ADDITIONAL NOTES ON THE DEVELOPMENT OF THE ARGULIDÆ, WITH DESCRIPTION OF A NEW SPECIES.

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INTRODUCTION.

This fifth paper in the series based on the Collection belonging to the U. S. National Museum gives for the first time an account of the newly hatched larvæ of two of our common Argulids, one, *Argulus funduli*, a salt-water form, and the other, *Argulus maculosus*, found only in fresh water.

It also gives a description and figures of the male of *Argulus catostomi*, which is the oldest of our North American species.

In each of the three instances the form here described is the only one needed to complete a full account of the species, including its life history. We have now, therefore, six native species whose entire development is known, two infesting marine fishes and the other four those inhabiting fresh water.

For the opportunity of obtaining the present material the author is indebted again to the courtesy and assistance extended by the Bureau of Fisheries. The larva of *Argulus funduli* was obtained during the summer of 1905 while the author was working as a temporary assistant at the station of the Bureau of Fisheries at Beaufort, North Carolina. The other two forms were obtained during the present summer, 1906, while holding a similar position at Lake Maxinkuckee, Indiana. Grateful acknowledgment is here made for these favors.

I. THE MALE OF ARGULUS CATOSTOMI Dana and Herrick.

This was the first American Argulid to be described. For this reason and also because of the excellent figures given by Dana and Herrick with their original description, it was at once accepted by European scientists and has taken the same place in America that is occupied by *Argulus foliaceus* in the European fauna. But Dana and Herrick did not secure any specimens of males, and consequently their species diagnosis was based entirely upon females. This has been the

case with every zoologist since their day also. Even the present author, in a previous paper on the Argulidæ, was forced to be content with the one sex in consequence of an unfortunate accident which destroyed the few male specimens he possessed.

Accordingly this, the best known and one of the most widely distributed American species, has waited almost seventy years for the completion of the original diagnosis.

In the spring of 1905 the author visited the State fish hatchery at Swanton, Vermont, on the Missequoi River, near the shores of Lake Champlain. At this station are hatched every year many millions of the eggs of the wall-eyed pike, *Stisostedion vitreum*, one of the most common food fishes in the lake and its tributaries. The females are obtained for stripping by means of seines, and through the superintendent of the station permission was obtained from the State authorities to examine all the fish taken in the seines. For this and for many other courtesies the author acknowledges his indebtedness to the superintendent, who kindly placed at his disposal every facility which the station afforded.

Among other fish obtained were several red-fin and black-fin suckers, *Catostomus nigricans* and *C. catostomus*, and from these were taken about twenty specimens of *Argulus catostomi*, five of which proved to be males. Both sexes of this species were also obtained from the black sucker, *C. catostomus*, caught in Lake Maxinkuckee, Indiana, in August, 1906.

None of these specimens were as large as those obtained by the author from the same sucker in Massachusetts, but which were accidentally destroyed. Swanton, Vermont, is a long way from Mill River in Connecticut, where Dana and Herrick secured their specimens, and Lake Maxinkuckee is even farther removed.

Furthermore, the water is entirely fresh in both these localities instead of being brackish. But the one lot of material supplements the other and enables us to complete the account begun so long ago.

ARGULUS CATOSTOMI Dana and Herrick.

Plate XXIX, figs 1–9.

The Male.—Carapace orbicular, about one-tenth wider than long, with evenly rounded sides. Posterior sinus very wide, especially at the base, and a little more than one-third the length of the carapace. Grooving of the dorsal surface like that of the female. Abdomen elliptical and relatively much larger as would be expected in this sex, about one-third the length and one-fourth the width of the carapace. Testes elliptical, pear-shaped, and fully three-fifths the length of the abdomen, their dorsal surface sprinkled with small dots of dark pigment. Anal sinus wide, less than one-third the length of the abdomen;

papillæ basal and minute. The accessory sexual characters are very prominent and markedly different from those of any other species.

In the fourth legs both joints of the basipod carry a flap, heavily fringed with plumose setæ on their posterior margin, that on the basal joint being several times larger than that on the proximal. The peg on the anterior margin of the proximal joint is quite similar to that in *Argulus versicolor*, but relatively larger. The two parts of the peg, basal and terminal, are more clearly defined than in any species yet examined, and together make a pear-shaped organ with an evenly rounded outline. The tip of the tube is enlarged and surrounded by a fringe of minute hairs as in other species. The basal portion of the peg connects on the inside of the leg with a long spindle-shaped receptacle which extends inward through both joints of the basipod and almost to the mid-line of the body. Its walls are muscular and no doubt aid in ejecting the sperm.

In the third legs the proximal joint of the basipod is semi-lunar and the ends curve outward in long flaps, one in front of and the other behind the terminal joint. The posterior flap is wide and bluntly rounded at the tip; it carries a heavy fringe of plumose setæ and reaches only to the center of the distal basipod joint. The anterior flap is narrower and tapers to a long curved point which overlaps the base of the exopod for some little distance. There are no plumose setæ on its margin, but instead its entire dorsal surface is covered with small spines.

The distal joint of these third basipods bears the semen receptacle which is also similar to that of *Argulus versicolor*, except that the opening is nearer the center on the dorsal surface, instead of being at the posterior margin.

There is also a cone-shaped funnel extending forward from the anterior margin of the opening, along the dorsal surface of the basipod. This cone has a slit running along the dorsal side for the whole length; the outside of the cone and the inside at the tip are covered thickly with small spines.

The receptacle inside these legs is cylindrical and extends inward, like that of the fourth legs, through both basipod joints and into the third thorax segment.

The base of the exopod of these legs is enlarged on its anterior border where it joins the basipod into a rounded knob thickly covered with short spines.

The basal joint of the second legs bears a small flap on its posterior margin and ventral surface similar to those on the other legs but much smaller. It carries only four plumose setæ, at its outer end. The distal joint of the basipod of the first and second legs is armed with a flagellum, which projects from its ventral surface at the outer anterior, corner.

The reproductive organs are very prominent, being colored a cinnamon brown, which stands out in strong contrast to the surrounding gray and yellow. From the anterior end of each of the large testes a vas efferens leads forward to the semen receptacle, which is situated in the second thorax segment.

The vasa deferentia given off from the anterior end of this receptacle are very large at their bases and project somewhat into the first thorax segment. They taper gradually backward to the fourth segment, where they curve down on the outside of the vasa efferentia and meet below in the common ejaculatory duct.

Color of the Lake Champlain specimens a grayish green, similar to that of the female, the ventral surface of the thorax in the male and in several young females taken with them being sparsely covered with small spots of a brick-red pigment.

Color of the Lake Maxinkuckee specimens a light grayish brown, without any tinge of green. Eyes dark brownish black, brain a purplish hue, reproductive organs a dark cinnamon brown.

The ventral surface of each testis has a long line of the same dark brown running through the center lengthwise, the line becoming bifurcate toward the posterior end.

On the ventral surface of each joint of the thorax at the center and on the basipods of the swimming legs are small spots of brick-red pigment.

Total length 5–6 mm.; length of carapace 4.5 mm., of thorax 1.5 mm., of abdomen 1.35 mm. Width of carapace 4.8 mm.

II. THE LARVA OF ARGULUS FUNDULI Kröyer.

Plate XXX, figs. 10–14.

Only a single larva, that of *Argulus megalops*, of the true salt water Argulids has been described up to the present time.

The one here presented is therefore the second and is of peculiar interest in that it substantiates many of the characters in which the *megalops* larva was found to differ from the fresh-water forms. Two ripe females of *Argulus funduli* were obtained from *Fundulus heteroclitus* at Beaufort, North Carolina, on August 4, 1905. On being placed in fresh sea water one of the females deposited her eggs; these were then kept in a small glass surrounded by running sea water at a constant temperature of about 27° C. The eggs began to hatch on August 22, eighteen days after being laid. This is in marked contrast with the *megalops* larvæ, which required sixty days of incubation, but it shows that there is the same difference between the salt-water forms that we find in fresh-water species.

The eggs of *Argulus funduli*, therefore, among the salt-water forms correspond with those of *A. americanus* and *A. maculosus* from fresh

water. Furthermore we are certain that in the present instance the period of development is normal, for these eggs were kept at the same temperature as the ocean water in which they would naturally have been laid. The following is a description of the larvæ obtained:

Carapace heart shaped, a little wider than long; not much narrowed anteriorly; its entire margin fringed with delicate hairs, amongst the anterior two-thirds of which are scattered longer tactile hairs. Posterior sinus very shallow, the lateral lobes wide and well rounded. The large eyes are placed well forward and are widely separated. The cephalic area is clearly differentiated from the lateral areas at the sides and from the thoracic area posteriorly, and considerable movement is possible between these areas. The skin glands are not as large as those of the *megalops* larvæ, but there is a row of ten or twelve of medium size on either side parallel with the margin of the posterior portion of the lateral lobes.

The first antennæ, like those in the *megalops* larva, have assumed nearly their permanent form. The basal joint is armed with a broad and blunt posterior spine, and the usual sickle-shaped claw on its lateral margin. The terminal joints are comparatively stout and do not project much beyond the claw of the basal joint. The second antennæ are also of the adult form, slender, four jointed, and terminating in a small claw.

On the ventral surface, inside the base of these antennæ and immediately behind the large posterior spine of the first pair on either side, is another spine of the same size and shape.

The first maxillipeds are very large and stout and three jointed, the basal joint much swollen and bearing on its ventral surface near the distal end two large flat spines.

The second joint is much shorter and narrower, though still stout; the terminal claw is sickle-shaped, with the usual three barbs on its inner margin at the tip. The posterior maxillipeds are large and stout also, the basal joint with a pair of strong spines on its posterior border, the terminal joint with two stout and movable claws and a straight, rounded knob.

The ventral surfaces of the three middle joints are well armed with flattened laminæ, one edge of which is raised and cut into long and sharp teeth. Between the bases of these maxillipeds, on either side of the mid line, is a slender and sharp spine.

The mouth tube is short and wide, with a framework quite similar to that in *megalops*. The mandibles, however, are not toothed along their inner border, and there are no labial palps visible. The retractile proboscis is comparatively large and stout. Free thorax segments wide and quite long, leaving considerable space between the posterior border of the carapace and the abdomen. Each segment carries a pair of swimming legs fully developed and of practically the

same form as in the adult, with the exception that the endopod of the first pair is three jointed instead of two jointed.

Abdomen large and regularly elliptical, being a little longer than wide; anal sinus deep and triangular, the lobes on either side evenly rounded; anal papillæ large and basal, each armed with four long curved setæ which reach well beyond the posterior margin of the abdomen. We do not find in this abdomen the few large skin glands on either side which were so prominent in the *megalops* larvæ, but instead a large number of tiny glands scattered over the entire dorsal surface, with a row of six or seven on either side of the intestine a trifle larger than the rest.

Total length, 0.66 to 0.7 mm. Length of carapace, 0.43 mm. Width of carapace, 0.47 mm. Length of free thorax, 0.147 mm. Length of abdomen, 0.125 mm.

The larva of *A. funduli* thus takes its place with those of *A. megalops* and *A. stizostethii* as one in which most of the metamorphosis takes place within the egg before hatching.

Like the two species mentioned the larva, when it does come forth, has the same appendages and structure as the adult, with the single exception of the first maxillipeds. Even these, however, are prehensile, although by means of a claw instead of a sucking disk. As soon as they come out of the egg these larvæ begin to swim by means of the same appendages which they are to use through life. In the case of *megalops* and *stizostethii* this is what would naturally be expected, the former spending sixty and the latter eighty days in the egg.

But these *funduli* larvæ hatched in eighteen days, and it is at least noteworthy that they were able to reach the same advanced development in so small a fraction of time.

The digestive tract and the circulatory apparatus are not as far advanced in the present species as in *megalops*, and presumably in *stizostethii*, although we have no record in this respect for the latter species. But in external morphology, and particularly in the locomotor apparatus, these eighteen-day larvæ have fully reached the same advancement as the other two species.

III. THE LARVA OF ARGULUS MACULOSUS Wilson.

Plate XXXI, figs. 15–22.

Two females of this species with ripe eggs were obtained at Lake Maxinkuckee, Indiana, August 8, 1906, from the redeye, *Ambloplites rupestris*. It was afterwards found that this was not their true host, but only a temporary one, used while they were searching for a suitable place to deposit their eggs.

Numerous specimens of both sexes were subsequently obtained from the two catfish, *Ameiurus natalis* and *A. nebulosus*, which are evidently

their true hosts. As the previous description[a] of this species was made entirely from preserved specimens, it will be well to note here the color of the living adults.

The body in both sexes is beautifully transparent and of a soft yellow color, like rich cream. Against this background the grooves on the dorsal surface of the carapace and the spots over the semen receptacles in the female and over the testes in the male show a clear cinnamon brown, while the claws and spines on the ventral surface are a darker brown, tinged with reddish.

The small spots which cover the entire dorsal surface, and from which the species was named, are a light brown, distinctly visible even to the naked eye.

The two females deposited their eggs that same evening upon the sides of a wide-mouthed bottle in which they had been placed.

The eggs were arranged in single straight rows, not end to end like those of *megalops*, but the first one inclined to the right, the second to the left, the third to the right, and so on.

The jelly envelope assumes a form characteristic of this species and much resembling that in *A. catostomi* and *A. americanus*, with this difference. In *catostomi* the jelly hardens into rows of papillæ, all about the same size, and running lengthwise of the egg; where the eggs come together these papillæ rows simply fuse into one another. In *americanus* there are similar longitudinal rows in which the papillæ are the same size, and in addition there are also a few scattered masses of jelly, some of which are nearly two-thirds as large as the entire egg. But they are scattered at random, and there are never more than one or two for each egg. Here in *maculosus* the longitudinal rows are the same as in the other two species, and there are in addition the large masses of jelly. But instead of being scattered they are arranged with perfect regularity, a row of them standing out like the spokes of a wheel at the junction of every two eggs, and at right angles to the long axis of the egg row.

The eggs are twice the size of those of *americanus*, measuring 0.64 by 0.43 mm., exclusive of the jelly envelope. They are light yellow and transparent when first laid, but become darker and opaque about the fourth day. The eyes appeared on the eleventh day, and the eggs began to hatch on August 24, sixteen days after they were laid, about the same length of time as that required for the *americanus* eggs. They did not all hatch at once, but kept coming out for about sixty hours. They were kept immersed in the lake for the first twelve days, the temperature of the water for that time averaging 76° F. They were then removed to an aquarium in which the water temperature stood nearly constantly at 72° F.

[a] Proc. U. S. Nat. Mus., XXV, p. 715.

The newly hatched larvæ are sluggish and move about slowly like those of *americanus*, but they do not stick to the bottom of the dish like the latter. Moreover, their motion is not jerky and cyclops-like, but is similar to that in the adults. They are beautifully transparent, the small amount of pigment present only serving to bring out more clearly the internal anatomy. The following is a description of these larvæ:

Carapace broadly elliptical, the width to the length in the proportion of 13 to 16; anterior margin broad and rounded, with a fringe of long cilia, among which are scattered tactile hairs; as in other species. The posterior sinus is broad and shallow, while the free thorax and abdomen form a wide triangle relatively shorter than in other species. The first free segment is considerably less than half (five-thirteenths) the width of the carapace; the remaining segments and the abdomen diminish regularly in size. The abdomen is relatively smaller than in any other species; its shape is that of three-quarters of a circle, the chord forming the base, while the diameter is considerably less than the width of the last thorax segment.

The anal laminæ are close together, small, slightly divergent, and each carries two or three spines, of which the inner is the longer.

The first antennæ are three-jointed, the two terminal joints approximately spherical, the basal joint large and armed with a powerful hook. The curve of this hook reaches to the tip of the terminal joint, while in the *americanus* larva it scarcely reached the center of the second joint.

The second antennæ are similar to those of the *foliaceus* larva, but the two joints of the basal portion are very unequal, the distal one being fully twice as large as the proximal.

The temporary exopod is without joints and of the same length as the endopod, while this latter, which is permanent, has three joints increasing regularly in length, the terminal one the longest and tipped with a short curved claw and a pair of bristles.

The temporary mandibular palps are situated as far forward as in the *americanus* larva and are three-jointed. The spine connected with their base is outside of the mouth tube, straight instead of curved, and much nearer the mouth opening than in other larvæ. In fact, the tip of the spine is almost on a level with the rim of the mouth opening.

The anterior maxillipeds are stout and four-jointed and terminate in the usual pair of sickle-shaped claws, the dorsal one of which is barbed. The large cells in the basal joint which are to form the sucking disk are not apparent when the larva is first hatched, but can be seen forming two or three days afterward. The posterior maxillipeds are large and five-jointed, each joint armed on its ventral surface with spines and bristles. The terminal joint ends in two small and strongly curved claws and a conical papilla, tipped with a single minute spine, which frequently gets broken off. There is a stout spine on the

posterior border of the basal joint and a still longer one farther in on the ventral surface of the carapace close to the mid-line.

Of the swimming legs the first pair only are developed, the others being immovable stumps. This first pair consists of two basal joints, the distal one much the smaller and armed with spines on its ventral surface, and two rami. The endopod is three-jointed, each basal joint armed with a long spine at its distal end and shorter ones on its ventral surface, the terminal joint ending in two short spines. The exopod is one-jointed, with bristles along its anterior margin and two long nonplumose setæ at the tip. The leg stumps of the other pairs show plainly the division into endopod and exopod, the latter of which is tipped with two short spines, the former with only one, while both are covered on their ventral surface with small spiny hairs.

The internal anatomy is similar to that of other species already described. The digestive tract is not as well formed as in the *americanus* larva, and there is only the faintest trace of the shell glands in front of the side branches of the stomach. The chitin rings in the posterior lobes of the carapace are prominent and already possess the same shape as in the adult, and so are characteristic of the species.

The only other part deserving special mention is the skin glands. In the *americanus* larva there was only a single small group of these glands on either side near the posterior edge of the carapace lobes. In the present larva no skin glands at all are visible on first hatching; very small ones afterwards appear in the posterior carapace and the abdomen.

IV. ARGULUS APPENDICULOSUS, new species.

Plate XXXII, figs. 23–30.

Carapace orbicular, longer than wide, projecting slightly anteriorly, with broad and well-rounded posterior lobes, which just reach the abdomen in the male but fall a little short in the female. Posterior sinus broad, its sides slightly divergent, showing in dorsal view the bases of the posterior legs on either side of the last two or three thorax segments. Eyes small, situated far forward and well separated; cephalic area nearly as wide posteriorly as anteriorly, with evenly rounded sides. Chitin rings in the lobes of the carapace large and well defined, having the same general pattern as in *A. catostomi*, *americanus*, and *versicolor*, namely, an outer larger, semilunar ring with a much smaller spherical one inserted in its inner border near the anterior end.

In the present species the anterior portion of the outer ring, in front of the spherical ring, is larger than usual and reaches almost to the center of the disks of the first maxillipeds.

The spherical rings are relatively smaller than in the species mentioned and are buried more deeply in the sides of the large rings.

Abdomen small, one third the length of the carapace, nearly as wide as long, and ovate. Anal sinus reaching just to the center of the abdomen; posterior lobes triangular, slightly divergent and very wide at the base, almost obliterating the anal sinus. Anal papillæ minute and basal, almost concealed between the bases of the posterior lobes.

First antennæ stout, the claw twice the length of the rest of the basal joint and stoutly curved; the two terminal joints minute and scarcely reaching the tip of the claw.

At the base of these antennæ is a pair of stout spines, one on either side of the mid-line and some distance from it; each is strongly curved outward. Second antennæ small, no longer than the first, the joints diminishing regularly in size, the last three armed with bristles in the usual manner.

Mouth-tube stout and somewhat swollen at the tip; mouth opening subterminal and very similar to that in *A. versicolor*. Mandibles slender and not strongly curved, the teeth on the convex side large with bluntly rounded tips; those on the concave side slender and needle-like, longest at the point of the mandible, then growing rapidly smaller, and entirely disappearing at about the center of the side.

First maxillipeds large, the sucking disks being fully one-fifth the width of the carapace. This margin is supported in the usual manner by rods, which, instead of being made up of segments, as in most species, appear to be continuous and perfectly homogeneous.

Second maxillipeds stout and of the usual pattern, the basal joint armed with a triangular plate, which is broad and projects far behind the appendage. Its posterior margin is cut into three wide and blunt teeth, or, rather, laminæ, evenly rounded and very similar to those on *A. catostomi*. Nearly the entire ventral surface of the appendage is covered with spines and papillæ; the terminal claws are short and blunt.

Swimming legs of the usual pattern, the fourth pair with large boot-shaped posterior lobes, the toes of which project beyond the lateral margins of the abdomen.

The male is similar to the female, with the exception of the sex differentiations. The posterior lobes of the carapace are longer, as already stated, and just reach the anterior margin of the abdomen. The latter is relatively longer than in the female and narrower; the anal sinus does not extend to the center, and the tips of the posterior lobes are more bluntly rounded. The testes are long and narrow and situated close to the mid-line on either side.

The accessory sexual organs are in the form of broad laminate appendages, very prominent even in a superficial view. The two rami of the fourth legs are much widened, particularly the proximal joint of the endopod, whose posterior border is flattened into a broad lamina several times as wide as the terminal joint. At its base where it

joins the basipod it is enlarged posteriorly into a rounded lobe, whose surface is covered with rough papillæ. But the most prominent feature of these legs is the enormous lobe or lamina attached to the posterior margin of the basipod. This is boot-shaped, as in the female, but is fully twice as large, the toe of the boot being pointed, considerably widened, and turned forward so that it projects anteriorly in front of the exopod. The flap thus covers the whole of the endopod and about half of the exopod.

The basipod of the third legs is also furnished with broad laminate lobes, one along the posterior margin, which extends outward a little beyond the base of the endopod, and another on the ventral surface turned diagonally forward and outward.

The peg on the anterior margin of the basipod of the fourth legs and the semen receptacles on the posterior margin of the third legs are as in other species.

Female, total length 7.4 mm.; length of carapace 5.5 mm.; width of same 5.1 mm.; length of abdomen 1.8 mm.; width of same 1.6 mm.

Male, total length 8 mm.; length of carapace 5.9 mm.; width of same 5.4 mm.; length of abdomen 2.1 mm.; width of same 1.45 mm. Color (preserved material) a uniform creamy white with the dorsal surface sparsely covered with small spots of brown pigment.

There is a noticeable absence of pigment spots over the testes in the male and the ovary and semen receptacles in the female.

About twenty specimens of this new species, including both sexes, were obtained from a sucker (species not given) at Montpelier, Vermont, and were sent to the U. S. Bureau of Fisheries at Woods Hole in August, 1898. These have been made the types of the new species, and are numbered 32829 in the catalogue of the U. S. National Museum (*appendiculosus*, with many appendages, referring especially to the large laminate lobes on the posterior legs of the male, which look like extra appendages).

V. NOTES ON DEVELOPMENT.

On October 9, 1902, a paper was read before the South London Entomological and Natural History Society on "*Argulus foliaceus*, a Contribution to the Life History."

This was written by Frederick N. Clark, one of the vice-presidents of the society, and was published in their proceedings for 1902. It proves to be a valuable contribution and one which has not gained the prominence it deserves. This may be partly due to the fact that it is published in an entomological journal where one would not ordinarily look for important papers on the crustacea.

Several facts there published have an important bearing in connection with the present paper. The author writes on page 12:

> My observations commenced in 1896, since when I have had good opportunities of studying its life history, having repeatedly bred them from the egg to the adult stage, and so on again.

So far as known this is the only instance on record of the actual breeding of any parasitic copepod throughout its entire life history. The facts presented, therefore, are of special value since they are actual facts and not partial deductions.

On pages 19 and 20 are many interesting statements in reference to oviposition and the time required for hatching.

> Statistics which I have taken from twenty cases of oviposition show that the average time from the laying of the egg until hatching occupies 25 days.

It was found that temperature greatly influences the length of incubation, and that this period also varies still more widely for reasons which are apparently inexplicable. In testimony thereof witness the following:

> In confinement I have records of ova laid on November 29 and hatching on May 6 of the following year. On the other hand, some batches laid on August 30 and September 2 remained over the winter and hatched on April 10.

The former is a period of five months and eight days, the latter of seven months and two days either period being far in excess of any previously recorded. It must be remembered also that these were "in confinement"—that is, in aquaria, where the temperature would be much higher than out of doors during these winter months.

The moral for the investigator would seem to be that if the eggs he is watching do not hatch within the allotted time he must still keep them, even to a period of six months; they may yet come around all right and hatch into normal larvæ at the eleventh hour.

Again, Clark states that eggs which began hatching on February 27 and continued into March "became adult on June 27, and laid ova which hatched on July 20 (twenty-three days.") In this case the entire period from the birth of the parents to the birth of the children was a week less than five months.

This enormous difference from an average of 25 days to a maximum of 212 days emphasizes more forcibly than ever before the necessity of keeping an accurate record of the attendant temperatures and conditions if we would form a rational conclusion in reference to the period of incubation. Fortunately the daily temperature of the water was carefully recorded during the incubation period of both of the larvæ here described, and is supplied in the account as given. It would be very interesting to determine what relation, if any, the length of the incubation period bears to the subsequent length of life of the Argulid. Would the continuance of the larvæ for 200 days within the egg tend to shorten its subsequent life?

Again Clark writes on page 20:

> The newly hatched Arguli immediately attach themselves to the fish, and only leave it to undergo their metamorphosis.

This is what would naturally be expected, for, in reviewing the development of the various families of parasitic copepods, we find that those larvæ which, like *Caligus*, *Ergasilus*, and the like, hatch into a typical nauplius form, remain free swimming through several nauplius and metanauplius stages before seeking their host.

On the contrary larvæ like those of *Chondracanthus*, *Lichtheres*, etc., which pass the nauplius stage inside the egg, or moult from it as soon as they are hatched, remain free swimming but a very short time, seeking their host almost immediately.

In like manner these *Argulus* larvæ, which pass all the earlier stages inside the egg and hatch out in an advanced cyclops stage, seek their host immediately. It is no wonder that the efforts hitherto made to keep them through several moults without any host have all failed. But since they are not as particular about the species of host as many of their relatives, it ought to be easy in the future to supply some small and hardy fish to the newly hatched larvæ, that would serve as a temporary host and carry them through to the adult form. This suggestion bids fair to be of great value in future investigations not only of the Argulidæ, but of all the parasitic copepods.

Clark gives the average length of life of an Argulus as "probably over six months." In the opinion of the present author this ought to be lengthened somewhat, since adult Arguli have been repeatedly found, which had laid one batch of eggs, and another batch was beginning to form within the ovaries.

The prevalence of such specimens makes it probable that the normal female lays at least two batches of eggs. The formation and maturation of these eggs, in addition to the time required for the development of the larva to sexual maturity, almost certainly exceeds six months.

On page 21 it is stated that—

> If hungry or pressed for food the stickleback will sometimes swallow the Arguli, but generally speaking they are avoided, and if swallowed are ejected from the mouth.

This agrees fully with the experience of the present author as already recorded for the adults of *Argulus versicolor*[a], but the experience with the larvæ of *A. catostomi* given[b] in the same paper would suggest that some fish are in the habit of using these larvæ as a normal food supply.

Finally Clark records that *A. foliaceus* is frequently the victim "of a filamentous fungoid disease precisely similar in its nature to that of its

[a] Proc. U. S. Nat. Mus., XXV, p. 647. [b] Idem., p. 652.

host" (the stickleback). Without being able to prove their actual death as a result of the fungoid growth, many specimens of North American Arguli, of both the salt and fresh-water forms, have been obtained which showed the presence of such parasitic plants.

EXPLANATION OF PLATES.

PLATE XXIX.—The male of *Argulus catostomi*.

Fig. 1, dorsal view; fig. 2, first antenna; fig. 3, second antenna; fig. 4, second maxilliped; fig. 5, basipod of second swimming leg, dorsal view; fig. 6, basipod of third leg, ventral view; fig. 7, basipod of fourth leg, ventral view; fig. 8, testes and sperm receptacles; fig. 9, basipod of second leg, ventral view (turned from a horizontal to a vertical position), showing the appendage.

PLATE XXX.—The newly hatched larva of *Argulus funduli*.

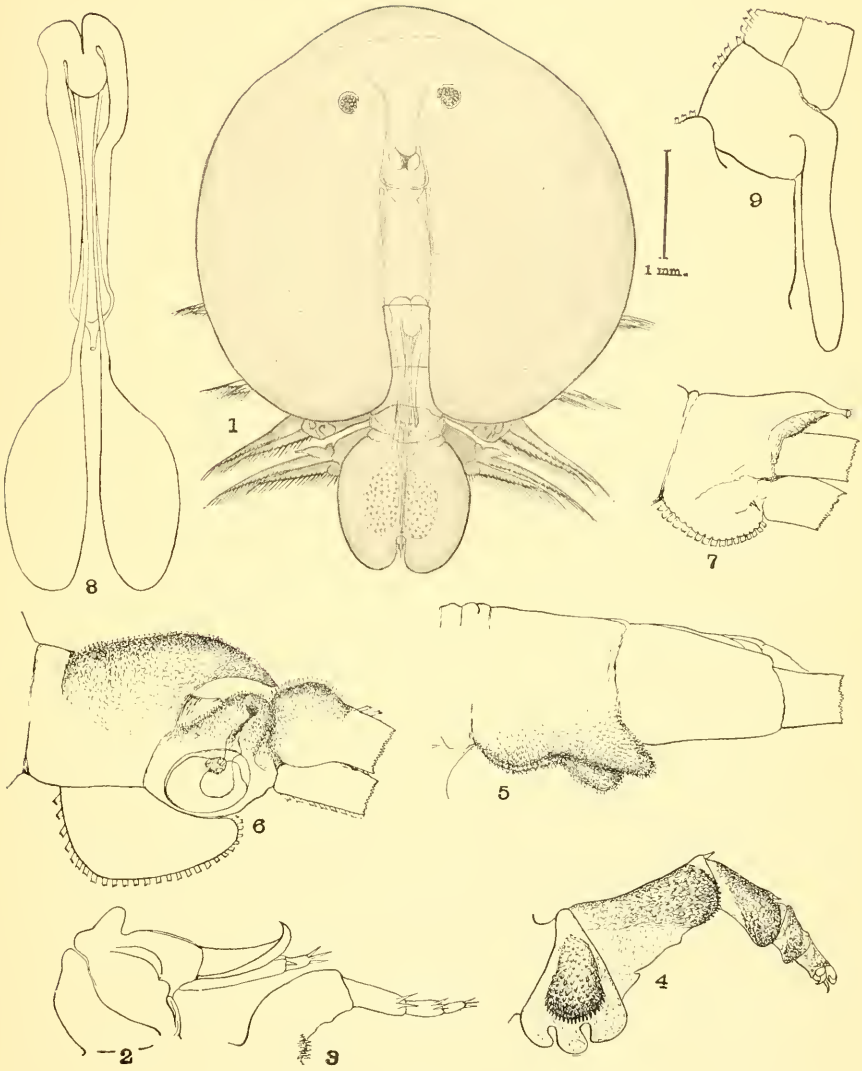
Fig. 10, dorsal view; fig. 11, first and second antenna; fig. 12, the mouth tube; fig. 13, first maxilliped; fig. 14, second maxilliped.

PLATE XXXI.—The newly hatched larva of *Argulus maculosus*.

Fig. 15, three freshly laid eggs, showing their arrangement and the form assumed by the jelly envelope; fig. 16, dorsal view of larva; fig. 17, first antenna; fig. 18, second antenna with temporary rowing apparatus; fig. 19, temporary mandibular palp at the base of the mouth tube; fig. 20, second maxilliped; fig. 21, first swimming leg; fig. 22, second, third, and fourth swimming legs.

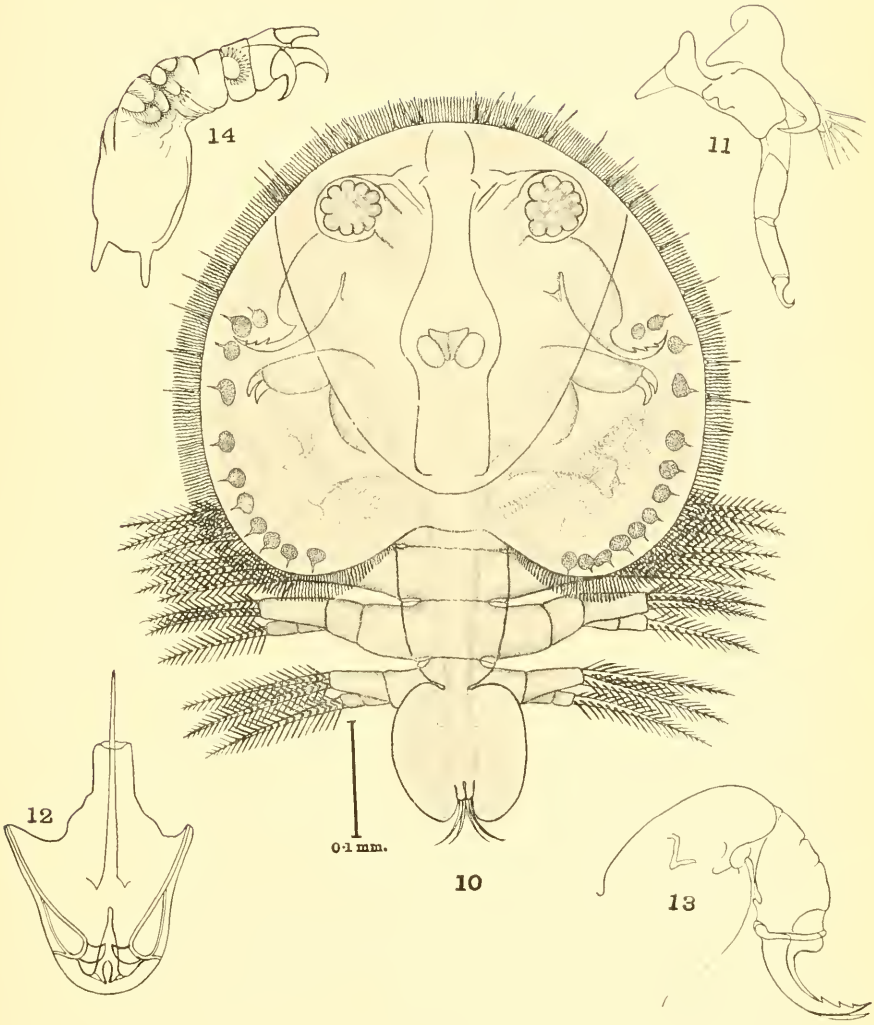
PLATE XXXII.—The male and female of *Argulus appendiculosus*, new species.

Fig. 23, dorsal view of female; fig. 24, dorsal view of male; fig. 25, first and second antennæ of female; fig. 26, mandible; fig. 27, second maxilliped; fig. 28, basipod of third leg of male; fig. 29, fourth leg of female; fig. 30, fourth leg of male, ventral view, showing the enormous boot-shaped appendage on the basipod.



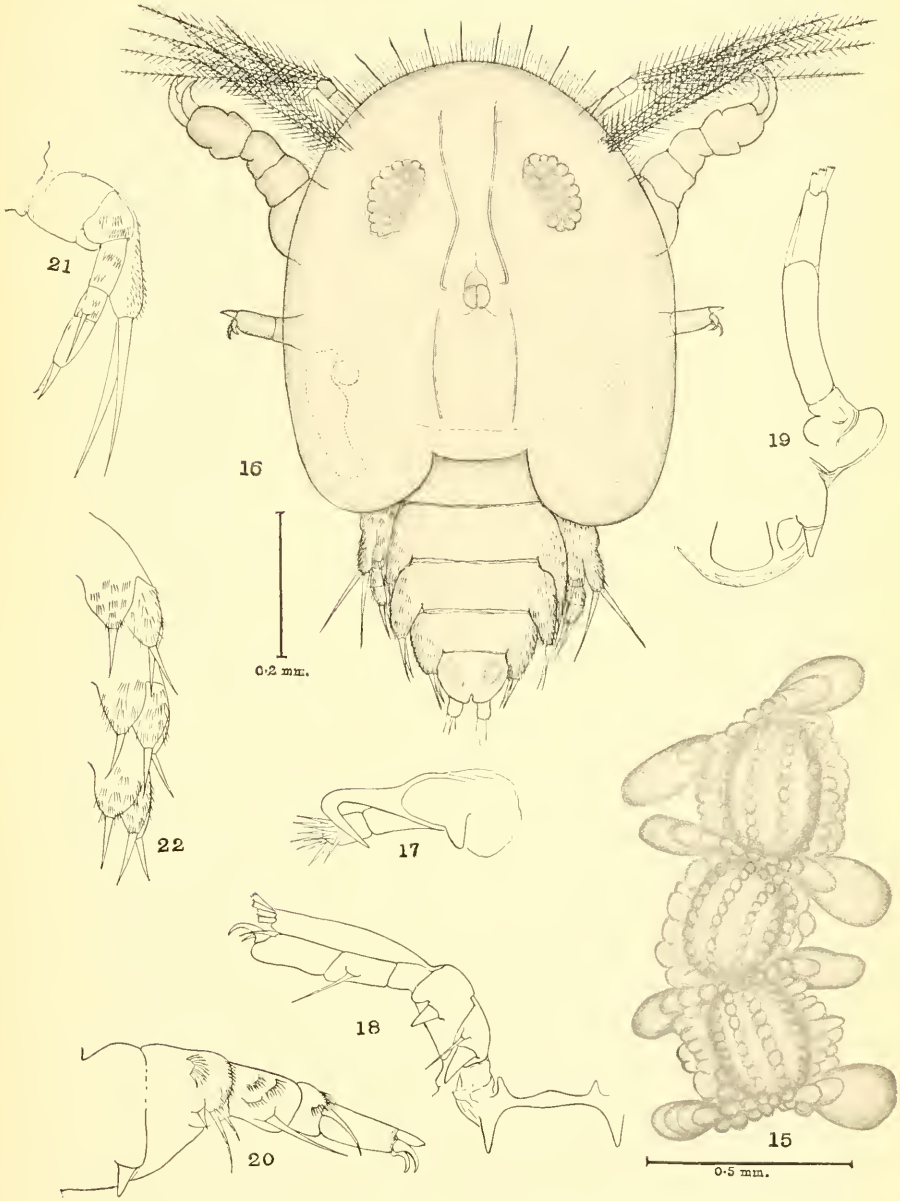
THE MALE OF ARGULUS CATOSTOMI.

FOR EXPLANATION OF PLATE SEE PAGE 424.



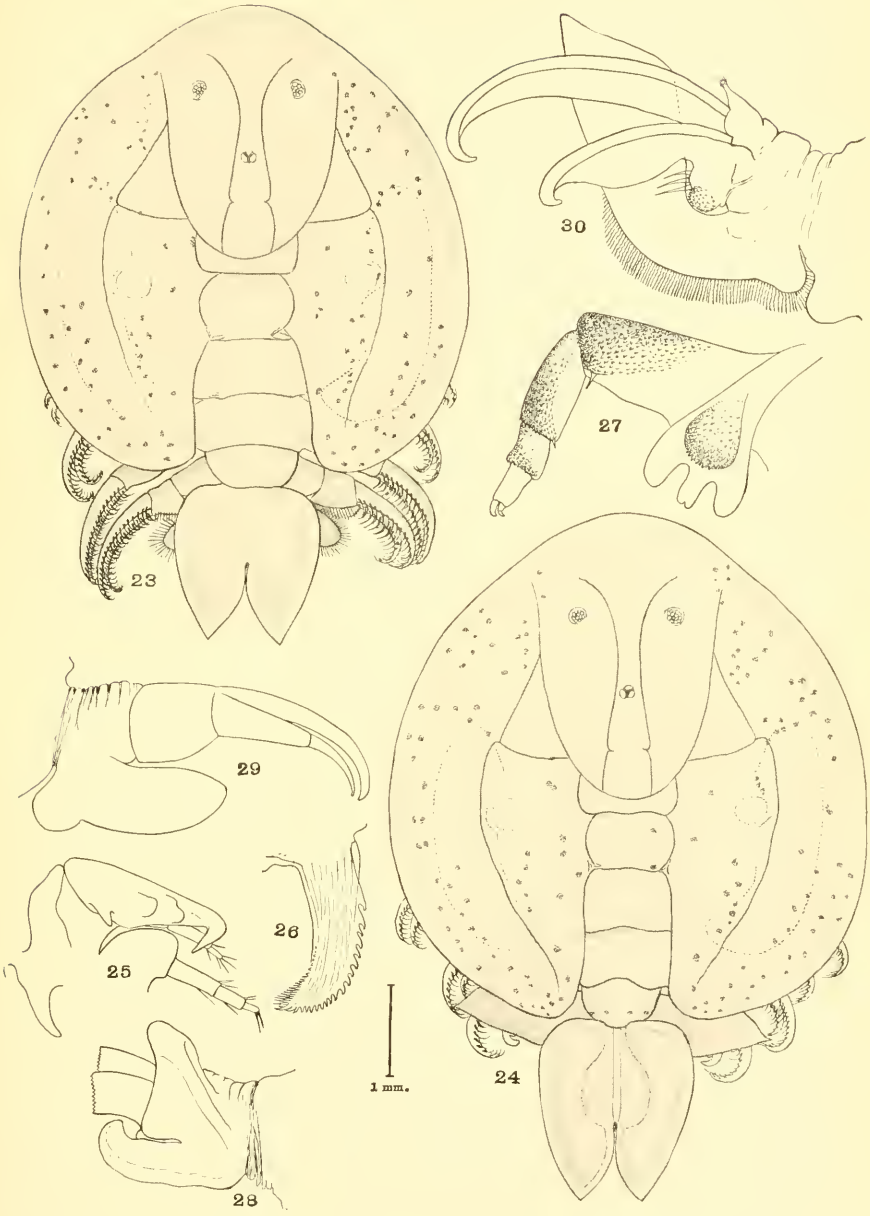
THE NEWLY HATCHED LARVA OF ARGULUS FUNDULI.

FOR EXPLANATION OF PLATE SEE PAGE 424.



THE NEWLY HATCHED LARVA OF ARGULUS MACULOSUS.

FOR EXPLANATION OF PLATE SEE PAGE 424.



THE MALE AND FEMALE OF ARGULUS APPENDICULOSUS.

FOR EXPLANATION OF PLATE SEE PAGE 424.