.—Six males: Wing, 71–77 (average, 74.1); tail, 72–78 (average, 73.8); exposed culmen, 11.5–13 (average, 12.3);

^a Original description of type, Meyer, Rowley's Ornith. Misc., vol. 3, 1878, p. 163.

^b Meyer, Rowley's Ornith. Misc., vol. 3, 1878, p. 163.

^c Birds of Celebes, vol. 1, 1898, p. 378.

tarsus, 16–17 (average, 16.4) mm. Five females: Wing, 70–76 (average, 72.9); tail, 68–76.5 (average, 73.2); exposed culmen, 11.5–13 (average, 12.2); tarsus, 15.5–16.5 (average, 16.3) mm.

Type-locality.—Menado, northern Celebes.^a

Geographical distribution.—Celebes.

Although the only specimens examined were taken in northern Celebes, this form occurs in all parts of the island, to which, however, it is apparently confined. There is considerable individual variation among adults, in the shade of the blue, this in some being much richer than in others. There is apparently no sexual difference in color, but the female averages slightly smaller than the male. Immature birds, however, seem to be paler and of a more grayish blue.

Measurements of specimens of Hypothymis puella puella examined.

Museum and No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Ex-posed culmen.	Tar-sus.
U.S.N.M. 178228....	Male....	Northern Celebes.	1883.....	F. Von Faber.	73.5	72	13	16
J. H. Fleming 10864.	...do....	T o t o k, Minahasa, Celebes.	Apr. —, 1899	.....	75	74	12	16
J. H. Fleming 10862.	...do....	.....do.....	Jan. 27, 1899	.....	77	78	13	16.5
J. H. Fleming 10865.	...do....	.....do.....	Mar. 13, 1899	.....	74	72	12	16.5
J. H. Fleming 10863.	...do....	.....do.....	Jan. 27, 1899	.....	74	74.5	12	17
A.N. S. Phila.51715.	...do....	Rorakan, Minahasa, Celebes.	Oct. —, 1895	Chas. Hose....	71	72	11.5	16.5
U.S.N.M. 178229....	Female.	Northern Celebes.	1883.....	F. Von Faber.	71	73.5	11.5	16.5
A.N. S. Phila.51716.	...do....	M o u n t Masarang, Celebes.	Oct. —, 1895	Chas. Hose....	70	68	12.5	16.5
J. H. Fleming 10861.	...do....	Rorakan, Minahasa, Celebes.	Apr. —, 1899	.....	76	76.5	12	16.5
J. H. Fleming 10868.	...do....	K o t t a B u n a, Minahasa, Celebes.	May —, 1899	.....	72.5	72	13	16.5
J. H. Fleming 10866.	...do....	Bojat, Minahasa, Celebes.	June —, 1899	.....	75	76	12	15.5

HYPOTHYMIS PUELLA BLASII Hartert.

Hypothymis puella blasii HARTERT, Nov. Zool., vol. 5, 1898, p. 131 (Sula Besi and Sula Mangoli islands, Sula Islands).

Chars. subsp.—Similar to *Hypothymis puella puella*, but upper parts, throat, and jugulum deeper, more azure, blue.

Type-locality.—Sula Besi Island,^b Sula Islands, east of Celebes.

Geographical distribution.—Sula Islands; Peling and Banggai islands, east of Celebes.

No specimens of the Sula Islands race have been examined in the present connection, but judging from Doctor Hartert's description,^c *Hypothymis p. blasii* is undoubtedly distinct from the Celebes form. Birds from Peling and Banggai islands are said by Doctor Hartert^c to be the same as those from the Sula Islands.

^a Type in British Museum, examined by Mr. Gerrit S. Miller, jr.

^b Doctor Hartert, *in litt.*

^c Nov. Zool., vol. 5, 1898, p. 131.

HYPOTHYMIS ABBOTTI Richmond.

Hypothymis abbotti RICHMOND, Proc. Biol. Soc. Wash., vol. 15, 1902, p. 189 (Pulo Babi, western coast of Sumatra).

Chars. sp.—Entire plumage of male uniform bright cyanine blue; but wing-quills and tail blackish clove brown, broadly edged externally with marine blue; no black on occiput or jugulum; a tiny chin spot and the narial bristles black. Female blackish sepia brown, washed with marine blue, less so on wing-quills and tail, the whole head and throat dull, dark cyanine blue.

Measurements.—Six males: Wing, 75–79.5 (average, 77.7); tail, 75.5–80.5 (average, 78); exposed culmen, 11–12.5 (average, 11.8); tarsus, 17–19 (average, 17.9) mm. One female: Wing, 77; tail, 76; exposed culmen, 12; tarsus, 18 mm.

Type-locality.—Pulo Babi, off the western coast of Sumatra.

Geographical distribution.—Pulo Babi and Pulo Lasia, off the western coast of Sumatra.

This remarkable distinct species is most closely allied to *Hypothymis azurea richmondi*,^a from Engano Island, which, except for the lack of black jugular band and black occipital crescent, it closely resembles. In its lack of black on occiput and jugulum it agrees with *Hypothymis rowleyi*, but in size and color is very different. The feathers of the jugulum are peculiarly truncated, and end in a sharp line posteriorly, as in *Hypothymis azurea* and its forms; and sometimes there are small hidden black spots on a few of the feathers at this line of demarcation between the square ended feathers of the jugulum and the normal feathers of the breast. Thus *Hypothymis abbotti* seems to be virtually a *Hypothymis azurea richmondi* that has lost practically all the black of occiput and jugulum, not, as might at first sight appear, a close ally of *Hypothymis rowleyi* or *Hypothymis puella puella*.

The five adult males of our series are very uniform in coloration. Birds from Pulo Lasia seem to be identical in size and color with those from Pulo Babi. An immature female is essentially like the single adult female.

Measurements of specimens of Hypothymis abbotti examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^b	Wing.	Tail.	Exposed culmen.	Tarsus.
179431	Male....	Pulo Lasia, west- ern Sumatra.	Jan. 6, 1902	Dr. W. L. Abbott.	181	75	77	12	17
179430	...do.....	...do.....	...do.....	...do.....	181	78	78	11.5	17.5
179426c	...do.....	Pulo Babi, west- ern Sumatra.	Jan. 11, 1902	...do.....	181	77.5	78	11	18.5
179427	...do.....	...do.....	Jan. 10, 1902	...do.....	187	79.5	80.5	11.5	18.5
179428	...do.....	...do.....	Jan. 13, 1902	...do.....	179	79	79	12	17
179429	...do.....	...do.....	Jan. 8, 1902	...do.....	178	77	75.5	12.5	19
179432	Female .	Pulo Lasia, west- ern Sumatra.	Jan. 6, 1902	...do.....	178	77	76	12	18

^a See p. 613.^b Measured in the flesh by the collector.^c Type.

HYPOTHYMIS AZUREA AZUREA (Boddaert).

Muscicapa azurea BODDAERT, Tabl. Planch. Enlum., 1783, p. 41 (based on the "Gobe-mouche bleu des Philippines" of Daubenton, Planch. Enlum., 666, fig. 1).

Muscicapa caerulea GMELIN, Syst. Nat., vol. 1, pt. 2, 1788, p. 943 (Philippine Islands).

Muscicapa occipitalis VIGORS, Proc. Zool. Soc. Lond., 1831, p. 97 (Manila, Luzon, Philippine Islands).

Chars. subsp.—Upper parts, throat, and breast of male hyacinth blue, the pileum lighter; a narrow line across forehead, a small chin spot, a somewhat crescentic bar across jugulum, and a crescentic patch on occiput black; abdomen, sides, flanks, and crissum white, the first two sometimes washed anteriorly with blue; axillars white, little, if at all, tinged with blue.

Female with head, throat, and breast dull cyanine blue, paler on the last; posterior lower parts white, washed with grayish laterally; rest of upper surface rufescent bistre brown; wings and tail clove brown, margined with the warmer brown of back, and with little or no tinge of blue; a narrow black line on extreme forehead, but no black on occiput or jugulum.

Measurements.—Twenty-five males: Wing, 65–72.5 (average, 67.6); tail, 64.5–73.5 (average, 67.9); exposed culmen, 10–12 (average, 11); tarsus, 14–17 (average, 15.7) mm. Twenty-two females: Wing, 63–69.5 (average, 66.2); tail, 62–72.5 (average, 67.9); exposed culmen, 10–12 (average, 11); tarsus, 14.5–17 (average, 15.8) mm.

Type-locality.—Philippine Islands.

Geographical distribution.—Philippine Islands, including the Palawan group; and Formosa.

A good series from the Philippine Islands shows that this race is almost as white below as *Hypothymis azurea coeruleocephala* from India; the lower tail-coverts, flanks, and lower abdomen are white, but the blue of the breast extends somewhat farther back than in the Indian form. Daubenton's plate,^a on which *Muscicapa azurea* Boddaert^b was based, is thus not so inaccurate as has been supposed, and there now seems to be no satisfactory reason for not applying the name *azurea* to the Philippine bird, to which it exclusively refers. The *Muscicapa caerulea* of Gmelin,^c founded upon the "Petit azur" of Buffon,^d the "Gobe-mouche bleu des Philippines" of Daubenton,^e and the "Azure flycatcher" of Latham,^f is of course synonymous; and the same is to be said of *Muscicapa occipitalis* Vigors,^g from Manila.

^a Planch. Enlum., 666, fig. 1.

^b Tabl. Planch. Enlum., 1783, p. 41.

^c Syst. Nat., vol. 1, pt. 2, 1788, p. 943.

^d Hist. Nat. Ois., vol. 4, 1778, p. 534.

^e Planch. Enlum., 666, fig. 1.

^f Gen. Syn. Birds, vol. 2, pt. 1, 1783, p. 339.

^g Proc. Zool. Soc. Lond., 1831, p. 97.

This bird is of very general distribution throughout the Philippine Archipelago, but seems to be practically identical on the several islands, at least on the considerable number from which we have seen specimens. A single example from Formosa, however, is rather lighter, less purplish blue above, though this is possibly individual. The immature male of this species is practically identical in color with the adult female.

Measurements of specimens of Hypothymis azurea azurea examined.

Museum and No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Ex-posed cul-men.	Tar-sus.
U.S.N.M. 37790....	Male....	South western Formosa Is-land.	1861.....	R. Swinhoe...	69.5	70	.....	15.5
U.S.N.M. 161511....	...do....	Palawan Island, Philippine Is-lands.	Sept. 9, 1887	Dr. F. S. Bourns	66	65.5	11	15
U.S.N.M. 161512....	...do....	.....do.....	Sept. 5, 1887	.....do.....	67	69.5	11	15
U.S.N.M. 161517....	...do....	.....do.....	Aug. 31, 1887	D. C. Worces-ter.	66	66.5	10.5	15.5
U.S.N.M. 161510....	...do....	.....do.....	.....do.....	Dr. F. S. Bourns	66	65.5	11	15
A.N.S. Phila. 51714	...do....	.....do.....	.....do.....	A. Everett....	72.5	72	11	16
J. H. Fleming 10413	...do....	Puerto Princesa, Palawan Is-land, Philip-pine Islands.	Sept. 19, 1887	E. L. Moseley.	71	71	11.5	16
U.S.N.M. 190252....	...do....	Pantar, Minda-nao Island, Philippine Is-lands.	Sept. 9, 1903	Dr. E. A. Mearns.	66.5	65.5	11	15
U.S.N.M. 192046....	...do....	Surigao, Minda-nao Island, Philippine Is-lands.	Apr. 25, 1904	.....do.....	68	64.5	10.5	16.5
U.S.N.M. 192045....	...do....	Tubay River, Mindanao Is-land, Philip-pine Islands.	Apr. 24, 1904	.....do.....	69.5	66	10.5	15.5
U.S.N.M. 190624....	...do....	Davao, Minda-nao Island, Philippine Is-lands.	Oct. 24, 1903	.....do.....	69	66	12	17
U.S.N.M. 211516....	...do....	Boganga River, Mindanao Is-land, Philip-pine Islands.	May 13, 1908	Paul Bartsch..	66.5	67	11	15
U.S.N.M. 211515....	...do....	Capunuyyugan Point, Minda-nao Island, Philippine Is-lands.	May 10, 1908	.....do.....	65	67	10	15
U.S.N.M. 148508....	...do....	Basilan Island, Philippine Is-lands.	.....do.....	A. Everett....	65	65	10.5	16.5
U.S.N.M. 161509....	...do....	.....do.....	1887.....	Dr. F. S. Bourns	68	66	11.5	16.5
U.S.N.M. 201265....	...do....	Henry Musser's place, Basilan Island, Philip-pine Islands.	.....do.....	Dr. E. A. Mearns.	69.5	67.5	10.5	16
U.S.N.M. 202317....	...do....	Calapan, Min-doro Island, Philippine Is-lands.	Dec. 8, 1906	.....do.....	68.5	68	10.5	.....
U.S.N.M. 202309....	...do....	Nagpartian, Ilocos Norte, Luzon Island, Philippine Is-lands.	Feb. 17, 1907	.....do.....	72	71	11	17
U.S.N.M. 202310....	...do....	.....do.....	Feb. 21, 1907	.....do.....	67	68.5	11.5	15.5
U.S.N.M. 202315....	...do....	.....do.....	Mar. 2, 1907	.....do.....	65.5	67.5	11.5	16
U.S.N.M. 172446....	...do....	Bayambang, Luzon Island, Philippine Is-lands.	June 10, 1900	Capt. H. C. Benson.	67	65.5	10	17

Measurements of specimens of *Hypothymis azurea azurea* examined—Continued.

Museum and No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Exposed culmen.	Tarsus.
A.N.S. Phila. 49787.	Male....	Tayabas, Luzon Island, Philippine Islands.	Mar. 12, 1904	Dr. E. H. Porter.	68.5	68.5	12	15.5
A.N.S. Phila. 49788.	..do....	..do....	..do....	..do....	68	71	11	16
A.N.S. Phila. 49786.	..do....	Province of Sorsogon, Luzon Island, Philippine Islands.	Apr. 7, 1903	..do....	65.5	69	10.5	15
A.N.S. Phila. 51712.	..do....	Philippine Islands.	.....	.....	72.5	73.5	12	14
A.N.S. Phila. 51713.	Female..	Puerto Princesa, Palawan Island, Philippine Islands.	.....	.....	64.5	68.5	11	14.5
J. H. Fleming 10414	..do....	..do....	Sept. 9, 1887	E. L. Moseley.	65.5	67	11	15
A.N.S. Phila. 51711.	..do....	Philippine Islands.	.....	.....	65	67	11	15.5
U.S.N.M. 161516.	..do....	Palawan Island, Philippine Islands.	Aug. 31, 1887	D. C. Worcester.	68	72	11	15.5
U.S.N.M. 161513.	..do....	..do....	..do....	Dr. F. S. Bourns.	64.5	66	10	16
U.S.N.M. 161514.	..do....	..do....	Aug. 30, 1887	..do....	66.5	69.5	10	15
U.S.N.M. 202318.	..do....	Nanjan Lake, Mindoro Island, Philippine Islands.	Mar. 25, 1907	Dr. E. A. Mearns.	66.5	65.5	11	16
U.S.N.M. 190253.	..do....	Pantar, Mindanao Island, Philippine Islands.	Aug. 13, 1903	..do....	64.5	66	11	16
U.S.N.M. 190682.	..do....	Camp Pantar, Mindanao Island, Philippine Islands.	Sept. 26, 1903	..do....	63	64	10	16
U.S.N.M. 202521.	..do....	Catagan, Mindanao Island, Philippine Islands.	May 21, 1906	Robert A. Schroder.	66	64.5	.....	15.5
U.S.N.M. 202522.	..do....	..do....	May 24, 1906	..do....	65	62	10.5	15
U.S.N.M. 161508.	..do....	Guimaras Island, Philippine Islands.	Dec. 28, 1887	D. C. Worcester.	66	67	10.5	17
U.S.N.M. 161507.	..do....	..do....	Jan. 6, 1888	..do....	69.5	69	11	16.5
U.S.N.M. 211514.	..do....	Port Binang, Luzon Island, Philippine Islands.	Jan. 9, 1908	Paul Bartsch..	68.5	68.5	11	16.5
U.S.N.M. 202316.	..do....	Nagpartian, Ilocos Norte, Luzon Island, Philippine Islands.	Mar. 3, 1907	Dr. E. A. Mearns.	66	70	12	16
U.S.N.M. 202312.	..do....	..do....	Feb. 23, 1907	..do....	65	67	11.5	16
U.S.N.M. 202311.	..do....	..do....	..do....	..do....	65	68	11.5	15.5
U.S.N.M. 202313.	..do....	..do....	Mar. 2, 1907	..do....	65	69	11.5	16.5
U.S.N.M. 202314.	..do....	..do....	..do....	..do....	68	72	12	16
U.S.N.M. 172447.	..do....	Bayambang, Luzon Island, Philippine Islands.	June 10, 1900	Capt. H. C. Benson.	67	67	10	16
U.S.N.M. 202319.	..do....	Balabac Island, Philippine Islands.	Oct. 16, 1906	Dr. E. A. Mearns.	68.5	72.5	11.5	15.5
U.S.N.M. 200609.	..do....	Sibutu Island, Philippine Islands.	Jan. 7, 1906	..do....	69.5	72	12	16

HYPOTHYMIS AZUREA COERULEOCEPHALA (Sykes).

Muscicapa coeruleocephala SYKES, Proc. Zool. Soc. Lond., 1832, p. 85 (Deccan, India).

?*Myiagra torquata* SWAINSON, Monogr. Flycatchers, 1838, p. 208 (no locality).

Siphia styani HARTLAUB, Abh. Nat. Ver. Bremen, vol. 16, pt. 2, 1898, p. 248 (Hoihow and Nodouha, Hainan Island).

Chars. subsp.—Similar to *Hypothymis azurea azurea*, but averaging larger; posterior lower parts of the male rather more extensively white; upper surface lighter, less purplish blue.

Measurements.—Two males: Wing, 70–72 (average, 71); tail, 69.5–71 (average, 70.3); exposed culmen, 10–10.5 (average, 10.3); tarsus, 15.5–16 (average, 15.8). Three females: Wing, 68–72 (average, 70); tail, 69.5–74.5 (average, 71.3); exposed culmen, 10.5–12.5 (average, 11.3); tarsus, 14–17 (average, 15.5) mm.

Type-locality.—Deccan, India.

Geographical distribution.—India north to the Himalayas, including Nepal; east in Burmah to Pegu and Tenasserim; Cochin China; and Hainan.

This form is closely related to *Hypothymis azurea azurea*, and undoubtedly is but subspecifically distinct, since to the southward along the Malay Peninsula it passes into *Hypothymis a. prophata*, which in turn intergrades with *Hypothymis a. azurea*.

Birds from Pegu and Tenasserim are intermediate between *coeruleocephala* and *prophata*, but belong with the former.

Females of *H. a. coeruleocephala* are larger than those of *H. a. azurea*, are paler above, and somewhat more extensively white on the posterior lower parts.

The earliest name for this race is undoubtedly *Muscicapa coeruleocephala* Sykes,^a for both *Muscicapa azurea* Boddaert^b and *Muscicapa caerulea* Gmelin^c refer exclusively to the Philippine bird, as I have above shown.

Not having examined any specimens from Hainan, I follow Doctor Hartert^d in referring the bird from this island to the present form, although from geographical considerations and from the measurements given by Hartlaub in his description of *Siphia styani*^e I should be inclined to call it *Hypothymis azurea azurea*.

^a Proc. Zool. Soc. Lond., 1832, p. 85.

^b Tabl. Planch. Enlum., 1783, p. 41.

^c Syst. Nat., vol. 1, pt. 2, 1788, p. 943.

^d Nov. Zool., vol. 17, 1910, p. 225.

^e Abh. Nat. Ver. Bremen, vol. 16, pt. 2, 1898, p. 248.

Measurements of specimens of Hypothymis azurea coeruleocephala examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Wing.	Tail.	Exposed culmen.	Tarsus.
201398	Male....	India.....	.....	.....	70	69.5	10.5	16
148507	do.....	do.....	.....	.....	72	71	10	15.5
95317	Female..	Thaungyin River, Tenasserim, Burmah.	Mar. 28, 1880	C. T. Bingham.	68	70	12.5	17
95318	do.....	Meplay, Thaungyin Valley, Tenasserim, Burmah.	Jan. 15, 1882	do.....	72	74.5	10.5	14
95414	do.....	Munluiam, Burmah...	Jan. 26, 1877	do.....	70	69.5	11	15.5

HYPOTHYMIS AZUREA CEYLONENSIS Sharpe.

Hypothymis ceylonensis SHARPE, Cat. Birds Brit. Mus., vol. 4, 1879, p. 277 (Kandy Hills, Ceylon).

Chars. subsp.—Similar to *Hypothymis azurea coeruleocephala*, but black occipital patch of male less evident; and black bar on fore neck absent.

Measurements.—Male: Wing, 71; tail, 63; culmen, 14; tarsus, 17 mm.^a One female: Wing, 70.5; tail, 71.5; exposed culmen, 10; tarsus, 16 mm.

Type-locality.—Kandy Hills, Ceylon.

Geographical distribution.—Ceylon.

From what Mr. Oates has to say of this bird,^b the adult male of which we have not seen, it is evidently not a distinct species, though a good race.

HYPOTHYMIS AZUREA PROPHATA, new subspecies.

Hypothymis occipitalis AUTHORS, not of VIGORS.

Chars. subsp.—Similar to *Hypothymis azurea azurea*, but larger; sides, flanks, and upper part of abdomen in the male more tinged with bluish; crissum not pure white, but usually more or less faintly washed with bluish or grayish; black occipital patch averaging larger; axillars less purely white, more grayish, and often more bluish; and black collar on foreneck usually wider.

Description.—Type, adult male, No. 180281, U.S.N.M.; Great Karimon Island, May 25, 1903; Dr. W. L. Abbott. Throat, breast, and upper parts hyacinth blue, rather lighter below, much so on pileum; extreme forehead along the culmen, a tiny chin spot, a crescentic occipital patch, and a somewhat crescentic bar on the jugulum velvety black; wings and tail slate black, the wing-quills and rectrices broadly margined with marine blue, the wing-coverts edged with the blue of the back; posterior lower parts white, the fore

^a Converted into millimeters from Sharpe, Cat. Birds Brit. Mus., vol. 4, 1879, p. 277.

^b Faun. Brit. India, Birds, vol. 2, 1890, pp. 49–50.

part of abdomen, the sides, and flanks washed with blue, most heavily on the first mentioned, the crissum faintly bluish or grayish, not pure white; under wing-coverts exteriorly hyacinth blue, otherwise slate gray mixed with white; axillars dull white washed with blue; thighs slate gray tinged with blue.

Measurements.—Eighteen males: Wing, 66.5–72.5 (average, 70.5); tail, 63.5–72.5 (average, 70); exposed culmen, 9.5–12.5 (average, 11.3); tarsus, 14.5–16.5 (average, 15.6) mm. Nineteen females: Wing, 64–70 (average, 67.1); tail, 62–71.5 (average, 67.2); exposed culmen, 10–11.5 (average, 11); tarsus, 14.5–16.5 (average, 15.6) mm.

Type-locality.—Great Karimon Island, eastern coast of Sumatra.

Geographical distribution.—Malay Peninsula north to Lower Siam; Sumatra; Great Karimon Island; Lingga Island; Banka Island; Billeton Island; Borneo; Daat Island; Java; Lombok; Sumbawa; Flores; Alor Island.

Authors have heretofore considered the birds of this species inhabiting the Malay Peninsula and various neighboring East Indian islands identical with those from the Philippine Archipelago, which represent true *Hypothymis azurea*,^a but a careful comparison of series from both regions indicates that the former may well be sub-specifically separated on the strength of characters given above. It differs conspicuously from *Hypothymis azurea opisthocyanea*^b of the Anamba and Tambelan islands, in its much inferior size, usually more whitish abdomen of the male, and usually less bluish lower tail-coverts and axillars. From the Indian *Hypothymis azurea coeruleocephala*, the range of which it probably meets in Tenasserim or thereabouts, it is distinguishable in the male by the much more bluish abdomen, flanks, and sides; less purely white, that is, more grayish or bluish, crissum and axillars; and darker, more purplish blue upper parts. The birds from the Malay Peninsula are the most whitish of any on the posterior lower parts, showing thus an inclination toward *Hypothymis a. coeruleocephala*; but birds from Trong, Lower Siam, are just like those from farther south; from which fact we may infer that the range of *H. a. prophata* extends still some distance to the northward along the Malay Peninsula. Occasional specimens from Borneo, eastern Sumatra, and neighboring islands have the lower tail-coverts decidedly bluish. Birds from Tapanuli Bay, northwestern Sumatra, are like *Hypothymis a. prophata* in size and in color of the lower parts of both male and female, but the crown averages rather darker, less contrasted with back, and they thus verge somewhat toward the Banjak Islands form.

^a *Muscicapa azurea* Boddaert, Tabl. Planch. Enlum., 1783, p. 41.

^b See p. 602.

Measurements of specimens of *Hypothymis azurea prophata* examined.

Museum and No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
U.S.N.M. 181665....	Male....	Batu Jurong, southwest- ern Borneo.	June 20, 1908	Dr. W. L. Abbott.	165	66.5	63.5	11	15.5
U.S.N.M. 178226....	do.....	Borneo.....	Jan. 6, 1894	J. Büttikofer.	.....	70.5	70.5	9.5	15
U.S.N.M. 181585....	do.....	Pulo Laut, southeast- ern Borneo.	Dec. 18, 1907	Dr. W. L. Abbott.	160	70	69	12	16
U.S.N.M. 181395....	do.....	Pulo Panebangan, western Borneo.	May 16, 1907	do.....	162	71	72.5	11	15.5
J. H. Fleming 6055....	do.....	L a w a s, northern Borneo.	May —, 1896	J. B. Bell....	.....	70	69	10.5	16
U.S.N.M. 180605....	do.....	Pulo Mendanan, near Bille- ton Island.	July 15, 1904	Dr. W. L. Abbott.	162	71.5	71	11	15
U.S.N.M. 180602....	do.....	T a n j o n g T e d o n g, B a n k a Island.	June 5, 1904	do.....	158	69.5	69.5	10.5	15.5
U.S.N.M. 180281 ^b	do.....	Great Kari-mon Is- land, east- ern Suma- tra.	May 25, 1903	do.....	158	72.5	72	10	15
U.S.N.M. 181143....	do.....	Pulo Seim- bilan, east- ern Suma- tra.	Nov. 16, 1905	do.....	166	71	71	11	14.5
U.S.N.M. 181324....	do.....	Little Siak River, east- ern Suma- tra.	Nov. 6, 1906	do.....	165	69.5	68	12	16.5
U.S.N.M. 181325....	do.....	do.....	Oct. 27, 1906	do.....	.....	70	69	11	15
U.S.N.M. 179438....	do.....	T a p a n u l i Bay, north- west- ern Sumatra.	Feb. 26, 1902	do.....	162	71	70.5	10	15
U.S.N.M. 179439....	do.....	do.....	Mar. 24, 1902	do.....	162	71.5	71.5	11	16
A.N.S. Phila. 51708	do.....	P a h a n g, Malay Pen- insula.	Dec. 27, 1890	do.....	.....	72	71.5	12	16
U.S.N.M. 175107....	do.....	D u n g a n River, Tring- ganu, Malay Peninsula.	Sept. 22, 1900	Dr. W. L. Abbott.	155	69	69	11	15
U.S.N.M. 160628....	do.....	T r o n g, Lower Siam.	Sept. 17, 1896	do.....	.....	72	70	12.5	16.5
U.S.N.M. 160630....	do.....	do.....	Jan. 29, 1897	do.....	155	69.5	71.5	11	16
U.S.N.M. 160629....	do.....	do.....	Jan. 2, 1897	do.....	155	71.5	71	11.5	16.5
A.N.S. Phila. 51710	Female	T e u t o n, northern Borneo.	July —, 1895	J. B. Bell....	.....	66.5	67	11	16.5
A.N.S. Phila. 51709	do.....	L a w a s, northern Borneo.	May —, 1896	do.....	.....	67.5	67	10	15
J. H. Fleming 6056....	do.....	do.....	do.....	do.....	.....	67.5	67.5	10.5	15.5
U.S.N.M. 95884....	do.....	Northwest- ern Borneo.	do.....	do.....	.....	65.5	67	11	15.5
U.S.N.M. 95885....	do.....	do.....	do.....	do.....	.....	68	65.5	11	14.5
U.S.N.M. 178227....	do.....	L i a n g K o e b o e n g, western Borneo.	Apr. 13, 1894	J. Büttikofer.	.....	65	63.5	10	16
U.S.N.M. 181586....	do.....	Pulo Laut, southeast- ern Borneo.	Dec. 18, 1907	Dr. W. L. Abbott.	161	68	66	11	16
U.S.N.M. 180604....	do.....	Buding Bay, Bille- ton Island.	Aug. 2, 1904	do.....	148	64	62	10.5	15

^a Measured in the flesh by the collector.^b Type.

Measurements of specimens of Hypothymis azurea prophata examined—Continued.

Museum and No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
U.S.N.M. 180603....	Female.	Tanjong Bedaan, Banka Island.	June 8, 1904	Dr. W. L. Abbott.	160	68	66	11	16
U.S.N.M. 170813....	do.....	Peak of Lingga Island, Rhio Archipelago.	June 14, 1899	do.....	152	68.5	70	10.5	16
U.S.N.M. 170814....	do.....	do.....	June 16, 1899	do.....	.....	65.5	67	11	15
U.S.N.M. 181323....	do.....	Siak River, eastern Sumatra.	Dec. 23, 1906	do.....	160	65	67	11.5	15.5
U.S.N.M. 154056....	do.....	Trong, Lower Siam.	Feb. 22, 1896	do.....	159	66.5	67.5	11.5	16
U.S.N.M. 154057....	do.....	do.....	Feb. 29, 1896	do.....	152	66.5	67	11.5	16
U.S.N.M. 169976....	do.....	do.....	Jan. 1, 1899	do.....	.....	67.5	67.5	11	16
U.S.N.M. 160627....	do.....	do.....	Sept. 9, 1896	do.....	155	70	70	11.5	16
U.S.N.M. 173301....	do.....	Pulo Lankawi, western Malay Peninsula.	Dec. 8, 1899	do.....	165	70	71.5	11.5	15.5
A.N.S. Phila. 51707.	do.....	Pahang, Malay Peninsula.	Sept. 14, 1889	.....	.....	67.5	69	11.5	15.5
U.S.N.M. 219506....	do.....	Depok, Java.	July 31, 1909	W. Palmer	.....	69	68	11.5	16

^a Measured in the flesh by the collector.

HYPOTHYMIS AZUREA GIGANTOPTERA, ^b new subspecies.

Chars. subsp.—Similar to *Hypothymis azurea prophata*, but decidedly larger.

Description.—Type, adult male, No. 174828, U.S.N.M., Bunguran Island, Natuna Islands, July 12, 1900; Dr. W. L. Abbott. Throat, breast, and upper parts hyacinth blue, slightly paler below, decidedly so on pileum; forehead at base of culmen, a tiny chin spot, a crescentic occipital patch, and a somewhat crescentic bar on jugulum velvety black; wings and tail slate black, the wing-quills and rectrices broadly edged with marine blue, the wing-coverts with the color of the back; posterior under parts grayish or bluish white, the fore part of abdomen, the sides, and flanks tinged with blue, most so on the first; outer inferior wing-coverts hyacinth blue, the others slate gray mixed with white; axillars grayish white, slightly washed with blue, chiefly exteriorly; thighs slate gray overlaid with blue.

Measurements.—Two males: Wing, 73.5–74.5 (average, 74); tail; 73–74 (average, 73.5); exposed culmen, 11.5–12 (average, 11.8), tarsus, 16.5–17 (average, 16.8) mm.

Type-locality.—Bunguran Island, Natuna Archipelago.

Geographical distribution.—Natuna Islands.

^b A similar specific name—*Amytornis giganturus* (Milligan)—has been rejected by Dr. R. B. Sharpe (Hand List Gen. and Species Birds, vol. 4, 1903, p. 246), because supposed to be a hybrid; but it may readily be seen that *gigantoptera* is correctly formed from γίγας, γίγαντος, and πτερόν.

To judge from the limited Natuna Island series at hand, this form appears to be identical in color with *Hypothymis azurea prophata*, from Borneo and Sumatra, but in size it is sufficiently greater to warrant subspecific separation.

Measurements of specimens of Hypothymis azurea gigantopectera examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
174828 ^b	Male....	Bunguran Island, Natuna Islands.	July 12, 1900	Dr. W. L. Abbott.	168	74.5	73	11.5	17
174829	...do....	Sirhassen Island, Natuna Islands.	June 3, 1900	.....do.....	168	73.5	74	12	16.5
174830	Male, immature.	Pulo Lingung, Natuna Islands.	June 17, 1900	.....do.....	165	-----	-----	-----	-----

^a Measured in the flesh by the collector.

^b Type.

HYPOTHYMIS AZUREA FORRESTIA, new subspecies.

Chars. subsp.—Similar to *Hypothymis azurea opisthocyanea*,^c but posterior lower parts of male much more whitish, the crissum without tinge of blue; upper parts, throat, and breast averaging darker; axillars with little or no blue; size slightly smaller.

Description.—Type, adult male, No. 173302, U.S.N.M.; Loughborough Island, Mergui Archipelago, January 23, 1900; Dr. W. L. Abbott. Entire upper surface, sides of head and neck, chin, throat, and breast hyacinth blue, the throat and breast slightly, the top and sides of head much, paler than the back; a narrow line across the base of the forehead, a tiny spot at the apex of the chin, a somewhat crescentic bar across the jugulum, and a large crescentic patch on the occiput velvety black; wings and tail sepia, margined externally with marine blue; abdomen and crissum white, the upper portion of the former washed with the blue of the breast; outer inferior wing-coverts hyacinth blue, the rest gray mixed with white and washed with blue; axillars white, slightly washed with blue exteriorly; thighs grayish, washed with blue; "feet dark blue; eyelids blue; bill blue, black at tip."

Measurements.—Two males: Wing, 75–77 (average, 76); tail, 77.5–80 (average, 78.8); exposed culmen, 11–12.5 (average, 11.8); tarsus, 17.5–18 (average, 17.8). Two females: Wing, 72.5–73 (average, 72.8); tail, 73.5–75 (average, 74.3); exposed culmen, 12; tarsus, 17–17.5 (average, 17.3) mm.

Type-locality.—Loughborough Island, Mergui Archipelago, Tenasserim.

Geographical distribution.—Southern islands of Mergui Archipelago, Tenasserim.

With the single exception of *Hypothymis a. opisthocyanea*, this is the largest form of the group, and by size alone is distinguishable.

^c See p. 602.

Otherwise it differs from *H. a. coeruleocephala* in darker, more purplish blue upper parts of the male, and greater backward extension of the blue below; from *H. a. azurea* in average darker blue of upper and lower surface; from *H. a. prophata* in the more whitish posterior lower parts (the flanks and crissum being without blue), and in rather more purely white axillars; from *H. a. calocara* and *H. a. idiochroa* in darker, more purplish blue of throat, breast, and upper surface, together with much less bluish posterior lower parts, and additionally from *H. a. calocara* in the greater contrast between pileum and back. Females are darker than those of *H. a. coeruleocephala*, and, except for larger size, are not with certainty distinguishable from females of *H. a. prophata*.

This form doubtless prevails throughout the Mergui Archipelago, though all our specimens come from Sullivan and Loughborough islands in the southern portion. One male from Sullivan Island is lighter, both above and below, than the type.

Measurements of specimens of Hypothymis azurea forrestia examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
173302 ^b	Male....	Loughborough Island, Mergui Archipelago.	Jan. 23, 1900	Dr. W. L. Abbott.	178	77	80	12.5	18
173303	...do.....	Sullivan's Island, Mergui Archipelago.	Feb. 3, 1900	.....do.....	175	75	77.5	11	17.5
173304	Female..	.....do.....	.....do.....	.....do.....	171	73	75	12	17.5
173305	.....do.....	.....do.....	Feb. 4, 1900	.....do.....	171	72.5	73.5	12	17

^a Measured in the flesh by the collector.

^b Type.

HYPOTHYMIS AZUREA OPISTHOCYANEA, new subspecies.

Chars. subsp.—Similar to *Hypothymis azurea azurea* from the Philippine Islands, but very much larger; male somewhat darker; the posterior lower parts usually much more extensively and deeply shaded with the blue of the breast, the under tail-coverts also usually blue; axillars more grayish and more tinged with blue.

Description.—Type, adult male, No. 170909, U.S.N.M.; Pulo Piling, Anamba Islands, August 17, 1899; Dr. W. L. Abbott. Upper surface, throat, and breast hyacinth blue, a little lighter below, much paler on pileum; a crescentic occipital patch, the extreme forehead, a somewhat crescentic bar across the jugulum, and a tiny chin spot velvety black; wings and tail blackish slate color, the outer webs of all the wing-quills and tail-feathers broadly margined with marine blue, the wing-coverts with blue like that of the back; abdomen medially on posterior part almost pure white, but elsewhere heavily shaded with the blue of the breast; lower tail-coverts also strongly bluish; under wing-coverts slate gray, the exterior ones hyacinth

blue; axillars grayish white, shaded with blue; thighs slate grayish, washed with blue; "feet blue; bill blue, black at tip."

Measurements.—Ten males: Wing, 75.5–80 (average, 77.7); tail, 76–80 (average, 77.3); exposed culmen, 10–12 (average, 11.4); tarsus, 16–18 (average, 17). Six females: Wing, 74.5–78 (average, 76.4); tail, 74–78 (average, 76.1); exposed culmen, 11–12 (average, 11.4); tarsus, 16–17.5 (average, 16.6) mm.

Type-locality.—Pulo Piling, Anamba Islands.

Geographical distribution.—Anamba and Tambelan islands.

This new form is similar to *Hypothymis azurea prophata*, but much larger, and has the posterior lower parts, with the axillars, usually more extensively shaded with blue. In some respects of color it resembles *Hypothymis azurea tytleri*, from the Andaman Islands, but is easily distinguishable from that race by its larger size, and, in the male, by the greater contrast between pileum and back, and the more whitish median portion of abdomen. It differs from *Hypothymis a. calocara* and *H. a. idiochroa* in larger size, darker, more purplish upper and lower surfaces of the male, and in much more deeply bluish crissum. In addition, it may be distinguished from *H. a. calocara* by its paler pileum, much more contrasted with the back. It seems to be one of the best marked subspecies of *Hypothymis azurea*, and in size is approached by only one other. Birds from the Tambelan Islands seem to be absolutely identical with those from the Anamba Islands.

Measurements of specimens of Hypothymis azurea opisthocyanea examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
170957	Male....	Pulo Siantan, Anamba Islands.	Aug. 24, 1899	Dr. W. L. Abbott.	159	79	.....	11	17
170958	...do.....	...do.....	...do.....	...do.....	168	76.5	76	10.5	16
170959	...do.....	...do.....	Sept. 11, 1899	...do.....	165	75.5	78.5	12	16.5
171045	...do.....	Pulo Manguan, Anamba Islands.	Sept. 1, 1899	...do.....	.....	77	78	11	17.5
170909 ^b	...do.....	Pulo Piling, Anamba Islands.	Aug. 17, 1899	...do.....	175	80	76	10.5	18
170875	...do.....	Big Tambelan Island, Tambelan Islands.	Aug. 10, 1899	...do.....	175	.....	.....	12	16.5
171132	...do.....	Pulo Selindang, Tambelan Islands.	Aug. 3, 1899	...do.....	191	77.5	76	11	17
170866	...do.....	Pulo Bunoa, Tambelan Islands.	Aug. 6, 1899	...do.....	.....	76	77	12	17
170865	...do.....	...do.....	Aug. 5, 1899	...do.....	184	77.5	77	12	17
170887	...do.....	Pulo Wai, Tambelan Islands.	Aug. 13, 1899	...do.....	184	80	80	12	17.5
171044	[Female]	Pulo Manguan, Anamba Islands.	Aug. 31, 1899	...do.....	.....	74.5	74	11	17.5
170920	Female.	Pulo Riabu, Anamba Islands.	Aug. 18, 1899	...do.....	171	78	75	12	17
170922	...do.....	...do.....	...do.....	...do.....	171	74.5	75	11.5	16
170921	[Female]	...do.....	...do.....	...do.....	.....	77	78	11	16.5
170864	Female.	Pulo Bunoa, Tambelan Islands.	Aug. 5, 1899	...do.....	178	77	76.5	11.5	16.5
170867	...do.....	...do.....	Aug. 7, 1899	...do.....	175	77.5	78	11.5	16

^a Measured in the flesh by the collector.

^b Type.

HYPOTHYMIS AZUREA IDIOCHROA, new subspecies.

Chars. subsp..—Similar to *Hypothymis azurea calocara*,^a but much larger; blue of upper and lower parts paler and appreciably less purplish; pileum strikingly paler, and much more contrasted with back.

Description..—Type, adult male, No. 178873, U.S.N.M.; Car Nicobar Island, Nicobar Islands, January 25, 1901; Dr. W. L. Abbott. Upper surface, chin, throat, upper breast, with sides of head and neck cyanine blue, much lighter on pileum; a somewhat crescentic bar across jugulum, a narrow frontal line around the base of the culmen, and a crescentic occipital patch black; wings and tail sepia, more or less tinged or margined externally with marine blue, the entire exposed surface of wing-coverts cyanine blue; posterior lower parts white, anteriorly and laterally much tinged with blue, the crissum somewhat so; under wing-coverts exteriorly blue, interiorly white mixed with grayish; axillars grayish white, slightly tinged with bluish; "iris blackish brown; bill blue, the tip blackish; feet dull blue."

Measurements..—Two males: Wing, 73–73.5 (average, 73.3); tail, 71–74.5 (average, 72.8); exposed culmen, 12–13 (average, 12.5); tarsus, 17–17.5 (average, 17.3). One female: Wing, 71; tail, 71; exposed culmen, 12.5.; tarsus, 17 mm.

Type-locality..—Car Nicobar Island, Nicobar Islands.

Geographical distribution..—Car Nicobar Island, Nicobar Islands.

This form is geographically very near *H. a. calocara*, but it is so much larger and so different in color that I can not consistently consider it identical; it is larger than either *azurea* or *prophata*. So far as known it is confined to the island of Car Nicobar.

Measurements of specimens of Hypothymis azurea idiochroa examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^b	Wing.	Tail.	Exposed culmen.	Tarsus.
178873 ^c	Male....	Car Nicobar Island, Nicobar Islands.	Jan. 25, 1901	Dr. W. L. Abbott.	165	73	71	12	17.5
178872	...do....	.....do.....	.....do.....	.....do.....	168	73.5	74.5	13	17
178701	Female	.....do.....	.....do.....	.....do.....	165	71	71	12.5	17

^b Measured in the flesh by the collector.

^c Type.

HYPOTHYMIS AZUREA PONERA, new subspecies.

Chars. subsp..—Similar to *Hypothymis azurea prophata*, but wing averaging slightly, the tail considerably, longer; blue of upper and lower parts in the male less purplish, and paler, except on pileum, the upper surface thus noticeably more nearly uniform.

^a See p. 610.

Description.—Type, adult male, No. 179916, U.S.N.M.; Tana Masa Island, Batu Islands, western Sumatra, February 17, 1903; Dr. W. L. Abbott. Pileum intermediate in color between cobalt blue and campanula blue; remainder of upper parts intermediate between French blue and hyacinth blue; throat and breast between smalt blue and ultramarine; a bar across the forehead at the base of the bill, a very small chin spot, a crescentic occipital patch, and a somewhat crescentic bar on jugulum velvet black; wings and tail slate black, the wing-quills and rectrices broadly margined externally with marine blue, the wing-coverts with the color of the back; posterior lower parts white, the fore part of abdomen, the sides, flanks, and crissum washed with blue, most heavily on abdomen, but slightly on crissum; exterior under wing-coverts blue like the throat, the rest of wing lining slate gray mixed with white; axillars grayish white, somewhat washed with blue; thighs slate gray, heavily overlaid with blue.

Measurements.—Three males: Wing, 71–72 (average, 71.5); tail, 70–74 (average, 72.7); exposed culmen, 10.5–11 (average, 10.8); tarsus, 15–16 (average, 15.5) mm.

Type-locality.—Tana Masa Island, Batu Islands.

Geographical distribution.—Batu Islands, western Sumatra.

This new form is somewhat intermediate between *Hypothymis azurea prophata*, from Sumatra, and *H. a. leucophila*^a from the Pagi Islands, but since it is easily recognizable and seems to be confined to the Batu Islands, it is best separated subspecifically. The birds from Tana Bala and Tana Masa islands are typical, but the single adult male from Pulo Pinie is intermediate between this race and *H. a. prophata*; but whether or not other specimens from the same island would be identical remains to be seen. No females have been examined.

Measurements of specimens of Hypothymis azurea ponera examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^b	Wing.	Tail.	Exposed culmen.	Tarsus.
179915	Male	Tana Bala Island, Batu Islands.	Feb. 9, 1903	Dr. W. L. Abbott.	169	71	74	11	16
179916 ^c	...do	Tana Masa Island, Batu Islands.	Feb. 17, 1903	.....do.....	164	71.5	70	11	15.5
179914	...do	Pulo Pinie, Batu Islands.	Mar. 5, 1903	.....do.....	165	72	74	10.5	15

^a See page 607.

^b Measured in the flesh by the collector.

^c Type.

HYPOTHYMIS AZUREA ISOCARA, new subspecies.

Chars. subsp..—Similar to *Hypothymis azurea amelis*,^a but decidedly larger; male with abdomen less extensively bluish; upper parts somewhat paler, less purplish blue, the pileum slightly more contrasted with back; female resembling that of *Hypothymis azurea amelis*, but paler below, the abdomen conspicuously more whitish.

Description..—Type, adult male, No. 179437, U.S.N.M.; Pulo Bangkaru, Banjak Islands, western Sumatra, January, 1902; Dr. W. L. Abbott. Upper surface, throat, and breast rather light cyanine blue, the pileum perceptibly paler, the throat and breast barely so; a narrow frontal line at the base of the bill, a very small chin spot, a crescentic occipital patch, and a slightly crescentic bar on jugulum velvety black; wings and tail slate black, the wing-quills and rectrices broadly margined externally with marine blue, the wing-coverts with cyanine blue; middle of lower abdomen white, almost pure; rest of abdomen, sides, flanks, and crissum grayish or grayish white, heavily washed with deep campanula blue; under wing-coverts exteriorly cyanine blue, otherwise slate gray, mixed a little with whitish; axillars pale grayish, the outer ones edged with deep campanula blue; thighs slate gray, overlaid with blue.

Measurements..—Two males: Wing, 71.5–72 (average, 71.8); tail, 70–72 (average, 71); exposed culmen, 10.5–11 (average, 10.8); tarsus, 15.5–17 (average, 16.3) mm. One female: Wing, 69; tail, 68; exposed culmen, 9.5; tarsus, 16 mm.

Type-locality..—Pulo Bangkaru, Banjak Islands, western Sumatra.

Geographical distribution..—Banjak Islands, western Sumatra.

The present form is larger than *Hypothymis azurea prophata*, and in the male has the posterior lower parts, especially the crissum, more bluish, the latter being seldom strongly bluish in *H. a. prophata*, always (?) so in *H. a. isocara*; axillars somewhat more grayish and more extensively blue; pileum darker, less contrasted with back; blue of remaining upper parts and of under surface paler and less purplish. The female does not differ appreciably in color from the same sex of *H. a. prophata*. From *Hypothymis a. gigantoptera* of the Natuna Islands, *H. a. isocara* differs as from *H. a. prophata*, except that it is not larger. It may be distinguished from *Hypothymis a. ponera*, male, by its rather less purplish blue upper parts; the darker pileum less contrasted with back; the more extensively bluish abdomen; the more grayish and more heavily blue-washed crissum; and somewhat more grayish and somewhat more extensively blue axillars. Compared with *Hypothymis azurea leucophila*,^b it is slightly larger; in the male the posterior lower parts, especially the crissum, are more grayish and more washed with blue; the

^a See p. 608.

^b See p. 607.

axillars more grayish and more extensively blue; and the upper parts, particularly the pileum, are rather less purplish. The colors of the female are the same as in *H. a. leucophila*.

This new form is apparently confined to the Banjak Islands. Birds from Pulo Tuanku and Pulo Bangkaru are identical in size and coloration.

Measurements of specimens of Hypothymis azurea isocara examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
179435	Male....	Pulo Tuanku, Banjak Islands.	Jan. 23, 1902	Dr. W. L. Abbott.	165	71.5	70	11	17
179437 ^b	...do....	Pulo Bangkaru, Banjak Islands.	Jan. —, 1902	.....do.....	165	72	72	10.5	15.5
179436	Female.	.....do.....	Jan. 19, 1902	.....do.....	162	69	68	9.5	16

^a Measured in the flesh by the collector.

^b Type.

HYPOTHYMIS AZUREA LEUCOPHILA, new subspecies.

Chars. subsp.—Similar to *Hypothymis azurea ponera*, but tail decidedly shorter; pileum of male darker, more purplish blue; back averaging slightly more purplish; the pileum thus less contrasted with back; axillars and middle of abdomen more purely white—less grayish—and with less wash of blue; crissum usually pure white.

Description.—Type, adult male, No. 179913, U.S.N.M.; North Pagi Island, western Sumatra, January 8, 1903; Dr. W. L. Abbott. Upper surface, throat, and breast rather light cyanine blue, the pileum somewhat lighter; a narrow frontal band at the base of the bill, a tiny chin spot, a crescentic occipital patch, and a slightly crescentic bar on jugulum velvet black; wings and tail slate black, the wing-quills and rectrices broadly edged with marine blue, the wing-coverts with the color of the back; posterior under surface white, purely so on the crissum and middle of abdomen, washed with blue on sides, flanks, and upper abdomen; exterior under wing-coverts cyanine blue, the rest slate gray, mixed with white; axillars white, very slightly washed with blue exteriorly; thighs slate gray, much mixed with blue, bill and eyelids cobalt blue in life; feet plumbeous blue.

Measurements.—Four males: Wing, 69–73 (average, 71); tail, 67–69 (average, 68.1); exposed culmen, 10–11.5 (average, 10.8); tarsus, 15.5–17 (average, 16) mm. One female: Wing, 67.5; tail, 68; exposed culmen, 11.5; tarsus, 15 mm.

Type-locality.—North Pagi Island, western Sumatra.

Geographical distribution.—Pagi Islands, western Sumatra.

The male of the present race differs from *Hypothymis azurea prophata* in having the upper surface more nearly uniform—the back

paler, less purplish blue, the head darker, slightly less purplish blue, and not so much in contrast to the remaining upper surface; the crissum pure white; and the axillars pure white, but slightly, if at all, washed with blue exteriorly. The female is apparently indistinguishable from that of *Hypothymis azurea prophata*. In the whiteness of its posterior ventral surface *Hypothymis a. leucophila* is like *Hypothymis azurea azurea*, but is easily distinguishable by its usually longer wing, less purplish blue color, lighter back, rather darker pileum, with consequently less contrast between head and back.

Birds from South Pagi Island are identical with those from North Pagi; and *Hypothymis a. leucophila* apparently does not range beyond this group of islands.

Measurements of specimens of Hypothymis azurea leucophila examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
179913 ^b	Male....	North Pagi Island, western Sumatra.	Jan. 8, 1903	Dr. W. L. Abbott.	160	70.5	67	10	15.5
179911	...do....	...do....	Nov. 23, 1902	...do....	158	71.5	68.5	11.5	16
179910	...do....	South Pagi Island, western Sumatra.	Dec. 13, 1902	...do....	166	69	68	10.5	17
179909	...do....	...do....	Dec. 2, 1902	...do....	164	73	69	11	15.5
179912	Female.	North Pagi Island, western Sumatra.	Nov. 23, 1902	...do....	148	67.5	68	11.5	15

^a Measured in the flesh by the collector.

^b Type.

HYPOTHYMIS AZUREA AMELIS, new subspecies.

Chars. subsp.—Similar to *Hypothymis azurea leucophila*, but wing shorter; male with blue color everywhere darker, more purplish; pileum less contrasted with back; abdomen more grayish and more extensively washed with blue; axillars and crissum grayish, much washed with blue.

Description.—Type, adult male, No. 179920, U.S.N.M.; Lafau, Nias Island, western Sumatra, March 21, 1903; Dr. W. L. Abbott. Upper surface, throat, and breast cyanine blue, slightly paler below, more so on pileum; feathers across the forehead at the base of the culmen, a very small chin spot, a crescentic occipital patch, and a somewhat crescentic bar on the jugulum velvety black; wings and tail slate black, the wing-quills and rectrices edged externally with marine blue, the wing-coverts with the color of the back; sides, flanks, and abdomen pale gray overlaid with deep campanula blue, but middle of abdomen almost pure white; crissum grayish white, heavily washed with blue; inferior wing-coverts outwardly cyanine blue, otherwise slate gray mixed with whitish; axillars pale gray, margined

with pale cyanine blue, especially on the outer ones; thighs slate gray almost hidden by blue.

Measurements.—Six males: Wing, 66–70 (average, 68.2); tail, 65–71.5 (average, 67.9); exposed culmen, 10–11 (average, 10.4); tarsus, 14.5–17 (average, 16) mm. Two females: Wing, 63; tail, 63–64 (average, 63.5); exposed culmen, 11; tarsus, 15.5 mm.

Type-locality.—Nias Island.

Geographical distribution.—Nias Island, western Sumatra.

The female of this form differs from that of *Hypothymis azurea leucophila* in having the abdomen duller, more grayish, and less extensively white. Compared with *Hypothymis azurea prophata*, the present race is smaller; in the male the posterior lower parts are more extensively blue, the crissum pale grayish, with usually a heavy wash of blue; axillars more grayish and more washed with blue; pileum darker, not decidedly paler than the back; and the blue of back slightly less purplish; in the female the white area on the abdomen is less extensive, and duller, more grayish. From *Hypothymis a. ponera*, the Batu Islands bird, the male of *H. a. amelis* may be distinguished by its smaller size; usually darker, more purplish blue of upper and lower parts, particularly the head, which is less contrasted with the back; less whitish (more grayish) abdomen, which is more heavily and more extensively overlaid with blue; much more grayish and blue-washed crissum; and axillars more grayish and more extensively overlaid with blue. The adult male of the present race somewhat resembles the same sex of *Hypothymis azurea consobrina*, but is slightly smaller; has the pileum appreciably lighter than the back, instead of practically concolor; axillars and posterior under parts, including the crissum, paler, more whitish, and with less wash of blue. The immature male has the abdomen decidedly paler than in the same sex and age of *H. a. consobrina*. The adult male is like that of *Hypothymis azurea tytleri* on the upper surface, but is paler, more whitish, and much less washed with blue on the abdomen and crissum, and is also very much smaller.

The Nias form is to some extent intermediate between *Hypothymis azurea prophata* and *H. a. consobrina*, but is sufficiently distinct from either. As in most of the races of *Hypothymis azurea*, there is noticeable individual variation in the whiteness of the middle abdomen, the extent of blue on the lower parts behind, and in the shade of the upper surface. The immature male is very similar to the female, but is usually, if not always, more bluish both above and below.

Measurements of specimens of Hypothymis azurea amelis examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
179918	Male....	Siaba Bay, Nias Island.	Mar. 19, 1903	Dr. W. L. Abbott.	156	67	66	10	14.5
179920 ^b	...do....	Lafau Bay, Nias Island.	Mar. 21, 1903	.....do.....	160	70	71.5	10.5	16
180905	...do....	Samasama, Nias Island.	Feb. 20, 1905	.....do.....	161	68	68	10.5	17
180906	...do....	.....do.....	Feb. 21, 1905	.....do.....	161	69	69	10.5	16.5
180904	...do....	Teilwaa, Nias Island.	Mar. 19, 1905	.....do.....	163	69	68	10	16
180903	...do....	Mojeia River, Nias Island.	Mar. 14, 1905	.....do.....	160	66	65	11	16
179917	Female.	Siaba Bay, Nias Island.	Mar. 18, 1903	.....do.....	153	63	63	11	15.5
179919	...do....	Lafau, Nias Island.	Mar. 24, 1903	.....do.....	157	63	64	11	15.5

^a Measured in the flesh by the collector.^b Type.**HYPOTHYMIS AZUREA CALOCARA**, new subspecies.

Chars. subsp.—Similar to *Hypothymis azurea prophata*, but averaging smaller; blue of upper parts in the male paler, less purplish; that of ventral surface slightly so; crown less contrasted with back; posterior under parts rather more washed with blue, the lower tail-coverts almost always more or less bluish.

Description.—Type, adult male, No. 178705, U.S.N.M.; Nankauri Island, Nicobar Islands, February 8, 1901; Dr. W. L. Abbott. Pileum, sides of head and neck cyanine blue, rather lighter than the back; a narrow line across the base of the bill at the extreme forehead, and a large crescentic patch on the occiput velvety black; rest of upper surface cyanine blue, rather duller on upper tail-coverts; tail sepia, shaded and margined on outer webs with marine blue; wings sepia, the quills edged externally with marine blue, the coverts margined on outer webs with the blue of the back; chin, throat, and breast cyanine blue, the mental apex with a tiny spot of black, the jugulum with a narrow crescentic bar of velvety black; remainder of ventral surface dull white, washed with cyanine blue, least so on middle of abdomen and on lower tail-coverts; thighs pale grayish, washed with blue; under wing-coverts exteriorly cyanine blue, interiorly white mixed with grayish and washed with blue; axillars grayish white, somewhat washed with blue; "feet dark blue."

Measurements.—Eight males: Wing, 65–69 (average, 67.6); tail, 63.5–70.5 (average, 67.4); exposed culmen, 9.5–11 (average, 10.3); tarsus, 16.5–17.5 (average, 17) mm. Four females: Wing, 64–67 (average, 66.3); tail, 62–67.5 (average, 65.5); exposed culmen, 9.5–11 (average, 10.5); tarsus, 16.5–17 (average, 16.6) mm.

Type-locality.—Nankauri Island, Nicobar Islands.

Geographical distribution.—Nicobar Islands, excepting Car Nicobar Island.

The small size, much more bluish posterior lower parts, and darker, more uniform upper surface of this form distinguish it from *Hypothymis a. coeruleocephala*, as do its much more bluish sides, flanks, abdomen, and crissum, less contrasted pileum, and usually less purplish upper parts from *H. a. azurea*. It is very similar to *Hypothymis a. amelis*, from Nias Island, but the male is lighter, somewhat less purplish blue both above and below; the abdomen is more whitish and less extensively washed with blue; the crissum less heavily bluish; the axillars more whitish and less tinged with blue.

Females are less whitish on the abdomen than those of *H. a. azurea*, but are not otherwise different. Specimens from the following islands have been examined: Nankauri, Great Nicobar, Kamorta, Trinkut, and Tilanchong.

Measurements of specimens of Hypothymis azurea calocara examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
178697	Male....	Great Nicobar Island, Nicobar Islands.	Mar. 15, 1901	Dr. W. L. Abbott.	146	.....	.....	10.5	17
178696	...do.....	...do.....	Mar. 10, 1901	...do.....	159	68	67.5	10.5	17
178698	...do.....	...do.....	Mar. 18, 1901	...do.....	155	65	63.5	10.5	17
178695	...do.....	...do.....	Mar. 7, 1901	...do.....	155	67	65	9.5	17
178706	...do.....	Tilanchong Island, Nicobar Islands.	Jan. 29, 1901	...do.....	155	69	70.5	10	17
178705 ^b	...do.....	Nankauri Island, Nicobar Islands.	Feb. 8, 1901	...do.....	155	68.5	66.5	10.5	16.5
178704	...do.....	...do.....	Feb. 6, 1901	...do.....	159	67.5	69.5	10	17
178702	...do.....	Kamorta Island, Nicobar Islands.	Feb. 10, 1901	...do.....	152	68.5	69	11	17.5
178707	Female.	Tilanchong Island, Nicobar Islands.	Jan. 28, 1901	...do.....	149	64	62	11	16.5
178699	...do.....	Trinkut Island, Nicobar Islands.	Feb. 2, 1901	...do.....	152	67	66	9.5	17
178700	...do.....	...do.....	...do.....	...do.....	152	67	66.5	11	16.5
178703	...do.....	Kamorta Island, Nicobar Islands.	Feb. 12, 1901	...do.....	152	67	67.5	10.5	16.5

^a Measured in the flesh by the collector.

^b Type.

HYPOTHYMIS AZUREA TYTLERI (Beavan).

Myiagra tytleri BEAVAN, Ibis, 1867, p. 324 (Port Blair, South Andaman Island).

Chars. subsp.—Similar to *Hypothymis azurea prophata*, but larger; posterior lower parts in the male all more grayish and much more shaded with blue, leaving only the center of lower abdomen sometimes whitish; axillars more grayish and bluish; back rather lighter, the crown darker and thus less contrasted with the back.

Measurements.—Two males: Wing, 71–75 (average, 73); tail, 70–73.5 (average, 71.8); exposed culmen, 11.5; tarsus, 17.5–18 (average, 17.8). One female: Wing, 71; tail, 70.5; exposed culmen, 12.5; tarsus, 17 mm.

Type-locality.—Port Blair, South Andaman Island, Andaman Islands.

Geographical distribution.—Andaman Islands and the Great and Little Cocos Islands.

The male of this well-marked form may be distinguished from *H. a. coeruleocephala* by its darker, more purplish blue upper surface and anterior lower parts, wholly blue posterior lower parts; more grayish and bluish axillars, and more nearly uniform upper surface; from *H. a. azurea* by larger size, blue abdomen, flanks, and crissum, rather paler upper surface, darker pileum less contrasted with the back, and more grayish, bluish axillars; from *H. a. calocara* and *H. a. idiochroa* by its darker, more purplish blue above and below, more extensively and deeply bluish abdomen and crissum, more grayish and bluish axillars, as well as additionally from the latter by darker, less contrasted pileum, and from the former by larger size; from *H. a. opisthocyanea* by smaller size, more uniformly blue abdomen, less contrasted pileum, and more bluish and grayish axillars; and from *H. a. forrestia* by smaller size, blue posterior lower parts, lighter upper surface, except pileum, which is less contrasted with the back, and by more grayish and bluish axillars. The female of *H. a. tytleri* is darker on both back and breast and less whitish on abdomen than the same sex of *H. a. prophata*. An adult male from Little Andaman Island seems to incline not at all toward *Hypothymis a. idiochroa* from the island of Car Nicobar. Count Salvadori has recorded *H. a. tytleri* from Engano Island,^a but the bird occurring there is, of course, *Hypothymis azurea richmondi*.^b

Measurements of specimens of Hypothymis azurea tytleri examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^c	Wing.	Tail.	Exposed culmen.	Tarsus.
178870	Male....	Little Andaman Island, Andaman Islands.	Jan. 20, 1901	Dr. W. L. Abbott.	168	75	73.5	11.5	18
178708	...do....	Henry Lawrence Island, Andaman Islands.	Jan. 8, 1901	.....do.....	152	71	70	11.5	17.5
178871	Female.	South Andaman Island, Andaman Islands.	Jan. 15, 1901	.....do.....	155	71	70.5	12.5	17

^c Measured in the flesh by the collector.

HYPOTHYMIS AZUREA CONSOBRINA Richmond.

Hypothymis consobrina RICHMOND, Proc. Biol. Soc. Wash., vol. 15, 1902, p. 189.

Chars. subsp.—Similar to *Hypothymis azurea tytleri*, but averaging decidedly smaller; and pileum darker, less contrasted with the back.

Measurements.—Six males: Wing, 68–71.5 (average, 69.4); tail, 66–70.5 (average, 68.3); exposed culmen, 10–12 (average, 11); tarsus, 16–17.5 (average, 16.8) mm.

Type-locality.—Simalur Island, western coast of Sumatra.

^a Ann. Mus. Civ. Genova, vol. 32, 1892, p. 129.

^b See p. 613.

Geographical distribution.—Simalur Island, western coast of Sumatra.

Notwithstanding its geographical isolation, this form resembles *H. a. tytleri* more closely than any other, but it averages much smaller, and has a slightly darker back and a decidedly darker pileum, which is scarcely different in color from the back.

Measurements of specimens of Hypothymis azurea consobrina examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
179433 ^b	Male....	Simalur Island, western Sumatra.	Dec. 24, 1901	Dr. W. L. Abbott.	165	69	69	11.5	16
179905	....do....	.....do.....	Oct. 21, 1902	.....do.....	165	71.5	70.5	12	17.5
179906	....do....	.....do.....	.....do.....	.....do.....	161	69	66	11	17
179434	....do....	.....do.....	Nov. 19, 1901	.....do.....	155	68.5	68	10	16
179908	....do....	Sibobo Bay, Simalur Island, western Sumatra.	Oct. 24, 1902	.....do.....	160	70.5	69.5	10.5	17
179907	....do....	Simalur Island, western Sumatra.	Oct. 23, 1902	.....do.....	159	68	66.5	11	17

^a Measured in the flesh by the collector.

^b Type.

HYPOTHYMIS AZUREA RICHMONDI,^c new subspecies.

Chars. subsp.—Similar to *Hypothymis azurea consobrina*, but much larger; male with black occipital patch larger; blue areas darker, particularly on upper surface; lower parts still more uniform blue, the abdomen barely whitish or grayish medially.

Description.—Type, adult male, No. 180757, U.S.N.M.; Engano Island, western Sumatra, November 24, 1904; Dr. W. L. Abbott. Upper and lower parts deep cyanine blue, the pileum, throat, and breast rather lighter, the abdomen and crissum still more so (from the showing through of the slate gray portions of the feathers beneath), the middle of lower abdomen slightly whitish; a line across the forehead next the base of the culmen, a tiny chin spot, a crescentic occipital patch, and a somewhat crescentic jugular bar velvety black; wings and tail slate black, the wing-quills and rectrices margined externally with marine blue, most broadly on the latter, the wing-coverts widely edged with the blue of the back; lower wing-coverts exteriorly cyanine blue, interiorly slate gray washed slightly with blue; axillars slate gray, margined with cyanine blue; thighs deep slate gray, heavily overlaid with cyanine blue.

Adult female, No. 180765, U.S.N.M.; Engano Island, November 22, 1904; Dr. W. L. Abbott. Head and throat intermediate between

^c Dedicated to Dr. Charles W. Richmond, as a slight token of appreciation for courtesies too numerous to mention.

cyanine blue and Paris blue; rest of upper surface grayish seal brown; wings and tail fuscous, the latter with a slight bluish sheen exteriorly, the former edged with grayish seal brown, the bend of the wing and primary coverts more or less bluish; breast and remainder of lower parts slate gray, the middle of lower abdomen paler, the breast and upper abdomen washed with blue, heavily on the former, the sides, flanks, and crissum tinged with brown, most so on flanks; external lower wing-coverts blue like head, the others, together with axillars, slate gray washed with blue; thighs slate gray, washed with blue.

Measurements.—Eleven males: Wing, 69.5–74.5 (average, 72.9); tail, 66–74 (average, 70.2); exposed culmen, 11–12.5 (average, 11.7); tarsus, 16.5–18 (average, 17.1) mm. Five females: Wing, 69–72.5 (average, 70.1); tail, 63–69 (average, 66.4); exposed culmen, 11.5; tarsus, 17–18 (average, 17.3) mm.

Type-locality.—Engano Island, western Sumatra.

Geographical distribution.—Engano Island.

The immature male of this race is practically identical with the adult female, and differs from the immature male of *Hypothymis a. consobrina* in its darker, duller, more grayish (less whitish) posterior lower parts, especially the middle of abdomen. From *Hypothymis azurea tytleri*, of the Andaman Islands, with which it has been considered identical,^a *Hypothymis a. richmondi* may be readily distinguished in the adult male by its decidedly darker upper and lower parts, particularly the abdomen, and by the almost entire lack of contrast between the color of pileum and of back; in the female by darker coloration, especially of the blue areas above, and the grayish of the posterior lower parts, the middle of abdomen not at all, or but very slightly, whitish.

This new form is most nearly allied to *Hypothymis azurea consobrina* and *H. a. tytleri*, and is very distinct from the geographically intervening races. It is apparently confined to the island of Engano. Individual variation is most noticeable in the color of the pileum, which is occasionally lighter in contrast with the back, and on the lower abdomen, which is sometimes appreciably whitish medially. These differences, however, do not interfere with the characters of the subspecies as above given.

^aSalvadori, Ann. Mus. Civ. Genova, vol. 32, 1892, p. 129.

Following are detailed measurements of all the specimens examined:

Measurements of specimens of Hypothymis azurea richmondi examined.

U.S.N.M. No.	Sex.	Locality.	Date.	Collector.	Total length. ^a	Wing.	Tail.	Exposed culmen.	Tarsus.
180752	Male....	Engano Island, western Sumatra.	Nov. 9, 1904	Dr. W. L. Abbott..	170	74	71.5	11	17
180753	..do.....	..do.....	Nov. 11, 1904	..do.....	168	74.5	70	12	16.5
180755	..do.....	..do.....	Nov. 17, 1904	..do.....	165	72.5	69.5	11.5	17
180754	..do.....	..do.....	..do.....	..do.....	165	74	71	11.5	17
180756	..do.....	..do.....	Nov. 21, 1904	..do.....	167	71.5	70	12.5	17.5
180757 ^b	..do.....	..do.....	Nov. 22, 1904	..do.....	168	74.5	71.5	12	16.5
180758	..do.....	..do.....	Nov. 23, 1904	..do.....	165	69.5	66	11	17
180760	..do.....	..do.....	Nov. 29, 1964	..do.....	167	72	67	12	17
180759	..do.....	..do.....	..do.....	..do.....	173	72.5	71	12.5	18
180761	..do.....	..do.....	Dec. 5, 1904	..do.....	175	74.5	74	11	18
180766	..do.....	..do.....	Nov. 27, 1904	..do.....	165	72	70.5	12	16.5
180762	Female..	..do.....	Nov. 6, 1904	..do.....	..	69.5	63	11.5	17.5
180763	..do.....	..do.....	Nov. 7, 1904	..do.....	163	69	68	11.5	17
180764	..do.....	..do.....	Nov. 9, 1904	..do.....	162	69.5	66	11.5	17
180765	..do.....	..do.....	Nov. 22, 1904	..do.....	158	70	66	11.5	17
180767	..do.....	..do.....	Dec. 4, 1904	..do.....	165	72.5	69	11.5	18

^a Measured in the flesh by the collector.

^b Type.

DESCRIPTIONS OF NEW HYMENOPTERA. 1

By J. C. CRAWFORD,

Assistant Curator, Division of Insects, U. S. National Museum.

In this paper some new parasites from the United States are described, together with two new species of bees which were found while arranging part of the collections of bees. There are also new species of parasites from Japan, described mostly from a small collection of reared Hymenoptera sent in for determination by Mr. Takeshi Fukai, of Konosu, Saitama, Japan.

Family ANDRENIDÆ.

NOMIA HOWARDI, new species.

Female.—Length about 9 mm. Black, with opalescent bands on the apical margins of segments 1-4; face below antennæ with coarse sparse punctures; those on the clypeus more scattered; above antennæ with fine scattered punctures; mesonotum anteriorly and laterally with close, coarse punctures; disk of mesonotum and metanotum (postscutellum of authors) almost impunctured, polished; truncation of propodeum with sparse, large, setigerous punctures, the surface between with fine shallow punctures and almost hidden by the silky white pubescence; metapleuræ striate; wings subhyaline, the apical margin with a broad infuscated band; legs brown, the hind tibiæ and tarsi reddish-brown; outer spur of hind tibiæ bent at an obtuse angle; abdomen finely reticulated and with sparse, fine punctures; opalescent bands, except the first, broad, but not covering the depressed apical margins of the segments, the dark portion punctured.

One specimen from San Jose de Guaymas, Mexico. Dr. L. O. Howard, collector.

Type.—Cat. No. 13455, U.S.N.M.

Named for Dr. L. O. Howard.

NOMIA MOCTEZUMÆ, new species.

Female.—Length 8 mm. Very similar to *mesillensis*, but differs as follows: Punctures of the mesonotum smaller and uniform in size; the metapleuræ finely striate and with minute punctures between the striæ (in *mesillensis* the metapleuræ have a few coarse striæ and the upper part punctured); mesopleuræ with finer punctures; punctures of truncation of propodeum separated by two or more times their own diameter, the sculpture of the intervening spaces much finer; hind tibiæ and tarsi brown; outer spur of hind tibiæ at apex bent at right angles; punctures of abdomen coarser and closer and lineolation more apparent; opalescent bands much narrower.

One specimen from San Jose de Guaymas, Mexico. Dr. L. O. Howard, collector.

Type.—Cat. No. 13456, U.S.N.M.

Family PTEROMALIDÆ.

TRICHOMALUS APANTELOCTENUS, new species.

Female.—Length about 1.75 mm. Bright green, the head and thorax including the propodeum, with shallow thimble-like punctures; antennæ brown, with two ring joints, the scape testaceous; joints of the funicle subquadrate, the pedicel longer than the first; antennæ inserted just above the lower level of the eyes; mandibles with four distinct teeth; occiput margined; prothorax anteriorly truncate; propodeum with a long neck, with a median and lateral carinæ; spiracles small, elongate; postmarginal vein about as long as the marginal; the stigmal vein shorter; legs, except the green coxæ, testaceous; abdomen depressed.

Male.—Length 1.5 mm. Similar to the female, the front coxæ light with a green spot exteriorly, the middle coxæ entirely testaceous.

Konosu, Saitama, Japan. Five females and one male reared from an *Apanteles* on *Naraga diffusa* by T. Fukai.

Type.—Cat. No. 13457, U.S.N.M.

One female paratopotype does not show any indication of a median carina on the propodeum.

Family EULOPHIDÆ.

DIPACHYSTIGMA, new genus.

Type.—*D. cushmani* Crawford.

Belongs to the Tetracampini; antennæ clavate, inserted near the mouth parts, twelve-jointed (fig. 1) with three ring joints; joints of club fused; submarginal vein appearing broken (fig. 2), since basad of the apparent break the upper (anterior) margin of the vein is colored and the lower part is not, and beyond the apparent break the

lower margin is colored and the upper is not; marginal vein at base with an enlarged parastigma; stigmal vein and knob enlarged; postmarginal indistinct because almost colorless; tarsi in female five-jointed; parapsidal furrows complete; scutellum without longi-

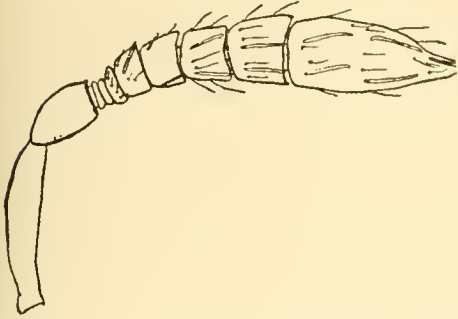


FIG. 1.—DIPACHYSTIGMA CUSHMANI. ANTENNA OF FEMALE.

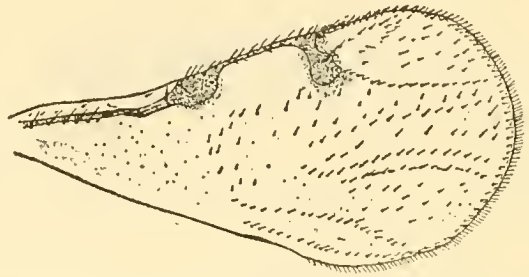


FIG. 2.—DIPACHYSTIGMA CUSHMANI. FORE RING OF FEMALE.

tudinal lines; propodeum short, median carina indistinct, spiracles small, round, placed in depressions.

To this tribe belongs apparently the genus *Pleuropachus* Westwood, which has the marginal vein enlarged and the stigmal knob also enlarged.

DIPACHYSTIGMA CUSHMANI, new species.

Female.—Length about 1 mm. Head dark blue, the mesonotum greenish, the abdomen aeneous, with blue at the base and sides; head closely punctured, but so finely that the surface appears granular; antennæ brown, the scape at apex whitish; mesonotum with fine thimble-like punctures; propodeum smooth; prepectus punctured, mesepisternum finely striate, the rest of the mesopleuræ smooth; legs dark brown with more or less metallic lustre, the tarsi whitish; wings subhyaline, stigmal vein and parastigma surrounded by small stigmal clouds (represented in fig. 2 by the stippling); abdomen smooth, shiny.

Male.—Unknown.

Described from eighteen specimens bred from *Stephanoderes*, species, at Tallulah, Louisiana, by Mr. R. A. Cushman, Bureau of Entomology, Department of Agriculture, and recorded under Hopkins number 8634.

Type.—Cat. No. 13458, U.S.N.M.

Named for Mr. R. A. Cushman.

PLEUROTROPIS ATAMIENSIS Ashmead.

This species, which was described by Doctor Ashmead without the host being known, was reared by Mr. T. Fukai at Konosu, Japan, together with *Euplectrus fukaii*, from *Naraga diffusa*, and is probably a secondary parasite on the *Euplectrus*.

WINNEMANA, new genus.

Type.—*W. argei* Crawford.

Belongs to Tetrastichini; antennæ very similar in the two sexes, nine-jointed, scape, pedicel, two ring joints, funicle two-jointed, club three-jointed (fig. 3); mesonotum without a median furrow; pronotum transverse; scutellum with two longitudinal lines; submarginal vein slightly shorter than marginal; stigmal vein about one-half as long as marginal; propodeum with a median carina; spiracles small, round; abdomen short, broadly ovate.

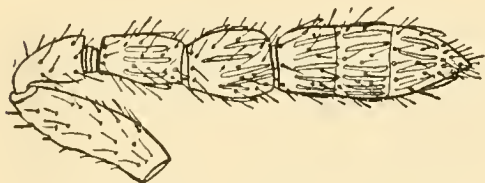


FIG. 3.—WINNEMANA ARGEI. ANTENNA OF FEMALE.

This genus is readily recognized by the funicle having only two segments.

WINNEMANA ARGEI, new species.

Female.—Length about 1 mm. Head and thorax black, abdomen brown; antennæ brown, the scape darker, the pedicel at apex light yellowish; mesonotum finely reticulated; propodeum indistinctly finely irregularly reticulated; mesopleuræ finely, indistinctly reticulate; coxæ black, femora with the basal two-thirds dark brown, rest of legs yellowish.

Male.—Length about 1 mm. Very similar to the female, except in secondary sexual characters.

Habitat.—Plummer's Island, Maryland.

Described from many specimens reared from the eggs of *Arge*, species. This is the species recorded by Mr. E. A. Schwarz^a as *Hylotoma pectoralis* Leach.

Type.—Cat. No. 13459, U.S.N.M.

Genus EUPLECTRUS Westwood.

The following table will separate the species of this genus found in Japan:

1. Head and thorax partly yellow.....	<i>nigromaculatus</i> Ashmead.	2
Head and thorax, black.....		3
2. All coxæ pale.....		4
Hind coxæ black.....	<i>japonicus</i> Ashmead.	4
3. Scutellum finely indistinctly reticulated.....		
Scutellum at basal deeply reticulated, apically longitudinally rugose,	<i>fukaii</i> , new species.	
4. Clypeal area black.....	<i>kæbelei</i> , new species.	
Clypeal area white.....	<i>kuwanæ</i> , new species.	

EUPLECTRUS FUKAII, new species.

Female.—Length about 2 mm. Head and thorax black, clypeal area whitish; antennæ testaceous, becoming brown apically; pedicel

^a Proc. Ent. Soc. Wash., vol. 11, 1909, pp. 106-108.

about one-half as long as first joint of funicle, following joints of funicle successively shorter, the last longer than wide; median lobe of mesonotum coarsely rugoso-reticulate, the lateral lobes more finely and indistinctly so; scutellum and axillæ finely, indistinctly reticulated with impressed lines; legs entirely reddish-testaceous, longer spur of hind tibiæ as long as first two joints of hind tarsi; first joint of hind tarsi not much longer than second; abdomen with a large basal testaceous spot.

Male.—Unknown.

Habitat.—Japan.

Atami, A. Koebele, collector, seven specimens; also one paratype from Konosu, Saitama, T. Fukai, collector, reared from *Naraga diffusa*.

Type.—Cat. No. 13460 U.S.N.M.

Named in honor of Mr. Takeshi Fukai, who collected one of the series.

EUPLECTRUS KOEBELEI, new species.

Female.—Length, 2 mm. Head and thorax, including clypeal region, black; scape and pedicel yellowish, funicle brownish, becoming darker apically; first joint of funicle not distinctly longer than pedicel, following joints shorter, hardly longer than wide; median lobe of mesonotum coarsely rugosely reticulated, posteriorly with a short median carina, lateral lobes with much finer sculpture; reticulations of axillæ and scutellum of impressed lines and still more indistinct; propodeum with a median and lateral carinæ, between these smooth; pleuræ smooth, legs, including coxæ, reddish testaceous; first joint of hind tarsi almost twice as long as second; longer spur on hind tibiæ as long as joints one and two of hind tarsi together; abdomen brownish, with a large basal testaceous spot, venter largely pale.

Male.—Unknown.

Hakone, Japan. A. Koebele, collector. Six specimens.

Type.—Cat. No. 13461, U.S.N.M.

Named in honor of Mr. Albert Koebele.

EUPLECTRUS KUWANÆ, new species.

Female.—Length about 2 mm. Head and thorax black, clypeal area white; scape and pedicel light yellow, funicle more brownish; pedicel distinctly shorter than first joint of funicle, following joints of funicle successively shorter, but even the last longer than broad; median lobe of mesonotum coarsely rugosely reticulated, the lateral lobes with somewhat finer reticulations; axillæ very indistinctly reticulated with impressed lines; scutellum with irregularly longi-

tudinal lines, basally these more or less reticulated; legs entirely yellowish; longer spur on hind tibiæ as long as first two joints of tarsi; first joint of hind tarsi almost twice as long as second; abdomen dark brown, with a large basal light spot; venter largely pale.

Male.—Length about 1.5 mm. Similar to the female, except in secondary sexual characters; the first joint of funicle about twice as long as the pedicel.

Habitat.—Japan.

One female and one male bred from *Parnara guttatus* by Prof. S. I. Kuwana; also three paratype specimens from Atami, A. Koebele, collector.

Type.—Cat. No. 13462, U.S.N.M.

Named in honor of Prof. S. I. Kuwana.

ELACHERTUS HYPHANTRIÆ, new species.

Female.—Length about 2 mm. Head and thorax purplish-black, the face more bronzy, the abdomen dark brown with a honey-colored spot at base; face almost smooth, occiput lineolate; head with many rather long hairs; antennæ brown; prothorax and mesothorax finely reticulated, inner edges of parapsidal areas smooth; scutellum, metathorax, and propodeum between the lateral folds polished; median carina of propodeum well developed; propodeum laterally finely roughened; wings hyaline, the veins almost colorless; legs, including the coxæ, light honey color; abdomen polished.

Male.—Unknown.

Five specimens, reared from *Hyphantria cunea* Drury, at Cuero, Texas.

Type.—Cat. No. 13463, U.S.N.M.

CRATOTECHUS HOPLITIS, new species.

Female.—Length about 2.5 mm. Head and thorax bright green; abdomen at base and apex green, a large reddish-testaceous band near base, back of this black; antennæ light brown, the pedicel shorter than the first joint of the funicle, about as long as the second; head lineolated, the lineolations somewhat reticulated; below the antennæ the face transversely rugulose; mesonotum with shallow thimble-like punctures; those on the scutellum finer; metathorax with similar, still finer punctures; propodeum with still finer punctures, which are somewhat irregularly thimble-like; propodeum with a median carina; spiracles large, round; prepectus and metapleuræ with thimble-like punctures; mesepisternum and lower part of mesepimerum with reticulations of raised lines somewhat like irregular, shallow thimble-like punctures; upper part of mesepimerum, in the shape of an inverted triangle, smooth; marginal vein about twice as long as the postmarginal; stigmal vein shorter than

the postmarginal; legs testaceous, the femora somewhat suffused with brown; anterior coxæ brown, the apical part testaceous; middle coxæ green exteriorly, anteriorly brown; hind coxæ green.

Male.—Unknown.

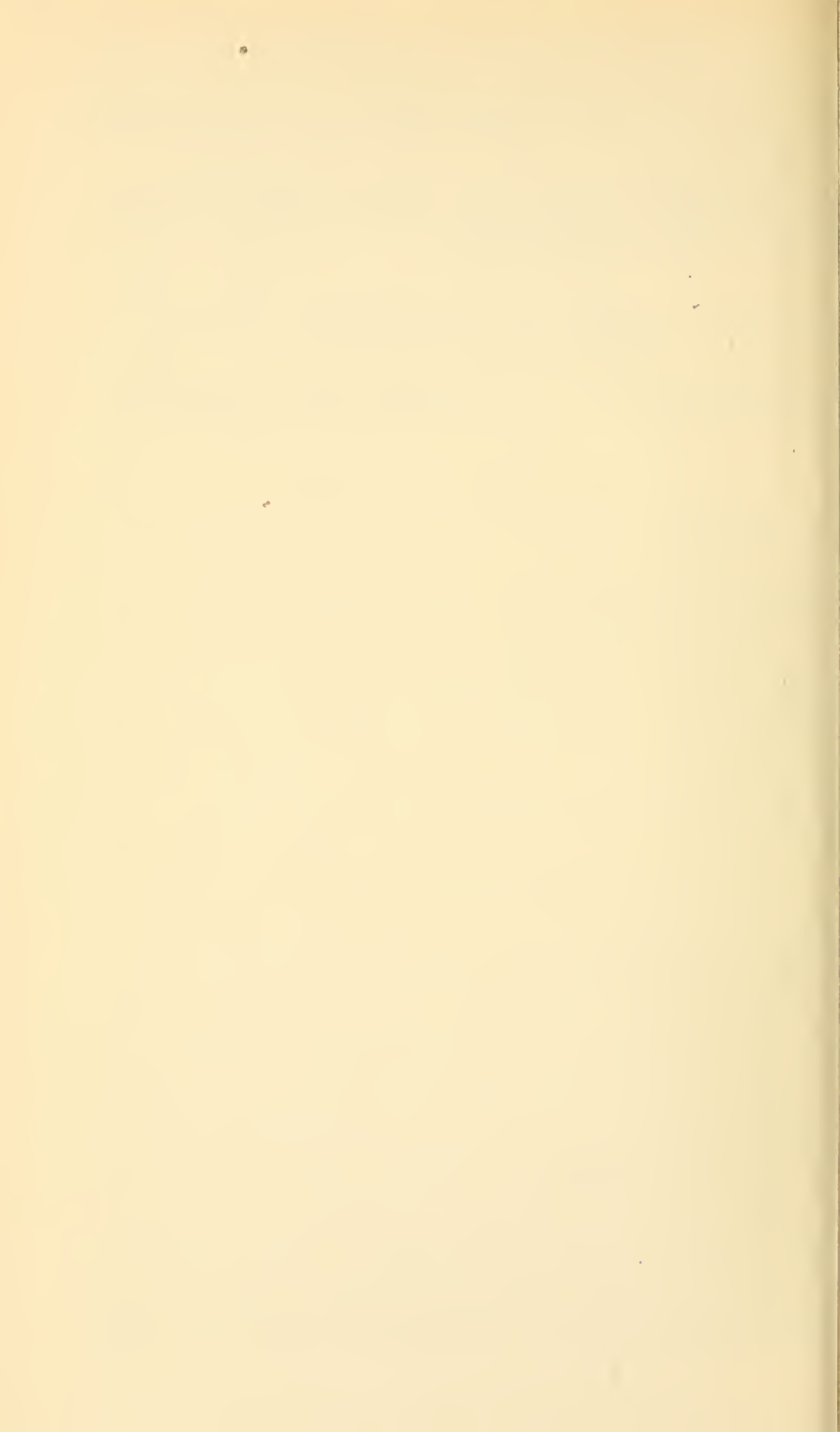
Konosu, Saitama, Japan. Eight specimens reared by T. Fukai on June 18, 1910; the host not given.

Type.—Cat. No. 13464, U.S.N.M.

Family TRICHOGRAMMIDÆ.

TRICHOGRAMMA JAPONICUM Ashmead.

Reared from the eggs of *Chilo simplex* at Konosu, Saitama, Japan, by Mr. T. Fukai.



NORTH AMERICAN PARASITIC COPEPODS. DESCRIPTIONS OF NEW GENERA AND SPECIES.

By CHARLES BRANCH WILSON.

Department of Biology, State Normal School, Westfield, Massachusetts.

This eleventh paper^a in the series dealing with the North American Parasitic Copepods includes four new species, two of which are made the types of new genera. Two of the species were sent to the author by Dr. Barton W. Evermann of the U. S. Bureau of Fisheries, one was collected by Dr. Edwin Linton at the Tortugas, Florida, and the fourth was found in the Museum of the Johns Hopkins University. Sincere thanks are hereby returned to each of the senders, not merely for these favors but also for many others similarly conferred.

MIDIAS,^b new genus.

General form intermediate between that of *Caligus* and *Euryphorus*. First three thorax segments united with the head to form the carapace; frontal plates poorly defined but furnished with lunules. Fourth or free thoracic segment short and wide, with a pair of very rudimentary dorsal plates in the female.

Genital segment greatly enlarged and carrying a pair of rudimentary legs at the posterior corners in both sexes. Abdomen long, distinctly

^a The ten preceding papers are: 1. The Argulidæ, Proc. U. S. Nat. Mus., vol. 25, pp. 635-742, pls. 8-27. 2. Descriptions of Argulidæ, idem, vol. 27, pp. 627-655, 38 text figures. 3. The Caliginæ, idem, vol. 28, pp. 479-672, pls. 5-29. 4. The Trebinæ and Euryphorinæ, idem, vol. 31, pp. 669-720, pls. 15-20. 5. Additional Notes on the Argulidæ, idem, vol. 32, pp. 411-424, pls. 29-32. 6. The Pandarinæ and Cecropinæ, idem, vol. 33, pp. 323-490, pls. 17-43. 7. New Species of Caliginæ, idem, vol. 33, pp. 593-627, pls. 49-56. 8. Parasitic Copepods from the Pacific Coast, idem, vol. 35, pp. 431-481, pls. 66-83. 9. Development of *Achtheres ambloplitis* Kellicott, idem, vol. 39, pp. 189-226, pls. 29-36. 10. The Ergasilidæ, idem, vol. 39, pp. 263-400, pls. 41-60.

^b *Midias*, a disreputable Athenian.

two-jointed in the female, the basal joint with large lateral lobes; indistinctly jointed and without lobes in the male. Maxillary hooks and furca present; first three pairs of legs biramose; endopod of first pair rudimentary; both rami of third pair distinctly three-jointed. Egg-cases like those of the *Caliginæ*.

Type-species.—*M. lobodes*, new species.

MIDIAS LOBODES,^a new species.

Female.—General body form elongate and strongly flattened; carapace elliptical, the margin very evenly rounded, almost as wide as long and two-fifths of the entire length. Frontal plates not well differentiated, with a shallow median sinus; lunules small and widely separated, semicircular and projecting but little; posterior sinuses oval and shallow, lateral lobes curved inward at the tip; median lobe a little more than one-third the entire width and not reaching to the ends of the lateral lobes; thoracic area very small, transversely elliptical, one-half wider than long, and covering only the posterior third of the central portion of the carapace.

Free segment half the width of the genital segment, considerably enlarged through the bases of the fourth legs, and bearing a pair of rudimentary dorsal plates, which are slightly elevated and distinctly visible in the living female but flattened down and are easily overlooked in preserved specimens.

Genital segment the shape of an inverted U, squarely truncated posteriorly and two-thirds the size of the carapace, with a pair of legs plainly discernible at the posterior corners.

Abdomen nearly as long as the genital segment and two-jointed, with a large semielliptical lobe on either margin of the basal joint. These lobes are as long as the segment to which they are attached and extend outward to the level of the lateral margin of the genital segment. Posteriorly the abdomen is produced into a long cylindrical lobe on either side of the anal laminae. The latter are situated on the squarely truncated posterior margin of the abdomen, are about the same size as the posterior lobes, and are each armed with four terminal spines.

The egg-cases are twice the width of the anal laminae and a little longer than the entire body; the eggs are small and numerous, about 100 in each case.

Maxillary hooks of medium size, with a basal portion five times the width of the nearly straight terminal portion.

Mouth-tube short and semicircular in outline; first maxillae stout, not quite reaching the tip of the mouth-tube, and furnished with an accessory tooth or spine on the inner margin near the center. Ter-

^a *Lobodes*, λοβώδης, (λοβός + ἔδος), like a pea-pod, lobed, alluding to the large lobes on the sides of the basal joint of the abdomen in the female.

minal claw on the maxillipeds slender, bent into a half circle two-thirds the length of the basal joint, and carrying a tiny spine on its ventral surface one-third the distance from the base.

Furca short and stout, rami divergent and strongly curved. First legs slender, the basal joint with a rudimentary two-jointed endopod on its posterior margin; the three terminal claws with compound tips, made up of several points or teeth, and with a row of saw-teeth along each lateral margin.

Spines on the exopods of the second legs large and finely toothed along both margins. Spine at the base of the exopod of the third leg also large and bifurcated, the ventral branch shorter than the dorsal. Both rami of these third legs distinctly three-jointed.

Basal joint of the fourth legs enlarged into a broad lamina, three-fourths as wide as long; the three terminal joints the same length as the basal and armed with simple spines, all about the same length.

Total length 10 to 14 mm. Carapace 4.1 mm. long, 4 mm. wide. Free segment 0.8 mm. long. Genital segment 2.75 mm. long, 2.75 mm. wide. Abdomen 2.5 mm. long. Egg-tubes 12 mm. long.

Male.—Posterior body shorter and relatively smaller than in the female; carapace elliptical and as large as that of the female, with the same general proportions. The body behind the carapace, however, is only half as long as in the female, and relatively narrower, thus making the carapace more than half the entire length.

Free segment two-thirds the width of the genital segment and widened through the bases of the fourth legs.

Genital segment two-fifths the width of the carapace, nearly circular in outline, but broken at the posterior corners by the attachment of the fifth legs; on the ventral surface there is also a sixth pair of legs, inside the fifth pair and a little posterior to them.

Abdomen one-jointed and lacking the lateral lobes found in the female, somewhat shorter than the genital segment and only half as wide.

Maxillary hooks not much enlarged; first maxillæ without the accessory tooth on the inner margin; fourth legs with a much smaller basal joint, otherwise like the female.

Total length 7.25 mm. Carapace 4 mm. long, 3.9 mm. wide. Genital segment 1.5 mm. long and the same width. Abdomen 1.1 mm. long, 0.8 mm. wide.

Color of young specimens a rich cream yellow, becoming orange brown with maturity, the color being deepest over the convolutions of the oviducts and vasa deferentia in the genital segment.

Ten specimens of this species, including two males, were obtained from the outside surface of the head of a great barracuda, (*Sphyraena barracuda*), by Dr. Edwin Linton at the Tortugas, Florida, and are numbered 39613, U.S.N.M.

The present genus forms another connecting link between the Caliginæ and the Euryphorinæ. The presence of lunules marks its close affinity with *Caligus*, and the preserved material first obtained was referred to that genus. During the past summer, however, there has been an opportunity to study an abundance of living material, and a more careful examination reveals so many characteristics of the Euryphorinæ that it must be placed in the latter subfamily. These include among general characters the large size of the copepod, fully twice that of most species of *Caligus*, the possession of rudimentary dorsal plates on the fourth (free) segment, a strongly inflated genital segment, and an abdomen with lateral lobes on the basal joint and posterior lobes on the terminal joint.

In addition, the first legs have a rudimentary endopod which is two-jointed, both rami of the third legs are distinctly three-jointed, and the fourth legs have an enlarged basal joint, and three small terminal joints arranged like those in *Gloiopotes* and not at all like those in *Caligus*.

These, with minor differences in the anatomy of the other appendages, will not allow the species to remain among the Caliginæ, but it must be placed with other intermediate forms in the Euryphorinæ.

PARALEBION,^a new genus.

General form similar to that of *Alebion*. First three thoracic segments united with the head; frontal plates poorly defined and without lunules. Free thoracic (fourth) segment narrow and long, with barely the rudiments of a pair of dorsal plates in both sexes.

Genital segment elongate in the female, with conical lobes at the posterior corners; much shorter and without lobes in the male.

Abdomen long and narrow; anal laminae large and armed with nonplumose spines.

Maxillary hooks present; first maxillæ single; furca large and double.

First three pairs of thoracic legs biramose; endopod of first pair rudimentary; exopod of third legs divided differently from those of *Caligus* and *Lepeophtheirus*. Egg-cases like those of the Caliginæ.

Type-species.—*P. elongatus*, new species.

PARALEBION ELONGATUS,^b new species.

Female.—Carapace transversely elliptical, a little wider than long, the anterior margin slightly reentrant and without a median sinus, the posterior margin nearly straight. Posterior sinuses inclined outwards and egg-shaped; median lobe half the entire width, lateral lobes curved inward at the tips until they touch the sides of the median lobe. Grooves separating the areas arranged like the letter H as in the Caliginæ, but with certain modifications. The posterior portion

^a *Paralebion*, from παρά, near, and *Alebion*.

^b *Elongatus*, elongate.

of the H is much wider than the anterior and is transversely elliptical in form, being fully twice as wide as long. A series of grooves connect the anterior portion of the H with the lateral margin of the carapace on either side, each groove producing a slight indentation where it meets the margin. Another groove extends diagonally inward from the tip of the side of the H, the two almost meeting at the midline. This produces a configuration whose nearest approach is seen in *Caligus aliuncus* and *C. hæmulonis*.

Free thorax segment about one-fifth the width and one-fourth the length of the carapace, widened through the bases of the fourth legs, and showing there a rudimentary dorsal plate on either side, over the base of the leg. These plates are minute, but evidently correspond to the better developed ones in *Alebion* and *Gloiopotes*.

Genital segment, including the posterior lobes, as long as the carapace, but less than half as wide, with nearly straight sides and produced at each posterior corner into a conical process, three-fifths as long as the body of the segment.

Abdomen flattened cylindrical, five times as long as wide, two-jointed, with the joints about equal; anal laminae large, spatulate, each armed with four nonplumose spines. Egg-cases cylindrical, reaching just beyond the tips of the anal laminae; eggs large, about thirty in each case.

First and second antennæ like those of *Lepeophtheirus*, each of the second pair with a large spine on the posterior margin of the basal joint. Maxillary hooks long and sickle-shaped, their bases opposite the tips of the second antennæ.

First maxillæ large and undivided, each maxilla curved outward a little and reaching well beyond the tip of the mouth tube.

Furca double, the proximal end of the terminal portion telescoped inside the distal end of the basal portion, the branches strongly curved so as to make the sinus between them a half circle.

Terminal claw of the maxillipeds slender, strongly curved, and about half the length of the basal joint.

First legs with a rudimentary endopod attached to the basal segment, cylindrical in form, three-jointed, and tipped with three spines and a short rounded process. Terminal claws of the exopod diminishing a little in length from without inwards; there is no seta at the distal corner, but the three plumose setæ on the posterior margin are of the usual size.

Second legs like those of *Lepeophtheirus*; third pair with an enormous sickle-shaped claw at the base of the exopod. The groove between the two joints of this exopod, instead of being transverse as it is in *Caligus* and *Lepeophtheirus*, is fully as diagonal as it is in the fourth legs. The endopod overlaps the exopod at its base, but is considerably shorter.

Fourth legs with a stout basal joint fully as long as the three terminal joints, each of the second and third joints tipped with a short claw, the terminal joint tipped with three claws, the inner of which is three times the length of the others.

Total length, 9.4 mm. Carapace 3.2 mm. long, 3.6 mm. wide. Free segment 0.8 mm. long, 0.6 mm. wide. Genital segment 3.2 mm. long, 1.8 mm. wide. Abdomen 3.2 mm. long, 0.6 mm. wide.

Male.—Carapace and free segment like those of the female and almost exactly the same size, but the posterior body is shorter and narrower.

Genital segment spindle-shaped, only a little longer than the free segment and about the same width; abdomen one-fifth longer than the genital segment and only two-thirds as wide, two-jointed, the basal joint less than half the length of the terminal. Anal laminae fully as large as those of the female and armed with longer spines, which, however, are nonplumose.

Second antennae much inflated and covered on the ventral surface with corrugated pads, the terminal claw stout, and reinforced by several accessory claws. Basal joint of fourth legs much smaller than in the female; fifth legs not visible in dorsal view; other appendages as in the female.

Total length 6.8 mm. Carapace 3.2 mm. long, 3.4 mm. wide. Free segment 0.8 mm. long, 0.6 mm. wide. Genital segment 1.2 mm. long, 0.8 mm. wide. Abdomen 1.3 mm. long, 0.6 mm. wide. Color a light sulphur yellow, deepening into orange in the thicker portions of the carapace and the genital segment; eggs yellow.

A fine lot of specimens numbering twenty females and six males was obtained from the mouth of a shark caught in Chesapeake Bay, and belong to the museum of the Johns Hopkins University. These are cotypes of the new species, and from them two females and a male have been selected as types and deposited in the National Museum, under the Cat. No. 39553, U.S.N.M.

This new genus belongs to the Euryphorinae and is closely related to *Alebion*, but differs from it in having fully developed fourth legs, in the presence of a pair of maxillary hooks and a furca, and in the absence of the enlarged corneous claws on the first three pairs of swimming legs.

ACHTHEINUS DENTATUS,^a new species.

Female.—Carapace slightly obovate, widest anteriorly; frontal plates projecting nearly their width, but thoroughly fused with the carapace, their anterior margin evenly rounded, with a slight incision at the center. Sides of carapace and posterior margin quite convex, the latter with a deep incision on either side where the lateral area joins the thoracic. Lateral areas wide but curved over ventrally so as

^a *Dentatus*, toothed, in allusion to the teeth on the second antennae.

to appear narrow in dorsal view, and without any visible transverse groove; posterior lobes short and inclined outwards. No visible dorsal grooves on the carapace.

Second and third segments fused and covered with a single pair of elliptical dorsal plates, which are entirely distinct but overlap slightly at the center, and together are one-fourth wider than the carapace.

There is also a pair of small lateral plates covering the bases of the second legs, which are evidently the rudiments of another pair of thoracic plates, but they are concealed beneath the posterior lobes of the carapace and can not be seen except in lateral or ventral view.

Fourth segment free, with a pair of elliptical plates similar to those on the preceding segment, but a little larger. Genital segment the same width as the plates on the fourth segment, one-half wider than the carapace and evenly rounded; posterior sinus deep and triangular; posterior lobes inclined toward each other and meeting for some distance.

Abdomen attached to the ventral surface of the genital segment in front of the posterior margin, one-jointed and triangular, one-half wider than long. Anal laminae large and evenly rounded, projecting slightly beyond the posterior margin of the genital segment, each armed with four small spines. Egg strings narrow and straight, twice as long as the entire body; eggs small and numerous. Terminal joint of first antenna longer and narrower than the basal, with a tuft of setae at its tip.

Second antennae enlarged and ending in strong claws bent into a half circle, each armed with a row of stout teeth along its ventral surface near the tip. Once buried in the skin of its host, these teeth act like barbs and hold the antennae securely in place.

The mouth-tube is very pointed, with the under lip projecting some distance in front of the upper one (fig. 24); the hinge is close to the base of the tube. The mandibles are slender and reach the very end of the mouth-tube; each is armed with a dozen large teeth shaped like those on a hack saw.

Each first maxilla forms a short and stout cone, flattened side-wise, and tipped with a single small spine; on the anterior margin near the tip are three small spines close together. These maxillae stand out at right angles to the ventral surface of the head, while the mouth-tube is nearly parallel with it (fig. 24).

The second maxillae are of the usual pattern; the maxillipeds are stout and swollen and shaped much like a pair of wide boots or moccasins. The leg is the basal joint, the foot the terminal joint; from the heel projects a stout curved claw which shuts down against the sole; the latter is flat with a raised margin, and evidently acts as a suction disk to assist in attaching the parasite to its host.

All four pairs of legs are biramose; basal joints of first two pairs small, of third and fourth pairs large and laminate; rami of first three pairs two-jointed, of fourth pair one-jointed, sparingly armed with short spines without setæ.

Color a uniform cream white except in the genital segment, where the convolutions of the oviduct show an orange color; egg strings a light orange.

Total length 8.5 mm. Carapace 2.8 mm. long, 2.35 mm. wide. Dorsal thorax plates together 2.35 mm. long, 3.40 mm. wide. Genital segment 4 mm. long, 3.5 mm. wide. Egg strings 18 mm. long.

Four females belonging to this new species were obtained by Dr. R. E. Coker, for the Peruvian Government from the body and fins of a soupfin shark (*Galeus zyopterus*) near Pacasmayo, Peru, on March 12, 1907, and were sent to the author by Dr. B. W. Evermann, of the U. S. Bureau of Fisheries.

Type.—Cat. No. 39617, U.S.N.M.

These specimens were especially interesting because they served to confirm a new Pacific coast genus established by the present author in 1908.^a

This genus was founded upon a few specimens obtained from a leopard or cat shark, (*Triakis semifasciatus*), at La Jolla, California. It is closely related on the one hand to Dana's *Pholidopus* (*Lepidopus*), and on the other to Steenstrup and Lütken's *Perissopus*, but is generically distinct from both, as was clearly shown.^a The present specimens agree in every generic particular with the type species, *A. oblongus*, and thus substantiate the new genus. The teeth upon the terminal claws of the second antennæ will distinguish this species at once from *oblongus*, and, from the way in which these antennæ are carried, the teeth are very prominent and easy to observe.

LERNÆOPODA INERMIS,^b new species.

Female.—Body plump and cylindrical and bent into a crescent shape; head nearly rectangular in dorsal view, with none of the appendages except the second maxillæ visible. Both pairs of antennæ and the maxillæ are held so closely to the head that it is almost impossible to discern them from any point of view.

The first antennæ are small unsegmented papillæ, each tipped with a minute spine; the second antennæ are stout and flattened laterally into broad laminae. These antennæ are imperfectly segmented and are biramose at the tip, the dorsal ramus being a large rounded knob with a smooth surface, the ventral ramus a narrow cone made up of two joints. At the base of this cone, upon the ventral margin of the proximal portion of the appendage, is a rounded protuberance covered with short and stout spines.

^a Proc. U. S. Nat. Mus., vol. 35, 1908, p. 450.

^b *Inermis*, unarmed, in allusion to the lack of claws or spines on the maxillipeds.

The mandibles are short and stout, each bent near the center and armed at the tip with four large teeth and three small ones.

The first maxillæ are of the usual pattern; the second pair are at the extreme posterior margin of the head, are cylindrical in shape, and nearly as long as the body. The cord extending from the end of these appendages is stout, about half the diameter and one-fifth the length of the "arms" themselves, and terminates in an enormous umbrella-shaped bulla, whose diameter is considerably larger than that of the creature's body.

From the junction of the stem with the umbrella a series of ridges radiate outward toward the edge of the bulla, very similar to the ribs of an umbrella. The maxillipeds are situated a short distance in front of the second maxillæ, are stout, three-jointed, and entirely destitute of claws or armature of any sort.

The egg cases are cylindrical, as long as the thorax and nearly half as wide, and are carried turned forward against the sides of the thorax. The eggs are rather small and are arranged in twelve to fifteen longitudinal rows, about twenty-five eggs in a row.

Color, a uniform light orange yellow.

Total length 4.6 mm. Length of head 2 mm., of thorax 2.6 mm., of second maxillæ 3 mm., of egg-strings 2.6 mm. Diameter of egg strings 0.8 mm., of bulla 2.2 mm., of thorax 1.8 mm.

Three lots of this species, each consisting of a single specimen, were taken from the upper angle of the gill cavity of *Leucichthys harengus*, at the following localities: Blind River, Lake Huron; Bay Port, Michigan; Marquette, Lake Superior. One hundred and forty specimens were obtained from the same host taken in trap nets at Saginaw Bay, Lake Huron.

All of the specimens were collected by the U. S. Bureau of Fisheries through Dr. B. W. Evermann.

Type-locality.—Knife River, Duluth, Minnesota.

Type-specimen.—Cat. No. 42283, U.S.N.M.

The species is closely related to *L. extumescens* Gadd, but differs in the arrangement of the appendages, and especially in the shape of the mandibles and the teeth with which they are armed. The comparative size of the bulla is also a prominent character and perhaps the easiest one to recognize.

EXPLANATION OF THE PLATES.

PLATE 65.

Male and female of *Midias lobodes*.

- Fig. 1. Dorsal view of female.
 2. Dorsal view of male.
 3. Second antenna and maxillary hook.
 4. First maxilla of female.
 5. First maxilla of male.
 6. Furca.
 7. Second maxilla
 8. Maxilliped.
 9 to 12. First, second, third, and fourth swimming legs.

PLATE 66.

Male and female of *Paralebion elongatus*.

- Fig. 13. Dorsal view of female.
 14. Dorsal view of male.
 15. First and second antennæ, maxillary hooks, first maxillæ, and mouth-tube.
 16. Furca.
 17. Maxilliped.
 18 to 21. First, second, third, and fourth swimming legs.

PLATE 67.

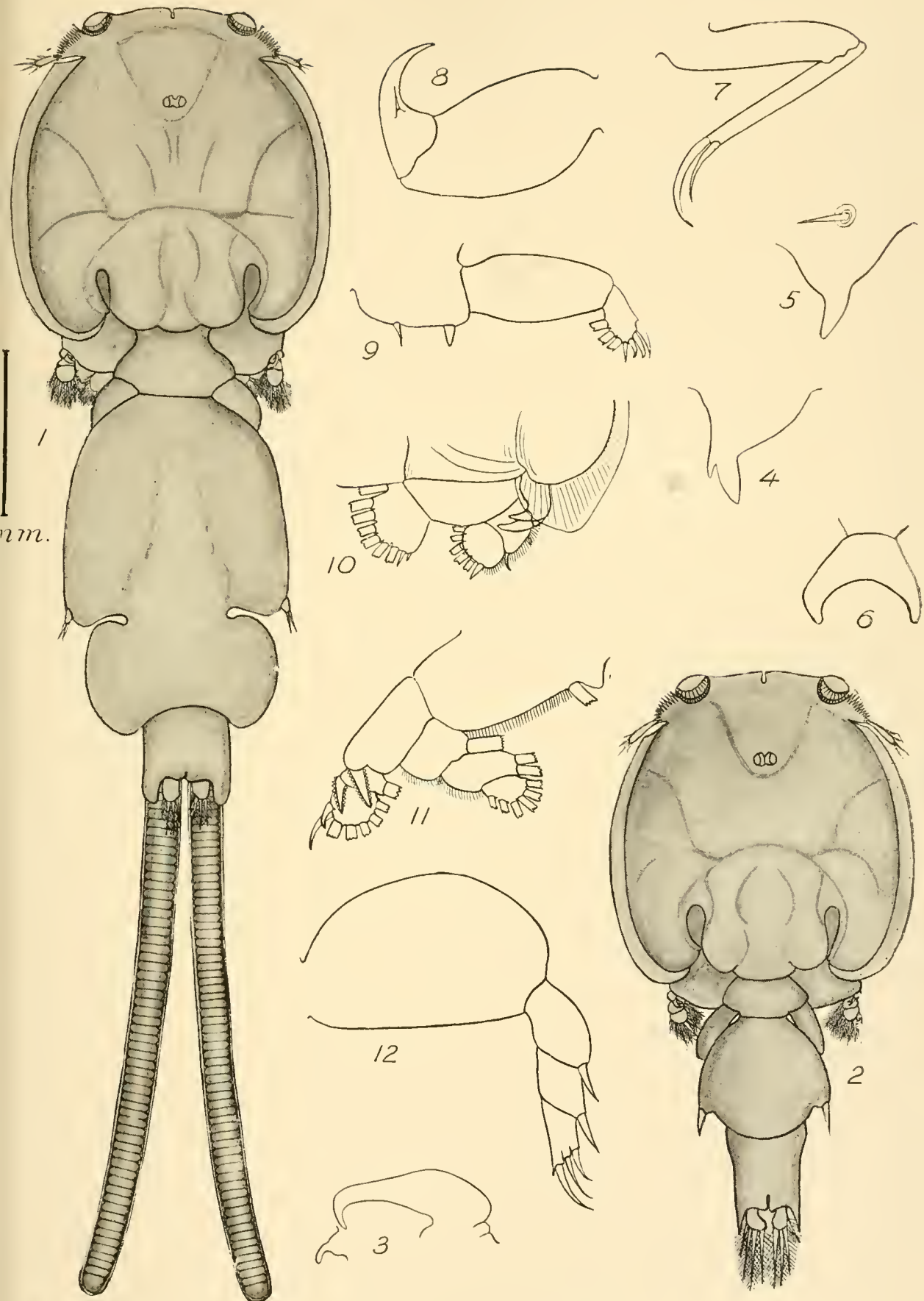
Female of *Achtheinus dentatus*.

- Fig. 22. Dorsal view of female.
 23. Second antenna.
 24. Mouth-tube and first maxilla in side view.
 25. Mandible.
 26. Second maxilla.
 27. Maxilliped.
 28 to 31. First, second, third, and fourth swimming legs.
 32. Second antenna of the male of *Paralebion elongatus*.

PLATE 68.

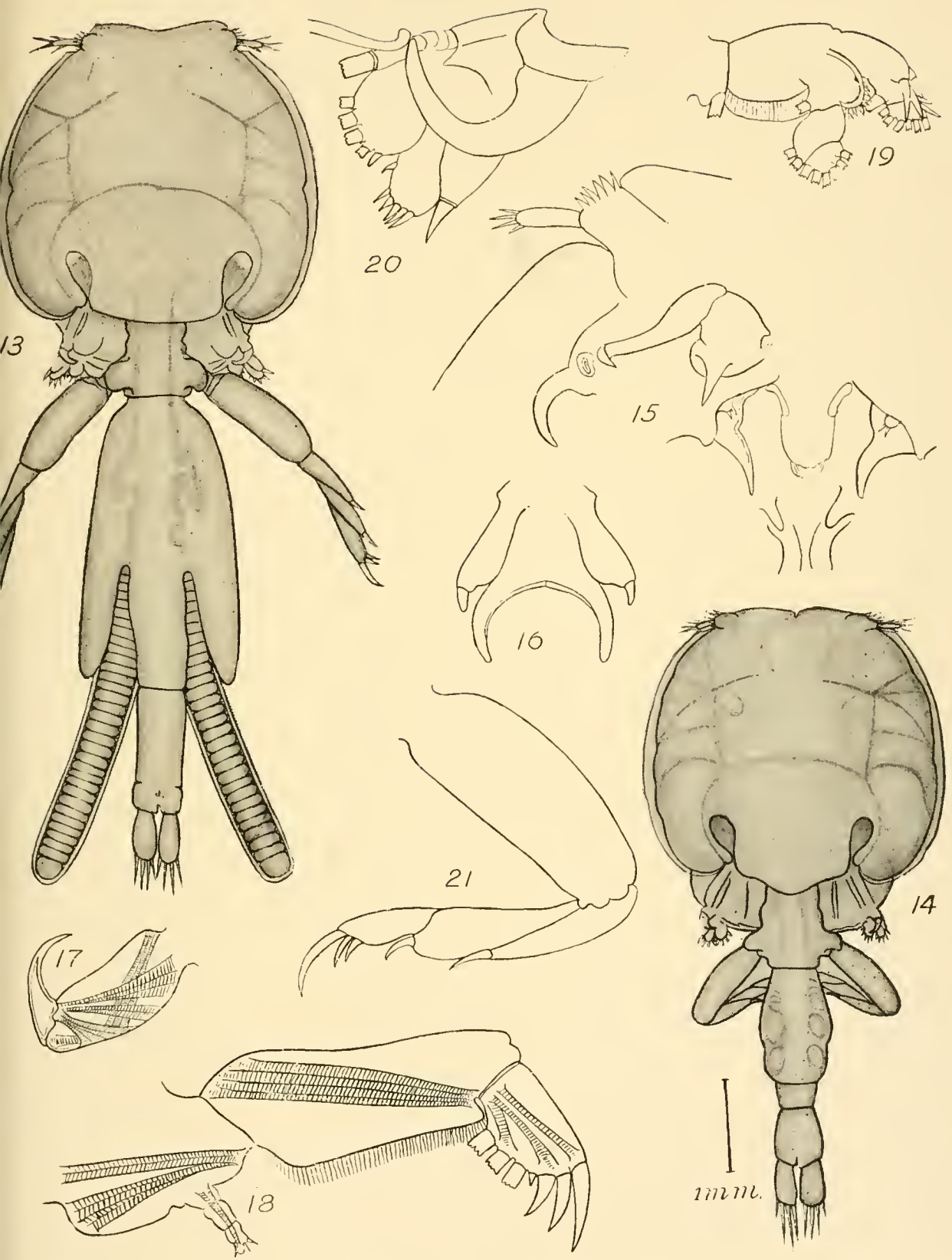
Female of *Lernæopoda inermis*.

- Fig. 33. Side view of female.
 34. Ventral view of mouth-tube and second antenna.
 35. Mandible.
 36. Maxilliped.



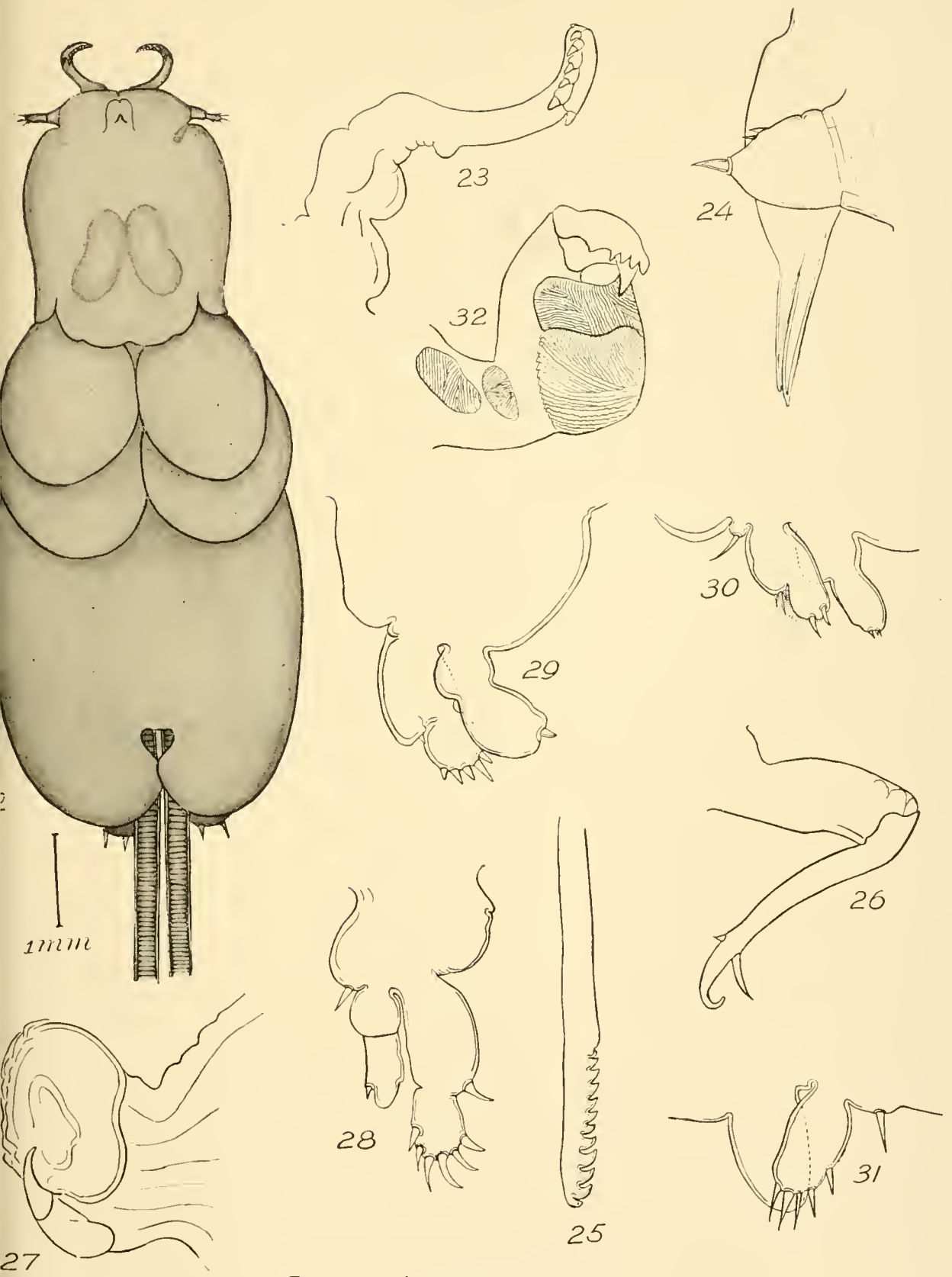
MALE AND FEMALE OF MIDIAS LOBODES.

FOR EXPLANATION OF PLATE SEE PAGE 634.



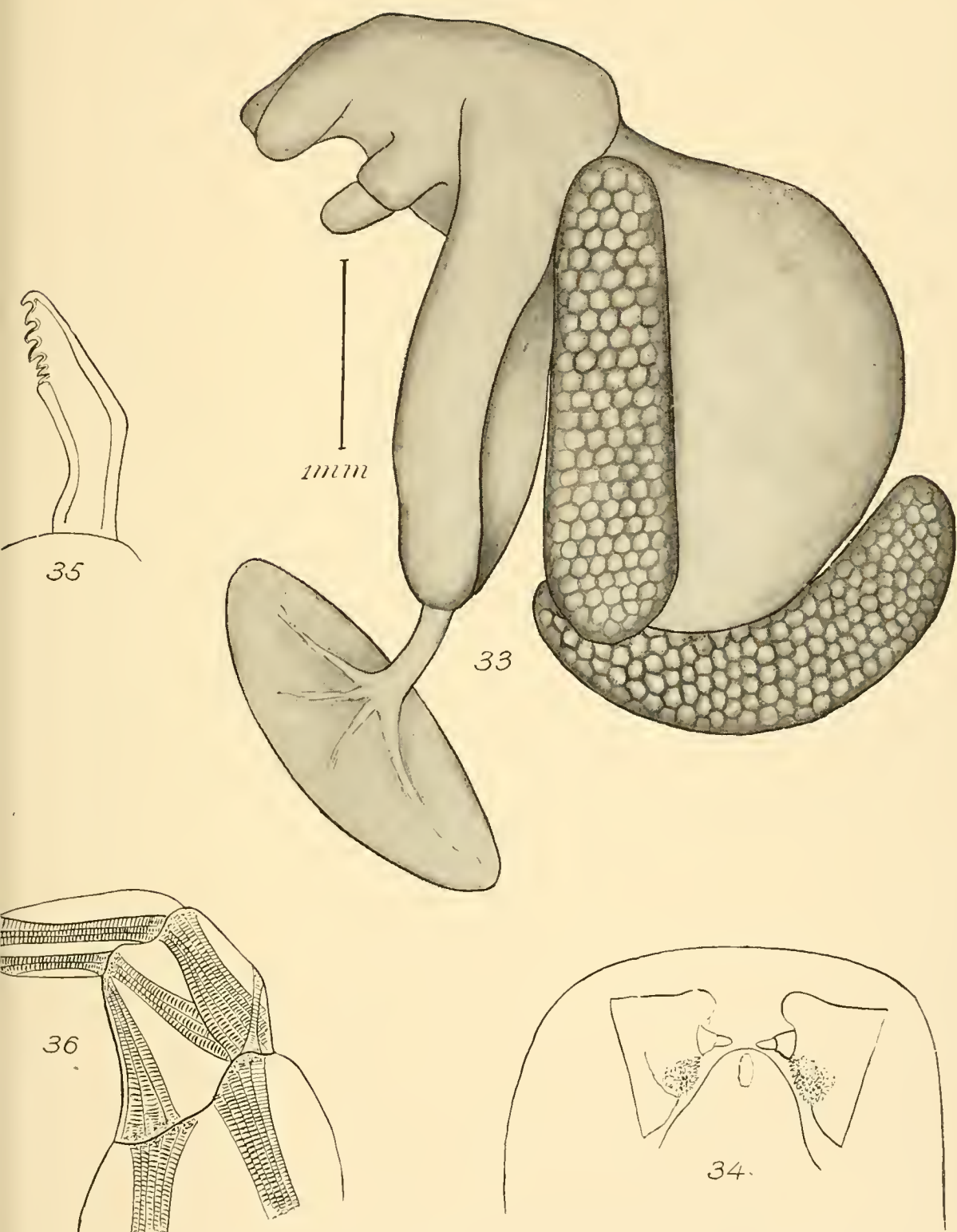
MALE AND FEMALE OF *PARALEBION ELONGATUS*.

FOR EXPLANATION OF PLATE SEE PAGE 634.



FEMALE OF *ACHTHEINUS DENTATUS*.

FOR EXPLANATION OF PLATE SEE PAGE 634.



FEMALE OF LERNÆOPODA INERMIS.

FOR EXPLANATION OF PLATE SEE PAGE 634.

BEES IN THE COLLECTION OF THE U. S. NATIONAL
MUSEUM. 1.

By T. D. A. COCKERELL,
Of the University of Colorado, Boulder.

In all large museums, the entomological collections tend to accumulate faster than they can be worked up. New species may be collected, and remain unstudied for many decades, and perhaps eventually be described from specimens captured many years later. Thus, I have recently had occasion to work up some bees from Mexico in the Berlin Museum, collected by Ferdinand Deppe as long ago as 1829. Several were still new, but others had been published in the meanwhile by Cresson and myself. In the case of the United States National Museum, the collections do not date so far back, but there is nevertheless a quantity of valuable material among the bees, which deserves to be described or reported. It will be the purpose of this series of papers to discuss such portions of this material as may be submitted to the present writer from time to time.

In the descriptions of the venation the following abbreviations are used: *s. m.* = submarginal cell; *r. n.* = recurrent nervure; *t. c.* = transverse-cubital nervure; *b. n.* = basal nervure; *t. m.* = transversomedial nervure.

CERATINA (CERATINIDIA) HIEROGLYPHICA, var. JAPONICA, new variety.

Female.—Prothorax, including tubercles, entirely black. The specimen is of the full size of *hieroglyphica*; the light reversed T on the clypeus has the arms longer than the stem, and the latter is partly divided into two parts by a median longitudinal black line; the lateral face-marks are reduced to a longitudinal mark above and a transverse mark below; the mesothorax has two slender discal lines, and a short mark above each tegula; the scutellar patch is deeply notched in front; the other markings call for no remark. Scape entirely black.

Habitat.—Japan (Koebele). *C. hieroglyphica* is quite variable, but the mainland forms, including the Chinese var. *morawitzii* Stadelmann, always have yellow on the prothorax, so far as I know.

Type.—Cat. No. 13420, U.S.N.M.

A word may be added concerning the Philippine species of *Ceratinidia*. As described, they can be separated as follows:

Larger, length 9 to 11 mm., clypeus marked with yellow, scape with yellow only in male (Philippines, see Ashmead).....	<i>hieroglyphica</i> Smith.
Smaller, length 7 mm. or less.....	1.
1. Clypeus, and scape in front yellow; "female" (?male).....	<i>compacta</i> Smith.
Clypeus only marked with yellow.....	2.
2. Scape of female nearly all yellow; lateral face-marks of female not divided into separate marks (Manila).....	<i>philippinensis</i> Ashmead.
Scape of female black; lateral face-marks divided.....	<i>tropica</i> Crawford.

The exact locality of *compacta* is unknown. I think it probable that it came from one of the southern islands, as the greater development of yellow is characteristic of the more southern species of *Ceratinidia*. There may perhaps be some doubt about the reputed sexes of the types of *compacta* and *philippinensis*. Some years ago I hastily examined the type of *philippinensis* and sketched the face-marks, which are essentially as in *hieroglyphica*. The vertical mark on the clypeus is strongly notched above. The difference in the lateral face-marks of *tropica* and *philippinensis*, as given in the table is probably due to individual variation; at least, *hieroglyphica* varies in this manner. It is probable that *C. hieroglyphica* does not really occur in the Philippines, being represented there by the smaller forms (extremely closely allied to it) called *philippinensis* and *tropica*.

Since writing the above, I have received from Mr. S. A. Rohwer particulars concerning *C. tropica* and *philippinensis*, each of which is represented by both sexes in the National Museum. The two forms are separable as follows:

Female.

Mesothorax with two pale lines; tibiae yellow, black beneath; abdominal markings heavy, broader; clypeus with a large light reversed T; lateral face-marks not divided; scape partly light.....	<i>philippinensis</i> Ashmead.
Mesothorax unmarked; tibiae nearly entirely black; abdominal markings much narrower; clypeus with only a transverse subapical light bar; lateral face marks each divided into two spots; scape dark.....	<i>tropica</i> Crawford.

Males.

Pale spot on scutellum quadrate; tibiae yellow except a black spot beneath; clypeus yellow; lateral face-marks broader; scape partly light.....	<i>philippinensis</i> Ashmead.
Pale spot on scutellum triangular; tibiae black except a pale line above; clypeus dark, with a very broad light bar, which has a median lobe or process above; lateral face-marks narrower; scape dark.....	<i>tropica</i> Crawford.

APIS INDICA JAPONICA Radoszkowski.

Worker.—Darker than typical *indica*; bases of abdominal segments 3 to 5 with conspicuous narrow whitish hair-bands.

Form a. Scutellum dark; abdomen without fulvous. Sapporo Agricultural College, Japan, December, 1896 (M. Matsumura). Two examples.

Form b. Scutellum dull yellow; second abdominal segment variably fulvous, always so at base. Japan, two examples (Mitsukuri); Swatow, China (Kœbele).

Male.—Abdomen broad and short, black without bands, but with dense pale hair at base. Japan, No. 127.

This is a feebly distinguished subspecies, perhaps originally confined to Japan, but now occurring also in China. It always has the labrum more or less reddish or yellowish, as usual in the *indica* group. Ashmead makes *A. cerana* Fabricius a distinct species, with *sinensis* Smith and *japonica* Radoszkowski as synonyms. The identity of *cerana* seems to be doubtful, and *sinensis* is not the same variety (in a restricted sense) as *japonica*. Smith records *A. nigrocincta* Smith also from Japan. I have a Chinese *nigrocincta* from Smith's collection, and can not agree with Buttel-Reepen's view that it is identical with *peroni* Latreille. True *peroni*, as described by Latreille, has the fulvous color confined to the first three abdominal segments, while *nigrocincta* has all the segments fulvous, with black borders.

APIS INDICA PERONI Latreille.

I refer here to a series of specimens from Peking, China (M. L. Robb) and Foochow, China (J. P. Grant). The amount of fulvous on the abdomen varies, from that required by the original description (first two segments fulvous except broad hind margins, base of third fulvous) to the small amount at base described for the variety *picea* Buttel-Reepen. These are evidently only individual variations. The scutellum is usually dark, but sometimes dull yellow. There is also a worker *peroni* from Horisha, Formosa (T. Fukai).

APIS INDICA Fabricius.

Shanghai, China (E. Deschamps). A pallid form, with the scape red.

XYLOCOPA CIRCUMVOLANS Smith.

Japan; three females and one male. One female is from Tokyo. The male and two females were collected by Mitsukuri. One female labeled "Southern China" has the middle of the occiput with yellow hair, to that extent approaching *X. appendiculata* Smith, but otherwise it is like *circumvolans*. Pérez suggests that *appendiculata* and *circumvolans* are varieties of a single species.

XYLOCOPA LATIPES (Drury).

Buitenzorg, Java (D. G. Fairchild); Trong, Lower Siam (W. L. Abbott); Thagata, Tenasserim (Fea). In Bingham's description of the male (Fauna of British India) for tibiae read basitarsi.

XYLOCOPA LUNULATA MINENSIS Cockerell.

South China; one male.

XYLOCOPA CONFUSA Pérez.

Bg. Tambelan Island, China Sea (W. L. Abbott); Trong, Lower Siam (W. L. Abbott); Shanghai, China (E. Deschamps); Buitenzorg, Java (D. G. Fairchild).

XYLOCOPA SINENSIS Smith.

Four females from Foochow, China (H. R. Caldwell). This is the type-locality.

XYLOCOPA COLLARIS Lepeletier.

Khow Sai Dow Mountain, 1,000 feet, Lower Siam (W. L. Abbott); Trong, Lower Siam (W. L. Abbott).

XYLOCOPA NITIDIVENTRIS Smith.

Kukiar, eastern Turkestan, July 28, 1894 (W. L. Abbott).

XYLOCOPA COLLARIS NIGRESCENS Friese.

Like *X. collaris binghami* Cockerell, from the Khasia Hills, but distinguished as follows:

Female.—Abdomen distinctly greenish; light hair of front and sides of thorax bright fulvous, that on thorax in front more extensive and not distinctly defined posteriorly; sides of mesothorax and hind part of scutellum with short pale fulvous hair; wings, as in *binghami*, paler than in typical *collaris*.

Male.—Almost exactly like *binghami*, but a little larger (length about 21 mm.), and the fifth abdominal segment with a broad band of pale hair, which is separated from the pale-haired part of abdomen in front by a dark band (the first four segments being pale-haired).

Habitat.—Horisha, Formosa (T. Fukai).

This was described as new, but after the manuscript was sent in Friese published it as *X. sauteri*, var. *nigrescens*.

The following table separates the males of the *collaris* type:

First four abdominal segments pale-haired, and a broad pale band on fifth.	<i>nigrescens</i> .
First three segments pale-haired.....	<i>binghami</i> .
First two segments pale-haired.....	<i>collaris (dejeani)</i> .

SPHECODES JAPONICUS, new species.

Male.—Length 8 to 9 mm.; head and thorax black, very coarsely punctured, with dull white pubescence conspicuous on the face, prothorax (including tubercles), and pleura; mandibles dark; head transversely oval; face very broad, orbits strongly converging below; antennæ black, joints 2 and 3 mere rings, shorter together than fourth; joints 5 to 13 greatly swollen below, so that the flagellum is very strongly crenulated; mesothorax and scutellum with very large, irregular, partly confluent punctures; metathorax very coarsely sculptured all over with irregular ridges; posterior face of metathorax ill-defined

having a strong median sulcus; tegulæ piceous at base, but the outer half pallid; wings hyaline basally, but the outer half of anterior and third of posterior suffused with dark fuscous; second *s. m.* narrow, receiving first *r. n.* at beginning of last third; third *s. m.* very large; legs black with pale hair, the knees and last joint of tarsi red; abdomen shining, sparsely punctured, constricted at base of second segment; first segment black except sides and broad apical margin, which are red; second and third segments entirely red, fourth and following segments black.

Habitat.—Japan; two males. The name adopted was given in manuscript by Ashmead, without description.

Type.—Cat. No. 13422, U.S.N.M.

Resembles the Indian *S. fumipennis* Smith in most respects, but the wings are more broadly pale at base, and the abdomen shows more black. *S. oriundus* Vachal, from Japan, differs by the proportions of the antennal joints and the lighter wings. There is much resemblance to the European *S. gibbus*. The antennæ are quite of the *gibbus* type, but the fourth joint is considerably shorter.

SPHECODES MONTANUS Smith.

Bingham (Fauna of British India) states that the wings are hyaline, but I have examined Smith's type and find them pale fuscous.

OSMIA CHALYBEA Smith.

Edna, Texas, March 25, 1907 (F. C. Bishopp).

OSMIA LIGNARIA Say.

Dallas, Texas, March 7–17, at flowers of *Cercis canadensis* (Bishopp, Hood, and Cushman); Pittsburg, Texas, April 7 (F. C. Bishopp); Paris, Texas, March 3 and April 15 (A. A. Girault and C. T. Brues); Ardmore, Oklahoma, March 12, at flowers of peach (Bishopp); Mound, Louisiana, on turnip, March 7 (Bishopp).

OSMIA MITSUKURII, new species.

Female.—Length almost 12 mm.; head and thorax obscure greenish; abdomen black, with the hind margins of the segments rather broadly fulvous; ventral scopa orange, but seeming redder than it really is, owing to the orange pollen it carries; hair of head and thorax long but not dense, rather dull white more or less mixed with black, not at all ochreous or fulvous; face and vertex with much dark hair; lower part of cheeks with a large beard of white hair; dark hair of thorax above scanty; clypeus with a great triangular shining black excavation, strongly keeled down the middle, and bounded on each side by a large triangular projecting lamina; part of clypeus outside of the excavation green and punctured, the part just above the apex of excavation somewhat keeled; mandibles broad, tridentate, but the

middle tooth short, and the broad inner one rudimentary; malar space short but distinct; mesothorax and scutellum shining, well punctured, but not very densely; tegulæ dilute orange; wings hyaline stained with reddish-brown; legs black with red spurs; hair on middle basitarsus conspicuously red, on hind basitarsus dark fuscous; abdomen without hair-bands or spots, but with scanty long pale hair, and fuscous subapically on fourth and fifth segments; last dorsal segment with fine appressed hair. The flagellum is faintly reddish beneath.

Habitat.—Japan; No. 134, probably collected by Mitsukuri.

Type.—Cat. No. 13423, U.S.N.M.

Closely related to *O. taurus* Smith, from which it is known by the absence of fulvous pubescence on head and thorax, and to *O. excavata* Alfken, which is, however, only $8\frac{1}{2}$ mm. long. The area of the metathorax is dull and without evident sculpture, and the abdomen is rather long. As seen from above the general size and shape recalls *O. fulviventris* Latreille, but *fulviventris* has a larger head, a blue-black abdomen, and a brilliantly shining area of metathorax. *O. fulviventris* has an orange scopa, and the structure of its clypeus shows a certain approach to the condition in *O. mitsukurii*.

OSMIA MATSUMURÆ, new species.

Male.—Length about $8\frac{1}{2}$ mm.; head and thorax very dark bluish-green; abdomen dark olive green, the apical margins of the segments extremely narrowly, hardly noticeably, testaceous; antennæ long and slender, black, last joint normal; face with abundant long white hair, as also cheeks below; more or less pale hair on upper part of head, but sides of front, vertex, and upper parts of cheeks with a good deal of black hair; head and thorax quite closely punctured, scutellum less closely; area of metathorax dull, without evident sculpture, somewhat shining in certain lights; hair of thorax long, slightly yellowish, not mixed with black; tegulæ piceous, slightly rufous in middle; wings brownish-hyaline; recurrent nervures entering second submarginal cell at about the same distance from base and apex, whereas in *O. mitsukurii* the first recurrent enters about twice as far from the base as the second from the apex; legs black with pale hair; last two tarsal joints ferruginous; hind basitarsus simple with ferruginous hair on inner side; abdomen with scanty long hair like that of the thorax; sixth segment entire, quite simple, not reflexed; seventh entire, broadly truncate; ventral segments quite simple; stipites simple, with a mere obtuse median angulation; notch in sagittal plate a little longer than half breadth of plate.

Habitat.—Sapporo, Japan (Matsumura). Apparently close to *O. mitsukurii*, but owing to the quite different tegulæ and the venation can not be its male. It is structurally similar to the male of *O. taurus*, and among European species to *O. bicornis* Linnæus.

Type.—Cat. No. 13424, U.S.N.M.

CROCISA JAPONICA Friese.

One from Japan. *C. centrimacula* Pérez, also from Japan, and published in the same year (1905) is very closely allied, but apparently separable by the pattern of the first abdominal segment, the white (instead of blue) hair on hind basitarsi, and some other small details.

BOMBUS SAPPOROENSIS, new species.

Female.—Like the European *B. terrestris* Linnæus, but hair on last three abdominal segments pale reddish-fulvous; yellow bands on second abdominal segment and prothorax pale and dull, the thoracic one with black hairs intermixed; labrum with a transverse curved ridge, and below this much red hair; third antennal joint about as long as fifth, fourth a little shorter; malar space broader than long.

Habitat.—Japan; from M. Matsumura, Sapporo Agricultural College. This is a Japanese form of *terrestris*, regarded as a distinct species because the European *terrestris* seems to present no such color-variety. *B. terrestris japonicus* Friese, 1909, has the end of the abdomen black; it may perhaps be a variation of *sapporoensis*, but if so, the name *japonicus* is not available, having been earlier used by Dalla Torre. *B. harmandi* Pérez has the abdomen colored like that of *sapporoensis*, but it is a species with elongated head, allied to *B. hortorum*.

Type.—Cat. No. 13425, U.S.N.M.

BOMBUS SENILIS Smith.

One worker; Sapporo Agricultural College, Japan, December, 1896 (M. Matsumura). Smith described only the female. The worker looks exactly like *B. silvarum*, but the specimen before me has the light pubescence creamy-white, with a strong yellow tinge on the second abdominal segment.

BOMBUS DIVERSUS Smith, 1869.

Eleven from Japan; some collected by Mitsukuri. One is from Tokyo. These agree with a *diversus* from F. Smith's collection. Friese makes both *diversus* Smith and *japonicus* Dalla Torre (*terminalis* Smith, 1873) varieties of *B. hortorum*, subspecies *ussurensis* Rałoszkowski, 1877. If this is considered correct priority demands that *diversus* be used for the subspecies.

BOMBUS IGNITUS Smith.

Seven from Japan; some collected by Mitsukuri. Very like *B. lapidarius* Linnæus, but malar space shorter. Pérez considers that it is structurally nearer to *B. terrestris*. The pubescence of *ignitus* varies, the black becoming a dark chocolate brown, as is also seen in *B. hæmorrhoidalis*. This brown variation is especially marked in a female labeled "South China." This Chinese *ignitus* is readily known from *B. simillimus* Smith by the paler wings.

BOMBUS SPECIOSUS Smith.

Seven from Japan (Mitsukuri). This greatly resembles the Chinese *B. trifasciatus* Smith, but is clearly distinct.

BOMBUS BICOLORATUS Smith.

Horisha, Formosa (T. Fukai).

BOMBUS BIZONATUS Smith.

One female; Tagdumbash, Pamir, 13,000 feet, June 9, 1894 (W. L. Abbott). In Schmeideknecht's tables this runs nearest to *nivalis*, but is not of that group. It looks much like *braccatus* Friese, but differs in the antennæ, mandibles, etc. It is very close to *B. hortorum*, but distinct.

The following characters may be noted: Mandibles strongly notched near inner apical corner; third antennal joint about as long as 4+5; third *s. m.* much longer than in *hortorum*; apical segments of abdomen whitish-red, black abdominal band narrow, thoracic band much narrower than in *hortorum*.

CHELYNIA ELEGANS Cresson.

Two from Flagstaff, Arizona, at flowers of *Iris*, June 11, 1909 (F. C. Pratt).

HABROPODA PEKINENSIS, new species.

Male.—Closely related to *H. zonatula* Smith; on comparison with a *zonatula* from Smith's collection (Nicopolis, May, 1836) the following differences are found: A little less robust; abdomen narrower, less triangular, more as in *Anthophora*; pubescence paler, not so red; flagellum longer and more slender, fourth antennal joint much longer; first *r. n.* not quite reaching apex of second *s. m.*; black on clypeus reduced, the middle broadly yellow to top, the large black markings variable, but constricted in middle; pygidial plate much broader; anterior femora strongly keeled beneath at base; hind tarsi red. The anterior coxæ have the characteristic long backwardly-directed spines, and the hind basitarsi the great flattened lamina. The male is the type.

Female.—About 16 mm. long, with the same ochreous hair covering thorax, the same black abdomen with light hair-bands; face, mandibles, and antennæ entirely dark; fifth abdominal segment with the hair clear fox-red in middle, cream-colored at sides; scopa of hind legs light golden-ferruginous; eyes pale green, stained with red.

Habitat.—Pekin, China, 1901 (M. L. Robb). Four males; April 19 (2), April 20, April 21. Twenty-three females; April 19 (12), April 20 (5), April 21 (5), April 22 (1).

Type.—Cat. No. 13426, U.S.N.M.

Known from *H. krishna* Bingham by the deep yellow face markings of male (face marks white in *krishna*); from *H. fulvipes* Cameron by the absence of light face marks in the female, and the dark legs (legs are fulvous in female *fulvipes*); from *H. montana* Radoszkowski by the dark, pale-banded abdomen (abdomen densely covered with hair in *montana*); from *H. magretti* Bingham by the black flagellum of the male and the darker legs; from *H. mælleri* Bingham by the dark abdomen (abdomen and legs honey-yellow in *mælleri*); from *H. balassogloi* Radoszkowski by the black flagellum of the male, etc.; from *H. turneri* Cockerell by the unicolorous hair of thorax, etc.

ANTHOPHORA ZONATA (Linnæus).

Four from Foochow, China (H. R. Caldwell).

ANTHOPHORA FIMBRIATA Smith.

Khow Sai Dow Mountain, 1,000 feet, Lower Siam (W. L. Abbott); Trong, Lower Siam (W. L. Abbott). These females differ from the type as described by Bingham and Smith by having the metathorax black-haired. The hair of the thorax above is not "grey," as Bingham states, or "bluish-white, tipped with black," as Smith has it, but is very pale blue mixed with black. This species strongly imitates *Mesotrichia abbotti* Cockerell, which lives in the same region.

MEGACHILE XYLOCOPOIDES Smith.

Five females, Mansfield, Louisiana, at flowers of *Helenium tenuifolium*, July 4 and August 22 (F. C. Bishopp).

MEGACHILE VELUTINA Smith.

One female, Khow Sai Dow Mountain, 1,000 feet, Lower Siam, February, 1899 (W. L. Abbott); five females, Trong, Lower Siam, January, February, 1899 (W. L. Abbott). Only one (Trong) has the first two abdominal segments with red hair; the others have the first and basal part of second with red hair. The allied *M. dimidiata* varies in the same manner, according to Bingham. The one from the mountain is smaller than the others.

HETERANTHIDIUM CHIPPEWAENSE (Graenicher).

I am indebted to Doctor Graenicher for a cotype of his *Anthidium chippewaense*; it proves to belong to *Heteranthidium*.

DIANTHIDIUM ILLUSTRE (Cresson).

At Flagstaff, Arizona, at flowers of *Iris*, June 11, 1909, Mr. F. C. Pratt took a large variety of the female of this species, about 17 mm. long, the width of the abdomen fully 6 mm. The wings are very dark; the first *r. n.* joins the second *s. m.* a short distance from base (as in

A. conspicuum), and the second goes a like distance beyond apex. There is a small pulvillus, present also in typical *illustre*. I think there is no doubt that *Anthidium illustre* must be referred to *Dianthidium*. The Flagstaff specimen also has these characters: First two abdominal bands notched behind laterally; black on inner side of hind femora not notched; other colors, of head, legs, etc., normal; hair of face, and head and thorax above strongly reddish; yellow occipital band not interrupted. This female takes on some of the color characters normal for the male. It is possible that a distinct subspecific form of *D. illustre* exists in the region about Flagstaff, but more material is needed to decide this.

NOMADA BELFRAGEI, var. XANTHOGASTER, new variety.

Female.—Agrees with Cresson's description of *N. befragei*, except as follows: Only a slight blackish suffusion about ocelli; thoracic markings clear lemon yellow; abdominal segments 1 to 5 each with a very broad lemon yellow band, but those on first and second narrowly interrupted in middle, and that on first including a small red spot on each side posteriorly; venter with yellow spots down the middle, those on segments 3 and 4 large and conspicuous. As in true *befragei* (concerning which I have notes from Mr. Viereck, based on Cresson's type), the third antennal joint is conspicuously larger than the fourth, and the basal nervure meets the transversomedial. The second *s. m.* is considerably narrowed above, and receives the first *r. n.* a little beyond the middle. The anterior coxal spines are present, but very short. From the related *N. wheeleri* Cockerell this is easily known by the entirely terra-cotta red mesothorax and metathorax. Superficially, it looks exactly like *N. lamarensis* Cockerell, but is easily separated by the very large, strongly punctured tegulæ; the much lighter wings; and the hair at apex of abdomen all pale (much black in *lamarensis*). The coarsely punctured abdomen separates it at once from the similar species of *Xanthidium*.

Habitat.—Texas (Belfrage).

Type.—Cat. No. 13427, U.S.N.M.

NOMADA MACULIFRONS, var. COMPARATA, new variety (? new species).

Female.—Length about 10 mm.; differs from Smith's description of *maculifrons* as follows: Lateral black bands of mesothorax much enlarged, so that it is better described as black marked with red; antennæ clear ferruginous, not at all fuscous above; vertex and front except sides (which are red) black, the black extending down to sides of clypeus, but inclosing a large red supraclypeal mark; metathorax black, with two obscure small red spots on each side; scutellum black, strongly bigibbous, the gibbosities yellow with a red margin;

postscutellum with a short yellow band; band on fourth abdominal segment notched but not interrupted; that on fifth divided into two large spots; third ventral segment with two large yellow marks, fourth with one. Especially characteristic of the species is the large, smooth and shining yellow mark on each side of face. Structural characters, not mentioned by Smith, are as follows: Mandibles simple; third antennal joint shorter than fourth, though both are quite long; tegulæ rather large, well punctured; area of metathorax rugose basally; wings long; *b. n.* going far basad of *t. m.*; second *s. m.* receiving first *r. n.* before middle; abdomen very finely punctured; crescentic apical patch rather large. The femora, tibiæ, and tarsi are entirely red, except that the hind femora have a blackish streak behind. The tubercles are prominent, yellow margined with red, and the upper border of the prothorax is yellow, red at each side. There is a very large red patch on the pleura. This is perhaps a distinct species, but as it is evidently close to *N. maculifrons*, and I have not been able to compare specimens; I leave it for the present as a variety. The abdomen, in its color and pattern, shows a strong superficial resemblance to that of *N. ruficornis* Linnæus, variety, from Jena; but in the *ruficornis* the yellow spot on the third segment is sublateral instead of lateral, and there is no yellow spot laterad of the band on the fourth. In Schmiedeknecht's table of European species it runs to 52, and runs out because the yellow spots on scutellum are separated, and the hind tibial apical spinules are red. It runs nearest to *N. lineola* Panzer, which it really does resemble to a considerable extent.

Habitat.—Japan.

Type.—Cat. No. 13428, U.S.N.M.

NOMADA RUFICORNIS KOEBELEI, new subspecies.

Female.—Length about 9 mm., not especially robust, ferruginous, marked with black and yellow, the yellow confined to the abdomen. Head broad, ferruginous, including labrum and the simple mandibles; a black band extends from each side of clypeus to middle of front, which is broadly black; ocelli on a black patch, but a transverse red band in front of them; eyes light red; antennæ long, rather thick, entirely ferruginous; third joint long, but shorter than the very long fourth; fifth about as long as third; mesothorax and scutellum little hairy, very densely punctured; mesothorax with three black bands, the lateral ones partly evanescent; scutellum moderately elevated, entirely red; area of metathorax large, triangular, plicate at base; metathorax with a broad median black band, becoming greatly enlarged below the area; mesopleura red; tegulæ red, well punctured; wings with a broad dark apical margin; *b. n.* meeting *t. m.*; second

s. m. not nearly so broad as third, receiving first *r. n.* beyond the middle; legs red, the femora wholly without black; abdomen bright ferruginous, nearly the basal half of first segment black, the margin of the black straight; first segment wholly without yellow; second with a very large triangular lemon-yellow mark on each side, the distance between the yellow patches less than the length of one; third segment without yellow; fourth with an interrupted yellow band; fifth with a very large quadrate yellow patch, about twice as broad as long; apical pubescent lunule narrow (anteroposteriorly); pygidial plate broad; apical hair pale brown; third and fourth ventral segments each with a broad yellow band. Japan (Kœbele); =type.

Female (var. *a.*).—Third antennæ joint shorter; middle of face black, with a red supraclypeal spot; metathorax with more black; *b. n.* going some distance basad of *t. m.*; second *s. m.* broader, receiving first *r. n.* at middle; femora with a little black at extreme base; band on fourth abdominal segment entire; no yellow on underside of abdomen. Japan. "23.4" on the label may mean that it was taken on April 23. This is very possibly a distinct species.

Male.—Agrees in venation with the type female. Head and thorax black; broad lower margin of clypeus, mandibles except tips, labrum, and very narrow lateral face-marks ending in a point about level of antennæ, all yellow; scape stout, black behind, red in front, with a yellow patch on inner (mesad) side; flagellum black above, ferruginous beneath; third antennal joint much shorter than fourth; posterior half of tubercles, and two small spots on scutellum, red; middle femora with a black band behind, hind femora largely black; black of first abdominal segment broadly lobed in middle, and a small black spot on each side; second segment with a broad black basal triangle, projecting between the yellow marks; third and fourth with about the basal half black; third with a yellow band below the black on each side; fourth with a narrow interrupted yellow band; fifth with a patch; apical plate truncate, not notched; venter with large yellow markings. Japan, No. 163.

Type.—Cat. No. 13429, U.S.N.M.

I first compared this insect with the Old World *Nomadæ* in my collection, and concluded that it was very close to *N. ruficornis* (Linnæus). I then ran it in Schmiedeknecht's tables of European *Nomada*, and found that the male ran directly to *ruficornis*; the female less certainly, but still better there than anywhere else. It is well known that *N. ruficornis* is exceedingly polymorphic, and while the Japanese insect may be specifically distinct, and perhaps the var. *a* is another species, it seems best to treat the scanty material at present available as a subspecies only. On the whole, it evidently comes nearest to the northern variety *glabella* Thomson. The male is very like the American *N. illinoensis* Robertson.

NOMADA FRIESIANA Cockerell.

This has been known only by the unique type. The U. S. National Museum contains 2 females collected at Denver, Colorado, May 23, 1898. The name of the collector does not appear on the labels. The insect has a curious superficial resemblance to the European *Pasites maculatus*.

NOMADA HAKONENSIS, new species.

Male.—Length slightly over $6\frac{1}{2}$ mm.; head and thorax black, densely punctured, with the usual amount of hair, which is pale ochreous above and white beneath; head broader than long; lower margin of clypeus, narrowly in middle, broadly at sides, lower corners of face, ending in a fine point above which hardly reaches level of antennæ, labrum, and mandibles except their ferruginous apices, all *yellow*; mandibles simple; labrum densely covered with light hair; eyes pale greenish; antennæ long, black above, ferruginous beneath, the red on the rather stout scape reduced to a streak; third antennal joint hardly half length of fourth; fourth long; fifth longer than third; tubercles and a little of upper margin of prothorax red, but scutellum, etc., wholly black; area of metathorax shining and strongly plicate basally; femora with much black; tibiæ and tarsi red, the tibiæ with a weak black stripe; hind basitarsi, dark above; tegulæ ferruginous; wings strongly dusky on apical margin; stigma and nervures dark ferruginous; *b. n.* going far basad of *t. m.*; second *s. m.* about as broad above as below, receiving first *r. n.* before the middle; abdomen shining, without distinct punctures, dull ferruginous marked with black, the markings suffused, the general effect being very dark red; first segment with the basal half black, the black broadly lobed in middle, and having a dark spot on each side; the other segments obscurely blackish at base; hind margins of segments, especially the posterior ones, more or less pale golden; apical plate deeply notched; venter dark ferruginous.

Habitat.—Hakone, Japan (Kœbele).

Type.—Cat. No. 13430, U.S.N.M.

A small species of *Nomada s. str.*, quite different from all those reported from Japan, but superficially like the European *N. flavoguttata*. In Schmiedeknecht's table it runs near to *N. fabriciana* (Linnæus), but it is by no means identical.

NOMADA XANTHIDICA Cockerell.

A slight variety of the female having the metathorax wholly black. Two from Peking, China (M. L. Robb). One is dated May 7, 1901.

NOMADA ZEBRATA Cresson.

Male.—At flowers of *Helianthus pumilus*, Boulder, Colorado, July 21, 1908 (S. A. Rohwer); female, Fort Collins, Colorado, 1899 (No. 26).

NOMADA LIBATA Cresson.

Female.—Custer County, Colorado (Cockerell). This fine species looks exactly like *N. vallesina* Cockerell, except that it is larger and more robust. The following differences appear on minute comparison:

Inner orbits almost parallel; third antennal joint longer; anterior coxæ with a rudimentary spine; scutellum slightly bigibbous; apical part of flagellum darkened; cheeks entirely red; tegulæ large.....	<i>N. libata</i> .
Inner orbits diverging above; third antennal joint shorter; scutellum strongly bigibbous; apical part of flagellum red like the rest; posterior part of cheeks black; tegulæ ordinary.....	<i>N. vallesina</i> .

NOMADA SEMISCITA Cockerell.

A male from Denver, May 26, 1898, has a short broad supra-clypeal mark in the manner of *N. martinella* and *scita*. The species differs from these by the comparatively short and thick fourth antennal joint (in *martinella* this joint is quite long and excavated on the outer side), the fifth joint with a prominent thorn-like spine, the second *s. m.* receiving the first *r. n.* at the middle (beyond in *martinella*), the postscutellum entirely black, the two light marks on the first abdominal segment each inclosing a ferruginous spot. In the new specimen the apical plate of the abdomen is strongly notched. This is perhaps the male of *N. frieseana*.

NOMADA SCITA Cresson.

Males are from Denver, Colorado, May 26, 1898; Colorado, 2076 (Baker collection), and Los Pinos, Colorado, at *Erigeron* May 22, 1899. This is smaller than male *N. martinella*, but on comparing a series the supposed differential characters seem evanescent and I am not altogether satisfied that the two species are distinct. The female of *N. scita* has not been described, but one was taken by Baker at Los Pinos, Colorado, on *Erigeron*, May 22, 1899. It is smaller and darker than *N. martinella*, but otherwise similar. Comparison was made with the usual Colorado *martinella*; but the true type of that species from New Mexico was small, though clear bright red.

NOMADA MARTINELLA Cockerell.

The U. S. National Museum contains 7 females from Colorado (Baker 2076 and 1332). In my original description ^a for Sioux City read Sioux County.

NOMADA (MELANOMADA) HELENIELLA, new species.

Female.—Length 5–5½ mm.; head and thorax black, abdomen clear red; mandibles rather dark red; face broad, covered with appressed pale hair; antennæ dark, third joint reddish, shorter than fourth on

^a Proc. Acad. Nat. Sci. Phila., 1903, p. 590.

under side; tegulae shining dusky red; wings dusky at apex; *b. n.* meeting *t. m.*; legs dark reddish-brown, with white hair; sides and apex of abdomen with white hair. Closely resembles *N. grindeliae* differing by the smaller size and slightly in coloration. The abdomen may have a slight dusky suffusion. In both species there is a semi-circular finely white-tomentose area at the end of the abdomen.

Male.—Length about $4\frac{1}{2}$ mm.; resembling *N. grindeliae*, but much smaller, with the abdomen variably suffused with reddish at the apices of the first two segments.

Habitat.—Victoria, Texas, at flowers of *Helenium tenuifolium* Nuttall, September 26, 1904 (J. C. Crawford). Four males and three females are before me, and as the small size is uniform, I think the species must be considered distinct. Mr. S. A. Rohwer had already recognized it as new. There is some question whether *Melanomada* should not stand as a distinct genus. Mr. J. C. Crawford examined the mouth-parts of *N. grindeliae*, and found that the maxillary palpi had joints 3 to 5 subequal, 6 longer; joint 2 about equal to 3+4; joint 1 shortest. He pointed out that the development of joint 2 was characteristic.

Type.—Cat. No. 13431, U.S.N.M.

There is a rather close resemblance between *Melanomada* and *Viereckella*. Doctor Graenicher has sent me both sexes of *Viereckella pilosula* (*Nomada pilosula* Cresson) from Milwaukee, Wisconsin, where it flies in July and August. Both sexes have the abdomen black, resembling the male of *Melanomada*. The males are separable by several good characters, as follows:

Face broad, inner orbits parallel; venation ordinary for <i>Nomada</i> , second <i>s. m.</i> receiving first <i>r. n.</i> well before end, third <i>s. m.</i> narrow above; legs ordinary; apical plate of abdomen broad, rounded, broadest at base.....	<i>Melanomada</i> .
Inner orbits strongly converging above, so that the lateral ocelli are distant from eyes less than their own diameter; second <i>s. m.</i> receiving first <i>r. n.</i> very near end, third <i>s. m.</i> very broad above; middle and hind femora incrassate; apical plate of abdomen spoon-like, narrower toward base.....	<i>Viereckella</i> .

The type of *N. heleniella* is a female.

NOMADA WHEELERI ENGELMANNIÆ, new subspecies.

Female.—Length $7\frac{1}{2}$ to 9 mm., agreeing with the description of *N. wheeleri* except as follows: Light markings cream-color; red line along anterior orbits interrupted in frontal region; mesothorax with a broad black band, and the red in front deeply emarginate on each side; light color of scutellum narrowed but not divided in middle; pleura red, broadly margined, except below, with black, and with no yellow spot; wings more dusky, the broad apical margin dark; first abdominal segment with the basal half black; second and third segments with much black at base, band on second narrowly or broadly interrupted, but always extremely broad laterally.

Habitat.—Dallas, Texas, May 22, 1906, at flowers of *Engelmannia pinnatifida* Torrey and Gray (W. S. Pierce); also one from Dallas, May 17, 1908 (F. C. Bishopp). Perhaps a distinct species, but certainly very close to *N. wheeleri*, which is known from a single specimen. These species fall in a little group, in which the coxal spines are not distinctly developed, and yet the insects accord in general with the subgenus *Micronomada*.

Type.—Cat. No. 13432, U.S.N.M.

The following key contrasts the members of this group:

- | | |
|---|-------------------------------|
| Mesothorax at least largely red (Texas)..... | 1. |
| Mesothorax black without red..... | 2. |
| 1. Markings yellow; pleura with a yellow spot..... | <i>wheeleri</i> Cockerell. |
| Markings cream-color; pleura without a yellow spot..... | <i>engelmanniæ</i> Cockerell. |
| 2. Markings yellow (Virginia)..... | <i>mimula</i> Cockerell. |
| Markings creamy-white (Washington State)..... | <i>jennei</i> Cockerell. |

Since the above was written I have examined two males of *N. wheeleri engelmanniæ* collected by Mr. C. L. Marlatt in Riley County, Kansas, September. They have the following distinctive characters:

Length about 9½ mm.; coxal spines absent; face light lemon yellow up to level of antennæ, the lateral face marks extending obliquely upward laterally, ending in a sharp point on orbital margin near level of middle of scape; supraclypeal mark square; labrum, and base of mandibles broadly, pale yellow; posterior orbital margin narrowly pale yellow; *scape greatly swollen, entirely bright ferruginous red*; flagellum darker red; third antennal joint much longer than fourth; mesothorax very densely punctured, entirely black; metathorax black, with a small red spot on each side; upper border of prothorax, tubercles, tegulæ, scutellum, and postscutellum cream-color; pleura with a very large red patch, inclosing a variable yellow one; legs red, hind coxæ with a large whitish spot; abdomen like that of female; apical plate broad and rounded, with a feebly indicated notch. Some one had labeled this "*heiligbrodtii* Cresson?". It is entirely different from the described male of *heiligbrodtii*, which (according to Viereck, who examined the type for me) has a slender scape. I have long thought that the described male of *heiligbrodtii* did not truly belong with the female, but the female of the present insect is known, and is quite distinct from *heiligbrodtii*.

NOMADA RUBICUNDA Olivier.

Liberty, Texas, 2 females, March 18, 1908 (E. S. Tucker).

NOMADA ARTICULATA Smith.

Mound, Louisiana, April 2 (F. C. Bishopp) and May 12 (C. R. Jones). Boulder, Colorado, nesting in my garden, June (Cockerell). I examined the spine on the anterior coxa of a Louisiana male, and found it about 150 μ long, very broad at base, hidden among plumose hairs twice its length, which carry pollen.

NOMADA LIMATA Cresson.

Brownsville, Texas, November 24, 1909 (F. C. Pratt). A species heretofore known from tropical Mexico only. *N. pampicola* Holmberg, which I have from Paraguay (Schrottky), is closely allied.

NOMADA VIERECKI Cockerell.

Ladonia, Texas, May 25, 1904, at flowers of *Rudbeckia* (Bishopp). Previously known only from New Mexico and the State of Chihuahua, Mexico.

NOMADA GARCIANA Cockerell.

This species was described from a specimen taken in the Mesilla Valley, New Mexico. The specimens from Texas have a slightly different aspect, but after careful comparison I can not find any characters on which to separate another species. The insect looks like a small *N. texana*, but the mesothorax is shining, with well separated punctures. The Texan variety may be distinguished by the yellow markings of the head and thorax (varying in depth of color), those of the New Mexico type being ivory color.

Falfurrias, Texas, at flowers of *Helianthus*, May 18, 1907 (A. C. Morgan); Runge, Texas, September 20, 1906, both sexes (J. C. Crawford); Calvert, Texas, April 5 and 10 (C. R. Jones); Eagle Pass, Texas, March 30, 1908 (Jones and Pratt).

NOMADA PUTNAMI Cresson.

Like a large *N. garciana*, the punctures on mesothorax well separated; the markings of head and thorax yellower. Laredo, Texas, at flowers of *Prosopis glandulosa*, June 5, 1907 (R. A. Cushman); Ladonia, Texas, at *Rudbeckia*, species, May 25, 1904 (Bishopp). *N. putnami* was described from Utah; the insect from Texas may prove to be distinct, but as it agrees with Cresson's description I can only refer it to his species.

NOMADA RIVALIS Cresson.

California, one male (Morrison). This species is very close to the Rocky Mountain *N. ornithica* Cockerell; they may be separated as follows:

Larger; *b. n.* going a considerable distance basad of *t. m.*; second *r. n.* received about middle of third *s. m.*; black bands from antennæ half way down sides of clypeus; scutellum with two yellow spots; postscutellum black; hind femora ordinary. . . *rivalis*.
Smaller, but variable in size; *b. n.* meeting *t. m.*, sometimes a little on the basad side; second *r. n.* received much beyond middle of third *s. m.*; no black bands extending down from antennæ; yellow of scutellum not divided into spots; postscutellum with a yellow band; hind femora stout. *ornithica*.

NOMADA CROTCHII Cresson.

Two females, Los Angeles County, California, April (Coquillett).

NOMADA PASCOENSIS Cockerell.

One male, Los Angeles County, California (Coquillett 482).

NOMADA MARGINELLA Cockerell.

A slight variety, with the *b. n.* going some distance basad of *t. m.*, but all other characters normal. One female, Los Angeles County, California (Coquillett).

NOMADA VINCTA Say.

Females, Riley County, Kansas, August and September (Marlatt).

NOMADA LAMARENSIS Cockerell.

This was described from a single male taken at Lamar, Colorado. Mr. W. M. Mann sends me one of each sex from Canadian, Texas, July 27 and 29, 1905. The male is larger than the original type (fully 11 mm. long), and the black is much reduced, on the head to the ocellar area, on the thorax to a slight stain along the anterior edge of the mesothorax. All the tibiae are marked with yellow. These differences are apparently not racial. The female looks like the male, but the face is all red, with a slight yellowish suffusion on each side. The legs show less yellow.

NOMADA TEXANA Cresson.

According to the material before me, this is by far the most abundant *Nomada* in Texas. The localities represented are:

(1) Dallas, May 22, at *Engelmannia pinnatifida* flowers (W. D. Pierce); May 19, at *Gaillardia pulchella* flowers (Bishopp); September 13 (Bishopp). A large (about 10½ mm. long) male was taken at *Monarda citriodora*, July 3 (Crawford).

(2) Plano, about 17 miles north of Dallas, July (Tucker).

(3) Falfurrias, at *Helianthus*, May 18 (A. C. Morgan).

(4) Wolfe City, at turnip, May 20 (Bishopp).

(5) Mathis, May (A. W. Morrill).

(6) Paris, on cotton (C. R. Jones). Others taken at Paris by Bishopp have the tegulae more or less orange, perhaps the effect of cyanide.

(7) Ladonia, at *Rudbeckia*, May 25 (Bishopp); September 29, on cotton (Bishopp).

(8) Mineola, at *Heterotheca subaxillaris*, October 2 (Bishopp).

(9) Waco, at *Vernonia baldwinii*, July 25 (Bishopp).

(10) Riverside, August 22 (W. W. Yothers).

(11) Wichita Falls, at *Monarda*, April 11 (C. R. Jones).

(12) Cotulla, at *Verbesina encelioides*, April 17 (F. C. Pratt); at *Pithecolobium*, April 18 (F. C. Pratt).

(13) Beeville, June 5, in cotton fields (C. R. Jones).

Also East Point, Louisiana, September 5 (Bishopp).

The following localities produced a rather small variety, intermediate between *texana* and *crucis*:

(14) Kerrville, over 50, only one being a male. Collected in April, many at *Marrubium vulgare* flowers (Pratt and Dunham).

(15) Devils River, at *Monarda citriodora*, May 6 (Bishopp); at *Gaillardia pulchella*, May 2 and 6 (Bishopp); at Sumach, May 3 (Bishopp); at *Marilaunidium organifolium*, May 3 and 4 (Bishopp and Pratt).

(16) Del Rio, at *Ratibida columnaris* and *Pyrrhopappus carolinianus*, May 1 (Bishopp).

(17) Brewster County, Rio Grande, June 13-17 (Mitchell and Cushman).

NOMADA TEXANA CRUCIS (Cockerell).

Nomada crucis was described in 1903 as a doubtful subspecies of *N. texana*, based on the smaller size and coarser sculpture of the metathorax. As it occurs in southern New Mexico it appears sufficiently distinct from typical *N. texana* of east-central Texas, but the abundant material now before me clearly shows intergradation in south-central Texas, north of the Rio Grande. I give a figure of the genitalia of *N. crucis* from Devils River. I also prepared a slide of the genitalia of quite typical *texana* from Plano, and so far as I can see there is no essential difference. As we go down the valley of the Rio Grande, practically normal *N. crucis* is found to be mixed with larger individuals, which can be regarded as rather small *texana*. The females lead in this increase of size, but in humid Texas both sexes are of full *texana* size, and even at Cotulla (10 males 6 females examined) this is the case, with rare exceptions. It is not unlikely that *crucis* is largely or even wholly an environmental product, not gametically different from true *texana*.

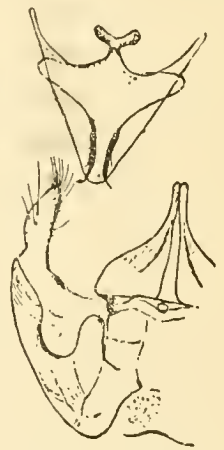
A single male *crucis* (here a mutant or dwarf of *texana*?) comes from Ardmore, Indian Territory, August 18 (Bishopp). The Texan material is as follows:

(1) Eagle Pass, March 30; male with third antennal joint shorter than usual (Jones and Pratt).

(2) Del Rio, both sexes, May 1 (Bishopp). Some are from flowers of *Pyrrhopappus carolinianus*.

(3) Cotulla, a single male from *Verbesina encelioides*, May 11 (J. C. Crawford).

(4) Devils River, 28 males, 1 female. Collected from *Marilaunidium organifolium*, May 3 (Pratt); *Sphæralcea angustifolia*, May 3 (Bishopp); *Aster* sp., May 1 (Bishopp); Sumach, May 6 (Bishopp); *Monarda citriodora*, May 4 (Pratt); *Gaillardia pulchella*, one specimen (Bishopp).



GENITALIA OF MALE
NOMADA TEXANA
CRUCIS.

NOMADA (MICRONOMADA) MITCHELLI, new species.

Female.—Length 6 to 7 mm.; black, red, and yellow; head short and broad, face shining; clypeus, labrum, mandibles except tips, and whole of sides of face rather light ferruginous; supraclypeal area suffusedly reddish, front and vertex black; the red continues broadly upward some distance above antennæ, and then stops abruptly, except for a narrow line (sometimes absent) along the orbital margin, uniting with the narrow post orbital ferruginous stripes; vertex shining, not closely punctured; antennæ entirely ferruginous, the flagellum a little dusky above; third joint conspicuously longer than fourth; second joint of labial palpi much less than half length of first; thorax black, pleura with a large but variable red patch, and inclined to be suffused with reddish above; upper border of prothorax, tubercles, tegulæ, the rather strongly bilobed scutellum (except the posterior middle) and the postscutellum chrome yellow; the metathorax without light marks; pleura strongly and quite densely punctured; mesothorax shining, with well-separated punctures; wings dark, strongly reddish; stigma ferruginous; *b. n.* meeting *t. m.*; second *s. m.* broad, receiving first *r. n.* about middle (one specimen has only two submarginals on both sides, the second *t. c.* being wholly obliterated); legs entirely clear ferruginous, anterior coxæ with long spines; abdomen shining, but well punctured, black inclining to reddish, especially on the hind margins of the segments, with bright yellow bands, that on first segment narrow and interrupted, with a notch on each side in front, or reduced to two little crescents, or wholly absent; that on second extremely broad, but greatly narrowed in the middle; fifth with most of the surface yellow; venter wholly black.

Type.—Cat. No. 13433, U.S.N.M.

Male.—About 6½ mm. long; clypeus and broad lateral marks bright yellow, the latter receding from orbits above. This male is very close to *N. tiftonensis*, but the hind femora are merely dusky behind; the supraclypeal mark is reduced to an obscure dot; and the mesothorax is shining, the punctures distinctly separated. It is known from *N. garciana* by its very dark wings, very bright yellow face marks, and form of lateral marks.

Habitat.—Type (female) from Victoria, Texas, May 25, 1907 (J. D. Mitchell); also two others from the same place, May 3 and 25, 1907 (J. D. Mitchell). Male from Del Rio, Texas, May 8, 1907 (F. C. Bishopp). Nearest to *N. tiftonensis* Cockerell, from Georgia.

NOMADA (HOLONOMADA) AFFABILIS DALLASENSIS, new subspecies.

Female.—Looking exactly like *N. zebrata* Cresson, but with the mesothorax much more coarsely sculptured, and the *b. n.* going for basad of the *t. m.* The flagellum is entirely clear ferruginous, in the manner of *N. morrisoni* Cresson, not dark above as in *affabilis* Cresson. The

third antennal joint is always distinctly longer than the fourth, not about equal as in *morrisoni*. Superficially, the insect is like *N. lama-rensis*, but it is a *Holonomada*, and the metathorax, except the black (or black and red) basal area, is nearly all yellow. The basal area is considerably smaller than in *N. zebrata*. The pleura has a variable amount of yellow, and the mesothorax is always red with a single black band. The face is red, variably suffused with yellow.

Male.—Length 11 or 12 mm.; similar to *N. affabilis*, but obscure mark at top of eyes red; flagellum red, with its first six joints black above, the sides of the black sharply defined; wings yellowish; last abdominal segment (like the others) with a yellow band, the abdominal bands not narrowed in middle, except the first two slightly. The scape is thick, entirely yellow beneath. The yellow on the pleura is broadly margined with ferruginous. In my table ^a this runs to *affabilis*, except that the legs must be described as red, with yellow and black markings. The second *s. m.* is very large, and receives the first *r. n.* beyond the middle.

Habitat.—Dallas, Texas. Eight females (the type is a female), six from dewberry flowers, April 9, 1906 (Crawford and Pratt); one from blackberry, March 21, 1907 (Bishopp). One male at *Cercis canadensis*, March 22, 1909 (Bishopp).

Type.—Cat. No. 13434, U.S.N.M.

NOMADA (XANTHIDIUM) LUTEOLA BISHOPPI, new subspecies.

Female.—Third antennal joint almost or quite as long as fourth; flagellum clear red, dusky at the sutures above; mesothorax red banded with yellow, varying to reddish-black, with the median bands abbreviated; yellow of metathorax covering sides of basal area; pleura with a large yellow patch. This looks much like *N. affabilis dallasensis*, but is smaller, with the third antennal joint evidently shorter, and the mesothorax with yellow stripes.

Habitat.—Dallas, Texas, type at flowers of wild plum, March 16, 1907 (Bishopp); also one at flowers of dewberry, April 9, 1906 (J. C. Crawford). Dark variety, Monroe, Louisiana, March 4, 1908, at *Cratægus* flowers (R. A. Cushman).

A male *N. luteoloides* Robertson was taken at Logansport, Louisiana, March 24 (E. S. Tucker). I will also take occasion to record *N. luteola* Olivier from Helena, Montana, August 6, 1909 (Mann).

Type.—Cat. No. 13435, U.S.N.M.

The only male *Xanthidium* from Texas before me was taken by F. C. Bishopp at Wolfe City, at flowers of plum, March 5, 1908. It is *N. luteoloides*, but the anterior tibiæ have a large black mark behind.

NOMADA COQUILLETTI Cockerell.

A new locality is Troy, Idaho, May 7, 1909 (Mann).

^a Proc. Phila. Acad. Nat. Sci., 1903, p. 580.

NOMADA EXCELLENS Cockerell.

A female from Los Angeles County, California, collected in May by Coquillett, is about 13 mm. long, but apart from its unusually large size agrees well with this species.

NOMADA JAPONICA Smith.

Specimens from Japan in the U. S. National Museum agree with one from Hiogo, from the F. Smith collection.

NOMADA CAROLINÆ Cockerell.

Longview, Texas, four females, March 26, 1908 (E. S. Tucker). Previously known from North Carolina and Virginia (Falls Church, Banks). The Texan specimens have the mesothorax variable from distinctly banded to bandless, and the band on the metathorax absent, though the lower corner of the inclosure is black.

NOMADA LEPIDA Cresson.

Mound, Louisiana, "on turnip," one male, March 7, (Bishopp).

Females are from Dallas, Texas, March 17, at *Rubus* (Cushman); Dallas, April 9, on dewberry (Crawford); Beaumont, Texas, March 18 (Tucker); Wolfe City, Texas, on *Cratægus*, March 27 (Bishopp); Paris, Texas, April 10 and 11 (Bishopp).

From Ardmore, Oklahoma, come many specimens. The males (on wild plum, Mar. 31, Bishopp) are small, and the tegulæ are pale reddish or yellowish-red, tending toward *cuneata*. The females are light colored, as in *lepida* (*cuneata* must evidently stand as *N. lepida cuneata*). The Ardmore females were taken by Bishopp on wild plum, and by Bishopp and Jones on blackberry, in March and April. Two have yellow marks on the fifth abdominal segment; all have the mesothorax with a single dark band. Ardmore is only a short distance from the Texas line, and while classed in the humid austral, is very near the boundary between the humid and arid. Paris and Wolfe, Texas, are well in the humid division.

NOMADA PARVA Robertson.

Females from Ardmore, Oklahoma, April 11, at *Salix* (Bishopp) and Denton, Texas, April 26 (C. R. Jones). The basal nervure does not go so far basad of the *t. m.* as in *N. infantula*, but the two are separated with difficulty in the female, especially as in the Denton specimen there are only two spots on each side of the abdomen.

NOMADA SAYI Robertson.

Females from Paris, Texas, April 11 (Bishopp), and Mound, Louisiana, April 2 (Bishopp). In these the basal nervure goes less basad of the *t. m.* than in a male *sayi* received from Robertson. From Pittsburg, Texas, April 7 (Bishopp) comes a female with two yellow

spots on the fifth abdominal segment, and the pygidial plate broadly rounded, closely and very finely pubescent. This ought to be *N. illinoensis* Robertson, but the antennæ are practically as in *sayi*—certainly not shorter, and there is no yellow on the lower corners of the face. Probably the *sayi*—*illinoensis* group—includes one or two species which have not been separated, but more material is needed, especially males. For the present I call the Pittsburg insect *N. illinoensis*, var. *a*.

NOMADA ILLINOENSIS Robertson.

Two males, Ardmore, Oklahoma, at flowers of wild plum, March 12 (Bishopp) and April 10 (Jones).

NOMADA VICTRIX, new species.

Female.—Length $7\frac{1}{2}$ to 9 mm., expanse up to about 15 mm.; bright ferruginous red, the strongly and closely punctured mesothorax without any black band, the scutellum very flat, not bilobed, shining, with large sparse punctures. Head broad, inner orbits parallel; face strongly punctured, no yellow at lower corners; mandibles simple; no black on head except a little stain between the ocelli, and sometimes a little on the hindmost part of the cheeks; antennæ entirely ferruginous, third joint longer than fourth, fourth shorter than twelfth; thorax nearly without black, but a variable black stain in the middle of the metathorax; hair at sides of metathorax short and scanty; tegulae bright ferruginous; wings reddish-dusky, *b. n.* meeting *t. m.*; only two submarginal cells, the second *t. c.* wholly absent in all three specimens; legs red, hind femora and tibiae more or less stained with dusky behind; abdomen dullish, without distinct punctures, red, the hind margins of the segments blackish; second segment with two large pyriform or oblong yellow spots or patches; third and fourth with small lateral spots; fifth without spots, or with very faint indications of them; silvery apical lunule small and narrow (short); pygidial plate broadly rounded; venter red without spots.

Habitat.—Victoria, Texas, three females at flowers of *Aster* November 6, 1904 (A. J. Leister). By the low scutellum, this is related to *N. simplex* Robertson. The possession of only two submarginal cells would suggest relationship with *N. (Heminomada) obliterated* Cresson, but this is fallacious, since in *obliterated* it is the first *t. c.* that is absent. *Nomada (Nomadita) montana* Mocsary is a European species with only two submarginal cells.

Type.—Cat. No. 13436, U.S.N.M.

NOMADA (GNATHIAS) BELLA CALLURA, new subspecies.

Male.—Length about 10 mm.; lower half of clypeus and narrow lateral marks pale yellow, the clypeal yellow more or less tridentate above; third antennal joint shorter than fourth; scape rather stout, black on inner (mesad) side, broadly red on outer; flagellum stout,

red, with the first five joints black above, and the others with blackish stains; thorax black, coarsely punctured, with the upper border of prothorax more or less, the tubercles and the scutellum red; a small red mark on pleura anteriorly; femora, tibiæ, and tarsi clear red, the femora black at base beneath; tegulæ red, punctured; second *s. m.* very broad, not narrowed above, receiving first *r. n.* beyond middle; abdomen clear light ferruginous red, with the spots light lemon yellow; base of first segment black right across; yellow markings consisting of two small marks on first segment, a very broad band, rather broadly interrupted in middle, on second, a broad band, broadly interrupted in middle, on third, and two small transverse marks on fourth; yellow on venter confined to a large spot on apical segment; apical plate strongly notched.

Habitat.—West Cliff, Colorado (T. D. A. Cockerell). From Ashmead's collection. Some of the assigned characters are doubtless variable, but the light abdomen is likely to be distinctive. The first abdominal segment is very much broader than in *N. perplexans* Cockerell, which also differs in other ways.

Type.—Cat. No. 13437, U.S.N.M.

NOMADA FORMULA Viereck.

Los Angeles County, California (Coquillett), one male. The apical plate of the abdomen is deeply notched.

NOMADA SEMISUAVIS Cockerell.

California, with number 324, one male; Coronado, California, June 18, 1890 (Coquillett), one female. New to California, and the female is new. The female resembles the male, and is distinguished from *N. suavis* by the very densely punctured mesothorax. The legs are yellow and black, with only a little red, and the metathorax has two very large yellow patches. The anterior coxæ are strongly spined.

HYALINOTHRIX, A NEW GENUS OF STARFISHES FROM THE HAWAIIAN ISLANDS.

By WALTER K. FISHER,
Of Stanford University, California.

The type of the new genus and species herein described was collected in 1902 by the U. S. Fisheries steamer *Albatross*, near the island of Molokai, Hawaiian Islands. The two specimens were received after the publication of my report on the starfishes of the Hawaiian Islands.

Hyalinothrix superficially resembles two genera, which are not commonly considered closely related, namely *Chætaster* and *Nepanthia*. The resemblance to *Chætaster* is chiefly in the character of the spinelets, in the tabulate abactinal plates, and in the form and armature of the adambulacral and mouth plates. The most important differences between the two genera are listed below in parallel columns.

Hyalinothrix.

Abactinal plates with four or five lobes which overlap those of neighboring plates; no internal independent connecting ossicles.

Abactinal plates in quincunx only on dorsolateral region of ray, and there in more evident oblique and straight transverse than in direct longitudinal series; median radial plates more or less irregular; abactinal plates in about forty longitudinal series.

Spinelets conspicuously longer than height of tabulum, extremely delicate and glassy.

Marginal plates very small; an odd interradial marginal probably absent.

Superambulacral plates absent. Ampullæ of tube feet incipiently two-lobed, wider than high.

Disk moderately small; rays tapering from swollen base.

Chætaster.

Abactinal plates with six very short lobes which do not appreciably overlap those of neighboring plates; four internal independent ossicles present, binding together the plates of adjacent longitudinal series.

Abactinal plates arranged in quincunx in nine very regular longitudinal series, the median radial plates the largest.

Spinelets not longer than height of tabulum and only moderately delicate.

Marginal plates conspicuous; an odd interradial marginal present.

Superambulacral plates present. Ampullæ of tube feet single, higher than wide.

Disk very small; rays very slender and finger like.

Gray included two species in his genus *Nepanthia*, 1840—*tessellata* (= *Chætaster longipes*), and *maculata*. No type was indicated; *maculata*, the only available species, is therefore the type. This species has rather long slender rays, and is of the general habit of *Chætaster longipes*.^a I have examined a closely related form from the Philippines. The spinelets, though very short, are delicate, and are distally clear and glassy. The middorsal area of externally crescentiform pseudopaxillæ is clearly distinguishable from the several dorsolateral longitudinal series of squarish or roundish pseudopaxillæ. Internally both sorts of plates are lobed and imbricated. The crescentic appearance of the plates externally is due to the fact that, being arranged in quincunx, two lobes of a plate overlap the abcentral side of the next two plates toward center of disk. In the interval between the lobes the papulæ emerge, and the exposed surface has a crescentiform cluster of minute spinelets. The abactinal plates of *Hyalinothrix* imbricate in the same fundamental manner, but the plates of the radial regions have five lobes, so that in overlapping they frequently but not always join three plates adcentrally. In *Hyalinothrix* the actinal intermediate plates imbricate to form chevrons, or both longitudinal and transverse series, and the adambulacral spinelets are basally webbed, though not forming fans in the actinal series as in *Nepanthia*. But the presence of well-developed tabula on the plates of *Hyalinothrix* excludes the genus from the Asterinidæ (restricted), where the abactinal plates are essentially lamelliform and notched on the adcentral side.

Neither does it seem possible to place *Hyalinothrix* in the Chætasteridæ of Ludwig, for the resemblances are only superficial and are outweighed by the differences, namely, the small marginal plates, no odd interradiial marginals, absence of superambulacrals, the more numerous and fundamentally different abactinal plates which lack internal connecting ossicles, the incipiently bilobed ampullæ.

The Ganeriidæ have lobed paxilliform plates and small marginals, and the actinal intermediate plates in series extending from the adambulacrals to the marginals. *Hyalinothrix*, although quite different from *Ganeria*, *Cycethra*, *Radiaster*, and *Scotiaster*, appears to belong in this group. Eventually, when the anatomy of the above genera is known, it may be advisable to segregate *Hyalinothrix* in a special subfamily, the Hyalinothricinæ.

HYALINOTHRIX, new genus.

Type.—*Hyalinothrix millespina*, new species.

Stellate, with rounded rays. Marginal plates very small. All plates more or less tabulate, the abactinals strongly four or five lobed, and imbricating by the lobes; abactinal plates numerous, irregularly

^a For figures see Sladen, *Challenger Asteroidea*, pl. 64, figs. 1 to 4.

arranged along median radial areas but in regular oblique and cross-wise series on dorsolateral portions of ray; tabula of plates surmounted by a dense brush of very many extremely delicate sharp glassy hair-like spinelets. Papulæ in four or five areas about each abactinal plate; one or two papulæ to an area. Adambulacral plates squarish, with three or four furrow spinelets basally webbed and very numerous, smaller, actinal spinelets. Actinal interradial areas small, the plates in three to five rows, with a central convexity or tabulum, and strongly imbricated in chevrons. Superambulacral plates absent; anus present; gonads interradial; tube feet in two series with sucking disks, without deposits; ampullæ incipiently bilobed; interbrachial septa calcified.

HYALINOTHRIX MILLESPINA, new species.

Diagnosis.—Rays 5; $R=45$ to 50 mm., $r=10$ to 11 mm.; $R=4$ to 5 r; breadth of ray at widest part 13 mm. Disk small; rays well arched abactinally, subplane actinally, bluntly pointed and slightly constricted at base. Abactinal plates four or five lobed, with low tabula bearing 75 to 100 very slender clear spicules, which give the appearance of the pile or nap of plush; papulæ one or two to an area, usually four areas about each plate; marginal plates only slightly larger than adjacent abactinals; proximally three or four regular series of actinal intermediate plates, distally only one. Adambulacral plates with three or four furrow spinelets in a straight series, and on actinal surface a dense squarish or roundish paxilliform group of numerous slender spinelets.

Description.—The skeleton is in the form of irregularly four or five lobed tabulate plates, which overlap by the lobes, leaving irregular papular areas smaller than the plates and containing usually single papulæ. On the midradial area and center of disk the plates are not regularly arranged, but on the sides of the rays they are in pretty regular quincunx as far as the superomarginal series, being arranged in straight as well as oblique transverse series; and on some rays near the base, on either side of the midradial area, a less regular arrangement in longitudinal lines is observable. Each plate is raised into a low convex tabulum equal to or lower than its width at top, surmounted by a dense brush or group of very numerous and diverging delicate spicules. These spicules or spinelets are more delicate and slender than any to be found elsewhere in the Asteroidea. They vary in length from 0.75 mm. to 0.975 mm., and the articulating base is about 0.06 mm. thick, and thence tapers toward the tip, near which the spinelet is 0.0155 mm. thick. The distal three-fourths or four-fifths of each spicule is clear and glassy, only the basal part being reticulated, or perforated, in the characteristic way. The epidermis

seems to be lacking except on the basal portion of each spinelet. Some of the spicules are forked near the base, the two branches being unequal. The spinelets are longer than the height of tabulum, and owing to their extreme tenuity are well preserved abactinally only in the interradian sulcuses. Over most of the abactinal surface the distal part of the spinelets is broken off. On the interradii where the spinelets are well preserved those of neighboring paxillæ touch across the interspaces, and each group is distally slightly convex. There are between seventy-five and one hundred spinelets to an average sized paxilla, and the paxillæ decrease in size toward the end of ray and laterally toward the marginal plates.

The papulæ are distributed all over the abactinal surface, except at the very tip of ray, and laterally as far as the superomarginal plates. Each plate is surrounded by four papulæ except on the midradial area, where there are sometimes five papular areas around each paxilla, and often there are two papulæ to an area.

On the actinal surface of the distal half of each ray are three series of paxilliform plates, slightly lower and larger than the lateral paxillæ of abactinal surface, arranged parallel to the still larger squarish adambulacrals. The outer two, which are the marginals, toward the base of ray diverge from the inner (which is the first actinal intermediate series and reaches very nearly to tip of ray) and at the interradian line are nearly on the ambitus, being separated from the adambulacrals by about four longitudinal series of actinal intermediate plates. These marginal plates are very small, and the inferomarginal series is slightly the more regular of the two. The plates of the two series are subequal and a trifle larger than adjacent abactinals. The plates are so small that it is not possible to ascertain if an odd interradian plate is surely absent; from a study of the arrangement of adjacent actinal intermediate plates, I think they are. In one or two interradii, however, it is difficult to be sure, as the plates are pushed out of position.

As mentioned above, one series of actinal intermediate plates nearly reaches tip of ray, the second row reaches about two-fifths length of ray measured along side (or about one-half R), while the third and fourth rows contain only a few plates and extend but a short distance; a few plates of a fifth row are present in two interradii. It is the interpolation of these three extra rows of intermediate plates which causes the marginals to be crowded toward the ambitus. Spinelets of actinal intermediate plates are about 0.675 mm. in length and are perforated to the tip, which commonly ends in two or three short, sharp, glassy prongs. The intermediate plates have prominent convex tabula and overlap plates of both their own and adjacent series. The free edge of the plate is toward the furrow and interradian lines.

Adambulacral plates nearly square, slightly larger than adjacent actinal intermediate plates. The actinal surface is slightly raised for the articulation of a roundish or squarish paxilliform group of numerous delicate spinelets which increase in thickness, but not in length, toward the furrow. The furrow series consists of three or four still longer basally webbed spinelets, which reach nearly across the narrow groove and which are slightly longer than width of plate. The central one or two of these spinelets is slightly the longest. The outer subambulacral spinelets are similar in character to the actinal intermediate spinelets, except that the two or three prongs are longer, the whole spinelet being about 0.75 mm. long. Toward the furrow, however, the spinelets become thicker and end in five or six short thorns, and the shaft is perforated by several longitudinal series of pores, forming the characteristic reticulum; only the little prongs are clear. In contrast to the abactinal spicules these spinelets are 0.1 mm. thick at base and 0.06 mm. at tip. The subambulacral spinelets on at least two series adjacent to furrow are basally webbed.

Mouth plates with a dense triangular group of numerous spinelets on actinal surface, the two groups on companion plates being separated by a prominent median suture. Marginal spinelets about seven, similar to those of adambulacral plates.

Madreporic body small, nearly hidden by overlapping paxillæ; striæ coarse and irregular. Anal aperture, subcentral.

Color in alcohol, bleached yellowish brown.

Anatomical notes.—Tube feet with strong sucking disks; no deposits. Ampullæ single, incipiently two-lobed. Gonads interradiial. Interbranchial septa strongly calcified. Integumentary layer beneath plates, thick and tough. No superambulacral plates present, the lower end of each ambulacral ossicle being, instead, produced into a short lobe. Strong retractors of stomach present.

Variations.—The cotype has somewhat slenderer rays. The marginal plates do not form quite such regular series as in the type, and there are much fewer actinal intermediate plates. The series adjacent to the adambulacral plates extends only half the length of ray or even less; the second series is one-third as long as the first; the third, very short (only about half a dozen plates); the fourth is either absent or represented by only two or three plates; in one interradius the fifth is just starting (one or two plates).

Type.—Cat. No. 27674, U. S. N. M.

Type-locality.—Albatross station 3863, Pailolo Channel, between Molokai and Maui Islands, Hawaiian Islands, 127 to 154 fathoms, broken coral, coarse gravel, rocks; two specimens.

EXPLANATION OF PLATES.

(All plates represent *Hyalinothrix millespina*.)

PLATE 69.

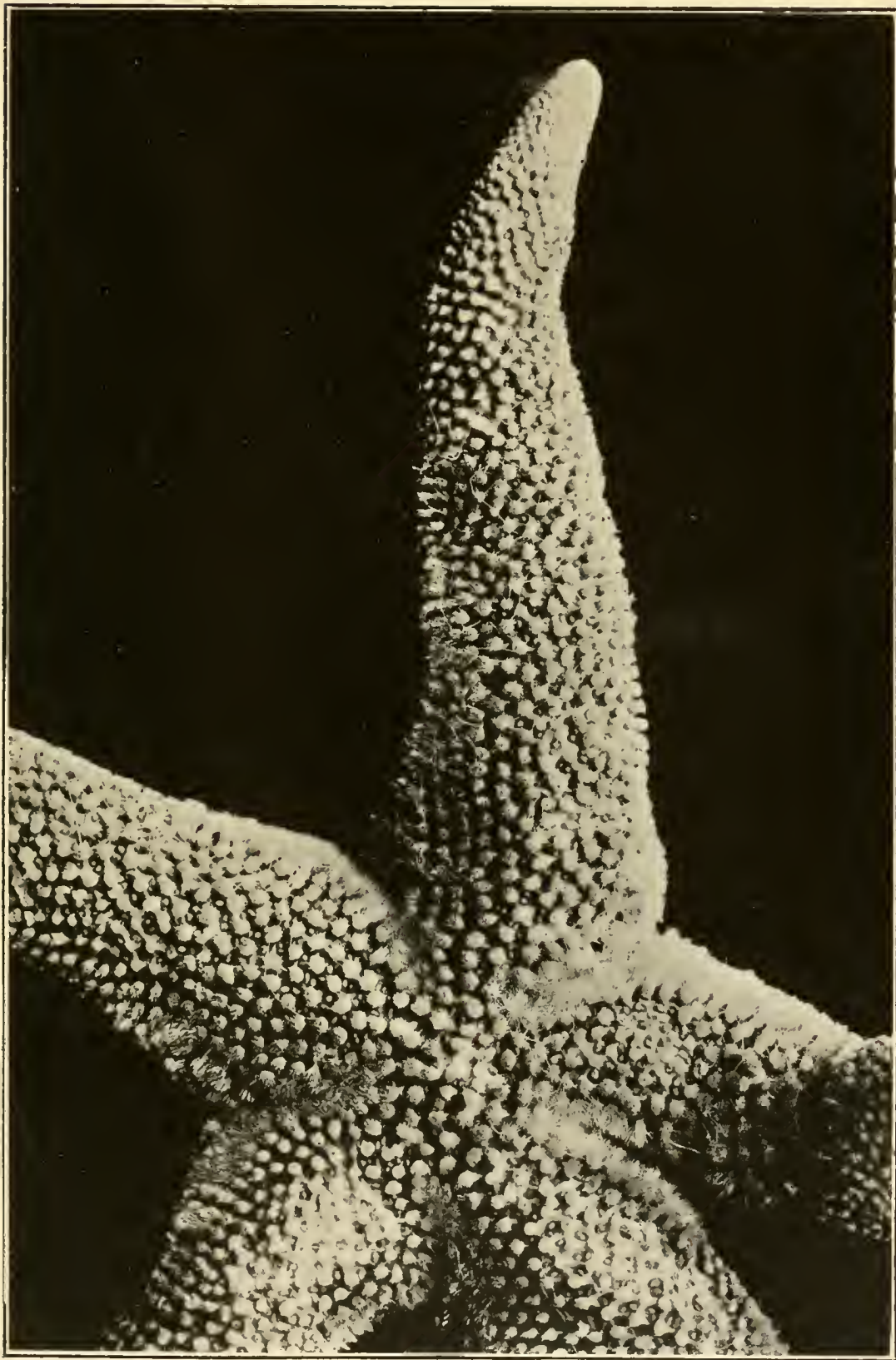
Abactinal view of type, enlarged about $2\frac{1}{2}$ times.

PLATE 70.

A portion of actinal surface of type enlarged; *int*, actinal intermediate plates; 1-5, the five series of actinal intermediate plates. The three plates of the fifth series are marked with white spots, there being an unpaired plate, and one to each ray; *inf*, inferomarginal, and *sup*, superomarginal plates. Between the two white lines indicating these plates are seen the first superomarginals of each ray. The lines in both cases point to the second plate of the series.

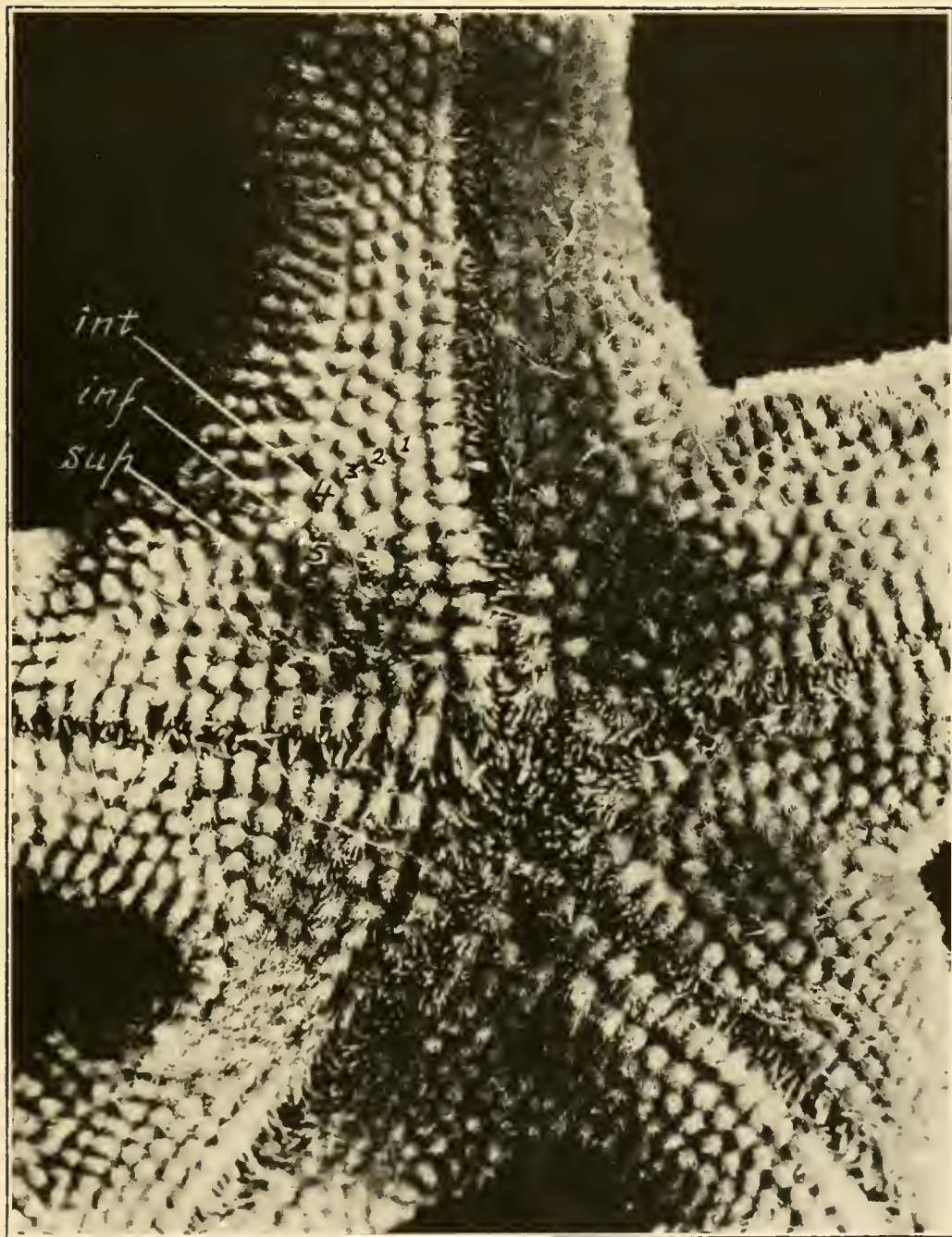
PLATE 71.

- Fig. 1. Abactinal plate from near base of ray, side view; $\times 30$. This is to give an idea of the relative size of tabulum and spinelets; not all the latter are shown, and most of these are represented somewhat too stout.
2. Spinelets from abactinal plates; $\times 70$.
 3. The base and tip of a spinelet; $\times 250$.
 4. Abactinal plates from near base of ray and border of midradial area, seen from outside to show the tabula and papular areas, in which the one or two papulae are not indicated; $\times 10$.
 5. Abactinal plates from near base of ray and adjacent portion of disk, seen from inside; $\times 10$. The plates to right are those of the radial area, those to the left showing the more regular arrangement of the dorsolaterals. Papular areas shaded; s, position of interbrachial septum.
 6. An adambulacral plate from proximal half of ray; $\times 10$. Not all the subambulacral spinelets can be shown.
 7. Three ambulacral plates from near base of ray to show the lobes at lower end over-lapping the suture between the adambulacral plates; $\times 10$.



HYALINOTHRIX MILLESPINA, TYPE.

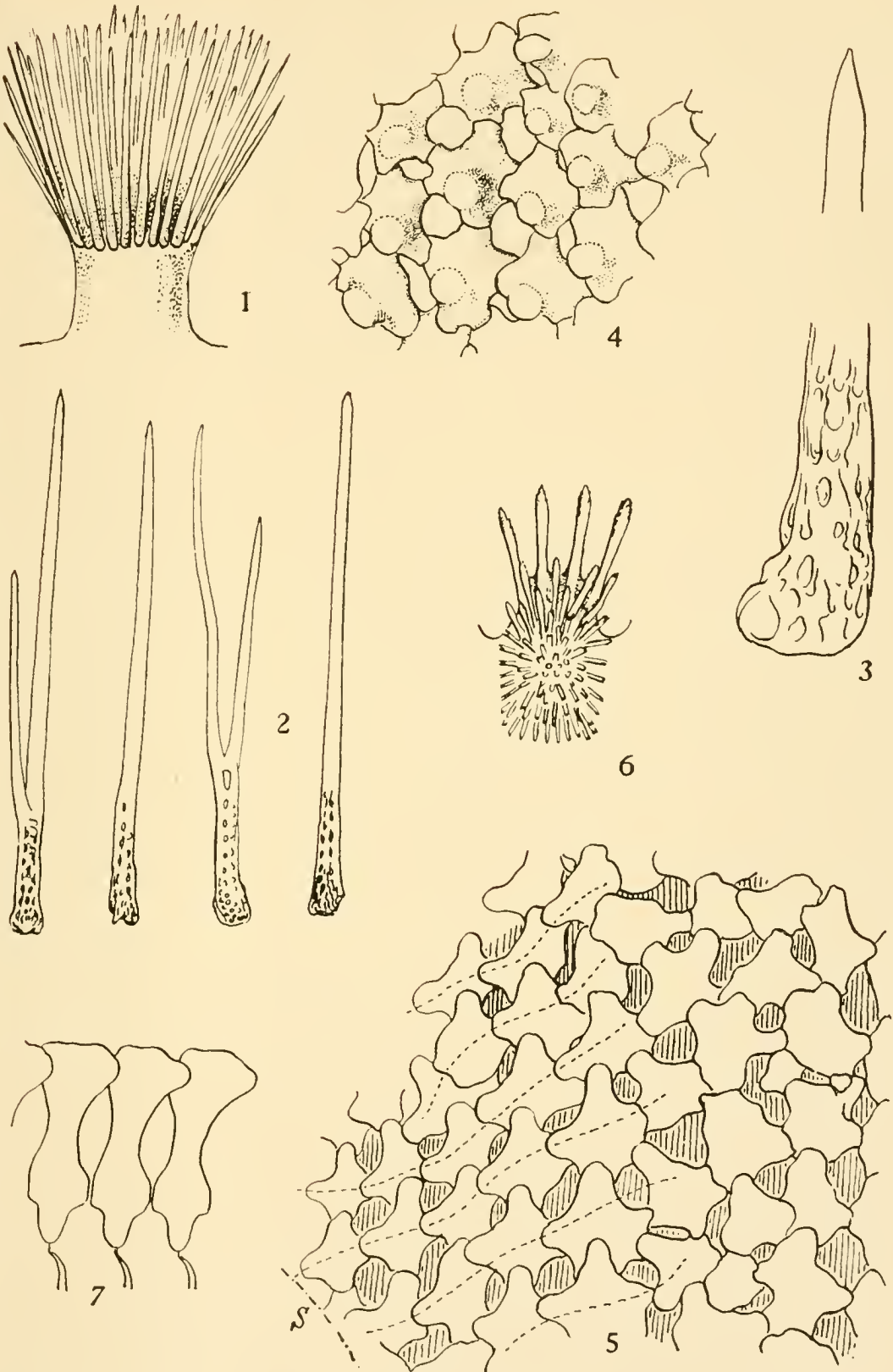
FOR EXPLANATION OF PLATE SEE PAGE 664.



HYALINOTHRIX MILLESPINA, TYPE.

FOR EXPLANATION OF PLATE SEE PAGE 664.





HYALINOTHRIX MILLESPINA.

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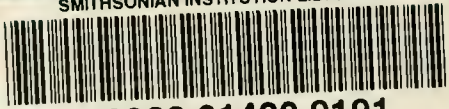
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