

NORTH AMERICAN PARASITIC COPEPODS
BELONGING TO THE FAMILY
CALIGIDÆ

Parts 3 and 4.—A REVISION OF THE PANDARINÆ
AND THE CECROPINÆ

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INTRODUCTORY.

The present is the sixth paper in the series based upon the collection of the U. S. National Museum and finishes the family Caligidæ. For many reasons a large amount of careful and painstaking collating has been rendered necessary before this paper could be published. And in consequence, as its title indicates, it has taken the nature of a thorough revision of the two subfamilies which it includes. Such a revision was found to be absolutely demanded for any intelligent discussion of the group, and especially for its accurate systematization.

In the first place, up to the present time we have been acquainted with both sexes of but one or two species in the entire subfamily Pandarinæ. Of all the other forms either the male or the female have been described alone.

This has been due not to any scarcity of the missing sex, as might be supposed, but to the fact that when found it was located elsewhere on account of the great morphological dissimilarity between the sexes. So that we find repeatedly the anomaly of a female classified under one genus and subfamily, while the male is located under an entirely different genus, and often in another subfamily.

Furthermore, all previous attempts to bring together the sexually separated species have been confined to individual cases or to closely related forms. And there has been in these attempts such an utter disregard of morphological and developmental data that they have only served to render the confusion worse confounded. To the best of the author's knowledge the present paper is the first to systematize

the group upon a morphological basis. As will be seen the structure in a few instances supports the suggestions that have been made regarding the identity of sexes, while in the great majority of cases it is directly opposed to them. It is obvious, however, that any suggestion of species identity which is not supported, or which may even be contradicted by the anatomy of the two sexes, is worthy of very little consideration.

And it is really surprising how much similarity a careful examination reveals when we remember that the two sexes have been considered generically distinct. The differences are found to be much more apparent than real, and this is particularly true of the appendages which afford a ready clew for the determination of the genera, as can be seen from the key which follows (p. 345).

There is of course no expectation of being able, in this initiatory effort, to reach a final conclusion respecting all the *Nogaus* species. Considerable additional information will be needed before that becomes even possible. But at least a good beginning can be made, and the treatment of the species can be placed upon a rational and scientific basis, which will yield good results in the future.

Each male has been included in the genus to which it belongs, so far as this is positively known, and its characteristics have been given under the genus diagnosis.

There are here described twenty species, of which one is new to science, namely, *Echthrogaleus torpedinis*, while two others, *Echthrogaleus denticulatus* Smith and *Nesippus alatus* Wilson, are figured for the first time, the latter including both sexes.

In addition the males of eight of the other species have been definitely located, described, and figured, four of them being new to science, while the other four have been boarding around among the various genera as was formerly the custom with the teachers in our old-fashioned country schools.

The males of the three species belonging to the Cecropinæ, of *Gangliopus pyriformis*, and of *Pandarus bicolor* were already known so that we now have the males of 14 of the 20 species, including at least one for every genus.

And lastly, much the hardest task of all, in the discussion of the genus *Nogaus*, which is made up entirely of males, 34 species, described by half as many authors and in seven different languages, have been carefully contrasted with one another and with the types here established, so far as the data given made this possible.

It has been found necessary to change the names of two genera on account of preoccupation. The name *Lepidopus*, proposed by Dana in 1852, had been used by Gouan for a fish genus in 1770. In its place is suggested the name *Pholidopus* which has the same meaning, namely, scale-footed.

The name *Stasiotes*, proposed by Wright in 1877, had been used by Jan for a snake genus in 1862. In its place is suggested the name *Prosaetes*, from *προσαίτης*, a beggar, who torments one by his persistence.

A complete life history is also presented by using different stages of development from different genera, but as none of the developmental stages have ever been described even this is a considerable advance.

Part 3.—THE PANDARINÆ.

ECOLOGY.

The Pandarinæ are peculiarly shark parasites; the genera and even the species, almost without exception, infesting some one of the numerous selachians along our coasts. In general the females remain throughout life fixed in the same position on their host, and even the males are rarely found swimming about freely. And yet upon occasion, as will be seen later, these males can swim as well as any of the Caliginæ. Hence it is not a case of necessity but one of choice that keeps them in close proximity to the fixed females.

In this connection Hesse writes:^a

Les poissons sur lesquels on les trouve n'étant pas, comme ceux des autres espèces, enduits d'une sécrétion mucilagineuse qui, en lubrifiant la peau, la rend plus souple et plus pénétrable et facilite ainsi les fonctions des organes destinés à la perforer. Privés de ces avantages et insuffisamment fixés sur une enveloppe épaisse et coriace, ils ne tardent pas, lorsqu'ils sont sortis de l'eau, à s'en détacher et à tomber à terre, ou dans le fond des bateaux, et alors, à raison de leur extrême petitesse, il est bien difficile de les retrouver.

This statement might give the impression that the Pandarinæ are outcasts among the parasites, unable to find anything better in the way of hosts, and so compelled to put up with these thick-skinned sharks. But such does not seem to be the case; the shark's skin is tough, but is not particularly thick for so large a fish, and it is certainly covered with mucus the same as that of other fishes. It is therefore as easy to penetrate as the skin of a fish covered with heavy scales.

Furthermore, as Hesse himself says, immediately after the passage quoted, these Pandarinæ seek out those places on the shark's body where the skin is the thinnest, such as the fins, the inside of the operculum, the border of the anal and genital orifices, and even the eyes. In fact this same preference is shown by all the Caligidæ, and is just as pronounced on a scaly fish as on these selachians, for the skin in the localities mentioned is always soft and tender enough, even on a shark, to be easily penetrated, especially by such large parasites as the Pandarinæ. Hence the reason implied by

^a Annales des Sciences Naturelles (6), XV, Article 3, p. 39.

Hesse, and stated clearly in a footnote at the bottom of the page just referred to, can not be the only one. He says in the footnote:

C'est sans doute à raison de la plus grande épaisseur de leur peau que je n'ai jamais rencontré ces parasites sur les *Scyllium canicula*, *catulus* et *annulatus*, qui cependant sont des Squales que l'on trouve plus fréquemment que les autres dans notre localité.

It is very doubtful if the skin of these sharks he mentions is any thicker than that of the dusky shark, *Carcharhinus obscurus*, and other large sharks of our own coasts which are commonly infested

with these parasites. And even if it were thick and tough enough elsewhere, it would still be thin and soft at the localities mentioned, and easily penetrated by the sharp probosces of these large Pandarids. Some other reason must be found to account for the lack of parasites on the sharks mentioned.

Again Hesse writes:^a

J'ai, en effet, visité, avec le plus grand soin et depuis un assez grand nombre d'années, les poissons de toutes les espèces qui fréquentent nos côtes et je suis parvenu à trouver vingt *Caliges* différentes, ainsi que dix *Trébies*; et toutes, sans aucune exception, ont été recueillies sur le corps ou sur les branchies de poissons à peau molle, conséquemment autres que les *Squales*.

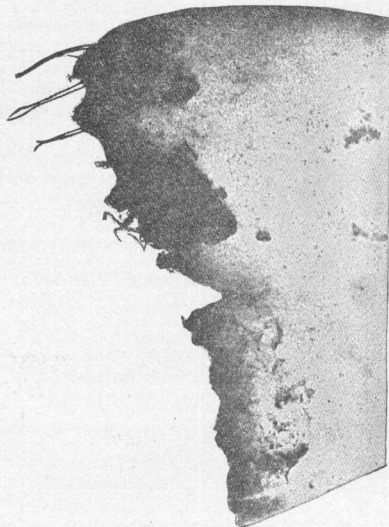


FIG. 1.—PHOTOGRAPH OF DORSAL FIN OF SAND SHARK, SHOWING BOTH SEXES OF *PANDARUS SINUATUS*. IN THE LOWER BUNCH THE PARASITES ARE ENTIRELY COVERED WITH ALGÆ.

those on the coast of France, since the author has found two of the Argulidæ, *Argulus laticauda* and *A. megalops*, two of the Caliginæ, *Caligus rapax* and *Lepeophtheirus edwardsi*, and two of the Euryphorinæ, *Alebion gracilis* and *A. glaber*, very commonly upon them. The two last mentioned species are practically confined to the Dogfish and Sand Shark, and are found all over the outside surface of these fishes, apparently never hunting for any thin places in the skin.

Furthermore the Caliginæ are common also upon Skates and Rays, whose skin is as tough and leathery as that of the sharks, at least six species being found on these fish.

We may reasonably conclude, therefore, that the sharks are selected by these parasites as their chosen hosts. And there is no reason for believing that they do not prove as satisfactory as any bony fish (fig. 1).

The sharks along our Atlantic coast must be very different from

^a Same article, p. 30.

We have already stated that the females remain throughout life fixed in one position upon their host. This is true of all the genera belonging to the subfamily and constitutes a fourth step in degeneration as well marked as the three which have preceded it.^a

The last three of these steps, however, and a part of the first one, have been confined to the female, while the male has escaped their influence.

As a result we find in the present subfamily the greatest sexual dissimilarity in the entire family of the Caligidæ.

Indeed, the two sexes of every genus in the Pandarinæ are so unlike that the males have been considered a separate genus from the females. And not only so, but the males of all the genera have been made congeneric, and grouped together under the single genus "*Nogagus*." Furthermore, this male "genus" has been placed by the great majority of writers in the subfamily Caliginæ rather than in the Pandarinæ, where the females all belong. This will be more fully discussed under the genus name *Nogaus* (see p. 439). It serves here simply to emphasize the sexual differences, and to make it evident that in considering their ecology as well as their morphology most if not all of the statements must be understood as confined to a single sex. The first step in degeneration, as already noted under the Caliginæ, was the mechanical hindrance afforded by the egg strings, and the strong incentives for remaining on the body of the host. Of course the latter was the only one operating upon the male, and it did not exert much influence so long as the female retained the power of free swimming.

As, however, this power gradually weakened in the Caliginæ and still more in the Euryphorinæ, the incentive for the male to remain upon the host with the female became stronger.

And here in the Pandarinæ, where the female has become a fixed form and correspondingly degenerate, the incentive operates with its full power on the male, and we find him in the same condition as were the females of *Lepeophtheirus* and other Caligids, that is, capable of swimming freely but under ordinary conditions remaining upon the same fish, along with the female, during his entire life. While the male has thus resisted the degenerative influences so much longer than the female, yet when he once yields the transition is more rapid, and in the very next subfamily, the Cecropinæ (see p. 465), we find the male degenerated into a fixed form exactly like that of the female.

^a The three previous steps are: (1) The mechanical hindrance afforded by the egg strings and the lack of incentive to free swimming; (2) the loss of the lunules on the frontal plates, and the consequent restriction of the free scuttling motion; (3) the development of dorsal plates on the thorax segments, thereby diminishing the freedom of bodily movement.

LOCOMOTION.

The female has entirely lost the power of free swimming, and almost entirely that of moving about on her host. She can and does change her position, but only for the most strenuous reasons and during the earlier stages of development. Such motion is of necessity very slow, since it involves the loosening and refastening of the hold maintained by the different prehensile organs. Some of them must remain fastened all the time, and the only progress made is the distance that can be covered by the stretching of the body between the alternate fastenings. When removed from the fish and placed in an aquarium these females simply lie upon their backs, moving the swimming legs spasmodically, but producing no change of position at all. The males, on the contrary, can swim as freely as *Caligus*, and when placed in an aquarium with the latter they resemble them so closely in form and movements as to be distinguished only by careful scrutiny. Accordingly we should expect to find some of the males swimming about freely at the breeding season, like those of *Caligus*, and there are in the U. S. National Museum collection several specimens so recorded.

None of either sex, so far as known, have lunules on the frontal plates, and hence they do not exhibit the scuttling movements characteristic of *Argulus* and *Caligus*. And yet they can move about easily and rapidly over the outside of the shark's body and are by no means confined to the immediate vicinity of the females. This motion is accomplished by means of the adhesion pads, maxillipeds, and swimming legs. The former hold the copepod to the skin of its host, while the latter push the body forward. Instead of a scuttling movement, therefore, each side of the body being advanced alternately, there is a forward gliding motion of the entire body, similar to that shown in swimming. All four pairs of swimming legs in these males are biramose, and the rami are wide flattened laminae which propel the animal swiftly through the water.

There is no broad basal apron connecting the third legs across the mid line, which was characteristic of the Caliginæ, but this is largely compensated by the fact that the fourth legs are as broad and powerful as the third pair, while in the Caliginæ they were of no actual service for swimming.

PREHENSION.

The organs of prehension include adhesion pads, claws, and modified chelæ. The adhesion pads are common to all the genera and to both sexes; they arise as accessory organs in connection with the various appendages, and are usually of different shapes in the different genera and even in the different species, thereby affording good

supplementary means of differentiation. In the genus *Pandarus*, which may be taken as the type of the subfamily, there are four pairs of these pads (fig. 2).

The first pair are connected with the bases of the first antennæ, are elliptical or oval in outline, and stand close to the lateral margins of the carapace, sometimes even projecting beyond the margin. The second pair are connected similarly with the bases of the second antennæ, are usually circular or oval in outline, and stand inside of and posterior to the first pair. The long diameters of both pairs are parallel with the body axis, as a rule. The third pair are connected with the bases of the second maxillipeds, are sometimes circular and sometimes elliptical in outline, and stand on either side of and close to the mid line about in the center of the ventral surface of the carapace. The fourth pair arise as prominences on the bases of the first pair of dorsal plates in the female, or the lateral processes of the first free segment in the male. The exterior margin of each of these plates reaches forward under the carapace to a point opposite the bases of the first legs, and here at its antero-lateral corner the pad is developed. These pads are elongate-elliptical in outline, their long diameters parallel with or slightly inclined to the body axis. There are also in some genera pads on the basal joints of the swimming legs; these are usually elliptical, with their long diameters at right angles to the body axis (fig. 3).

The first two pairs of pads are the most important, and the necks or stems by which they are united to the ventral surface of the carapace are so arranged that the pads can be lowered and pressed against the skin of the host's body. The adhesive surface of the pad is formed of a thick cushion of skin whose outer layer is raised into ridges similar to those in the epidermis on the palms of our hands. These ridges are usually transverse, but are sometimes arranged concentrically, as on the tips of our fingers. They seem to serve the same purpose on these pads that they do on our hands—the development of friction and the prevention of slipping.

The claws or chelæ are found on the tips of the second maxillipeds, which are the chief organs of prehension. In the males of all the genera and in the females of some of them the second maxillipeds end in curved claws similar to those found in the *Caliginæ* and *Euryphorinæ*.

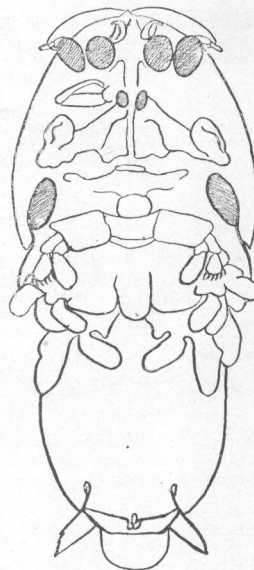


FIG. 2.—VENTRAL SURFACE OF FEMALE *PANDARUS SINUATUS*, SHOWING ADHESION PADS.

But in the females of *Pandarus*, *Nessipus*, and allied genera the claw disappears in the fully developed adult and in its place appears a pair of knob-like protuberances, armed with minute papillæ or scales which operate like a chela and obtain a hold by pinching a fold of skin between their inner surfaces.

Sometimes the males are also found with knobs instead of claws, the two occurring interchangeably, even in the same species.

Either of them give the copepod a firm grasp upon its host and, assisted by the adhesion pads, fasten it securely in place.

Indeed, it has been the author's experience that living specimens have to be removed with great care in order to avoid breaking their prehensile appendages. On the other hand, Hesse speaks of them in the quotation just given as "insecurely fastened to a skin which is tough and leathery." And he then adds: "They are not slow,

when taken from the water, to detach themselves and fall to the ground or the bottom of the boat."

In the experience of the present author no Pandarid has ever voluntarily detached itself; some have fallen or been rubbed off their host, but only when dead. Many scores of times, after pulling the pound-net at the U. S. Bureau of Fisheries or the Marine Biological Laboratory at Woods Hole, Massa-

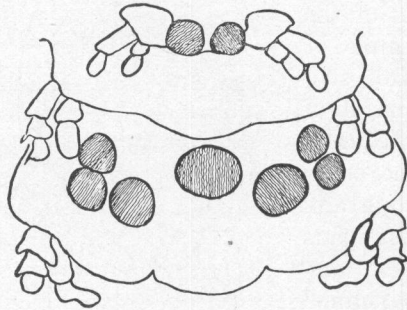


FIG. 3.—VENTRAL SURFACE OF FIRST THREE PAIRS OF SWIMMING LEGS OF ECHTHROGALEUS DENTICULATUS, SHOWING ACCESSORY ADHESION PADS.

chusetts, the sharks obtained, which varied from two or three to twenty-five or more in number, have been thrown on the bottom of the boat and towed from 1 to 3 miles behind a small steamer before being examined. But on reaching the wharf the Pandarid parasites were found still clinging to them, and after careful trial it was decided that so far as sharks are concerned, the chief thing to be gained by going out to the net and removing the parasites on the spot was the chance of keeping them alive a little longer. And here again the experience of the author is different from that of Hesse, who says: "I have been able occasionally to secure them alive, but have not been able to keep them in that condition for any length of time. In this they are very different from *Caligus* and *Trebius*, and even from *Cecrops* and *Læmargus*, which I have kept alive for some time."

If he is speaking of the females this is partially true, and yet the author has repeatedly kept Pandarid females alive for several days.

But the males are always as hardy as any of the genera he mentions, and usually when placed with *Caligus* or *Lepeophtheirus* they outlive the latter.

Hesse's mistakes have probably originated from another fact which has an important bearing on the length of life in these parasites. In the Caliginæ the arched carapace acts as a large sucking disk, its margin being pressed close to the surface, made continuous posteriorly by the broad lamina connecting the third legs, and the contact sealed with water and slime.

The space beneath the carapace is filled with water, and this is often retained for a long time after the surface of the fish has become dried. Living and active specimens have often been obtained from fish whose outer surface and fins had been dried for two or three hours. On the inside of the operculum and in the gill cavity they sometimes remain alive out of water for twenty-four hours after the death of the fish.

In the Pandarinæ the carapace is not thus arched and there is nothing to continue its margin posteriorly; consequently it does not retain the water, but the latter escapes as soon as the skin of the fish dries, just as it does from beneath the cover glass on a microscope slide. As soon as the fish dries, therefore, all the Pandarids on its outer surface also quickly die, and they do then drop off, or can be brushed off very easily. For the same reason, while the sharks are being brought ashore these parasites usually become exhausted for want of moisture. And although they may still be alive when removed from the fish they do not live very long afterwards. But given a fair chance, the females are as long lived as any of the fixed parasites, while the males who do retain moisture under their carapaces in the same manner as *Caligus* and *Trebius* are fully as long lived as the latter.

This subfamily of Pandarinæ are thus clearly differentiated from the Caliginæ, Trebinæ, and Euryphorinæ on the one side and from the Cecropinæ on the other by many distinct peculiarities of morphology and habits. The most striking differences are to be found perhaps in the males, although the other sex is by no means deficient in them.

In the Caliginæ we find the sexes similar, the male usually smaller, but sometimes larger than the female. The young females, and even the adults when without egg-strings, are as active as the males, and both sexes have retained fully their power of locomotion in spite of their parasitic habits. This equality of the sexes is partially explained by the fact that neither of them carry any dorsal plates on the thorax or genital segment. The family includes one genus, *Echetus*, in which the adult female has become fixed in position, but this is due to the burying of the head and thorax in the flesh of the host.

The mouth-tube is short and broad, with a bluntly rounded tip.

First maxillæ are present in the form of short claws near the margin of the carapace; the second maxillæ are in the form of simple, slender, and acuminate spines; the furca is biramose; the first and fourth legs are uniramose, while the rami of the second and third pairs have peculiar patterns of the joints, easily recognized after a little experience.

In the Euryphorinæ the sexes are also similar, the male always smaller, more slender, and more active than the adult female. The young females, however, are still as active as the males, since they are unhindered by either egg strings or dorsal thorax plates. The presence of the latter in the adults helps to render them sluggish, and yet there is no genus which actually becomes fixed like *Echetus* among the Caliginæ.

For the other characters, the mouth tube is like that of the Caliginæ, but there are no first maxillæ nor any furca. The second maxillæ show a transition from simple pointed spines in *Caligeria*, through a blunted biramose shape in *Gloiopotes*, into a flattened lamina in *Alebion*. All the legs are usually biramose, the pattern of the rami of the second and third pairs similar to that in the Caliginæ.

In the Pandarinæ, on the contrary, the sexes are very dissimilar; the females, even when young, carry so many dorsal plates on the thorax and genital segment as to render them practically helpless. They can swim but little and quickly become stationary upon their host. But the males retain the powers of locomotion and can swim or scuttle about over their host's body with as much freedom as those of either of the preceding subfamilies. They have no trace of dorsal plates, either on the thorax or genital segment; the sex differences in this subfamily, therefore, are the greatest anywhere shown in the Caligidæ. The mouth tube is long and pointed, and the mouth parts are transformed into blade-like, smooth laminæ, without spines or setæ, or they remain rudimentary. The swimming legs are also characterized by the equality of the rami on the first pair and by a general tendency toward degeneration in the females. This usually affects only the last pair (*Dinematura* females), or the last two pairs (*Pandarus* females), but sometimes affects them all (*Demoleus* females). But whether degenerate or not their pattern is always totally different from that in the two preceding subfamilies.

Finally in the Cecropinæ we find the sexes again similar, but this time they both carry dorsal plates on the thorax and genital segments which effectually prevent free swimming. And both sexes become permanently fixed as soon as they have found lodgment on their host's body. The mouth tube is not as long as in the Pandarinæ, but is fully as pointed, while the maxillæ remain laminate and are much larger proportionally than in any preceding sub-

family. There is a tendency to degeneration in the swimming legs similar to that shown in the Pandarinæ, but while it was there confined to the female sex only it here extends to both sexes, and may even include both the third and fourth pairs of legs in the male (*Orthagoriscicola* males).

ONTOGENY.

The life histories in this subfamily are almost the same as in the Caliginæ and Euryphorinæ. The differentiation between the two must be sought chiefly in the habits and sexual characters, as already stated. The number and size of the eggs and the changes during their development are similar to those given in the preceding subfamilies. From eight to ten weeks are required for development, and

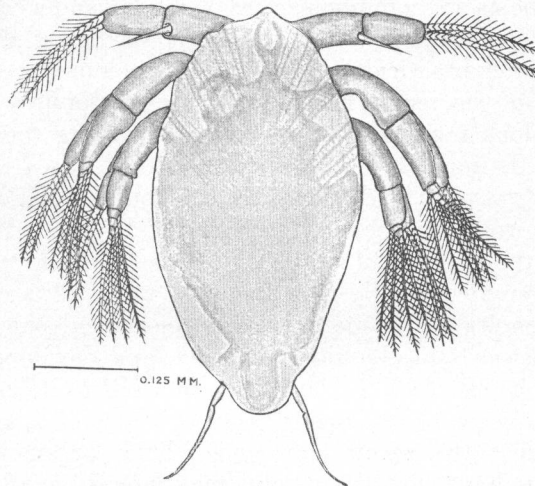


FIG. 4.—A NEWLY HATCHED NAUPLIUS OF *PANDARUS SINUATUS*.

all the eggs in the strings of any given female hatch at practically the same time. The issuing nauplius is almost an exact counterpart of that seen in the Euryphorinæ; its body has the outline of an elongated ellipse, is well rounded anteriorly, but is somewhat contracted posteriorly through the bases of the balancers (fig. 4). The eye spot is far forward and not prominent. The three pairs of appendages are of the usual pattern and arrangement. The anterior part of the body is transparent, and inside of it can be plainly seen the muscles which move the appendages. The balancers are very long, cylindrical, and narrow acuminate; they stand out nearly at right angles to the body axis and are curved slightly forward. The central portion of the posterior half of the body is filled with opaque yolk granules, leaving a narrow transparent margin around the edge. These granules are colored a uniform and very pale brownish-yellow, and there are no

pigment spots nor any color patterns in the nauplii thus far observed, a condition very different from that found in the nauplii of the Caliginæ and Euryphorinæ.

The difficulty of hatching these nauplii and rearing them through successive molts is fully as great as in the case of the Euryphorinæ, but for a very different reason. In the Euryphorinæ the unripe female moved restlessly about the aquarium all the time, and finally crawled up out of the water and remained there until dead and dried; consequently the eggs were dried and killed before they had time to hatch. Here in the Pandarinæ, on the other hand, the female is incapable of motion, and when placed in an aquarium simply falls to the bottom and lies there inert, usually upon her back. In this way the eggs fail of proper aeration and die almost as surely as when taken out of the water and dried. Fortunately here also, as in the Euryphorinæ, the hosts are common species of sharks, and a careful examination of the gills and body of these sharks during the parasites' breeding season is practically sure to yield development stages. The eggs for most of the genera hatch about the first of July, so that the best time to look for development stages is during the middle and latter part of the month.

Those of *Perissopus* and *Pandarus* are found upon the external surface, the former on the head and especially around the mouth, the latter in the vicinity of the fins. Those of *Nesippus* are found attached to the gills, usually near the ends of the gill arches. When the nauplius molts into a metanauplius the second pair of antennæ are turned forward side by side, enlarged, and developed into long prehensile hooks, whereby the larva fastens itself to its host. At the same time the second maxillipeds become organs of attachment and materially assist the second antennæ. Both organs retain their function throughout life, the second maxillipeds usually increasing in size and efficiency until they become the chief organs of prehension in the mature adult, while the second antennæ diminish somewhat, but never lose their function entirely.

The development, therefore, is very similar to, and in fact almost identical with, that of the Caliginæ. And when the metanauplius molts into a chalimus the similarity is further increased by the fact that a frontal filament is formed, very different in length and structure from that found in the Caliginæ, but entirely similar in function.

Hesse claims (1883, p. 4) to have found a larva belonging to the "Pandaridæ," which he calls "*Nogagus spinacii-achantias*" and which he says was attached by a long and slender frontal filament to its "mother's" carapace. But when his account is examined it is found that very little can be accepted as authentic until further evidence is given.

In the first place the only reason which he can give for regarding the adult as the mother and the larva as her offspring is the fact that the latter was attached to the carapace of the former. The absurdity of drawing such a conclusion from this single premise has been already shown^a and may be briefly restated as follows: When first hatched the nauplii swim freely at the surface; after two or three molts they seek out a suitable host and attach themselves to it. There is not one chance in a million that they will find the same host again, to which their mother is attached, and still less chance of finding the mother herself among other parasites of the same and different kinds. In fact, to find the mother at all necessitates the assumption of the ability on the part of the larva or the mother, or both, to recognize the other, which one hardly cares to concede.

Again, the individual to which this larva was attached, and which Hesse calls the "mother," is unfortunately of the male sex, as is clearly shown by his figures and description. It has the typical *Nogaus* form; there are no signs of dorsal plates on thorax or genital segment, and none of the swimming legs show any signs of degeneration. This fact renders any close relationship between the two practically impossible.

Finally, Hesse writes that this larva was 3 millimeters long and 1 millimeter wide, with a fully developed frontal filament. But he describes and figures only a single pair of swimming legs, and they are on the second thorax segment. Every metanauplius which has thus far been observed possesses at least two pairs of these swimming legs, and a chalimus 3 millimeters in length belonging to any of the subfamilies of the Caligidæ must possess at least three pairs, and ought to possess four pairs, of such legs, the first of which would be attached to the ventral surface of the carapace and not to the second thorax segment. Again, the first antennæ are represented as attached to either side of the "umbilical button" at the base of the frontal filament. They are half the length of the carapace, two-jointed, and free to their very base; in other words, the chalimus has no frontal plates. The posterior half of the body is cylindrical and five-jointed, the joints diminishing in size backward. The first of these joints carries the single pair of legs and, in addition, on its ventral surface:

On remarque, à l'extrémité d'un article fémoral, assez long, des lames plates, denticulées sur les bords et garnies de soies, qui sont destinées à favoriser les mouvements de propulsion et de natation, et, de chaque côté de l'anneau suivant, deux lames plates, denticulées, qui sont consacrées aux mêmes fonctions (p. 6).

^a Proc. U. S. Nat. Mus., XXVIII, p. 548.

What these "lames plates" could be would furnish something of a puzzle to the comparative anatomist.

Hesse then adds, under what he is pleased to call "Physiologie":

J'ai d'abord exprimé l'opinion que cet embryon pourrait bien être un mâle qui, joint à une femelle *adulte*, douée conséquemment de moyens de locomotion plus puissants que les siens, pouvait l'entraîner sur un autre poisson et aller ainsi, avec lui, fonder une autre colonie et contribuer par là à favoriser la reproduction et la dissémination de l'espèce (p. 31).

That is to say, a male, which is free swimming in all the *Nogaus* species, attaches itself to a female, which in every species of the Pandarinæ is fixed and helpless, in order to facilitate its locomotion from one fish to another.

Since in a description of this sort there is no hint of the family, to say nothing of the generic position of the larva, we are compelled to set it aside entirely and to get our knowledge of the development of the Pandarinæ from original sources.

THE NAUPLIUS as seen in the genera *Nesippus* and *Pandarus*.

Body an elongate ellipsoid, evenly rounded in front, but somewhat contracted posteriorly through the bases of the balancers.

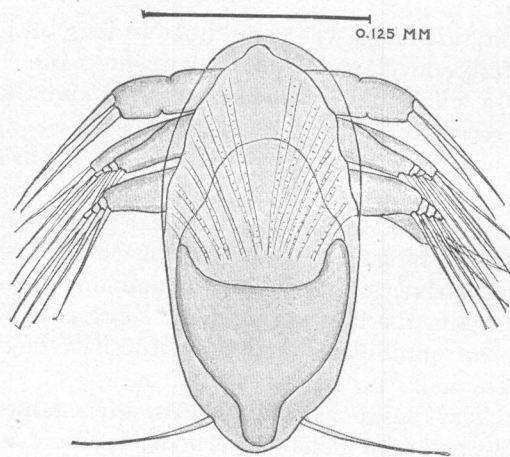


FIG. 5.—A NEWLY HATCHED NAUPLIUS OF *NESIPPUS ALATUS*.

The three pairs of appendages are bunched rather closely at the anterior end and are of the usual pattern. The balancers are fully one-third the entire length of the body, differing markedly in this respect from those found in the preceding subfamilies. In the *Nesippus* nauplius they take the form of simple, slightly curved, and acuminate spines; in the *Pandarus* nauplius

they are slightly S-shaped, with a double curve and contracted at a point one-fourth of their length from the base, as though jointed. In *Nesippus* the color is a uniform grayish brown, with a broad, transparent, and colorless margin, and without pigment spots or other markings. (See fig. 5.) In *Pandarus* the center of the body is olive green by transmitted light, appearing cinnamon-brown by reflected light in the egg strings, or even almost black.

The transparent margin is also very irregular in pattern and width, especially opposite the bases of the locomotor appendages.

The central mass of pigment reaches forward anteriorly in a long median, two-pronged projection and sends out branches also on either side opposite the second pair of appendages and the balancers. The anterior half of the body is more or less transparent and shows the muscles plainly, while the posterior part is opaque from the presence of yolk granules (see fig. 4).

Length, 0.25 mm.; width, 0.12 mm.

THE METANAUPLIUS as seen in the genus *Nesippus*.

On molting from the nauplius into the metanauplius the body becomes divided into regions consisting of a carapace, two free thorax segments, and a fusion of the genital segment and the abdomen (fig. 6). The carapace has an elongated acorn shape, the length twice the width, and squarely truncated posteriorly, with the corners produced into narrow lobes reaching to the center of the first free segment. The frontal plates are large and prominent, but folded under the anterior margin, so that very little of them can be seen in dorsal view. They are folded more evenly than in the *Alebion* larva and do not leave conical projections at the anterior corners. The eyes are situated even farther back than in *Alebion*, nearly half the distance from the anterior margin. They are quite large and not fused, although in contact on the mid-line.

The first free segment is evidently a fusion of the second and third thorax segments, as is indicated by the attachment of the legs. As these two segments are more or less fused in all the adults belonging to this subfamily, their fusion here in the metanauplius is what would naturally be expected.

The fused segment is nearly as wide as the carapace, and is furnished with broad lateral lobes at the sides over the bases of the legs. Such lateral lobes or plates are also characteristic of all the adults of both sexes, but in later development they become longer and nar-

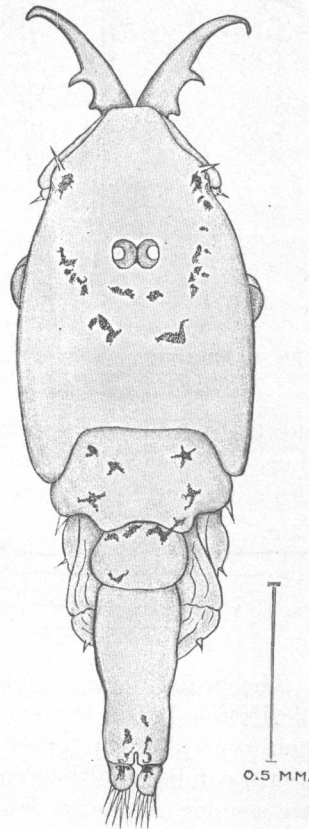


FIG. 6.—THE METANAUPLIUS OF *NE-SIPPUS ALATUS*.

rower. The second free, which is really the fourth thoracic, segment is just half as wide as the first, with strongly convex sides.

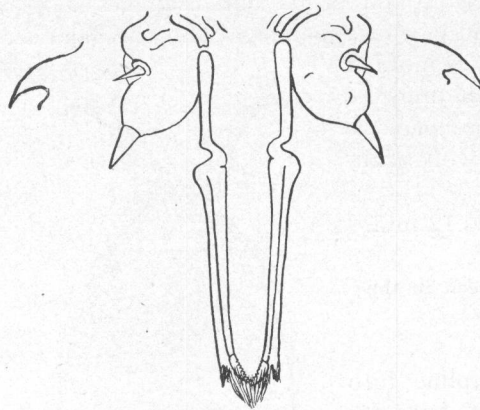


FIG. 7.—THE MOUTH TUBE, MAXILLÆ, AND MANDIBLES OF THE METANAUPLIUS OF NESIPPUS ALATUS.

out the plumose setæ found in both the *Caliginæ* and the *Euryphorinæ*. The second antennæ are similar to those of *Alebion*, but with two stout accessory spines on the inner margin near the base.

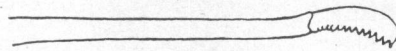


FIG. 8.—A MANDIBLE OF THE METANAUPLIUS OF NESIPPUS ALATUS.

The proboscis is also similar to that of *Alebion*, but is longer and of a more uniform width throughout (fig. 7). At its tip can be seen the mandibles, which are slender, somewhat enlarged, curved toward the free ends, and coarsely toothed along the inner concave margins. At this stage only the tips of the mandibles touch each other. Later, when the end of the mouth tube is compressed laterally, the entire toothed portion is interlocked (fig. 8).

The second maxillæ are close to the base of the mouth tube on either side, are simple, and consist of a stout conical base tipped with a short and straight spine. On the outer side of the base is another shorter spine, representing the rudimentary exopod; this rudiment is seemingly lost in later development. The first maxillipeds are slender and two-jointed,

The last segment, which is a fusion of the genital segment and abdomen, has the same width as the fourth thorax segment, but is three times as long and somewhat narrowed posteriorly.

The anal laminæ are relatively larger than in *Alebion*, but are tipped with much shorter setæ, five on each lamina.

The first antennæ are two-jointed, the terminal joint short and armed with small spines only, with-

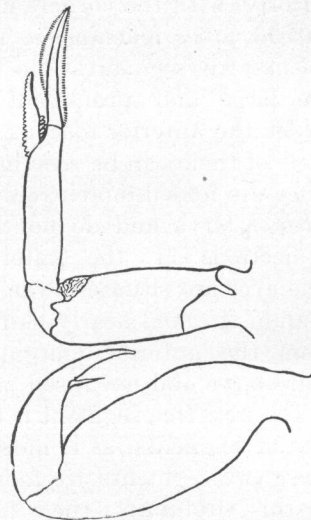


FIG. 9.—THE FIRST AND SECOND MAXILLIPEDS OF THE METANAUPLIUS OF NESIPPUS ALATUS.

the terminal joint narrower and longer than the basal, and tipped with two claws, the shorter ventral one with a few coarse teeth on the inner side at the base and a narrow-toothed flange along its outer margin (fig. 9). The dorsal claw is narrower and longer and has a narrow-toothed flange along either side.

The second maxillipeds are two-jointed, as in the adult, but are slender, with the terminal claw two-thirds the length of the basal joint, strongly curved, and with a small accessory spine on the inner margin near the tip.

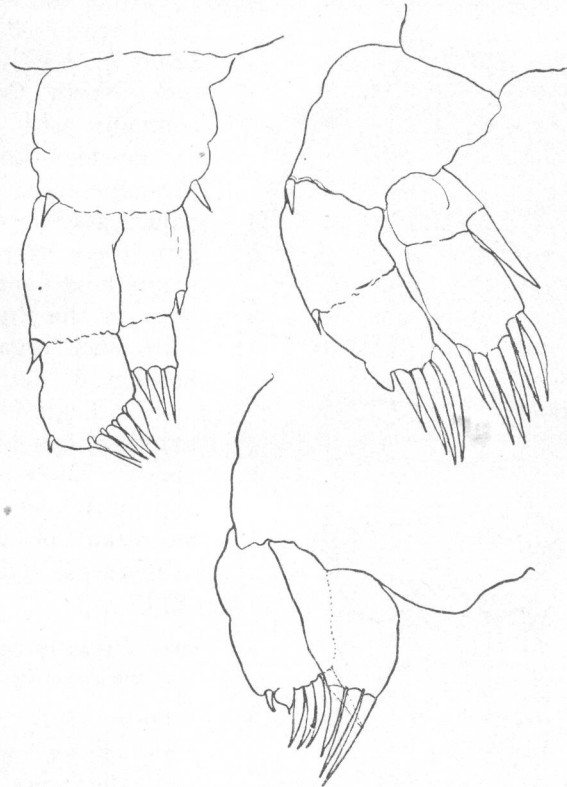


FIG. 10.—THE FIRST THREE PAIRS OF SWIMMING LEGS OF THE METANAUPLIUS OF NESIPPUS ALATUS.

There are three pairs of swimming legs, all biramose; the rami of the first two pairs are indistinctly two-jointed, while those of the third pair are one-jointed (fig. 10). The basal joint of each ramus has a single spine at its distal corner, on the outside in the exopod, on the inside in the endopod, while the terminal joint is tipped with a row of large and nearly straight setæ.

This metanauplius is of a yellowish horn color, quite transparent except through the center of the body. The pigment is scattering

and consists of a V-shaped string of small spots starting at the bases of the first antennæ on either side and extending obliquely backward to meet behind the eyes.

The two free segments have a few spots irregularly arranged, and there are a few more at the posterior end of the abdomen and in the anal laminae. These spots are all of a reddish purple color; the eyes are a deep purple with bright red lenses. Total length, including the second antennæ, 2.1 mm. Length of carapace, 1 mm. Width of same, 0.5 mm. Length of fused genital segment and abdomen, 0.51 mm.

This metanauplius stage was obtained from the gill filaments of the sharp-nosed shark, *Scoliodon teræ-novæ*, at Beaufort, North Carolina, in company with two adult females and three males of the same species. The peculiar stag-horn antennæ give these larvæ a more secure hold upon their host than in the Euryphorinæ. With such organs of prehension it would also be more difficult for the larva to loosen its hold and move about. There is thus perhaps in this larval stage an indication of the greater subsequent fixity of the adult.

THE CHALIMUS as seen in the genus *Perissopus*.

Only fully developed male chalimi were found, and they are described under the species *Perissopus communis* on page 357.

Single specimens of the female chalimus in three

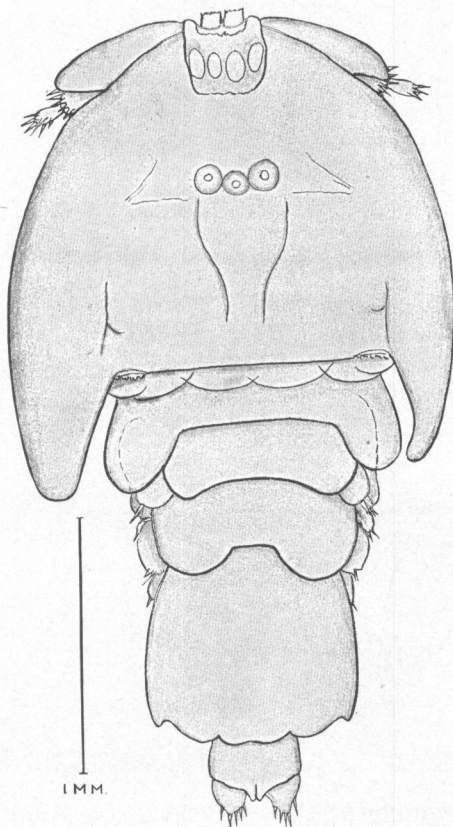


FIG. 11.—A CHALIMUS OF *PERISSOPUS COMMUNIS*.

stages of development were obtained, measuring, respectively, 3, 4, and 4.5 mm. in length.

(1) In the chalimus 3 mm. long the carapace, including the posterior lobes, is semielliptical, longer than wide, and has strongly convex sides (fig. 11). The posterior lobes are long and wide, reaching back to the fourth segment, and are bluntly rounded at the tip. The frontal plates are narrow at the center and widened at the

distal ends. There are three large eyes in a transverse row just in front of the center of the carapace, the central one smaller than the other two and slightly posterior to them. The frontal gland and attachment filament secreted by it are very different from those found in the *Caliginæ*.

The gland is a huge quadrangular affair, filling the entire center of the front of the carapace. In place of the two large gland cells seen in the *Caliginæ*, we find here four, arranged in two pairs, one on either side of the mid line.

Each cell is ellipsoidal in form, the ones nearest the mid line being larger and farther back than the outer ones.

In place of the single slender and cylindrical filament produced in the *Caliginæ*, we find here in *Perissopus* two broad and ribbon-like filaments placed side by side. Each is strongly compressed dorso-ventrally, and is barely long enough to reach the fish's skin and obtain a firm hold. The chalimus is thus held with the frontal margin of the carapace almost in actual contact with the fish's skin, and its condition is very different from that of the *Caligus* chalimus which floats out at the tip of a filament as long as its own body.

When these double filaments disappear in the adult they leave a broad and well-defined sinus at the center of the frontal margin, between the frontal plates. In all the adult *Nogaus* males this central sinus and the remains of the frontal gland can be clearly seen, often with shreds of the frontal filaments still attached at the base of the sinus, but in the adult females the glands and sometimes the sinus disappear. In younger females, however, they can still be distinguished.

In the size, arrangement, and general appearance of the free thorax segments of this chalimus there is a striking resemblance to the male form (see p. 357). The latter sex, therefore, must be taken as the typical form in this subfamily, and from this the female degenerates on becoming fixed.

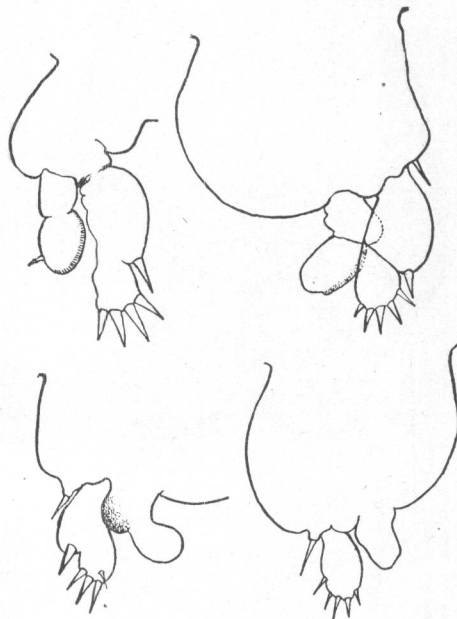


FIG. 12.—THE FOUR PAIRS OF SWIMMING LEGS OF THE CHALIMUS SHOWN IN THE PRECEDING FIGURE.

On the posterior margin of the carapace just inside the posterior lobes is a small fold of skin on either side, similar to that found in the male. The second thorax segment does not fill the entire space between the posterior lobes of the carapace, but leaves an interval on either side as in the male.

The first dorsal plates appear as lateral lobes on the sides of this segment. The third segment a little more than fills the space between these lateral lobes of the second segment and overlaps them on either

side. At this stage there is no trace of dorsal plates on the third segment.

The fourth thorax segment is wider than the third and slightly wider than the genital segment, and the dorsal plates on it appear as large circular lobes at its posterior corners.

The genital segment is subquadrangular, with slight rounded projections at the posterior corners and no median posterior sinus.

The abdomen is nearly half the width of the genital segment and projects for its entire length behind the latter; the anal laminae are triangular and armed with short and weak nonplumose spines. The swimming legs are like those of the adult in every particular except size (fig. 12). All the other appendages also are the same save the mouth tube; this is broader at the tip and closely resembles the form

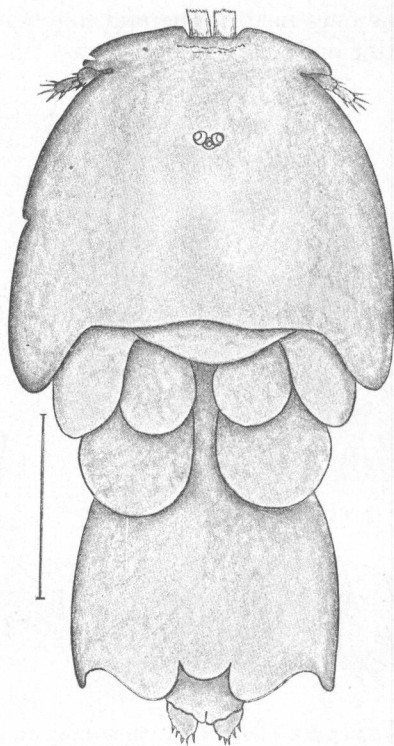


FIG. 13.—A CHALIMUS OF *PERISSOPUS COMMUNIS*, ONE-THIRD LARGER THAN THE ONE IN FIG. 11.

seen in the metanauplius.

The flexible lips have not yet rolled in around the mandibles and given the tube its final stiletto shape.

Total length, 3 mm.; length of carapace on mid-line, 1.35 mm.; width, 1.72 mm.; length of free segments, 0.72 mm.; length of genital segment, 0.77 mm.; width of same, 0.78 mm.

(2) The second chalimus, 4 mm. in length, differs from the first chiefly in the shortening of the posterior lobes of the carapace; in the development of the dorsal plates on the free thorax segments and the relative shortening of the segments themselves; in the enlarging of the genital segment and the formation of a deep and wide sinus

in the center of its posterior border, and in the partial migration of the abdomen to the ventral surface of the genital segment so that only a portion of it can be seen in dorsal view (fig. 13). This migration is apparent and not real; what actually happens is that the dorsal surface of the genital segment grows back over the abdomen, so that the latter appears to have moved forward along the ventral surface of the former.

Total length, 4 mm.; length of carapace on mid line, 1.66 mm.; width, 2.1 mm.; length of free segments, 0.75 mm.; length of genital segment, 1.40 mm.; width, 1.5 mm.

(3) The third chalimus has practically the adult form; there has been a still further shortening of the posterior lobes of the carapace and a corresponding widening of the carapace itself (fig. 14).

The dorsal plates now cover the entire surface of the free segments and overlap well onto the genital segment; the posterior portion of the first and third pairs is distinctly toothed.

There has been a further shortening of the free segments and a further enlarging of the genital segment, while the median posterior sinus of the latter has narrowed and deepened.

The abdomen has been entirely covered by the backward growth of the genital segment, so that the only thing which can be now seen in dorsal view is the tips of the anal laminæ, and they are seen through the posterior sinus of the genital segment.

The reproductive organs are now well formed in the genital segment, especially those which have to do with the receiving and storing of the sperm. It is probable, therefore, that the sexes come together immediately at the close of this chalimus period, before the female has become permanently fixed.

Total length, 4.5 mm.; length of carapace on mid line, 2.05 mm.; width, 2.95 mm.; length of free segments, 0.75 mm.; length of genital segment, 1.8 mm.; width of same, 2.6 mm.

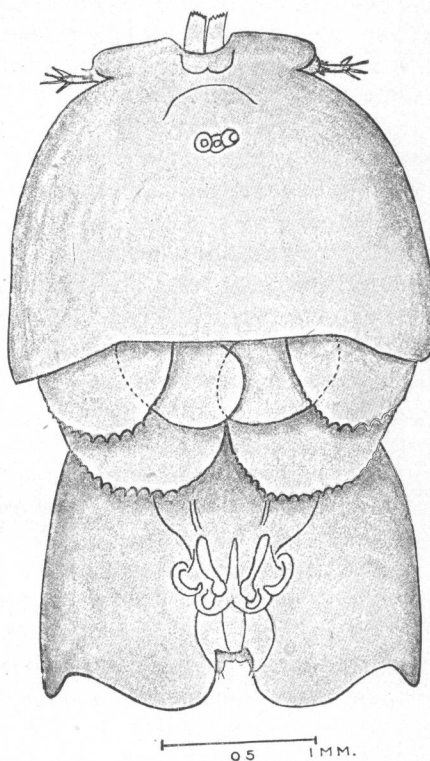


FIG. 14.—A CHALIMUS OF *PERISSOPUS COMMUNIS*, FULLY DEVELOPED.

SUMMARY.

The life history of the genera belonging to this subfamily is similar to that of the Caliginæ and Euryphorinæ except in the following particulars:

(1) The pigment which develops in the nauplii takes the form of a large central mass rather than scattered spots, and is often so dense as to appear almost black.

(2) The balancers are slender and cylindrical, as in the Euryphorinæ, but they are attached nearer to the posterior end of the body of the nauplius, and point backward at an angle of about 45° to the central axis.

(3) In the metanauplius the first thorax segment is fused with the carapace as in the Euryphorinæ, but the first antennæ are like those of the adult and not dichotomously branched, nor even armed with long plumose setæ. The rami of the second maxillæ are fused and each consists of a stout basal joint tipped with a single spine. The swimming legs are laminate, but the separate joints are long and narrow, and they reach far back on the ventral surface.

(4) The chalimi are attached by frontal filaments, not single and cylindrical as in the Caliginæ, but double, each strand broad and ribbon-like, the two strands standing side by side and only long enough to reach the fish's skin, and allow the frontal margin of the chalimus's carapace to swing clear of it. These filaments have no enlargements at their bases like those seen in the Caliginæ, but are of uniform width throughout. The frontal glands developing these filaments are quadruple instead of double.

(5) The body form of the young female chalimus is almost exactly the same as that of the adult *Nogaus* male, the carapace having elongate posterior lobes, the free thorax segments being entirely distinct and almost uncovered by the dorsal plates, and the abdomen projecting its entire length behind the genital segment. We thus have visible and convincing proof of the relationship of the two sexes, and also of the fact that the female degenerates after becoming fixed.

(6) The appendages of the young chalimus are almost exactly like those of the adult; the second maxillipeds have not yet attained their proportionate size, but are small and the terminal joint is folded over against the basal joint.

(7) In subsequent development the posterior lobes of the carapace are shortened, the free thorax segments are telescoped together, and the dorsal plates are developed to cover them; the genital segment is increased in size, often becoming larger than the carapace, and in this increase it grows gradually back over the abdomen, so that the latter comes to lie on the ventral surface of the former, and is completely concealed in dorsal view.

SYSTEMATIC DISCUSSION.

Subfamily PANDARINÆ.

The first thorax segment only fused with the head, the others free; sexes quite dissimilar.

Female.—Carapace short and well rounded; frontal plates distinct. Eyes three in number, fused on the median line, the lenses arranged in the form of a triangle. One or more of the free thorax segments furnished with paired dorsal plates; genital segment enlarged and often covered with similar dorsal plates. Body stiff in consequence of these plates and not capable of much motion. Abdomen elongate, often with lateral processes; anal laminae large and broad, with stout plumose setae. Eggs numerous, uniseriate, and borne in straight cases, visible for their entire length and usually much longer than the body. Mouth-tube elongate and tapering to a sharp point; first maxillae lacking, second pair simple flattened laminae, tipped with short claws. Second maxillipeds massive and nodose. All four pairs of legs biramose; some or all of them lamellar and destitute of plumose setae.

Male.—A typical *Nogaus* form. Carapace more elongate than that of the female and produced posteriorly into better defined lateral lobes. Free segments all well separated, of about the same length, but diminishing regularly in width, and none of them furnished with dorsal plates. Genital segment also without dorsal plates and enlarged but little. Abdomen two-jointed; anal laminae large and foliaceous, furnished with long and stout plumose setae. The adult males are as free swimmers as any of the Caliginæ and move about with as much ease over their host's body, thus affording a marked contrast to the fixed females. The young are attached by two broad and ribbon-like filaments, placed side by side and very short.

KEY TO THE GENERA.

- a. Females, first thorax legs uniramous, the other pairs biramous; only two pairs of dorsal plates. *Pholidopus*, new genus name, p. 347.
- a. Females, all four pairs of legs biramous; one, three, or four, but never two, pairs of dorsal plates; abdomen one-jointed and wholly concealed in dorsal view. b.
- a. Males, all four pairs of legs biramous and armed with long plumose setae; no dorsal plates; abdomen one or two jointed, wholly visible. g.
- b. Rami of all the legs with the same number of joints, and all armed with long plumose setae. c.
- b. Rami differing in the number of joints, and some or all of them destitute of plumose setae, or even spines. d.
- c. Four pairs of dorsal plates; first and third pairs median, second and fourth pairs lateral; fourth pair on the genital segment, elongate, narrow, partly fused. *Lepimacrus* Hesse, 1883, p. 348.
- c. A single pair of small dorsal plates on the fourth segment; genital segment elongate, with a deep posterior incision; abdomen unsegmented. *Demoleus* Heller, 1865, p. 349.

- d. Rami of second and third legs three-jointed, of first and fourth pairs two-jointed; no setæ on the fourth pair, those on the other pairs rudimentary. e.
- d. Rami of first three pairs of legs two-jointed, with plumose setæ; of fourth pair one-jointed, setæ nonplumose. f.
- d. Rami of second and third legs two-jointed; of fourth pair one-jointed; exopods of first pair one-jointed, endopods two-jointed.
Gangliopus Gerstaecker, 1854, p. 350.
- d. Rami of first and second legs two-jointed; of third and fourth pairs one-jointed and very rudimentary; three pairs of dorsal plates.
Perissopus Steenstrup and Lütken, 1861, p. 352.
- d. Rami of third legs two-jointed, of all the other legs one-jointed, lamellar and without spines or setæ. *Laminifera* Poche, 1902, p. 361.
- e. Dorsal plates on fourth segment large, covering half the genital segment or more; sixth segment not separated; exopods of second and third legs three-jointed, all the other rami two-jointed.
Echthrogaleus Steenstrup and Lütken, 1861, p. 362.
- e. Sixth segment distinctly separated as a median lobe or lamina, attached to the posterior sinus of the genital segment, and armed with a pair of dorsal plates and a rudimentary pair of swimming legs; both rami of the second and third legs three-jointed. *Dinematura* Latreille, 1829, p. 374.
- f. Sixth segment distinctly separated as a rudimentary plate or lamina, attached to the posterior sinus of the genital segment; anal laminae transformed into horny conical processes; four pairs of dorsal plates, the fourth on the genital segment. *Pandarus* Leach, 1816, p. 387.
- f. No sixth segment; anal laminae normal; second and third thorax segments fused *inter se*, and carrying a pair of good-sized lateral lobes; a single pair of dorsal plates, on the fourth segment, close together, and with their bases fused. *Nesippus* Heller, 1865, p. 424.
- f. No sixth segment; anal laminae normal; second and third segments distinct, with small lateral lobes; a single pair of dorsal plates, on the fourth segment, feebly developed, and widely separated, their margins fringed with hairs. *Prosartes*, new genus name, p. 439.
- g. Rami of all the swimming legs two-jointed. h.
- g. Rami of fourth legs one-jointed, of all the others two-jointed. i.
- g. One or both rami of the second and third legs three-jointed, of all the others two-jointed. k.
- h. An accessory lobe on the posterior margin of the carapace just inside each posterior lobe; both the fifth and sixth legs visible on the genital segment; abdomen two-jointed, the joints equal. *Pandarus* Leach, 1816, p. 387.
- h. Second maxillipeds not swollen, with ordinary terminal claws; anal laminae very large; no legs visible dorsally on the genital segment.
Demoleus Heller, 1865, p. 349.
- h. Second maxillipeds much swollen, with a long terminal claw; anal laminae medium size; no legs on the genital segment, or but one pair.
Perissopus Steenstrup and Lütken, 1861, p. 352.
- i. Free thorax segments two or three times as wide as long; fourth segment the longest; no legs visible on the genital segment; abdomen one-jointed.
Nesippus Heller, 1865, p. 424.
- i. Free thorax segments orbicular, all about the same width, second segment the longest, with large lateral wings; genital segment with one pair of legs at the posterior corners; abdomen two-jointed, basal joint the larger.
Gangliopus Gerstaecker, 1854, p. 350.

i. Free thorax segments wider than long; second segment the longest, with small lateral wings; abdomen two-jointed, terminal joint the larger.

Perissopus Steenstrup and Lütken, 1861, p. 352.

k. Exopods only three-jointed; fourth segment lunate, fitting down over the genital segment.... *Echthrogaleus* Steenstrup and Lütken, 1861, p. 362.

l. Both rami three-jointed; fourth segment orbicular, not overlapping the genital segment..... *Dinematura* Latreille, 1829, p. 374.

PHOLIDOPUS, new genus name.

Lepidopus DANA, 1852, p. 1373, pl. xcv, figs. 5 a—k.

Perissopus STEENSTRUP and LÜTKEN, 1861, p. 394 (part).—BASSETT-SMITH, 1899, p. 468 (part).

Female.—First thorax segment joined with the head to form the carapace, which is subquadrangular and widest posteriorly. Second and third thorax segments fused, and furnished with a single pair of large, rounded dorsal plates. Fourth segment free and armed with a similar pair of dorsal plates. Genital segment wider and longer than the carapace, its posterior margin bilobed, the two halves evenly rounded like the two pairs of dorsal plates on the free segments. Abdomen minute, attached to the ventral surface of the genital segment some little distance in front of the posterior margin, so as to be wholly concealed in dorsal view. Anal laminae short, tipped with small spines. Frontal plates well differentiated and larger than in the other Pandarinæ. Second antennæ three-jointed and uncinatæ, the terminal hook considerably longer than the basal joints, sickle-shaped and armed with two rows of teeth along its inner margin. Mouth-tube long and slender, as in *Pandarus*; mandibles with a straight tip, and the inner margin serrulate. Second maxillæ close to the base of the mouth-tube, composed of two short, well-rounded joints terminated by a small and nearly straight spine. Terminal joint of second maxillipeds widened and flattened into a broad lamina, covered with scales on its ventral surface, each scale terminating in a minute spine. First swimming legs slender, uniramous, and three-jointed, the terminal joint armed with five short setæ. Second, third, and fourth swimming legs biramous; second pair with slender basal segments and two-jointed rami; third and fourth pairs with the basal segments broadly lamellar, and the rami minute, rudimentary, one-jointed processes attached to the posterior edges of these lamellæ; setæ all very short. Nothing is known of the egg cases or eggs.

Male.—Unknown.

(*Pholidopus*, φολίς, a scale, and πούς, foot.)

The new name given above is suggested in place of Dana's *Lepidopus*, which was preoccupied in 1770 by Gouan for a genus of fishes. That this is a valid genus and not a synonym for *Perissopus*, as suggested by Steenstrup and Lütken in 1861, by Brady in 1883, and again by Bassett-Smith in 1899, can be readily seen by the following comparison:

In *Perissopus* there are three free thorax joints, each carrying a pair of dorsal plates, of which the first pair is lateral, the second median, while the third extends entirely across the body; the genital segment is squarely truncated posteriorly, with sharp spines at the corners; the second antennæ are short, with a small terminal claw; all four pairs of swimming legs are biramose, with enlarged and lamellar basal joints; rami of the third and fourth pairs minute and rudimentary, the exopod differing from the endopod, and the third pair from the fourth pair.

In *Pholidopus*, on the contrary, the second and third thorax segments are fused together, and carry but a single pair of dorsal plates, which are like those on the fourth segment, extending entirely across the body; the genital segment is incised at the center posteriorly, each side being evenly rounded in a semicircle, without any spines; the second antennæ have short basal joints, with a very long sickle-shaped terminal claw, set with two rows of teeth; the first pair of legs is uniramose and three-jointed, the other pairs are biramose; but the basal joints of the first two pairs are narrow and slender, not lamellar; the last two pairs have lamellar basal joints, but all of their rami are just alike and armed with spines at their tips.

Genus LEPIMACRUS Hesse.

Lepimacrus jourdaini HESSE, 1883, p. 6, pl. IV, figs. 8-17.

Hesse described, in the above reference, a new genus and species based upon a single female specimen obtained from *Lamna cornubica*. The species has never been seen by any other writer, so that Hesse's description is all the knowledge we have of it. And although this description is faulty and the figures give us few reliable details, yet enough is shown to determine with reasonable certainty that the specimen really represented a new genus. Consequently it is here included and is differentiated as well as possible from the other genera in the following diagnosis.

Female.—Carapace elliptical, rather pointed anteriorly, the sides slightly emarginate; frontal plates prominent; eyes small and close together. Four pairs of dorsal plates on the thorax segments, first and third pairs median, second and fourth pairs lateral. First two pairs subquadrangular; first pair fused at the base but separated for most of their length by a broad sinus; second pair widely separated, even at their bases. Last two pairs narrow and elongate; third pair separated at their bases but meeting at their tips on the midline; fourth pair on the genital segment, each plate semilunar, the convex sides toward each other and fused for some distance at the center. The tips of these plates are divergent; they project far behind the genital segment and are armed with stout spines; abdomen small, one-

jointed, and concealed beneath the genital segment; mouth-tube, appendages, and adhesion pads similar to those in other Pandarids.

Male.—Unknown.

(*Lepimacrus*, *λεπίς*, a scale, and *μακρός*, long, referring to the long and narrow dorsal plates on the genital segment.)

Genus DEMOLEUS Heller.

Caligus paradoxus OTTO, 1828, p. 352, pl. xxii, figs. 5, 6.

Nogagus grandis STEENSTRUP and LÜTKEN, 1861, p. 386, pl. x, fig. 18.

Demoleus paradoxus HELLER, 1865, p. 199, pl. xix, fig. 3.

In 1828 Otto described the male and female of a new species of copepod parasite which he named *Caligus paradoxus*. The male had the typical *Nogagus* form, but was much larger than other species, being 12.5 mm. in length. In 1865 Heller rediscovered the female of Otto's species and made it the type of a new genus, which he called *Demoleus*, and for which he gave the following genus diagnosis:

Cephalothorax emarginate posteriorly, two following segments free, fourth segment with dorsal plates (in the female); frontal plates prominent, first antennæ partly concealed by them, two-jointed. All the legs biramose, rami two-jointed, armed with plumose setæ, those of the first and fourth pairs minute, of the second and third pairs lamellar and enlarged. Genital segment elongate, abdomen very short, not jointed, covered with a foliaceous dorsal lamina, appendages large. Male of the typical *Nogagus* form.

With this description and the excellent figures published by Otto and Heller to guide us we can locate in this genus the form *Nogagus grandis*, described by Steenstrup and Lütken in 1861 from two specimens obtained in the warmer portion of the Atlantic, the definite locality and host not given. At the conclusion of their description these authors suggest: "If *Dinematura ferox* and *Nogagus grandis* could be proved to come from the same locality they might well be the male and female of the same species" (p. 387).

But in this they are mistaken, because neither the carapace, the fourth thorax segment, the swimming legs, nor the abdomen correspond with those found in *Dinematura* males, for the carapace in *Dinematura* is wider and its lateral margins are more strongly convex; the third segment is considerably larger, and the fourth segment carries a pair of rudimentary dorsal plates, which are entirely lacking in this *Nogagus*. The genital segment is relatively much wider in *Dinematura*, and has no posterior lobes; the abdomen is very much narrower and two-jointed, with the joints equal. But the essential difference is found in the swimming legs; in *Dinematura* males the rami of the second and third pairs are three-jointed like those of the female, while here in *Nogagus grandis* all the rami are two-jointed.

Furthermore, a careful comparison of this species with Otto's type male of *Caligus paradoxus* show the two to be identical.

They differ from all the other *Nogaus* types here given in their size, being from 13 to 16.5 mm. in length; in the relative size of the third thorax segment, which is much the smallest of the three free segments; in the semilunar shape of the fourth segment; in the segmentation of the abdomen, each joint of which is considerably wider than long, and in the huge size of the anal laminae, which, however, are armed with very small and rudimentary setae. These considerations render it fairly certain that *Nogagus grandis* is the male of *Demoleus paradoxus*, and we may revise the genus diagnosis as follows to include both sexes:

Female.—Carapace orbicular, about one-third the entire length; frontal plates narrow and distinct; eyes close together. Second and third thorax segments of the same width and just filling the space between the posterior lobes of the carapace; second segment with small lateral lobes; fourth segment less than half the width of the other two, and carrying a pair of small dorsal plates. Genital segment elongate, more than twice as long as wide, deeply incised posteriorly, with evenly rounded lobes. Sixth segment separated in the form of a circular plate concealed between the genital segment and the abdomen. Abdomen minute, triangular, and entirely concealed in dorsal view; anal laminae very large, projecting beyond the posterior margin of the genital segment, but armed with small and rudimentary setae. Second antennae small, with a weak terminal claw; second maxillipeds with a medium-sized claw. All the swimming legs biramose, the rami two-jointed and armed with plumose setae; basal joints of the first and fourth pairs small, of the second and third pairs enlarged and lamellar. Egg-strings looped once so as to give three strands.

Male.—Carapace similar to that of the female, about half the entire length; a pair of minute accessory lobes on the posterior border, just inside the posterior lobes. Lateral lobes on second thorax segment like those in the female; fourth segment without dorsal plates. Genital segment elongate, with short and well-rounded posterior lobes, but with no legs visible in dorsal view. Abdomen two-jointed, terminal joint the wider; anal laminae huge, but armed as in the female with small and rudimentary setae. Second maxillipeds not much swollen and armed with ordinary terminal claws. All the swimming legs biramose, the rami two-jointed and armed with large plumose setae.

(*Demoleus*, a Greek slain by Æneas before Troy.)

Genus GANGLIOPUS Gerstaecker.

Gangliopus pyriformis GERSTAECKER, 1854, p. 192, pl. VII, figs. 9–16.

Nogagus angustulus GERSTAECKER, 1854, p. 193, pl. VII, figs. 17, 18.

Both sexes of this genus were obtained together from the gill arches of a shark captured on the west coast of Africa, and were described by Gerstaecker in 1854. He recognized the female as the

type of a new genus which he named *Gangliopus*, but he classed the male with the genus "*Nogagus*," and gave it the name *N. angustulus*. The fact that they were found together did not suggest to Gerstaecker that they might be male and female of the same species, but such seems to be the case as evidenced by the following facts:

(1) Negative evidence: Each of the two forms is different from the other types of its own sex which belong to this subfamily. This is a necessary preliminary for the formation of any new genus, and the male should differ as well as the female, as we find it actually does in the present instance.

(2) Positive evidence: The frontal plates and first antennæ are very similar in the two forms; the carapace is relatively longer in the male, but this is what would naturally be expected. In both sexes the carapace is narrowed posteriorly.

Each sex shows three free thorax segments, diminishing in size backward; in the female they are armed with dorsal plates, but these are lacking in the male, which carries but a single pair of lateral lobes on the first segment.

The genital segment in each is enlarged and quadrangular; it is emarginate in the female and carries a pair of posterior lobes in the male. The four anterior pairs of legs are biramose, the rami of the first three pairs two-jointed, the fourth pair one-jointed. The relative sizes are what would be expected in the male and female of the same species, 9 mm. in the female and 7.5 mm. in the male.

In view of these facts "*Nogagus angustulus*" may be regarded with considerable certainty as the male of *Gangliopus pyriformis* and we shall have the following genus diagnosis for both sexes.

Female.—Carapace obovate, strongly narrowed posteriorly; the lateral areas divided by transverse grooves as in *Echthrogaleus*. Frontal plates prominent; posterior lobes short and triangular. A pair of small dorsal plates on each of the three free segments, all lateral, the first pair with a wide interval between their bases, the other two pairs meeting on the mid-line. Genital segment somewhat enlarged, quadrangular, with evenly rounded posterior corners. Sixth thorax segment well separated and carrying a pair of rudimentary legs as in *Dinematura*. Abdomen small and square, attached by one corner to the sixth segment; anal laminae minute, attached to the lateral corners of the abdomen, and destitute of setæ or spines. Swimming legs all biramose, rami small and laminate, those of the first three pairs two-jointed, of the fourth pair one-jointed. Rami of the first two pairs armed with adhesion pads; exopods all carrying short, nonplumose spines, endopods naked. Egg-tubes narrow and twice as long as the body.

Male.—Carapace obovate-elliptical; frontal plates prominent; posterior lobes long, narrow, and pointed. Free segments transversely

elliptical and widely separated, the first one carrying a pair of good-sized lateral lobes. Genital segment subquadrangular, with short and acute posterior lobes. Abdomen two-jointed, the basal joint the larger; anal laminae large, each armed with four plumose setae. Appendages as in the female: all the swimming legs biramose, the first three pairs of rami two-jointed, the fourth pair one-jointed.

(*Gangliopus*, γάγγλιον, a tumor or swelling, and ποὺς, foot, swollen-footed.)

Neither of these forms has been seen since Gerstaecker first described them, and there are several points with reference to their anatomy which need explanation.

In the female the exopod of the first swimming legs is represented as one-jointed and the endopod as two-jointed. But the arrangement of the spines on the exopod shows clearly that it is at least a fusion of two joints. And a more careful examination of fresh material would probably show that it is imperfectly segmented; accordingly it has been given here as two-jointed. Again, Gerstaecker says that the abdomen of the female is two-jointed, and that the basal joint carries at its posterior corners two oval laminae. Such appendages are not found on any Caligid, but their interpretation becomes easy if we regard them as rudimentary legs like those in *Dinematura*.

What he calls the basal joint of the abdomen will thus become the sixth thorax joint, well separated from the genital segment as in several other species. He does not mention any dorsal plate for this sixth segment, but such a plate might be easily overlooked when it was concealed between the genital segment and abdomen. The similar plate which exists in *Echthrogaleus* has escaped detection up to the present time.

For the male nothing is said in the text about the swimming legs and all information has to be taken from the figure given, which, however, does not show either the first or second pairs. Accordingly we have to fall back upon the supposition that these are the same as in all the *Nogaus* species or Gerstaecker would have noted the difference. This method is not very scientific, but it is all we have at present.

Genus PERISSOPUS Steenstrup and Lütken.

Perissopus dentatus, STEENSTRUP and LÜTKEN, 1861, p. 393, pl. XII, fig. 25.

Female.—Carapace wider than long, narrowed anteriorly; posterior lobes short, sometimes almost lacking. Frontal plates narrow but distinct, with a broad and well defined median incision. Eyes three in number, placed nearly in a row, the middle one the smaller. Three free thorax segments, each with a pair of dorsal plates, the first pair lateral and oblique, the second median and nearly horizontal, the third the largest, extending entirely across the body.

Genital segment considerably larger than the carapace, evenly rounded anteriorly, but almost squarely truncated posteriorly, with short and acute spines at the corners and a wide median incision. Fifth legs some distance from the margin on the ventral surface. Abdomen small and entirely hidden in dorsal view; anal laminae also small, with very short and nonplumose spines. Terminal joints of the second maxillipeds enlarged and fleshy, reniform, with a rough scaly surface. Legs all biramose; rami of third and fourth pairs minute and rudimentary. Egg-strings narrow and much longer than the body.

Male.—Carapace, including the posterior lobes, elliptical, slightly longer than wide, narrowed anteriorly; posterior lobes long and narrow; posterior margin between the lobes nearly straight. Eyes three in a row, the median one much smaller than the others. Free thorax segments about the same length, diminishing regularly in width. Genital segment small, subquadrangular, with the fifth legs very prominent at the posterior corners. Abdomen large, one-jointed; anal laminae large and armed with long plumose setae. Second antennae larger than in the female, but with the adhesion pad much reduced in size. Second maxillipeds with a stout, curved, terminal claw shutting down against a pair of corrugated knobs as in *Pandarus*.

Swimming legs all biramose, rami of fourth pair indistinctly segmented, of the other pairs two-jointed.

(*Perissopus*, περίσσως, more than the regular number or size, and πούς, foot, alluding to the enlarged second maxillipeds.)

KEY TO THE SPECIES.

- a. First pair of dorsal thorax plates bilobed; second pair not meeting at the mid-line; third pair fused.....(*Chlamys incisus* Van Beneden, 1892, p. 354.)
- a. None of the thorax plates bilobed; second and third pairs meeting at the mid-line, but not fused..... b.
- b. Carapace about half the size of the genital segment; its posterior lobes narrow, long, and overlapping the first dorsal plates; rami of third legs fused into a semicircular plate.
dentatus Steenstrup and Lütken, 1861, p. 353.
- b. Carapace more than four-fifths as large as the genital segment, its posterior lobes very short and wide; rami of third legs distinct and similar to those of the third pair.....*communis* Rathbun, 1887, p. 354.

This genus *Perissopus* was established by Steenstrup and Lütken in 1861 for a species which they named *P. dentatus*, and for which they gave the following genus diagnosis:

Cephalothorax undivided; abdominal segments free, carrying four or six dorsal plates; genital segment enlarged and a little widened, covering the short tail and the caudal stylets; abdominal feet destitute of plumose setae, rami of first and second pairs (at least in *P. dentatus*) two-jointed, the other rami not jointed, very rudimentary. Male unknown.

They wished to include in the same genus Dana's *Lepidopus*, and the above diagnosis was evidently made out with that in view.

And they also gave two species diagnosis, one for their new species *dentatus*, and the other for Dana's species *armatus*.

But in this they were mistaken, for Dana's genus *Lepidopus* can not be identified with *Perissopus* for reasons already mentioned (see p. 348). This leaves the genus with the original type species *dentatus*, the new species, *communis*, established by Rathbun in 1887, and a third species, *incisus*, described in 1892.

In that year Van Beneden published an account of a copepod parasite belonging to the present subfamily, which he made the type of a new genus, called *Chlamys*. He recognized its resemblance to Dana's *Lepidopus*, but was either unacquainted with, or had forgotten Steenstrup and Lütken's genus *Perissopus*, which it resembles even more closely. In fact there is little doubt that it is a species of *Perissopus*, as Bassett-Smith has suggested (1899, p. 468), and as such it is here included in the key. The only doubt as to its identity is found in the utter confusion of details characteristic of Beneden's figures and descriptions. In his ventral view of the female (Plate II, fig. 3) he pictures the first swimming legs as uniramous and two-jointed, while the other three pairs are biramous, with all the rami one-jointed. In the enlarged figure (fig. 9) of these same legs he shows them all biramous, each endopod one-jointed, and each exopod two-jointed. His description in the text (pp. 230 and 231) agrees with this last figure, except for the fourth legs, of which he says: "La quatrieme paire de pattes n'est pas biramée." In the face of such flat contradictions, one has to be guided chiefly by the general makeup of the body and the relation of its regions. These are so similar to those of *Perissopus* as to leave no doubt of generic identity.

PERISSOPUS COMMUNIS Rathbun. .

PLATES XVII and XVIII.

Perissopus communis RATHBUN, 1887, p. 560, pls. XXIX, XXX.

Perissopus dentatus (part) BASSETT-SMITH, 1899, p. 468.

Female.—Carapace semielliptical, narrowed but little anteriorly, widest at or near the posterior angles; lateral margins slightly convex, sometimes nearly straight; posterior lobes short and angular; posterior margin straight or slightly concave, sometimes with a small spine on either side. Frontal plates narrow but distinct, frontal margin nearly straight, with a broad and shallow median incision. Eyes usually invisible in the adult, but distinct in the young, three in number and arranged in a transverse row, the central one slightly behind and a little smaller than the other two. Visible portion of the dorsal plates of the second thorax segment standing out at an angle of 45° to the central axis, and elliptical in outline, the longer diameter nearly

twice the length of the shorter one. The outer margin of these plates really extends forward to the reniform pads of the second maxillipeds, so that if removed from the body the plates are found to be spindle shaped, pointed at either end, about twice as long as wide and attached nearly at the center of the inner margin, leaving both ends free. A wide space between the bases of these plates and behind the posterior margin of the carapace is left uncovered or with a small central plate, as in some *Pandarus* species. Dorsal plates of the third thorax segment smaller than the first pair, also elliptical, but nearly horizontal or only slightly oblique, with their tips meeting and often overlapping a little on the mid-line. Dorsal plates of the third pair considerably enlarged, circular and extending across the entire width of the body, their inner margins overlapping on the mid-line, their posterior margins reaching some distance over the genital segment. The posterior margins of the first and third pairs of plates are scalloped, the points ending in short and sharp teeth; the margins of the second pair of plates are smooth. Genital segment about the same size as the carapace, evenly rounded anteriorly, its lateral margins convex, its posterior margin cut obliquely on either side, with small and sharp spines at the posterior corners and a wide and deep median sinus. The margin between the sinus and the corner spine on either side has a double or S-shaped curve, sweeping backward at the side of the sinus and forward close to the spine.

Abdomen small and plump, a little longer than wide, barrel-shaped, one-jointed, and entirely concealed beneath the genital segment. Anal laminae short, triangular, and armed with minute and irregular spines. First antennae small and two-jointed, the basal joint heavily, the terminal joint lightly, armed with setae. The basal joint is much wider than the terminal and twice as long, and its tip reaches well beyond the margin of the frontal plate. Second antennae also small and weak, the terminal claw as long as the rest of the appendage, but slender and not very strongly curved. Adhesion pads much smaller than in *Pandarus*, the first pair ovate, their long diameter inclined outward and forward at an angle of 45° to the body axis, the second pair much smaller, circular, and at the very base of the second antennae, on the ventral surface of the carapace, so that they can not be lowered against the fish's skin as in *Pandarus*.

Mouth-tube and mandibles of the usual form for this subfamily; second maxillae lamellar, each tipped with a long and narrow spine. In other genera these lamellae are attached along a line at right angles to the body axis, or one inclined outward and backward, so that the appendages when at rest against the surface of the carapace are parallel with the mouth-tube or turn inward and overlap it. But in the present genus the line of attachment is inclined backward and inward, parallel with the tapering margin of the mouth-tube, so that

when turned down against the carapace, the appendage points directly away from the proboscis nearly at right angles.

First maxillipeds of the usual pattern, the terminal claws rather stout, the external one considerably longer than the internal. Second maxillipeds swollen and fleshy, the terminal joint enlarged into a huge kidney-shaped adhesion pad, destitute of pinchers, knobs, or claws. This pad has exactly the same structure as those at the bases of the antennæ; the adhesion surface is tough and leathery, is surrounded by a raised margin, and is minutely corrugated and irregularly furrowed, but shows no traces of scales or anything of the sort even under a one-twelfth oil immersion lens. Opposite these large second maxillipeds the lateral margin of the carapace on either side is raised into a large spherical knob on the ventral surface, pointing downward and inward toward the base of the maxilliped, and even in contact with the latter in preserved specimens.

Swimming legs all biramose, each ramus of the first two pairs distinctly two-jointed, of the third pair partially, and of the fourth pair almost wholly, fused into a single joint. Exopods each armed with stout spines, of the same number and similarly arranged, one at the outer distal corner of the proximal joint and four in a row across the end of the distal joint. Endopods with portions of the surface covered with minute papillæ or spines. Outside of each exopod in the three posterior pairs is a small rounded knob, like a rudimentary third ramus, bearing on its summit a long and flexible spine.

The basal joints of each pair of legs are subrectangular in outline and increase rapidly in size from in front backward, those of the fourth pair being fully eight times the size of the first. In the first two pairs these basal joints are attached by their anterior margins, in the third pair by the antero-interior corners, and in the fourth pair by the centers of the interior margins, the rami in each case being borne on the posterior margins. In all the exopods the basal joint is considerably larger than the terminal; in the endopods of the first and second pairs the terminal joint is the larger, while in the third and fourth pairs it is reduced to a mere knob on the side of the basal joint. The fifth legs consist of a long papilla, broadly triangular at the base and strongly flattened, attached to the ventral surface of the genital segment halfway between the lateral margin and the mid-line, and armed with three slender spines.

Of the reproductive organs each egg tube is coiled once in the genital segment, and each of the three strands of the coil runs the entire length of the segment and fills its side out to the lateral margin. The vulva or oviduct opening is at the tip of a raised rectangular papilla, situated close to the base of the abdomen on either side. The spermatophores are club-shaped, narrow and elongate, and apparently jointed at the center. They are attached just outside the

vulva papilla, in the angle between it and the ventral surface of the genital segment on either side, and their duct empties on the same side without crossing the mid-line, as in *Pandarus*.

Semen receptacle globular, a little wider than long and just in front of the base of the abdomen; its anterior margin is evenly rounded, its posterior one is split at the center, dividing the receptacle into two conical, widely divergent branches, which run out into the vulva papilla on either side and there open into the oviduct. Cement glands almost invisible in preserved material, the only thing that could be made out with reference to them being their position on either side of and close to the mid-line, and their general shape that of parentheses marks.

External egg-sacs slender, one and a half to two times as long as the entire body; eggs small, strongly flattened and numerous, with very little pigment.

Total length 4 mm. Length of carapace 1.5 mm. Width 1.9 mm. Length of genital segment 1.6 mm. Width of same 1.8 mm. Length of egg-strings 6 to 8 mm.

Color a light yellowish white, without pigment, often turning brown in alcohol.

(*communis*, common).

Male.—No adult male has ever been obtained, not merely for this species, but for the whole genus. Two fully developed chalimus males, however, were obtained in company with chalimus females and young adults on a smooth dog-fish captured September 2, 1904, at Woods Hole. The following is a description of these males and would be correct for the adults except in size.

Carapace, including the posterior lobes, forming an ellipse, strongly narrowed anteriorly, its lateral margins moderately convex. Posterior lobes long and narrow and bluntly rounded at the tip; posterior margin between the lobes nearly straight, with the rudiments of accessory lobes on either side. Eyes large and prominent, a little in front of the center and close together, but not in actual contact. Frontal lobes large and prominent, narrow at the center but broad at the outer ends, where they cover most of the basal joints of the first antennæ. Free thorax segments diminishing regularly in width backward, the fourth one the same width as the genital segment, the first one considerably narrower than the distance between the posterior lobes of the carapace, leaving a wide open space on either side. Lateral processes of this first segment long, large, and curved outward at the tips.

Genital segment oblong, the anterior margin nearly straight, the lateral margins evenly rounded, the posterior margin concave.

The fifth legs appear as large and prominent papillæ at the postero-lateral corners, about one-fifth of the distance in front of the posterior

margin. It must be remembered that this is still a chalimus, and in the subsequent development of the genital segment these fifth legs may become partially or even wholly concealed on the ventral surface.

The large spherical sperm receptacles can be seen in the posterior portion of the segment, just in front of the fifth legs.

Abdomen half as wide as the genital segment, one-jointed; anal laminae small, triangular, each tipped with four large setae, three close together at the inner corner, and one removed a little distance at the outer corner. Outside of the latter there is also a minute spine. Appendages similar to those of the female, the second antennae somewhat larger, the terminal claw stouter and carrying an accessory claw on its ventral surface.

The adhesion pads at the bases of these antennae are reduced still more in size, and might easily be overlooked unless sought for particularly. The second maxillipeds are radically changed from the pad-form of the female and are tipped with a stout claw, well curved, which shuts down against a pair of corrugated cushions as in *Pandarus*. Swimming legs all biramose, the rami of the first three pairs two-jointed, of the fourth pair one-jointed. But from the arrangement of the spines and the indentation of the margins these fourth rami are each evidently a fusion of two joints, and possibly become as fully two-jointed in later development as in *Pandarus*.

The number and arrangement of the spines and setae are as follows: First exopod 1, 0; 4, III: endopod 0, 0; 0, III: second exopod 1, I; 4, V: endopod 0, I; 0, V: third exopod 1, I; 3, V: endopod 0, I; 0, V: fourth exopod 1, 0; 3, V: endopod 0, I; 0, IV.

Total length, 3 mm.; length of carapace, including lobes, 1.7 mm.; width, 1.55 mm.; length of free thorax segments, 0.92 mm.; length of genital segment, 0.56 mm.; length of abdomen, 0.4 mm. Color a light yellowish white without pigment.

Chalimus.—Female chalimi were secured in three different stages of development, which have already been described under the ontogeny (see p. 340). It only remains here to emphasize their specific characters. The smallest of the three is exactly the same length as the male just described, but is in an earlier stage of development. The similarity between the two is much closer than in the adults, and affords a striking proof that they are really the two sexes of the same species. The carapace of this female chalimus is almost exactly like that of the male, its posterior lobes being long and well rounded, very different from their shape in the adult. The frontal plates are also much more prominent than in the adult female, and are like those of the male. The eyes are visible in both sexes, are of the same size, and similarly placed.

Again, the second, third, and fourth thorax segments are visibly free in this young female, and are remarkably like those in the male.

The lateral plates of the first segment are just starting and correspond closely to the lateral processes of the same segment in the male. The second pair of plates have not started, while the third pair appear as two broad and short lobes on the fourth segment.

The genital segment is comparatively wider in the female, and the fifth legs are on the ventral surface instead of at the posterior corners. The abdomen is visible for its entire length behind the genital segment and is very similar to that of the male, having only a single joint. The anal laminæ are also similar, and while the spines on them are non-plumose and very short, they are arranged similarly to those in the male.

The appendages in this young female, however, are like those of the adult of the same sex. The terminal joints of the second maxillipeds are in the form of adhesion pads. They have not yet assumed the reniform shape characteristic of the adult, but are otherwise the same. The swimming legs are exactly like those in the adult female, as can be seen from fig. 12, p. 341.

In the second chalimus, 4 mm. in length, we find the carapace approaching the adult form. The posterior lobes have shortened, and the carapace has widened. The free thorax segments have become more compactly joined, and the dorsal plates are all of good size. Those on the second segment, however, are now circular, and neither they nor the third pair meet at the center, but leave a wide median space between them (fig. 13, p. 342).

The genital segment has widened and approached more nearly to the size of the carapace. It has also grown backward over the abdomen, so that the posterior margin of the latter is just even with that of the former. Much of the dorsal surface of the abdomen is still visible, however, through the median sinus of the genital segment.

In the third chalimus, 4.5 mm. long, we find practically the same structure as in the adult. The carapace has widened and its posterior lobes have shortened. The eyes have moved nearer the anterior margin, and the frontal plates have become relatively much less prominent. On the thorax segments the dorsal plates have increased in size until they overlap on the mid-line, while the posterior margins of the first and third pairs are handsomely scalloped (fig. 14, p. 343).

The genital segment has now become a little larger than the carapace, while the abdomen has entirely withdrawn beneath it so that only the tips of the anal laminæ are visible at the base of the median sinus.

Variety *stimpsoni*: Carapace wedge-shaped, one and a half times wider than long, strongly narrowed anteriorly as in *dentatus*, but with the sides nearly straight instead of strongly convex, and with very short posterior lobes. The under surface of the carapace shows

the same large raised knobs opposite the second maxillipeds as in the type species (figs. 20 and 21).

First pair of dorsal plates widely separated, their posterior margins reaching far behind those of the second pair, and far outside the lateral margins of the third pair. The posterior margins of the first and third pairs of plates are not toothed in any of the specimens at hand.

Genital segment much larger than the carapace, a little wider than long, the width greatest near the center and a little more than that of the carapace. Posterior angles reaching farther back than in the typical form, making the posterior margin more squarely truncated; median sinus narrow and shallower than in the type form. Appendages exactly like those of the type form except that they are larger. Egg-strings relatively narrower than in the type form and much longer.

Ten females belonging to this variety were obtained from a dusky shark, *Carcharhinus obscurus*, at Woods Hole. They are excellently preserved, and are of the same color as the type form, a light yellowish white. They are all fully developed females with egg-strings, are all exactly alike, and differ from the type in the above particulars, the most noticeable difference being the increase in size and in the length of the egg-strings.

Rathbun founded his variety on a single specimen which had been in alcohol many years and was of a dark brown color.

On comparing these fresh specimens with his, they are found to agree in every particular of structure, but are somewhat larger, and are of the same color as the type instead of being brown.

This species was established by Rathbun in 1887 upon six lots of specimens obtained from four different hosts. Two additional lots have since been obtained, one of which included the developmental stages and was obtained from a new host.

The U. S. National Museum collection now includes the following: From the dusky shark, *Carcharhinus obscurus*, Cat. No. 12685 from Vineyard Sound, Massachusetts; Cat. No. 8181 from Noank, Connecticut, and the variety *stimpsoni*, Cat. No. 4414 and Cat. No. 32775, both from Woods Hole, Massachusetts.

From the sharp-nosed shark, *Scoliodon terre-novæ*, Cat. No. 6085, taken at Pensacola, Florida, and Cat. No. 32776 taken at Beaufort, North Carolina. From the blue shark, *Carcharhinus milberti*, Cat. No. 8180 taken at Woods Hole. From the shovel-head shark, *Reniceps tiburo*, Cat. No. 8182 taken at St. Marys River, Florida. From the smooth dog-fish, *Mustelus canis*, Cat. No. 32777 taken at Woods Hole; this lot included the *chalimi* already described.

That this is a valid species and not a synonym of *Perissopus dentatus*, as Bassett-Smith would have us believe, may be seen in the following comparison:

In *Perissopus dentatus* the carapace is wedge-shaped, the posterior margin twice the width of the anterior, the posterior lobes one-third as long as the carapace on the mid-line; there are no lobes or knobs on the ventral surface. The first pair of dorsal plates are elliptical, not reaching forward to the bases of the first legs. The basal joints of the first two pairs of legs are attached by their postero-interior corners, with the rami attached to their exterior margins. The rami of the third legs are fused into a single semicircular lamella tipped with two minute spines. Rami of the fourth legs one-jointed exactly alike, but the exopod tipped with a single spine while the endopod has none.

In *Perissopus communis* the carapace is semielliptical, scarcely narrowed at all; the posterior lobes are less than one-seventh the length of the carapace on the mid-line, and are often virtually eliminated; there is a large hemispherical knob on the ventral surface of the carapace near the lateral margin on either side, opposite the reniform pad of the second maxilliped. The first dorsal plates reach forward to the base of the second maxillipeds. The basal joints of the first two pairs of legs are attached by their anterior margins, with the rami on the posterior margins. The exopods have each the same number of spines similarly arranged, one on the exterior margin and four in a row at the end; the rami of the third legs are as distinct as those of the other pairs; the endopods of the third and fourth pairs of legs are very different from the exopods.

Genus LAMINIFERA Poche.

Phyllophora MILNE EDWARDS, 1840, p. 471. (*Phyllophora cornuta* MILNE EDWARDS, 1840, p. 472, pl. XXXVIII, figs. 13, 14.—BASSETT-SMITH, 1899, p. 465. *Laminifera cornuta* POCHE, 1902, p. 8.)

Female.—Carapace triangular, narrowed and rounded anteriorly, the lateral margins only moderately convex; posterior lobes widely divergent, as long as the entire carapace on the mid-line, broad and well rounded; posterior margin between the lobes very narrow. The three pairs of dorsal plates on the thorax developed into overlapping foliaceous wings, each pair considerably wider than the carapace. The first two pairs are widely divergent, like the posterior lobes of the carapace, and just meet on the mid-line; the third pair are horizontal, their inner margins overlapping considerably. Genital segment quadrangular with rounded corners and a squarely truncated posterior margin; sixth segment in the form of a dorsal rounded plate, as in *Pandarus*. Abdomen attached to the ventral surface of the genital segment, one-jointed, with modified anal laminæ attached to its sides at the base, and a ventral plate as in *Pandarus*. Appendages similar to those in the other Pandarinæ; first antennæ three-jointed; second pair much enlarged, their terminal claws stout and not much

curved, reaching back to the thorax. Second maxillipeds swollen but little and ending in short claws. All the swimming legs biramose; basal joints of the first and fourth pairs not united across the mid-line; rami lamellar and destitute of setæ or spines, those of the third pair two-jointed, of the other pairs one-jointed; fifth legs on the ventral surface close to the base of the abdomen. Egg-strings narrow, a little longer than the body. Length, 22.5 mm.

(*Laminifera*, lamina and *fero*, to bear.)

Male.—Unknown.

This genus was founded by Milne Edwards in 1840 upon female specimens obtained near Tongatabu; the host is not given, but was probably a shark. Milne Edwards named the genus *Phyllophora*, but this name had been preoccupied three times previously, for a genus of birds in 1812, a genus of flies in 1838, and again for a genus of mammals in the same year; accordingly Poche suggested the name *Laminifera* in 1902.

Milne Edwards gives no genus diagnosis, but only a short description, from which and from the two excellent figures he published the above diagnosis has been deduced. There is some doubt on one point, and what are here given as the fifth legs may prove, on later investigation, to be the sixth pair, attached to a well differentiated sixth segment.

Genus ECHTHROGALEUS Steenstrup and Lütken.

Pandarus (part) MILNE EDWARDS, 1833.—JOHNSTON, 1835.

Dinematura (part) BURMEISTER, 1834.—GUÉRIN, 1837.

Dinemoura MILNE EDWARDS, 1840.—BAIRD, 1850.

Echthrogaleus STEENSTRUP and LÜTKEN, 1861, p. 380 (*Echthrogaleus coleoptratus* STEENSTRUP and LÜTKEN, 1861, p. 380, pl. viii, fig. 15).

Female.—Carapace large and well rounded; frontal plates distinct but not prominent; posterior lobes long and blunt; dorsal surface with a longitudinal groove on either side, a transverse groove across the mid-line, and a short groove across the lateral area on either side; three small eyes, the lenses close together and arranged in the form of a triangle. Three free segments, each bearing a pair of dorsal plates; first two pairs rudimentary, first pair lateral, second pair median, third pair well developed and extending the entire width of the body.

Genital segments enlarged, sometimes wider than the carapace, with a deep posterior sinus and long rounded lobes. A small median lobe at the base of the sinus represents the sixth thorax segment, and corresponds to the similar lobes found in *Pandarus*, *Dinematura*, etc. It is on the ventral surface and entirely concealed between the genital segment and abdomen (*coleoptratus*), or on a level with the dorsal surface and visible (*denticulatus* and *torpedinis*). Abdomen small, one-jointed, concealed beneath the genital segment or partially visi-

ble in the base of the sinus; anal laminæ large but armed with non-plumose setæ.

Second maxillipeds tipped with stout claws; all the swimming legs biramose; rami of first pair two-jointed; exopods of second and third pairs three-jointed, endopods two-jointed, all with rudimentary plumose setæ; fourth pair transformed into imperfectly jointed lamellæ, destitute of setæ. Egg-tubes very slender and several times the length of the body.

Male.—Carapace like that of the female but proportionally larger, frontal plates more prominent. Lateral lobes of the second thorax segment corresponding to the first pair of dorsal plates in the female; no lobes on the third segment; a rudimentary pair on the fourth segment, which are closely appressed to the anterior margin of the genital segment. The latter smaller than in the female, with one pair of legs at or just in front of the posterior corners. Abdomen small and two-jointed; anal laminæ large and armed with plumose setæ. Appendages as in the female.

(*Echthrogaleus*, ἐχθρόζ, an enemy, and γαλέος, a shark.)

KEY TO THE SPECIES.

- a. Females, third dorsal plates much enlarged, covering half the genital segment or more; genital segment also enlarged, sometimes to the size of the carapace; abdomen small, one-jointed, hidden..... b.
- a. Males, no dorsal plates or only the rudiments of them; genital segment scarcely enlarged; abdomen entirely free and two-jointed..... i.
- b. Body more than twice as long as wide; third dorsal plates with rounded anterior corners, without spines..... c.
- b. Body short and wide, length to width as 5 to 3; third dorsal plates with sharp spines at the anterior corners..... f.
- c. Carapace definitely wider than long; posterior lobes of genital segment parallel and not touching along the mid-line..... d.
- c. Carapace as long as, or longer than, wide; posterior lobes of genital segment convergent and overlapping on the mid-line..... e.
- d. Carapace larger than the genital segment; fourth segment plates without transparent dots and covering more than half the genital segment.
braccatus Dana, 1852, p. 366.
- d. Carapace much smaller than the genital segment; fourth segment plates covered with transparent dots and overlapping less than half the genital segment..... *coleoptratus* Guérin, 1837, p. 367.
- e. Carapace definitely longer than wide; abdomen small and entirely concealed, not even the anal laminæ visible in dorsal view.
affinis Milne Edwards, 1840, p. 364.
- e. Carapace the same length and width; abdomen half as large as the genital segment and partly visible in dorsal view..... *indistinctus* Kröyer, 1863, p. 364.
- f. Posterior carapace lobes not touching the third dorsal plates; genital segment decidedly smaller than the carapace..... g.
- f. Posterior lobes of the carapace overlapping the third dorsal plates; genital segment as large as or larger than the carapace..... h.
- g. Third dorsal plates covering more than half the genital segment and toothed on their posterior and inner margins; fifth legs projecting beyond the lobes of the genital segment; abdomen invisible..... *denticulatus* Smith, 1874, p. 369.

- g. Third dorsal plates covering less than half the genital segment, their margins smooth; fifth legs invisible; abdomen partly visible.
perspicax Olsson, 1869, p. 364.
- h. Third dorsal plates covering nearly the whole genital segment; no spines at their anterior corners; posterior lobes of the genital segment turned strongly inward and almost touching each other; fifth legs invisible.
torpedinis, new species, p. 371.
- h. Third dorsal plates covering about two-thirds of the genital segment, spines at their anterior corners; posterior lobes of the genital segment parallel and separated by a wide sinus; fifth legs visible beyond the tips of the lobe.
neozelanicus Thomson, 1889, p. 365.
- i. Carapace three times the width of the genital segment; frontal plates broad and prominent; third thorax segment as wide as the fourth.
perspicax Olsson, 1869, p. 364.
- i. Carapace two and a half times the width of the genital segment; frontal plates very small and narrow; fourth thorax segment short, wider than the genital segment and semilunar.....*neozelanicus* Thomson, 1889, p. 365.
- i. Carapace twice the width of the genital segment; frontal plates wide and prominent; fourth thorax segment long and narrower than the genital segment.
braccatus Dana, 1852, p. 366.

This genus was established by Steenstrup and Lütken in 1861 to include, as they said, four species which had up to that time been classed with the genus *Dinematura*, namely *D. alata* Milne Edwards, *D. affinis* Milne Edwards, *D. coleoptrata* Guérin, and *D. braccata* Dana. These agree with each other and differ from the true *Dinematura* species in the following: (1) The first two free thorax segments are fused together; (2) the genital segment is broad and flat, not long and narrow; (3) the dorsal plates are larger and cover half the genital segment or more; (4) the abdomen is not jointed, it carries only a single dorsal plate, and it is often concealed beneath the genital segment; (5) the fourth swimming legs are small and their basal joints are not wing-like when developed; (6) the first three pairs of legs do not deserve the name of swimming legs, and their plumose setæ are poorly developed.

The authors might have added a seventh difference which would have been at least as valuable as any of the others. In *Dinematura* the sixth thoracic segment is well separated from the genital segment, and it bears a pair of dorsal plates and also a rudimentary pair of swimming legs. In *Echthrogaleus*, on the other hand, this sixth segment is reduced to a mere lobe attached to the base of the posterior sinus of the genital segment, and there is not even a trace of any dorsal plates or swimming legs. To this genus *Echthrogaleus* belong also the following five species, which have appeared since 1861:

"*Dinematura*" *indistincta*, described by Krøyer in 1863 (p. 183), but of which no figures have ever been published; rightly referred to the present genus by Bassett-Smith in 1899.

Echthrogaleus perspicax, described by Olsson in 1869; includes both sexes and is well illustrated.

Echthrogaleus denticulatus, described by S. I. Smith in 1874, but of which no figures have hitherto been published.

"*Dinematura*" *neozelandica*, described and figured by Thomson in 1889, and rightly referred to the present genus by Bassett-Smith in 1899.

Echthrogaleus torpedinis, new species (p. 371).

Dana's *Dinematura braccata* is possibly a young female of *Echthrogaleus coleoptratus* rather than of *E. affinis*, as Bassett-Smith would have us believe; eight valid species appear in the above key.

In 1833 Milne Edwards described a new species of parasitic copepod, to which he gave the name *Pandarus alatus*. Two years later Johnston published a description of what he claimed to be the same species, giving it Milne Edwards's name. On founding the present genus Steenstrup and Lütken decided that Johnston's species was the same as Guérin's "*Dinematura coleoptrata*," and that it was not identical with Milne Edwards's species. This latter decision is confirmed by the following differences: Milne Edwards's species shows: 1. No division of the lateral areas of the carapace. 2. No transparent spots on the dorsal plates of the fourth thorax segment. 3. Second maxillipeds armed with slender terminal claws and without accessory claws or spines. 4. Marked differences in the shape of the second antennæ, first maxillipeds, and maxillæ. 5. Both rami of the second and third pairs of legs three-jointed. 6. Rudimentary legs just in front of the abdomen.

Johnston's species, on the contrary, shows: 1. Distinct divisions of the lateral areas. 2. Transparent spots on the fourth segment plates. 3. Thick and stout terminal claws on the second maxillipeds, furnished with large accessory claws. 4. The rami of all the legs two-jointed. 5. No rudimentary legs in front of the abdomen. Such differences are rather too numerous and important to allow any assumption of the identity of the two species. Johnston's description does agree with that of Guérin and Steenstrup and Lütken in every particular, and his species may therefore be taken as a synonym of Guérin's *E. coleoptratus*.

As to the location of Milne Edwards's original "*Pandarus alatus*," it is difficult to decide. In the structure of the mouth-tube, maxillæ, and second maxillipeds, in the three-jointed endopods of the second and third legs and in the presence of rudimentary legs just in front of the abdomen it conforms to the genus *Dinematura* rather than *Echthrogaleus*. But in the fusion of the second and third thorax segments, in the broad shape of the genital segment, in the absence of any dorsal plates for the sixth segment, and in the small size of the fourth legs it conforms to *Echthrogaleus* and is unlike *Dinematura*.

Hence it can not be located with certainty according to available data; Milne Edwards's statements seem to favor its inclusion under

the present genus. But if so, it is a distinct species and is not a synonym of any of the known species.

Milne Edwards claimed to have both sexes, but the specimen he has figured as a male (Pl. VIII, figs. 2 and 3) was certainly a female without egg-strings. He says nothing about its size. If it were not fully developed some of the discrepancies, and possibly all, might be explained, for no development stage of any species of this genus has ever been seen.

In view of these facts, we are warranted in omitting the species for the present and awaiting further evidence.

ECHTHROGALEUS BRACCATUS Dana.

Dinematura braccata DANA, 1852, p. 1370, pl. xcv, fig. 4.

Echthrogaleus (*Nogagus*) *braccatus* HELLER, 1865, p. 197, pl. xx, fig. 3.

Nogagus braccatus BASSETT-SMITH, 1899, pp. 460, 464.

Dana, who first described this species in 1852, referred it to the genus *Dinematura*, but Steenstrup and Lütken in 1861 created a new genus *Echthrogaleus* out of several of the *Dinematura* species, including this one of Dana. Heller in 1865 described a *Nogagus* form as the male of this species, and Thomson recorded in 1889 the capture of the species at Auckland, New Zealand. Finally Bassett-Smith in 1899 made the species a synonym of *Echthrogaleus affinis*. After a careful examination of the evidence the present author can not agree with Bassett-Smith. Dana plainly states as his reasons for distinguishing the species from *affinis* the difference in the shape of the lateral plates on the second thorax segment, the size and position of the anal laminæ, the relative size of the carapace and genital segment, and the size and shape of the third thorax segment. In Dana's species also the posterior sinus of the genital segment is very deep and the rudimentary sixth segment plate is not visible, while in *affinis* the sinus is much shallower and the sixth segment plate is visible at its enlarged base.

These reasons are sufficient to separate the two species when supported by such authorities as Steenstrup and Lütken and Heller.

When we come to compare Dana's species with *coleoptratus*, however, the evidence is not as conclusive; still there are enough differences to prevent us from declaring the two species synonymous on present evidence. These differences are found in the shape of each of the three pairs of dorsal plates on the thorax segments, in the fact that the third pair of plates have no transparent dots in Dana's species, while these are very prominent in *coleoptratus*, and in the relative size of the carapace and genital segment. Dana's species was without egg-strings; and if it was a young female, not fully matured, some, if not all, of these differences could be readily explained. But Dana gives the length as half an inch, which is larger than an adult *coleoptratus*.

In 1865 Heller described a male which he referred to this species, giving the following diagnosis:

Cephalothorax half the length of the animal, of about the same length and width, posterior lobes elongate, with a border around the inner margin.

Frontal plates wide, with a sinus at the center of the frontal margin. Second abdominal segment winged on either side, wings truncated posteriorly, with a thin border on the inner side.

All the abdominal feet biramose, rami of the first and fourth pairs two-jointed, exopod of the second and third pairs three-jointed, endopod two-jointed. Genital segment almost quadrate, with rounded angles. Tail one-half shorter than the genital segment, two-jointed, second joint the longer, appendages elongate. Length of body 7 mm.

This shows plainly that the copepod is a male of the genus *Echthrogaleus*, and as it was found, according to Heller, in company with females of Dana's species, and as its anatomy agrees with that species, there is no reason to doubt its identity.

We are thus warranted in leaving the species as Dana and Heller published it, awaiting further evidence.

ECHTHROGALEUS COLEOPTRATUS Guérin.

PLATE XIX.

Dinematura coleoptrata GUÉRIN, 1837, pl. xxxv, fig. 6.

Dinematura alata GUÉRIN, 1837, pl. xxxv, fig. 7.

Pandarus alatus (MILNE EDWARDS) JOHNSTON, 1835, p. 202, two text figures.

Echthrogaleus coleoptratus STEENSTRUP and LÜTKEN, 1861, p. 380, pl. viii, fig. 15.

Female.—Body elongate, length more than twice the width; carapace orbicular, as wide as long, including the posterior lobes; lateral and frontal margins strongly convex, posterior margin slightly convex; posterior lobes long and narrow and curved inward at the tips, not reaching the anterior margin of the dorsal plates on the fourth segment by quite a distance. Lateral areas very narrow, the transverse suture at about their center; the transverse suture of the median area far forward and not straight, but zigzag.

Second thorax segment distinctly separated from the third with lateral plates like the lateral lobes in the male extending outward and backward, but not concealed by the carapace.

Second dorsal plates median and rudimentary, relatively wider than in *denticulatus*; the broad apron of the third legs visible at the sides of these plates in the space between the posterior lobes of the carapace and the fourth segment. Third dorsal plates much enlarged, trapezoidal in shape and covering a little less than half the genital segment. They fit very snugly to the genital segment and project only their own thickness beyond the lateral margins of the latter. They just meet on the mid line without overlapping, and their entire margin is free from teeth or spines. Their chief characteristic, and one which will distinguish the present species from all others, is the

tracery of transparent dots or points which are scattered over their dorsal surface. These dots are circular in outline, sharply defined, of a light yellowish color, and transparent, thus showing prominently against the dark-brown background of the general surface. They are not arranged in any definite pattern, differing in different individuals, but they are approximately symmetrical in the two plates of any specimen.

Genital segment much larger than the carapace, elliptical or spindle shaped, tapering considerably toward either end; posterior sinus two-fifths of the entire length, narrow and slit-like, and enlarged but little at the base; posterior lobes closely appressed but not overlapping; sixth segment lobe small and entirely concealed between the genital segment and abdomen, but plainly visible on the ventral surface after removing the abdomen.

Abdomen transversely elliptical, one-half wider than long, with evenly curved margins. On either side of the anterior margin is a small rounded knob which projects forward beneath the genital segment. Anal laminae large, each one as long as the abdomen and half as wide, tipped with three rudimentary setae at the center of the terminal margin, two small spines near the outer corner and one near the inner one.

First antennae slender and not prominent; second pair stout with a long terminal claw which is strongly curved. First pair of adhesion pads ovate and small; second pair angular and still smaller; on each half of the apron of the third legs two of the pads are in close contact near the lateral margin, while the third one is removed some little distance from them toward the median line. Mouth tube relatively short and slender; second maxillae boot-shaped and relatively large, their bases far forward in front of the base of the mouth tube. First maxillipeds slender, terminal joint longer than the basal, both claws with a fringe of setae. Second maxillipeds with a strongly swollen basal joint and a stout terminal claw, which shuts down against two large corrugated knobs.

The spines on the rami of the swimming legs are short and stout with toothed margins, while the setae are all rudimentary, except those at the tip of the endopod of the second legs. The arrangement is as follows: First exopod 0, I; 4, III: endopod 0, 0; 5, III: second exopod 0, 0; 1, I; 7, III: endopod 0, I; 5, III: third exopod 1, I; 1, I; 5, II: endopod 1, 0; 3, II: fourth exopod 3, VII: endopod 0, IV.

In the fourth leg joints the rami are fused indistinguishably, but the spines are scattered along the margin in such a way as to indicate that the ramus is a fusion and not a single joint, a fact still further attested in the endopod by indentations on the margin. Of the genital organs the oviducts are coiled once in each half of the genital

segment, passing back to the end of the posterior lobe, then forward to the anterior margin, and then back to the vulva, which opens between the abdomen and the genital segment. The vaginal openings are on the ventral surface, close together, one on either side of the mid line just in front of the base of the abdomen. From these may often be seen protruding the ends of the ducts of discharged spermatophores. The cement glands are very large, as would be expected when we remember that the egg strings are several times the length of the body. They occupy a large share of the ventral surface of the genital segment in front of the abdomen; each is in the shape of a figure 7 inverted.

Total length, 13 mm.; length of carapace on mid-line, 4 mm.; length of fourth segment plates, 4 mm.; length of abdomen, 6.5 mm.; width of carapace, 5 mm.; width of fourth segment plates, 6 mm.

Color, a dull grayish yellow, uniform and lighter on the ventral surface, darker on the dorsal surface, with the center of the carapace between the lateral grooves and the entire surface of the fourth segment plates a dark chestnut brown. The internal coils of the oviduct also show through the dorsal surface of the abdomen as light brown in color.

(*coleoptratus*, *κολεός*, sheath and *πτερόν*, wing, the dorsal plates of the fourth thorax segment resembling the elytra of beetles.)

This is the type species upon which Steenstrup and Lütken founded the present genus and was identified by them from Guérin's figures and description. They gave as one of its synonyms "*Pandarus alatus*," described by Johnston in 1835; the latter believed his species to be identical with the "*Pandarus alatus*" published two years earlier by Milne Edwards.

Steenstrup and Lütken doubted this identity of the two species, and careful examination confirms their doubt. (See p. 365.) Hence the specific name used by Johnston can not stand, although it was published two years prior to that of Guérin.

There are three lots of specimens belonging to this species in the U. S. National Museum collection, Cat. No. 6185, from the back fin of *Isurus dekayi* at Woods Hole, Cat. No. 8179, from Cornwall, England, in exchange with A. M. Norman, no host given, and Cat. No. 12056, from a shark captured near Unalaska, Alaska.

ECHTHROGALEUS DENTICULATUS Smith.

PLATE XX.

Echthrogaleus denticulatus SMITH, 1874, p. 576.—RATHBUN, 1884, p. 488.

Female.—Carapace orbicular, a little wider than long; lateral and anterior margins strongly convex, posterior margin nearly straight.

Dorsal surface divided by two longitudinal grooves into a very wide median and narrow lateral areas similar to those in *Pandarus* males.

Median area with a transverse groove a little in front of its center; the three eyes close together and arranged in the form of a triangle, two in front of this groove and one behind it. Transverse grooves dividing the lateral areas placed far back, only a little in front of the posterior margin of the carapace and curved forward. Frontal plates narrow and showing but little in dorsal view.

Free segments short and telescoped together so that the posterior lobes of the carapace touch or overlap the third pair of dorsal plates. First dorsal plates lateral and nearly concealed beneath the carapace and its posterior lobes; but they extend forward under the carapace and each bears an adhesion pad on its anterior margin as in *Pandarus*. Second dorsal plates median and rudimentary, like those just starting in young females of *Pandarus* and *Perissopus*. Third dorsal plates enormous, as wide as the carapace, and covering two-thirds of the genital segment. Each is armed at its anterior corner with a short but stout spine; the plates do not quite meet at the mid-line and are armed along their entire median and posterior borders with sharp spines, thickly set. Genital segment elliptical, one-third narrower than the carapace, with wide and conical posterior lobes. From the tips of these lobes extend the modified fifth legs in the form of narrow pointed processes whose bases reach forward on the ventral surface to the base of the abdomen. Although every species thus far examined shows these fifth legs on the ventral surface, the present species and *neozelanicus* are the only ones in which they extend beyond the tips of the posterior lobes so as to become visible in dorsal view. The rudimentary sixth segment lobe is about half the width and length of the posterior lobes of the genital segment, and is evenly rounded. It is on a level with the dorsal surface of the carapace and is entirely visible from above.

Abdomen wedge-shaped, relatively large, but placed so far forward on the ventral surface of the genital segment that only the anal laminae are visible from above. These laminae are twice as long as wide and are each tipped with two or three rudimentary setae, short and non-plumose.

First antennae of the usual pattern, terminal joint slender and club-shaped. Second antennae stout and placed far back of the anterior margin, opposite the base of the mouth-tube; terminal claw short, strong, and well curved. First adhesion pads obovate, of medium size, and close to the lateral margin; second pair very small and nearly circular; third pair elliptical and larger than the second; fourth pair on the outer margins of the first dorsal plates as in *Pandarus*, elliptical and the same size as the third pair. In addition to these four pairs there are also adhesion pads on the basal joints of the first and third pairs of swimming legs. One pair on the first legs close together on

either side of the median line, three pairs on the third legs circular in form and arranged in a triangle at some distance from the median line on either side. There is also a median unpaired pad on the anterior margin of these legs, transversely elliptical in form.

Mouth-tube long and slender; second maxillæ laminate, rather narrow, and tapering to a rounded point. First maxillipeds stout, the anterior terminal claw more than twice the length of the posterior, both claws fringed with hairs. Second maxillipeds not much swollen, the terminal claw semicylindrical, the flat side shutting down against a pair of spherical knobs on the basal joint. All the swimming legs biramose; rami of the first pair two-jointed; basal joint of the exopod as long as both joints of the endopod; terminal joint circular in outline, half as long as the basal; endopod joints the same length.

Exopods of second, third, and fourth legs three-jointed, endopods two-jointed, the joints thoroughly fused in the fourth pair.

Endopod joints subequal in the three pairs; basal exopod joint of the second pair longer than the two (equal) terminal joints; basal joint in the third pair a little longer than either of the others; the three joints in the fourth pair subequal.

Setæ and spines arranged as follows: First exopod, 0, 1; 4, III: endopod, 0, 0; 4, 0: second exopod, 1, I; 1, I; 4, III: endopod, 0, 0; 3, 0: third exopod, 1, I; 1, I; 6, II: endopod, 0, 0; 3, IV: fourth exopod, 0, I; 0, I; 0, I: endopod, 0, 0; 0, 0.

Total length, 9 mm.; length of carapace on mid-line, 3.25 mm.; width, 4.57 mm.; length of free segments, 1.5 mm.; length of third dorsal plates, 2.85 mm.; length of genital segment, 4.3 mm.; width of third plates, 4.5 mm.

Color of preserved specimens a yellowish brown, probably discolored by the alcohol.

(*denticulatus*, armed with minute teeth, referring to the margins of the third dorsal plates.)

The U. S. National Museum collection contains a single specimen, the original type described by Smith in 1874. It was taken from Atwood's shark, *Carcharodon carcharias* captured in Vineyard Sound, Woods Hole and is numbered 6169. Smith gave a brief description of the species without any figures, and it has remained unrecognized.

The full description and figures here given should establish its validity. It can be readily recognized by the spines or teeth on the third dorsal plates and by the projecting fifth legs.

ECHTHROGALEUS TORPEDINIS, new species.

PLATE XXI.

Type.—Cat. No. 11350, U.S.N.M.

Female.—Body short and wide; length to width as 5 to 3. Carapace orbicular, considerably wider than long, even including the pos-

terior lobes; lateral areas of medium width, the transverse grooves crossing them nearly at the center; posterior lobes long and narrow, their tips extending under the third dorsal plates for some distance; posterior margin concave. Frontal plates not well defined nor prominent; eyes small and situated about two-fifths of the distance from the frontal margin.

The fused second and third thorax segments rather short; first dorsal plates large and extending out beneath the posterior lobes nearly to the lateral margins of the carapace. These plates are semicircular and end in blunt spines at their anterior corners. Second dorsal plates rudimentary and narrow, leaving a space on either side between their lateral margin and the posterior lobe of the carapace. Third dorsal plates enormous, covering the entire genital segment except the very tips of the posterior lobes; each plate is one-half longer than the carapace on the mid-line, and together they are considerably wider than either the carapace or the genital segment, projecting far beyond the lateral margins of the latter. Their outer margins are strongly curved, their posterior margins nearly squarely truncated, and there is a wider space between their inner margins than in most species. They are smooth and without any trace of spines. Genital segment broadly elliptical, a little wider than the carapace, but longer than wide, its posterior lobes wide and bluntly rounded, and turned in toward each other but not overlapping. Posterior sinus one-third the entire length, much enlarged at the base, and showing plainly there the dorsal surface of the sixth segment lobe. This latter is much longer than in *coleoptratus* or *denticulatus*, with parallel sides and an evenly rounded posterior margin, and it extends backward about half the length of the sinus.

Abdomen relatively as large as in *denticulatus*, but much wider posteriorly, being subquadrangular; anal laminae large and broad, each tipped with a few coarse spines. The base of the abdomen reaches forward to the center of the genital segment and is about one-third the width of the latter, while the ends of the anal laminae just reach the tips of the posterior lobes.

First antennae slender and small; second pair large and stout, with a long and strongly curved terminal claw; the basal joint carries a stout spine behind the adhesion pad.

First two pairs of adhesion pads small, those on the base of the second antennae reduced to mere points. Two small circular pads on the basal joint of the first legs; the three pairs on the apron of the third legs arranged as in *coleoptratus*, two side by side on each half of the leg and one at a little distance, nearer the mid-line. Mouth tube exceptionally long and slender; second maxillae also long and relatively larger and wider than in the other species here described. The terminal joints of these maxillae are boot-shaped, and are folded over

inward toward each other, so that they lie across the mouth tube like a pair of folded hands. Further back on either side, opposite the base of the first maxillipeds, is a flattened spine, larger than the maxilla and pointing backward.

Second maxillipeds with a stout but rather short terminal claw, and two large corrugated knobs on the basal joint against which the claw shuts. Swimming legs biramose and of the usual pattern, but with the plumose setæ on the terminal joints better developed than in *coleoptratus*. The arrangement of the spines and setæ is as follows: First exopod, 0, 1; 6, 0: endopod, 0, 0; 3, 0: second exopod, 1, I; 1, I; 5, II: endopod, 0, 0; 4, III: third exopod, 0, I; 1, I; 6, III: endopod, 0, 0; 4, 0: fourth exopod, 0, I; 0, I; 0, VII: endopod, 0, 0; 0, 0.

Outside of the base of the exopod of the fourth legs and inside of the base of the endopod of the third legs is a small papilla armed with a long and flexible spine, similar to those found in *Perissopus*. The fifth legs are larger than in *coleoptratus*, but not as large as in *denticulatus*, and their tips just reach the margins of the posterior lobes.

The oviduct is coiled once in the usual fashion, the vulvæ opening just beneath the base of the abdomen. The cement glands are large and are arranged like parentheses marks on either side of the mid-line; their posterior ends are enlarged and bent inward nearly at right angles. The semen receptacle is just in front of the base of the abdomen, with the vaginæ opening side by side at the mid-line. The spermatophores are fastened on either side of the genital segment, outside and in front of the vulva, and the duct from each crosses the mid-line and empties into the vagina on the opposite side of the body.

Total length, 13 mm.; length of carapace on mid-line, 4 mm.; width of same, 6.5 mm.; length of free segments, 2 mm.; length of third dorsal plates, 5.65 mm.; width of same, 8 mm.; length of genital segment, 7.38 mm.; width of same, 7 mm.; length of abdomen, without anal laminæ, 2.5 mm.; length of egg-strings, 40 mm. Color a dark cinnamon brown, uniform over the entire body.

(*torpedinis*, the name of the host.)

The U. S. National Museum collection includes two lots, both obtained from the Torpedo, common along our Atlantic coast, *Torpedo occidentalis*. The first is Cat. No. 6187, U.S.N.M., and includes two females taken from one of the pectoral fins of a Torpedo captured at Woods Hole in 1875. The other lot is Cat. No. 11350, U.S.N.M., and includes seven females taken from the ventral fins of a Torpedo captured at Provincetown, Massachusetts, October 20, 1885.

Genus DINEMATURA Latreille.

Caligus (*C. productus*) MÜLLER, 1785, p. 132.

Dinemoura (*D. producta*) LATREILLE, 1829, p. 197.

Pandarus (*P. lamnæ*) JOHNSTON, 1835, p. 203.

Dinematura (*D. producta*) BURMEISTER, 1833, p. 284.

Female.—General body form elongate, the length more than twice the width. Carapace transversely elliptical, its lateral margins strongly arched, with narrow frontal plates and long well rounded posterior lobes; grooving similar to that in the *Caliginæ*; eyes invisible in the adult. Second thorax segment with large lateral wings; third segment narrow, with rudimentary dorsal plates, or entirely without them; fourth segment with plates of medium size, separated by a deep median fissure, and covering the anterior portion of the genital segment; fifth or genital segment oblong, with broad and well-rounded posterior lobes; *sixth segment distinct, separated from the genital segment, furnished with a pair of dorsal plates, and carrying ventrally a pair of rudimentary swimming legs*. Abdomen small, one-jointed, projecting but little behind the genital segment, with large anal laminae, carrying non-plumose setæ.

Two adhesion pads instead of one behind each first antenna, the posterior one the larger. Mouth-tube long and very slender; second maxillæ slender, three-jointed; first maxillipeds with a tuft of setæ, or a small setiferous third claw, between the usual two at its tip; second maxillipeds with a stout terminal claw which shuts down between two knobs on the basal joint.

All the swimming legs biramose; rami of first pair two-jointed, of second and third pairs three-jointed, of fourth pair enlarged, laminate, and one-jointed. First three pairs with plumose setæ, fourth pair without setæ or even spines. Egg-strings straight and several times the length of the body.

Male.—Carapace like that of the female but considerably wider than long; eyes visible and situated far forward. Lateral wings on second thorax segment small; third segment without any traces of dorsal plates; fourth segment with a rudimentary pair overlapping the genital segment a little. Genital segment oblong wedge shaped, widest posteriorly; sixth segment not distinctly separated as in the female, but indicated by an abrupt narrowing of the genital segment, and by notches in its lateral margins. Abdomen very narrow, two-jointed, the joints equal; anal laminae large and armed with long and stout plumose setæ. Appendages like those of the female; first maxillipeds with a tuft of hairs between the two terminal claws, corresponding to the middle claw in the female. All the swimming legs biramose; rami of first and fourth pairs two-jointed, of second and third pairs three-jointed; first three pairs with long plumose setæ, fourth pair with spines only.

(*Dinematura*, $\delta\acute{\iota}\varsigma$, two, $\nu\acute{\eta}\mu\alpha$, thread, and $\acute{o}\nu\rho\alpha$, tail, that is a tail made up of two threads, the egg-strings.)

KEY TO THE SPECIES.

- a. Females, carapace only one-third the entire length and not much wider than the genital segment; rami of the fourth legs and anal laminæ long and prominent; egg-strings four or five times the length of the body. b.
- a. Females, carapace half the entire length or more and much wider than the genital segment; rami of fourth legs and anal laminæ short and partly concealed; egg-strings only twice the length of the body or less. c.
- a. Males, carapace several times the size of the genital segment; dorsal plates reduced to mere stumps or entirely lacking; rami of fourth legs two-jointed and well armed with spines. d.
- b. Lobe of sixth segment not projecting beyond the posterior lobes of the genital segment; sixth legs reduced to mere papillæ; length 30 mm. or more. *ferox* Krøyer, 1863, p. 377.
- b. Lobe of sixth segment projecting half its length behind the posterior lobes of the genital segment; sixth legs as well developed as the fourth; length 18 to 20 mm. *producta* Müller, 1785, p. 380.
- c. Carapace half the entire length or less, not quite twice the width of the genital segment; anal laminæ broadly foliaceous. *latifolia* Steenstrup and Lütken, 1861, p. 383.
- c. Carapace two-thirds the entire length and four times as wide as the genital segment; anal laminæ narrow oblong. *hamiltoni* Thomson, 1889.
- d. Fourth thorax segment three times as long as wide; abdomen nearly square, one-jointed; anal laminæ narrow-oblong. *hamiltoni* Thomson, 1889.
- d. Fourth thorax segment considerably wider than long; abdomen oblong and two-jointed; anal laminæ as broad as long. *latifolia* Steenstrup and Lütken, 1861, p. 383.

This genus was established by Latreille in 1829 for the species which Müller had described as *Caligus productus* in 1785. Latreille called his new genus *Dinemoura*, and fortunately gave the etymology of the new word, as so many of his associates have failed to do (see above). Acting upon this, Burmeister in 1833 changed the spelling of the name to *Dinematura* which certainly corresponds more correctly to the etymology and was at once adopted universally.

There was a great amount of confusion in the early descriptions, both in regard to the species and to their hosts, even among such careful investigators as Gerstaecker and Steenstrup and Lütken. As late as 1889 Thomson described four species which he referred to this genus; three of them really belong here, but the fourth is as unmistakably an *Echthrogaleus* species.

The simplest way to rectify this and other similar mistakes is to present a list of the 18 species which have been ascribed to this genus by the various investigators, with a proper identification for each, so far as this has been rendered possible:

- Dinemoura affinis* Milne Edwards, 1840, shown by Steenstrup and Lütken to belong to their new genus *Echthrogaleus*, and accordingly becomes *Echthrogaleus affinis*.
Dinemoura alata Milne Edwards, 1840, also shown by Steenstrup and Lütken to be a probable species of the genus *Echthrogaleus*.

- Dinematura braccata* Dana, 1852, shown on page 366 of the present paper to be still another species of *Echthrogaleus*.
- Dinematura carcharodonti* Thomson, 1889, one of the four species to which reference is made above, a genuine *Dinematura*, but apparently a synonym of *D. ferox* as suggested by Bassett-Smith.
- Dinemoura colcoptrata* Guérin, 1837, taken by Steenstrup and Lütken in 1861 as the type species of their new genus *Echthrogaleus*.
- Dinemoura elongata* Van Beneden, 1857, shown by Steenstrup and Lütken to be a synonym of *D. producta* (see also p. 382).
- Dinemoura ferox* Kröyer, 1838, valid (see p. 377).
- Dinematura hamiltoni* Thomson, 1889, valid (see p. 375).
- Dinematura gracilis* Burmeister, 1833, shown on page 452 of the present paper to be probably a young male of *Dinematura producta*.
- Dinematura indistincta* Kröyer, 1863, probably belongs to the genus *Echthrogaleus*, as suggested by Bassett-Smith, but only a brief description without figures has ever been published.
- Dinematura lamnæ* Kröyer, 1863, first described by Johnston in 1835 as *Panadarus lamnæ*, but really a synonym for *Dinematura producta*, as shown by Steenstrup and Lütken in 1861.
- Dinematura latifolia* Steenstrup and Lütken, 1861, valid (see p. 383).
- Dinemoura musteli-lævis* Hesse, 1880, shown on page 386 of the present paper to be probably a *Demoleus* species.
- Dinematura neozealanica* Thomson, 1889, another of the four species to which reference is made above, and one which certainly belongs to the genus *Echthrogaleus*, as suggested by Bassett-Smith.
- Dinemoura producta* Latreille, 1829, the species first described by Müller as *Caligus productus* in 1785, and taken by Latreille as the type species of his new genus *Dinemoura* (see p. 381).
- Dinematura serrata* Kröyer, 1863, shown by Horst in 1897 to be a new genus and named by him *Philorthragoriscus* (see p. 479).
- Dinematura sexsetacea* Burmeister, 1833, established to include the two species described by Otto, *Caligus heptapus* in 1821 and *Caligus paradoxus* in 1828. But the latter was used by Heller as the type of his new genus *Demoleus* in 1865, and hence Burmeister's species becomes a synonym of that genus.
- Dinematura thynni* Kollar, a name given by Kollar on the labels of certain specimens in the Vienna Museum. These specimens were made the types of a new genus, called *Arneus thynni* by Kröyer in 1863. They have since been identified with Gerstaecker's *Elytrophora brachyptera*, which was described in 1853.

We thus see that out of the eighteen species which have been ascribed to this genus only four prove valid, and they have been included in the key given above. Of the other fourteen, seven belong to the two new genera established by Steenstrup and Lütken and Horst, while the remaining seven are synonyms of other species.

The confusion in this genus has apparently arisen from a singular inability on the part of the different investigators to appreciate the significance of the structures found just behind the genital segment. It is easy to understand how Müller, Latreille, and Burmeister failed in this regard; they were pioneers in the work and accomplished wonders in the face of the greatest difficulties. Moreover, we must never forget that they dealt almost wholly with isolated material, and were thus deprived of those suggestions and explanations which

come from a broad survey and comparison of all the known genera and species.

But even with these advantages the recent writers have still failed to recognize the structures behind the genital segment as a sixth thorax segment with its dorsal plates and rudimentary swimming legs. These structures are plainly marked here in *Dinematura*, but are rudimentary or even lacking in the other genera. They are, of course, morphologically the same in all the genera, however rudimentary they may be, but have been very differently regarded by different investigators.

For instance, the dorsal process has been considered a process of the genital segment in the present genus, as the first segment of the abdomen in *Pandarus* and *Gangliopus*, as a foliaceous dorsal lamina of the abdomen in *Demoleus*, while it has been wholly overlooked in *Laminifera* and *Echthrogaleus*, in both of which, however, it exists and can be easily found.

One of the most recent investigators, Bassett-Smith, in his Enumeration of the Known Species of Parasitic Copepods (1899), describes this sixth segment as "a small median process (of the genital segment) partially covered by two narrow plates" (p. 463), while he regards the rudimentary swimming legs upon its ventral surface as lateral processes of the abdomen. But as soon as we realize that this is really a sixth segment we have recognized the most important characteristic of the genus *Dinematura* and one which will certainly distinguish it from all its relatives. This has been indicated in the diagnosis given above by the use of italics.

DINEMATURA FEROX Kröyer.

PLATE XXII.

Dinematura ferox KRÖYER, 1838, p. 40, pl. I, fig. 5.—MILNE EDWARDS, 1840, p. 465.—STEENSTRUP and LÜTKEN, 1861, pp. 376, 379, pl. VII, fig. 14.
Dinematura carcharodonti THOMSON, 1889, p. 360, pl. XXVI, fig. 2.

Female.—Body three times as long as wide, both the carapace and genital segment thick and strongly arched. Carapace, including the posterior lobes, nearly orbicular; lateral areas narrow, their transverse suture just in front of the posterior margin of the carapace, and forming a well-defined notch on each lateral margin; posterior lobes long, conical, and curved inward at their tips. Frontal plates very narrow and insignificant; median incision scarcely visible; eyes small and about one-third the distance from the anterior margin. The three free thorax segments about the same length, but diminishing regularly in width backward. Lateral plates on the second segment reaching back to and overlapping the plates on the fourth segment. No dorsal plates on the third segment; those on the fourth segment short and narrow, the same width as the genital segment and

two-fifths as long, the median sinus two-thirds the entire length, narrow and enlarged a little at the base.

Each plate is rounded in the form of a semicircle at its posterior end and at the anterior corner, the latter projecting prominently. Genital segment five-sevenths the width of the carapace, a little less than twice as long as wide, with parallel sides and wide, evenly rounded, but very short posterior lobes. The dorsal plates on this segment are a little narrower and shorter than the segment itself, their posterior ends cut off obliquely and separated by a short sinus.

Dorsal process of the sixth segment filling little more than half the entire space between the posterior lobes of the genital segment, but not reaching quite to their tips. Dorsal plates of this segment shorter and wider than the process, the median sinus less than one-third their length and enlarged a little at its base. Abdomen one-jointed, subtriangular, the anterior corners rounded, the posterior margin projecting slightly beyond the genital segment. Anal laminae huge, as long and two-thirds as wide as the dorsal plates on the fourth segment, and armed with short, nonplumose spines. Egg strings narrow and about four times the length of the body; eggs small and very numerous.

First antennae small, two-jointed, armed with but few setae, both joints visible in dorsal view. Mouth tube very long and narrow; maxillae curved in toward the base of the mouth tube and then out again, so as to assume the shape of a half moon. Each maxilla three-jointed, the two basal joints subequal, the terminal joint much shorter. First maxillipeds rather large, the two joints approximately the same length; the accessory claw on the posterior margin of the distal joint is removed some distance from the terminal claw. Both claws are flat and laminate and fringed along both margins with cilia; between them and nearer to the base of the terminal one is a rounded knob carrying a heavy tuft of setae.

Second maxillipeds not swollen as much as in some of the other species, and armed with an ordinary terminal claw which shuts down against two corrugated knobs on the basal joint.

All the swimming legs biramose and of the usual pattern; the proximal joint of the exopod of the first pair is enlarged more than in any other species, being more than five times the size of the distal joint. The arrangement of the spines and setae on the different legs is as follows: First exopod, 1, 0; 3, III: endopod, 0, 0; 0, III: second exopod, 1, I; 1, I; 3, IV: endopod, 1, I; 0, II; 0, VII: third exopod, 1, I; 1, I; 3, IV: endopod, 0, I; 0, II; 0, IV: fourth rami without spines or setae.

The legs on the sixth segment are reduced to mere stumps, attached to either side of the segment and projecting outward at right angles to the body axis. They are bluntly rounded at the tips which just

reach a level with the lateral margins of the abdomen. Of the reproductive organs, the cement glands are large and of the usual shape; they reach from the base of the sixth segment nearly to the anterior margin of the genital segment; the anterior ends are bluntly rounded, while the posterior ones are enlarged and somewhat angular. The semen receptacle is in the form of a semicircle, its ends enlarged and resting against the base of the sixth segment, while the curve is directed forward. The oviducts are each coiled once in the genital segment, the coil passing backward into the posterior lobe, then forward to the anterior margin, and then backward to the vulva which opens just in front of the base of the sixth segment on either side.

Total length, 32 mm.; length of carapace on mid-line, 7 mm.; width of same, 10 mm.; length of third dorsal plates, 6 mm.; length of genital segment, 13 mm.; width of same, 7 mm.; length of anal laminae, 5 mm.; length of egg strings, 120 mm.

Color (preserved material) a dark yellow tinged with brown, but without pigment markings.

(*ferox*, ferocious.)

Steenstrup and Lütken state that if it can be fairly proved that the present species and *Nogagus grandis* live in the same region, then it will be reasonably certain that they are the male and female of the same species (1861, p. 387).

After careful examination this does not seem probable for the following reasons: First, *Nogagus grandis* is not like the *Dinematura* males already determined in that its second and third legs are two-jointed instead of three-jointed, and its second maxillipeds are of the ordinary form instead of swollen.

In the second place, it is like the male form named *Caligus paradoxus* by Otto in 1828, and corresponds, in the structure of its appendages, with the female form presented at the same time and afterwards (1865) used by Heller as the type of his new genus *Demoleus*. For these reasons *Nogagus grandis* has been placed with the genus *Demoleus* (see p. 349).

The collection of the U. S. National Museum includes two lots of this species; one numbered 12036 and containing more than thirty females excellently preserved was obtained from the shark fishermen of Iceland; the other, Cat. No. 32783, contains six well-preserved females whose origin and host are unknown.

DINEMATURA PRODUCTA Müller.

PLATE XXIII.

Caligus productus MÜLLER, 1785, p. 132, pl. XXI, figs. 3 and 4.

Dinemoura producta LATREILLE, 1829, p. 197.

Pandarus lamnæ JOHNSTON, 1835, p. 203, fig. 22 (text).

Dinemoura lamæ BAIRD, 1850, p. 286, pl. XXXIII, fig. 8.

Nogagus productus, GERSTAECKER, 1853, p. 63, pl. IV, figs. 1 to 10.

Dinematura elongata VAN BENEDEN, 1857, p. 226; 1860, p. 149, pl. XXIV.

Dinematura producta STEENSTRUP and LÜTKEN, 1861, pp. 371, 374, pl. VII, fig. 13.

Female.—Carapace orbicular, a little wider than long; frontal plates wider and more prominent than in *ferox*, their anterior margin nearly straight, with a deep and well-defined central sinus.

Lateral areas wide, their transverse grooves far in front of the posterior margin of the carapace and making only small indentations on the lateral margins; posterior lobes short and wide, and curved inward strongly at the tips. Eyes not visible in any of the specimens examined. Free thorax segments very short but wide, filling the entire space between the posterior lobes of the carapace. Lateral plates on the second segment short and oblique; no plates on the third segment; those on the fourth segment narrow and nearly as long as the carapace on the mid-line, being more than twice as long as wide. Together, these plates are no wider than the genital segment, and are evenly rounded at their anterior corners, not projecting as in *ferox*; the posterior ends are also evenly rounded, while the median sinus extends about three-fourths the entire length and is somewhat enlarged at its base.

Genital segment oblong, a little more than half the width of the carapace, with short and rather narrow posterior lobes; dorsal plates covering this segment a little narrower and shorter than the segment itself, as in *ferox*. Their posterior ends are cut off obliquely but in a direction opposite to that of *ferox*, leaving a sharp corner at the inner, instead of the outer, angle; median sinus wide, fairly deep, and wedge-shaped, with a squarely cut base. Dorsal process of the sixth segment narrow and elongate, reaching far behind the genital segment and abdomen; dorsal plates covering the process also narrow and elongate, not quite as long as the process itself, divergent, and separated by a triangular sinus two-thirds of their entire length.

The base of this sinus is opposite the tips of the dorsal plates on the genital segment. Body of the sixth segment short and about the same width as the abdomen; sixth legs large and somewhat boot-shaped, with the heels turned outward. They reach back to the tip of the dorsal process, are armed with rudimentary spines like the fourth legs, and are plainly visible in dorsal view. Abdomen small and subquadrangular, projecting behind the genital segment, but entirely concealed in dorsal view by the process, legs, and dorsal

plates of the sixth segment. Anal laminae large and elliptical, articulated by their outer corners only to the outer corners of the abdomen; each armed with three terminal spines, and one on the outer margin. Egg-strings narrow and about twice the length of the body.

First antennae of medium size, their basal joints entirely concealed beneath the frontal plates; second pair enlarged with a short, sickle-shaped terminal claw. Mouth-tube as long as in *ferox* and a little wider; maxillae large and three-jointed, the basal joint much the largest and carrying on its outer margin two small processes, in contact with each other, and each tipped with a small spine. These are evidently the rudiments of the exopod; the endopod is made up of two cylindrical joints, the terminal one considerably the smaller.

First maxillipeds similar to those in *ferox*; second pair with the basal joint more swollen and armed with larger corrugated knobs; the terminal claw rather slender but of the usual pattern. Swimming legs similar to those in *ferox*, the basal joint of the first exopod not enlarged as much and more pointed.

The spines and setae are arranged as follows: First exopod, 1, 0; 3, III: endopod, 0, 0; 0, III: second exopod, 1, 0; 1, 0; 2, V: endopod, 0, 1; 0, 1; 0, VI: third exopod, 1, I; 1, I; 3, VI: endopod, 0, 0; 0, II; 0, VI. Fourth rami each with four rudimentary spines near their tips.

Total length, 17 mm.; length of carapace on mid-line, 5 mm.; width of same, 7 mm.; length of second and third thorax segments, 1 mm.; of genital segment, 8 mm.; of dorsal process of sixth segment, 3.5 mm.; of egg-strings, 40 mm.; width of genital segment, 4 mm. Color of preserved material a light brown without pigment spots. (*producta*, elongated, drawn out.)

The present is the species described by Müller in 1785 as *Caligus productus*, and afterwards taken by Latreille as the type of the new genus *Dinemoura* which he established in 1829.

Neither Müller's nor Latreille's description was very satisfactory, but fortunately the specimens upon which these descriptions were founded were preserved in the museum in Copenhagen, and Steenstrup and Lütken were enabled to recognize Müller's species and to correct some of the errors in regard to it and to its hosts. Accordingly they have given us a history of this species up to 1861, which clears up many of the difficult puzzles and mistakes in identity and nomenclature. They declare in substance that the present species was described and figured first by Herbst in an article entitled "Beschreibung einer sehr sonderbaren Seelaus vom Hemorfische," published in *Schriften der Berlinischen Gesellschaft naturforschenden Freunde* for 1780, pp. 56 to 67. Herbst obtained his specimens from Pastor Chemnitz, of Copenhagen, who in turn had them from the Faroe Islands with the information that they had been fastened to

the tail of a "Hemorfische," which was in all probability *Lamna cornubica*.

The Zoological Museum of the university at Copenhagen possesses several specimens of this species from the Faroe Islands which were taken from *Lamna cornubica*. The Physiological Museum of the same university possesses another particularly fine lot of females of *D. producta* fastened tightly to a piece of shark's skin. This piece of skin looks as if it came from *Scymnus glacialis*, and it has been so recorded by one or two investigators, but the scales on it show that it really belonged to a *Lamna cornubica*. Such a shark was captured and kept on exhibition for some time, and then purchased by the University Museum. It bore numerous marks of fish lice and the specimens fastened to it while on exhibition were all *D. producta*.

Müller was the next to describe the species in 1785; he does not state whence he obtained his specimens, but Steenstrup and Lütken think it probable that they came from the same Faroe Island collection. Müller's figures and description are less satisfactory than Herbst's, and he makes the serious blunder of including Fabricius's *Binoculus salmoneus*, which belongs to the genus *Lepeophtheirus*, with his "*Caligus productus*."

In 1829 Latreille, recognizing that this was not a *Caligus*, made of it a new genus which he called *Dinemoura*. He was content, however, to accept the descriptions already given and added almost nothing in the way of further information. Consequently his contribution consisted of little more than a change of name.

In 1835 Johnston described a British species which he called *Pandarus lamnæ*, and which was taken from a Beaumaris shark, *Lamna monensis*. Baird incorporated this in his Natural History of the British Entomostraca in 1850 under the name of *Dinemoura lamnæ*. He recognized that it was the same that Herbst had described, but singularly enough did not identify it with Müller's *Caligus productus*; the name he gave it therefore becomes another synonym of that given by Latreille.

P. J. Van Beneden in 1857 described and figured this species under the name *Dinemoura elongata*, still another synonym.

It might have been difficult to decide whether Beneden really had a new species or not, but Steenstrup and Lütken found that his specimens came from Copenhagen and that they were taken from the same piece of shark's skin already mentioned.

Their host, therefore, was *Lamna cornubica* and not *Scymnus glacialis*, as Beneden states, and the species is identical with those described before. Thirty-five years later, in 1892, Beneden presented what he claimed was the male of his *D. elongata*, still retaining his former name for it, although he acknowledges in so many

words that both Steenstrup and Lütken and Olsson had shown that it was a synonym of *D. producta*.

This male is figured very poorly; no frontal plates are shown; there are no dorsal grooves or markings of any kind upon the carapace, and the second and third thorax segments are hopelessly confused. But the general outline, the relative proportion of the various parts, and such of the details as can be made out correspond closely with those of the male of *latifolia* here for the first time shown (see p. 386). The rami of the second legs are three-jointed, as they should be, but he describes the basal joints of the third legs as fused across the mid-line into a broad apron wholly covering the fourth pair. The rami of these third legs are attached to the sides of the apron and appear to have only two joints in the figure given; nothing is said of the number of joints in the text.

In the *latifolia* male the basal joints of these legs are greatly enlarged and nearly meet on the mid-line, but the rami are attached to the posterior margins and are distinctly three-jointed. The first maxillipeds also in Beneden's specimen show no tuft of setæ between the two terminal claws, while the first swimming legs as he has represented them are unlike anything known amongst the parasitic copepods. They are cylindrical, uniramous, and one-jointed, with three plumose setæ attached to the anterior margin near the end and curved over the ventral surface; the end of one is split and armed with small spines; the other is entire and bluntly rounded. In the text these appendages are said to be the same as those of the female.

In the presence of such inconsistencies it is of course impossible to locate the species with accuracy, but the resemblance between this male and the one of *latifolia* about to be described seem to overbalance the differences, and the form Beneden has presented may be a *Dinematura* male as he claims.

The Museum collection contains three lots of this species; one, Cat. No. 12678 U.S.N.M., contains two females obtained from a large shark in Casco Bay, Maine. The second is Cat. No. 12679 U.S.N.M. and contains six females taken from a large shark captured at the surface in latitude 38° 07' N. and longitude 74° 21' W. on May 10, 1887, by the Bureau of Fisheries schooner *Grampus*. The third is Cat. No. 8106 U.S.N.M. and consists of a single female taken from a shark near Shetland; it was obtained by exchange.

DINEMATURA LATIFOLIA Steenstrup and Lütken.

PLATES XXIV AND XXV.

Dinematura latifolia STEENSTRUP and LÜTKEN, 1861, p. 378, pl. viii, fig. 16.—
BRIAN, 1898, p. 14, pl. ii, fig. 10.—BASSETT-SMITH, 1899, p. 463.

Female.—Carapace transversely elliptical, the width twice the length on the median line; frontal plates narrow but distinct, their

combined length not more than one-third the width of the carapace. Posterior margin almost straight and with a triangular flap on either side projecting backward over the lateral plates of the second thorax joint. Lateral areas wider than in *ferox* and *producta* and without any visible transverse grooves; posterior lobes wide, broadly rounded, and extending backward toward and somewhat overlapping the dorsal plates of the fourth segment. Thoracic area almost rectangular, more than half the entire width of the carapace and about half the length on the mid-line; cephalic area small and elliptical.

Second thorax joint much shorter than the third, but wider, and furnished with a pair of good-sized lateral plates, which fill the entire space between the posterior lobes of the carapace. Third joint wedge-shaped and without dorsal plates; fourth joint with a pair of large ones which extend out laterally nearly to the margin of the carapace and posteriorly over the basal third of the genital segment. These two plates are fused anteriorly, the narrow median sinus not reaching quite to their base; each is somewhat triangular in shape, the anterior, lateral, and inner margins being convex, while the posterior margin is slightly concave. Each plate has the same width and length, thus differing radically from those of the other two species already described. The fourth segment is much narrower than the third, and the base of the dorsal plates is contracted to about half the width of the third segment.

Genital segment elongate, nearly twice the length of the carapace on the midline, with wide and evenly rounded lobes at its posterior corners. Its dorsal plates are considerably narrower and shorter than the segment itself; their posterior ends are broadly rounded and separated by a triangular sinus whose sides are much more divergent than in *ferox* or *producta*.

Dorsal process of the sixth segment club-shaped or spatulate, and prolonged backward over the abdomen and the base of the anal laminae. Its two small dorsal plates are separated by a narrow median sinus; they do not reach the tip of the process and do not extend beyond its lateral margins, except at the base. Abdomen broad, heart or kidney shaped, about twice as wide as long, and entirely concealed in dorsal view. Its lateral margins are somewhat flattened, while to its postero-lateral margins are attached the huge anal laminae, each fully as large as the whole abdomen and tipped with four long plumose setae. Egg strings slender and about twice as long as the body of the copepod.

On the ventral surface of the carapace there are four adhesion pads on either side of the body and a single median one just behind the bases of the first swimming legs. These are similar to the pads found in *Pandarus*, and characterize the present genus as one of the *Pandarinae*. The first two pairs of these pads lie posterior to the bases of

the first antennæ and outside the second antennæ. They are arranged on either side one behind the other, the posterior one being three or four times as large as the anterior and both being elliptical in shape. The third pair are nearly circular and lie on either side of the mouth tube at about its center; the fourth or posterior pair are formed on the edges of the lateral plates of the second thorax segment. They are elongated, irregular in outline, and inclined toward the central axis.

Of the appendages the first antennæ are very small and two-jointed, the joints not very well supplied with setæ; the second antennæ are large, three-jointed, and terminate in the usual claw, which has a double curve like the letter S. The mouth tube is very slender and pointed, and is fully twice the length of the second maxillæ. The latter consist of a thick conical basal joint terminating in a spherical knob, from which extend the two slender, cylindrical terminal joints, which are inclined outward at an angle of about 45°. The mandibles are slender, the two joints about the same length, and they end in a terminal claw strongly curved toward its tip and fully as long as the joints. On the outer margin of the terminal joint, near the base of this claw, is a shorter accessory claw, and between the two claws the usual tuft of long cilia; both these claws are also densely covered with short hairs.

The second maxillipeds are massive and nodose, exactly like those in *Pandarus*, and different from what we have seen in *ferox* and *producta*. The swimming legs are all biramose, the rami of the first pair two-jointed, of the second and third pairs three-jointed, of the fourth pair two-lobed and foliaceous.

There is a row of three large adhesion pads along the inner margin of each of the first legs, two of the pads being on the basal joint and the other on the first joint of the endopod.

The arrangement of the spines and setæ on the swimming legs is as follows: First exopod, 1, 0; 2, III: endopod, 0, 0; 0, III: second exopod, 1, I; 1, I; 3, V: endopod, 0, I; 0, II; 0, VI: third exopod, 1, I; 1, I; 4, III: endopod, 0, 0; 1, II; 0, IV. Both rami of the fourth legs have smooth edges without spines or setæ.

The sixth legs are well developed and are situated close to the mid-line just in front of the base of the abdomen, on the ventral surface of the genital segment. Each consists of a two-lobed foliaceous lamina, similar to those of the fourth legs, but considerably smaller.

Total length, 15 mm.; length of carapace on mid-line, 4 mm.; width of same, 7.9 mm.; length of genital segment, 7 mm.; width of same, 4.65 mm.; length of egg-strings, 30 mm.

Color a yellowish green, considerably darker in the thicker parts of the body, the dorsal plates and thin margins a clear yellow.

(*latifolia*, *latus*, wide, and *folia*, plates or wings.)

Male.—Carapace proportionally much enlarged and very evenly rounded, the width one and three-quarters times the length on the mid-line. All the thorax joints except the first free as in the female, and diminishing in size backward.

Dorsal plates on the fourth joint much smaller than in the female, scarcely overlapping the base of the genital segment, and bordered with fine hairs. Genital segment oblong, suddenly and considerably enlarged just back of the center, and then contracted abruptly to the base of the abdomen, with a deeply concave posterior margin. At its widest point it is only one-third the width of the carapace, and is about one-fourth longer than wide. Abdomen two-jointed, the terminal joint a little larger than the basal and wedge-shaped, the large anal laminae being attached to the inclined posterior margins. Each of them is fully as large as the joint itself, and carries three large and one small plumose setae.

The appendages are exactly like those in the female, with the exception of the fourth legs; here the rami have not been transformed into laminae, but are each two-jointed and armed with short plumose setae and spines, like the other legs.

Total length, 8.3 mm.; length of carapace on mid-line, 3 mm.; width of same, 5.2 mm.; length of genital segment, 2 mm.; width of same, 1.65 mm.; length of abdomen, 1.7 mm.

Color as in the female.

This species appears fairly common upon the large sharks along our Atlantic coast, and the U. S. National Museum collection includes five lots, all from the mackerel shark, *Lamna cornubica*. Cat. No. 32782 U.S.N.M., six females from a station 120 miles off Woods Hole; Cat. No. 32784, U.S.N.M., three males taken with the females of the preceding lot; Cat. No. 12676, U.S.N.M., six females, locality unknown; Cat. No. 12677, U. S. N. M., six females from Cox's Ledge, Massachusetts; Cat. No. 8107, U. S. N. M., a single female taken on the coast of England.

DINEMATURA MUSTELI-LÆVIS Hesse.

Dinemoura musteli-lævis HESSE, 1880, p. 5, pl. I, figs. 1 to 16.

The description of both sexes as given by Hesse, and the figures, make this an anomalous and entirely original form, unlike anything found in the entire group of parasitic copepods.

It is stated in the text that the female is 15 mm. long and 8 wide; both full-length figures of the female are a little more than three times as long as wide. The text further states that this sex has three free thorax segments in front of the genital segment, the third one bearing a pair of dorsal plates. The first antennae are four-jointed, the second pair six-jointed; the maxillae are also six-jointed and end in a long curved claw. The swimming legs are all biramous, but each ramus

contains only a single joint; the abdomen is entirely concealed beneath the genital segment, and there is not even a trace of any sixth segment. The egg-tubes come out of the posterior lobes of the genital segment, behind the tips of the anal laminae.

The male is even more wonderfully made; he possesses five free thorax segments in front of the genital segment, but there are only two pairs of swimming legs for the entire five segments.

The first antennae are three-jointed, the second pair four-jointed; the maxillae are five-jointed and terminate in a stout claw. The mouth-tube is jointed twice, and the three parts are of different diameters; the eyes are triangular. The swimming legs are all biramose and the rami are one-jointed, as in the female, while each anal lamina is furnished with a large sucker on its base, close to the anus.

Of course such a description takes away all possibility of locating the species accurately; the only thing we can affirm with certainty is that the species does not belong to the genus *Dinematura*, where Hesse has placed it. The size and shape of the female's body, especially when seen in dorsal view, suggests strongly the genus *Demoleus*. But the male is a perfect enigma, in view of which we are obliged to leave the species unlocated and await further information.

Genus PANDARUS Leach.

Pandarus (*P. bicolor*) LEACH, 1816, p. 405.

Female.—Body an elongated oval or ellipse; cephalothorax semielliptical, usually narrowed anteriorly, and covered with a smooth carapace destitute of grooves; posterior lobes short, the margin between them armed with teeth or spines, or sometimes sinuate (fig. 15.) Eyes usually invisible in the adult, but visible in the young. Free thorax segments each furnished with a pair of dorsal plates, which are stiff and rigid, elytra-form; those on the second segment are lateral, the others median, the third pair overlapping to a greater or less extent the genital segment. This latter is considerably enlarged, elliptical, or sometimes narrowed posteriorly and prolonged backward into lobes at the posterior corners. The dorsal surface of this segment is hardened like the carapace, and in most species gives evidence of being a fusion of two plates, like those

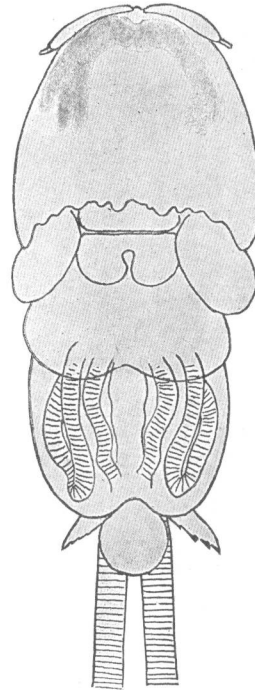


FIG. 15.—DORSAL VIEW OF A FEMALE PANDARUS SINUATUS, SHOWING THE PARTS OF THE BODY.

on the other thorax segments. Sixth segment represented by a median lobe or process attached to the base of the posterior sinus of the genital segment, and without dorsal plates or rudimentary legs. Abdomen short and broad, two-jointed, usually narrowed anteriorly and attached to the ventral surface of the genital segment. Abdomen covered dorsally by the rudimentary sixth segment lobe, ventrally by a plate, short and wide, and not reaching the posterior margin of the dorsal lobe.

Attached to either side of the ventral plate at its base, and to the side of the abdomen, is a peculiarly modified anal lamina; the two are usually divergent, with a thickened conical outer margin and two membranous wings, dorsal and ventral, on the inner margin. Four

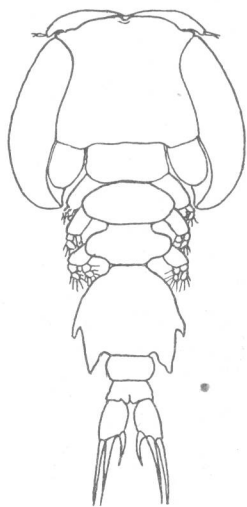


FIG. 16.—DORSAL VIEW OF A MALE OF *PANDARUS CRANCHII*: THIS IS THE "*NOGAUS LATREILLII*" UPON WHICH LEACH FOUNDED HIS GENUS *NOGAUS*. DRAWN BY EMERTON.

pairs of adhesion pads on the ventral surface of the carapace, one pair at the base of the first antennæ, one at the base of the second antennæ, a third between the bases of the first maxillipeds, and the fourth on the lateral margins of the first pair of thorax plates, opposite the first legs.

Second maxillipeds much swollen and enlarged, armed with a pair of roughened, forceps-like knobs instead of a terminal claw. Four pairs of biramous swimming legs, the rami all laminate, indistinctly jointed, and usually armed with spines only. Egg tubes straight, uniseriate, close together, and usually much longer than the body.

Male.—The original type of the genus *Nogaus* (fig. 16). Carapace broad and well rounded; posterior lobes prominent, triangular, and usually turned inward; posterior margin straight and armed with a pair of secondary lobes, one on either side, close to the base of the posterior lobe; lateral grooves

distinct, turned sharply outward near the anterior end and extending to the margin of the carapace just behind the first antennæ. Frontal plates wide and prominent, anterior margin fairly straight and not deeply cut at the center; eyes often visible in the adults. Free thorax segments without dorsal plates, diminishing in width from in front backward, the first one (really the second segment) with a pair of lateral lobes extending diagonally backward and outward, the others without lobes.

Genital and sixth segments fused, considerably enlarged, and furnished with two pairs of rudimentary legs, one, the sixth, at the posterior corners, and the other, the fifth, on the lateral margins; both

pairs prominent. Abdomen two-jointed, joints the same size; anal laminae large, well flattened, and armed with four large setae, of which the inner one is separated from the other three.

Ventral surface of the carapace with the same adhesion pads as in the female. Second maxillipeds enlarged, sometimes with a terminal claw and sometimes with pincher knobs, both varieties occurring in the same species. The four pairs of swimming legs biramose, all the rami two-jointed and armed with large plumose setae.

(*Pandarus*, the leader of the Lycians in the Trojan war.)

The distinguishing characters of a female *Pandarus* are the paired dorsal plates on the free thorax segments, the rudimentary sixth segment, and the peculiarly modified anal laminae (fig. 15). Of the dorsal thorax plates, the first pair extend diagonally backward over the lateral margins of the third pair and may even reach beyond the latter (*satyrus*).

In some species (*sinuatus*) they are short and plump, with well-rounded outlines; in others (*satyrus*) they are long and narrow, with their lateral margins comparatively straight.

Between their bases lies an unpaired median plate, which covers the remainder of this second segment and projects but a comparatively short distance behind the posterior margin of the carapace, either terminating in a straight line (*sinuatus*, *satyrus*, *cranchii*), broadly concave (*bicolor*) or convex (*smithii*), both the latter overlapping the third segment. The bases

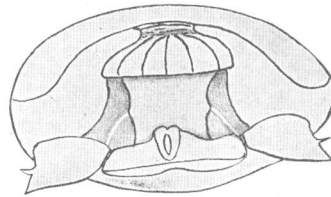


FIG. 17.—SECTION OF THE GENITAL SEGMENT OF *PANDARUS SINUATUS*, WITH THE SIXTH SEGMENT AND ABDOMEN STILL ATTACHED. END VIEW, SHOWING THE DISTANCE BETWEEN THE DORSAL PLATE AND THE ABDOMEN.

of this first pair of plates are furthermore separated by so wide an interval as to leave nearly the whole of the small second pair uncovered between them. These latter are much the smallest pair in every species, and are more or less fused at the median line, the sinus separating them being sometimes a mere notch at the center of the posterior edge of the fused plates (*cranchii*), or even entirely lacking, so that the plates seem like one (*brevicaudis*).

Anteriorly their articulation is usually concealed beneath the posterior border of the central plate of the second segment.

The third pair of plates are the largest of the three and they overlap the genital segment for a greater or less distance, sometimes nearly covering it (*armatus*, *smithii*, *satyrus*).

The rounded posterior extremity of the body is a second characteristic of the genus; this extremity is formed dorsally by a rudimentary lobe or process representing the sixth thorax segment, which is elliptical or oval in young females and does not completely fill the sinus of the genital segment, but in mature females it fits this sinus

exactly, leaving no space around its margin. That this is really the rudiment of a sixth thoracic lobe and not a part of the abdomen, as it has been hitherto regarded, is proven in several ways. First, by analogy, it corresponds exactly to the similar lobe found in *Dinematura* (see p. 374) and *Echthrogaleus* (see p. 362). Again, it is not connected with the abdomen, but is raised some distance above the dorsal surface of the latter (fig. 17). Furthermore, it is not a fusion of two plates, but is unpaired and median from the very beginning (see fig. 182). In the matured female it is always above the egg strings, while the abdomen is below them. If it is to be regarded as a dorsal abdominal plate, therefore, we have the anomaly of the egg strings passing through the abdomen, or at least beneath its dorsal plate. Some writers have claimed this very thing, but it is entirely without precedent, and would constitute an anatomical freak of the most capricious sort.

On the other hand, if this be the rudimentary sixth segment, everything is exactly as in the other genera; the egg strings come out from the ventral surface of the genital segment, beneath the sixth segment and above the abdomen exactly as they do in *Dinematura* and *Echthrogaleus*.

Finally, we have the testimony of the male, in every species of which, so far as known, a sixth pair of legs is prominent on the genital segment as well as a fifth pair.

Such cumulative evidence is convincing and fairly proves that the dorsal plate can not belong to the abdomen, but must represent the sixth segment.

The ventral plate, on the other hand, does remain in contact with the ventral surface of the abdomen to the very tip of the latter. As a consequence the terminal half of the abdomen is drawn down to the plate tightly and lies along its dorsal surface. As the two lobes at the tip of the abdomen on either side of the anus fuse with the ventral plate, the tips of the lobes themselves also fuse with each other and the anus ceases to be any longer terminal, but opens up dorsally from the surface of the ventral plate. When the genital segment is thickened by the maturing of the eggs and the coiling of the distended oviduct, the dorsal plate of the sixth segment and the ventral plate of the abdomen are separated some distance from each other, while the body of the abdomen lies between them (fig. 17).

When the eggs finally emerge into the egg strings, the latter are pushed through the spaces between the posterior lobes of the genital segment and the body of the abdomen, above the ventral plate of the latter. They do not, therefore, pass through the abdomen at all, but are entirely outside of it. In this way, although the openings of the oviduct are some distance apart, the egg strings are brought together on the mid line and carried backward side by side so close together as to be often in actual contact.

The anal laminae next demand attention. They are modified so peculiarly as to have deceived many of the investigators who have examined only adult specimens. Leach, who founded the genus in 1816 upon two species, *Pandarus bicolor* and *P. boscii* (really two variations of the same species), described them as the notched apex of the "abdomen." But this term "abdomen" as he used it included the genital segment and the sixth segment, as well as the true abdomen, which latter he seems to have entirely overlooked, since no mention is made of it.

Many of the long list of observers since his day have likewise overlooked the anal laminae altogether or have designated them as a part of the genital segment. Desmarest (1825), in his brief diagnosis of this genus, twice mentions the "deux soies" at the posterior end of the body. But since under the species diagnoses he states that these "soies" are from one and a half to two times as long as the body, he is evidently speaking of the egg strings, and no mention is made of the anal laminae.

Milne Edwards (1840) says:

L'abdomen est court, et présente une structure très singulière: il se compose de deux segmens, dont le premier porte de chaque côté un appendice, et se trouve recouvert au dessus par le second qui naît près de son bord antérieur, et a la forme d'une lame caudale (p. 466).

He is thus the first to definitely recognize any appendages in this part of the body, but he evidently found considerable difficulty in the arrangement of the "two segments" of the abdomen, since what he calls the "second" arises from the anterior border of the "first" and lies directly over the latter. This would be a mistake, however we may regard the "appendages," since it would assign them to the "first" or basal segment, when they are plainly borne on the terminal segment in the young female (Plate XXXII, fig. 182).

Dana (1852) seems to be the first to recognize these appendages as actually anal laminae. In his diagnosis of this genus he says:

Abdomen two to three jointed, second segment posteriorly rounded, and having on the sides the caudal stylets, last segment concealed below the second. * * * Caudal stylets styliform, acute, nearly naked (p. 1364).

In all his descriptions Dana regards the genital segment as the first segment of the abdomen, hence his "second segment" would be this dorsal plate or lobe, while his "last segment" would be the true abdomen.

He thus reverses the arrangement given by Milne Edwards and presents the segments in their true sequence, but the "caudal stylets" are not attached to the sides of the dorsal lobe, nor are they connected with it in any way; they arise from the sides of the true abdomen, his "last segment."

Heller (1865) gives as the conclusion of his genus diagnosis:

Annulus genitalis subquadratus, postice angustior, angulis posterioribus acutis cauda ovalis, stylis duplo longioribus.

In the text he speaks of these appendages as "die seitlichen Anhänge" (p. 204) and "die seitlichen Schwanzanhänge" (p. 206), but makes no attempt to explain them or their position. This, taken in connection with the fact that he is so particular to designate them as "seitlichen," would indicate that he did not recognize them as anal laminae.

Brady (1883), in his genus diagnosis, says clearly:

Abdomen two or three jointed, rounded behind; caudal stylets borne on the side of the abdomen, acute, styliform, nonsetiferous (p. 133).

This, together with Dana's clear statement, ought to have established the nature of these appendages, and yet we find Bassett-Smith as late as 1899 giving a genus diagnosis in which he says: "Genital segment terminating in two minute points, and at the base of the abdomen are two lateral, sharp, dentate appendages" (p. 466).

Nothing further is said in reference to them, and we are left to interpret them as we please.

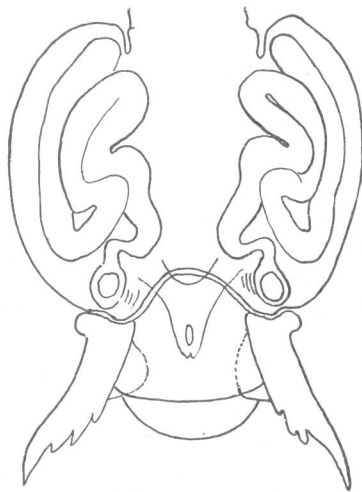
That they are really anal laminae is abundantly proven by an examination of the young of any species. In some of these the laminae are similar to those in other genera belonging to this subfamily, with the single exception that they are armed with nonplumose spines instead of plumose setae (see *sinuatus*, Plate XXXII, fig. 182).

As development proceeds the laminae change their position from the posterior margin to the base of the abdomen, at the same time becoming modified in form until

FIG. 18.—THE GENITAL SEGMENT AND ABDOMEN OF *PANDARUS CRANCHII*, SHOWING ANAL LAMINAE WITH TWO WINGS, DORSAL AND VENTRAL.

they finally reach the adult condition. In other species (*bicolor*, *cranchii*, etc.) the laminae are changed considerably, even in very young specimens, by a thickening of the outer margin and the addition of two wings, a dorsal and a ventral, on the inner margin (fig. 18).

As to the function of these specially modified anal laminae they may perhaps serve as a guide to the egg-strings while the latter are issuing from the genital segment. The openings of the oviducts are widely separated and relatively close to the lateral margins of the genital segment. Instead of passing directly back from their respective openings, and thus remaining some distance apart, the egg-



strings are bent inward as soon as they emerge from the genital segment and are brought together on the mid-line. They then turn backward side by side and so close together that they are usually in contact.

In those species whose anal laminae have well-developed wings on the inner margin the egg-strings pass backward between the two wings. This brings the thickened conical outer margin of the laminae outside the egg-strings and thus holds them in together.

The distinguishing characters of a male *Pandarus* are the large secondary lobes arising from the posterior border of the carapace inside the regular posterior lobes, the two pairs of rudimentary swimming legs on the genital segment, the two-jointed abdomen with the joints of equal length, and the fact that all the rami of the swimming legs are two-jointed.

Secondary lobes are found on the posterior margin of the carapace in some of the other genera also (*Perissopus*, *Nesippus*, etc.), but they are much smaller than in *Pandarus*, and are easily overlooked, while here they are prominent in all the species examined and one of the first characters that would be noticed.

In most of the other *Nogaus* males there are no rudimentary legs visible on the genital segment; here in each of the known species there are two pairs, well defined and prominent.

Their presence is indicative that the so-called genital segment is really a fusion of two segments, the fifth and sixth thoracic segments, each with its pair of legs. This idea has been already advanced by the author,^a and it receives particular confirmation here, where evidences of fusion are shown also in the genital segment of the female. Scattered testimony was furnished by the two pairs of legs on the genital segment of some *Caligus* species (for instance, *isonyx*, *pelamydis*, *stromatei*, etc.) and of many *Lepeophtheirus* species (for instance, *nordmanni*, *hippoglossi*, *edwardsi*, *dissimulatus*, etc.) and in the structure of the genital segment in the male of the genus *Homoiotus*. Here among the Pandarinæ the segment itself is plainly differentiated in *Dinematura*, and is indicated by the rudimentary plate in *Pandarus* and *Echthrogaleus*.

With this accumulation of evidence we can no longer doubt that there are really six segments in the thorax of all the Caligidæ, two of which, the fifth and the sixth, are ordinarily so thoroughly fused as to be indistinguishable. When only one pair of legs is visible on the genital segment it is usually the sixth pair at the posterior corners, instead of the fifth pair, as we have been calling them.

In 1861 Steenstrup and Lütken suggested that the genus *Pandarus* ought to be separated into two subdivisions—one to include the true genus *Pandarus*, made up of *Pandarus cranchii* as a type, together

^a Proc. U. S. Nat. Mus., XXVIII, p. 662.

with Dana's *brevicaudis*, *concinus*, and *satyrus*, and Milne Edwards's *dentatus*, *pallidus*, and *vulgaris*.

The other subdivision which was to constitute a new genus, differing from *Pandarus* as *Echthrogaleus* differs from *Dinematura*, was to have *Pandarus bicolor* for its type, and to differ from the true *Pandarus*, first, in the fact that the two anterior thorax segments are so far fused as to have a common four-parted dorsal plate; secondly, in the somewhat different, more elongated form of the thorax segments, and, lastly, in the fact that the anal laminae are not spine-like, but laminate.

Under any conditions the authors would have to change their recommendation and leave *P. bicolor* the type of the true genus, because this is the species upon which Leach originally founded the genus *Pandarus*. But differences of the sort they mention would have to be far more pronounced than we actually find them in order to become of generic value, and also more constant.

Different specimens of *bicolor* show very different degrees of fusion in the first two thoracic plates, and different degrees of elongation in the thoracic segments; and in every species so far as known the anal laminae are flattened and plate-like in the young, and tend to become spine-like on further development.

It is much preferable, therefore, with our present knowledge of the species, to keep them all in one genus.

KEY TO THE SPECIES.

- a. Females, free thorax and genital segments covered by paired dorsal plates; sixth segment as a rudimentary plate attached to the posterior sinus of genital segment; abdomen wide and very short, one-jointed; anal laminae modified into dentate appendages on the sides of the abdomen near the base b.
- a. Males, carapace with accessory lobes on the posterior margin inside the posterior lobes; no dorsal plates; genital segment with two pairs of rudimentary legs; abdomen elongate, two-jointed, joints about the same length h.
- b. Lateral plates of second segment more or less fused with median ones of third segment, which lie between them and reach beyond their tips. . . . c.
- b. Lateral plates of second segment reaching far behind the tips of the median plates of third segment, which lie between them, but are entirely distinct. e.
- b. Plates of second segment fused across the mid-line in front of those on third segment; the latter fused *inter se*, but distinct from the former.
- brevicaudis* Dana, 1852, p. 397.
- c. Fused plates of second and third segments about the same size as those on the fourth and genital segments; sixth segment plate circular in outline d.
- c. Fused plates of second and third segments much shorter than those on the fourth and genital segments; the latter apparently fused; sixth segment plate elliptical in outline and nearly as large as the genital segment.
- affinis* Beneden, 1892, p. 431.
- c. Fused plates of second and third segments the same size as those on the fourth segment, but much smaller than those on the genital segment; sixth segment plate wide, but nearly concealed. *spinacii-achantias* Hesse, 1883, p. 458.

- d. Frontal plates projecting as a semicircular rostrum between the antennæ; sinuses between the dorsal plates very deep and slit-like; sixth segment plate half the width of the genital segment....*unicolor* Hesse, 1883, p. 396.
- d. Frontal plates projecting as a semicircular rostrum between the antennæ; lateral plates of second segment linear; sixth segment plate only one-fourth the width of the genital segment.....*carcharii-glaucus* Hesse, 1883.
- d. Frontal plates scarcely projecting; frontal margin straight; plates on second segment as wide as those on third; sixth segment plate three-fifths the width of the genital segment.....*bicolor* Leach, 1816, p. 400.
- e. Dorsal plates on the free and genital segments approximately the same size; carapace wedge-shaped, not much narrowed anteriorly.....*f.*
- e. Dorsal plates quite unequal, at least one pair much enlarged or diminished; carapace much narrowed anteriorly, with strongly convex sides.....*g.*
- f. Frontal plates very narrow, especially on the mid line; dorsal plates on third and fourth segments more than twice as wide as long.....*cranchii* Leach, 1819, p. 403.
- f. Frontal plates wide, and widest at the center; dorsal plates on third and fourth segments about the same width and length, each armed with a stout spine on the dorsal surface.....*armatus* Heller, 1865.
- g. Plates of third segment much diminished and completely separated on the mid line; the other median sinuses deep and acute; plates on fourth and genital segments equal.....*lugubris* Heller, 1865.
- g. Plates of fourth segment much enlarged, nearly covering the genital segment; sinus between plates of third segment deep, often separating them entirely; other sinuses shallow; sixth segment plate strongly narrowed at its base.....*smithii* Rathbun, 1886, p. 410.
- g. Plates of genital segment enlarged, the others nearly equal; all the median sinuses very shallow; sixth segment plate as long as genital segment, narrowed but slightly at its base.....*satyrus* Dana, 1852, p. 415.
- g. Plates of fourth and genital segments enlarged, with broad and shallow sinuses; sinus between plates of third segment narrow and much deeper; sixth segment plate strongly narrowed at its base.....*sinuatus* Say, 1817, p. 417.
- h. Carapace longer than wide; free segments all as wide or wider than the genital segment; abdomen wider than long.....*i.*
- h. Carapace wider than long, the lateral margins strongly curved; fourth segment narrower than genital segment; abdomen decidedly longer than wide.....*k.*
- i. Carapace elliptical, strongly narrowed anteriorly and posteriorly; eyes distinctly visible; exopod of first legs twice the size of the endopod.....*brevicaudis* Dana, 1852, p. 397.
- i. Carapace orbicular, not visibly narrowed; eyes invisible; rami of first legs about equal; only one pair of adhesion pads, at base of first antennæ.....*smithii* Rathbun, 1886, p. 410.
- k. Length of carapace on mid line only one-third the entire length; both fifth and sixth legs large and prominent, triangular, and acuminate.....*cranchii* Leach, 1819, p. 403.
- k. Length of carapace on mid line two-fifths the entire length; fifth and sixth legs both small, inconspicuous, and bluntly rounded.....*sinuatus* Say, 1817, p. 417.
- k. Length of carapace on mid line three-eighths the entire length; sixth legs much smaller than the fifth and hardly visible.....*bicolor* Leach, 1819, p. 400.

All the species considered valid have been included in this key; the following have been omitted for the reasons stated: *P. alatus* described by Johnston in 1836 has been proved a synonym for *Echthrogaleus coleoptratus*. *P. boscii* Leach, 1816, becomes a synonym of *P. bicolor* of the same author and date. Dana's *P. concinnus* can not be distinguished, in the description he has given of it, from *P. cranchii*, and may therefore be left as a synonym of the latter until further described. The same may also be said of Milne Edwards' *P. dentatus*, which becomes another synonym of *P. cranchii*. The *P. fissifrons* of this latter author is probably a synonym of *P. bicolor*. *P. lamnæ*, Johnston, 1835, is a synonym of *Dinematura producta*.

No figures of *P. lividus* Frey and Leuckart, 1847, have ever been published, and it is impossible to distinguish it from *P. bicolor* by the author's description. Of Hesse's *P. musteli-lævis*, 1883, neither the description nor the figures given will warrant its inclusion in the genus *Pandarus*. The description says nothing whatever about the thoracic legs except that they are made up of a large femur, terminated by flat laminae, armed with rigid plumose setæ. In the three figures given, two of which are the dorsal and ventral surface of the same specimen, there are so many discrepancies in essential details, even between the right and left sides of the same figure, that no definite information can be obtained. As figured and described, not one of the specimens can belong to the genus *Pandarus*.

P. pallidus Milne Edwards, 1840, is a synonym of *P. cranchii*, and *P. vulgaris* of the same author is probably a synonym of this species also. Hesse's *unicolor* has been left in the key, but it may be noted that he has made many wretched errors in describing it. He had what he called an adult female, a young female, and a young male; Plate VI on which the figures of this species are given evidently suffered a bad mixup in the arrangement of the numbers assigned to the several figures. The present author secured a reprint of the original paper, bearing Hesse's autograph, in which there has been a thorough correction (in ink) of the references and a rearrangement of the numbers. It is impossible to tell whether this was done by Hesse himself or by another, but the new numbers fit the description much better than those originally published.

And yet there are still so many discrepancies between text and figures that the species must be left on the doubtful list until further substantiated. And finally Brady presented in 1883 what he claimed as a new species, calling it *P. zygænæ* since it was found on *Zygæna malleus* near the Cape Verde Islands. After careful examination this proves to be a synonym of *P. satyrus* Dana (see p. 416).

PANDARUS BREVICAUDIS Dana.

PLATE XXXVI.

Pandarus brevicaudis DANA, 1852, p. 1368, pl. xcv, figs. 3 a-h.

Pandarus brevicaudatus BASSETT-SMITH, 1899, p. 467.

Nogagus validus DANA, 1852, p. 1363, pl. xciv, figs. 9 a-h.

This species includes the two sexes obtained from a shark taken in the Pacific Ocean, northeast of New Zealand, in the year 1840. The female Dana described under the name *Pandarus brevicaudis*, and the male under the name *Nogagus validus*.

No subsequent mention is made of the species until 1889, when Thomson includes it in his list of the parasitic copepods of New Zealand, on Dana's authority. He did not see any specimens himself, and he adds that Dana's description "is brief and unsatisfactory." In his Entomostraca from the Gulf of Guinea, published in 1894, Scott mentions a single specimen of *Nogagus validus* which was taken in a tow net gathering from a depth of 30 fathoms. And finally Bassett-Smith in his Enumeration of Known Species in 1899 mentions both *Nogagus validus* and Dana's three species of *Pandarus*. He calls the latter, however, "*Pandarus brevicaudatus*, *satyrus*, and *cocinnatus*," and says of them . . . "From Sharks in the Pacific Ocean: imperfectly described" (p. 467). His criticism would have had more weight if he had shown enough familiarity with Dana's descriptions to spell correctly the specific names which the latter used.

The descriptions Dana has given are brief, but they are also very accurate, and, taken with the excellent figures he published, they do not seem to deserve being called either unsatisfactory or imperfect. The following includes practically all that was given by Dana, with the addition of many new facts, especially with reference to the male.

Female.—Carapace, including the posterior lobes, slightly longer than wide, suboval, narrowed anteriorly. Frontal plates narrow and appressed closely to the carapace; scarcely enlarged at their outer ends, where they overlap two-thirds of the basal joints of the first antennæ. Posterior lobes remarkably long, half the length of the carapace on the mid-line and reaching back to the posterior margin of the third segment; triangular in shape with obtuse ends. Posterior margin of the carapace between the lobes smooth, with no trace of teeth or spines, and slightly concave. Eyes close together and about two-fifths of the length of the carapace from its anterior margin.

Dorsal plates on the second thorax segment fused across the mid-line by a band which is longer than the second or third pair of plates, and which causes the segment to resemble very closely the corresponding one in the male, the slightly oblique wings on the lateral margins answer-

ing to the lateral processes in the male. The second pair of dorsal plates are much shorter and fit inside the wings of the first pair; there is only a shallow emargination (no sinus at all) on their posterior border to indicate their dual origin. The third pair are more deeply incised, a trifle wider, and considerably longer; the sinus between them is broad and evenly rounded.

Genital segment subquadrate, narrowed a little posteriorly and armed with a minute spine on either side just in front of the posterior corners, which are obliquely truncated. The posterior margin of this segment, instead of having a single deeply rounded sinus at the center, as in most species, has two shallow sinuses, one on either side, meeting at the center in a point which projects backward over the abdomen. The anal laminae project from beneath the center of these sinuses and are about three times the length of the dorsal plate of the sixth segment.

They are only slightly divergent, with the outer margins straight, while the inner ones are armed with the usual wings, dentate near their posterior ends. Sixth segment plate wider than long, with an evenly rounded margin; abdomen very small, its ventral plate scarcely projecting behind its posterior border.

The two joints of the first antennae about equal; no setae on the basal joint and only a few on the terminal; second antennae stout, the terminal claw with a swollen base and a sharp curve close to the tip; no accessory spines. The adhesion pads relatively small, the first two pairs about the same size and shape, circular, the fourth pair narrow elliptical, twice as long as wide. Second maxillae triangular, short and very blunt; first maxillipeds stout and fleshy, the two joints of nearly the same length, as are also the two claws at the tip of the terminal joint. Second pair large and much swollen, with the distal knob of the pincher jaws several times the size of the proximal one. Basal joint of the first swimming legs subquadrate, exopod nearly twice the length of the endopod; basal joint of the exopod longer than the terminal; the two joints of the endopod the same length. Second and third legs with two-jointed rami, which are smaller than usual; spines confined to the tips of the terminal joints; rami of the fourth legs apparently one-jointed, exopod only with spines, endopod naked.

Total length, 6.2 mm.; length of carapace on mid-line, 3 mm.; width of same, 3.7 mm.; combined length of dorsal plates on the three thorax segments, 2 mm.; length of genital segment, 1.6 mm.

Male.—Carapace a little longer than wide, including the posterior lobes, ovate, the anterior portion considerably narrowed.

Frontal plates narrow, closely compressed to the carapace, not enlarged at the outer ends, but overlapping nearly the whole of the basal joints of the first antennae as in the female.

Posterior lobes broad, bluntly rounded, and exceptionally long, reaching back nearly to the fourth thorax segment; posterior margin between the lobes nearly straight; accessory lobes small, semi-elliptical, wider than long. Eyes close together and in approximately the same position as in the female. Three free thorax segments of about the same length, but the first one-half as wide again as the other two, which are nearly equal.

Lateral appendages of the second segment wide, divergent, bluntly rounded at the tip and reaching beyond the posterior margin of the third segment. Each is reenforced on its inner margin with a wide, transparent, membranous flap. Third and fourth segments the same width as the genital segment, with evenly rounded sides, and without lateral appendages.

Genital segment subquadrate, the sides slightly convex, the posterior angles prolonged a little into small rounded lobes, with a second pair of small lobes just in front of them on the lateral margins; both pairs of lobes are armed on their ventral surface with small spines.

Abdomen two-jointed, joints the same width, but the basal one not more than half the length of the terminal; the latter has its posterior angles obliquely truncated and the anal incision is deep and triangular. Anal laminæ large, a trifle longer than wide, the posterior margins nearly straight and armed with four large plumose setæ, evenly graded in length, the outer ones the longest. Joints of the first antennæ the same length, setæ longer than in the female; terminal claw of the second antennæ also much longer and more slender, but the claw is bent similarly at a sharp angle near the tip.

First maxillipeds the counterpart of those of the female, except that the outer terminal claw is one-third shorter than the inner; second pair very large and swollen, the movable finger of the forceps jaws developed into a long curved claw, the stationary one a rounded knob. All the swimming legs biramous, the rami two-jointed, with the spines and setæ arranged as follows: First exopod, 1, 0; 4, III: endopod, 0, 0; 0, III: second exopod, 1, I; 3, VI: endopod, 0, I; 0, VI: third exopod, 0, I; 3, VI: endopod, 0, I; 0, VI: fourth exopod, 1, I; 0, VI: endopod, 1, I; 0, IV.

Total length, 7.5 mm.; length of carapace on mid-line, 3 mm.; width of same, 3.85 mm.; length of three free segments, 2.13 mm.; length of genital segment, 1.66 mm.

Color of both sexes (preserved material) a yellowish brown, darker along the mid-line, without pigment markings.

(*brevicaudis*, *brevis*, short, and *cauda*, tail.)

The U. S. National Museum Collection contains a male of this species with the following label: "*Nogagus validus* (Dana), No. 6822, on *Carcharias* between Papua and Japan, G. S. Brady, England, Acc. No. 14181, Exchange." This therefore is not one of Dana's original specimens, but was taken on the Challenger expedition and

identified by Brady with Dana's species, which came from exactly the same locality. It is now made the type male of *Pandarus brevicaudis*, the perfect agreement in anatomy being sufficient to identify the two specimens as male and female of the same species. Furthermore, Dana's original specimens of *Nogagus validus* and *Pandarus brevicaudis* were found together on the same fish.

PANDARUS BICOLOR Leach.

PLATE XXVII.

Pandarus bicolor LEACH, 1816, p. 405, pl. xx, 2 figs.

P. boscii LEACH, 1816, p. 406, pl. xx, 10 figs.

Caligus bicolor LAMARCK, 1818, p. 142.

Pandarus fissifrons MILNE EDWARDS, 1840, p. 470.

Female.—Body elongate, length more than twice the width; carapace semielliptical, one-third the entire length, widest across the posterior margin. Frontal plates wide and prominent, the groove between each frontal plate and the margin of the carapace S-shaped, the center of the carapace projecting as a knob on either side of the central incision between the frontal plates.

Posterior lobes short and broad; posterior margin a nearly uniform curve, the center of which is sinuate, but not toothed.

Dorsal plates of second thorax segment short and narrow, not reaching the tips of the plates on the third segment and fused across the mid-line, their posterior margins forming an evenly rounded semicircle, without any break that can be detected.

Second pair of plates nearly circular, with a deep and broad median incision, which is somewhat enlarged at its base. These plates reach back a little beyond the first pair. Third pair much enlarged, elliptical, as wide as the carapace, and overlapping the genital segment for about half its length. The central sinus is deep, broadly triangular, and rounded at its base.

Genital segment elliptical, one-fifth narrower than the carapace, with broadly rounded posterior lobes and a shallow sinus.

Sixth segment plate half the width of the genital segment, its posterior two-thirds the evenly rounded arc of a circle, its anterior third fitting into the sinus in the genital segment.

Abdomen medium size, its ventral plate quadrangular, with the free portion broadly rounded and the posterior margin slightly concave. Anal laminae triangular, as wide at the base as they are long, extending out at right angles to the median axis and so short that they scarcely reach the lateral margin of the genital segment. They are not toothed, but have smooth edges.

First antennae small, the whole basal and part of the terminal joint concealed beneath the frontal plates, neither joint heavily armed with setae. Second pair small, the basal joints not much

swollen, the terminal claw slender, with an accessory spine on the inner margin. The four pairs of adhesion pads all have their long diameters parallel with the body axis. The first two pairs are close together, those at the base of the first antennæ being elliptical and half as long again as the second pair, which are broadly obovate, the width and length being the same. The fourth pair are also elliptical, twice as long as wide, and considerably larger than the first pair.

Mandibles and mouth tube of the form usual in this genus; maxillæ biramose, the endopod more than twice the length of the exopod, each ramus armed with a short terminal spine.

First maxillipeds slender, the two joints about the same length, the longer terminal claw strongly curved, the shorter one nearly straight. Second pair much swollen, armed with a corrugated ridge having a spherical knob at either end, the knobs roughened on their inner surfaces and shutting together like forceps. The rami of all the swimming legs are indistinctly jointed; first pair small and weak, the exopod considerably longer than the endopod and bearing five spines, four on the outer end and one on the inner margin; no spines on the endopod. In the exopod the basal joint is much larger than the terminal, in the endopod it is much smaller; both rami are enlarged at their tips. The second, third, and fourth legs increase regularly in size, and particularly in the length of the rami.

In the second pair the two joints of the exopod are equal, the basal joint with a single spine at its outer distal corner, the terminal with a row of ten curved spines around its terminal and inner margins. The terminal joint of the endopod is four times the size of the basal and is armed with three spines, two in the position of a toe nail on the inner margin and one on the outer. In the third legs the terminal joints of both rami are much longer than the basal. The terminal joint of the endopod has two claw spines at the inner distal corner, while the entire tip of the exopod is covered with a row of spines.

In the fourth legs the endopod is apparently one-jointed, with a single spine at its inner distal corner, but in all probability it is really a fusion of two joints in conformity with the other species of the genus. The exopod carries a spine at the outer distal corner of the basal joint and two at the inner distal corner of the terminal joint.

Of the reproductive organs, the semen receptacle is V-shaped, the point of the V being anterior, with the two sides almost entirely separated from each other. Each side is short, straight, and slightly enlarged at the end. The oviduct is so densely coiled in the genital segment, especially in its posterior portion, as to effectually conceal the cement glands. These oviduct coils are wider than those in *cranchii* and more tightly packed.

Total length, 9 mm.; length of carapace on mid-line, 3 mm.; width of same, 3.65 mm.; length of first plates, 1 mm.; of second

plates, 1.375 mm.; of third plates, 1.65 mm.; width of third plates, 3.4 mm.; length of sixth segment plate, 1.65 mm.; length of egg-strings, 13 mm.

Color a rich creamy yellow, the dorsal surface of the carapace and of the second and third pairs of thoracic plates a deep chocolate brown, a light and transparent spot being left around the eyes, much the same as in *cranchii*.

(*bicolor*, *bi*, or *bis*, two, and *color*, colored.)

Male.—Carapace orbicular, a little more than one-third the entire length on the mid-line, wider than long. Frontal plates wide and prominent, with a broad and shallow central sinus; posterior lobes wide and bluntly rounded. Second thorax segment about filling the space between the posterior lobes; third and fourth segments narrowing regularly, the fourth segment of peculiar form, like an inverted flask, the anterior half twice the width of the posterior. Genital segment elliptical with two pairs of rudimentary legs, one at the posterior corners and the other some little distance in front of them on the lateral margins; the two pairs about the same size and similarly armed. Abdomen two-jointed, joints equal; anal laminae large and broad, armed with four setae, all about the same length. Terminal claws on the second antennae longer and more powerful than in the female, with two accessory spines. Second maxillipeds with a distinct claw in place of the knob-like forceps. All the legs biramose, the rami two-jointed and armed with stout plumose setae.

Total length, 6 mm.; length of carapace on mid-line, 2.1 mm.; width of same, 2.6 mm.; length of free thorax, 1.65 mm.; length of genital segment, 1.2 mm.

Color, yellow slightly tinged with brown.

This species possesses peculiar interest, because it is the one on which Leach founded the genus *Pandarus* in 1816. But he gave practically no distinctive characters for the two species which he presented, the only differences cited being a black pigment in the "shell and the middle of the abdominal lamellae" of *bicolor*, the first and therefore the type species, while *boscii*, the second species, had a pale body devoid of pigment. There was also a trifling difference in the length of the egg-tubes. From the figures given by Leach of these two species on Plate XX of his 1816 article it is evident that they are identical and that the species named *boscii* is simply a young female *bicolor* in which the pigment has not yet been formed.

This is shown by an identity of structure so great that Leach presents but a single set of figures to illustrate the appendages of the two species, and by a little difference in size, *bicolor* being larger and having longer egg-strings, as would naturally be expected. This same condition is often noticed in *sinuatus*, and, in fact, in all the pigmented species; the younger and immature forms usually have no

pigment, while the mature adults may be densely colored with it. Every lot of specimens containing more than a few individuals shows these variations. The U. S. National Museum Collection contains but a single lot of this species, Cat. No. 8120, U.S.N.M., obtained from a dogfish off the coast of Shetland.

Evidently this is a European species, since nearly every European author mentions it, while it has not yet been found on this side of the Atlantic.

PANDARUS CRANCHII Leach.

PLATE XXVIII.

Pandarus cranchii LEACH, 1819, p. 535.

Pandarus carchariæ (?) LEACH, 1819, p. 535.

Pandarus pallidus MILNE EDWARDS, 1840, p. 468.

Pandarus vulgaris MILNE EDWARDS, 1840, p. 468.

Pandarus dentatus MILNE EDWARDS, 1840, p. 469, pl. xxxviii, fig. 19.

Nogaus latreillii LEACH, 1819, p. 536 (male).

Pandarus cranchii MILNE EDWARDS, Atlas du Regne animal, pl. lxxviii, figs. 2 a to d.

Female.—Body obovate, strongly narrowed posteriorly; carapace somewhat wedge-shaped, widest posteriorly, with the lateral margins only slightly rounded. Frontal plates wide and prominent at their outer ends, thin and linear toward the mid-line. Eyes situated far forward, visible in those specimens which have no pigment or in which there are large clear spaces at the center of the carapace; concealed in the heavily pigmented specimens.

Posterior margin of carapace a shallow reentrant curve, armed with seven to ten large spines or teeth along the center.

The posterior corners are short and wide and stand out prominently beyond the first pair of dorsal thoracic plates.

The teeth are separated a greater distance from one another than their own length and reach backward nearly to the posterior margin of the central plate of the second thorax segment.

Dorsal plates of second segment much enlarged, more than twice the length of those on the third segment, and reaching beyond the center of those on the fourth segment. They are slightly enlarged at the base, but the tip is also broad and evenly rounded.

Plates on the third segment nearly as long as the free portion of the following pair, with a broad and deep central sinus.

Plates on the fourth segment overlapping almost the whole of the genital segment, broad and evenly rounded with a shallow central sinus. In young females these plates do not reach much beyond the center of the genital segment; in mature adults they often reach its posterior margin.

Genital segment obovate, strongly narrowed posteriorly and produced into a long triangular point on either side of the sixth segment

plate. The latter is ovate, one-third longer than wide, and the posterior lobes of the genital segment reach about to its center. Its broad posterior end is evenly rounded with a smooth margin, while the narrowed anterior end is slightly reentrant on either side. The ventral plate of the abdomen is short and broad, its posterior margin straight or a little concave, and reaching nearly to the tip of the sixth segment plate (fig. 131).

The anal laminae point diagonally outward and backward at an angle of 45° with the central axis; their thickened outer margin is nearly straight and slightly enlarged where it joins the abdomen. In young females it is furnished with two wings, the ventral one triangular in shape and extending from the base to about the center of the lamina, the dorsal one of uniform width and extending the whole length of the appendage. This dorsal wing is cut diagonally at the distal end and furnished with one or two small teeth. In mature females the wings are more or less absorbed and the thickened margin becomes cylindrical, with two prominent teeth on its inner side.

The basal joint of the first antennae is large, heavily armed on its ventral surface with setae, and nearly covered by the frontal plate. The terminal joint is peculiar in that it is strongly flattened dorso-ventrally, and each edge is rolled over ventrally toward the center; this joint is also destitute of setae. The second antennae are comparatively very large; the basal joint is considerably larger than the pad connected with it; the terminal claw is also stout and armed with two accessory spines. The adhesion pads of the first pair are obovate, nearly twice as long as wide, with the outer margins straight. Those of the second pair are circular, their diameter the same as the width of the first pair; they are separated by a greater distance than is common in this genus. The third pair are club-shaped, three times as long as wide, and narrowed anteriorly to a long blunt point. The fourth pair are elliptical, twice as long as wide, and inclined at an angle of 30° to the body axis. The mouth-tube and mandibles show nothing peculiar; the second maxillae have a short and circular exopod and a long, tapering endopod, which reaches beyond the center of the tube; each ramus is tipped with a spine.

First maxillipeds of the usual pattern; second pair enlarged, but relatively smaller than in *bicolor*, the forceps knobs close together and standing prominently above the surface.

First swimming legs very small and rudimentary, the exopod boot or foot shaped, the leg and heel being thick and swollen, while the toe is long and slender. There is one spine at the heel, another on the bottom of the foot in the instep, and two on the joint of the great toe. The endopod is two-thirds as long as the exopod, with a well-defined incision on the inner margin, representing the groove between

the joints, and a single spine at the outer distal corner. The terminal joint of the endopod of the second legs is three times as long as the basal joint and slightly enlarged at the end; both joints without spines.

The exopod joints on these legs are the same length, but the terminal one is much the wider and is armed with a row of eight or nine large curved spines around its margin. The terminal endopod joint of the third legs is two and a half times the length of the basal joint and somewhat barrel-shaped, neither joint with spines. The exopod joints are the same size, the terminal one with a cluster of four or five spines at its tip.

The rami of the fourth legs are broad and laminate, the exopod twice the size of the endopod; the jointing is indistinct and the only spines are on the exopod, one on the outer margin and a cluster of three at the tip.

Of the reproductive organs the semen receptacle is horseshoe-shaped, the opening being posterior, and the two ends of the shoe being enlarged into spheres; in preserved specimens it is usually white and opaque. The cement glands can be seen on either side of the intestine near the ventral surface of the genital segment. They are shaped like parentheses marks, and in alcoholic material are dark brown and opaque, with no traces of cells or divisions. The spermatophores are large and are attached one on either side of the abdomen at its base; the long thread-like ducts cross each other on the mid-line and each empties the contents of its spermatophore into the genital opening on the opposite side of the body. The oviduct is usually coiled once in each half of the genital segment, the last section passing down alongside of, and close to, the intestine and then turning abruptly outward to the external opening (vulva) which is in the posterior lobe and just in front of the base of the anal laminae.

Total length, 7.8 mm.; length of carapace on mid-line, 3.4 mm.; width of same, 4.5 mm.; length of first thorax plates, 2 mm.; of second pair, 1 mm.; of third pair, 1.2 mm.; of sixth segment plate, 1.6 mm.; of anal laminae, 1.8 mm.; of egg strings, 8.5 mm.

Color, a light brownish yellow, more or less covered with dark brown-black pigment; the amount of this pigment is very various, but in the mature adult it usually covers the whole dorsal surface of the thoracic plates except a narrow border around their margins, and the whole center of the carapace, leaving a single large or two separate small spots near the eyes, and the whole of the posterior lobes free.

Male.—General shape broad and flat, not strongly arched, with a weak keel on the dorsal surface of the free and genital segments.

Carapace a little wider than long, even including the posterior lobes, one-half wider than long measured on the mid-line, trans-

versely elliptical, the sides and frontal margin forming a very even curve. Frontal plates considerably enlarged at the outer ends and nearly covering the basal joints of the first antennæ. Posterior lobes wide, triangular, quite sharply pointed, and curved strongly inward toward the free throax; their tips reach a little beyond the center of the third thorax segment, and if straight would probably reach its posterior margin.

Grooves separating the cephalic and lateral areas extending forward visibly to the anterior margin just behind the base of the first antennæ. Posterior margin between the lobes nearly straight, with no traces of spines or teeth; secondary lobes elliptical, considerably longer than wide. Eyes visible in the younger specimens close to the mid-line, one-third the distance from the anterior margin of the carapace; invisible in mature adults. The three free segments together one-fourth shorter than the carapace, the second segment one-third wider than the other two, which are about equal. The lateral appendages of this segment are very oblique and are partially covered by the accessory posterior lobes of the carapace.

The sides of the third and fourth thorax segments project a distance equal to half their length and are evenly rounded, giving the segments an elliptical form, transversely elongated.

Genital segment flat and somewhat elongate, narrowed into a neck anteriorly where it joins the fourth segment, and carrying two pairs of lobes posteriorly. The larger pair are triangular and situated at the posterior corners; the smaller pair are just in front of them, on the sides of the segment.

The latter are armed on their ventral and inner margins with small spines and setæ and are evidently the rudimentary fifth legs. The sixth legs, however, are not on the posterior lobes, but inside of them on the posterior margin of the segment, between the lobes and the abdomen. They are well shown in this position by both Steenstrup and Lütken and Krøyer.

Abdomen two-jointed, joints the same length, but the basal one is somewhat the wider, with strongly convex sides and a slight notch at the center of the posterior margin. Terminal joint with an anal incision which reaches nearly to its base, and with its posterior margin straight or only slightly oblique.

Anal laminæ large, four-fifths as long as the entire abdomen and three-fifths as wide, each armed with four setæ, of which the inner one is considerably the smaller, is removed a little from the other three, and is abruptly curved inward near its base.

First antennæ minute and not heavily armed with setæ; the terminal claw of the second pair abruptly bent near its tip and armed with two accessory claws on its inner surface.

Adhesion pads similar to those in the female, but smaller, the pair on the margins of the lateral lobes of the second thorax segment especially well developed.

Second maxillæ peculiar in being bent outward away from the base of the mouth tube nearly in a half circle. Krøyer, in speaking of these appendages, says that they are small and indistinct, so that he could not make them out with certainty. He therefore refrains from describing them, but Steenstrup and Lütken show them in their figure of the ventral surface of this species. This figure, however, is very small and can not show details, and all they say of these appendages in the text is simply that they are of the usual form. Fig. 133 gives the details of their structure, and it can be seen that they consist of an enlarged basal joint, and a slender terminal spine pointed away from the mouth tube. First maxillipeds rather small and slender; terminal claw on the second pair also slender but long, the interval between the base of the claw and the immovable knobs being very wide.

The spines and setæ on the swimming legs are arranged as follows: First exopod, 1, 0; 4, III: endopod, 0, 0; 0, III: second endopod, 1, I; 4, VI: endopod, 0, I; 0, VIII: third exopod, 1, I; 3, IV: endopod, 0, I; 0, VI: fourth exopod, 3, I; 4, V: endopod, 0, I; 0, V.

Total length, 9.6 mm. Length of carapace on mid-line, 3.2 mm. Width of same, 4.8 mm. Length of three free segments, 2.4 mm.; of genital segment, 2.2 mm.; of abdomen, 1.6 mm.

Steenstrup and Lütken give their largest specimen as 11 mm. long; Krøyer states that of the four specimens examined by him the largest was over four lines (9 mm.), the two next in size a little over three lines (6.75 mm.), while the fourth was smaller. Color a uniform yellowish horn color, transparent in living specimens, and often nearly so in preserved material.

(*cranchii*, a proper name, see below.)

In 1892 Van Beneden published a description with figures of a *Nogaus* which he claimed to be the male of the present species. For a discussion of this form, see page 450.

Again, in 1899 Bassett-Smith suggested that Heller's *Nogaus elongatus* was the male of *Pandarus dentatus*, the latter being one of the synonyms of the present species. This *Nogaus* will be found discussed on page 451.

The true male described above was the type on which Leach founded in 1819 his new genus *Nogaus*. The genus itself is discussed elsewhere (p. 439). We wish to note here only the description which he gave of this type species:

Nogaus latreillii. Couleur pâle, sans tache. Découverte par Cranch, latitude sud, 1; longitude, est, 4; méridien de Londres (p. 535).

This Cranch is evidently the same person who found the females of the present species, and for whom it was named; in all probability the two were discovered together on the same fish although there is no definite testimony to that effect. Of course such a description as this of Leach's is absolutely worthless for purposes of identification, but fortunately Milne Edwards had an opportunity to examine Leach's original specimen in the British Museum, and he published a much better account of it in his History of the Crustacea in 1840 (p. 459). The description is not very long, but it contains two details which practically identify the species. The first is as follows:

Carapace très large et offrant de chaque côté sur le bord postérieur, tout près de son angle latéro-postérieur, un lobule arrondi qui semble appartenir au premier anneau thoracique.

This secondary lobe is one of the principal characters of *Pandarus* males, and would suggest that the species belongs to that genus.

The second detail is italicized by Milne Edwards as constituting the principal character for identification. He says:

Le dernier anneau du thorax (the genital segment) grand est armé de chaque côté de deux grands prolongements coniques dirigés obliquement en arrière.

This, with the added information "abdomen très-court, composé de deux articles, et terminé par des lames natatoires assez grandes," is sufficient to identify the species beyond question. But the figure which Milne-Edwards published^a was lacking in many particulars. It was therefore fitting for Steenstrup and Lütken in 1861, and for Krøyer in 1863, to supply the missing details and supplement the description.

Their combined account is the same as that here given, and has been freely used for suggestions and comparisons. The only thing they lacked was the definite location of the species as the male of *Pandarus cranchii*. Steenstrup and Lütken record their specimens as taken on the African coast along with females of the present species. Krøyer obtained his specimens from a large *Carcharias* taken in the open Atlantic, and found what he took to be females along with the males.

It is shown elsewhere (p. 441) that these females were really the young of the genus *Nesippus*, and not related in any way to the males. The true females of the present species have a complex history. Leach described in 1819 (p. 535) two new species of the genus *Pandarus* which he had founded three years before.

And he repeated the same mistake then made, for just as his two original species, *bicolor* and *boscii*, prove to be identical, so are these other two, *carchariæ* and *cranchii*, in all probability one and the same, as was recognized by Steenstrup and Lütken in 1861 and by all sub-

^a Atlas du Règne animal de Cuvier, Crustacés, pl. LXXVIII, fig. 1.

sequent authors. In Leach's paper the species *carchariæ* is given first and by the law of priority ought to be taken for the name of the species, while *cranchii* became a synonym. But unfortunately the type of *carchariæ* has never been seen by any other investigator, and hence the species can not be identified with certainty. On the other hand, the original type of *cranchii* has been examined and figured^a by Milne Edwards and others and can be identified accurately. Therefore preference in the present instance is given to that name which is open to the least doubt.

In 1840 Milne Edwards published three species, *pallidus*, *vulgaris*, and *dentatus*, which so far as can be made out from the descriptions he gave, and also from his figures of the last-named species, are identical with *cranchii*. At all events they do not deserve to be made anything more than varieties.

In 1852 Dana published the species *concinus*, which like Milne Edwards's *pallidus* appears to be the young of the present species before they have acquired the dark pigment which colors the carapace and dorsal plates so conspicuously in more mature specimens.

Dana says nothing of the color of his species, but he does say "body translucent or subtransparent," which certainly could not be the case if the pigment were present. Neither author gives the details of the appendages, and judgment must be based upon the general make-up of the body and the relative shape and proportion of its various parts. As these are practically identical, *concinus* must be placed as a synonym of the present species until proven to be distinct.

The U. S. National Museum Collection has a fine set of specimens illustrating this species. We may refer again to the fact that Cranch, for whom the species is named, found both males and females probably on the same fish. Steenstrup and Lütken record two similar instances in which Captain Hygom obtained the sexes together.

And here in the National Museum Collection there are three additional lots in which both sexes came from the same fish.

Of the female specimens we find Cat. Nos. 6019 and 6020, U.S.N.M., from *Carcharhinus obscurus*, taken at Station 1142 off Marthas Vineyard, and containing one and two females respectively. A single male was obtained at the same time and is Cat. No. 6031, U.S.N.M.

A second lot, consisting of six males, Cat. No. 8640, U.S.N.M., and five females, Cat. No. 8641, U.S.N.M., was obtained from a large shark at the surface at Station 2237 by the *Albatross* in 1884.

The third lot contains ten females, Cat. No. 10746, U.S.N.M., two young females, Cat. No. 32741, U.S.N.M., and a single male, Cat. No. 32752, U.S.N.M., obtained from a 10-foot shark at Station 2422 by the *Albatross* in 1884.

^a Atlas du Règne animal de Cuvier, Crustacés, pl. LXXVIII, figs. 2, 2 a.

There is also a single female, Cat. No. 8118, U.S.N.M., collected by Francis Day from *Lamna cornubica*, and another female, Cat. No. 6831, U.S.N.M., from a species of *Carcharhinus* between Papua and Japan, obtained by exchange from G. S. Brady, and collected during the *Challenger* Expedition.

PANDARUS SMITHII Rathbun.

PLATES XXIX and XXX.

Pandarus smithii RATHBUN, 1886, p. 315, pl. v, fig. 3; pl. vii, fig. 9.

Female.—Carapace ovate, a little wider than long, the anterior margin evenly rounded, the lateral margins convex; posterior lobes short, wide, and bluntly rounded; posterior margin between the lobes sinuate and wrinkled, each wrinkle ending in a sharp, spine-like tooth. Frontal plates broad and prominent, much wider at the outer ends than near the median line, and covering nearly the whole of the basal joints of the first antennæ. Eyes nearly always concealed by the dark pigment of the carapace, but sometimes visible two-fifths of the length of the carapace from the frontal margin.

Three distinct dorsal plates on the second thorax segment, the lateral pair elongate, elliptical, or ovate, about twice as long as wide, and strongly divergent. The odd plate median semielliptical or subtriangular, and about half the length of the lateral plates. Dorsal plates of the third segment almost circular in outline, less than half the length of the first pair, and completely separated to their base, often leaving a wide, open space between their inner margins. Dorsal plates of the fourth segment much enlarged, broadly rounded, and separated by a triangular posterior sinus of medium depth. These plates overlap the genital segment at least beyond its center, and often nearly to its posterior margin.

Genital segment obovate to elliptical, narrower than the plate on the fourth segment, and ending posteriorly in a short, rounded knob at either corner. Sixth segment plate ovate, strongly narrowed anteriorly, projecting for two-thirds of its length back of the genital segment, with an evenly rounded margin.

Abdomen small, its ventral plate of the usual shape, but not reaching beyond the center of the sixth segment plate; anal laminae the same length as the sixth segment plate, diverging at an angle of 45° to the body axis, so that almost the entire lamina is visible from above. Of the two wings on the inner margin, the dorsal runs the entire length of the lamina and is of the same width throughout; it is cut off obliquely at the tip, and the cut edge is more or less lacerated and armed with two or three small spines. The ventral wing is semi-circular in shape and occupies only the basal half of the lamina; its margin is smooth and without spines. The combined width of the

two egg-strings is three-fifths that of the sixth segment plate, while they are two-thirds as long again as the body.

First antennæ short, the basal joint as wide as long, and heavily armed with setæ, the terminal joint club-shaped, with a cluster of setæ at the tip. Second antennæ small and rather weak, the terminal claw of medium size and bent abruptly near the center. Its basal half is flattened and laminate, while the terminal portion beyond the angle is slender and cylindrical. The second joint has a wide laminate ear or flap projecting from its ventral surface toward the fleshy adhesion pad.

The first pair of these adhesion pads are large and broadly elliptical, one-fifth longer than the second pair; the latter are obovate, their widest (anterior) diameter equaling their length.

The fourth pair are especially long and narrow, their length fully two and a half times their width, and half as long again as the first pair. Mouth-tube of the usual pattern, inclosing the mandibles, which are very slender and armed with eight teeth at their tips on the inner margin. Second maxillæ with a thick and swollen base, a fleshy second joint, and a short terminal spine, which is stout and curved like a claw.

First maxillipeds slender and weak, the two joints about the same length, the dorsal terminal claw twice as long as the ventral, the latter with a short accessory spine at its base. Second maxillipeds much swollen, the terminal joint fully as wide and thick as it is long, and furnished with a movable claw, which shuts down against a raised, tabular knob. The claw is wide and thick, especially at the base, where it is armed with a large spherical knob at the posterior corner and a long slender accessory spine on the ventral surface. The raised knob, against which the claw shuts, has a flat, semicircular top, which is roughly corrugated, to afford a better hold against the skin of the host.

First swimming legs small and weak, the basal joint scarcely as wide as the exopod; both rami two-jointed, the joints in the exopod not as distinct as in the endopod. Second legs stouter, especially the basal joint, but still rather weak; third and fourth pairs with basal joints increasing regularly in size, their rami flat, laminate, and boot-shaped; those of the second and third legs distinctly two-jointed, those of the fourth legs with the jointing indicated only by marginal notches. The rami of these fourth legs are, as Rathbun writes, considerably longer than those of *cranchii*, and are also somewhat longer than even the longest of those found in *sinuatus*. There are no setæ, and the spines are arranged as follows: First exopod, 1,5; endopod, 0,3; second exopod, 0,10; endopod, 0,3; third exopod, 1,4; endopod, 0,2; fourth exopod, 1,5; endopod, 0,0.

The oviducts are coiled once in the genital segment, the three strands of the coil running the entire length of the segment. The semen receptacles are very similar to those of *bicolor*, horseshoe-shaped, with the ends somewhat enlarged.

The cement glands can not be seen in mature females on account of the pigment on the dorsal surface of the segment and in the eggs that fill the coiled oviduct, but they can be distinguished in young females. They are narrow and rod-like, close to the intestine on either side, and more or less sinuate; the component cells are very short and flattened like the eggs in the egg-strings.

Total length, 9 mm.; length of carapace on mid-line, 3.5 mm.; width across posterior margin, 4.5 mm.; length of first dorsal plates, 2 mm.; of second plates, 0.85 mm.; of third plates, 2 mm.; of sixth segment plate, 1.5 mm.; of egg-strings, 15 mm.

Color a rich brownish black, the margins of the carapace and of the dorsal plates, and a semicircular spot through the eyes much lighter and yellowish or reddish. The anal laminae are also without pigment. (*smithii*. Named for Prof. S. I. Smith, of Yale University.)

Young females.—In a young female only 3 mm. long the carapace is strongly wedge-shaped, the posterior margin twice the width at the frontal plates, the teeth along its central portion comparatively larger and blunter than in the adult. The lateral margins are nearly straight and show a well-defined notch, armed with two minute teeth, about three-fifths of the distance from the frontal plates. This notch evidently indicates the point of junction of the cephalic and thoracic portions of the carapace. The eyes are also plainly visible close to the mid-line, in the anterior third of the carapace.

The dorsal plates of the thorax are in a rudimentary condition; the first two pairs are about the same size and the third pair a trifle larger; the first pair does not quite touch the anterior margin of the third pair, and only the extreme tips of the second pair overlap the third.

The genital segment is thus left almost entirely free dorsally; on its ventral surface just in front of the openings of the oviducts may be seen the rudiments of a pair of swimming legs, in the form of two spines on either side, close together, the inner one broadly triangular, the outer one minute and very slender.

These afterwards disappear, or at least they can not be distinguished in the adult.

The sixth segment plate is circular and one-third the width of the genital segment; the anal laminae are much longer than this plate, comparatively slender, and the wings are not yet fully formed along their inner margins, which are armed at this stage with three small spines. The ventral plate of the abdomen reaches nearly to the posterior margin of the sixth segment plate and is much broader than the latter, more than half the width of the genital segment. The append-

ages and the legs are very similar to those in the adult, the segmentation and the spines being much cleaner and more distinct; they verify in every particular what has already been given for the adult.

In another developmental stage, 4.5 millimeters long, we find the same general shape and proportion of the various body regions as in the adult. The dorsal plates are now well formed and overlap, so that there are no spaces between them; the third pair are much enlarged and reach to the center of the genital segment; the sixth segment plate has increased to its normal proportions. But as no pigment has yet appeared the internal anatomy can be seen quite distinctly; in particular the ovaries and oviducts are manifest, and the beginning of the coils in the latter may be distinguished at the posterior end of the genital segment. This absence of pigment, together with the differences in the details of the appendages and dorsal plates make these young females appear like distinct species. And it is probably similar differences which led to the differentiation of *boschii* from *bicolor* by Leach in his original description of the genus, and also to the separation of *pallidus* from *cranchii* by Milne-Edwards in 1840.

Male.—Carapace elliptical, a little longer than wide, with the lateral margins only slightly curved; posterior lobes wide and bluntly rounded at the tips, extending straight backward; accessory lobes small, much wider than long and attached close to the base of the posterior lobes. Lateral grooves somewhat S-shaped, the curve at the anterior end being much more pronounced than at the posterior end. Eyes prominent and situated far forward. Carapace narrowed but little anteriorly; frontal plates wide and prominent, covering nearly the whole of the basal joints of the first antennæ. Free segments diminishing a little in width, but increasing in length from in front backward, their sides plumply rounded; the second segment filling the entire space between the carapace lobes, the fourth segment wider than the genital segment. Lateral lobes on the second segment broad and bluntly rounded, reaching back to the posterior margin of the third segment. Genital segment subquadrangular, a little wider than long, its sides only slightly rounded; the papillæ of the fifth legs small, blunt, and situated far back close to the posterior corners, those of the sixth pair larger and more pointed. Abdomen half as wide as the genital segment, much wider than long, somewhat the shape of an hourglass, the sides being reentrant at the groove between the two joints. The terminal joint twice the length of the basal and protruding somewhat at the anus between the bases of the anal lamellæ; the latter of about the same length and width, tipped with four large setæ, the inner one of which is separated a short distance from the others. The first antennæ have a long basal joint which is almost entirely concealed beneath the distal end of the

frontal plates. In the second pair the middle joint is considerably swollen, while the terminal claw is rather slender and weak. There is only one pair of adhesion pads, situated just behind the bases of the first antennæ and close to the edge of the carapace. The pair that usually accompanies the second antennæ have degenerated into minute disks, too small to be of any service for prehension.

The mouth-tube and second maxillæ are similar to those in the male of *sinuatus*; the first maxillipeds are stout, both joints considerably swollen, the terminal claw straight and more than twice the length of the secondary one. The second pair are also much swollen, and are armed with a strong forceps made of two stout knobs whose inner surfaces are flattened where they come together. The arrangement of the spines and setæ on the swimming legs is as follows: First exopod, 1, 0; 4, III: endopod, 0, 0; 0, III: second exopod, 1, I; 4, IV: endopod, 0, I; 0, VIII: third exopod, 1, I; 4, V: endopod, 0, I; 0, V: fourth exopod, 1, 0; 4, V: endopod, 0, I; 0, IV.

Total length, 7.57 mm.; length of carapace to tips of lateral lobes, 4.43 mm.; width of same, 4.23 mm.; length of free segment, 2 mm.; length of genital segment, 1.4 mm.

Color (preserved material) a uniform yellowish brown without pigment markings.

This species was established by Rathbun in 1886 upon two specimens taken from a dusky shark, *Carcharhinus obscurus*, Cat. No. 6198, U.S.N.M. Another specimen, Cat. No. 8119, U.S.N.M., was found upon an undetermined shark, taken in Vineyard Sound, and four specimens, Cat. No. 6022, U.S.N.M., upon a sand shark, *Carcharias littoralis*, from the same locality. Since the publication of the species five other lots have been secured; two of these, were obtained from sand sharks at Woods Hole; one, Cat. No. 32734, U.S.N.M., includes five young females in different stages of development; the other, Cat. No. 32732, U.S.N.M., includes a single male which is made the type of the species. Another lot, Cat. No. 6195, U.S.N.M., containing two females was found on Atwood's shark, *Carcharodon carcharias*; a second lot of three females, Cat. No. 11614, U.S.N.M., was found on a "Gray" shark in Vineyard Sound; a third lot of four females, Cat. No. 32754, U.S.N.M., from the back of a small shark (species not given) taken in the Gulf of Mexico.

The chief variation in these specimens is in the amount of pigment on the carapace and dorsal plates and in the relative size of the third pair of plates; similar variations are found in all pigmented species.

PANDARUS SATYRUS Dana.

PLATE XXXI.

Pandarus satyrus DANA, 1852, p. 1368, pl. XCV, figs. 2 *a-c*.

Pandarus zygænæ BRADY, 1883, p. 134, pl. LV, fig. 3.

Female.—General body outline short and wide; carapace widening posteriorly until it becomes broader than long, the posterior lobes short and blunt; posterior margin nearly straight and armed with eight or ten small spines or teeth. Frontal plates narrow at the center, wider at the ends, covering most of the basal joints of the first antennæ. Eyes concealed in mature specimens by the dark pigment of the carapace.

Thorax plates of the second segment elliptical, strongly divergent, wide and long, reaching beyond the center of those on the fourth segment; central plate between their bases narrow. Plates of the third segment small, nearly circular in outline, with a shallow median sinus; those of the fourth segment also circular, with a wide but not very deep median sinus; they overlap the genital segment beyond its center.

Genital segment ovate, two-thirds as wide as the carapace, and produced posteriorly into a slender conical process on either side of the sixth segment plate and directly over the bases of the anal laminæ. Abdomen short and wide, the dorsal or body portion the same length as the ventral plate and reaching about to the center of the sixth segment plate. Anal laminæ wide and longer than the sixth segment plate, their outer margins considerably thickened, the inner wings strongly divergent and irregularly toothed. Sixth segment plate ovate or elliptical, from one-half to two-thirds as long as the genital segment.

First antennæ long and slender, the terminal joint club-shaped, as long as the basal joint, and bluntly rounded, both joints well armed with short setæ. Second pair small with a weak terminal claw and one accessory spine. First adhesion pads semielliptical, their outer margins nearly straight, their anterior ends projecting beyond the margin of the carapace; second pair nearly circular, their diameter one-third less than the length of the first pair; third pair small and elliptical; fourth pair also elliptical and a little longer than wide.

First maxillipeds of the usual pattern but stout, the two joints of the same length, the terminal claws corrugated; second pair swollen and armed with a single pair of forceps knobs, close together at the center of the ventral surface.

First swimming legs small and weak, very similar to those of *cranchii*, the base of the terminal joint in the exopod and its tip in the endopod being covered with a large spiny pad or cushion. Second legs also weak, the rami the same size and their joints the same

length, the terminal joint of the exopod tipped with five, that of the endopod with three, curved spines or claws.

Third pair with a large basal joint, carrying at its outer distal corner a spiny pad and two boot-shaped rami, indistinctly two-jointed, the exopod armed with a single spine on the basal joint and a group of five or six large curved spines or claws at the tip of the terminal joint. Fourth legs also with a swollen basal joint and two boot-shaped rami, the endopod without spines, the exopod with one spine on the basal joint, and a group of four on the tip of the terminal joint larger than those on the third legs and curved. No legs visible on the genital segment.

Total length, 8.5 mm.; length of carapace on mid-line, 3 mm.; width of same, 4.2 mm.; length of dorsal plates of second segment, 2.1 mm.; of third segment, 0.8 mm.; of fourth segment, 1.2 mm.; of sixth segment plate, 1.4 to 1.8 mm.; egg-strings unknown.

Color a dark reddish yellow marked with a chocolate-brown blotch covering the center of the carapace, having a light spot on either side of the mid-line in the region of the eyes. There are similar chocolate-brown blotches on each of the dorsal plates, including the sixth segment plate, leaving the margins and angles reddish yellow. In some specimens the pigment is so dense and covers so much of the body that the copepod seems nearly black. The "opaque, dirty white or yellowish white" specimens spoken of by Dana were evidently immature, and their pigment had not yet been formed.

(*satyrus*, a satyr.)

The U. S. National Museum collection includes a single lot of fifteen females of this species, Cat. No. 32753, U.S.N.M., taken from the sides and pectoral fins of a blue shark, *Prionace glauca*, by the Fisheries steamer *Albatross* during the Hawaiian explorations in 1902.

These agree in every particular with the figures and description given by Dana, except that the third pair of dorsal thorax plates in his specimens were relatively shorter. But this is a difference that is likely to occur in any species, and is not therefore of any value. *Pandarus zygænæ* has been given above as a synonym of the present species after a careful examination and comparison of the two. There are two females of *P. zygænæ* in the National Museum collection which were obtained by exchange from G. S. Brady, the author of the species. They are Cat. No. 6857, U.S.N.M., and were taken on *Sphyrna zyggæna* at St. Vincent, Cape Verde Islands. Brady's description of this species in the Challenger Expedition Report^a is very short and says nothing whatever of the appendages. Nor is any hint of the latter given in the single figure he published, which he labeled "An adult male, seen from above." He certainly mistook the sex, for his figure and description are those of a female without

^a Vol. VIII, p. 134, pl. LV, fig. 3.

egg-strings and not of a male. Furthermore, the deep cracks in the posterior portion of the genital segment on either side in his figure are more likely to be cracks due to the brittleness of preservation than they are to indicate a normal structure. The species has not been noted by other investigators, the only mention of it being in the list published by Bassett-Smith in 1899. The two specimens mentioned above were evidently covered with fish slime when preserved, and this has become so incrustated around the appendages as to conceal many of the details. Enough can be made out, however, to show the identity of Brady's species with that of Dana, which had been described thirty years before, and hence it must stand as a synonym of the latter. Brady's specimens were a little shorter than Dana's, and were lighter in color, the plates on the third segment and the genital segment being without pigment. This would indicate that they were not fully mature, which is further evidenced by the fact that they had no egg-strings.

PANDARUS SINUATUS Say.

PLATES XXXII and XXXIII.

Pandarus sinuatus SAY, 1817, p. 436.—MILNE EDWARDS, 1840, p. 471.—SMITH, 1874, p. 576, pl. VII, fig. 31.—RATHBUN, 1886, p. 310, pls. V-VII.

Female.—Carapace semielliptical to ovate, broader behind than in front, and a little more than one-third the entire length; width to length as 6 to 5; posterior lobes short, more or less acute, and turned inward at the tips; posterior margin when perfect with a rounded median projection bordered on either side by three or four short and sharp teeth. Usually, however, all the projections are bluntly rounded and irregular, making the margin jagged and sinuate, as in figure 172. Frontal plates narrow and but little prominent, not covering more than half the basal joints of the first antennæ. Eyes invisible in the adults, visible in the young, one-third the distance from the anterior margin, and close together on either side of the midline.

Paired dorsal plates of second segment broadly elliptical to oval, one-half longer than wide, diverging at an angle of about 30° from the central axis; their inner margins are sometimes nearly straight or may even be concave; they are widely separated and scarcely touch the second pair, but reach back to the center of the lateral margins of the third pair. The unpaired median plate of this second segment is very wide, comparatively short, with a straight posterior margin without teeth or spines.

Dorsal plates of the third segment small, nearly circular and separated by a deep sinus, which is slightly enlarged at its base; owing to the wide separation of the first plates this second pair are entirely

visible in dorsal view. Dorsal plates of the fourth segment considerably enlarged, wider than the genital segment and covering its anterior third or two-fifths, thoroughly fused with only a broad and very shallow posterior sinus.

Genital segment elliptical, one-fifth longer than wide; posterior lobes broad and evenly rounded, with a shallow median sinus.

Sixth segment plate small, its margin forming four-fifths of a perfect circle, the remaining fifth narrowed into an anterior stem or neck where it joins the genital segment. It projects behind the lobes of the genital segment for a half or two-thirds of its length. Anal laminae rather narrow and slender, as long as the sixth segment plate, acute at the tips and armed with two or three small spines irregularly placed on the inner margin; wings entirely lacking in the adult. Ventral plate of the abdomen much wider than the sixth segment plate, its posterior margin usually evenly rounded.

First antennae slender, the basal joint three times the length of the terminal, its distal end enlarged, the anterior margin and corner evenly rounded and well armed with setae; terminal joint club-shaped, with a tuft of setae at the tip.

Second antennae slender, the second joint with a small fleshy lamina on its ventral surface, the terminal claw short and weak.

First adhesion pads elliptical, three-fourths longer than wide; second pair obovate, one-half longer than wide, but much shorter than the first pair; fourth pair elliptical, a little more than twice as long as wide, and longer than the first pair.

Mouth-tube of the usual shape, narrower and longer than in *bicolor*; mandibles like those of *smithii*; second maxillae short and broad, the basal joint twice as wide as long, the second joint as wide as long and ending in a slender and sharp spine which is nearly straight. First maxillipeds slender, the basal joint half as long again as the terminal; the latter armed with a terminal curved claw, nearly as long as the joint itself, a shorter and straighter accessory claw, toothed along both margins, on its ventral surface, and a short and straight spine on the inner margin, both the latter being inserted at the base of the terminal claw.

Second maxillipeds much swollen, armed with a pair of knobs acting like forceps; knobs oblong, the ends where they come together being flattened and corrugated.

Basal joints of the swimming legs increasing in size from in front backwards, all biramose and the rami two-jointed, but the joints on the fourth pair are thoroughly fused, and the jointing is only indicated by marginal notches. The arrangement of the spines (there are no true setae) on the different legs is as follows: First exopod, 1, 5; endopod, 0, 3; second exopod, 1, 9; endopod, 0, 5; third exopod, 1, 4 to 8; endopod, 0, 3; fourth exopod, 1, 3 to 5; endopod, 0, 0. The

relative size and shape of the four pairs of legs and their joints are shown in Plate XXXII, figs. 177 to 180, the magnification being the same for each.

Of the reproductive organs the oviducts are usually coiled once in the genital segment, each strand of the coil reaching the entire length of the segment. But sometimes there is a short extra coil in the extreme anterior portion of the segment. The cement glands are exceptionally large and broad and arranged like parenthesis marks on either side of the intestine; the basal third of each is enlarged to twice the width of the oviduct, is more or less rounded, and extends outward and forward at an angle of 45° to the central axis. The remaining portion, or body of the gland, is once and a half the width of the oviduct, curves around inward toward the intestine, and extends almost to the anterior border of the segment; the compound cells are short and flattened like the eggs. The semen receptacle has the shape of a spear or lance head, with a narrow tapering central sinus. The two halves are joined anteriorly at the point of the spear, and each has on its outer margin a rounded point or knob, corresponding to the barb.

Total length, 7 to 8 mm.; length of carapace on mid-line, 2.75 mm.; width at posterior margin, 3.3 mm.; length of first dorsal plates, 1.5 mm.; of second pair, 0.75 mm.; of third pair, 1.25 mm.; of sixth segment plate, 1 mm.; of abdomen, 2.25 mm.

Color dull yellow or yellowish white, with a spot on either side near the frontal margin of the carapace, or with the spots fused across the mid-line into a horseshoe-shaped blotch opening posteriorly. There is also a central irregular blotch on the third pair of dorsal plates. In mature females the pigment of the eggs in the coiled oviducts give the genital segment a grayish or brownish tinge. From this mean the color varies in both directions. In specimens from the Smooth Dogfish the brown or black markings often cover most of the carapace, all of the fourth segment plates, and a part of those on the second and third segments. On the other hand, specimens taken from Atwood's Shark and immature specimens from whatever source show no pigment at all, or only the faintest traces of it.

(*sinuatus*, sinuate, alluding to the posterior margin of the carapace.)

Male.—Carapace orbicular, wider than long, with the lateral margin evenly rounded; posterior lobes broadly triangular and curved a little inward toward the mid-line; supplementary lobes very short, at least three times as wide as long and close to the bases of the posterior lobes. In preserved material these secondary lobes often turn white or whitish and become opaque. Lateral grooves bent sharply outward at the anterior ends, nearly at right angles to the longitudinal axis, and terminating just behind the sucking disks.

Frontal plates nearly as wide as the carapace, projecting over the bases of the first antennæ and thus very prominent.

Free thorax segments about the same length but diminishing rapidly in width from in front backwards. The second segment does not entirely fill the space between the posterior lobes of the carapace and only slightly overlaps the inner margins of the secondary lobes; its lateral plates are broad and enlarged at the tip into a spatulate form, the posterior margin being nearly straight. Fourth segment one-fifth narrower than the genital segment, its lateral margins with a narrow, sharp curve at the center. Genital segment elliptical, much longer than wide, with evenly rounded corners. Fifth legs small and blunt, slightly enlarged at the tips and carried forward some distance in front of the sixth pair; the latter are a little longer, are situated at the posterior corners, and nearly always curve inward toward the mid-line. Inside of each and close to its base, on the posterior margin of the genital segment, is a single large spine. Abdomen elongate, longer than wide, the two joints of the same length; the basal one spindle-shaped, the terminal one wedge-shaped, with no protuberance between the bases of the anal laminae; the latter are nearly twice as long as wide, with the ends rounded diagonally, the outer margin being the longer. Each is armed with four setæ, the inner of which is removed some distance from the others.

The first antennæ are the normal size and shape, the basal joints being almost wholly covered by the projecting ends of the frontal plates. The first adhesion pads are ovate, with their longitudinal diameters inclined at an angle of 45° to the body axis. They are placed so near the edge of the carapace behind the first antennæ that nearly half the pad projects beyond the carapace and is visible in dorsal view, affording a good secondary means of identification of the species. The second pair is just outside the bases of the second antennæ, elliptical in form, with their long diameters parallel to the body axis.

The third pair are egg-shaped and in the usual position between the first maxillipeds; the fourth pair are elongate-elliptical, on the lateral margins of the second segment lobes, and parallel with the body axis. The first and second pairs are much smaller in the male than in the female, which would show that they do not function as clasping organs.

The second antennæ are larger than in the female; the two basal joints are considerably swollen besides sharing in the formation of the adhesion pad. The terminal claw is large and stout and is armed on its outer margin with two large accessory spines, one near the base and the other at the center.

The first maxillipeds have a stout basal joint and a short and slender terminal joint, with two accessory claws on its inner margin

close to the base of the terminal claw. The ventral of these two claws is more than twice the size of the dorsal. The second maxillipeds are much enlarged, relatively more so than in the female, and evidently they, with the second antennæ, form the chief clasping organs. They are armed with a stout and well-developed terminal claw, which shuts down against a group of three tuberculated knobs placed side by side on the basal joint. This combination of claw and forceps pinchers gives these copepods a very firm hold upon their host.

The arrangement of the spines and setæ on the swimming legs is as follows: First exopod, 1, 0; 4, III: endopod, 0, 0; 0, III: second exopod, 1, I; 4, VI: endopod, 0, I; 0, VIII: third exopod, 1, I; 4, V: endopod, 0, I; 0, V: fourth exopod, 1, I; 4, V: endopod, 1, I; 0, V. The sperm duct is coiled into a large bunch near the center of the genital segment on either side, and its posterior end then opens into a boot-shaped spermatophore receptacle which lies between the bunch and the posterior end of the genital segment, and whose long diameter is inclined at an angle of 45° to the central axis. The anterior end of this receptacle is narrowed into a sort of pointed appendix which curves around forward and inward. The posterior end is bluntly rounded and from it a short tube leads to the genital opening, which is near the posterior corner of the genital segment.

Total length, 7.23 mm.; length of carapace on the mid line, 3 mm.; width of same, 4 mm.; length of free segments, 1.63 mm.; of genital segment, 1.72 mm.; of abdomen, 1 mm.

Color the same as that of the female except that there are no pigment spots or blotches and the body is quite transparent.

Young females.—The smallest female thus far obtained is a little less than 5 mm. in length (fig. 182). In this the carapace is nearly half the entire length, as long on the mid-line as it is wide, with narrow lateral areas and short triangular posterior lobes. The posterior margin between these lobes is very wide and irregularly sinuate, the general direction being nearly straight. Eyes plainly visible one-third the distance behind the frontal margin, three in number, arranged in a triangle, the middle one posterior. Frontal plates wide and prominent and covering the whole of the basal joints of the first antennæ. Lateral areas divided considerably behind their center by a transverse groove representing the boundary line between the head and the first thorax segment. Second segment filling the entire space between the posterior lobes of the carapace, its lateral plates short, broad, and well rounded at their tips. The median plate of this segment has not yet been differentiated, but the two lateral plates are fused in a wide band across the mid-line. The dorsal plates of the third and fourth segments have just started and overlap the segments following them scarcely at all. The genital segment is elliptical, much smaller than in the adult female (less than half the width and

length of the carapace); its posterior sinus is very broad, with a squarely truncated base, while the posterior lobes are narrow and short. The abdomen projects nearly its whole length behind the sinus of the genital segment, and is plainly visible in dorsal view. The sixth segment plate has only just started, and covers less than half the dorsal surface of the abdomen. Anal laminae of the same pattern as in other genera of this subfamily, narrow and long, each tipped with four plumose setae. Appendages like those of the adult with the exception of the fourth swimming legs, in which the rami are much smaller, less laminate, and the exopod is armed with claws similar to those on the third legs, and is indistinctly jointed. The fourth endopod, however, even at this early stage is wholly devoid of spines or setae, and shows no signs of segmentation.

The *Nauplius* has already been described on page 336; owing to the inability of the female to move about when placed in an aquarium, the eggs always die unless they were just on the verge of hatching when obtained. This makes it difficult to secure the nauplii, and explains how it happens in a genus as common as *Pandarus* that they have not been seen and described oftener.

This species was first described by Say in 1817, from specimens taken from the dog-fish, *Squalus canis* Mitchill, and preserved in the cabinet of the Academy of Natural Sciences in Philadelphia. The original description was brief and lacked many details, but enough was presented to identify the species, and the missing details were supplied in an excellent description given by Rathbun in 1884. But neither author found the male, and that sex is here presented for the first time, together with additional information upon the anatomy of the female. The abundance of the species upon the sharks common along our Atlantic coast is proven by the following list of the specimens in the U. S. National Museum. Most of these were found upon the fins of the sharks, attached in such a way that the egg-cases would float free from the margin of the fin in the clear water (fig. 1). Hence the *Pandarus* always has its head toward the head of the shark; when more than one are found on the same fin they are attached side by side and strictly parallel, often as many as eight being found on one side of a single fin, and as many on the other side. Usually these females have algæ and protozoa of various kinds growing upon their carapace and dorsal plates; these are fastened to the margins and angles of the plates and float back in the water around the egg-strings.

Often the female will be so completely covered that none of the dorsal surface can be seen (fig. 1). The fins most commonly chosen are the dorsal, the anal, and the ventral. Specimens are less often found on the pectorals or the tail.

All the following specimens were taken at Woods Hole or in the immediate vicinity, unless otherwise stated:

From Atwood's shark, *Carcharodon carcharias*, Cat. No. 6172 U.S.N.M. (20 females); Cat. No. 6195, U.S.N.M. (2 males); Cat. No. 32756, U.S.N.M. (1 adult and 5 young females).

From sand shark, *Carcharias littoralis*, Cat. No. 6021, U.S.N.M. (25 females); Cat. No. 6023, U.S.N.M. (1 male); Cat. No. 6028, U.S.N.M. (8 females); Cat. No. 6029, U.S.N.M. (5 males); Cat. No. 6030, U.S.N.M. (3 young females); Cat. No. 6034, U.S.N.M. (15 females); Cat. No. 6041, U.S.N.M. (1 female); Cat. No. 6042, U.S.N.M. (2 males taken with Cat. No. 6041, U.S.N.M.); Cat. No. 6075, U.S.N.M. (2 males and 2 females, 1 pair in coition); Cat. No. 6202, U.S.N.M. (3 females); Cat. No. 6206, U.S.N.M. (2 males); Cat. No. 6208, U.S.N.M. (1 female); Cat. No. 8121 U.S.N.M. (6 females); Cat. No. 8128, U.S.N.M. (2 males); Cat. No. 10744, U.S.N.M. (20 females); Cat. No. 12227, U.S.N.M. (2 females); Cat. No. 12674, U.S.N.M. (5 females); Cat. No. 12675, U.S.N.M. (10 females); Cat. No. 32730, U.S.N.M. (5 young females); Cat. No. 32745, U.S.N.M. (2 males); Cat. No. 32746, U.S.N.M. (a young female); Cat. No. 32748, U.S.N.M. (20 females very pale in color without pigment); Cat. No. 32749, U.S.N.M. (a male and female in coition); Cat. No. 32750, U.S.N.M. (a male); Cat. No. 32751, U.S.N.M. (4 young females and 2 males); Cat. No. 32755, U.S.N.M. (5 females); Cat. No. 32759, U.S.N.M. (10 females and 2 males, 1 pair in coition); Cat. No. 32762, U.S.N.M. (5 females); Cat. No. 32763, U.S.N.M. (10 females and 5 males); Cat. No. 32764, U.S.N.M. (5 females); Cat. No. 32766, U.S.N.M. (25 females); Cat. No. 32767, U.S.N.M. (25 females); Cat. No. 32768, U.S.N.M. (5 females); Cat. No. 32769, U.S.N.M. (5 females); Cat. No. 32770, U.S.N.M. (20 females); Cat. No. 32774, U.S.N.M. (30 females and 3 males); Cat. No. 32755, U.S.N.M. (5 females).

From smooth dogfish, *Mustelus canis*, Cat. No. 6046, U.S.N.M. (5 females); Cat. No. 6199, U.S.N.M. (5 females); Cat. No. 6203, U.S.N.M. (3 females); Cat. No. 6207, U.S.N.M. (1 female); Cat. No. 8124, U.S.N.M. (1 female); Cat. No. 8125, U.S.N.M. (1 male taken with Cat. No. 8124, U.S.N.M.); Cat. 8126, U.S.N.M. (2 young females); Cat. No. 10745, U.S.N.M. (3 females); Cat. No. 16090, U.S.N.M. (3 females and 1 male, taken off Avon, N. J.); Cat. No. 32733, U.S.N.M. (2 young females and 1 male); Cat. No. 32758, U.S.N.M. (2 females); Cat. No. 32760, U.S.N.M. (8 females); Cat. No. 32761, U.S.N.M. (3 females).

From dusky shark, *Carcharhinus obscurus*, Cat. No. 6031, U.S.N.M. (1 male); Cat. No. 6032, U.S.N.M. (1 male); Cat. No. 32747, U.S.N.M. (3 females and 1 male); Cat. No. 32773, U.S.N.M. (3 females).

From mackerel shark, *Lamna cornubica*, Cat. No. 32765, U.S.N.M. (75 females).

From sharp-nosed shark, *Scoliodon terræ novæ*, Cat. No. 32771 U.S.N.M. (2 females, taken at Beaufort, North Carolina).

From the outside of a menhaden, Cat. No. 32734, U.S.N.M. (1 male).

From "Shark," no species given, Cat. No. 8640, U.S.N.M. (6 males taken at station 2237, steamer *Albatross*, 1884); Cat. No. 12670, U.S.N.M. (35 females); Cat. No. 32757, U.S.N.M. (1 male).

No locality or host given, Cat. No. 6028, U.S.N.M. (1 female).

Genus NESIPPUS Heller.

Nesippus (*N. orientalis*) HELLER, 1865, p. 193.

Nogagus (*N. augustatus*) VAN BENEDEN, 1892, p. 246.

Female.—Carapace transversely elliptical, much wider than long, with broad lateral areas and posterior lobes. Frontal plates distinct, prominent, covering the basal joints of the first antennæ. Eyes small, three in number, in a triangle near the anterior margin. Second and third thorax segments fused together, and carrying a single pair of more or less rectangular plates or lobes on their sides. Fourth segment free, with no dorsal plates, or with a very small pair scarcely overlapping the genital segment. The latter elliptical, much longer than wide, with an evenly rounded outline; no posterior lobes. Abdomen small, attached to the ventral surface of the genital segment, and nearly hidden in dorsal view; anal laminæ of medium size, wholly visible, each armed with four large setæ.

First antennæ like those of *Pandarus*; second pair uncinatæ; first adhesion pads much larger than the second, the two quite a distance apart. Mouth tube similar to that of *Pandarus*; second maxillæ three-jointed, with swollen bases and small terminal claws.

Second maxillipeds much swollen, with a flattened terminal claw. All the swimming legs biramose; rami of the first three pairs two-jointed, of the fourth pair one-jointed, all armed with plumose setæ. Egg tubes slender, straight, much longer than the body.

Male.—Body a typical *Nogagus* form; carapace elongate with narrow lateral areas and posterior lobes; no accessory lobes, as in the *Pandarus* males, but sometimes a large spine on the posterior margin, at the base of the posterior lobe on either side. Frontal plates narrow and not very prominent; eyes three in number, in about the same position as in the female; in front of the eyes there is often a pair of rounded knobs (*Dana's conspicilla*) rising above the surface of the carapace. Free thorax segments the same length but diminishing rapidly in width from in front backward, the fourth as wide as the genital segment; the second segment only with lateral lobes. Genital segment elongate, more or less angular, without lobes or rudimentary swimming legs, or with the latter reduced to small spines. Abdomen small, one-jointed, wider than long, more or less triangular, anal laminæ small, but armed with large plumose setæ.

Appendages like those of the female; second maxillipeds much swollen, with forceps knobs or a flattened terminal claw. All the legs biramous, rami like those of the female.

(*Nesippus*, etymology unknown.)

KEY TO THE SPECIES.

- a. Females, carapace much wider than long; second and third thorax segments fused inter se; fourth segment with small dorsal plates; genital segment longer than the carapace; abdomen hidden..... b.
- a. Males, carapace as long as wide; second and third thorax segments distinct; fourth segment without dorsal plates; genital segment much smaller than carapace; abdomen wholly visible..... d.
- b. Fourth segment plates not reaching the genital segment; lateral lobes of the fused second and third segments narrow and well rounded..... c.
- b. Fourth segment plates overlapping the genital segment a little; lateral lobes on the fused second and third segments large, wide, and angular.
alatus Wilson, 1905, p. 426.
- c. Genital segment medium size, quadrangular, with rounded corners and no posterior lobes; abdomen largely visible from above.
angustatus Beneden, 1892, p. 431.
- c. Genital segment somewhat enlarged, elliptical, with long and broad posterior lobes, separated by a narrow median sinus; abdomen wholly concealed.
crypturus Heller, 1865.
- c. Genital segment much enlarged, ovate, with an evenly curved margin; no posterior lobes; abdomen entirely concealed..... *orientalis* Heller, 1865.
- d. Carapace wider than long; genital segment also wider than long, barrel-shaped..... e.
- d. Carapace and genital segment decidedly longer than wide; genital segment oblong with parallel sides..... f.
- e. Carapace without conspicilla, posterior lobes short; fourth segment with strongly protruding sides; genital segment without rudimentary legs.
alatus Wilson, 1905, p. 426.
- e. Conspicilla present; posterior carapace lobes narrow and elongate; sides of fourth segment protruding but little; fifth legs showing on sides of genital segment..... *curticaudis* Dana, 1852, p. 434.
- f. Less than 6 mm. in length; genital segment nearly as wide as long; fourth segment biscuit-shaped, twice as wide as long.
angustatus Beneden, 1892, p. 431.
- f. From 8 to 11 mm. in length; fourth segment spindle-shaped, as long as wide; genital segment one-third or one-half longer than wide.
borealis Steenstrup and Lütken, 1861, p. 437.

This genus was founded by Heller in 1865 upon two species obtained on the Novara expedition at the island of Java.

They were both obtained from the gills of sharks, and although Heller does not make the statement, it is probable that they were found in the shark's throat rather than in the gill cavity.

Of one species which he called *orientalis* Heller claimed to have both sexes, but a careful study of the figures and description of his "male" show it to be really a young female before the egg strings have developed. It is not a *Nogaus* form at all, but exactly like the adult except that the genital segment is smaller and the abdomen not

concealed. If it be compared with the figure here given (Plate XXXIV, fig. 205) of a young female *alatus*, its identity is manifest at once.

Beneden made the same mistake in 1892 with his *Nogagus angustatus*, which is shown on page 431 to be a *Nesippus*. He described a young female as a male of the species. Kröyer in 1863 erred in another direction. He found a young female *Nesippus* and a *Nogagus latreillii* upon the same fish and described the two as the male and female of *Nogagus latreillii* (see p. 441).

The true male of the genus has never before been described. This is probably due to the fact that the male stays on the outside surface of the shark's body, in company, usually, with one or both sexes of some of the other genera. The young female stays in the same place, or in the gill cavity close to the surface, until after union with the male, which takes place very early in development, as in all the parasitic copepods, and then she crawls down into the shark's throat out of sight and remains there fastened to the inside of the gill arches. In the examination of several scores of sharks by the present author, a male has never yet been found in company with one of these mature females in the shark's throat, but many have been taken on the fins and in the gill cavity, some of which were in union with young females.

It was difficult, therefore, to locate the two sexes at first and required long continued search before they were definitely determined. This leaves Heller's two species, *orientalis* and *crypturus*, composed of females alone with the male unknown, while Dana's *curticaudis* and Steenstrup and Lütken's *borealis* are known only in the male sex. Dana's species was taken "from the body of a shark, northeast of New Zealand," while both of Heller's species came from Java. These localities are near enough together, especially when we remember that the hosts are large sharks, for it to be at least possible that future investigation will find two of the species more closely related.

NESIPPUS ALATUS Wilson.

PLATES XXXIV and XXXV.

Nesippus alatus WILSON, 1905, p. 130.

Nogagus tenax (?) STEENSTRUP and LÜTKEN, 1861, p. 388, pl. x, fig. 20.

Female.—Carapace transversely elliptical, the width once and three-quarters the length; frontal plates distinct, and, together with a portion of the cephalic area, projecting in a half circle from the anterior margin; deeply incised at the center. Posterior lobes short, scarcely overlapping the lateral lobes of the second and third segments; thoracic area quadrilateral, arched a little above the surrounding surface; lateral areas very wide; cephalic area small. Eye distinctly tripartite, appearing as three separate circular lenses arranged in a tri-

angle at the center of the carapace, about one-third the distance from the anterior margin. Second and third thorax segments fused together and carrying a single rectangular lobe or plate on either side, which extends obliquely backward nearly to the tips of the posterior lobes of the carapace. Fourth segment free, considerably narrower than the second and third segments and covered with a pair of fused dorsal plates. Each of these is nearly a perfect circle in outline, in strong contrast to the angular pair on the second and third segments. They do not extend out as far as the latter, but are about the same width as the genital segment, over whose anterior margin they extend for a little distance. Genital segment elliptical, or slightly ovate, with an evenly rounded margin, the length to the breadth in the proportion of 8 to 5. Abdomen invisible in dorsal view, but the two large anal laminae project nearly their entire length behind the posterior margin of the genital segment. Each of them is as wide as long, and as large as the entire abdomen, and is armed with four slender plumose setae. Seen ventrally, the abdomen is small, triangular in shape, and attached about its own length in front of the posterior margin of the genital segment. The apex of the triangle is represented by the narrow neck where the abdomen joins the genital segment while the broad base is at the posterior margin where the anal laminae are attached.

The first antennae are short and stout, the basal joint nearly twice the diameter of the terminal and thickly studded with setae, the terminal joint furnished with setae along its posterior margin as well as at the tip; second antennae large, with a long and stout terminal claw. First adhesion pads elliptical, close to the margin of the carapace, and more than twice the size of the second pair; the latter nearly circular and removed some distance from the first ones. In the young female these pads appear as short and slightly curved claws, and are then like the corresponding first maxillae in the *Caliginæ*. In the adults they are transformed into large pads, fastened for their entire length to the ventral surface of the carapace. Similarly the pads at the bases of the first maxillipeds are straight spines in the young.

The second maxillae are close beside the base of the mouth-tube and are apparently two-jointed; the basal joint is large and swollen, twice as long as wide; the terminal joint is a short curved claw.

The mouth-tube is long and pointed; the framework consists of a slender rib along either side extending from the base to the tip and almost perfectly straight, with the ends somewhat enlarged; the ends at the tip are joined by their inner margins, while those at the base are joined by a chain of three circular plates, the central one being considerably larger than the other two.

From the two side plates a pair of secondary ribs extend forward and inward, each pointing toward the tip of the maxilla on the opposite side. The mouth opening is terminal and heavily fringed with hairs. First maxillipeds of the usual form, the secondary terminal claw very short and conical; second pair large and swollen, the basal joint almost twice as wide as long and considerably flattened dorso-ventrally. The terminal joint is shaped like a flexible finger or thumb, and is attached transversely along the outer end of the basal joint.

The four pairs of swimming legs are all biramose, rami of the first three pairs two-jointed, of the fourth pair one-jointed.

The exopods of the first and fourth pairs are longer than the endopods; in the second and third pairs the rami are about equal; the basal joints of the first and fourth pairs are widened, but not more than half as much as those of the second and third pairs. None of these basal joints carry spines or setæ except the third pair, in which a very large seta projects diagonally backward from the inner corner. The fifth legs are entirely lacking; the arrangement of the spines and setæ on the other four pairs is as follows: First exopod, 1, 0; 4, III: endopod, 0, 0; 0, IV: second exopod, 2, I; 4, V: endopod, 0, I; 0, VI: third exopod, 1, I; 4, IV: endopod, 0, I; 0, IV: fourth exopod, 5, IV: endopod, 0, IV.

The ovaries are large and elliptical in form; they can be seen just above the digestive tract near the anterior margin of the thoracic area of the carapace. The oviduct leads back in the usual way to the genital segment, where it is coiled in three parallel strands running lengthwise along either side of the segment. It finally opens to the exterior on the ventral surface just in front of the abdomen. The cement glands are long and narrow, the cells in each being nearly as long as wide; they lie just beneath the inner coils of the oviduct and are slightly curved, the concave sides toward each other. The semen receptacle is large and crescent shaped; it consists essentially of three spherical pockets or sacs, one on either side below the opening of the oviduct, and the third at the center connecting the two. The duct leading from these lateral sacs is carried past the point where it opens into the oviduct, and is coiled into a blind pointed sac, which turns forward alongside the outer margin of the sperm receptacle (fig. 204).

Total length, 7 mm.; length of carapace, 2.8 mm.; width of same, 3.8 mm.; length of genital segment, 2.7 mm.; width of same, 1.7 mm.; length of egg strings, 13.5 mm.

Color a light yellowish white, fairly transparent and not showing very distinctly against the white background of the shark's throat.

The coils of the oviduct in the genital segment are a darker yellow and opaque; the egg-strings are almost pure white.

Male.—Carapace semielliptical, a trifle wider than long, squarely truncated posteriorly, with a long and narrow lobe at each of the posterior corners. Second and third thorax segments not fused, but distinct, of the same length as the fourth segment, the three diminishing regularly in width, and none of them bearing dorsal plates. Genital segment small, a little narrower than the fourth segment, of about the same length and width, with reentrant corners. Abdomen very short, the basal joint hardly visible beneath the posterior border of the genital segment. The anal laminae are no larger than in the female, but the plumose setae are considerably longer.

The appendages are like those of the female, with the usual sexual modifications in the second antennae and the second maxillipeds. There is a greater difference in size between the adhesion pads of the first two pairs than in the female, the first pair being enlarged. The mouth tube is the same, but the second maxillae are three-jointed, counting the terminal claw; this makes it practically certain that these appendages in the female are also three-jointed, although the two basal joints are usually fused, and they are so designated in the genus diagnosis.

The arrangement of the spines and setae on the swimming legs is as follows: First exopod, 1, 0; 4, III: endopod, 0, 0; 0, III: second exopod, 1, I; 4, V: endopod, 0, I; 0, VIII: third exopod, 1, I; 3, IV: endopod, 0, I; 0, IV: fourth exopod, 4, III: endopod, 0, IV. The basal joints of the second and third pairs carry a medium spine on their outer corner.

Total length, 4.55 mm.; length of carapace, 2 mm.; width of same, 2.3 mm.; length of genital segment, 0.88 mm.

The male is darker in color than the female and usually becomes a deep brown in alcohol; this color is uniformly distributed without pigment spots.

(*alatus*, furnished with wings. None of the other species have dorsal plates of any size.)

Young female.—General body form similar to that of the adult; the carapace is proportionally as wide, with broad and well-rounded posterior lobes and prominent frontal plates. The second and third thorax segments fused, with their single pair of lateral plates even more angular than in the adult, for the external margin of these plates is concave, thereby making the corners acute. No plates on the fourth segment as yet; the genital segment very small and elliptical, the same width as the fourth segment, and one-half longer than wide. Abdomen entirely visible, one-jointed, with reentrant sides and a convex posterior margin; anal laminae larger and the plumose setae longer than in the adult.

The only differences in the appendages are such as are common to young forms; the joints are relatively smaller, while the spines and

setæ are longer; this causes these young females to look much like males, and it deceived even so good an observer as Krøyer. But a careful examination of the genital segment reveals the presence of cement glands and sperm receptacles, and thus precludes any idea that these are males.

This species is found upon the gill arches of the common sand shark, *Carcharias littoralis*, rarely upon the floor or roof of the mouth. In nearly every instance it is solitary, a single female being fastened to either the fifth or the fourth arch on the posterior side, so that all one can see of it on looking down the shark's throat is the white or brownish egg-strings.

They are fastened rather more securely than *Pandarus*, by means of their second maxillipeds, and it requires considerable effort to dislodge them. On being removed to an aquarium it is found that the females can not swim, but are fully as helpless as the other genera in this subfamily, lying upon their backs and keeping their swimming legs in constant motion. They can be kept alive for a longer period than *Pandarus*, however, and seem much more hardy. The anterior portion of the body, including the carapace and free thorax segments, is very transparent and colorless. Hence it would be difficult to distinguish the animal against the white background of the shark's throat were it not for the fact that the digestive tube is dark colored, the coiled oviduct in the genital segment is brown, and the egg-tubes are also brown. The latter are long and slender and appear fragile, looking as if they would pull apart on slight provocation; but the very reverse is found to be true. Indeed they are so tough that the body of the female will pull apart at the fourth segment before the egg-strings will break.

In the living copepod these egg-strings are always encased in a heavy layer of mucus obtained from the shark's gills, and they often have in addition a growth of algæ or other foreign matter mixed with the mucus. When these substances extend up onto the genital segment of course they help to hold the egg-strings in place. But it not unfrequently happens that they fail to reach the genital segment, and in that case the egg-strings have to hold the entire mass in place. As the copepod is almost always found on the inside of the gill arches, or at least with the posterior part of the body and egg-strings on the inside, it must be subjected to more or less friction from the convulsive movements of the living fish upon which the shark feeds.

The utility, therefore, both of the heavy coating of mucus over the egg-strings, and of their secure attachment to the genital segment, becomes very apparent. The males are good swimmers and very active, like other *Nogaus* species, and in the aquarium they move about restlessly.

This can not be regarded as an abundant species, since in only one or two instances has more than a single adult female been found on the same fish. But it may be said to be common, since nearly every shark so far examined has yielded its specimen.

The U. S. National Museum collection includes the following, all from Woods Hole and vicinity unless otherwise stated:

From the sand shark, *Carcharias littoralis*, Cat. No. 6029, U.S.N.M. (5 males); Cat. No. 8127, U.S.N.M. (5 males); Cat. No. 32744, U.S.N.M. (1 male); Cat. No. 32788, U.S.N.M. (2 females); Cat. No. 32793, U.S.N.M., (2 females); Cat. No. 32795, U.S.N.M. (young female); Cat. No. 32834, U.S.N.M. (5 males).

From gray shark, Cat. No. 8183, U.S.N.M. (2 females).

From dusky shark, *Carcharhinus obscurus*, Cat. No. 6033, U.S.N.M. (7 males).

From flounder, Cat. No. 32740, U.S.N.M. (1 male).

From caudal peduncle of *Fundulus majalis*, Cat. No. 32743, U.S.N.M. (1 male).

From man-eater shark, Cat. No. 32786, U. S.N.M. (2 females).

From smooth dogfish, Cat. No. 32787, U.S.N.M. (1 male).

From sharp-nosed shark, *Scoliodon terræ-novæ*, Cat. No. 32790, U.S.N.M. (1 female); Cat. No. 32792, U.S.N.M. (7 females).

From *Sphyrna tiburo*, at Beaufort, North Carolina, Cat. No. 32791, U.S.N.M. (1 female).

From *Sphyrna zyggæna*, also at Beaufort, North Carolina, Cat. No. 32794, U.S.N.M. (10 females).

NESIPPUS ANGUSTATUS Van Beneden.

Nogagus angustatus VAN BENEDEN, 1892, (b), p. 245, pl. I, figs. 5-10.

Pandarus affinis VAN BENEDEN, 1892, (a) p. 226, pl. I, figs. 5 and 7-11 (the male form only).

In 1892 Van Beneden described The Male of Certain Caligids and a new Genus of the Family.^a The second male described was given the name *Pandarus affinis*. Beneden says that this new species was obtained "sur des *Squales* non déterminés de la baie de Dakar: nous en possédons les deux sexes; une femelle et deux mâles. Le corps de la femelle a une longueur de 6 millimètres; les ovisacs, 10 millimètres; les appendices, en général, sont complètement les mêmes dans les deux sexes, aussi bien ceux de la tête que ceux du thorax."

Then follows a description of the two sexes which is sadly lacking in just those particulars most essential for the determination of the species, namely in the details of the appendages.

The only appendages described for the female are the first antennæ; of the male, nearly all the appendages are mentioned, but no definite data are given for any of them. In the figure showing a dorsal view

^aBulletins de l'Académie royale de Belgique (3), XXIII, No. 3, pp. 220-235.

of the male the rami of the third legs are two-jointed on one side and one-jointed on the other, while those of the fourth legs are both one-jointed. In the ventral view both rami of the fourth legs, and the endopods of the third legs are one-jointed; all the other rami are two-jointed.

Such data are hardly sufficient to decide whether the two specimens are the male and female of the same species or not, nor even that they certainly belong to the genus *Pandarus*.

None of the genera here considered have one-jointed endopods in the third pair of swimming legs. But this is manifestly an error on Beneden's part, and the ramus should have two joints like the exopod. With this one correction, assuming that all the details are accurately stated, the appendages, the general body form, the relative size, and shape of the different segments, and particularly the narrow and elongated posterior lobes of the carapace, correspond exactly with those found in *Nesippus* males.

And at the same time they are radically different from those of *Pandarus* males; in particular the present species lacks the accessory lobes on the posterior margin of the carapace, there are no legs visible on the genital segment, and the abdomen has but a single joint. Furthermore *Nesippus* males are usually found in company with both sexes of other genera on the outside of the host, while the adult females are confined to the gill arches in the throat. We may reasonably conclude, therefore, that while the female undoubtedly belongs to the genus *Pandarus*, the male is not a *Pandarus* at all, but a *Nesippus*.

Later in the same year Beneden published another paper, entitled Some new Caligids from the Coast of Africa and the Azores Archipelago, in the same periodical.^a

The second of the new forms described he calls *Nogagus angustatus*, of which he claims to have found both sexes.

But his mistakes here are even worse than those of the former paper; in the first place his species is not identical with Gerstaecker's *Nogagus angustulus*, as he claims. The difference in spelling is accounted for by the fact that in Gerstaecker's paper (1854) the specific name is spelled "*angustulus*" in the text, and "*angustatus*" in the explanation of the plates. The former was evidently the one intended by Gerstaecker, and it is quoted by Steenstrup and Lütken, and by Bassett-Smith. If any reliance can be placed upon Beneden's figures, there are enough differences, even in a dorsal view, to distinguish the two species at a glance. (See *N. angustulus*, p. 351.)

Again, supposing the male had been the same as Gerstaecker's species, it was long ago proved that the entire genus *Nogagus* is made

^a Pages 241 to 262.

up of the males of other genera, and must wholly disappear as our knowledge of these parasites becomes more complete.

The thing to do, therefore, is not to refer the female to the genus of the male, for the male has no genus, but to do exactly the reverse, take the male out of this heterogeneous collection known as "*Nogagus*" and place him in a valid genus to which the female belongs. Hence, the question to determine is, to what genus does the female described by Beneden belong?

Bassett-Smith suggests (1899, p. 459) that it is a species of *Dysgamus*, but unfortunately no female of this genus has ever been described, so that we have no type with which to compare it.

The *Dysgamus* male, as described by Steenstrup and Lütken, the founders of the genus, is not a *Nogaus* form at all, but one in which the first three segments of the thorax are all united with the head to form the carapace, the fourth segment only being free.

A furca is present, and the details of the appendages, especially the swimming legs, are very different from what we find here.

The female, when found, must belong to the Euryphorinæ, while this female described by Beneden is evidently one of the Pandarinæ. Moreover it presents exactly the characters here given to the genus *Nesippus*; the carapace is wider than long; the second and third thorax segments are fused together and furnished with a single pair of lateral lobes; the frontal plates are conspicuous; the genital segment is elongated; the abdomen is short and one-jointed; the anal laminae are relatively small, but armed with large setæ; the swimming legs are all biramose, the first three pairs are two-jointed, the fourth pair one-jointed.

This "*Nogagus*," therefore, is really a female *Nesippus*, and the species must be called *Nesippus angustatus* Van Beneden, since it is different from those heretofore described.

Beneden made his third mistake in supposing that he had two sexes; what he describes as a male is really not a *Nogaus* form, but a young female, with the egg-strings as yet undeveloped (see p. 444). The true male of this species is probably the form mentioned above, which Beneden described as the male of *Pandarus affinis*. We have already shown that this was not a *Pandarus* but a *Nesippus* male; it came from exactly the same locality, the Bay of Dakar, was collected by the same man, M. Chevreux, and was sent to Beneden in the same lot with the female specimens.

Moreover it corresponds exactly in body form and in so much of the anatomy as can be made out from Beneden's data. We may conclude, therefore, 1, that the female of Beneden's *Pandarus affinis* was a true *Pandarus*, and as such it has been included in the key on page 394; 2, that what he described as the male of the same

species was really the male of *Nesippus angustatus*; 3, that his *Nogagus angustatus* was not the same as Gerstaecker's *N. angustulus*; 4, that it was not a *Nogaus* at all, nor did it even include the male sex, but was made up of two females, an adult with egg strings which he recognized as a female, and an immature female without egg strings, which he called a male. Both sexes of this new *Nesippus* species have been included in the key on page 425.

NESIPPUS CURTICAUDIS Dana.

PLATE XXXVI.

Specilligus curticaudis DANA, 1852, p. 1375, pl. xcy, figs. 6 *a-h*.—CLAUS, 1875, p. 352, pl. xxiv, fig. 32.—THOMSON, 1889, p. 365.

Nogagus curticaudis STEENSTRUP and LÜTKEN, 1861, pp. 383 and 390.

Male.—Carapace elliptical, a trifle wider than long, excluding the posterior lobes, with an evenly rounded anterior margin and a slightly concave posterior margin between the lobes.

Frontal plates narrow-linear and following closely the contour of the frontal margin of the carapace, not appreciably enlarged at the ends as in *borealis*. Posterior lobes very narrow, reaching nearly to the posterior margin of the third thorax segment, and turned outward a little. Eyes visible with difficulty, on the median-line in the usual position; just in front of them and separated a little are the large prominent conspicilla noted by Dana (see below), one on either side of the body axis.

The three free thorax segments are about the same length, but decrease regularly in width, the fourth being five-eighths as wide as the second. The lateral lobes of the second segment are narrow and extend diagonally backward as far as the posterior border of the third segment.

Genital segment the same width as the fourth segment, elliptical, a little wider than long, and squarely truncated both anteriorly and posteriorly. Its sides are evenly rounded and each shows just in front of the posterior corner a small papilla armed with a single spine. There is a well-defined furrow on either side of the dorsal surface, about one-fourth the width from the lateral margin. The surface between these grooves in the center of the segment is more strongly arched than that of the margins. The abdomen is triangular, considerably wider than long, with the apex projecting between the anal laminæ and deeply incised. Anal laminæ also triangular, reaching a little beyond the tip of the abdomen, and each armed with three large setæ. First antennæ rather slender, but both joints armed with long and bushy plumose setæ; second pair stout, the basal joint armed with a large roughened knob on its posterior margin, the terminal claw rather short, but stout and strongly curved. Mouth-tube long and slender, with the mandibles protruding at the

tip; mandibles of the shape usual in the Pandarinæ, the interlocking teeth along the inner margins being minute and triangular. Second maxillæ with the basal joint not enlarged as much as in *alatus*, the terminal spine long, pointed inward toward the mouth-tube, and somewhat enlarged at its base on the outer side. First maxillipeds with a terminal claw fully as long as the joint which bears it, and strongly curved. The accessory claw arises from the posterior border close to the base of the terminal claw, and is about half the size of the latter. Second maxillipeds much swollen, the very broad basal joint with a pair of knobs on its ventral margins, while the knoblike pinchers of the terminal joint cover the whole of that portion of the surface.

The spines and setæ on the swimming legs are arranged as follows: First exopod, 1, 0; 3, III: endopod, 0, 0; 0, III: second exopod, 0, I; 4, VI: endopod, 0, I; 0, VII: third exopod, 1, 0; 3, V: endopod, 0, I; 0, IV: fourth exopod, 4, IV: endopod, 0, IV.

Total length, 6.53 mm.; length of carapace on mid-line, 2.5 mm.; width of same, 2.7 mm.; length of free segments, 2.1 mm.; length of genital segment, 1.33 mm.

Color (preserved material) a uniform brownish yellow without pigment spots; the pigment of the paired eyes a deep blue, of the unpaired eye a bright red.

(*curticaudis*: *curtus*, short, and *cauda*, tail.)

This species was originally described by Dana in 1852 and made the type of a new genus called "*Specilligus*" from the lenticular bodies or conspicilla situated in front of the eyes. In his genus diagnosis Dana says: "The essential point of difference between this genus and *Nogagus* is the existence of two large transparent corneæ (conspicilla) exactly like those of the Sapphirinæ. These conspicilla are attached to the exterior shell, but with some difficulty may be separated. On pressure they proved to be brittle, though rather hard."

We now know that similar conspicilla are present in other *Nesippus* and *Perissopus* males, and occasionally in those belonging to some of the other genera. Being common to several genera, therefore, they would have no generic value; furthermore, they are not found at all in the females of any genus.

These two facts entirely destroy Dana's distinctions and leave us simply the problem of locating this male among the genera belonging to the Pandarinæ.

Steenstrup and Lütken in 1861 call attention to the fact that this species was taken in company with Dana's *Nogagus validus* and *Pandarus brevicaudis*, on the same day and spot, and presumably from the same fish. They also call the species *Nogagus* instead of *Specilligus*, but offer no explanation for the change.

We have already shown that *Nogagus validus* and *Pandarus brevicaudis* are probably the male and female of the same species, and hence the fact that the present species was found with them would not be specially significant.

Claus in 1875 mentions a similar form found in the Mediterranean, and concludes that Dana's *Specilligus* is really a *Nogaus* male of some genus belonging to the Pandarinae. He only mentions the genera *Dinematura*, *Echthrogaleus*, and *Pandarus*, but if we interpret his meaning aright these are given rather as samples than as comprising the only genera to which *Specilligus* could belong.

Gerstaecker in Brohn's Thierreich considered that this genus of Dana's was very closely related to if not identical with *Nogaus*. Thomson mentions the species in his Parasitic Copepoda of New Zealand (1889), but adds nothing new in the way of description or identification.

Bassett-Smith in 1899 makes "*Nogagus curticaudatus*" a synonym of *Gangliopus pyriformis*, referring to Steenstrup and Lütken for his authority. But he made a bad mistake both in his spelling of the specific name and in his reading of the Danish paper referred to. Steenstrup and Lütken declare that Gerstaecker's *Nogagus angustulus*, and not the present species, was taken on the same fish with *Pandarus dentatus* Edwards and *Gangliopus pyriformis* Gerstaecker. The statement they make in reference to Dana's species has already been given.

It is therefore practically certain that the present species is a *Nogaus* form, that it does not belong to any of the genera just mentioned, and that it does conform in all its details with the male of the genus *Nesippus*. Dana's description, though brief, is very accurate and his figures are excellent, but as the Museum collection contains several fine specimens of the species a more complete description has been given to accompany this definite location in the genus *Nesippus*. There are two lots of specimens, one, Cat. No. 6917, U.S.N.M., taken from a *Carcharias* between Papua and Japan on the Challenger Expedition, and obtained through exchange with G. S. Brady, of England; the other, Cat. No. 32742, U.S.N.M., contains five males taken from a 10-foot shark at Station 2422 by the Fisheries steamer *Albatross* in 1885. With reference to the conspicilla they show plainly in some specimens, while in others from the same bottle they can be seen only under strong light, transmitted through the body of the specimen. They evidently belong to the internal anatomy and bid fair, on further examination, to be closely related to the frontal attachment gland.

NESIPPUS BOREALIS Steenstrup and Lütken.

PLATE XXXVII.

Nogagus borealis STEENSTRUP and LÜTKEN, 1861, p. 387, pl. XI, fig. 21.—BASSETT-SMITH, 1899, p. 460.

Male.—Carapace strongly arched dorsally, about the same length and width, exclusive of the posterior lobes; narrowed anteriorly to a broad and rounded knob which projects over and some distance in front of the proximal ends of the frontal plates. Eyes large, placed far forward on either side of the median line, in contact with each other, but not fused. The frontal plates are enlarged at their distal ends and evenly rounded, and they cover the basal joints of the first antennæ. Posterior lobes narrow and reaching a little beyond the center of the second thorax segment; posterior margin between the lobes slightly concave and perfectly smooth. The projection of the carapace forward and the comparative shortness of these lobes is probably due to shrinkage in the alcohol, and is not the normal condition. The entire body of the copepod is perceptibly curled over ventrally, bringing the large conspiciilla in front of the eyes on the very margin in a dorsal view.

Free thorax segments, chiefly noticeable for their great length and contracted width, the two combining to produce an exceptionally elongated appearance. Some of this is no doubt due to the same shrinkage just mentioned, for the segments are all strongly arched and the lateral processes on the first one are turned over toward the ventral surface so as to be nearly invisible dorsally. But the shrinkage can have practically nothing to do with the length of the segments, so that the species is an elongate one under any conditions. In the figure given by Steenstrup and Lütken there has evidently not been as much shrinkage as in the present specimen.

The first free segment is seen to be considerably wider than the two following ones, with nearly straight sides and very small, triangular lateral lobes. The free segments together are the same length as the carapace on the mid-line, and the fourth one is three-fifths the width of the second and the same width as the genital segment.

The latter is longer than wide, with rather sharp corners and slightly convex sides. There are no traces of rudimentary legs either on the lateral margins or the posterior corners.

Posteriorly where it joins the abdomen the segment is narrowed into a sort of neck, and is traversed, on both the dorsal and ventral surfaces, by a pair of longitudinal furrows, one on either side, a short distance from the lateral margin. The ventral surface is flat throughout, while the dorsal surface between the furrows is strongly arched.

Abdomen one-jointed and triangular, with well-rounded angles, one of which, slightly incised, points backward between the anal laminae.

These latter are broad but short and occupy nearly the whole of the free sides of the abdomen; each is armed with four large setæ, one near the anterior margin and the other three bunched together on the posterior margin.

Both joints of the first antennæ are well armed with setæ, some of which are much longer than usual; neither joint has such bushy setæ as portrayed by Steenstrup and Lütken, but they are much better supplied than usual. There is a circular adhesion pad behind each antenna close to the margin of the carapace.

The second antennæ arise near the base of the mouth-tube, are of the usual shape, and end in a powerful claw, strongly curved. The second maxillæ have a stout basal joint, while the terminal spine is long and slender; the same is also true of the first maxillipeds, whose slender claw is nearly as long as the terminal joint. Close to the base of the claw can be seen the spindle-shaped finger mentioned by Steenstrup and Lütken as going out at right angles to the posterior border of the terminal joint, and a group of spines between the finger and the terminal claw and around the base of the latter. The long terminal claw is also fringed with fine spines as in their specimens.

The second mixillipeds have a single knob on the ventral surface of the swollen basal joint, and a pair of pincher-like knobs on the terminal joint. Steenstrup and Lütken give this appendage armed with a long claw instead of the pincher-like jaws, but this is no more of a variation than is commonly found in other species of this genus. As noted on page 330 the second maxillipeds of the males of *alatus* are sometimes furnished with claws and sometimes with pincher-like knobs.

The arrangement of the spines and setæ on the swimming legs is as follows: First basipod, 2 spines: exopod, 1, 0; 3, IV: endopod, 0, 0; 0, III: second basipod, 1 seta: exopod, 1, I; 3, V: endopod, 0, I; 0, VII: third basipod, 1 seta: exopod, 1, 0; 1, V: endopod, 0, I; 0, IV: fourth basipod, naked: exopod, 2, IV: endopod, 0, IV.

Total length, 8.2 mm.; length of carapace, including posterior lobes, 3.8 mm.; width of same, 3.2 mm.; length of free thorax, 2.8 mm.; length of genital segment, 2.1 mm.

Color (preserved material) a uniform yellowish brown, much darker on the genital segment and abdomen, but without pigment.

(*borealis*, northern, all the specimens having come from the far north.)

The U. S. National Museum Collection contains a single specimen of this species Cat. No. 32789, U.S.N.M., which came from an Alaska collection made by Dr. W. H. Dall. The size of this male and of those recorded by Steenstrup and Lütken, which were 11 mm. long, indicates that the female must also be larger than the ones already described.

Genus *PROSÆTES*, new genus name.

Stasiotes rhinodontis WRIGHT, 1874, p. 583, pl. xxxv, figs. 1 to 4.

In the above year E. P. Wright published an account of a new genus belonging to the Pandarinæ, which he named *Stasiotes*.

As this name had been employed by Jan for a snake genus in 1862, the name *Prosætes* is suggested in its place.

The parasites, to the number of 40 or 50, all females, were obtained from the gills of a huge shark, *Rhinodon typicus* Smith, at the Seychelles Islands. This is one of the largest and least known of the sharks, thus explaining the fact that this parasite has not been seen by any other investigator.

Female.—Carapace as broad as long; frontal plates distinct, but not prominent; lateral areas wide and divided by transverse grooves as in *Echthrogaleus*; posterior lobes wide and evenly rounded.

Second thorax segment short, with broad lateral lobes; third segment longer, but without dorsal plates or lobes; fourth segment very small, with a rudimentary pair of dorsal plates fringed with bristles. Genital segment orbicular, wider than long, with a shallow posterior sinus; a pair of legs visible at the posterior corners. Abdomen wedge-shaped, one-jointed, and wholly concealed beneath the genital segment; anal laminae long, narrow, and projecting beyond the posterior margin of the genital segment.

Appendages like those of *Nesippus*; second maxillipeds not swollen, armed with a long terminal claw, both the claw and the joint which carries it furnished with a large spine.

All the swimming legs biramose, rami of the first three pairs two-jointed, with plumose setæ, of the fourth pair with fused joints and non plumose setæ. Egg-strings unknown.

(*Prosætes*, *προσάιτης*, a beggar who is very persistent.)

Genus *NOGAUS* Leach.

This genus furnishes one of the best examples of a potpourri that has ever appeared on the pages of science.

Originally founded by Leach in 1819 upon a single male specimen which he called *Nogaus latreillii*, it quickly grew into a group of a dozen or more species. Nor did these additions cease when it became known that the genus as such could not stand, but new species have appeared at intervals up to the very beginning of the present century. In consequence there are now about twenty of these forms heterogeneously grouped about an imaginary type known as "*Nogagus*."^a

^a Milne Edwards substitutes this spelling for that originally given by Leach, Desmarest, and Burmeister without a word of explanation or justification. Subsequent writers have followed him rather than the founder of the genus.

The genus was very poorly described by its author and by the others who immediately followed him, and to this defect, no doubt, is partly due the confusion which has ensued ever since.

Leach's description is as follows:

Deux courtes soies à la queue, portant plusieurs styles à leur extrémité: les trois premières pièces de l'abdomen ont les côtés arrondis, tandis que le quatrième et le cinquième les ont terminés en pointe: tête en forme de fer à cheval (1819, p. 535).

Desmarest in 1825 copied Leach's description, but made a curious blunder in endeavoring to explain the "deux courtes soies."

For he wrote in his genus diagnosis of *Nogaus*:

Deux courtes soies ou tubes ovifères à la queue, portant plusieurs styles à leur extrémité (p. 340).

Egg-tubes carrying styles at their tip would be an anomaly indeed.

Burmeister repeated this blunder in 1833 by declaring:

Ausserdem gehören noch die beiden von Desmarest erwähnten Gattungen *Nogaus* Leach. und *Risculus* Leach. heigher (Caligina), welche sich durch Anhänge am Ende der Eierhalter von allen unterscheiden (p. 331).

These mistakes become doubly ridiculous when we remember that Leach's original specimen, which as yet remained the only one described, was a *male*.

Only a few details were added by other writers and even so good a systematist as Milne Edwards was content to say when defining this genus in his great work on the Crustacea published in 1840:

Il est caractérisé principalement par la structure des pates postérieures, lesquelles, au lieu d'être simples et subambulatoires comme chez les Caliges, sont biramées et natatoires comme celles des paires précédentes (p. 459).

As though this were not common, also, to every genus of the Pandarinæ. Indeed Milne Edwards himself, in describing the genera of the Pandarinæ, states under nearly every one, "Les pates sont conformées comme chez les Nogagues."

He then adds under *Nogagus*:

Le thorax se compose de quatre grands articles bien distincts; et le premier de ces articles (correspondant au second anneau thoracique, le premier anneau étant toujours confondu avec la tête) présente de chaque côté un petit prolongement lamelleux. Enfin, les deux petites lames natatoires qui terminent l'abdomen sont un peu plus développées que chez la plupart des Caligiens (p. 459).

In making this last statement he substituted one error for another; the anal laminæ are most certainly not "tubes ovifères," as he recognized, but neither can they be regarded as "lames natatoires."

With regard to their size he evidently failed to consider the fact that he was speaking exclusively of males. The anal laminæ in this sex are always larger than in the females, and those possessed by *Nogaus* species are no larger than would naturally be expected.

With reference to his first statement, in spite of the fact that the thorax segments are separate and free, only the first one being joined with the head, nevertheless he places the genus under the "Caligidæ," and not under the "Pandaridæ," where it would legitimately belong. To judge from his tabular key to the various genera this location of *Nogaus* was based upon the fact that none of the species (which he now increases to three) possesses any dorsal plates upon the free thorax.

But again he forgets that these three species are made up exclusively of males, upon whose free thorax there would naturally be no dorsal plates, while the genera which he placed under the Pandaridæ are made up just as exclusively of females, who are the usual plate-bearers. A little reflection also would show that this absence of dorsal plates is more than overbalanced by the freedom of the thorax segments, and particularly by the structure and position of the mouth-parts.

These latter Milne Edwards entirely ignores, when even a cursory examination would have shown that they are like those found in *Pandarus* and allied genera, and considerably different from those of *Caligus* and its near relatives.

The genus being thus founded exclusively upon the characters of the male sex, there has been a constant effort to discover, if possible, a female of some of the species, in order that the genus diagnosis might be completed.

Gerstaecker published in 1853 the first account of a *Nogaus* female, which he called *Nogagus productus*. In discussing the synonymy he makes Müller's *Caligus productus*, Otto's *Caligus paradoxus*, and Nordmann's *Binoculus sexsetaceus* synonyms of his *Nogagus*, and claims that the latter name must stand by priority.

Müller's *Caligus productus* has been proved to be a *Dinematura*, the genus established for it in 1829 by Latreille, while Otto's *Caligus paradoxus* was made the type of the genus *Demoleus* by Heller in 1865. Nordmann's *Binoculus* becomes a synonym of this latter genus. Gerstaecker thus made two mistakes, first in supposing that Müller's female and Otto's male were the two sexes of the same species, and, second, in assuming that Otto's male belonged to the same genus as *Nogaus latreillii*, Leach's original type. These mistakes render his paper of no value so far as the present genus is concerned, for the female which he presents is not a *Nogaus* at all, but a *Dinematura*.

The second attempt at finding a *Nogaus* female was made by Kröyer in 1863. He described (p. 168) several specimens of two kinds of these parasites which had been secured from the outside surface of a large *Carcharias* taken in the open Atlantic.

The larger of the two forms he found to be males, identical with Leach's *Nogaus latreilli*; the smaller ones were females, and he considered them as the females of the same species.

The only reasons actually given for this opinion were that the two forms were found on the same fish and were of the same color.

The statement was also made that a detailed examination confirmed this view, but no details were given.

This assumption of the identity of the two sexes led Kröyer to the further declaration (p. 173) that Dana's *Nogagus validus* and *Specilligus curticaudis*, which were taken together upon one fish, are probably the two sexes of the same species.

Nogagus tenax (Steenstrup and Lütken, 1861) and *Nogagus gracilis* (Burmeister, 1832) he also regarded as females of the same genus.

In fact, Kröyer regarded the two groups into which Steenstrup and Lütken had divided their *Nogagus* species as made up, the one group of males and the other of females.

A careful examination of Kröyer's description, and especially of his excellent figures, makes it reasonably certain that the smaller forms which he called the females of *Nogagus latreilli*, and which were stated to be immature, are really young females of the genus *Nesippus*. If his figures be compared with figure 205 of the present paper, which is certainly an immature *Nesippus*, it will be found that they are so similar as to leave little doubt that they belong to the same genus.

Furthermore, there are in the collection of the U. S. National Museum several lots of specimens obtained by the steamer *Albatross* of the Bureau of Fisheries. Each lot includes the species obtained from a single fish, and in three instances these embrace specimens of *Nogaus latreilli* and *Nesippus alatus*.

The two have been obtained together on the same fish by the author also on several occasions.

As to Dana's two species, *Nogagus validus* and *Specilligus curticaudis*, which have been personally examined and are described on pages 397 and 434, they are both certainly males, and therefore could not very well be the two sexes of the same species. This is also true of all the *Nogaus* species described by Steenstrup and Lütken which have come under the author's observation. They are all males and are clearly so described by those authors.

As the search for a *Nogaus* female progressed it became more and more evident that the forms grouped under the genus name "*Nogagus*" were in reality the males of several different genera.

As early as 1861 Steenstrup and Lütken, in speaking of the *Pandarinæ*, after deploring the fact that both sexes were known of but a single species in the entire subfamily, ask the question, "May not the forms included in the genus *Nogagus* be the true males of those females belonging to the genera *Dinemura*, *Phyllophorus*, *Pandarus*, *Ganglio-*

pus, and *Lepidopus*?" Not being able to answer the question definitely, they concluded to classify all male forms as "*Nogagus*" species, while the females were placed in the other genera. They then divided the "*Nogagus*" forms into two groups and the same division was subsequently adopted by Gerstaecker in Broun's Thierreich. In the latter publication Gerstaecker even names his second subfamily after this genus, calling it the *Nogagina*. The two groups as given by Steenstrup and Lütken are: A, those having the fourth legs biramose, the rami two-jointed, and the "tail" (abdomen) two-jointed; B, those having the fourth legs biramose, the rami one-jointed, and the "tail" also one-jointed.

A comparison of the data given on the following pages will show that this was really the first step toward a separation of the different genera included in this imaginary genus. Under the first group (A) would come the males of *Pandarus*, *Echthrogaleus*, and *Dinematura*, while in the second group (B) would be included the males of *Nesippus* and *Perissopus*. But there are two genera which were not included in either group, *Demoleus*, which belongs in the first group and is the largest of all the *Nogaus* forms, and *Gangliopus*, in the males of which the abdomen is two-jointed, but the rami of the fourth legs have only a single joint.

Gerstaecker reverses the order of the two groups and says nothing about the joints of the abdomen.

Steenstrup and Lütken and Heller place the "*Nogagus*" species under the Pandarinæ; Gerstaecker makes of them a third subfamily, distinct from both the Caliginæ and Pandarinæ, calls it, as noted above, the *Nogagina*, and includes in it along with "*Nogagus*" the genera *Nesippus*, *Demoleus*, *Dysgamus*, *Euryphorus*, *Trebius*, *Elytrophora*, *Alebion*, *Dinematura*, and *Echthrogaleus*.

Most other writers place the *Nogaus* forms under the Caliginæ, even so recent a writer as Bassett-Smith (1899) putting them there. That they really belong with the Pandarinæ was well argued by Hesse in 1883, who gave the following reasons for such a classification: (1) The grooves separating the areas on the dorsal surface of the carapace are not like those in the Caliginæ. This is due to the fact that (2) only one thorax segment is fused with the head, all the others being free, while in the Caliginæ three of the segments are fused with the head and only one is free. (3) The anal laminae are larger and flatter than those in the Caliginæ, and are similar to those in the Pandarinæ. (4) The eyes are not fused on the mid-line, but are separated after the manner of the Pandarinæ, and there is a third eye similar to that in many of the latter. (5) There are no lunules, furca, nor first maxillæ. (6) The mouth-tube is elongated and narrow-conical, terminating in a lanceolate point exactly like that of *Pandarus*, but very different from the short and wide tube of the Caliginæ, which is bluntly rounded at

the tip. (7) The structure of the third legs is radically different from that of the Caliginæ and similar to that of the Pandarinæ (p. 29).

These reasons are well stated and convincing, but unfortunately Hesse made such serious blunders, both morphological and physiological, in this same paper that they have virtually annulled the force of his systematic argument. Some of these errors have already been discussed elsewhere.^a It is sufficient to state here that Hesse describes his "*Nogagus spinacii-achantias*" as a female, with the male unknown. His attempt, therefore, to establish a female *Nogaus* is the third in chronological order. His only apparent reason for considering his specimen a female is the fact that he found a chalimus embryo attached to its carapace.

He accordingly assumes that the adult is the mother and the chalimus is her offspring.

Both the description and the figures which Hesse gives show that the adult is a male and not a female; and in all probability it is the male of "*Pandarus spinacii-achantias*," which Hesse obtained from the same fish and in company with the "*Nogagus*" (see p. 458).

The fourth attempt to find a *Nogaus* female was the publication by Beneden in 1892 of the two sexes of "*Nogagus angustatus*." Beneden states that he considers this the same as Gerstaecker's "*Nogagus angustulus*," the male of which was published in 1854. The difference in the spelling of the two species names is accounted for by a printer's error in Gerstaecker's paper. In the text the name appears as *angustulus*, but in the explanation of the plates it is changed to *angustatus*. But Beneden also made two mistakes here; in the first place the male of his species is quite different from that described by Gerstaecker, (a) in the relative size of the carapace, (b) in the fusion of the second and third thorax segments, which are entirely distinct in Gerstaecker's male, (c) in the size and more especially the shape of the genital segment, (d) in the abdomen, one-jointed and very short in Beneden's specimen, but two-jointed and two-thirds as long as the genital segment in Gerstaecker's species (see pp. 351 and 431).

The second error was in naming the female from the male; if Beneden's figure of the female is at all accurate, it belongs to the genus *Nesippus*. And hence his male becomes a male *Nesippus* instead of the female becoming a female *Nogaus*.

This latter genus is therefore left as it was at the beginning, without a single female representative of any of the species. Indeed, the only female which could possibly bear the genus name *Nogaus* would be the female of Leach's original type *Nogaus latreilli*. But this female is now found to be the form described by Leach in the same paper on the preceding page under the name *Pandarus cranchii*. This genus

^a Proc. U. S. Nat. Mus., XXVIII, pp. 547-548.

Pandarus was established three years previously by the same author, and hence the genus name *Nogaus* becomes a synonym of *Pandarus* and must be dropped.

Such being the condition, it becomes necessary to assort the various *Nogaus* species and connect them as the male sex with the proper females described in other genera. Several efforts have already been made in this direction, but there has been such an utter abandon of even the simplest rules of systematization that it would be deplorable if it were not so ridiculous.

With one or two exceptions, the only reason which an author has offered for considering a *Nogaus* form as the male of any species has been the simple fact that it was found with the female of that species upon the same fish. And some have not even taken the trouble to go thus far, but have considered a similarity of geographical distribution sufficient evidence of probable identity in the two sexes.

Geographical distribution certainly counts for something, and the finding of the two sexes upon the same fish counts for more, but neither of them has any weight at all when compared with morphological details, except in confirmation of the latter.

And yet these morphological details are the very things which have been most neglected. In the preparation of the present paper the author has had occasion to examine in minute detail the various genera which compose the subfamily Pandarinæ.

And along with the others came an extended study of this group known as the genus "*Nogagus*." An earnest endeavor has been made to separate these forms upon a morphological basis, and to connect each of the types with the genus which is its morphological counterpart. In this effort the author has been greatly assisted by the fact that he has himself taken three of the types in actual copulation with females of as many different genera. And about the same number have been recorded by other writers who have dealt with the Pandarinæ.

The parts of special importance in comparing the various species are the second maxillæ, the second maxillipeds, the rami of the swimming legs, the relative size and shape of the genital segment and abdomen; and the presence or absence of the fifth and sixth pairs of legs and of the lens-like protrusions called by Dana (1852) "conspicilla" on the dorsal surface of the carapace.

Using these morphological details as a basis of comparison, we may separate the *Nogaus* forms into the following genus types:

Genus Pandarus.—Carapace broad and well rounded, without conspicilla, but with accessory posterior lobes; genital segment enlarged, showing both the fifth and sixth legs; abdomen two-jointed, joints about the same size; legs all biramose, rami two-jointed; second

maxillæ flattened and laminate; second maxillipeds much enlarged and armed with both claws and knobs. Here belong—

Certainly: *Pandarus bicolor* Scott, 1900.

Nogaus latreillii Leach, 1819.

Nogagus validus Dana, 1852.

Pandarus sinuatus, new male type.

Pandarus smithii, new male type.

Probably: *Nogagus spinacii-achantias* Hesse, 1883.

Genus Demoleus.—Carapace large, orbicular, without conspicilla or accessory lobes; genital segment elongate, no legs visible dorsally; abdomen two-jointed, joints unequal; anal laminae very large; legs all biramose, rami, two-jointed; second maxillæ narrow and spine-like; second maxillipeds not swollen, with a normal terminal claw and no knobs. Here belong—

Certainly: *Caligus paradoxus* Otto, 1828.

Nogagus grandis Steenstrup and Lütken, 1861.

Probably: *Dinematura musteli-lævis* Hesse, 1880.

Genus Perissopus.—Carapace elongate-elliptical, with conspicilla and with minute accessory lobes; genital segment not enlarged, one pair of legs visible in young specimens; abdomen one-jointed; anal laminae small; legs all biramose, rami of first three pairs two-jointed, of fourth pair one-jointed; second maxillæ short, slender, spine-like; second maxillipeds much swollen, with a short, curved claw and corrugated knobs. Here belong—

Certainly: *Perissopus communis*, new male type.

Probably: *Nogagus cælebs* Heller, 1865.

Pandarus cranchii Beneden, 1892 a.

Nogagus elongatus Heller, 1865.

Nogagus lunatus Steenstrup and Lütken, 1861.

Nogagus socialis Olsson, 1869.

Genus Nesippus.—Carapace acorn-shaped, short and wide, with conspicilla, without accessory lobes; genital segment slightly enlarged, elliptical, no legs visible dorsally; abdomen one-jointed; legs all biramose, rami of first three pairs two-jointed, of fourth pair one-jointed; second maxillæ with enlarged and flattened basal joint and slender terminal joint; second maxillipeds much enlarged, the terminal claw flattened and laminate; or with knobs only. Here belong—

Certainly: *Nogagus angustatus* Beneden, 1892 b.

Nesippus alatus Wilson, 1905.

Nogagus borealis Steenstrup and Lütken, 1861.

Specilligus curticaudis Dana, 1852.

Nesippus orientalis Heller, 1865.

Probably: *Pandarus affinis* Beneden, 1892 a.

Nogagus tenax Steenstrup and Lütken, 1861.

Nogagus brevicaudatus Milne Edwards, 1840.

Genus Gangliopus.—Carapace elongate-elliptical, without conspica; genital segment enlarged, quadrangular, showing one pair of legs; abdomen two-jointed, joints equal; anal laminæ small; legs all biramose, rami of the first three pairs two-jointed, of the fourth pair one-jointed; second maxillæ narrow and spine-like; second maxillipeds swollen, but whether with knobs or claws is not known. Here belongs probably Gerstaecker's *Nogagus angustulus* found with females of *Gangliopus pyriformis*.

Genus Echthrogaleus.—Carapace wide elliptical, without conspica or accessory lobes; second and fourth thorax segments lunate, the fourth fitting down over the rounded anterior end of the genital segment; the latter oblong, enlarged, showing one pair of legs; abdomen two-jointed, basal joint much the smaller; anal laminæ medium sized; legs all biramose, exopods of the second and third pairs three-jointed, other rami two-jointed; second maxillæ narrow and spine-like; second maxillipeds not much swollen, with terminal claw only. Here belong—

Certainly: *Echthrogaleus braccatus* (male) Heller, 1865.

Echthrogaleus perspicax (male) Thomson, 1889.

Dinematura neozealanica (male) Thomson, 1889.

Probably: *Pandarus armatus* (male) Thomson, 1889.

Genus Dinematura.—Carapace wide orbicular, without conspica or accessory lobes; genital segment enlarged, oblong, no legs visible; abdomen two-jointed, joints equal; anal laminæ large; all the legs biramose, rami of the first and fourth pairs two-jointed, of the second and third pairs three-jointed; second maxillæ slender, elongate, spine-like; second maxillipeds moderately swollen, with a terminal claw only, no knobs. Here belong—

Certainly: *Nogagus productus* Gerstaecker.

Dinematura latifolia, new male type.

Dinematura hamiltoni (male) Thomson.

Probably: *Dinematura elongata* Beneden.

Nogagus gracilis Burmeister.

Indeterminate.—*Nogagus luetkeni* Norman; *Pandarus mustelilævis* (male) Hesse; *Pandarus unicolor* (male) Hesse; *Pandarus spinacii-achantias* (male) Hesse.

Belonging to the Euryphorinæ.—*Nogagus errans* Kröyer; *Nogagus murrayi* Brady.

In order to complete this review of the *Nogaus* species so far as present data will allow, each of the thirty-four forms just located is taken up alphabetically in the following pages, and all available information with reference to it is given. The five new male types have, of course, never been referred to the genus *Nogaus*.

PANDARUS AFFINIS (Nogaus male) Beneden.

Pandarus affinis BENEDEN, 1892 a, p. 224, pl. 1, figs. 5 to 11.

The male of *Nesippus angustatus* Beneden (see p. 431).

NOGAGUS ANGUSTATUS Beneden.

Nogagus angustatus BENEDEN, 1892 b, p. 245, pl. 1, figs. 5 to 10.

Two females, adult and young, the latter Beneden's "male," both belonging to the genus *Nesippus*, species *angustatus* (see p. 432).

NOGAGUS AUGUSTULUS Gerstaecker.

Nogagus augustulus GERSTAECKER, 1854, p. 193, pl. VII, figs. 17 to 18.

The male of *Gangliopus pyriformis* described in the same paper (see p. 350).

PANDARUS ARMATUS (Nogaus male) Thomson.

Pandarus armatus (male) THOMSON, 1889, p. 363, pl. XXVII, figs. 1 a to f.

In describing this species among the parasitic copepods of New Zealand in 1889, Thomson gives the figure and description of a specimen taken along with the females, which he assumed must be the male of the species. But, on comparing this figure and description with the one given in the same paper for the male of his new species, *Dinematura* (*Echthrogaleus*) *neozelandica*, it is at once evident that they are identical. Both were obtained, to quote his own language, which is the same in the two cases, "by the captain of the whaling barque *Splendid*, presumably off a shark." They agree exactly in size, in the proportions and shape of the various body parts, and in the details of the appendages. This agreement is most noticeable in the fourth legs, which in both forms have a two-jointed endopod and a three-jointed exopod, unlike all the other *Nogaus* species. With this single exception they both conform exactly to the type here established for *Echthrogaleus* males, and may be referred to that genus.

PANDARUS BICOLOR (Nogaus male) T. Scott.

Pandarus bicolor T. SCOTT, 1900, p. 157, pl. VI, figs. 33 to 38.

This author, who has done a large amount of excellent work upon fish parasites, particularly in Scottish waters, and who has published many valuable papers, described in the Eighteenth Annual Report of the fishery board of Scotland, a *Nogaus*-like copepod which he considered as the male of *Pandarus bicolor*.

On examination of his description and the figures which accompany it, this *Nogaus* is found to conform in every detail with the other *Pandarus* males, and it may therefore be accepted as the male of the species to which Scott refers it.

The carapace has broad posterior lobes; the genital segment is enlarged and shows a pair of sixth legs at its posterior corners, and a pair of fifth legs just in front of the corners on the lateral margins; the abdomen is two-jointed, the joints equal; the antennæ and mouth parts are like those of the female *bicolor*, and the rami of the swimming legs are all two-jointed.

NOGAGUS BOREALIS Steenstrup and Lütken.

Nogagus borealis STEENSTRUP and LÜTKEN, 1861, p. 387, pl. XI, fig. 21.

This species was first described by the above authors from five specimens, three of which had been taken on a voyage to the West Indies and the other two on a voyage to Greenland, the exact localities being given for the latter only. They show the following characteristics: Carapace oval, considerably less than half the entire length, with short and narrow posterior lobes; three free segments diminishing regularly in width, but about the same length; genital segment rectangular, twice as long as wide, with two longitudinal furrows on both dorsal and ventral surfaces.

Abdomen one-jointed, anal laminæ short and very wide. First antennæ with long and bushy setæ; first maxillipeds with stout terminal claw and small accessory claw, both armed with short hairs, and with a small bunch of hairs between their bases. Rami of the first three pairs of legs two-jointed, of the fourth pair one-jointed. These characters are the same as those of the single specimen described on page 437 and warrant the placing of this species under the genus *Nesippus*.

ECHTHROGALEUS BRACCATUS (Nogaus male) Heller.

Echthrogaleus braccatus HELLER, 1865, p. 197, pl. XX, fig. 3.

A male *Echthrogaleus* (see p. 366).

NOGAGUS BREVICAUDATUS Milne Edwards.

Nogagus brevicaudatus MILNE EDWARDS, 1840, p. 460.

Milne Edwards has given us the only description ever published of this species, a short and very incomplete one, as follows: "Espèce très voisine du Nogague grêle (*N. gracilis*), mais ayant l'abdomen plus court et composé d'une seule pièce subtriangulaire. Trouvé aux environs de Ténériffe."

There are no figures with this description, and thus while it is probable that the species is identical with Steenstrup and Lütken's *Nogagus tenax*, as those authors suggest, there is no possible way to prove this, and we must wait for further data before becoming able to locate it definitely.

NOGAGUS CÆLEBS Heller.

Nogagus caelebs HELLER, 1865, p. 208, pl. xx, fig. 4.

Like the preceding, only a single description of this species has ever been published, but that was so accurate, and the figures accompanying it so clear, that we have little difficulty in locating the species in the genus *Perissopus*.

It shows distinctly the narrow lateral lobes of the carapace, separated from the central portion by well-defined grooves; the characteristic conspicilla almost touching each other on the mid-line near the frontal plates; the short and very wide second thorax segment, with its lateral lobes directed backward; the third and fourth segments diminishing in width but increasing in length, the wide and short, one-jointed abdomen with large anal laminae.

The mouth-parts and maxillipeds are very similar to those in the female *Perissopus*, while the details of the swimming legs are almost identical with those of the latter species.

The only difference is found in the genital segment, which is trapezoidal, widened posteriorly with rounded angles, each armed with a large spine and a seta. But this may well be a specific difference and only serve to emphasize the resemblances.

The species is rather small (4 mm. long) for either *Pandarus* or *Nesippus*, but is just right for the genus *Perissopus*, where it undoubtedly belongs.

PANDARUS CRANCHII (*Nogaus* male) Beneden.

Pandarus cranchii BENEDEN, 1892 a, p. 221, pl. I, figs. 1-5.

In the same paper in which he described *Pandarus affinis* (see p. 444) Beneden also presented a *Nogaus* form which he claimed to be the male of *Pandarus cranchii*. Although the description in the text is no better than for *affinis*, yet the author has given for this species a view of the ventral surface, showing all the appendages. From this we can gather enough data to show clearly, in connection with the general body form, that the copepod is not a *Pandarus* at all, but belongs either to the genus *Nesippus* or *Perissopus*. The carapace is narrow and elongated, with narrow posterior lobes, and without accessory lobes; the three free segments and the genital segment are all about the same width; the latter is very small and shows no traces of legs on its sides or posterior corners; the abdomen is one-jointed, very small and triangular, and is armed with small and triangular anal laminae; the second maxillipeds are armed with forceps knobs and not with claws; the rami of the fourth legs have but a single joint.

Further along in the same paper Beneden describes what he calls a new genus, and to which he gives the name *Chlamys incisus*; Bassett-

Smith, in 1899, recognized this as a *Perissopus* and relocated it correctly under that genus.

Beneden gives us absolutely no data as to the size of either the *Nogaus* male or the female *Chlamys*, nor as to the hosts upon which they were found. We learn incidentally that they both came from the Archipelago of the Azores, and the *Chlamys* is further located from the Bay of Dakar. Since this *Chlamys* proves to be a *Perissopus* female, and since the *Nogaus* male conforms in its anatomy to the type of *Perissopus* males, it is possible that it will prove to be the male of this *Perissopus* (*Chlamys*) *incisus*.

At all events it is not a *Pandarus* male, and least of all that of the species *cranchii*, the true male of which is described on page 405.

SPECILLIGUS CURTICAUDIS Dana.

Specilligus curticaudis DANA, 1852, p. 1375, pl. xcv, figs. 6 a to h.

A male *Nesippus* (see p. 434).

DINEMATURA ELONGATA (Nogaus male) Beneden.

Dinemoura elongata BENEDEN, 1892 a, p. 231, pl. II, figs. 11 to 13.

Probably a *Dinematura* male (see p. 382).

NOGAGUS ELONGATUS Heller.

Nogagus elongatus HELLER, 1865, p. 206, pl. XX, fig. 5.

This was described as a new species by Heller, but he added the statement that it was found in company with *Pandarus dentatus* and was probably the male of this latter species.

Bassett-Smith, in 1899, accepted this statement and gave the name as a synonym of *Pandarus dentatus*, but with a question mark after it. A careful examination of the description and figures given by Heller render it probable that this species is not a *Pandarus* male, but that it belongs to the genus *Perissopus* for the following reasons: The carapace is much longer than wide with very long and narrow posterior lobes; well-defined conspicilla are present near the anterior border and there are no accessory lobes.

The swimming legs have long and slender rami instead of short and stocky ones; the pattern of the legs and the number and arrangement of the setae conforms more closely to the type seen in *Perissopus* than to that seen in *Pandarus*; the fourth legs have but a single joint in each ramus. The genital segment is not enlarged, but is short and small, and shows no traces of either the fifth or sixth legs. The abdomen is small and contains but a single joint, instead of the two found in *Pandarus* males.

It has therefore been placed under the genus *Perissopus* awaiting further evidence.

NOGAGUS ERRANS Kröyer.

Nogagus errans KRÖYER, 1863, p. 173, pl. x, fig. 3 a to h.

This species is based upon a single specimen captured in a tow-net while swimming freely at the surface in the Atlantic Ocean near Porto Santo. At the close of his description Kröyer states: "It is clear that this animal, in spite of its four free thorax segments, differs significantly from *Nogagus* forms in the shape of the rostrum, the presence of a furca, the rudimentary condition of the endopod of the first legs, and the absence of this ramus in the fourth legs. Consequently it forms a connecting link with the Caliginæ, but does not belong to any of the established genera in that group, as far as I can see.

It would therefore be justifiable to make of it a new genus, but I am not so inclined on account of the scarcity of material (only *one* specimen), and so will leave it for the present under *Nogagus*." This species evidently belongs to the *Euryphorinæ* instead of the *Pandarinæ*, and is closely related to *Dysgamus*, *Euryphorus*, and especially to the new genus, *Dissonus*, recently established by the present author upon material obtained from Ceylon.^a It certainly does not belong to any of the *Nogaus* types here established, and consequently should not, even temporarily, find shelter in the much-abused genus "*Nogagus*."

DINEMATURA GRACILIS (*Nogaus* male) Burmeister.

Dinematura gracilis BURMEISTER, 1833, p. 284, pl. xxiii, fig. 1.

Nogagus gracilis MILNE EDWARDS, 1840, p. 460.

This species was first described by Burmeister under the name *Dinematura*, in the belief that it was a male of that genus. Milne Edwards changed the name to *Nogagus*, but without giving any reasons for so doing, and without adding anything in the way of description. Frey and Leuckart, in their large work on the Wirbelloser Thiere, published in 1847, examined other specimens of this species and say of them (p. 166), that they could only find two segments in the abdomen instead of three as reported by Burmeister. The terminal segment showed a median posterior incision, and appeared to be made up, through the contraction of the basal joints of a pair of legs metamorphosed into swimming lappets; each of the latter was armed with four setæ instead of three. The posterior lobes of the carapace were longer and narrower than in Burmeister's specimen, and overlapped the following segment, whose lateral lobes were only feebly developed. At the close of his description Burmeister declares that he has but a single specimen, taken from a *Squalus acanthias*. And he can not, therefore, affirm with certainty

^a Report to the Government of Ceylon on the Pearl-Oyster Fisheries, Supplementary Report, XXXIV, p. 198, pl. iii.

that it is a new species, since the female is unknown. In his description he has mistaken the large glands connected with the double frontal filament for eyes; he also speaks of two "braune Knopfchen" situated farther back on the dorsal surface of the carapace. He gives but a single figure for the last three pairs of swimming legs, which he declares are just alike, even to the number of spines and setæ borne on the different joints of the rami. If this be true, the species can not possibly be a *Dinematura*, since in that genus the male, like the female, has the rami of the second and third legs three-jointed. In *Echthrogaleus* also the exopods of these legs are three-jointed, while the endopods are two-jointed.

On the other hand, Burmeister's species can not be a *Nesippus* or *Perissopus* male, because the rami of the fourth legs and the abdomen in those genera have each but a single joint.

Furthermore the statement of Beneden (1892 a, p. 220) that Burmeister's *Dinematura gracilis* and Leach's *Pandarus carchariæ* are the male and female of the same species is obviously wrong.

For *Dinematura gracilis* lacks the accessory lobes on the posterior margin of the carapace, there are no legs visible on the genital segment, and while the abdomen is two-jointed the joints are very unequal. In *Gangliopus* the rami of the fourth legs are one-jointed, and the abdomen is like that of *Pandarus*, two-jointed with the joints equal. This leaves us the single genus *Demoleus* amongst those whose males are known, and to this we find the present species corresponding in every particular except size.

But here the discrepancy is a serious one, for Burmeister's species is only half the size of the other males of the genus.

There is also the possibility that Burmeister did not examine the second and third legs very closely; indeed his statement that they are just like the fourth pair, even in the number of spines and setæ, would imply as much, for no *Nogaus* male has yet been discovered of which this would be true.

If he did not examine them closely, or if his specimen was immature and the segmentation not fully completed, then there is an agreement in every particular, even size, with the males of the genus *Dinematura*, and Burmeister located his species correctly.

His specimen was a little over 6 mm. in length; the adult males of *Dinematura* are 8 or 9 mm. long.

It is, of course, impossible to decide definitely in such a case, since the very data essential to a decision are lacking, but the presumption seems to be in favor of the latter proposition.

NOGAGUS GRANDIS Steenstrup and Lütken.

Nogagus grandis STEENSTRUP and LÜTKEN, 1861, p. 386, pl. x, fig. 19.

Probably a male *Demoleus* (see p. 349).

DINEMATURA HAMILTONI (Nogaus male) Thomson.

Dinematura hamiltoni THOMSON, 1889, p. 357, pl. xxv, figs. 1 a to j.

This species described by Thomson in 1889 included both sexes, and their anatomy conforms so closely as to leave no doubt of their identity. The male also corresponds in every detail given with the type here established for the genus *Dinematura*, and it may therefore be accepted as originally published.

NOGAUS LATREILLII Leach.

Nogaus latreillii LEACH, 1819, p. 536.

The male of *Pandarus cranchii* (see p. 405). For the form which Krøyer claims to be the female of this species see page 442.

NOGAGUS LUETKENI Norman.

Nogagus luetkeni NORMAN, 1869, p. 300.

This species was described briefly in the Shetland Final Dredging Report, in 1869, by the Rev. Canon A. M. Norman, and was apparently based upon a single specimen obtained from a skate.

Its carapace was orbicular with large and incurved posterior lobes; the genital segment enlarged, longer than broad, and without rudimentary legs; abdomen two-jointed, the joints unequal; anal laminae large and armed with large setae. But as absolutely nothing is said with reference to the size of the creature, or to the structure of the swimming legs, it is impossible to locate it definitely.

NOGAGUS LUNATUS Steenstrup and Lütken.

Nogagus lunatus STEENSTRUP and LÜTKEN, 1861, p. 389, pl. ix, fig. 17.

The above-named authors give the following for this species:

"Two specimens were taken by Captain Hygom on the same voyage and in the same latitude and longitude as *Echthrogaleus coleoptratus*, and so probably together with them. Whether they are possibly the males of that species we do not venture even a conjecture." In this respect they are wiser than Claus, who, in describing his new genus *Luetkenia* in 1864, says there is the same difference between the sexes in the posterior part of the body as there is between *Echthrogaleus coleoptratus*, Guérin and *Nogagus lunatus*, Steenstrup and Lütken, and ventures the conjecture that these latter are the two sexes of the same species.

Two things are very evident here, first, that the host of this *Nogagus lunatus* is not known, and it is therefore conjectural whether it came from the same fish as the *Echthrogaleus* or from a different one. In the second place there was evidently not enough agreement in the anatomy of the two forms to warrant even a conjecture on the part of the original describers as to their relationship. This indicates that

they are not likely to be the two sexes of the same species, and we find that their anatomy confirms such a conclusion.

The shape of the grooving of the carapace in the *Nogaus* form is radically different from that in the female of *Echthrogaleus coleoptratus*, and also from that of such of the males of this genus as are known. The fourth and genital segments are also very different from those in *Echthrogaleus* males in their relative size and shape. The second and third legs have only two joints in the exopods, while the rami of the fourth legs are one-jointed. The second maxillipeds are much swollen and are armed with short curved claws and corrugated knobs.

In all these particulars and in its size the species corresponds closely with *Nogagus caelebs* and *Nogagus elongatus*, and may therefore be temporarily assigned a place in the genus *Perissopus* instead of *Echthrogaleus*.

NOGAGUS MURRAYI Brady.

Nogagus murrayi BRADY, 1883, p. 136, pl. LV, fig. 1.

Brady's description in the Report on the Copepoda of the Challenger Expedition is as follows:

Length, 4 mm. Cephalothorax ovate, much longer than broad and nearly twice as long as the abdomen; frontal margin rounded, lateral margins somewhat sinuous, posterior angles moderately produced backward and rounded off. First abdominal (genital) segment about as long as broad, margins round; angles not at all produced nor acute. Two posterior abdominal segments much broader than long, the last pentagonal in shape, and produced backwards between the caudal lamellæ into two obtuse points; caudal lamellæ about as broad as long, subquadrate, each bearing four finely plumose setæ.

Taken in the open sea off Rio de Janeiro, and in the North Atlantic (about lat. 25° N.), April 28, 29, 1876. Very similar to *Nogagus errans* Krøyer, which, however, differs decidedly in the shape of the last abdominal and two posterior thoracic segments.

In the figure which accompanies this description and which is labeled "Adult female (?) seen from below," only two pairs of legs are shown, the third and fourth pairs, in both of which the rami are represented as one-jointed. No adhesion pads are shown at the bases of either pair of antennæ, nor anywhere else on the ventral surface. The mouth-tube is short, broad, and well rounded at the tip, and there is a very well-defined furca on the mid-line between the bases of the second maxillipeds.

These last details, if reliable, prove that the copepod is not a *Nogaus* at all, but one of the Euryphorinæ, resembling, perhaps, the genus *Dysgamus* more than any of the others.

PANDARUS MUSTELI-LÆVIS (Nogaus male) Hesse.

Pandarus musteli-lævis HESSE, 1883, p. 23, pl. VI, figs. 6-8, 14, 18, and 21-23.^a

This *Nogaus* form is another of Hesse's fabrications, his new species being founded on a single male and a young female.

Enough data can not be obtained from Hesse's text and figures to determine where this species belongs; the figures he presents are wretched, badly confused, and highly contradictory, while the text gives none of those data which are essential in accurate systematization. In fig. 6, which is a dorsal view of the male, the second legs are each uniramous and one-jointed; in fig. 7, which is a ventral view of the same specimen, the second legs are each biramous, the rami of the left one being one-jointed, while the right one has a two-jointed exopod and a three-jointed endopod. The first legs are similar to those described for his *Nogaus spinacii-achantias* (see p. 458), and are radically different from anything ever seen. The rami of the fourth legs as seen in dorsal view are one-jointed, while in ventral view they are two-jointed. The abdomen in dorsal view is two-jointed, the terminal joint extending out over the bases of the anal laminae in two broad, rounded lobes; in ventral view it is three-jointed, the terminal joint triangular and contracted nearly to a point between the anal laminae. The species as it stands, therefore, can not be located anywhere with even reasonable probability.

DINEMATURA MUSTELI-LÆVIS (Nogaus male) Hesse.

Dinemoura musteli-lævis HESSE, 1880, p. 5, pl. I, figs. 1-16.

Probably belongs to the genus *Demoleus* (see p. 386).

DINEMATURA NEOZEALANICA (Nogaus male) Thomson.

Dinematura neozealanica THOMSON, 1889, p. 359, pl. XXV, fig. 2.

Thomson here described both sexes of a new species which he placed in the genus *Dinematura*; they agree so fully in their anatomical details as to leave no doubt of their identity.

But as Bassett-Smith pointed out in 1899 they belong to the genus *Echthrogaleus* rather than *Dinematura*. The male (and incidentally the female also) corresponds in every essential detail with the types established for the genus *Echthrogaleus*, and thus the species will stand as the New Zealand representative of that genus.

^a The figures as published by Hesse were numbered incorrectly (see p. 396); figs. 4 and 6 should be interchanged, as also figs. 17 and 23.

NESIPPUS ORIENTALIS (Nogaus male) Heller.

Nesippus orientalis HELLER, 1865, p. 194, pl. XVIII, figs. 2, 3.

After establishing his new genus *Nesippus* in 1865, Heller describes two species, *orientalis* and *crypturus*.

For the first of these, which would become the type of the new genus, he presents the female and a form which he claims to be the male, and gives admirable descriptions and figures of each.

But the "male" differs from the female only in being smaller, in having a sharp terminal claw on the second maxillipeds, longer plumose setæ on the swimming legs, and in the abdomen being visible in dorsal view. If the figure of the young female of the species *alatus* given in the present paper (Plate XXXIV, fig. 205) be compared with that of the adult female (fig. 194), exactly the same differences will be found, while the true male (fig. 206) has a very different carapace, and the second and third thorax segments are free instead of being fused as in the young female (see p. 429). This "male" of Heller's therefore was almost certainly a young female similar to those repeatedly found by the present author in company with the adults of *alatus*.

CALIGUS PARADOXUS (Nogaus male) Otto.

Caligus paradoxus OTTO, 1828, p. 352, pl. XXII, figs. 5, 6.

The male of *Demoleus paradoxus* (see p. 349).

ECHTHROGALEUS PERSPICAX (Nogaus male) Olsson.

Echthrogaleus perspicax OLSSON, 1869, p. 18, pl. I, figs. 6, 7.

The description and figures of this species are found to correspond in every particular with those of the other males of the genus, and the species will therefore stand as originally described.

NOGAGUS PRODUCTUS Gerstaecker.

Nogagus productus GERSTAECKER, 1853, p. 63, pl. IV, figs. 1-10.

This proves to be a female *Dinematura*, Gerstaecker wrongly substituting the name *Nogagus* on the ground of priority (see p. 441).

NOGAGUS SOCIALIS Olsson.

Nogagus socialis OLSSON, 1869, p. 16, pl. I, fig. 5.

Found on the body of *Acanthias vulgaris* in the Sea of Skagerrack, together with both sexes of *Echthrogaleus perspicax*.

From the excellent description and figures given by Olsson we find that the carapace is elliptical with narrow posterior lobes; the genital segment is not enlarged; one pair of legs are visible at its posterior corners; the abdomen is one-jointed, with small anal laminae; the

second maxillipeds have a short, curved claw and corrugated knobs; the rami of the first three pairs of legs are two-jointed, of the fourth pair one-jointed.

This locates the species in the genus *Perissopus*, and on comparing it with Heller's *Nogagus caelebs* and *Nogagus elongatus*, the three are seen to be so nearly alike that it even seems probable they are but variations of the same species. At all events they are very closely related forms of the same genus.

NOGAGUS SPINACII-ACHANTIAS Hesse.

Nogagus spinacii-achantias HESSE, 1883, p. 1, pl. IV, figs. 1-7.

Pandarus spinacii-achantias HESSE, 1883, p. 10, pl. VI, fig. 9.

This species was described as a female by Hesse, and was based upon several specimens obtained from the head of a *Spinax achantias*; the male was said to be unknown. We have already given Hesse's reason for considering these specimens females (see p. 335). There can be no doubt that they are really males, but almost no dependence can be placed upon the figures and description given by Hesse. For example, in the dorsal view the second legs have a three-jointed exopod, while the endopod is not visible; in an enlarged figure of the same legs they are represented with a three-jointed endopod and a two-jointed exopod, while in the ventral view both rami are distinctly two-jointed. The text says nothing whatever about these legs.

In the face of these and many other similar discrepancies it would seem almost hopeless to attempt to locate the species.

But Hesse is at least consistent, and after a time we can learn what to expect and can make rational allowances.

A comparison of the figures and description he has given of the present species and of a new *Pandarus*, found upon the same fish, and named similarly *Pandarus spinacii achantias*, leaves not much doubt that they are the male and female of the same species.

First the relative sizes are correct, 5 or 6 mm. for the *Nogaus* and 6 or 7 mm. for the *Pandarus*.

In the second place, the new *Pandarus* is evidently located correctly, as is shown by the number and arrangement of the dorsal plates and by the appendages. Hesse, however, gives it but three pairs of swimming legs, describing in place of the first pair what he calls—

Appareil de fixation, qui est placé transversalement à la base du bouclier céphalique et représenté par un tige qui émet, de chaque côté, des appendices recourbés ainsi que de petits crocs, destinés à saisir et accrocher les objets et est terminé par une longue griffe qui contourne une ventouse cupuliforme placée à l'extrémité externe du bouclier céphalothoracique.

None of the known species of *Pandarus* has any such a prehensile apparatus as this, nor is there any genus of crustacea in which the first legs have disappeared, leaving the other three present and fully developed. If this structure be as Hesse has represented it, his specimens will have to be made the types of a new genus. But again he is consistent, for, in speaking of the new *Nogaus*, after describing the second maxillipeds which he calls the "third thoracic feet," he says:

Au-dessous de celles-ci on aperçoit, placée horizontalement, une patte très étroite fixée par son centre au bouclier céphalique et terminée à son extrémité par deux petits articles, dont le dernier est recourbé en forme de griffe.

This evidently corresponds to the fixation apparatus of the female and makes the analogy between the appendages just what would be expected in the two sexes of a species.

Finally the general make-up of the body in this *Nogaus* is similar to that in the *Pandarus* males. There is the same broad carapace with what are evidently accessory posterior lobes, partially concealing the second segment; a considerably enlarged genital segment with large posterior processes, and a two-jointed abdomen with good sized anal laminae. There is thus considerable probability that we have here the two sexes of a species of *Pandarus*; whether it is a new species can not be determined without further data.

Hesse begins his description of the *Pandarus* species with the words "Mâle inconnu" (p. 10), but further along (p. 15), and in his figures (Plate VI, fig. 9) he has presented what he calls a "jeune mâle (?)." If this were really a young male of the species in question, it ought to correspond with other *Pandarus* males. But no details are given in the text, and those to be deduced from the figure are decidedly against the probability that the creature belongs to the genus *Pandarus*.

NOGAGUS TENAX, Steenstrup and Lütken.

Nogagus tenax STEENSTRUP and LÜTKEN, 1861, p. 388, pl. x, fig. 20.

This species was described by the above authors as follows: It outwardly resembles *Nogagus borealis*, but is smaller (6 mm. long), and less elongate; eyes distinct and near the anterior border. First free thorax segment broadly quadrangular with wide lateral lobes; the second one smaller and somewhat six-sided; the third the smallest and broadly eight-sided.

Genital segment not much longer than wide, the posterior corners projecting slightly and armed with spines. Abdomen triangular and bearing triangular anal laminae. Second maxillipeds sometimes showing an end claw and sometimes a forceps structure like

that in *Pandarus*. Rami of fourth legs one-jointed, of all the others two-jointed.

They give *Nogagus brevicaudatus*, Milne Edwards, as a synonym of this species and say that it is probable when it becomes better known it will be found identical with *tenax*. They then add in closing:

Since *N. tenax* is smaller than *N. borealis*, and is found farther south in the Atlantic, it would seem probable that it is the male of the smaller and more southern *Dinematura* described by us, *D. latifolia*. Still this is nothing more than a conjecture.

It has already been shown in the present paper (see p. 449) that the morphology of *Nogagus borealis* renders it probable that it is a *Nesippus* male rather than one of the genus *Dinematura*.

Moreover, there will be found described on page 386 the true male of *Dinematura latifolia* which is very different from the two species here mentioned. *Nogagus tenax* therefore is probably a *Nesippus* male, and so far as can be seen is identical with the one described on page 429 as the male of *Nesippus alatus*. There are slight differences in the angularity of the thoracic segments of *tenax* and the rounded outlines of *alatus*, but Steenstrup and Lütken's material had been in alcohol a long time, while the drawings in the present paper were made from living males.

Furthermore, this same species (*tenax*) has been reported by S. I. Smith upon Atwood's shark (*Carcharias atwoodi*) in Vineyard Sound. It was found in company with "*Nogagus latreillii*," a species of *Pandarus*, and *Echthrogaleus denticulatus*. Smith recognized that it was very different from *N. latreillii* and probably belonged to a different genus. He suggested *Echthrogaleus*, but the structure of the second and third legs prohibits this. No specimens of *Nesippus alatus* females have yet been obtained from Atwood's shark, but they are so common in Vineyard Sound on other sharks that the presence of a free swimming male on this particular species can be readily understood.

Again *tenax* is represented with small sharp spines near the posterior corners of the genital segment; similar specimens have been found among the males of *alatus*, but the outlines given in fig. 206 are more common. In all other particulars the two are practically identical, and accordingly *Nogagus tenax* has been given as a synonym under *Nesippus alatus* (see p. 426).

PANDARUS UNICOLOR (Nogaus male) Hesse.

Pandarus unicolor HESSE, 1883, p. 20, pl. VI, fig. 5.

This species was described in the same paper with *Pandarus musteli-lævis* and *Nogagus spinacii-achantias* and in a similar manner. The discrepancies in the appendages of the male are similar to those enumerated for the other species, but here the swimming legs are

all represented with rami having but a single joint. This species, therefore, like the others, can not be located with any reasonable probability.

NOGAGUS VALIDUS Dana.

Nogagus validus DANA, 1852, p. 1363, pl. xciv, figs. 9a to h.

The male of *Pandarus brevicaudis* (see p. 398).

Part 4.—THE CECROPINÆ.

ECOLOGY.

This new subfamily is made to include at the present time four genera which closely agree with each other in habits and morphology, and which differ very markedly from the genera included in the Pandarinæ. As the latter were shark parasites, so the present genera may be said to belong to the family of Head-fishes or Sunfish (Molidæ), although they are occasionally found on other fish. Two of the genera are so closely confined to the common Sunfish (*Orthogoriscus*, or *Mola, mola*) that they have been given generic names derived from that of their host, *Orthogoriscicola* and *Philorthogoriscus*, respectively.

A third genus, *Cecrops*, makes the sunfish its chief host, but has been found also on species of *Diodon*, *Thynnus*, and *Pleuronectes*, while the fourth genus, *Luetkenia*, lives upon *Asterodermus*, *Luarus* and several shark species.

These parasites are more gregarious than the Pandarinæ and are found in bunches of fifteen to thirty or more, attached to the outside skin and gills of the fish. The combined laceration of their claws often produces a large pit or sore, in the bottom of which they cling tightly. This peculiarity has been noted by A. Scott (1892, p. 266), who describes *Orthogoriscicola* as burrowing in pits formed in the flesh of the fish behind the anal fin. Nothing of this sort is found among the Pandarinæ for two reasons—first, they do not collect in such numbers, and then they cling partly if not chiefly by means of their adhesion pads. Hence when several of them do get together, as often happens on a shark's fin, there is very little laceration and no bunch or sore is formed.

Not only the females of the present subfamily, but the males as well remain fixed in one position upon their host, and both sexes are incapable of swimming. As already noted (see p. 327), this constitutes the last step in degeneration as exhibited in the Caligidæ. The female became a fixed form in one of the Caliginæ (*Echetus*), in several of the Euryphorinæ, and in all the Pandarinæ, but the progress of degeneration was very slow, and the swimming legs were retained in their normal form and armed with plumose setæ through all the

Caliginæ and Euryphorinæ. But in the Pandarinæ the fourth legs become transformed into lamellæ and lose their swimming setæ, the abdomen at the same time being transferred to the ventral surface of the genital segment. While the female has been thus gradually yielding to degenerative influences, the male has successfully resisted them, and even in the *Nogaus* form characteristic of the Pandarinæ there has been no loss in morphological details or functional activity. When the male at last yields, however, the change is not only abrupt, but is also far reaching; the intervening stages are passed over entirely and it changes directly from a condition as active and agile as that of *Caligus* into one more degenerate than that of any female among the Pandarinæ. The fourth legs are enlarged into enormous lamellæ, the third legs are as degenerate as the fourth pair in the Pandarinæ, and there is not a plumose seta to be seen on any one of the four pairs in *Orthagoriscicola*. The abdomen also has been partially transferred to the ventral surface of the genital segment, and there has been a fusion of the frontal plates with the carapace. In short, although the male retains to the full its structure and functions until the female has become thoroughly degenerate, yet the first change in the male makes it as degenerate as the female with which it is associated, and there are no intermediate stages.

This abrupt transition and the consequent degenerate character of the male forms one of the chief characteristics of the subfamily, and of itself is sufficient to distinguish the members of this subfamily from all the other Caligidæ.

The only locomotion possible to either sex is such as can be accomplished by loosening one set of prehensile organs and obtaining a new hold by stretching the body, while still keeping a second set securely fastened. When once placed, with the second antennæ buried in the flesh of the host, it is probable that the female does not subsequently change her position. The male is usually found attached to the female, the front margin of its carapace burrowed beneath the apron of her third swimming legs, and its second antennæ clasped around her fourth thorax segment. And when he has once gained this position the male probably does not change it during life.

The organs of prehension are similar to those in the Pandarinæ. The chief hold is maintained by the second antennæ, which are buried for their entire length in the skin and underlying flesh of their host. During life the body of the copepod frequently trails off in the water, with no attachment to the host except these antennæ, which gives it the appearance of being fastened by a frontal filament.

Usually, however, the antennæ are reenforced by the second maxillipeds and the adhesion pads. The latter are similar to those in the Pandarinæ, but there are two of them behind each first antenna, while there is none on the base of the second pair.

Neither these nor the ones on the bases of the swimming legs seem as well formed and efficient as those of the preceding subfamily, and they are evidently not of much service in prehension.

The attachment of the parasite to its host being thus accomplished entirely by means of stout claws buried in the fish's flesh, it follows that there can be no loosening of the hold after the death of the fish. These parasites certainly never drop off into the boat or anywhere else, as was claimed for the genera in the preceding subfamily. Both the antennæ and the maxillipeds are set so firmly in position that they can not be loosened without breaking them. And even after the death of the parasite it is usually necessary to cut around these appendages if one would remove the animal entire.

On being placed in an aquarium they are more helpless than the Pandarinæ, and both sexes can only lie in the place where they are put, with an occasional weak and spasmodic movement of the swimming legs. Hence they can be kept alive only a very short time, shorter even than in the case of the Pandarinæ.

Although they resemble the preceding subfamily in that the carapace is not arched and converted into a disk to retain moisture after the skin of the host may have dried, yet they are kept alive by another means for quite a period. It has already been noted that they are gregarious and gather together in colonies, whose combined lacerations form a deep pit extending through the skin and into the flesh of the host. Such a pit does not dry as quickly as other portions of the surface of the host's body, and the parasites, being fastened in its very bottom, are not only protected from abrasion, but are also kept moist long after the fish's skin has become dry and parched.

In this way they may sometimes be found alive on sunfish brought in by the fishermen.

MORPHOLOGY.

The chief differences in the morphological details of the present subfamily are such as result from a further degeneration in consequence of the fixed position of both sexes, and they are clearly brought out in the diagnosis which follows.

ONTOGENY.

The development of this subfamily has never been observed, but it must be similar to that of the Pandarinæ, if we may judge from the size, shape, and coloration of the eggs and from the chalmus of *Orthagoriscicola*, described on page 476.

We find in the latter a pair of broad and ribbon-like frontal filaments exactly like those on the chalmus of *Perissopus*. In this case, also, it was the male which was thus found, indicating that the two sexes mature at different periods.

Hesse, in the thirty-seventh article of his series entitled *Crustacés rares ou nouveaux des Côtes de France*^a makes the following statements in regard to the issuing nauplius of *Cecrops*:

The latter, on issuing from the egg, are furnished with three pairs of legs, of which the first is simple and the two others biramous (p. 348).

Further along he says, while comparing *Cecrops* with "*Læmargus*:"

In *Cecrops* the two sexes, and even the young, are very remarkable for the two prolongations, lamellar and rounded, which precede the frontal margin of the carapace. Also for the lack of eyes in the adult and especially in the embryos. (P. 356).

He adds in a footnote at the bottom of the page:

This exception, which, I believe, is unique in its kind, is, moreover, the more inexplicable because if these organs are indispensable in the adults, they are of still greater use to the young, which have to search for a position in which they can be sheltered from dangers, and where they can procure the food necessary to their existence.

Whether it be true, as Hesse states, that these nauplii have no eyes remains to be proved by other investigators. In view of the serious mistakes which he has made in the same paper, it can not be accepted on his authority alone. It is unfortunate that he is apparently the only one who has ever seen these nauplii.

Subfamily CECROPINÆ.

The first thorax segment fused with the head, the second and third segments more or less fused inter se; the fourth segment with a pair of dorsal plates in both sexes, overlapping the genital segment. Sexes very similar.

Female.—Carapace orbicular and strongly arched; frontal plates more or less completely fused with the carapace and not distinct; grooving similar to that in the Pandarinæ. Three free thorax segments, the first two of which are usually fused and furnished with a single pair each of dorsal plates and lateral lobes; the third segment carries a pair of enlarged dorsal plates, which cover the anterior portion of the genital segment.

The latter is as large as or considerably larger than the carapace and furnished with a pair of dorsal plates which entirely cover this segment, as well as the abdomen.

Abdomen one-jointed, with large anal laminæ armed with spines instead of setæ; abdomen sometimes with broad wings extending to the lateral margins of the genital segment, in which case the egg-strings are concealed between these wings and the ventral surface of the genital segment (*Orthagoriscicola* and *Cecrops*); sometimes without wings, in which case the egg-strings are long, straight, and visible like those of the Pandarinæ (*Philorthagoriscus* and *Luetkenia*). First antennæ usually two-jointed, rarely three-jointed (*Orthagoriscicola*); second maxillipeds with terminal claws. All the legs biramous, rami of first three pairs two-jointed, of fourth pair one-jointed and usually enlarged into broad lamellæ, armed only with spines.

^a Ann. des. Sci. Nat. (7), V.

Male.—A fixed form like that of the female and incapable of locomotion; carapace and thorax segments similar to those of the female, the dorsal plates of the fourth segment being reduced in size. Genital segment also much smaller, with the abdomen partially visible beyond its posterior margin; abdomen without wings in all the genera. Second antennæ and second maxillipeds with stout prehensile claws; all the feet biramose, rami as in the female, except that those of the fourth pair are not much enlarged in any genus but *Orthagoriscicola*; rami of first three pairs with plumose setæ in *Philorthagoriscus* and *Luetkenia*, the fourth pair and all the rami in other genera without them.

Chalimus attached by two broad, ribbon-like frontal filaments very short and parallel.

KEY TO THE GENERA.

- a, Females, third dorsal plates of medium size, covering quite a portion of the genital segment; the latter as large as the carapace or much larger b.
- a, Males, third dorsal plates small, overlapping the genital segment but little; the latter much smaller than the carapace e.
- b, Abdomen with broad wings between which and the genital segment the long egg-strings are entirely concealed; genital segment much larger than the carapace c.
- b, Abdomen without wings; egg-strings long and entirely visible; genital segment a little smaller than the carapace d.
- c, First antennæ two-jointed, not prominent; second antennæ hidden; posterior border of carapace deeply concave; margin of carapace and dorsal plates smooth *Cecrops* Leach, 1816, p. 466.
- c, First antennæ three-jointed, prominent; second pair projecting beyond the carapace margin; posterior border of carapace slightly concave; margin of carapace and dorsal plates coarsely toothed... *Orthagoriscicola* Poche, 1902, p. 472.
- d, Margins of the carapace and dorsal plates finely toothed; third dorsal plates covering three-fifths of the genital segment; rami of first swimming legs normally developed *Philorthagoriscus* Horst, 1897, p. 478.
- d, Margins of carapace and dorsal plates smooth; third plates scarcely overlapping the genital segment; endopod of first legs very rudimentary (male) or entirely lacking (female) *Luetkenia* Claus, 1864, p. 464.
- e, Third dorsal plates relatively as large as in the female; grooving of the carapace nearly invisible; abdomen almost or quite concealed f.
- e, Third dorsal plates very much reduced; grooving of the carapace distinct; abdomen largely visible g.
- f, First antennæ two-jointed; second and third thorax segments fused inter se and furnished with a pair of broad lateral plates, concealed beneath the carapace; abdomen also entirely concealed ... *Cecrops* Leach, 1816, p. 466.
- f, First antennæ three-jointed; second and third thorax segments distinct and entirely visible, without plates; abdomen partly visible; margins of plates on fourth and genital segments coarsely toothed. *Orthagoriscicola* Poche, 1902, p. 472.
- g, Second antennæ much enlarged and projecting beyond the carapace; first dorsal plates large; genital segment with large spines at the posterior corners; first swimming legs normally developed *Philorthagoriscus* Horst, 1897, p. 478.
- g, Second antennæ smaller and concealed; all the dorsal plates very small; genital segment with smoothly rounded posterior corners; endopod of first swimming legs scarcely visible *Luetkenia* Claus, 1864, p. 464.

SYSTEMATIC DISCUSSION.

Genus CECROPS Leach.

Cecrops (*C. latreilli*) LEACH, 1816, p. 405, pl. xx, 8 figures.

Female.—Carapace oval, stout, strongly arched, and deeply notched posteriorly; frontal plates fused with the carapace; cephalic and thoracic portions of the lateral areas separated by a transverse groove. Second thorax segment with large lateral lobes; third segment with a pair of small dorsal plates; fourth segment with a pair of larger plates; genital segment small, but carrying a pair of dorsal plates larger than the carapace, and extending back beyond the tips of the anal laminae, forming the dorsal half of the bag in which the eggs are carried. Abdomen ventral and as large as the genital segment in front of its base, strongly flattened dorso-ventrally; its ventral surface produced laterally and anteriorly into large lobes, forming the ventral surface of the egg bag.

Egg-strings very narrow, twenty or thirty times the length of the body, irregularly convoluted and entirely hidden in the above-mentioned bag. First antennae two-jointed; second pair and second maxillipeds stout and furnished with strong curved claws for prehension. Maxillae huge, club-shaped, two-jointed, the terminal joint covered with small spines. Legs all biramose, rami of first three pairs two-jointed, of fourth pair one-jointed and enlarged into flattened laminae with a large fold of skin on the ventral surface.

Male.—A fixed and degenerate form, similar in all respects to the female, except as follows: Genital segment without dorsal plates, but covered by those of the fourth segment, which also reach nearly to the end of the abdomen. The latter is plump, not flattened, twice as wide as long, and without lateral lobes; anal laminae close together, armed with good-sized setae.

Fourth legs but little enlarged, rami one-jointed, but without the ventral fold of skin; plumose setae on the first three pairs of legs less rudimentary than in the female.

(*Cecrops*, the fabulous first king of Athens.)

This genus was established by Leach in 1816, who gave a fairly good description of the female with figures of both sexes. The figures are good for their time, but are too small to give details. In the ninety years since the above date the genus with its single species has been noted by nearly every investigator who has dealt with the parasitic copepods. But only in a very few instances have any figures been given. Guérin published a single figure, the dorsal view of a female, in 1817; Desmarest in 1825 published a set of figures almost exactly like those of Leach, but in which the details are more clearly shown. Latreille gave similar figures in 1835, and Baird a single

dorsal view of the female in 1850. Hoeven in 1857 published a paper on *Cecrops* and "*Læmargus*," which contains the only really good figures that have ever appeared; but even these show many mistakes and imperfections.

In 1883 Hesse presented what he claimed was a new species of *Cecrops*, and which he named *C. achantii-vulgaris*. The name is certainly wrong for the shark genus on which Hesse's specimens were found is *Acanthias* (from ἀκανθίας) and not *Achantius*, and even if Latinized the genitive would not be spelled as Hesse has given it. Furthermore, this so-called species is based upon a single female specimen, which, from Hesse's description and the little that can be learned with certainty from his figures, can not possibly belong to the genus *Cecrops*.

He has represented the first three thorax segments fused with the carapace; neither the genital segment nor the abdomen are mentioned in the text, nor can they be made out in the figures.

The swimming legs also are not mentioned in the text, and even a chirographic expert could not decipher them in the figures.

And finally, the second maxillipeds with their "thumb" in the form of a peduncled ball, shutting down into a cavity, are entirely unlike those of *Cecrops*. The size of Hesse's specimen, 6 mm. in length, the fact that it had no egg-strings, and the general appearance of the body, suggest that it is probably a very young female. But its true location must be left for future investigation; all we can decide at present is that the species, as Hesse has described and figured it, does not belong in the genus *Cecrops*.

Five years later, in 1888, Hesse published his thirty-seventh paper on New and Rare Crustacea of the Coast of France, which is entirely concerned with these two genera, *Cecrops* and "*Læmargus*."

The paper is profusely illustrated, but not a single one of the 25 figures representing *Cecrops latreillii* is correct, and all of them which show the entire animal are wretchedly confused. If compared with similar views given by the other authors mentioned, it would never be guessed that they were intended to represent the same animal. The third legs of the female, visible for the entire width of the body in dorsal view, the "plaque" (really the dorsal plates of the fourth segment) with its wonderful design of the cross and crown, and the two large lobes of the genital segment, "whose margins are rolled up in the form of a volute," are especially bizarre.

In the following year, 1889, Thomson gave several figures of *Cecrops* in his Parasitic Copepods of New Zealand, the most valuable of them being enlarged views of the four pairs of swimming legs. There are thus three sets of figures, those originally given by Leach, the excellent ones by Hoeven, and these by Thomson, which represent all that is known of the genus up to date. It is hoped that the figures

here shown may supply many of the missing details, particularly with reference to the structure of the abdomen, the formation of the case or bag in which the eggs are carried, and the details of the antennæ, mouth tube, mouth parts, and maxillipeds.

CECROPS LATREILLII Leach.

Plates XXXVIII and XXXIX.

Cecrops latreillii LEACH, 1816, p. 405, pl. xx, figs. 1 to 5.—HEVEN, 1857, p. 67, pls. III, IV.—THOMSON, 1889, p. 362, pl. xxvi, figs. 3 a to f.

Female.—Carapace oval, as wide as long, with a prominent frontal margin and a deep triangular posterior sinus. Frontal plates almost entirely fused with the carapace, separated by a wide and deep median sinus. On the lateral margins just behind the frontal plates is a well-defined notch on either side, in the base of which the first antennæ are attached. Another notch a little farther back on the lateral margins is caused by the transverse groove which separates the cephalic from the thoracic portion of the lateral areas. This groove is situated far forward, and in consequence the cephalic portion in front of it is small and triangular, while the thoracic portion behind it is nearly four times as large and trapezoidal in form. The second and third thorax segments are fused together and furnished with a single pair of lobes and a single pair of dorsal plates. The broad lateral lobes apparently belong to the second segment, and reach well out beneath the posterior lobes of the carapace.

The small dorsal plates belong to the third segment and overlap the following segment a little; the fourth segment has a pair of medium-sized plates which reach about to the center of those on the genital segment; each of them is triangular in shape with well-rounded corners. The genital segment with its dorsal plates is enlarged to nearly twice the length of the carapace and is elliptical in form, about one-fourth longer than wide, with the sides very evenly curved. It is covered by a pair of dorsal plates, whose edges are softened and project far beyond the lateral and posterior margins of the segment. These soft edges are rolled over ventrally into large scrolls which completely cover the sides and posterior end of the segment and lap quite a distance onto the ventral surface, completely concealing the abdomen, anal laminae, and egg-strings in dorsal view. The posterior sinus between these plates is sharply triangular and about one-fourth the entire length of the plates.

Abdomen semielliptical and fully as large as or often larger than that portion of the genital segment which precedes it. Its ventral surface is produced into a large lobe or lamina on either side, which extends outward laterally beneath the turned-over edge of the dorsal plates of the genital segment (Plate XXXIX, fig. 253).

When the female is without egg-strings, the lateral and anterior margins of these laminae are turned upward into scrolls, similar to those formed by the dorsal plates of the genital segment, and inside of them. The lateral margin is also caught inward in a large fold on either side about one-fourth the distance from its anterior end. This gives the ventral aspect of the abdomen a peculiar T shape, the upright portion being more than twice the width of the arms. When the egg-strings are extruded, these folds and the scrolls along the lateral margins are straightened out and each lamina rests flatly upon the ventral surface of the coiled egg-strings, completely concealing them in ventral view (fig. 254). The scrolls along the anterior margin are never entirely straightened, but the lamina on either side curls up over the eggs at that point and holds them securely in place. The anal laminae are small, orbicular, and attached close to the anus on either side; they are armed with short and stout spines and have no plumose setae.

The first antennae are two-jointed, the basal joint much the longer, each joint armed with a few short spines. Second pair large and powerful, the principal organs of prehension, three-jointed, the terminal joint a strong sickle-shaped claw, which is buried in the flesh of the host. The terminal joint of the first maxillipeds is much shorter and more slender than the basal; the terminal claw is nearly as long as the joint itself and only slightly curved; the accessory claw is much shorter, while both claws have serrate edges. The second maxillipeds are stout, but not swollen, as in the Pandarinæ, the curved terminal claw nearly as long as the basal joint and shutting down between two large corrugated knobs on the ventral surface of the latter.

Mouth tube and maxillae peculiar, the former conical with a wide and swollen base, tapering rapidly to a fairly sharp tip, from which protrude the ends of the mandibles. These latter are straight and coarsely toothed along their inner margins, the teeth being more or less rectangular. Maxillae enormous and club-shaped, each one as large as the whole mouth tube and two-jointed, its hemispherical terminal joint covered with small curved spines. On the ventral surface of each maxilla, at the base of the terminal joint, is a small knob representing the rudiments of the exopod.

Swimming legs biramose, rami two-jointed, except those of the fourth pair, which are modified into large laminae with indistinguishable joints. The basal joints of the exopods of the first two pairs are much larger than the terminal joints and are armed with a stout spine at their outer distal corners, the one on the second legs being exceptionally large. The segments of the third legs are all the same size, while in the fourth legs the rudimentary endopod is several times larger than the exopod. In these latter legs there is also a large fold of skin caught up on the ventral surface of each basal joint.

When the legs are in place, this fold fits into the groove between the abdomen and genital segment, and doubtless assists materially in holding the egg masses in place.

The arrangement of the spines and setæ is as follows: First exopod, 1, 0; 4, II: endopod, 0, 0; 0, III: second exopod, 1, 0; 4, V: endopod, 0, 0; 0, VII: third exopod, 1, 0; 0, V: endopod, 0, 0; 0, V: fourth exopod, 5, 0: endopod, 4, 0. All the setæ are extremely rudimentary, and their plumes are easily overlooked.

Of the reproductive organs the oviducts are coiled in the anterior part of the genital segment. They do not extend back of the vulva, which is situated in the groove between the abdomen and genital segment. The external coils are intricate and very irregular, and it is absolutely impossible to straighten them out, so we can only estimate their total length, which must be at least twenty-five times the length of the body. The strings are very narrow for so large a copepod, and the eggs themselves are thin, so that there are several thousands in each string.

They are held securely in place between the dorsal plates of the genital segment and the lateral lobes of the abdomen until they hatch, the nauplii escaping at the posterior end of the egg bag. The cement glands are narrow and sickle-shaped, arching out on either side parallel with the lateral margin of the segment. The tip of each gland is evenly rounded, and there are no signs of cells or other divisions.

The semen receptacle is situated just in front of the base of the abdomen, but its exact shape could not be determined in any of the available specimens. The spermatophores are fastened to the ventral surface of the genital segment just in front of the abdomen and lie close together on either side of the mid-line, and the duct leading from each can be traced to the vagina on the opposite side, where it opens close to the base of the abdomen.

All the internal organs of the genital segment are thus confined to the short space in front of the abdomen, and this is practically the limit of the segment itself. But the cavity of the segment extends much farther back, as can be readily proved by injecting water into its anterior portion.

In this genus, therefore, as in the others belonging to the subfamily, the abdomen is really fastened to the ventral surface of the genital segment.

Total length, 25 to 30 mm.; length of carapace on mid-line, 8 to 10 mm.; width of same, 12.25 mm.; length of genital segment plates, 17.75 mm.; width of same, 15.5 mm.

Color, a uniform yellowish white, deepening in alcohol to an orange brown in the center of the different carapace areas and the

dorsal surface of the genital segment. The anterior ventral surface of the abdomen and the edges of the dorsal plates of the genital segment have a few spots of light brown pigment.

Egg masses a deep orange brown.

Male.—Carapace similar to that of the female, and with the same grooving on its dorsal surface. The cephalic and thoracic portions of the lateral areas do not differ as much in size as in the other sex, and the posterior sinus is rather deeper. The lateral lobes on the second segment and the dorsal plates on the third and fourth segments correspond closely with those in the female, the last mentioned covering the whole of the genital segment and the most of the the abdomen.

Genital segment transversely elliptical, nearly twice as wide as long, narrowed into a neck where it joins the fourth segment.

Abdomen also transversely elliptical and terminal, a little more than half the diameter, but much less than half the length of the genital segment. Anal laminae terminal, small, and close to the anus on either side; the setae which they carry are plumose, but rudimentary. Appendages similar to those of the female, with the usual sex distinctions manifested in the larger size of the second antennae, maxillae, and second maxillipeds, and in an increase in the number and length of the plumose setae on the swimming legs. The fourth legs have large laminate basal joints and one-jointed rami, but there is no fold of skin in the basal joints, and the rami are not as large and rudimentary as in the female. The testes are large and very apparent in well-preserved specimens; the spermatophore receptacles in the genital segment are circular in outline and so large as to nearly fill the entire segment.

Total length, 14 to 17 mm.; length of carapace on mid-line, 8 mm.; width of same, 11 mm.; length of fourth segment plates, 4 mm.; width of same, 6 mm.; length of genital segment, 3 mm.; of the abdomen, 1.8 mm.

Color as in the female, but rather lighter and more transparent, and without pigment spots on the ventral surface.

(*latreillii*, in honor of Pierre André Latreille.)

The U. S. National Museum collection contains three lots of this species, all from the gills of *Mola mola*: one taken at Woods Hole, Cat. No. 6017, U.S.N.M., contains females only; the second, also taken at Woods Hole, and Cat. No. 32796, U.S.N.M., contains both sexes; the third was taken by the Fisheries steamer *Albatross* on the Pacific coast at Station 4345, and is Cat. No. 32797, U.S.N.M.; it also contains both sexes.

Genus ORTHAGORISCIÇOLA Poche.

Læmargus (*L. muricatus*) KRÖYER, 1837, p. 487.

Orthagoriscicola (*O. muricata*) POCHE, 1902, p. 13.

Female.—Carapace trapezoidal or wedge-shaped, one-fourth wider than long, much narrowed anteriorly, posterior margin scarcely reentrant; posterior lobes very broad and evenly rounded; eyes invisible; grooving on the dorsal surface indistinct; lateral margins of the carapace coarsely toothed; its dorsal surface sparsely covered with spines. Frontal plates fused with the carapace, but their outlines indicated by well-defined grooves. Second and third thorax segments distinct, free, without dorsal plates, and forming a narrow waist joining the carapace and genital segment. Fourth segment with a pair of dorsal plates covering half the genital segment, their margin serrate. Genital segment enlarged, its dorsal plates wider and longer than the carapace, and overlapping each other along the mid-line, their margins serrate. Abdomen on the ventral surface of the genital segment and entirely concealed, its lateral margins prolonged into broad laminae similar to those of *Cecrops*. Egg-tubes carried between these laminae and the dorsal plates of the genital segment as in *Cecrops*, irregularly coiled and many times the body length. First antennae three-jointed; second pair stout and uncinatè; maxillae much smaller than in *Cecrops*; mouth-tube about the same; second maxillipeds stout and with a large terminal claw. All the swimming legs biramose, but rudimentary and destitute of plumose setae; rami of first two pairs two-jointed, of third and fourth pairs one-jointed and enlarged into huge flattened laminae.

Male.—Carapace similar to that of the female, but relatively shorter and wider; thorax segments also similar; genital segment much smaller, only two-thirds the size of the carapace, its dorsal plate fused along the mid-line with a wide and shallow posterior sinus through which the abdomen shows. The latter is small and subquadrangular; anal laminae narrow and oblong. Appendages similar to those of the female; second antennae and second maxillipeds longer and stouter; third legs like the first two pairs, with two-jointed rami, but the fourth pair are one-jointed and enlarged as much as in the female.

(*Orthagoriscicola*, *Orthagoriscus*, the generic name of its host, and *cola*, inhabiting or dwelling upon.)

This genus was established by Kröyer in 1837 upon a few female specimens obtained from the sunfish, *Mola mola*. He called the genus *Læmargus*, but that name had just been used earlier in the same year for a fish genus, and so Poche in 1902 proposed as a substitute *Orthagoriscicola*, with a consequent change in the gender of the specific name.

This genus has been more fully described by the different investigators than the preceding and also better illustrated. Kröyer (1837),

Baird (1850), Hoeven (1857), Beneden (1861), A. Scott (1892), and T. Scott (1900) have all given good figures, but with the exception of those published by Hoeven they have been almost entirely of the female sex, the male having received very little attention. And yet the male is common and almost every group of these parasites yields several specimens.

From this list of names it will readily be understood that the descriptions given have been more accurate than those of *Cecrops* and there is very little to add. For the female little more has been done than to accumulate the facts given by the various authors, with the addition of some details in reference to the reproductive organs. For the male several changes in statement have been found necessary, and much has been added in the way of description, while the chalimus stage of development is entirely new.

Only a single species of the genus has been described up to the present time, but if we accept the statements and figures given by Hesse for what he has called "*Læmargus muricatus*" in the paper already referred to (p. 467), we must conclude that his specimens did not belong to the present species but were new.

The general body form is radically different, especially in the male, and there is not a single appendage described or figured by Hesse whose details agree with those of *muricatus*.

To be sure he made similar mistakes in describing *Cecrops*, but not so many of them, and while his general inaccuracy is well enough known to prevent the establishment of a new species upon his authority alone, yet it does not seem likely that he would have fallen into error in every particular. It will not be surprising, therefore, if future investigation shows that he had a new species, instead of *muricatus* as he claimed.

ORTHAGORISCICOLA MURICATA Kröyer.

PLATES XL and XLI.

Læmargus muricatus KRÖYER, 1837, p. 487, pl. v, figs. A to E.—BAIRD, 1850, p. 295, pl. xxxiv, figs. 3 and 4.—HOEVEN, 1857, p. 11, pl. iv, figs. 1 to 10, 12, 14, and 15.—BENEDEN, 1861, pp. 129, 149, pl. xix, figs. 1 to 4.—A. SCOTT, 1892, p. 266, pl. iii.—T. SCOTT, 1900, p. 158, pl. vi, figs. 39 to 42.

Orthagoriscicola muricata POCHÉ, 1902, p. 13.

Female.—Carapace trapezoidal or wedge-shaped, much narrowed anteriorly, with well rounded posterior lobes and a very shallow sinus.

Frontal plates fused with the carapace; eyes invisible in the adults; lateral margins set with fine conical teeth; grooves on the dorsal surface indistinct but separating a lateral area on either side, which is again divided into a very small cephalic, and a much larger thoracic, portion. The entire dorsal surface is sparsely covered with spines, which are coarser and more prominent on the ridges alongside the grooves. Second, third, and fourth thorax segments free, the first two with a pair of narrow, spine-like projections in the place of lateral

lobes, all three of the same width. The third segment has no dorsal plates; the fourth has a pair whose combined area is greater than that of the carapace, and which are separated by a deep posterior sinus, often a trifle enlarged at its base. Genital segment transversely elliptical, as large as the carapace, one-half wider than long, and covered with a pair of huge dorsal plates, which overlap each other along the mid-line, and extend back beyond the tip of the abdomen. The posterior and the postero-lateral borders of these plates and of those on the fourth segment are toothed, the teeth on the genital segment plates being considerably the larger and coarser. These genital segment plates do not round over ventrally in a scroll like those of *Cecrops*, but are flattened to the very edge.

Abdomen similar to that in *Cecrops*, the lateral lobes being prolonged sidewise and backward so that their edges coincide very nearly with those of the genital segment plates. The length of the abdomen plus these plates is about twice that of the genital segment in front of the abdomen. The lobes are also set with fine teeth along their margins, and are not rolled at the edges, but flat. In consequence, the space between them and the genital segment, in which the egg-strings are coiled, is not as thick dorso-ventrally, but is wider than in *Cecrops*, and thus accommodates about the same length of egg-strings, twenty or thirty times the length of the body. The strings are about the same diameter and the eggs fully as numerous.

First antennæ three-jointed, the joints diminishing regularly in diameter and in length from the base outward; they are very sparsely armed with setæ. Second antennæ large, three-jointed, and projecting well in front of the carapace; the terminal joint is a very powerful and strongly curved claw, which is buried its entire length in the flesh of the host.

Mouth-tube broadly conical, similar to that in *Cecrops*, the mandibles projecting through the opening at its tip, armed with square teeth on their inner margins only. Second maxillæ in the form of short conical knobs, apparently without joints, spines, or rudimentary exopods. In size they are in sharp contrast with those of the preceding genus, being less than one-fourth of the length of the mouth-tube. First maxillipeds two-jointed, both joints exceptionally stout, the terminal one slightly the longer. The terminal claw is short and wide and heavily fringed with stout spines; the accessory claw is in the form of a large spine. On the ventral surface of the joint opposite the accessory claw is a raised knob covered with small spines. Second maxillipeds swollen, the basal joint much longer than the terminal claw; on its inner surface are two pairs of knobs, one near the base of the terminal claw, and the other near its own base; the claw when closed lies between the two knobs of each pair. Legs all biramose, the rami transformed into flattened

laminae, destitute of plumose setae; those of the first two pairs are two-jointed, while the third and fourth pairs show but a single joint. The spines are arranged as follows: First exopod, 1, 3, endopod, 0, 0; second exopod, 0, 4, endopod, 0, 1; third exopod, 3, endopod, 0; fourth exopod, 6, endopod, 0. Of the reproductive organs the oviducts are coiled very tightly and in hopeless confusion in either half of the genital segment. In general the coils are narrower and more tightly wound in the anterior portion of the segment. The final coils are in the shape of a large S on either side of, and close to, the median line, the openings to the exterior being just in front of the base of the abdomen.

The cement glands are narrow and very long, and are bent into a sickle shape, the curve reaching backward on either side beneath the ventral lobe of the abdomen. The semen receptacle could not be distinguished with sufficient clearness to determine its exact shape, but it is situated in the usual position, just in front of the base of the abdomen. The spermatophores are ellipsoidal, twice as long as wide, and curved like a couple of parentheses marks; the ducts leading from them cross in the usual manner, and each empties into the vagina on the opposite side of the body. This genus, therefore, is unlike *Cecrops* in that the organs within the genital segment extend far behind the base of the abdomen; there is thus no doubt that the abdomen is fastened to the ventral surface of the genital segment and is not terminal. The certainty in this case increases the probability in the case of *Cecrops*, where it is not easy to decide.

Total length, 20 mm.; length of carapace on mid-line, 5.34 mm.; width of same, 7.1 mm.; length of fourth segment plates, 5.56 mm.; of genital segment plates, 8.35 mm.; width of latter, 9.5 mm.

Color a uniform light yellow without any pigment markings; the claws and chitin ribs which strengthen the carapace are darkened to a brownish hue.

Male.—Carapace similar to that of the female, but relatively a little shorter and wider; grooving on the dorsal surface indistinct; eyes invisible in the adult; no teeth along the lateral margins of the carapace. Fourth segment plates nearly circular, their combined area considerably less than the carapace, but covering more than half of the genital segment plates; their posterior margins are thickly set with teeth. They project forward at the anterior corners in a broad and rounded shoulder on either side.

Genital segment small, two-thirds the size of the carapace, orbicular in outline and strongly flattened dorso-ventrally, its dorsal plates fused along the mid-line for their anterior half, but separated for their posterior half, the posterior margins thickly set with teeth. Abdomen very small and weak, subquadrangular, fastened to the ventral surface of the genital segment so that its posterior margin

coincides with that of the latter; anal laminae narrow and oblong, nearly three times as long as wide, each armed with four small setae. Dorsal surface of the abdomen and anal laminae visible through the posterior sinus between the dorsal plates of the genital segment.

Appendages the same as in the female, the only differences being that the second antennae and second maxillipeds are larger, and there are more spines on the swimming legs. The fourth legs are fully as degenerate as in the female, being enlarged into broad laminae, with no signs of segmentation. The third legs are like the second pair and are not enlarged; each ramus is two-jointed, the joints about the same size, but those of the exopod nearly three times the size of those in the endopod.

The terminal joint of the endopod in these third legs is armed with a single long spine or claw, curved strongly outward, which seems to be characteristic of the genus. There are no plumose setae on the swimming legs, the spines being arranged as follows: First exopod, 0, 1, endopod, 0, 0; second exopod, 1, 5, endopod, 0, 5; third exopod, 1, 6, endopod, 0, 4; fourth exopod, 3, endopod, 1.

The spermatophore receptacles are very large and elliptical in outline; they are situated in the posterior portion of the genital segment, and are inclined at an angle of about 45° to the central axis; the ducts at their anterior ends are large and profusely coiled.

Color as in the female, but the spermatophore receptacles are a deep purple, and the ducts leading to them a lighter purple.

Total length, 10 to 15 mm.; length of carapace on mid-line, 5 to 7 mm.; width of same, 6.5 to 8 mm.; length of fourth segment plates, 4.25 mm.; width of same, 6.75 mm.; length of genital segment, 6.75 mm.; width of same, 5.75 mm.

Chalimus.—A male chalimus 8 mm. in length was among the specimens examined, and the following description shows the points in which it differs from the adult.

Carapace the same shape as that of the adult, but much more prominent anteriorly, relatively larger, and showing on its dorsal surface areas similar to those in the Pandarinæ; no eyes visible.

The entire front of the carapace is occupied by the large attachment gland, which is acorn-shaped, one-third the entire length of the carapace, and as wide as long. It gives origin to two broad, flat, ribbon-like frontal filaments, similar to those found on the *Perissopus* chalimus, the stumps of which can be plainly seen at the center of the frontal margin.

Second and third thorax segments narrower and longer than in the adult, with the lateral lobes hardly appearing on their sides.

Fourth segment plates divided to their very base; genital segment and its dorsal plates the same as in the adult, except that the posterior sinus is much broader and shallower.

The appendages are similar to those already described, except that the swimming legs are more plainly segmented and armed with larger spines. In the second and third pairs also there is a good-sized spine on the basal joint just outside of the base of the exopod. In the third legs there is the same difference in size between the exopod and endopod, and the terminal joint of the latter is armed with a similar large and strongly curved claw.

Total length, 8 mm.; length of carapace on mid-line, 3.75 mm.; width of same, 4.35 mm.; length of second and third segments, 1.15 mm.; of fourth segment plates, 2 mm.; of genital segment, 3 mm.; width of latter, 3 mm.

Color a uniform yellowish white, similar to that of the female and male already described.

(*muricata*, with sharp points or spines.)

This species is confined almost exclusively to the Sunfish, so that Poche's generic name is eminently fitting. But while *Cecrops* is usually found upon the gills, the present species frequents the outer surface of the body, the vicinity of the anal fin being a favorite locality. It is furthermore gregarious in habits, and from ten to twenty individuals gather together in bunches. The combined laceration of their sharp claws and probosces within so small an area quickly penetrates even the thick skin of the Sunfish. The groups of parasites thus come to lie in the bottom of depressions or pits which are eaten through the skin of the fish and into the raw flesh beneath; the edges of the pits are raised slightly above the surrounding surface and calloused. (See A. Scott, 1892, p. 266.)

With the claws of their second antennæ and second maxillipeds sunk deeply into the flesh of their host in the bottom of these pits, they are secure from friction and many of the other evils that come from living on the outside of the host's body.

But while thus protected from some dangers, their fixed habit renders them peculiarly liable to others. Chief among these is the fact that their bodies, and especially the chitinous plates which cover its dorsal surface, furnish admirable anchorage for many of the other fixed forms, animal and vegetable, which live in the ocean. It thus happens that we frequently find the dorsal surface of one of these parasites covered with algæ, infusoria, hydrozoa, or even barnacles. Of the latter the striped barnacle, which is found also upon *Pennella*, is the most common, and specimens of *Orthogoriscicola* may be found carrying a huge *Lepas* larger than their own bodies. Two such specimens are figured by Hoeven in the paper already cited, 1857, Plate IV, fig. 10.

Although this can not be regarded as a case where "Greek meets Greek," since the *Lepas* is not in any sense a parasite, yet the fastening of its heavy weight upon the back of the copepod must be a sore burden to the latter.

The collection of the U. S. National Museum includes the following lots, which are excellently preserved and especially rich in specimens of the male sex. They were all taken from the Sunfish, *Mola mola*, with the single exception mentioned. Cat. No. 3693, U.S.N.M., from Jeffreys Bank by the schooner *Paul Revere*, includes two females.

Cat. No. 12913, U.S.N.M., from Woods Hole in 1886, contains thirty females and seven males; Cat. Nos. 32783, 32784, and 32786, U.S.N.M., were obtained by the schooner *Grampus* 120 miles off Woods Hole in 1900; the first and last contain about thirty females each, the second one contains ten males. Cat. No. 32785, U.S.N.M., contains two males and one female and was obtained from the gills of a Moonfish, *Selene vomer*, at Woods Hole in 1905.

Genus PHILORTHRAGORISCUS Horst.

Dinematura (*D. serrata*) KRÖYER, 1863, p. 176.

Philorthragoriscus (*P. serratus*) HORST, 1897, p. 137.

Female.—Carapace well rounded, a little wider than long. First thorax segment only fused with the head; second and third segments fused inter se and furnished with a pair of small lateral plates; fourth segment with a pair of large dorsal plates, fully as wide as the carapace, and overlapping three-fifths of the genital segment. This latter nearly the size of the carapace and covered by a pair of large dorsal plates, whose margins are finely serrated. Abdomen small, considerably wider than long, one-jointed and attached to the ventral surface of the genital segment so far forward as to be almost entirely concealed in dorsal view. Anal laminæ large, foliaceous, divergent, each armed with four short spines. Frontal plates well fused with the carapace; first antennæ long and two-jointed; second pair three-jointed and uncinat. Mouth-tube long and pointed; mandibles with very wide and blunt teeth; second maxillæ short, jointed, and simple; second maxillipeds large, with a stout terminal claw.

All the swimming legs biramose; rami of first three pairs two-jointed and armed with both spines and plumose setæ, rami of fourth pair one-jointed, bearing short spines only; fifth pair entirely lacking. Egg-tubes straight or coiled outside the body, several times the body length; eggs as in the *Pandarinæ*.

Male.—Carapace much larger than the rest of the body, wider than long, its dorsal surface grooved as in the *Pandarinæ*; no eyes visible. Second and third thorax segments fused inter se, and furnished with a pair of small lateral plates; fourth segment with a pair of very small and rudimentary dorsal plates which scarcely overlap the genital segment at all. Genital segment subquadrangular, with slightly rounded sides; covered with two dorsal plates thoroughly fused along the mid-line, with a posterior margin and sinus exactly like that in *Perissopus*.

Abdomen the same shape as in the female, but more of it visible behind the genital segment; anal laminae narrower and smaller than in the other sex, each armed with three good-sized setae.

First antennae relatively longer than in the female; second pair also enlarged, their terminal claws projecting well in front of the carapace. Other appendages similar to those of the female, except that on all of them the claws and spines are longer and sharper.

(*Philorthragoriscus*, φιλέω, to love, and *Orthragoriscus*, the old generic name of its host.)

In 1863 Kröyer described a new species, which he referred to the genus *Dinematura* and called *D. serrata*. The present author obtained numerous specimens of both sexes of this species while at Woods Hole in 1904. On examination it was found that they could not belong to the genus *Dinematura* for the following reasons: First the general body make-up is entirely different; the body is too short; the genital segment is not elongated enough; the dorsal plates of the fourth segment are many times too large; the abdomen is much too large and in the wrong position. Again, there is no trace in the present species of the adhesion disks found on the ventral surface in *Dinematura*. In the third place there is no trace here of that sixth segment which is the characteristic of *Dinematura*, with its rudimentary legs and dorsal plate. And finally in *Dinematura* all the legs are biramous, the rami of the first pair are two-jointed, those of the second and third pairs three-jointed, while the rami of the fourth pair are enlarged into laminae in which there is almost no trace of jointing. Here the rami of the first three pairs are two-jointed, while those of the fourth pair are rudimentary, very much reduced in size, and one-jointed.

Accordingly a new generic name was given to the species, but fortunately the author afterwards found Horst's paper (1897), in which he had already renamed the species as given above.

Kröyer and Horst are the only two who have ever described the species. Kröyer had no specimens of the male sex and Horst had but a single one, of which he gives only one small figure, a dorsal view.

For this reason the male has been fully described and figured in the following account:

PHILORTHRAGORISCUS SERRATUS Kröyer.

PLATES XLII AND XLIII.

Dinematura serrata KRÖYER, 1863, p. 176, pl. VIII, figs. 4 a to i.
Philorthragoriscus serratus HORST, 1897, p. 137, pl. VII.

Female.—Carapace well rounded, about one-sixth wider than long, with large acuminate teeth along the lateral and posterior margins. Frontal plates wide and fairly distinct; but still fused with the carapace;

frontal margin smooth and slightly curved, with a small incision at the center. Dorsal surface of the carapace with well-defined grooves marking it off into areas similar to those in the *Pandarinæ*. The two longitudinal grooves are strongly concave toward each other, like parenthesis marks, the space between them being nearly two-thirds of the entire width. The lateral areas outside of these grooves are wider posteriorly, and are prolonged backward on either side in a large lobe which extends nearly to the anterior margin of the dorsal plates of the fourth thorax segment. Each of these lateral areas is divided by a transverse groove which starts from a deep sinus in the lateral margin and curves inward and backward to the longitudinal groove. The posterior or thoracic portion of the area is thus shorter but wider than the anterior portion, and has somewhat the appearance of a lateral plate attached to the posterior portion of the carapace.

The second and third thorax segments are fused together and furnished with a single pair of lateral plates, one on either side beneath the posterior carapace lobe and nearly concealed by it. The fourth thorax segment is considerably narrower than the second and third, but carries a pair of large dorsal plates which extend outward on either side to a level with the lateral margins of the carapace and backward until they overlap half the genital segment. The two plates are entirely fused anteriorly for about one-quarter of their length; the combined anterior margin is a nearly perfect arc of a large circle which terminates at either end in a short and sharp spine. Each plate is nearly circular in outline and is bordered by acuminate spines similar to those on the carapace, but not quite as large.

The sinus between the plates is wide and well rounded at the base, but farther back its sides approach until they are in actual contact. The combined dorsal plates of the fourth and genital segments are about the same size as the carapace, and inversely the same shape. As the abdomen is hidden, this gives the copepod a regular elliptical outline, broken across the short diameter by the waist between the carapace and fourth segment.

The joint between the third and fourth segments seems to be the only one which is really flexible, and the anterior half of the body is frequently folded over ventrally against the posterior half. The dorsal surface of the genital segment is also covered by a pair of plates similar to those on the fourth segment and finely serrate around the margins. The posterior sinus between these plates is deeply cut and is similar to that between the fourth segment plates.

The abdomen is of medium size, considerably wider than long, and unsegmented; it is attached to the ventral surface of the genital segment just in front of the base of the sinus, between the dorsal plates of the latter. Its own posterior margin is slightly reentrant on either side where the lamina is attached; these laminae are small, foliaceous,

and furnished with four short spines. The laminae vary considerably in length, but they usually project somewhat behind the genital segment.

The egg-strings are narrow and two and a half to three times as long as the whole body; the eggs are small and similar to those in the *Pandarinæ*. The first antennae are large and appressed close to the margin of the carapace; the two joints are nearly the same length, but the basal has twice the diameter of the terminal; both are well armed with setae.

The second antennae are large and three-jointed, and terminate in a stout curved claw, which has an accessory spine on its inner margin. When the antennae are turned forward these claws project beyond the anterior margin of the carapace; they are prehensile in function, and with the second maxillipeds are driven deeply into the flesh of the host. There are no first maxillae; the second pair are close beside the mouth-tube and only about one-third its length; they are simple and terminate in a short, blunt spine, directed outward.

The mouth-tube is very long and conical in shape; the base is wide, but at about the level of the tips of the second maxillae it narrows rapidly to a slender tip. The mouth-opening is terminal and fringed with long hairs, through which may be seen the tips of the mandibles. These are slender and toothed for some distance along their inner margins at the tip; the teeth are wide and blunt, and quite different from those in the *Pandarinæ*. The first maxillipeds are small and weak, the terminal joint about the same length as the basal, and ending in two claws the same size and covered with stiff hairs.

The second maxillipeds are considerably larger and stouter, with the terminal claw about three-quarters the length of the basal joint. On the inner surface of the latter, opposite the tip of the claw, is a pair of long, blunt spines; they are some distance apart and so situated that when the claw closes down upon the basal joint it shuts in between them and is locked securely in place. All four pairs of legs are biramose, the rami of the first three pairs two-jointed, of the fourth pair one-jointed. In the first pair the exopod is considerably larger than the endopod; its basal joint is three times the length of the terminal and nearly twice as wide; the endopod joints are about equal. In the second and third legs the basal joints are enlarged and connected across the mid-line by a wide lamina, larger in the third pair than in the second. The rami of the second pair are about the same size, but the joints are unequal; in the exopod the basal joint is twice the size of the terminal, while in the endopod the terminal joint is more than twice the size of the basal. The rami of the third legs are also equal and the four joints are nearly the same size. In the fourth legs the basal joints are well separated and have

no connection across the mid-line; the rami are one-jointed and rudimentary, the exopod being three times the size of the endopod; they are both armed with short spines and have no plumose setæ.

The arrangement of the spines and setæ on these legs is as follows: First exopod, 1, 0; 4, III: endopod, 0, 0; 0, III: second exopod, 1, I; 4, V: endopod, 0, I; 0, VII: third exopod, 1, 0; 2, IV: endopod, 0, 0; 0, IV: fourth exopod, 5: endopod, 2.

Of the reproductive organs the oviducts are coiled inside the genital segment as in the other genera; in early stages the coils do not extend much back of the base of the abdomen, but later one fold on either side pushes down into the very tip of the genital segment. The cement glands are considerably darker in color than the egg-tubes, and are bent into a sickle shape, the concave sides facing each other; the ducts leading from their posterior ends into the oviducts are very short.

The spermatophores are elliptical or slightly egg-shaped, the larger end being posterior, and from it a tube leads into the vulva. At first these tubes cross each other as in the other genera, but as the sperms are extruded into the sperm receptacle of the female, the spermatophores gradually shrivel up and each pulls across the mid-line to the opposite side, so that later they present the appearance seen in fig. 287. Each now stands up from the surface of the genital segment in a corkscrew coil, the tip of which is nearly snow white. The semen receptacle is situated just in front of the base of the abdomen; it is short, curved a little, with the concave side posterior, and slightly enlarged at the ends.

Total length, 7 mm.; length of carapace on mid-line, 2.75 mm.; width of same, 4.5 mm.; length of genital segment, 3 mm.; width of same, 4.4 mm.; length of abdomen, 1 mm.; of egg-strings, 15 mm.

Color, a mixture of yellow and gray, sometimes the one color predominating, sometimes the other.

Male.—Carapace proportionally much larger, more than twice the width of the rest of the body, and about the same length; grooves and divisions as in the female. Lateral plates on the fused second and third segments plainly visible just inside the posterior lobes of the carapace. Dorsal plates on the fourth segment very rudimentary, no larger than the lateral plates just mentioned, and barely overlapping the base of the genital segment.

The latter is subquadrangular, with slightly rounded sides, and the posterior angles armed with sharp spines; the posterior margin has a wide central sinus with divergent sides, showing most of the dorsal surface of the abdomen. The margin on either side of the sinus takes the shape of the letter S, almost exactly like that in the genus *Perissopus*. The abdomen is similar to that in the female, as also are the anal laminæ.

The first antennæ are longer than in the female and more densely armed with setæ; the second antennæ are much enlarged and the terminal claw projects well in front of the carapace.

The other appendages are similar to those of the female except that in all of them the spines and claws are longer and sharper.

The basal joint of the exopod of the first legs is somewhat swollen and armed along its outer margin and the adjacent ventral surface with stout curved spines pointing backward. The claw at the outer corner of this joint and those on the terminal joint are enlarged and furnished along their margins with a row of stout teeth. Of the reproductive organs the testes are of good size and quite prominent; the spermatophore receptacles in the genital segment are very large, filling almost the entire segment. The posterior part where the ripe spermatophores are lodged is club-shaped and fills nearly the whole half diameter of the segment. It is narrowed anteriorly where the duct from the testis enters it, but is not coiled as much as in most genera.

Total length, 5 mm.; length of carapace on mid line, 2 mm.; width of same, 4 mm.; length of genital segment, 1.58 mm.; width of same, 1.4 mm.

Color the same as in the female.

(*serratus*, toothed like a saw, alluding to the margins of all the body regions.)

The males and females of this species are found together and in company with those of *Cecrops* and *Orthagoriscicola* on the Sunfish. The collection of the U. S. National Museum includes five lots, all obtained from the Sunfish, *Mola mola*; Cat. No. 941, U.S.N.M., taken in Casco Bay in 1873; Cat. No. 32779, U.S.N.M., taken by the Fisheries steamer *Albatross* in September, 1886; Cat. Nos. 32778 and 32780, U.S.N.M., obtained by the schooner *Grampus* about 120 miles off Woods Hole; Cat. No. 32781, U.S.N.M., from a Sunfish taken at the surface in Vineyard Sound.

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EXPLANATION OF THE PLATES.

PLATE XVII. *Perissopus communis* Rathbun, and variety *stimpsoni* Rathbun.

Fig. 19, Dorsal view of female of *communis*; fig. 20, Dorsal view of variety *stimpsoni*; fig. 21, Ventral view of carapace, showing large knob opposite first maxillipeds; fig. 22, Mouth tube and second maxilla; figs. 23 to 25, First, second, and third swimming legs; fig. 26, Rami of third leg, enlarged; fig. 27, Fourth swimming leg; fig. 28, Rami of same, enlarged; fig. 29, Fifth swimming leg; fig. 30, Ventral view of genital segment and abdomen, showing abdomen (*a*), cement glands (*c. g.*), spermatophores (*s*) in position, and semen receptacle (*s. r.*); fig. 31, A single spermatophore, enlarged.

PLATE XVIII. Male chalimus of *Perissopus communis* Rathbun.

Fig. 32, Dorsal view; note especially the eyes and the large gland at the base of the frontal filaments; fig. 33, Ventral view of carapace, showing first and second antennae and their adhesion pads; figs. 34 and 35, First and second maxillipeds; figs. 36 to 39, First, second, third, and fourth swimming legs.

PLATE XIX. The female of *Echthrogaleus coleoptratus* Guérin.

Fig. 40, Dorsal view; fig. 41, First antenna; fig. 42, Mouth tube and second maxillae; figs. 43 and 44, First and second maxillipeds; figs. 45 to 48, First, second, third, and fourth swimming legs; fig. 49, Ventral view of genital segment and abdomen, showing abdomen (*a*), cement glands (*c. g.*), and sperm receptacles (*s. r.*); fig. 50, Ventral view of genital segment with abdomen removed, showing sixth segment plate and fifth legs.

PLATE XX. The female of *Echthrogaleus denticulatus* Smith.

Fig. 51, Dorsal view; fig. 52, Second antenna; fig. 53, Mouth tube and second maxilla; figs. 54 and 55, First and second maxillipeds; figs. 56 to 59, First, second, third, and fourth swimming legs; fig. 60, Ventral view of genital segment and abdomen.

PLATE XXI. The female of *Echthrogaleus torpedinis*, new species.

Fig. 61, Dorsal view, egg strings 40 mm. in length; fig. 62, Second antenna; fig. 63, Mouth tube, second maxillae, and the large spines posterior to the latter; fig. 64, Second maxilliped; figs. 65 to 68, First, second, third, and fourth swimming legs; fig. 69, Ventral view of genital segment with abdomen removed, showing the sixth segment plate and rudimentary fifth legs.

PLATE XXII. The female of *Dinematura ferox* Kröyer.

Fig. 70, Dorsal view, egg strings 120 mm. in length; figs. 71 and 72, First and second maxillipeds; fig. 73, Mouth tube and second maxillae; figs. 74 to 77, First, second, third, and fourth swimming legs; fig. 78, Ventral view of genital segment and abdomen, showing abdomen (*a*), cement glands (*c. g.*), semen receptacle (*s. r.*), and sixth segment (*x*), with its rudimentary legs.

PLATE XXIII. The female of *Dinematura producta* Müller.

Fig. 79, Dorsal view, egg strings 40 mm. in length; fig. 80, Second antenna; fig. 80a, Mouth tube and second maxillæ; fig. 81, Second maxilla, enlarged; fig. 82, Second maxilliped; figs. 83 to 86, First, second, third, and fourth swimming legs; fig. 87, Ventral view of genital segment and abdomen, showing the abdomen (a), and sixth segment (x) with its rudimentary legs (l).

PLATE XXIV. The female of *Dinematura latifolia* Steenstrup and Lütken.

Fig. 88, Dorsal view, egg strings 30 mm. in length; figs. 89 and 90, First and second maxillipeds; figs. 91 to 94, First, second, third, and fourth swimming legs; fig. 95, Fourth swimming leg of male; fig. 96, Ventral view of genital segment and abdomen, showing cement glands (c. g.), spermatophores (s) in position, sixth segment (x) with its rudimentary legs (l) and the abdomen (a).

PLATE XXV. The male of *Dinematura latifolia* Steenstrup and Lütken.

Fig. 97, Dorsal view; fig. 98, Second antenna; fig. 99, First maxilliped; fig. 100, Mouth-tube and second maxillæ; figs. 101 to 103, First, second, and third, swimming legs; fig. 104, Mandible; fig. 105, Ventral view of genital segment, showing spermatophore receptacles.

PLATE XXVI. The male of *Pandarus brevicaudis* Dana.

Fig. 106, Dorsal view; fig. 107, Second antenna; fig. 108, Second maxilliped; fig. 109, First maxilliped; figs. 110 to 113, First, second, fourth, and third swimming legs.

PLATE XXVII. The female of *Pandarus bicolor* Leach.

Fig. 114, Dorsal view, egg-strings 13 mm. in length; fig. 115, Ventral view of carapace, showing first and second antennæ and their adhesion pads; fig. 116, Mouth-tube and second maxillæ; figs. 117 and 118, First and second maxillipeds; figs. 119 to 122, First, second, third, and fourth swimming legs; fig. 123, Ventral surface of genital segment and abdomen, showing adomen (a), short anal laminæ (a. l.), spermatophores (s) in position and semen receptacle (s. r.).

PLATE XXVIII. The female and male of *Pandarus cranchii* Leach.

Fig. 124, Dorsal view of female; egg-strings 8.5 mm. in length; fig. 125, Second antenna; fig. 126, Second maxilliped; figs. 127 to 130, First, second, third, and fourth swimming legs; fig. 131, Ventral view of genital segment and abdomen, showing the abdomen (a), the anal laminæ (a. l.), spermatophores (s) in position, and the horse-shoe-shaped semen receptacle (s. r.); fig. 132, Dorsal view of male; fig. 133, Mouth-tube and second maxillæ; figs. 134 and 135, First and second maxillipeds; figs. 136 to 139, First, second, third, and fourth swimming legs.

PLATE XXIX. The female of *Pandarus smithii* Rathbun.

Fig. 140, Dorsal view, egg-strings 15 mm. in length; fig. 142, Second antenna; figs. 143 and 144, First and second maxillipeds; figs. 145 to 148, First, second, third, and fourth swimming legs; fig. 149, Mouth-tube and second maxillæ; fig. 150, Dorsal view of young female, 3 mm. in length; fig. 151, Ventral view of abdomen and part of genital segment.

PLATE XXX. The male of *Pandarus smithii* Rathbun.

Fig. 152, Dorsal view; fig. 153, Ventral view of carapace, showing first and second antennæ and their adhesion pads; figs. 154 and 155, First and second maxillipeds; fig. 156, Mandible; figs. 157 to 160, First, second, third, and fourth swimming legs; fig. 161, Dorsal view of young female 4.5 mm. in length.

PLATE XXXI. The female of *Pandarus satyrus* Dana.

Fig. 162, Dorsal view, egg-strings not fully developed; fig. 163, Second antenna; figs. 164 and 165, First and second maxillipeds; fig. 166, Mouth-tube and second maxillæ; figs. 167 to 170, First, second, third, and fourth swimming legs; fig. 171, Ventral view of genital segment and abdomen, showing folding of internal oviducts, the semen receptacle, spermatophores in position, and anal laminæ.

PLATE XXXII. The female of *Pandarus sinuatus* Say.

Fig. 172, Dorsal view, egg-strings 15 mm. in length; fig. 173, Second antenna; fig. 174, Mouth-tube and second maxillæ; figs. 175 and 176, First and second maxillipeds; figs. 177 to 180, First, second, third, and fourth swimming legs; fig. 181, Ventral surface of genital segment and abdomen, showing abdomen (a), anal laminæ (a. l.), cement glands (c. g.), and semen receptacle (s. r.); fig. 182, Dorsal view of young female, 4.5 mm. in length.

PLATE XXXIII. The male of *Pandarus sinuatus* Say.

Figs. 183 and 184, Dorsal and ventral views of the abdomen of a young female, showing the sixth segment plate just beginning to grow; fig. 185, Dorsal view of male; fig. 186, Second antenna; figs. 187 and 188, First and second maxillipeds; figs. 189 to 192, First, second, third, and fourth swimming legs; fig. 193, Ventral surface of genital segment, showing spermatophore receptacles and their coiled ducts.

PLATE XXXIV. The female of *Nesippus alatus* Wilson.

Fig. 194, Dorsal view, egg-strings 13.5 mm. in length; fig. 195, First antenna and adhesion pad; fig. 196, Second antenna; fig. 197, Mouth-tube and second maxillæ; figs. 198 and 199, First and second maxillipeds; figs. 200 to 203, First, second, third, and fourth swimming legs; fig. 204, Ventral surface of genital segment and abdomen, showing cement glands and semen receptacle; fig. 205, Dorsal view of young female 4 mm. in length.

PLATE XXXV. The male of *Nesippus alatus* Wilson.

Fig. 206, Dorsal view; fig. 207, First antenna, and its adhesion pad; fig. 208, Second antenna; fig. 209, Mouth-tube and second maxillæ; fig. 210, First maxilliped; figs. 211 to 214, First, second, third, and fourth swimming legs.

PLATE XXXVI. The male of *Nesippus curticaudis* Dana.

Fig. 215, Dorsal view; fig. 216, Second antenna; fig. 217, Mouth-tube and second maxillæ; figs. 218 and 219, First and second maxillipeds; figs. 220 to 223, First, second, third, and fourth swimming legs.

PLATE XXXVII. The male of *Nesippus borealis* Steenstrup and Lütken.

Fig. 224, Dorsal view; fig. 225, Second antenna; fig. 226 First maxilliped; fig. 227, Second maxilliped; figs. 228 to 231, First, second, third, and fourth swimming legs.

PLATE XXXVIII. The female of *Cecrops latreillii* Leach.

Fig. 232, Dorsal view; fig. 233, Mouth-tube and second maxillæ; fig. 234, Mandible; fig. 235, Second maxilliped; figs. 236 to 240, First, second, third, and fourth swimming legs; fig. 240, Ventral view of the fourth leg, showing fold of tissue which assists in keeping the external egg-strings in place; fig. 241, Ventral view of genital segment and abdomen in a young female; fig. 242, Dorsal view of young female 12 mm. in length.

PLATE XXXIX. The male of *Cecrops latreillii* Leach.

Fig. 243, Dorsal view; figs. 244 and 245, First and second antennæ; fig. 246, Mouth-tube and second maxillæ; figs. 247 and 248, First and second maxillipeds; figs. 249 to 252, First, second, third, and fourth swimming legs; fig. 253, Ventral surface of genital segment and abdomen of female, showing cement glands, spermatophores in position, and the peculiar rolling of the lateral laminae of the abdomen; fig. 254, Ventral surface of female with external egg-cases, showing how the laminae of the abdomen are unfolded and straightened out over the ventral surface of the external egg-cases.

PLATE XL. The female of *Orthagoriscicola muricata* Kröyer.

Fig. 255, Dorsal view; fig. 256, Second antenna; fig. 257, Mouth-tube and second maxillæ; fig. 258, Mandible; figs. 259 and 260, First and second maxillipeds; figs. 261 to 264, First, second, third, and fourth swimming legs; fig. 265, Ventral surface of genital segment and abdomen, showing the coiling of the internal oviducts, spermatophores in position, and the lateral laminae of the abdomen.

PLATE XLI. The male and a chalinus of *Orthagoriscicola muricata* Kröyer.

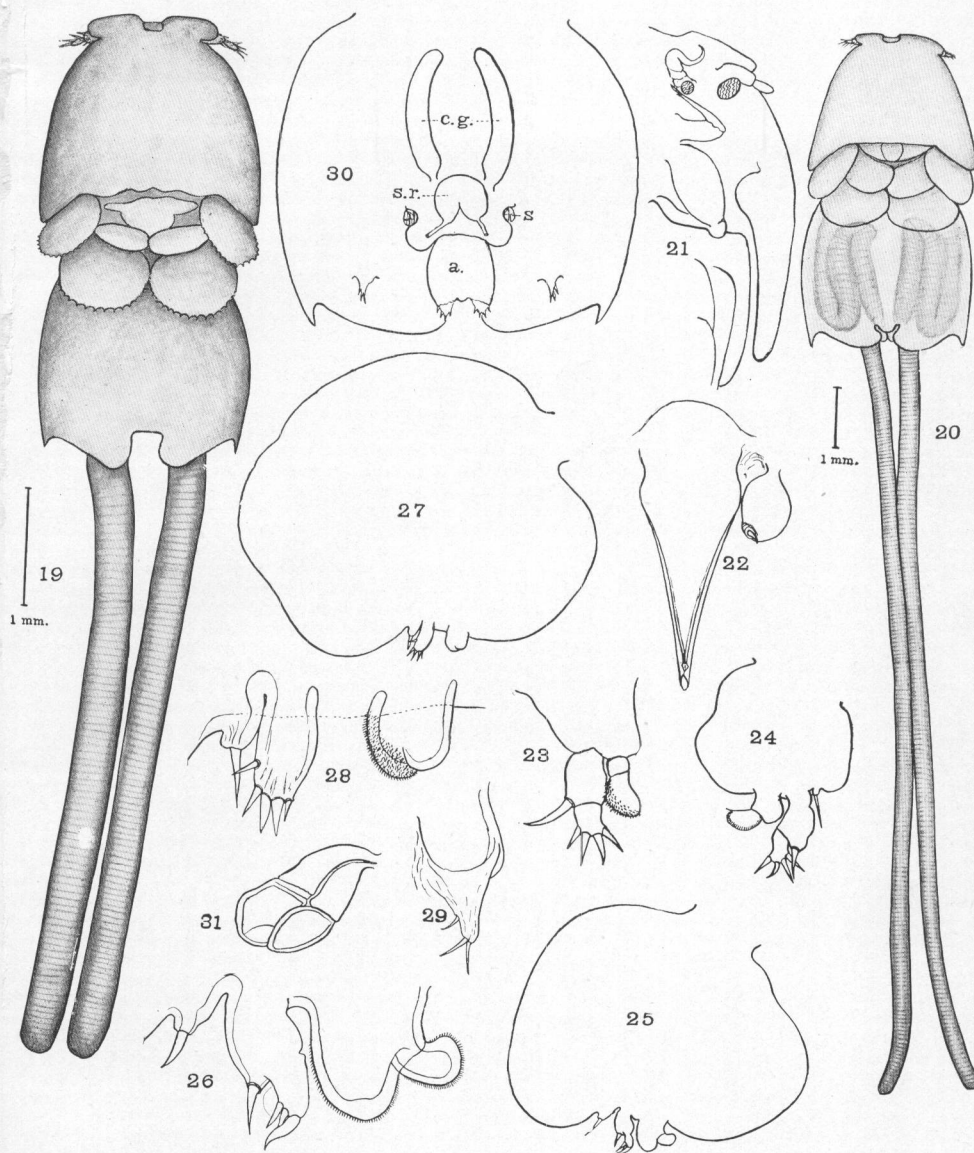
Fig. 266, Dorsal view of male; fig. 267, Second maxilliped; figs. 268 to 271, First, second, third, and fourth swimming legs; figs. 272 and 273, Dorsal and ventral surfaces of genital segment; fig. 274, Dorsal view of chalinus; figs. 275 to 278, First, second, third, and fourth swimming legs.

PLATE XLII. The female of *Philorthragoriscus serratus* Kröyer.

Fig. 279, Dorsal view; fig. 280, Mouth-tube and second maxillæ; fig. 281, Mandibles; fig. 282, Second maxilliped; figs. 283 to 286, First, second, third, and fourth swimming legs; figs. 287 and 288, Ventral and dorsal views of the genital segment and abdomen; fig. 289, Spermatophores in position.

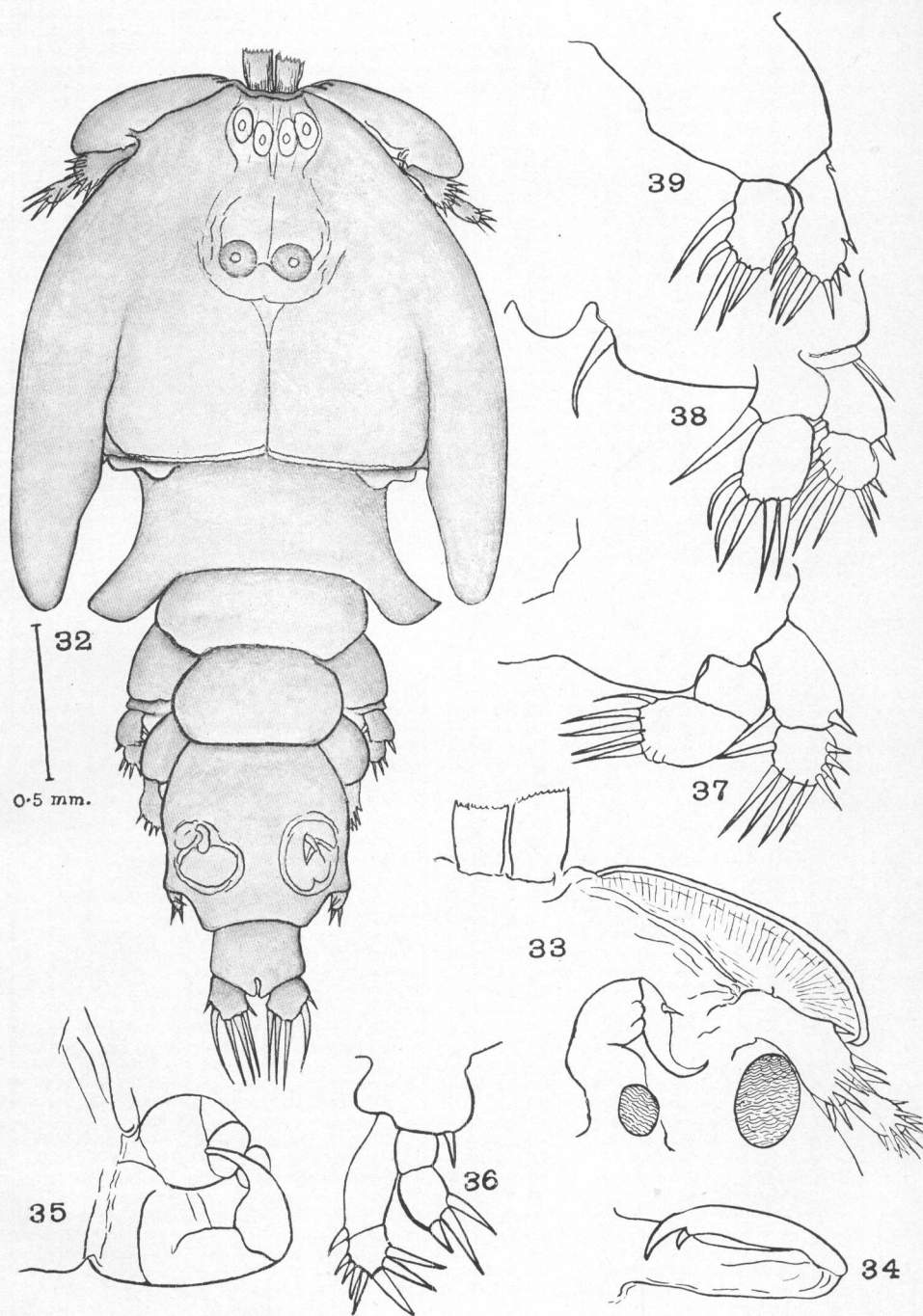
PLATE XLIII. The male of *Philorthragoriscus serratus* Kröyer.

Fig. 290, Dorsal view; fig. 291, Second antenna; figs. 292 and 293, First and second maxillipeds; fig. 294, Exopod of first swimming leg enlarged; figs. 295 and 296, Second and third swimming legs.



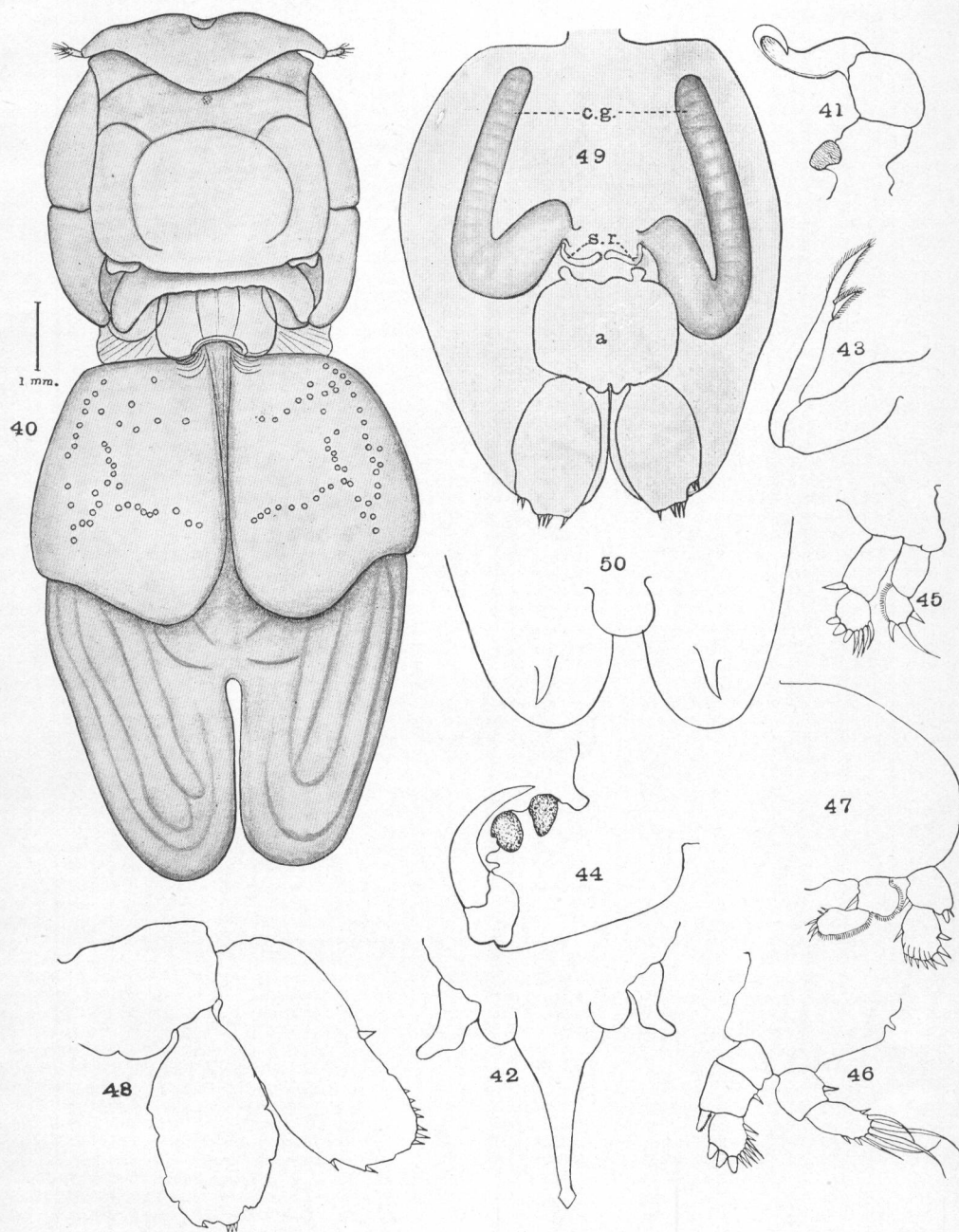
THE FEMALE OF PERISSOPUS COMMUNIS, AND THE VARIETY STIMPSONI.

FOR EXPLANATION OF PLATE SEE PAGE 487.



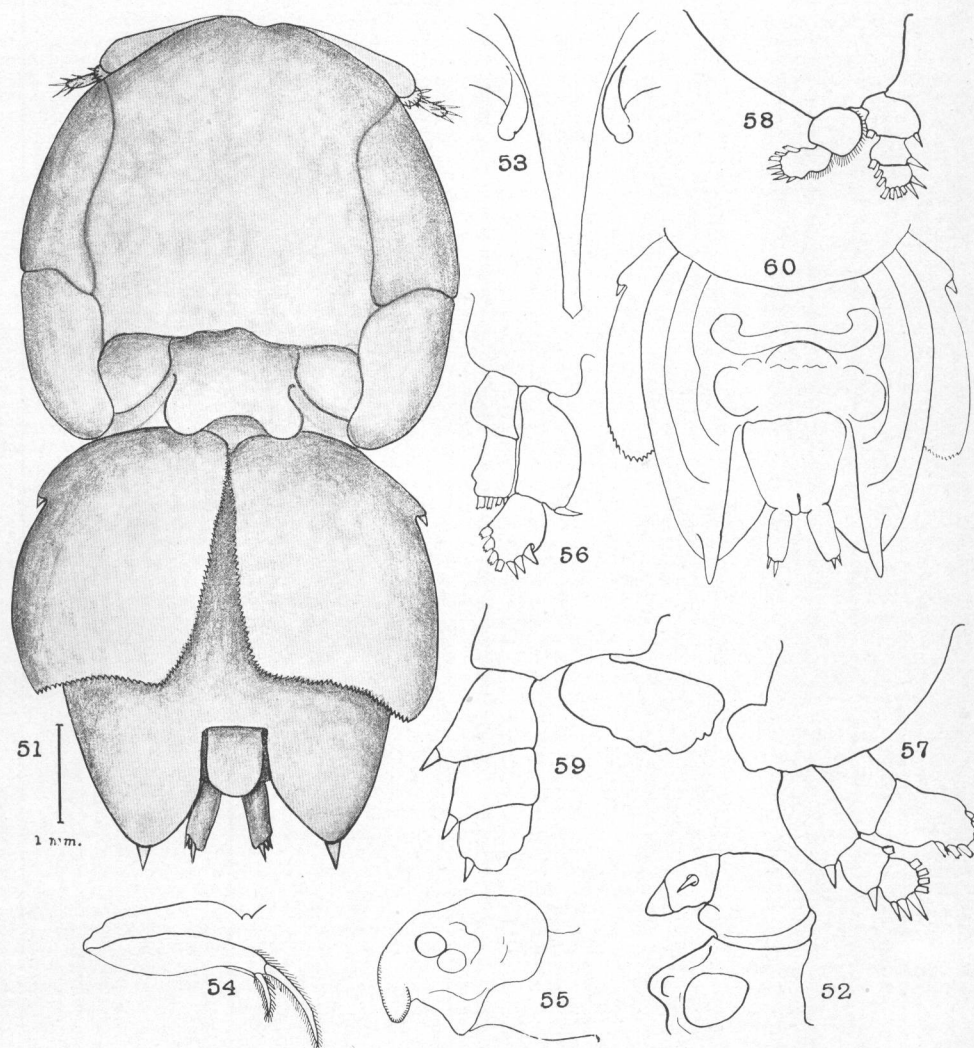
THE MALE OF PERISSOPUS COMMUNIS.

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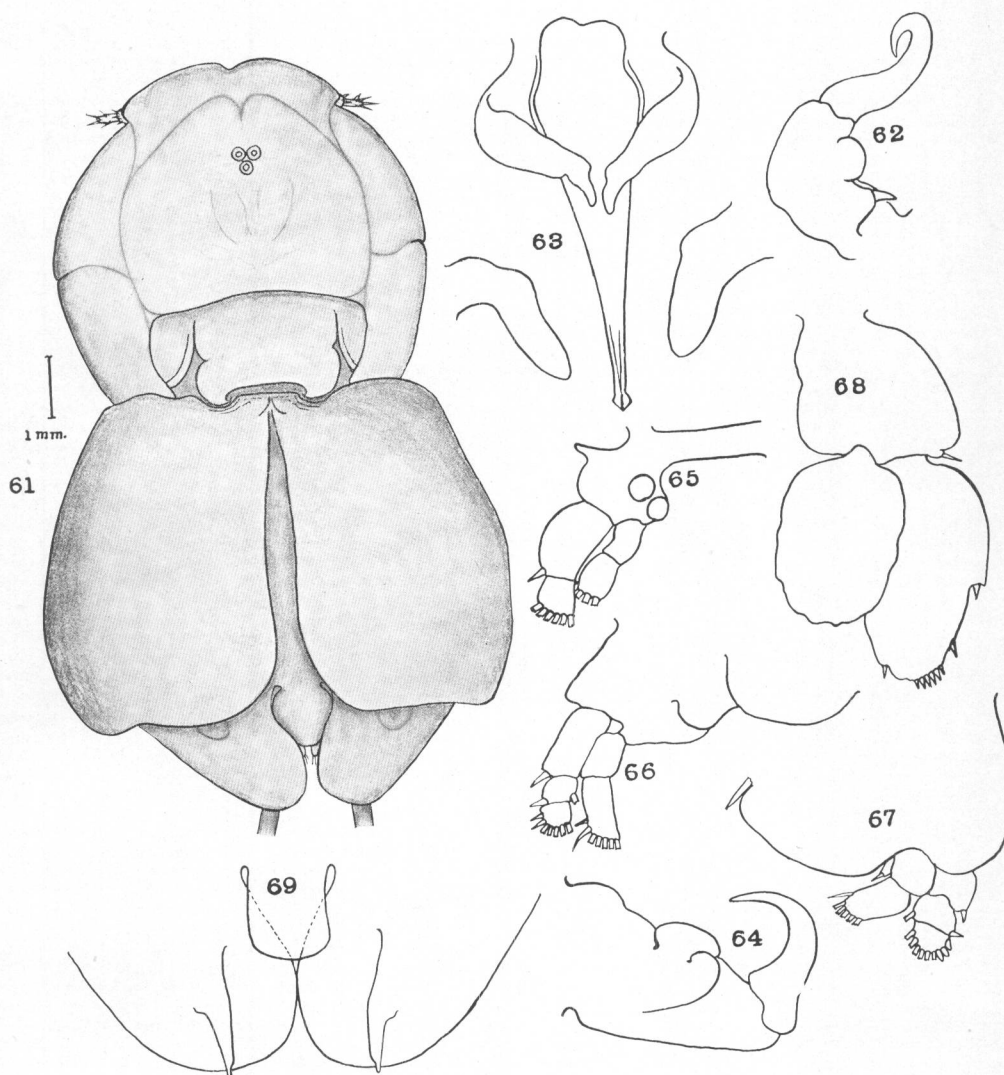
THE FEMALE OF *ECHTHROGALEUS COLEOPTRATUS*.

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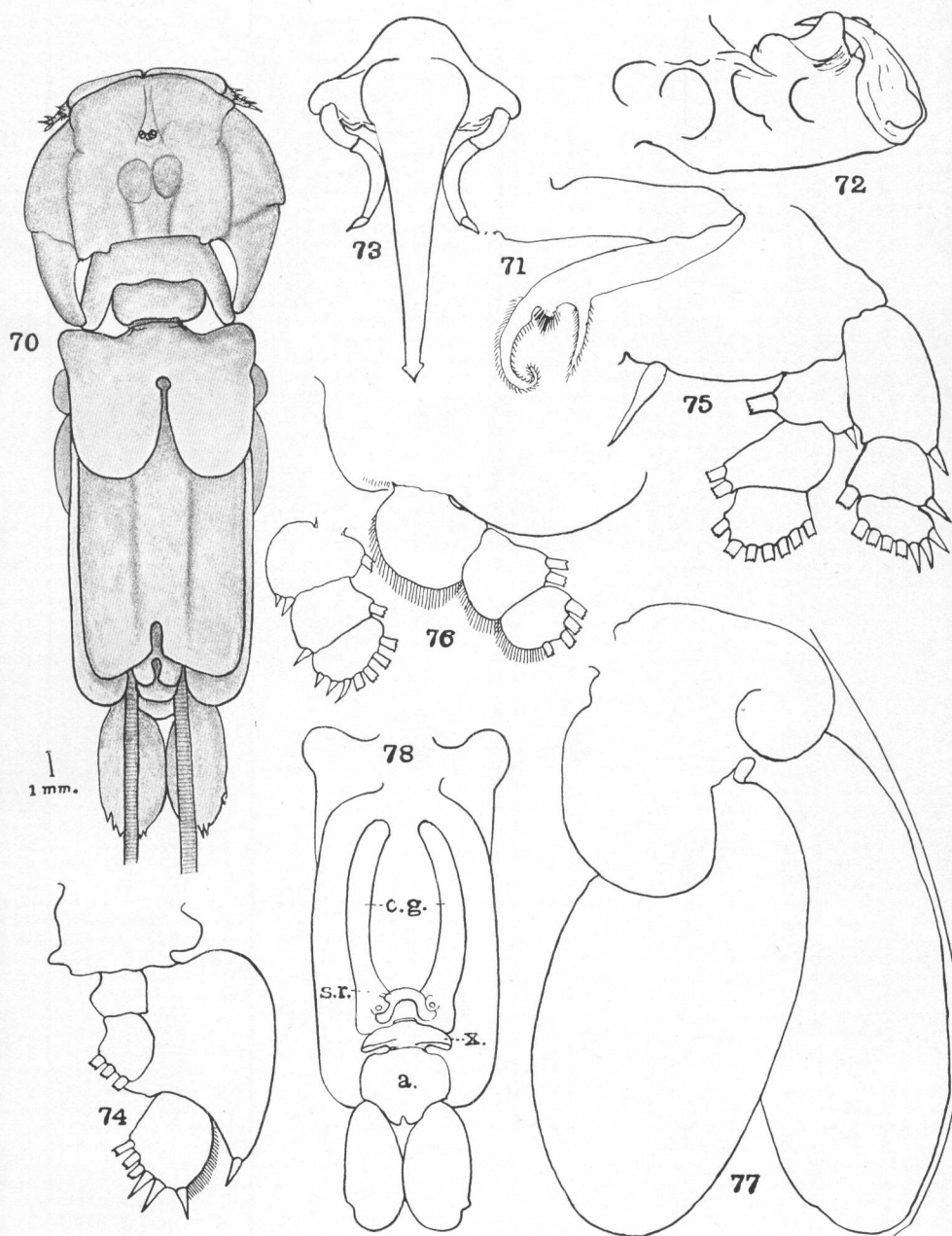
THE FEMALE OF *ECHTHROGALEUS DENTICULATUS*.

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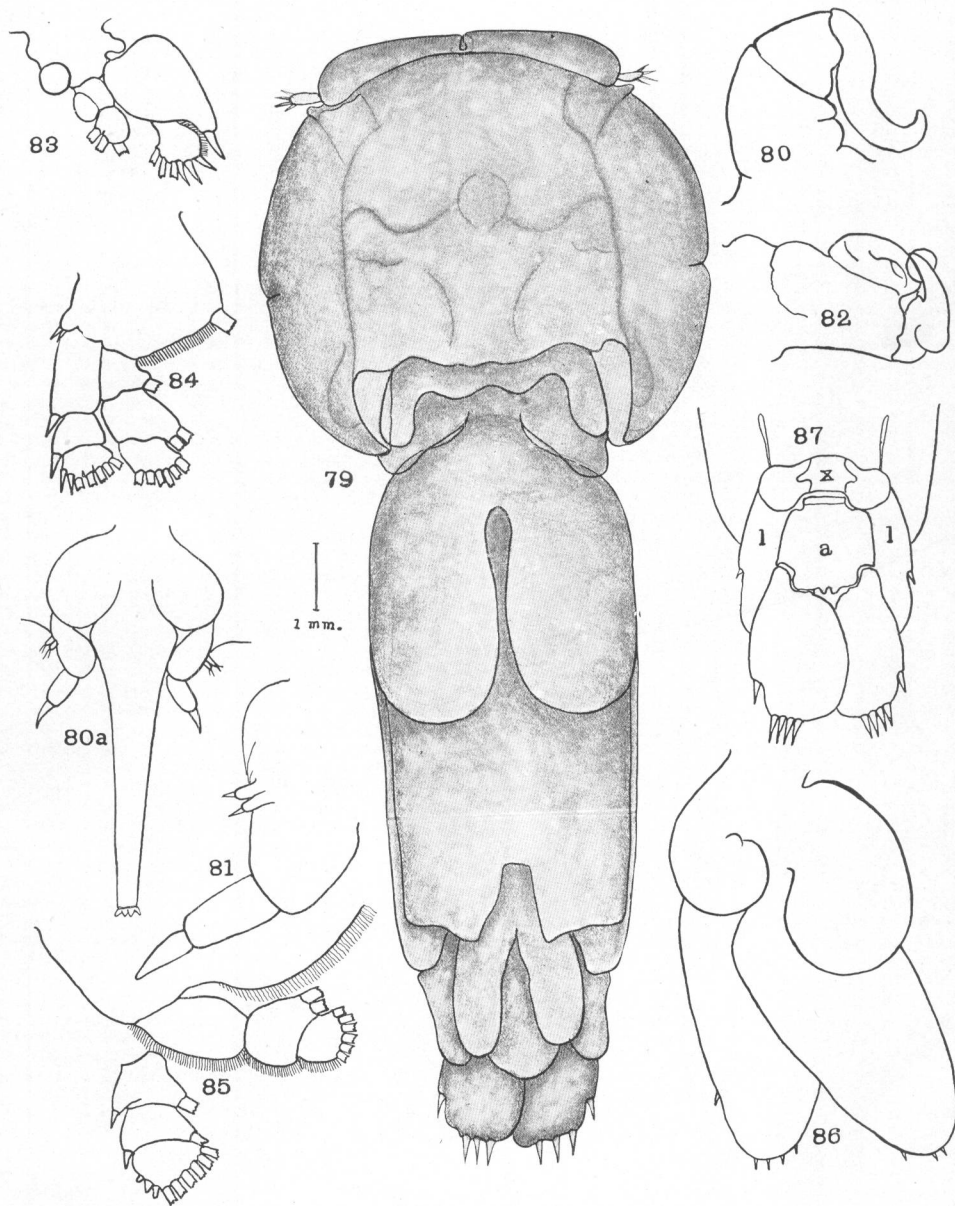
THE FEMALE OF *ECHTHROGALEUS TORPEDINIS*.

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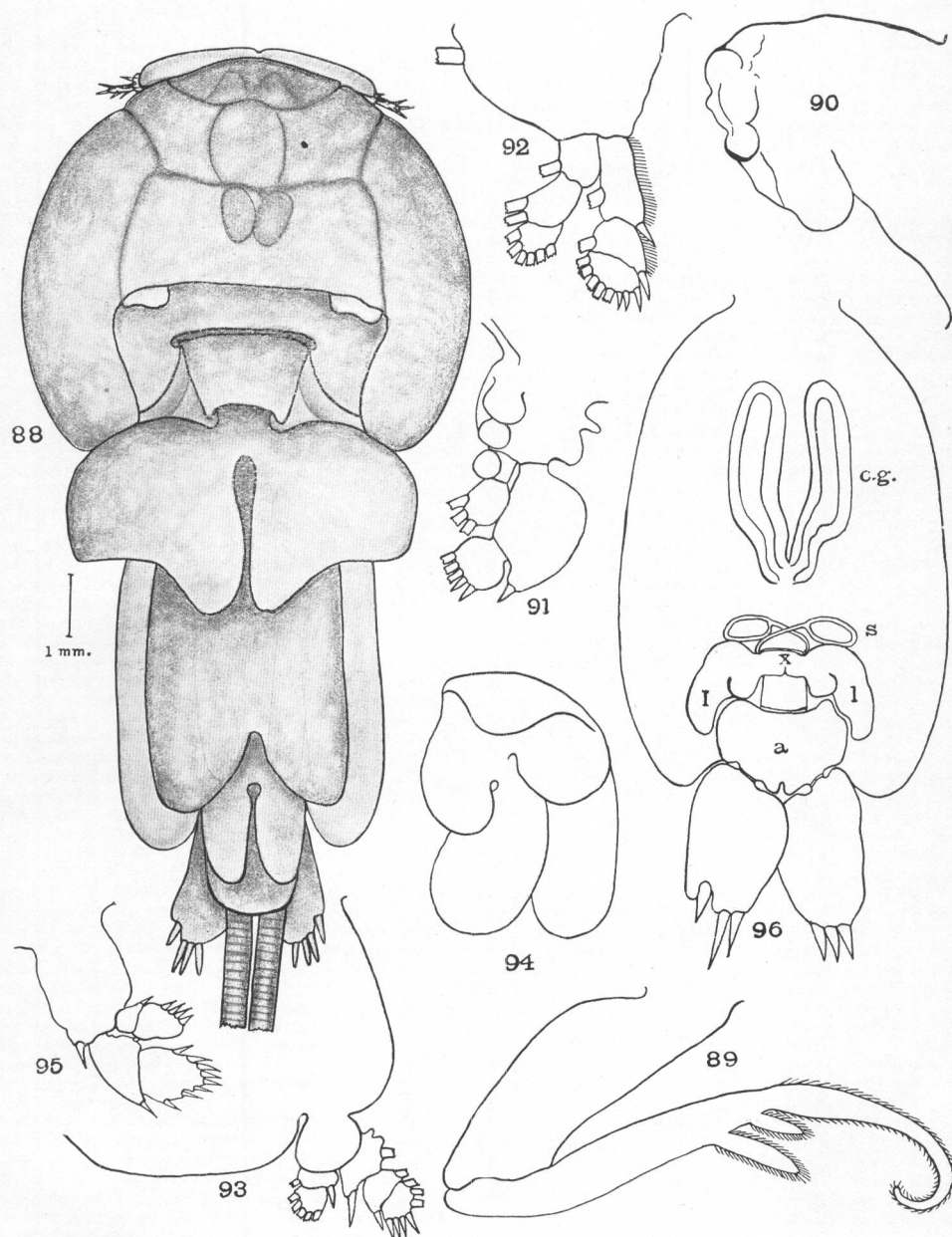
THE FEMALE OF *DINEMATURA FEROX*.

FOR EXPLANATION OF PLATE SEE PAGE 487.



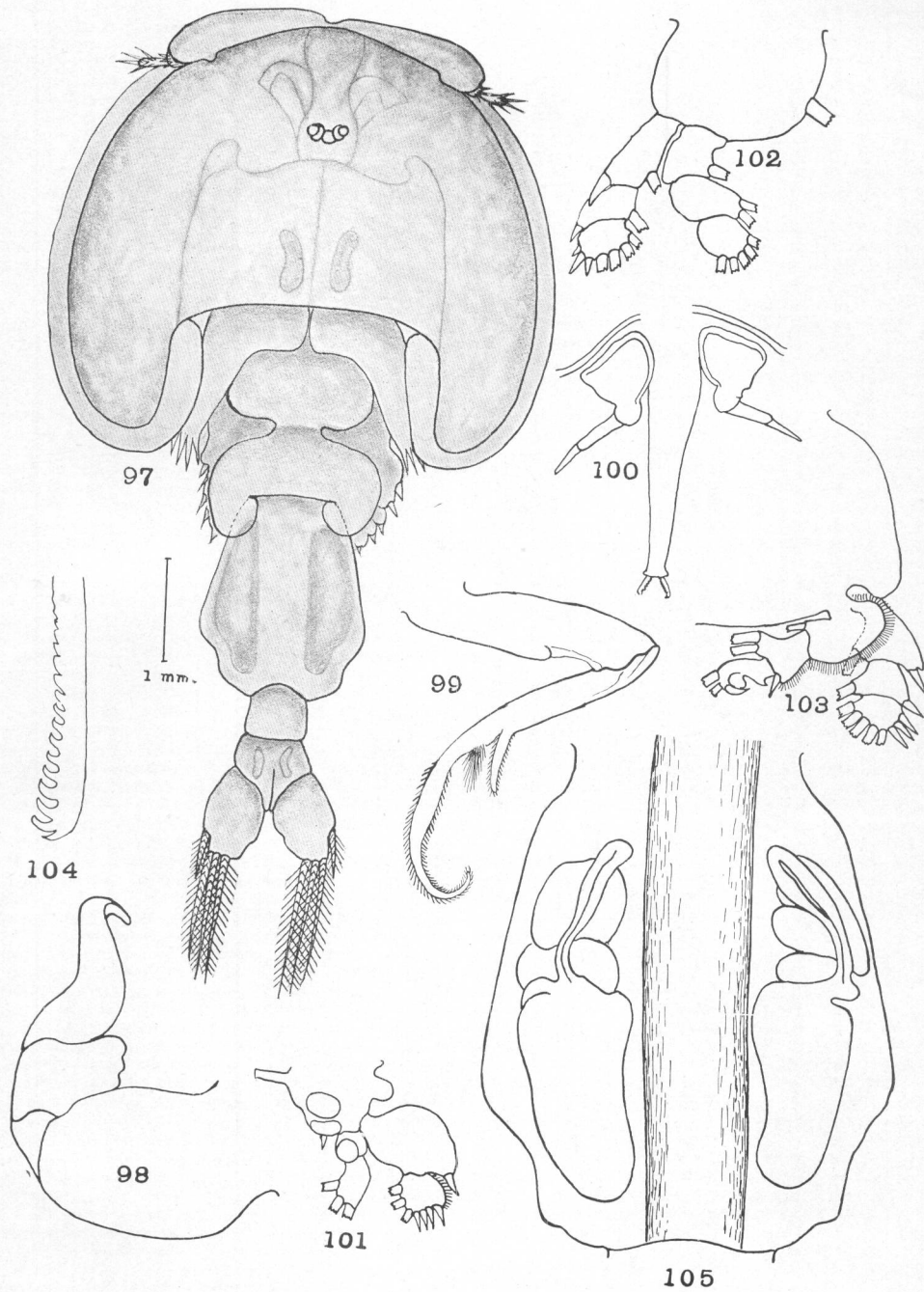
THE FEMALE OF *DINEMATURA PRODUCTA*.

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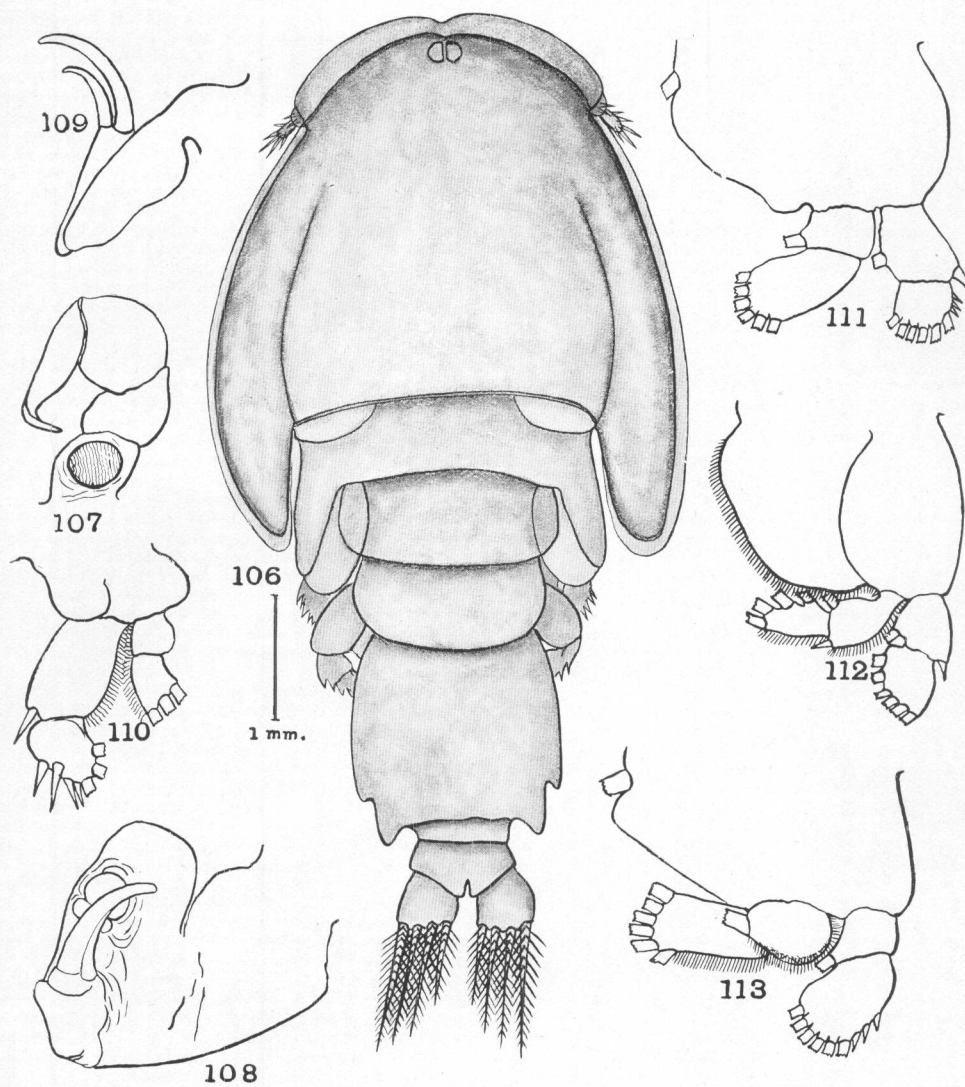
THE FEMALE OF *DINEMATURA LATIFOLIA*.

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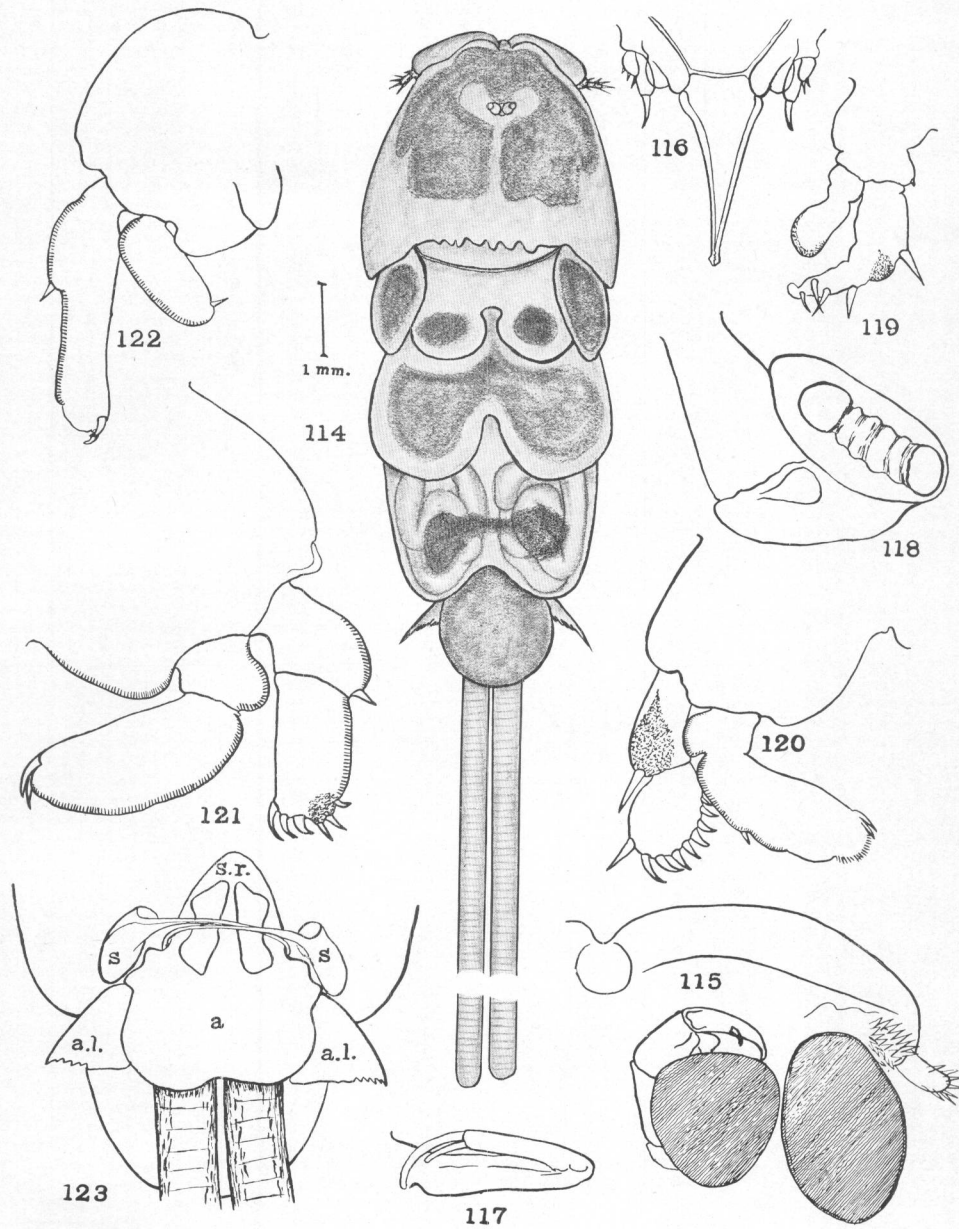


THE MALE OF *DINEMATURA LATIFOLIA*.

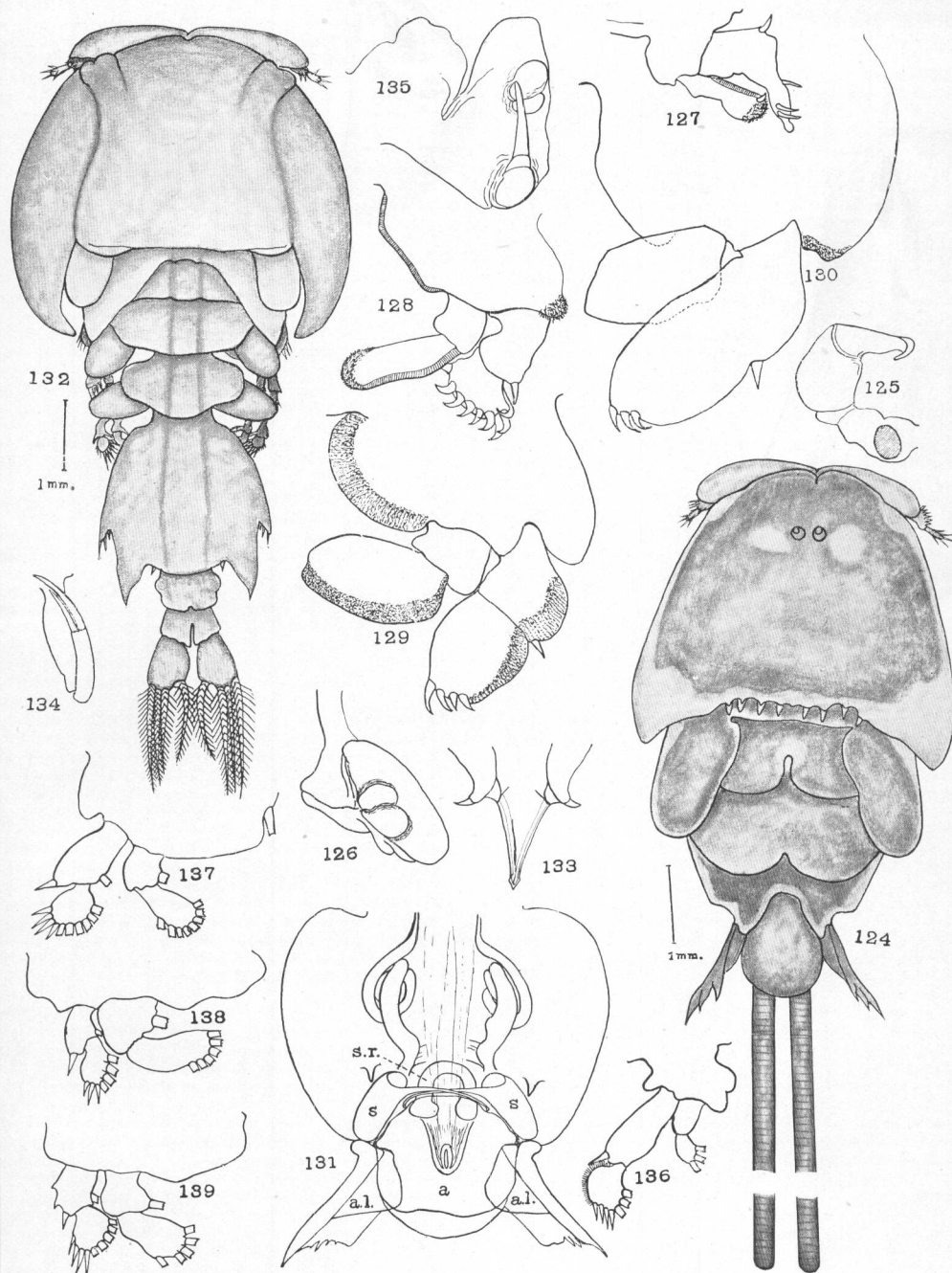
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THE MALE OF *PANDARUS BREVICAUDIS*.

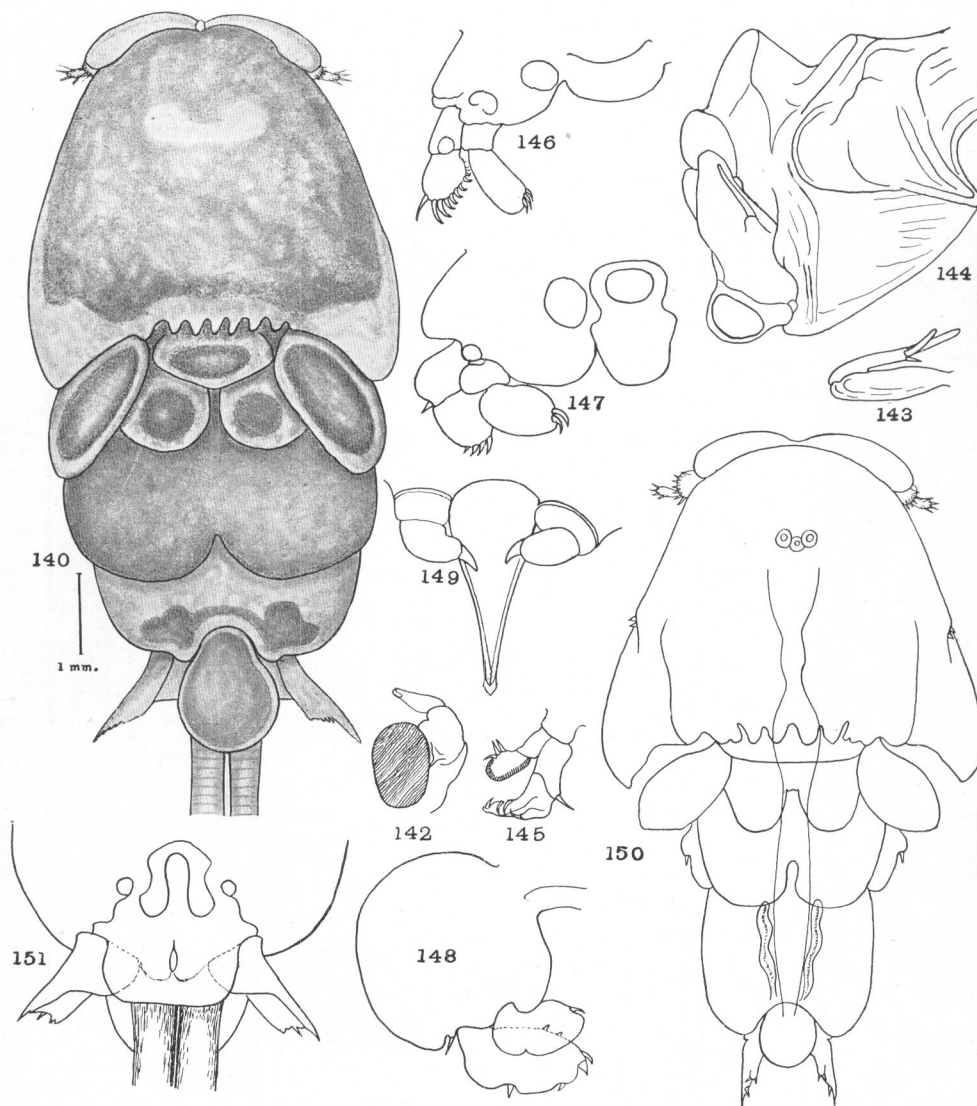
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THE FEMALE OF *PANDARUS BICOLOR*.

FOR EXPLANATION OF PLATE SEE PAGE 488.

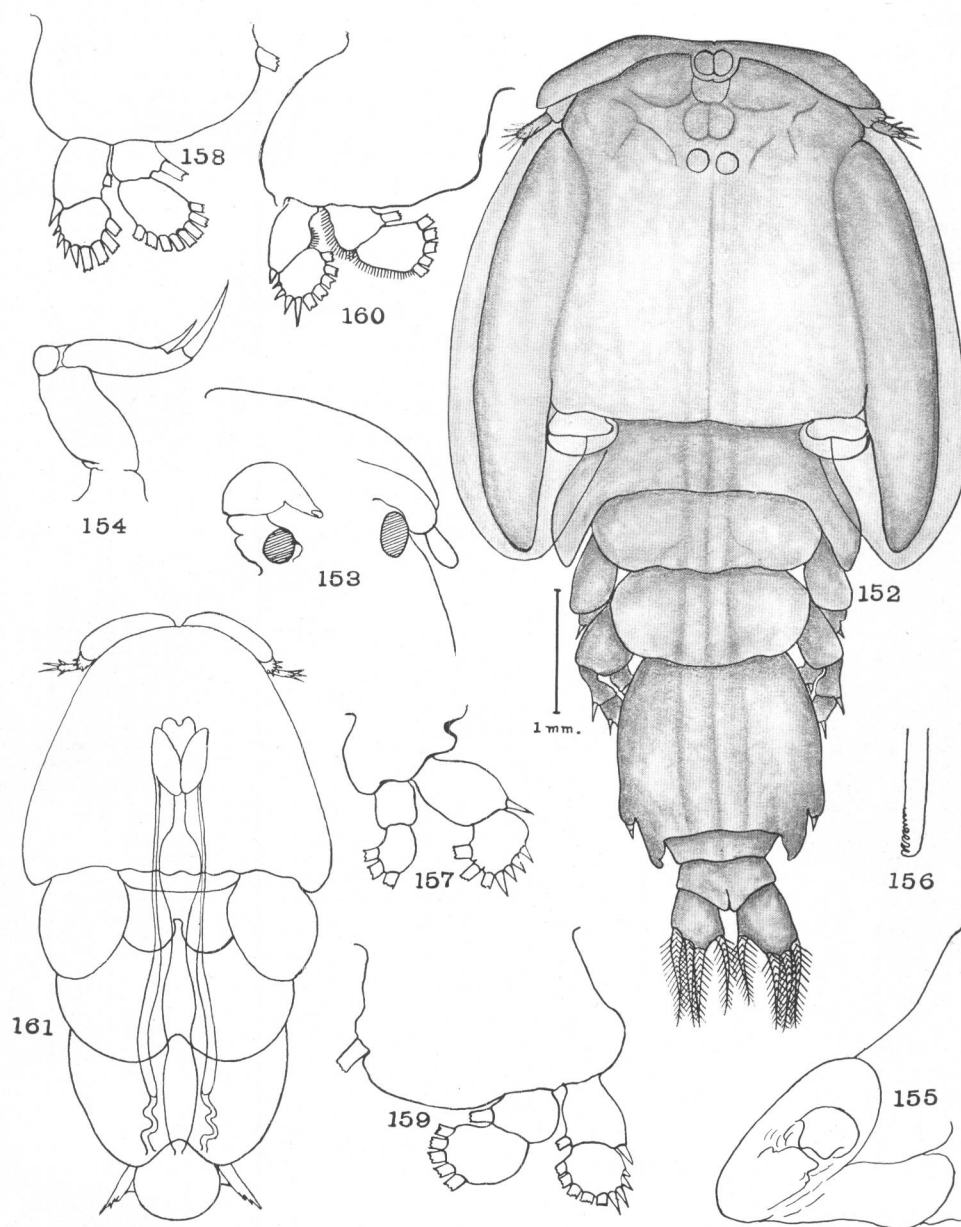
THE MALE AND FEMALE OF *PANDARUS CRANCHII*.

FOR EXPLANATION OF PLATE SEE PAGE 488.

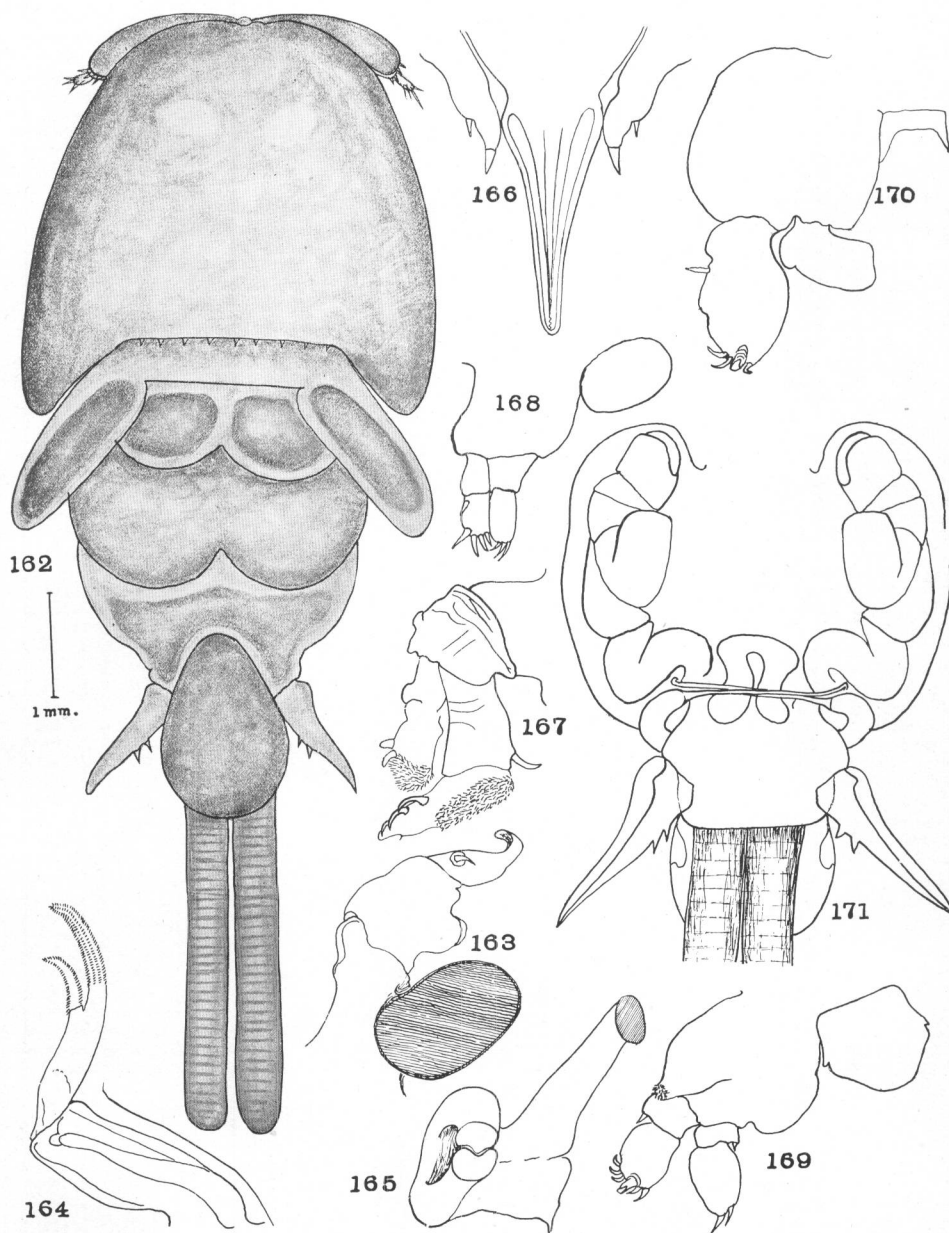


AN ADULT AND A YOUNG FEMALE OF *PANDARUS SMITHII*.

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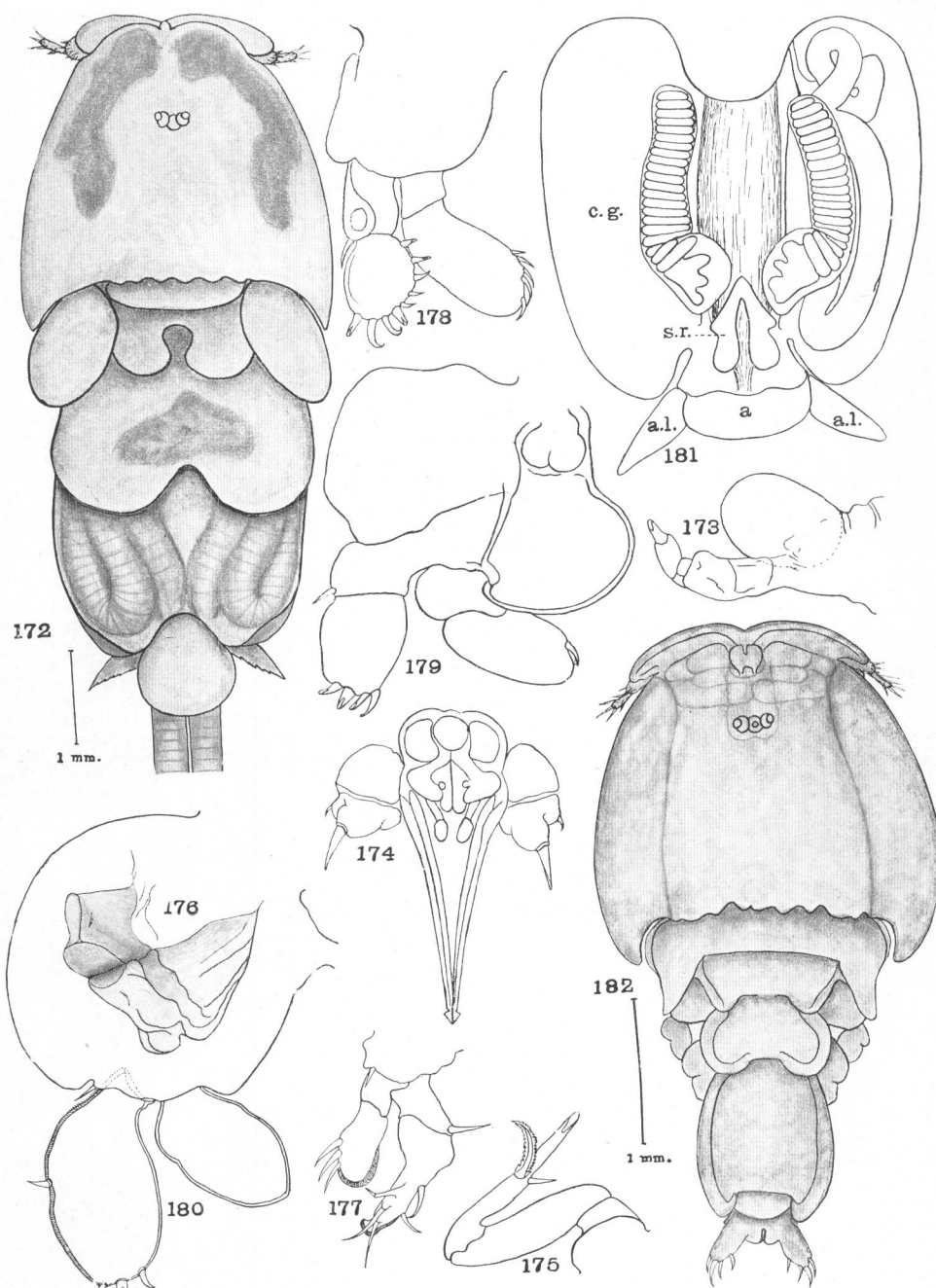
THE MALE AND A YOUNG FEMALE OF *PANDARUS SMITHII*.

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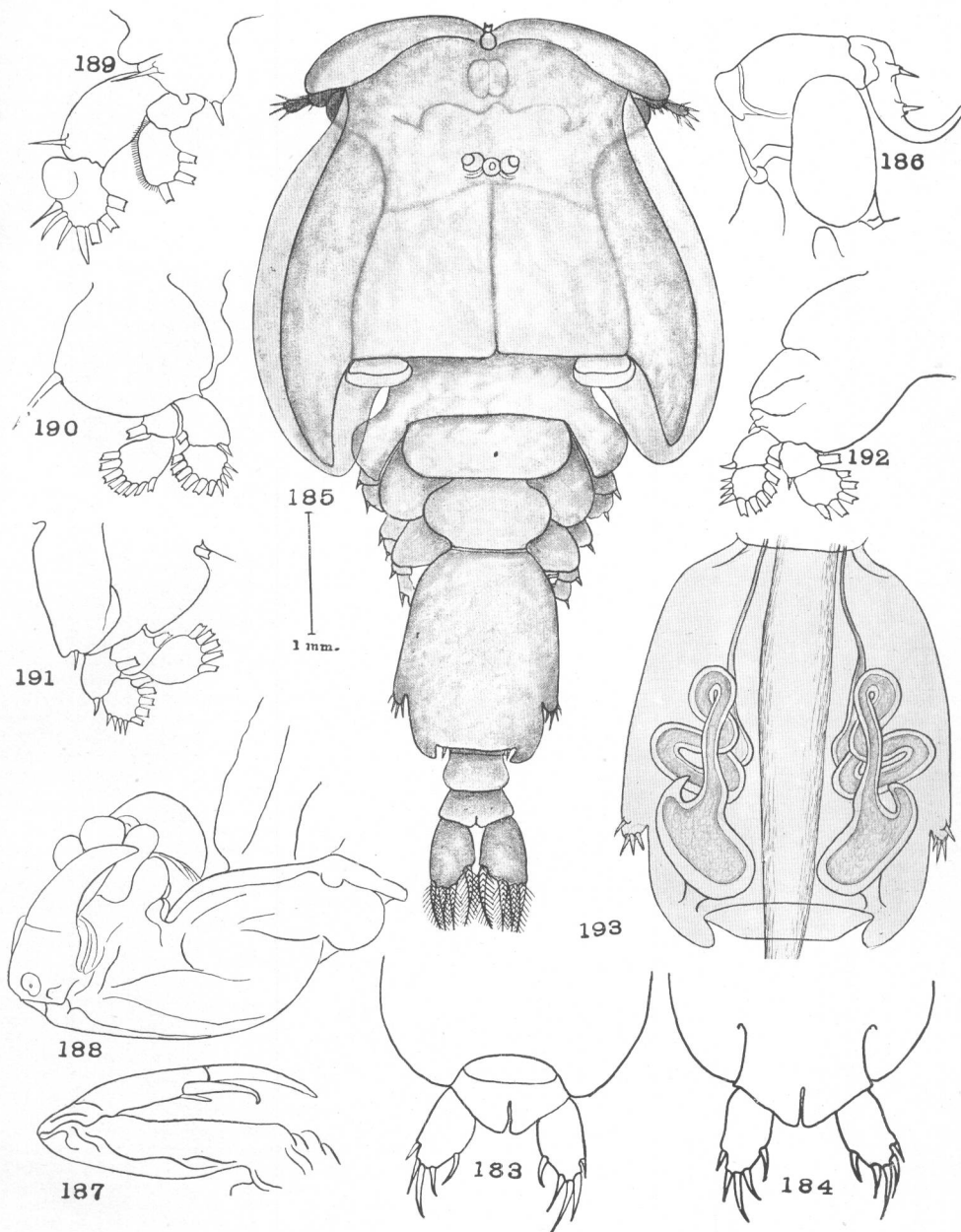
THE FEMALE OF *PANDARUS SATYRUS*.

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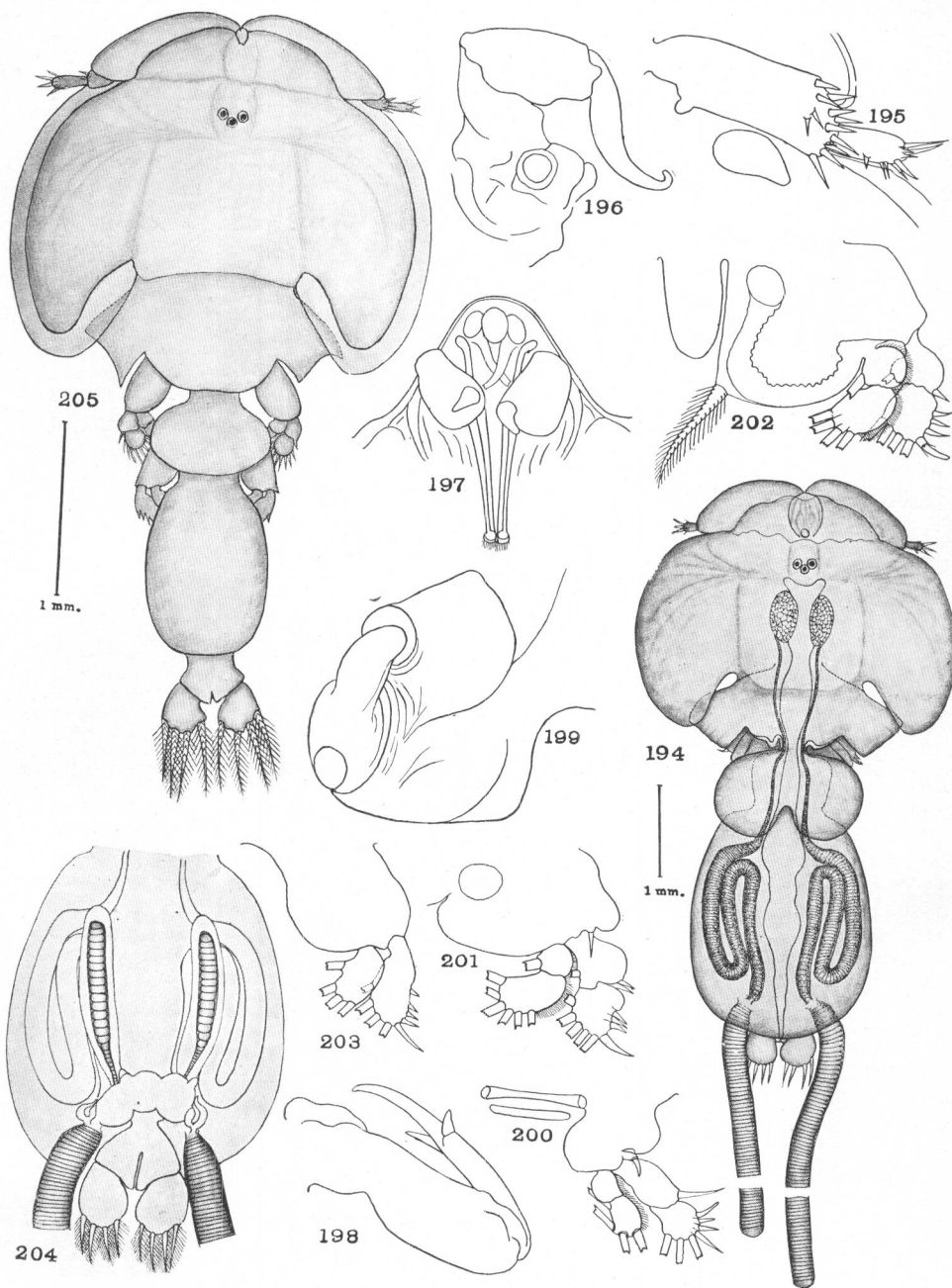
THE FEMALE OF *PANDARUS SINUATUS*.

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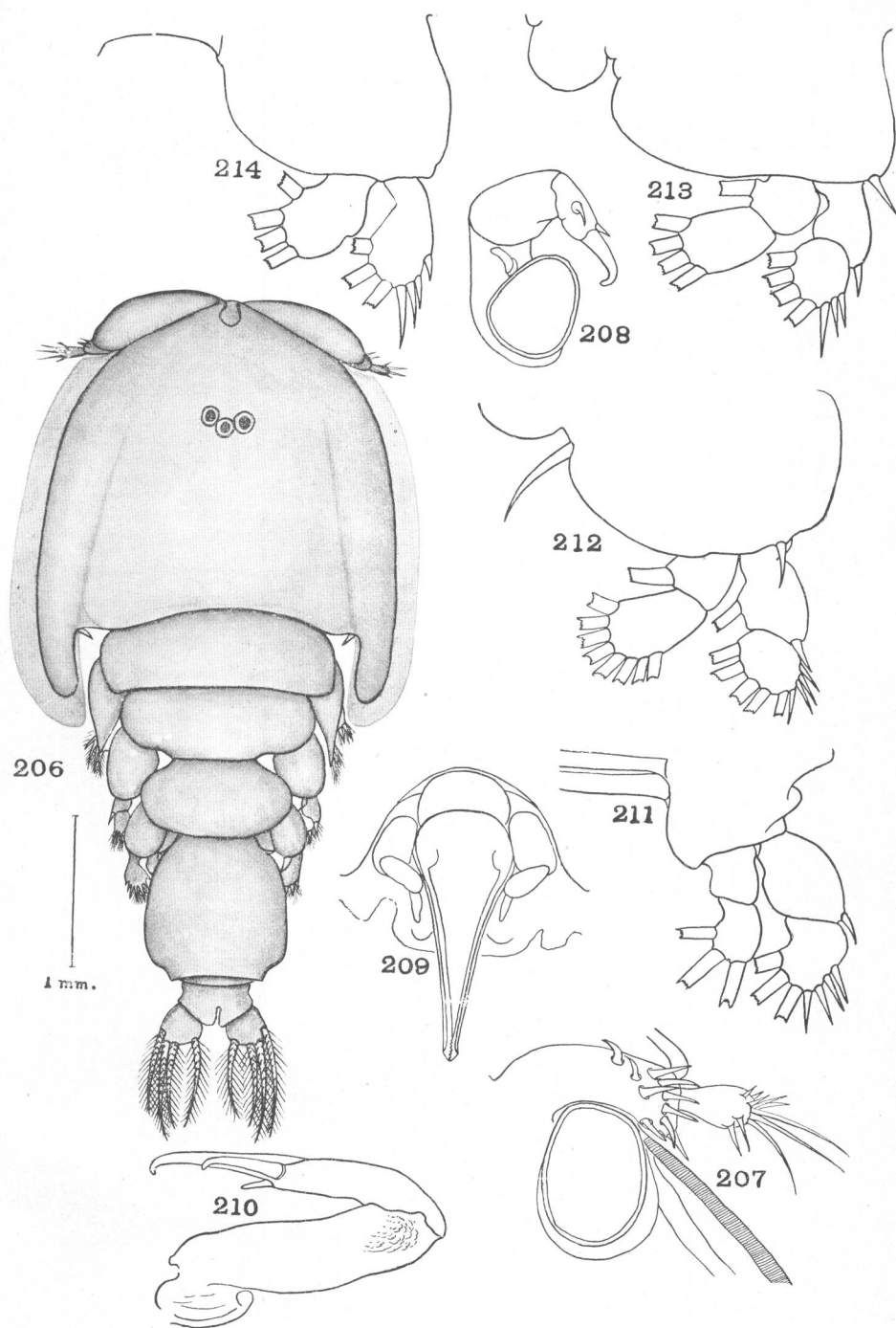
THE MALE OF *PANDARUS SINUATUS*.

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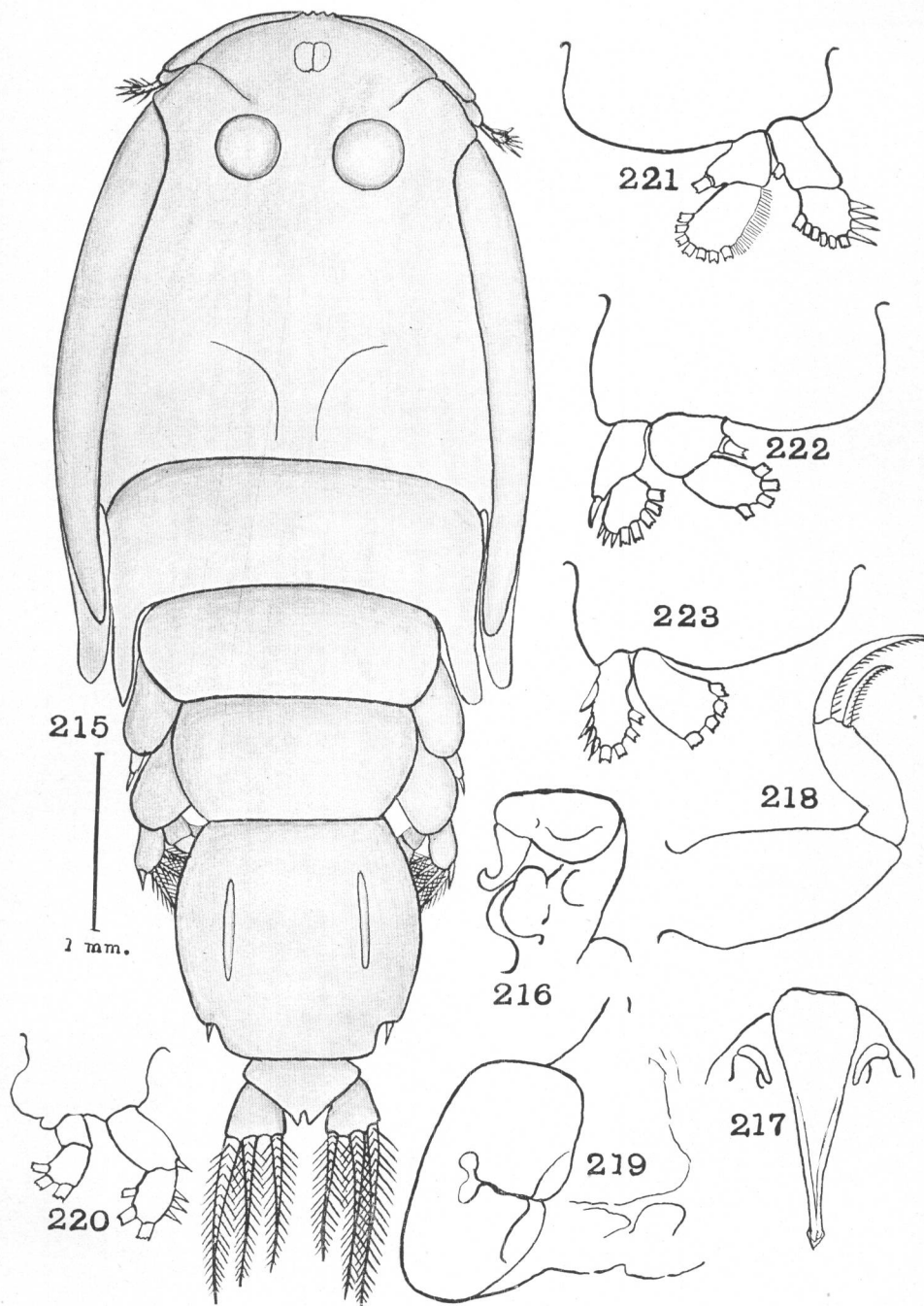


AN ADULT AND A YOUNG FEMALE OF *NESIPPUS ALATUS*.

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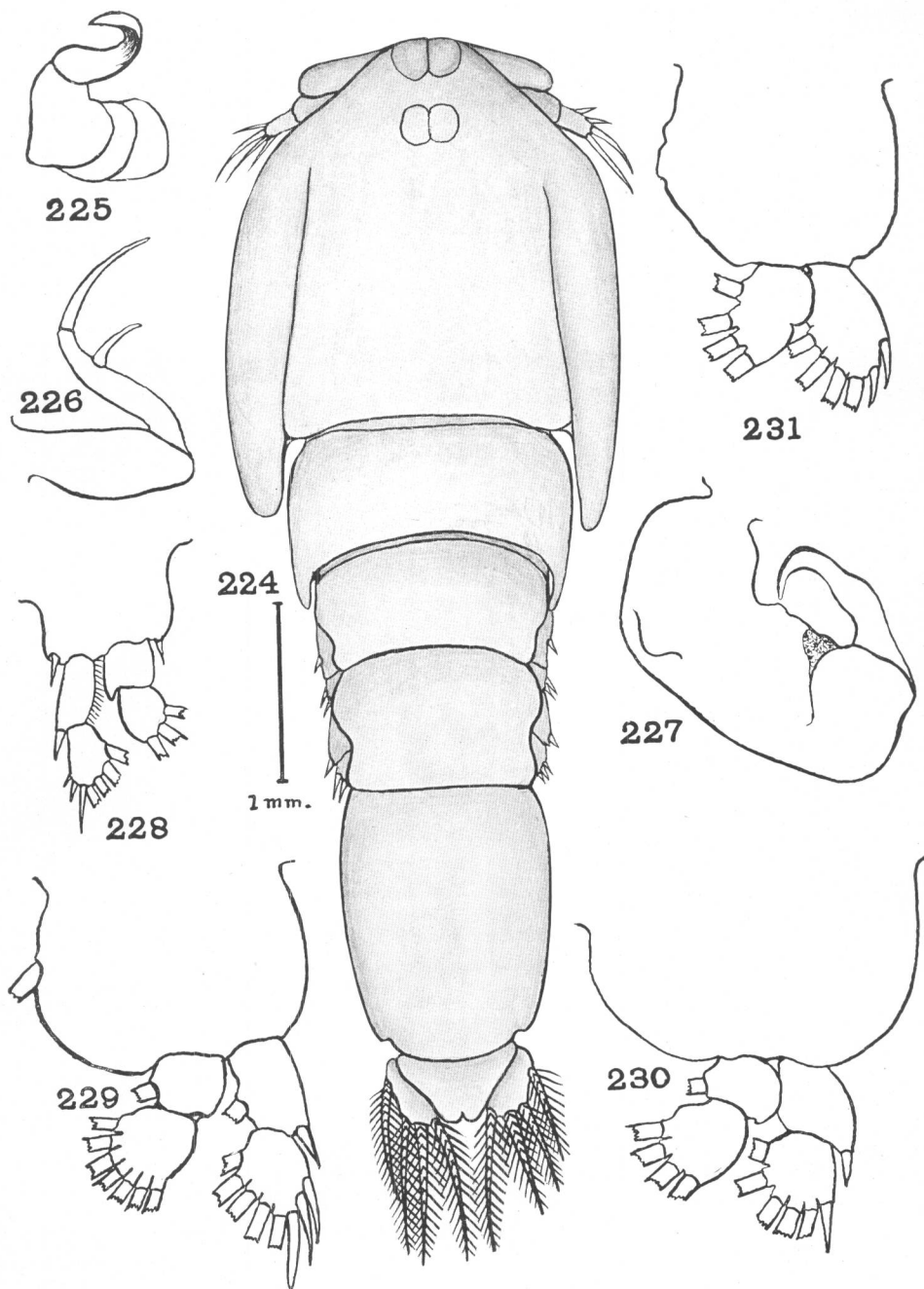


THE MALE OF NESIPPUS ALATUS.
FOR EXPLANATION OF PLATE SEE PAGE 489.



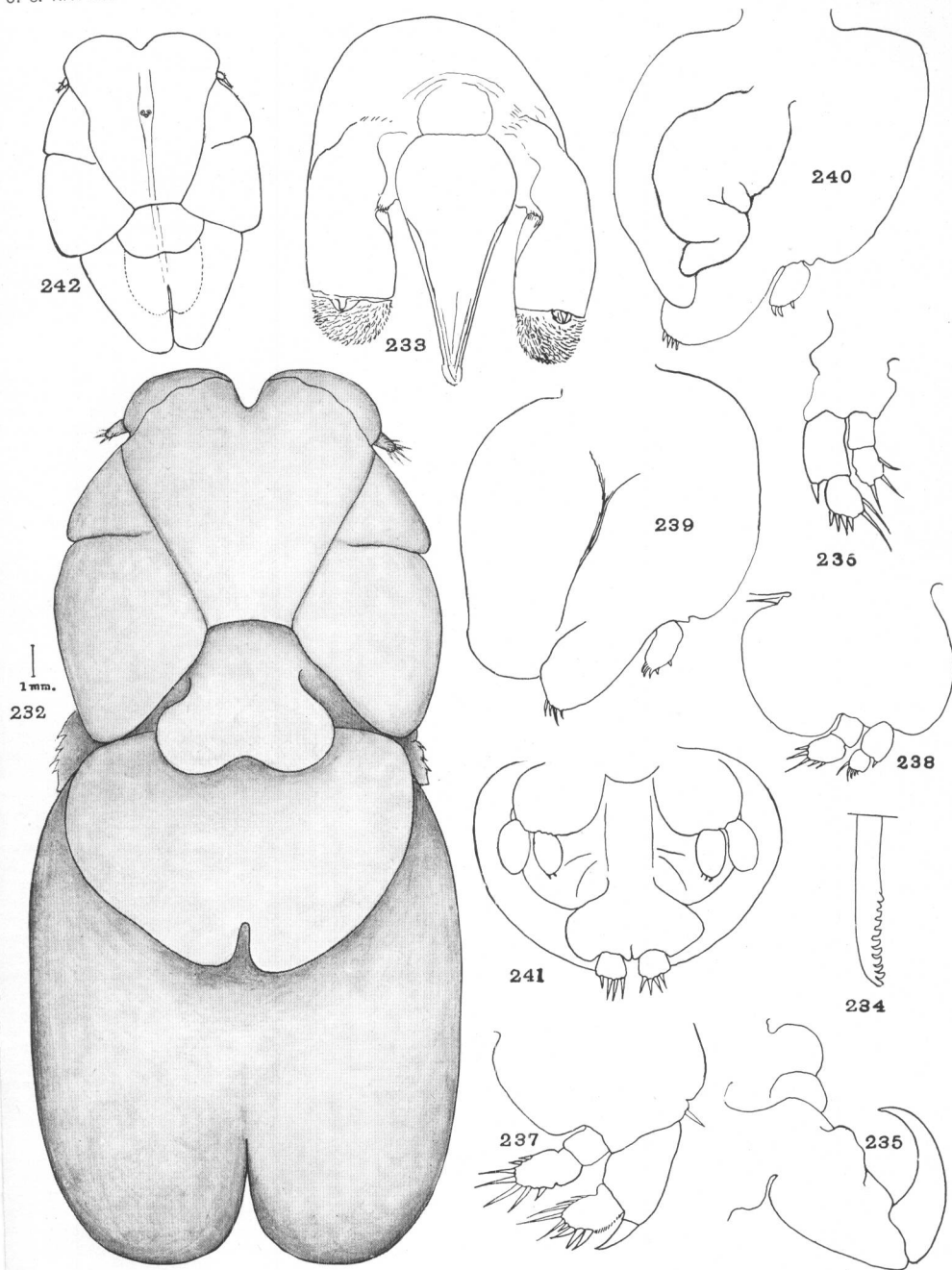
THE MALE OF NESIPPUS CURTICAUDIS.

FOR EXPLANATION OF PLATE SEE PAGE 489.



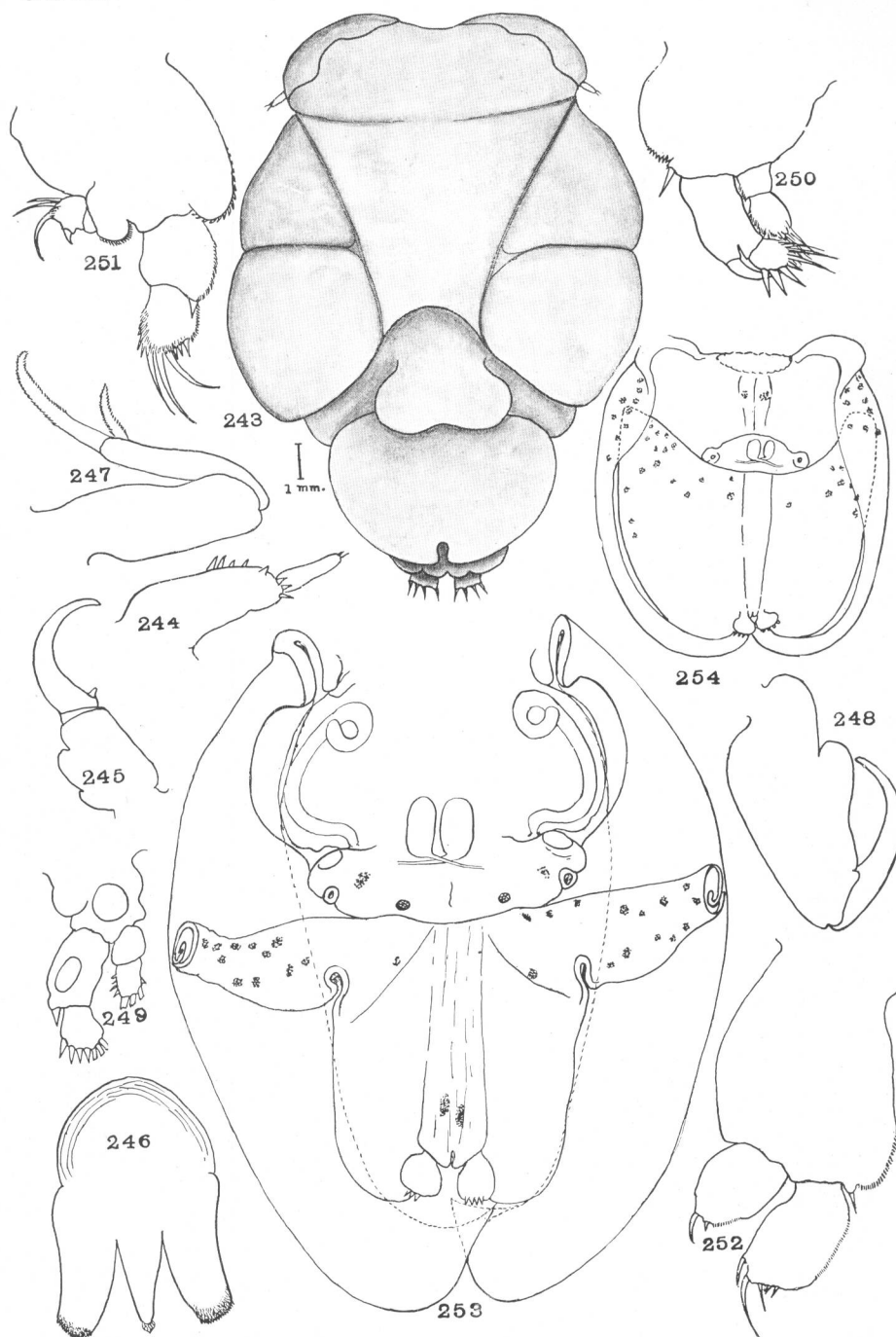
THE MALE OF NESIPPUS BOREALIS.

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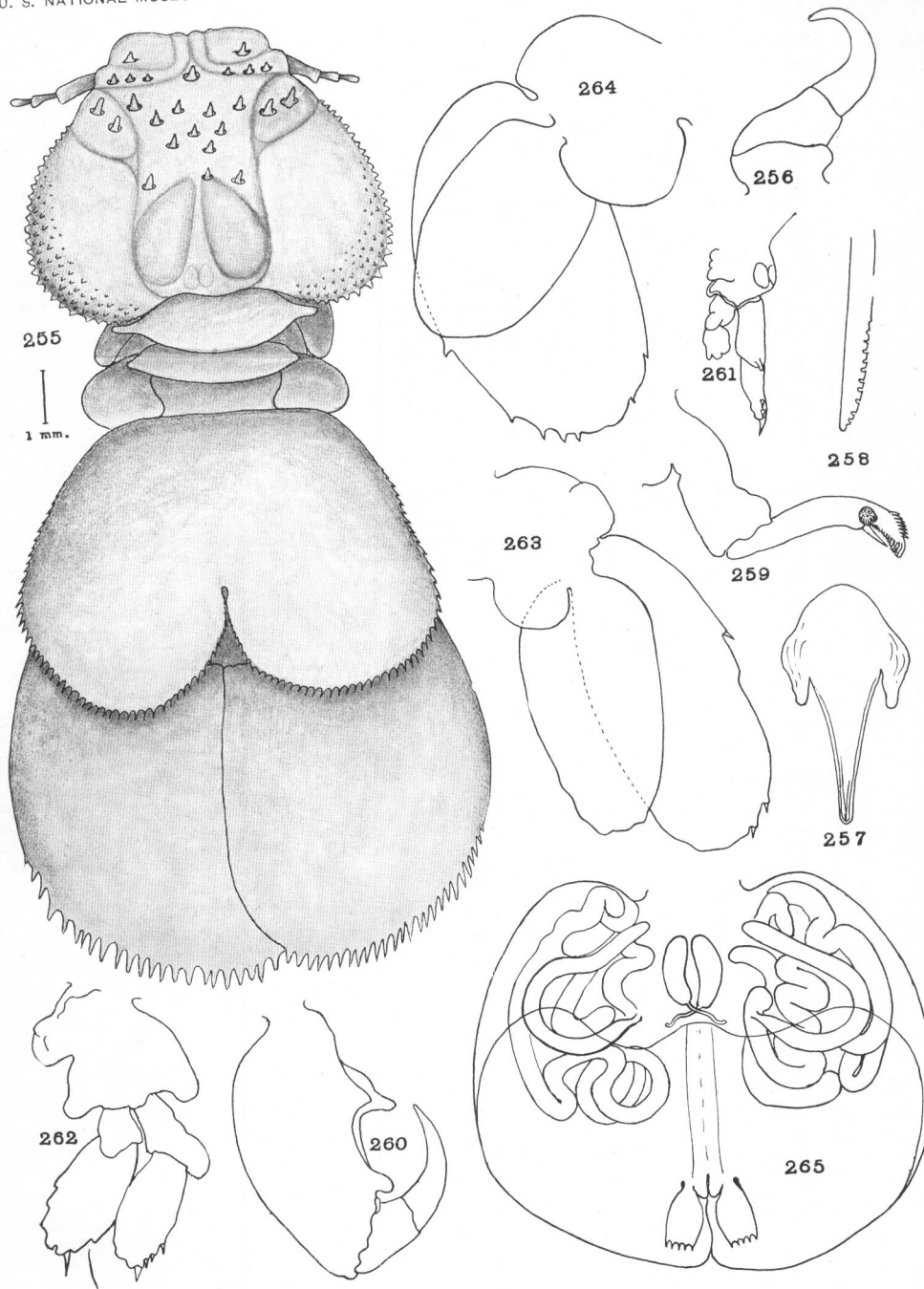


THE FEMALE OF CECROPS LATREILLII.

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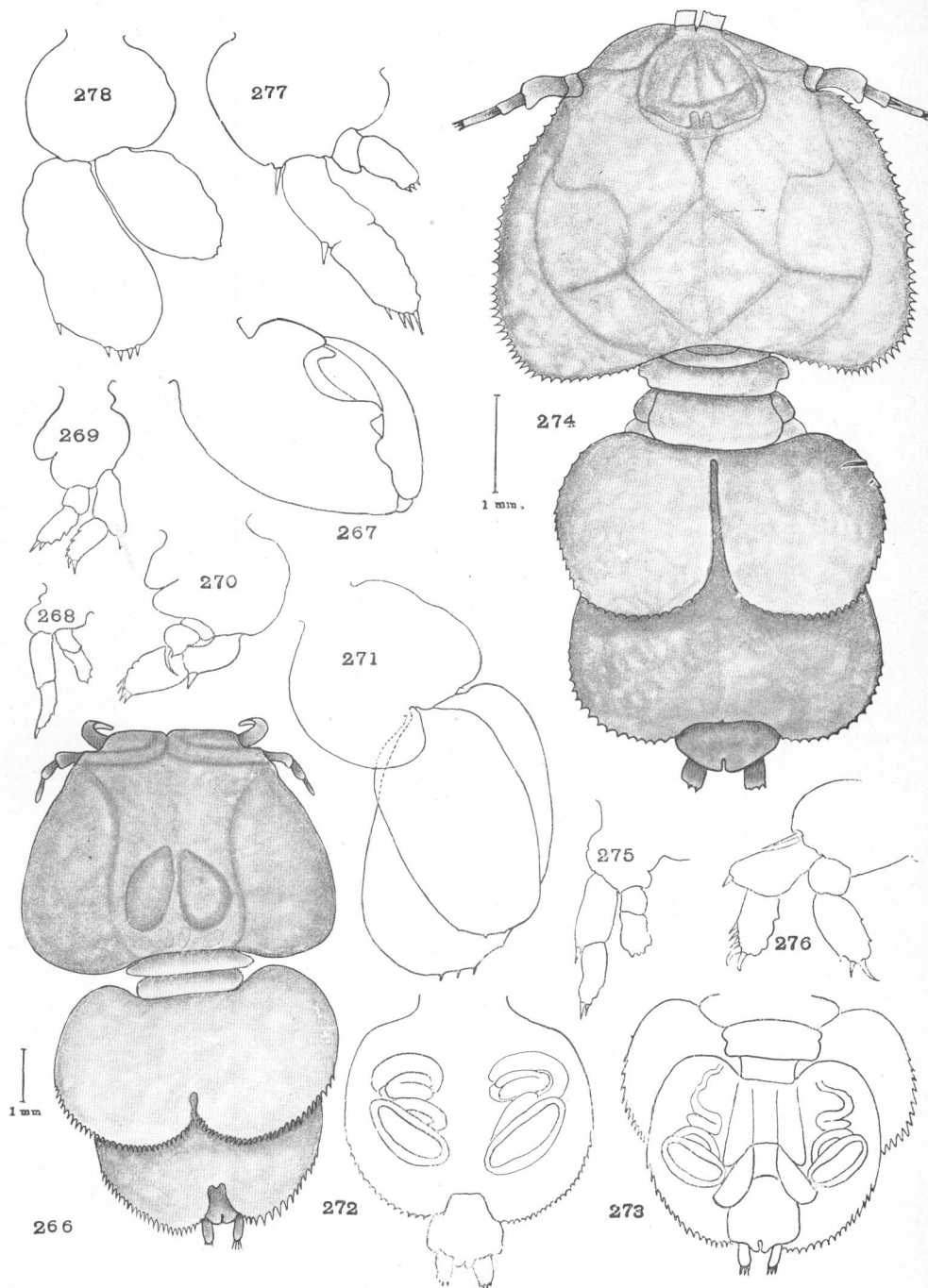
THE MALE OF *CECROPS LATREILLII*.

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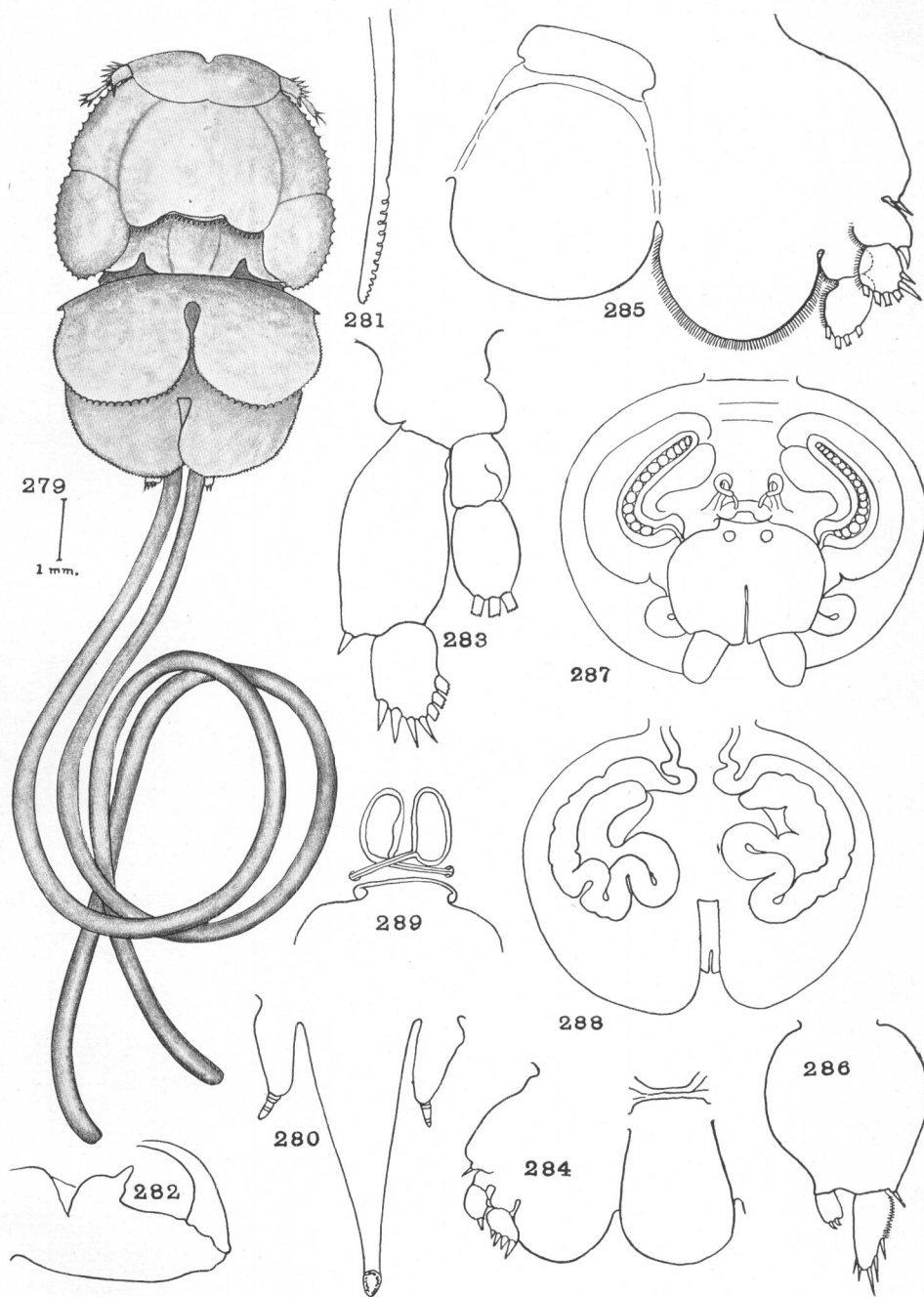
THE FEMALE OF *ORTHAGORISCICOLA MURICATA*.

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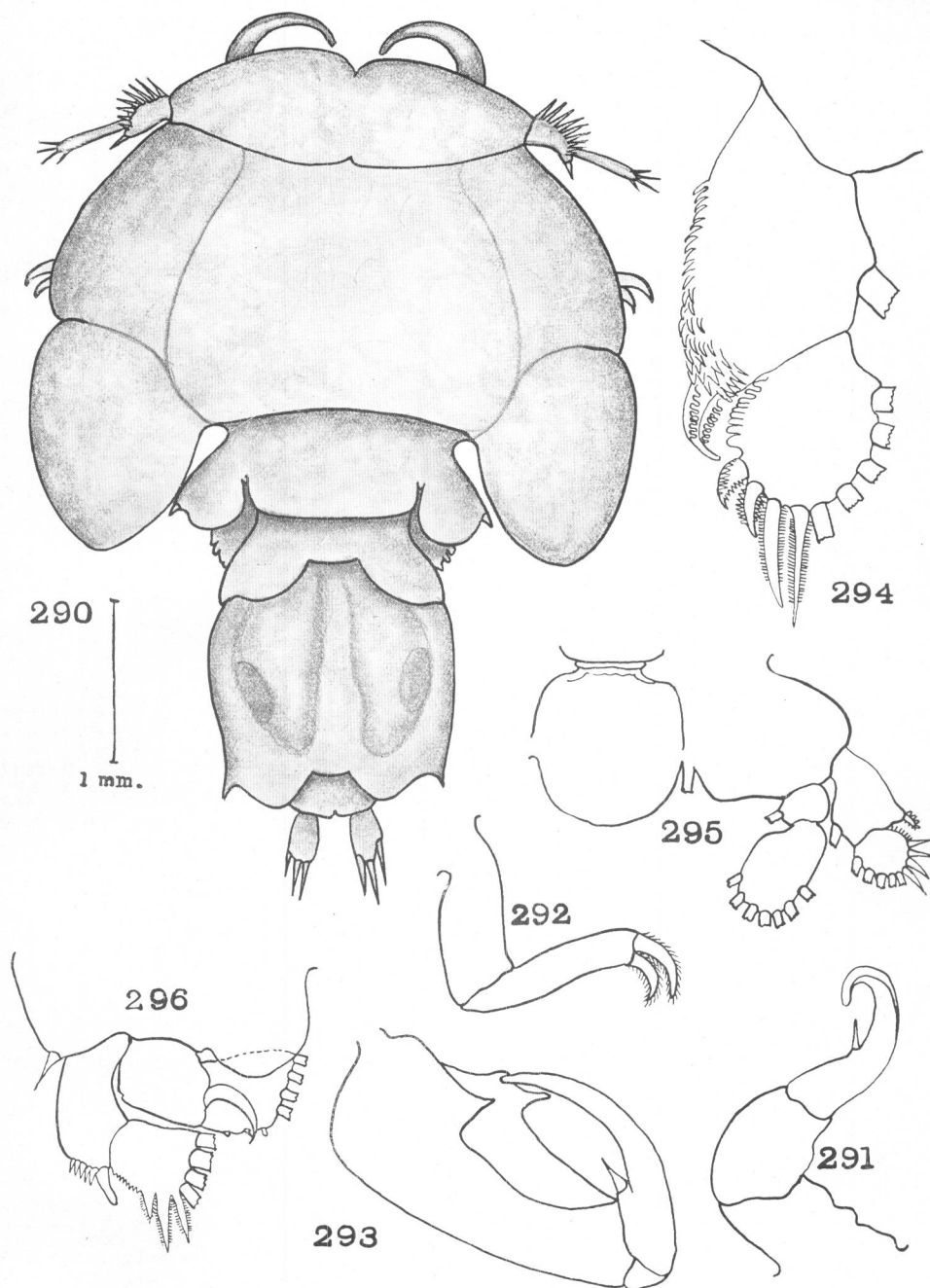
THE MALE AND A CHALIMUS OF *ORTHOGORISCICOLA MURICATA*.

FOR EXPLANATION OF PLATE SEE PAGE 490.



THE FEMALE OF *PHILORTHRAGORISCUS SERRATUS*.

FOR EXPLANATION OF PLATE SEE PAGE 490.



THE MALE OF *PHILORTHRAGORISCUS SERRATUS*.

FOR EXPLANATION OF PLATE SEE PAGE 490.