
CONTRIBUTIONS FROM THE BIOLOGICAL LABORATORY OF THE BUREAU OF FISHERIES
AT WOODS HOLE, MASS.

THE FISH PARASITES OF THE GENUS ARGULUS
FOUND IN THE WOODS HOLE REGION.

By CHARLES B. WILSON, A. M.,
Department of Biology, State Normal School, Westfield, Mass.

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The summer of 1871 witnessed the first effort on the part of the United States Fish Commission to obtain a knowledge of the invertebrate fauna of Vineyard Sound and adjacent waters, and thus of the parasites that infest the fish of that region. The results were embodied in an admirable monograph by Verrill and Smith, which has become the foundation of all subsequent work. In it were descriptions of three species of *Argulus*, all of which were new to science, but as they were captured while swimming freely at or near the surface, not even one of their hosts could be determined. Two other species were mentioned as likely to occur in the vicinity, but one of them, *alosa*, had never been seen since 1847, when it was found by Harris in Boston Harbor and very poorly described by Gould in his *Invertebrata of Massachusetts*, while the other species, *catostomi*, had been found only upon the suckers in Mill River, near New Haven, Conn.

Since this first effort in 1871, the work has been carried forward steadily by members of the Fish Commission, and large collections have been made, showing the hosts for the various specimens taken. Especially should be mentioned the efforts of Mr. Vinal N. Edwards, whose extensive study of the fishes themselves has brought him frequently in contact with the parasites which infest them. Fully three-fourths of the entire collection of *Arguli* bear his signature, so that the determination of hosts and breeding seasons is almost wholly a result of his labors.

The material thus accumulated eventually found its way into the United States National Museum, and about a year and a half ago the entire museum collection was placed in the author's hands for purposes of study, at which time and since every facility within the command of the Fish Commission has been generously placed at his disposal. This has made it possible to determine with accuracy much that was previously in question with regard to the sexes of the *Arguli*, their breeding seasons, the place and manner of depositing the eggs, the period of incubation, the main features of development, and many of the habits that result from parasitism. These facts are embodied in a paper already published in the *Proceedings of the United States National Museum* (Vol. XXV), but as that paper includes all the known species of the *Argulidae*, both American and foreign, fresh water and marine, it has been thought advisable to select the forms that are known or are likely to occur in the

vicinity of Woods Hole, and give with them a list of the hosts upon which they are found, their breeding seasons, and such additional facts as may be of general value. They can thus be presented in a more compact form and one easier of reference for the working naturalist. There has also been included a description of the eggs and emerging larvæ, so far as known, for identification when found in the tow or (in the case of the eggs) upon the surfaces where they have been deposited.

There is good reason for supposing that all the species have three breeding seasons a year, but however that may be, the dates here given are those actually known from eggs deposited in aquaria or from females obtained full of ripe eggs. Most species occur upon the external surface of the fish's body and may usually be found near the fins or the operculum, but a few live within the gill cavity and are seldom found anywhere else. These localities have been indicated under the separate species.

This family often becomes important economically as a factor in the propagation and life history of our common food-fishes, especially fresh-water forms. Ordinarily the *Argulidæ* roam about so freely as to occasion little discomfort to their hosts. They change frequently from one species of fish to another, and must of necessity desert their hosts at the breeding seasons, since their eggs are deposited upon some convenient surface at or near the bottom, and are not carried about with them. Any fish, therefore, no matter how badly it may be infested, has a chance three times a year to get comparatively well rid of its argulid parasites. Furthermore, under ordinary conditions only a few specimens will be found upon a single fish, and these probably do not occasion any greater discomfort than the fleas upon a cat or dog, and they certainly do not menace the life of the fish in the least. We must not forget, also, that these parasites, like every other creature, have active enemies, and at certain critical periods in their development they also find serious obstacles to overcome. Thus the great majority of them are destroyed and they are kept within due bounds.

Let any of these conditions change, however, and the whole situation is reversed. If a fish for any reason becomes inert or debilitated the influence of the parasites is increased, and they may effectually prevent recovery and thus become at least the indirect cause of death. While the great majority of the *Arguli* prefer a sound, healthy fish, there are some species that seem to congregate upon diseased individuals. This is especially true of *Argulus megalops*, and almost every specimen of a summer or winter flounder that is diseased when captured will yield a harvest of this species. Yet even here we need to remember that the diseased condition is the cause and not the effect of the presence of the parasites.

Again, surrounding conditions may become unfavorable to the fish, but not particularly so to the parasite, thus weakening the resistance of the host. A change of this sort always takes place when migrating fish leave the salt water and ascend a river or stream for the purpose of spawning. Of course stationary parasites are taken along with their host as a matter of necessity, but it has also been satisfactorily proved that many species of *Argulus* can live in fresh as well as salt water and probably accompany their host as a matter of choice. As the fish gradually succumb to the rigors of migration the pernicious effect of the parasites is increased twofold. In the first place all the fish are weakened by the tremendous effort required and the accompanying abstinence from food, and therefore would feel the irritation more; and then as fast as any of the fish die these free-swimming *Arguli* can congre-

gate upon the remainder and thereby increase their mischievous influence. Actual observations of the number of parasites present and their influence upon migrating fish are exceedingly meager and we have to be satisfied with a few crumbs of information, but it is more than evident that here is a field of inquiry which promises large returns for the future.

Another change that is always more unfavorable to the fish than to the parasite is the increase of temperature in our fresh-water ponds during the summer season. If the pond happens to be shallow there may be a sufficient rise to produce fatal results, along with the accompanying increase of *Arguli*. Several such instances are upon record. Mr. F. L. Washburn (American Naturalist, XX, p. 896) records the death of thousands of fish during the summer season for several years at Lake Mille Lac in Minnesota. This lake is quite shallow, and the water becomes correspondingly warm during July and August, at which time the fish die in such numbers that the beach is strewn for miles with their dead bodies. Washburn says:

The evident cause of death is the presence of an external parasite, one of the Siphonostomata, which we found swarming on head, operculum, and belly. These parasites are translucent, disgusting looking creatures about the size and shape of a wood-tick, though many are larger, the abdomen furnished with an umbrella-like disk, which apparently assists them in clinging to their slippery hosts.

This is far from being a scientific description, but there is little doubt that a species of *Argulus* is referred to, especially when the kinds of fishes mentioned and the attendant circumstances are considered. The parasites had gathered upon the back of the fish, choosing most frequently a spot near the head, but often there were large patches upon the sides and belly. Washburn enumerates the following species among the dead: The wall-eyed pike (*Stizostedion vitreum*) was by far the most abundant; after this came yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*), black bass (*Micropterus*), bull-head (*Ameiurus*), crappy (*Pomoxis annularis*), calico bass (*Pomoxis sparoides*), whitefish (*Argyrosomus arctedi*), ling (*Lota maculosa*), dogfish (*Amia calva*), pike (*Esox lucius*), and large suckers.

In the succeeding volume of the Naturalist (XXI, p. 188), Prof. R. Ramsay Wright mentions a corresponding mortality of an undetermined species of *Coregonus* in Lake of the Woods as reported to him by Mr. A. C. Lawson, of the geological survey of Canada. The death in this case was due almost entirely to a species of *Argulus* of which fortunately specimens were secured, and the author has had the pleasure of examining these recently. They prove to be *Argulus stizostethii* Kellicott, and thus add a new host for that species, besides confirming Kellicott's statement in regard to the original host, the blue pike (*Stizostedion vitreum*). This *Argulus* was first obtained from pike taken in the Niagara River at Buffalo, and Kellicott states that he has verified the reports of local fishermen to the effect that when the water is warm during midsummer this pike "gets too lazy to take food; that it then gets poor and, through its inertness, becomes infested with lice." They are usually found upon the top of the fish's head, often "huddled together in heaps, so the knife may remove a number at once."

It seems almost certain that some, at least, of the parasites found by Washburn must have been *A. stizostethii*, though there may have been other species also. Washburn recognizes the fact that the warm water played an important part in

killing the fish, and he states that "in smaller lakes in the vicinity which are fed by springs, the fish are comparatively free from such enemies." In such instances, therefore, it is evident that the heat weakens the fish and renders it possible for the parasite to kill it if the latter is present in sufficient numbers.

After all, however, it is in restricted areas like artificial fish ponds, hatcheries, aquaria, etc., that these parasites become most troublesome. Here every condition deleterious to the fish is advantageous to the parasite. The artificial surroundings make more or less of a drain upon the fish's vitality, and since the number of fish is restricted, there is a resultant concentration of the evil effects produced by the parasites. They are always assured of a suitable host and are enabled to choose the strongest and healthiest fish, thereby lowering the general tone. If the breeding of *Arguli* is once started in such a place it will rapidly assume dangerous proportions unless checked at the very outset. This truth was clearly stated by the first observer of the *Arguli*. Leonard Baldneur, in a manuscript dated 1666, deposited in the public library at Strassburg, while speaking of what he calls the "pou des poissons" (*A. foliaceus*), says that it is seldom found except upon trout, which it frequently kills, especially if they are kept in ponds. The United States Fish Commission has had several such experiences and is constantly on guard against these *Arguli*. Sometimes it is necessary even to remove fish from the aquaria and clean them, as was recently the case at Ann Arbor, Mich. The fish were *Amia calva* and the parasites *Argulus americanus*.

It is chiefly to the natural enemies of the *Arguli* that we must look for a practical solution of this important problem in fish economy. The author has elsewhere recorded^a some of these enemies discovered while investigating the cause of a serious mortality among the fish in a small artificial pond at Warren, Mass. Here the death was caused by a superabundance of *A. catostomi*. After much trouble the cause of the increase in these parasites was found to be the removal of all the small surface species, dace, roach, etc., which had been seined and sold for fish bait. These small fish feed upon the newly hatched *Argulus* larvæ, and as soon as they were restored to the pond the *Arguli* were reduced to their normal numbers and no further trouble has been experienced from them.

These facts have recently been confirmed by observations upon two species of *Fundulus* at Woods Hole. In September, 1902, many specimens of *A. fundulus* were obtained from *Fundulus majalis* and *F. heteroclitus*, both in the salt water of Woods Hole harbor and the almost fresh water near the head of Great Pond in Falmouth. On leaving Woods Hole, the writer attempted to take away some of the *Arguli* alive, for this purpose placing nine of the parasites upon two rugged specimens of *F. heteroclitus*, which were taken in a large fruit jar to Westfield, Mass. (125 miles), and placed in a salt-water aquarium. Everything progressed well for about three weeks, but not much food was given to the fish through fear of contaminating the limited supply of salt water. Consequently they became quite hungry, and one night deliberately ate all the parasites.

From these observations we are enabled to draw the following conclusions:

1. Under ordinary conditions it is not probable that the *Arguli* occasion their

^a Proceedings of the United States National Museum, vol. xxv, p. 651.

host any serious inconvenience; their natural enemies keep them within due bounds and every fish has a chance to rid itself almost entirely of parasites when the latter are breeding.

2. If a fish becomes diseased the influence of the parasites is thereby increased, so that they hasten, and may partly cause, its death.

3. Fish while undergoing the rigorous efforts necessary to migration become greatly weakened and hence more susceptible to the influence of these pests.

4. The increased temperature of summer, especially in shallow fresh-water ponds, makes the fish so inert that they often become seriously infested, and are killed in large numbers.

5. The restrictions existing in aquaria, artificial hatcheries, etc., greatly assist these parasites, which speedily become a serious nuisance unless destroyed in some way.

6. Their most effective enemies are the smaller surface fish, dace, roach, etc., which eat the larvæ. Some minnows (*Fundulus*) will even eat the adults under the constraint of hunger.

7. The protection of these small fish and their introduction wherever possible is thus one of the most practicable preventives of any serious multiplication of the *Arguli*.

DESCRIPTION OF SPECIES.

KEY.

- | | |
|---|---------------------------|
| 1. Carapace orbicular, wider than long, sucking disks very large..... | 2 |
| Carapace elliptical, considerably longer than wide, sucking disks relatively small..... | 4 |
| 2. Swimming legs of first and second pairs with recurved flagella..... | <i>catostomi</i> , p. 123 |
| Swimming legs without flagella..... | 3 |
| 3. Basal plate of second maxillipeds with three stout teeth..... | <i>funduli</i> , p. 125 |
| Basal plate prolonged posteriorly as an entire lobe without any teeth..... | <i>latus</i> , p. 138 |
| 4. Swimming legs of first and second pairs with recurved flagella..... | <i>laticauda</i> , p. 127 |
| Swimming legs without flagella..... | 5 |
| 5. Abdomen orbicular, wider than long, cut less than one-third, lobes well-rounded..... | <i>megalops</i> , p. 129 |
| Abdomen elongate, longer than wide, cut to the center, lobes lanceolate-acuminate..... | <i>alosæ</i> , p. 121 |

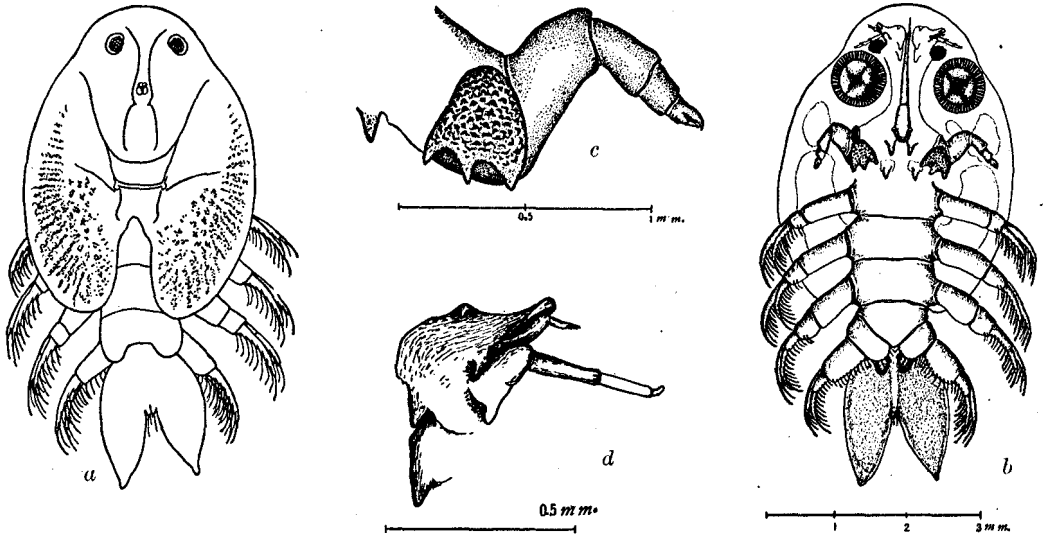
Argulus alosæ Gould. Male and female known.

Carapace relatively small, elliptical, much longer than wide, just reaching to the posterior thoracic segment; posterior sinus rather narrow and becoming contracted toward the base; eyes far forward, chitin rings in the lateral areas unequal, the smaller anterior to the larger, of nearly the same diameter, but much shorter; posterior segment of thorax projecting over the abdomen in a small rounded lobe on either side with a shallow sinus between; abdomen broad, elliptical, cut beyond the center; lobes divergent, lanceolate-acuminate; anal papillæ basal, no spines on the ventral surface of the carapace; antennæ rather small and poorly armed; posterior maxillipeds stout; basal plate triangular, considerably raised, and prominently roughened; posterior teeth short and blunt. Swimming legs reaching far beyond the carapace, without flagella; lobes on the basil joint of the posterior pair nearly rectangular and relatively very small. Male with no accessory sexual organs except the usual peg and semen receptacle; lobes of the basil joints of the posterior legs more pointed than in the female; abdomen much elongated; testes very large.

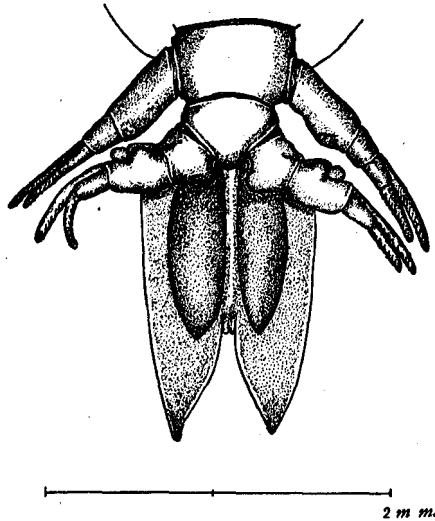
Color a uniform pale bluish-green with scattering pigment on the dorsal surface arranged in radiating dots and lines. Length of female, 7-10 mm.; length of carapace, 4-6 mm.; breadth of carapace, 3-5 mm.; length of abdomen, 2-3 mm.; breadth, 1.7-2.5 mm. Male about half this size. (Description from living specimens.)

Found upon the outer surface of the alewife (*Clupea pseudoharengus*) and the smelt (*Osmerus mordax*), usually in the vicinity of the fins; often numerous upon a single fish.

The eggs of this species are deposited in August (13th) and again toward the last of September and the first of October (September 24–October 5). Deposited eggs and larvæ unknown, but the



Argulus alose Gould. Female. a, Dorsal surface; b, ventral surface; c, posterior maxilliped; d, antennæ.

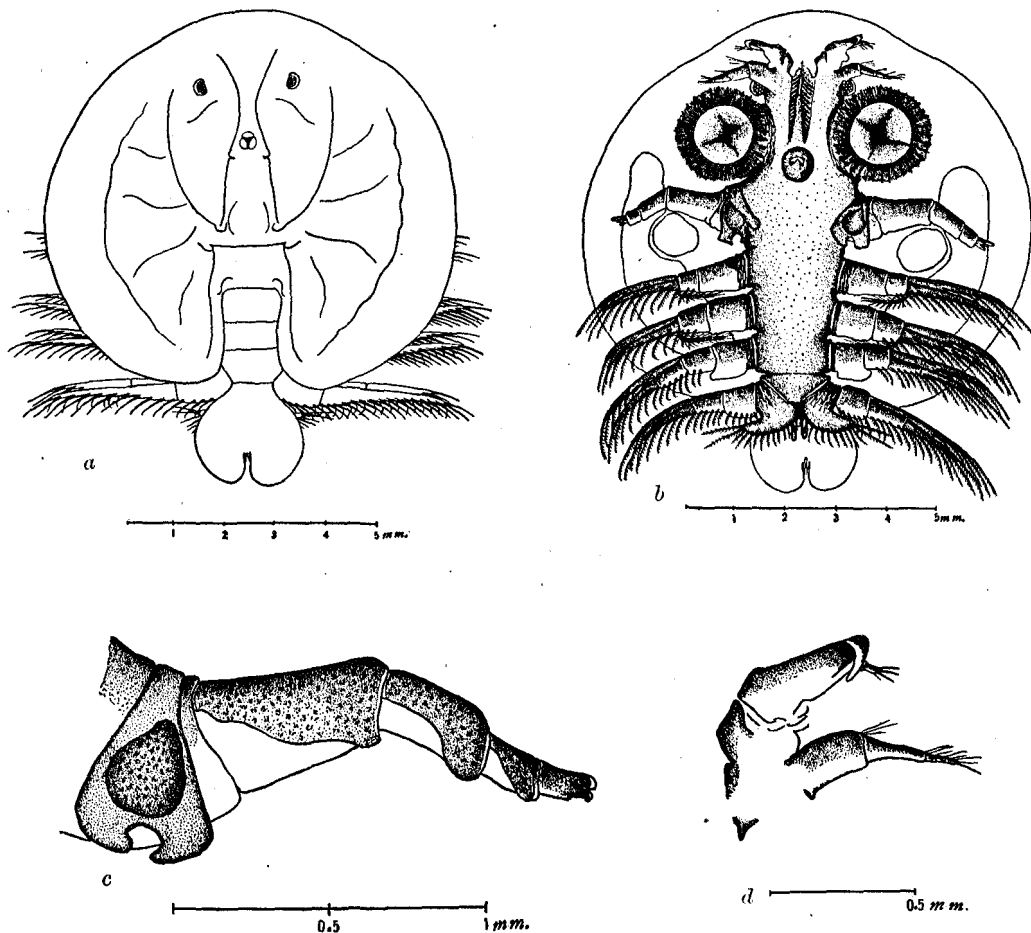


Argulus alose Gould. Male. Posterior legs and abdomen.

eggs must be considerably larger than those of the other species and comparatively few in number, judging from the ripe females examined. A specimen from near Key West, Fla., taken in April, was full of apparently ripe eggs. Probably the species lays a little later than this around Woods Hole.

Argulus catostomi Dana & Herrick. Female only known.

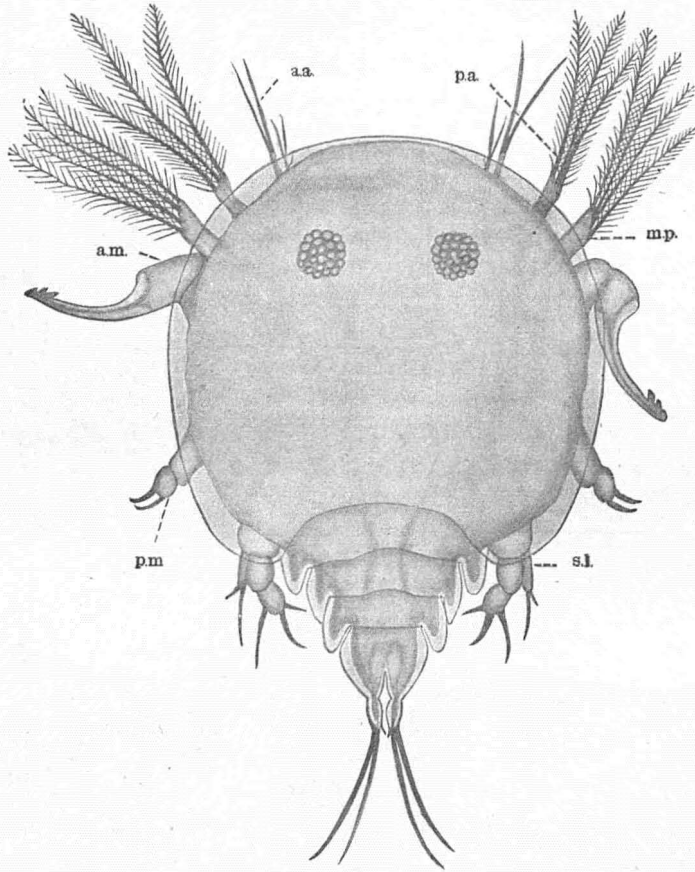
Carapace large, orbicular, wider than long, almost covering the swimming legs; posterior sinus broad, with its sides approximately parallel; antero-lateral sinuses scarcely noticeable; chitin rings in the lateral areas very unequal in size, the larger one extending forward to the sucking disks, and having a deep indentation on its inner margin near the center, into which the smaller one projects. Abdomen comparatively very small, orbicular, wider than long, cut less than one-third its length; anal sinus narrow; papillæ basal. Antennæ comparatively small and weak; poorly armed; sucking disks large, placed well forward; second maxillipeds large and strong, every joint with a roughened



Argulus catostomi Dana & Herrick. Female. a, Dorsal surface; b, ventral surface; c, posterior maxilliped; d, antennæ.

area on its ventral surface; basal plate with a raised pear-shaped area near its center; lobes (not teeth) on its posterior edge broad and squarely truncated, usually three in number but often reduced by fusion to two. Swimming legs scarcely reaching the edge of the carapace; two anterior pairs with recurved flagella; lobes on the basal joints of the posterior pair medium size, boot-shaped. Color a uniform light sea-green, turning much darker in alcohol. Length, 12 mm.; length of carapace, 9.6 mm.; breadth of carapace, 11.2 mm.; length of abdomen, 2.3 mm.; breadth of abdomen, 2.4 mm. (Description from living specimens.)

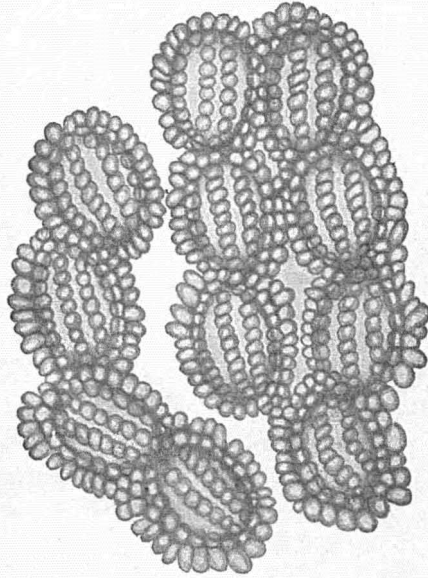
Found upon the common sucker, *Catostomus*, and the chubsucker, *Erimyzon*, in both salt and brackish water; deposits its eggs the middle or the last of May (May 20–June 5). Eggs of medium size, arranged in short rows, gathered into small patches containing 6 or 8 to 12 eggs; rows not parallel; eggs placed end to end and covered with a jelly envelope, the surface of which is raised into long rows of club-shaped papillæ, which are often twisted spirally. Eggs hatch in 30–35 days; emerging larva light grayish in color, unpigmented, not very transparent, totally unlike the adult; carapace elliptical, longer than wide, but scarcely reaching to the center of the second (the first free) thoracic



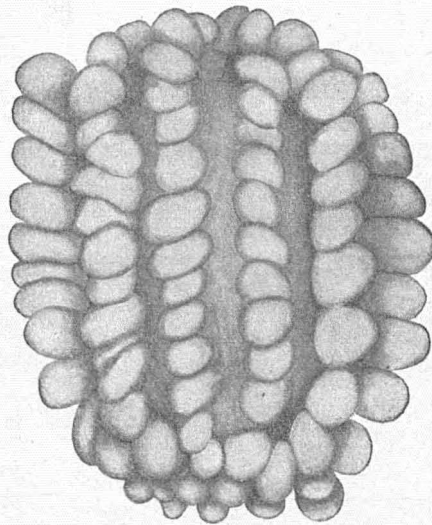
Newly hatched larva of *Argulus catostomi*, $\times 325$. *a. a.*, Anterior antennæ; *p. a.*, posterior antennæ; *a. m.*, anterior maxillipeds; *p. m.*, posterior maxillipeds; *m. p.*, mandibular palp; *s. l.*, swimming leg.

segment, leaving a very shallow posterior sinus; free thoracic segments rapidly diminishing in size. Abdomen narrower than last thoracic segment, elongate-triangular in shape, cut nearly to the center; anal sinus triangular; each lobe somewhat constricted at the base; papillæ terminal and ending in two very long setæ. Skin glands scattered about promiscuously, scarcely noticeable. Larva furnished with a temporary rowing apparatus, consisting of the greatly enlarged second antennæ and a pair of transitory mandibular palps, the former terminating in four long plumose setæ and a fifth much shorter, nonplumose one, like the thumb and fingers of a hand; the latter with 3

plumose setæ; each anterior maxilliped terminating in a pair of stout, curved claws, the ventral one of which is barbed; only the first pair of swimming legs at all developed, the others mere rudimentary stumps.



A single cluster of eggs of *Argulus catostomi*.
(Actual size, 0.45×0.3 mm.)

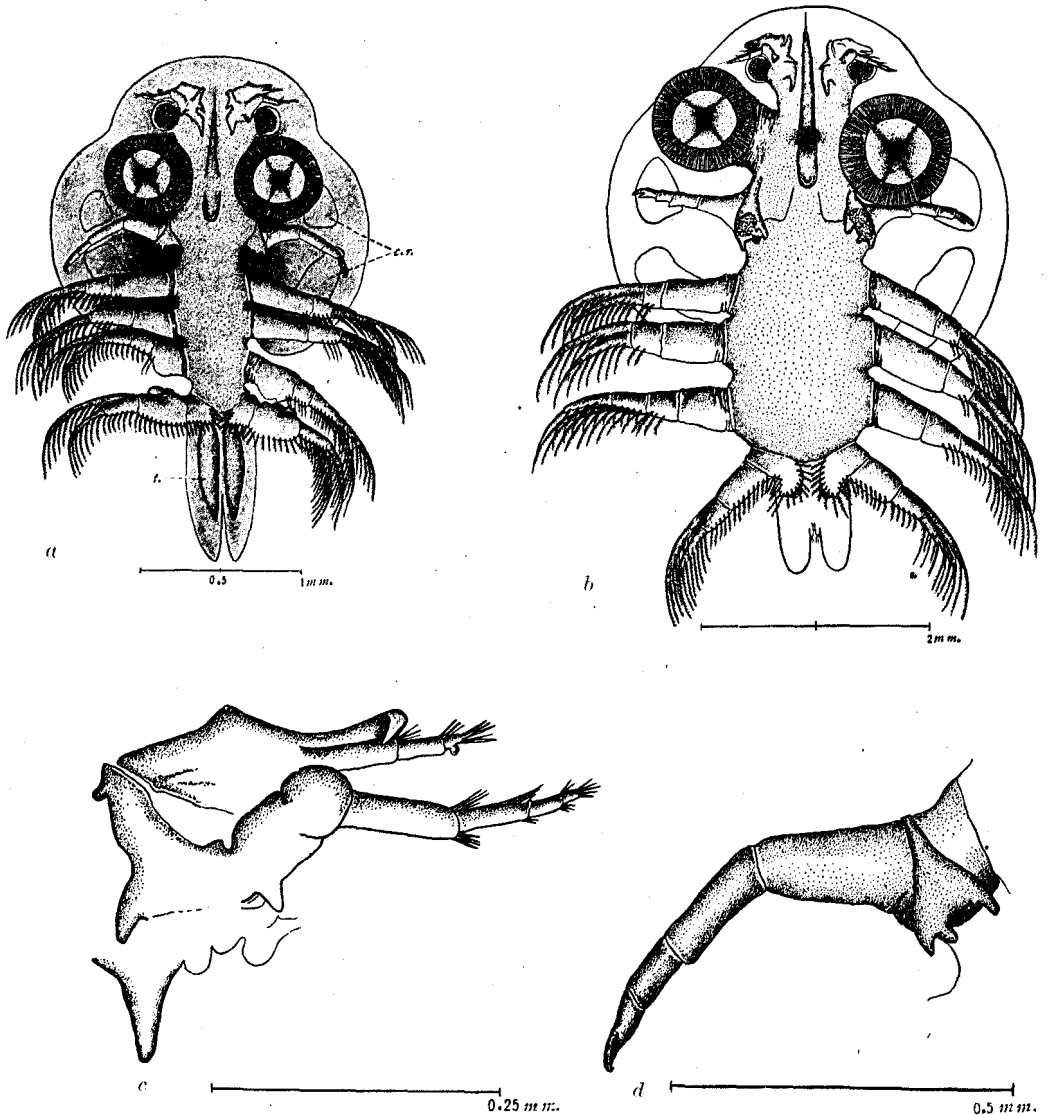


A single egg of *Argulus catostomi*, $\times 300$.

Argulus funduli Kroyer. Male and female known.

Carapace orbicular, wider than long, scarcely covering the second pair of swimming legs; posterior sinus wide and shallow, widely cut at its base; eyes large and placed far forward, chitin rings in lateral areas nearly equal. On the ventral surface the anterior portion is covered with stout spines, while the whole thorax is papillated. Abdomen long elliptical, cut nearly to the center in the female, about

one-fourth in the male. Antennæ large and well armed; sucking disks enormous, relatively the largest of any American species, occupying most of the breadth of the carapace; posterior maxillipeds long and slender; basal plate small, its teeth very short and blunt; anterior swimming legs reaching just beyond the edge of the carapace, posterior ones uncovered. Abdomen much elongated in the male, its lobes almost entirely filled by the large testes; a large conical appendage on the anterior of the swimming legs in addition to the regular accessory organs.



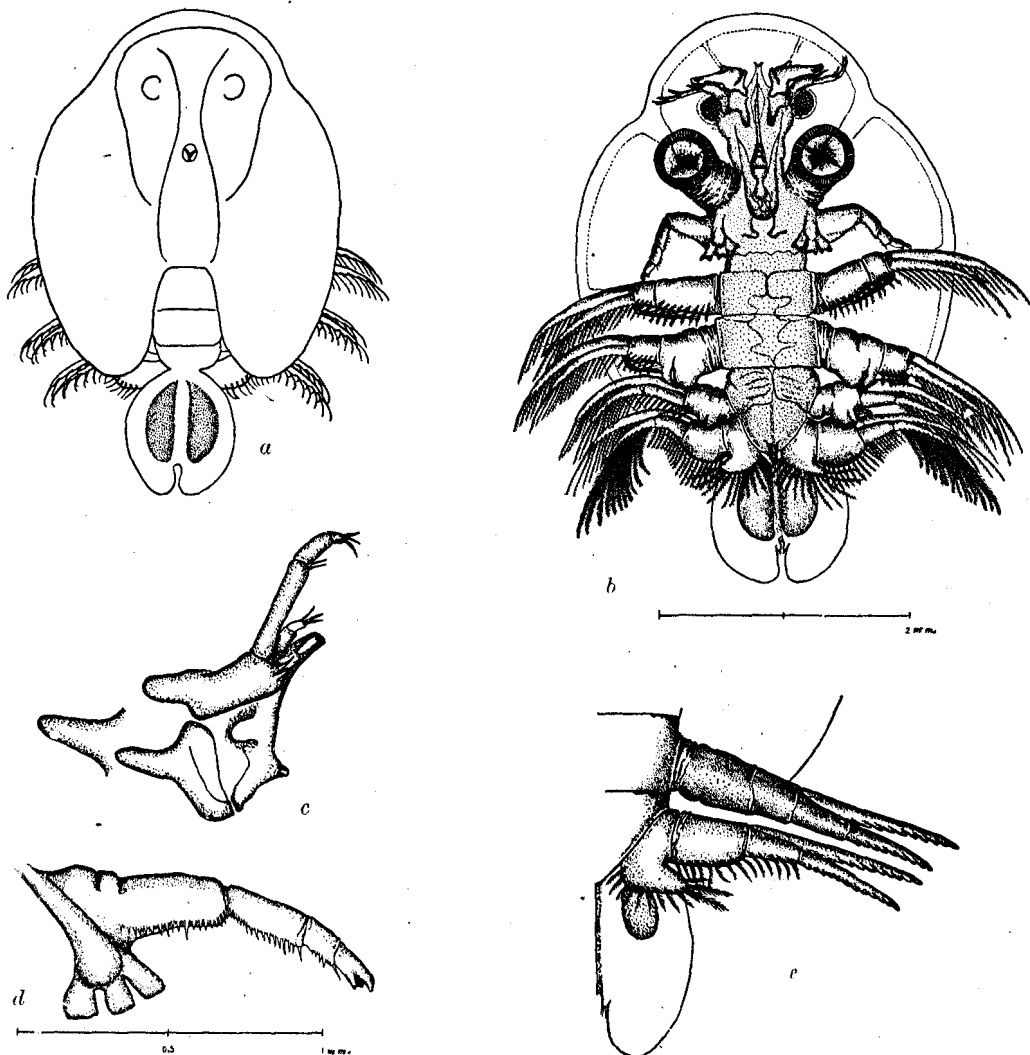
Argulus funduli Kroyer. a, Ventral surface of male; b, ventral surface of female; c, antennæ of male; d, posterior maxilliped of male.

Color yellowish-white, mottled with pale rust-color, the dorsal surface of the ovaries and testes heavily mottled with very dark brown pigment and thus contrasting strongly with the rest of the body. Length of the female, 5 mm.; length of carapace, 3.1 mm.; breadth of carapace, 3.5 mm.; length of abdomen, 1.1 mm.; breadth of abdomen, 0.6 mm.; male about three-fifths this size, but with an abdomen 1.3 mm. long. (Description from living specimens.)

Found upon the ventral surface of *Fundulus heteroclitus* and *Fundulus majalis* in both salt and brackish water; prefers the neighborhood of the fins; usually only one on a single fish; also likely to be taken in the tow during the breeding season. Deposits its eggs in July and October. Larvæ unknown.

Argulus laticauda Smith. Male and female known.

Carapace elliptical, longer than wide, just reaching the edge of the abdomen in the male; anterolateral sinuses well-defined, leaving a large frontal lobe; posterior sinus wide and deep. Eyes large, large.



Argulus laticauda Smith. Male. a, Dorsal surface; b, ventral surface; c, first and second antennæ; d, posterior maxilliped; e, two posterior swimming legs of female.

chitin rings in the lateral areas concealed by the abundant black pigment. Abdomen orbicular, slightly longer than wide, cut less than one-third; anal papillæ basal. Antennæ large and stoutly armed; sucking discs small; posterior maxillipeds medium size, stout, with a fringe of spines along the entire posterior margin. Basal plate elongate and narrow, its posterior edge cut into three oblong, squarely truncated lobes instead of teeth. Two anterior pairs of swimming legs with recurved flagella and entirely covered by the carapace; lobes on the posterior pair long and pointed, boot-shaped. Males much larger than any females so far obtained, and with a conical projection on the anterior border

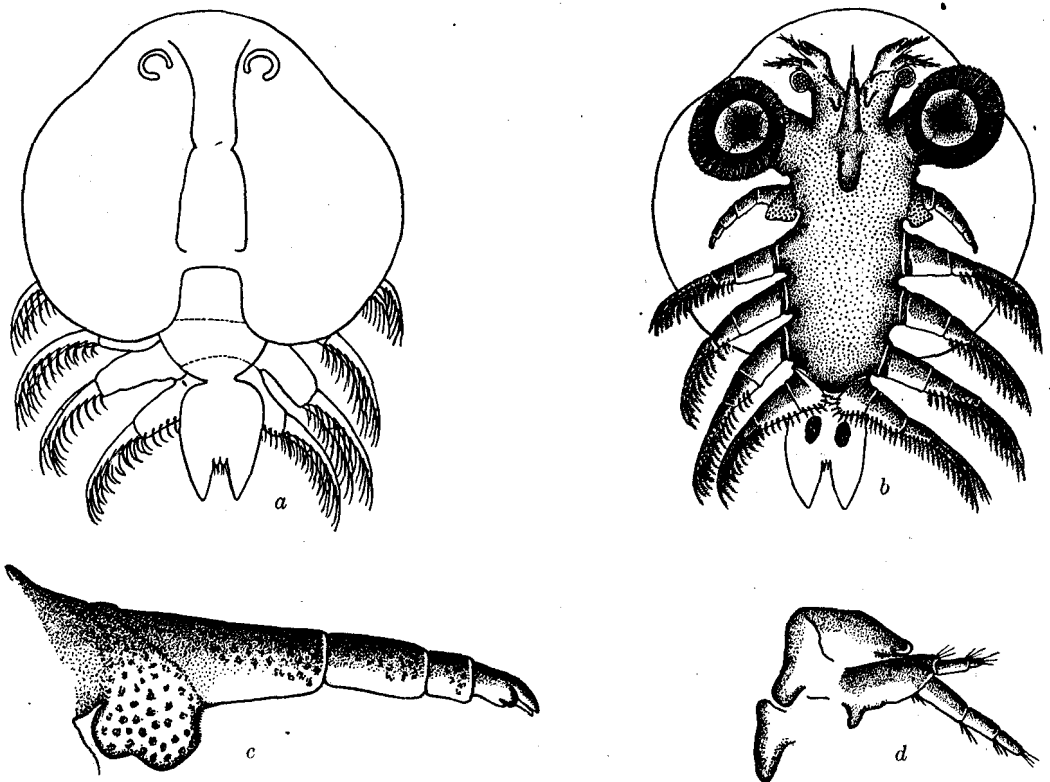
of the third legs and two large lobes on the posterior border of the second legs in addition to the regular accessory organs; testes medium size, hemi-ellipsoidal.

Color yellowish horn color, mottled with thick black pigment arranged in more or less radiating spots and bands, often so dense as to make the creature almost entirely black. Pigment sometimes dark reddish brown, inclining to purple, especially in the smaller specimens. The only black or very dark *Argulus* and the only species in which the male is larger than the female. Length of male 5-7 mm.; length of carapace 3.5-4 mm.; breadth of carapace 3.2-3.5 mm.; length of abdomen 1.3 mm.; breadth of abdomen 1.1 mm. Female two-thirds this size. (Description from living specimens.)

Found most commonly upon the eel (*Anguilla chrisypa*) and various members of the Pleuronectidae (*Pseudopleuronectes americanus*, *Paralichthys dentatus*). May be looked for occasionally upon the tomcod (*Microgadus tomcod*), upon skates, sculpins, and species of blenny. Deposits its eggs in August (14th) and the last of October (October 20-30). Larvæ unknown.

Argulus latus Smith. Female only known.

Carapace orbicular, wider than long, scarcely covering the second pair of legs; posterior sinus narrow and about one-fifth the length of the carapace; eyes large and very far forward. Abdomen



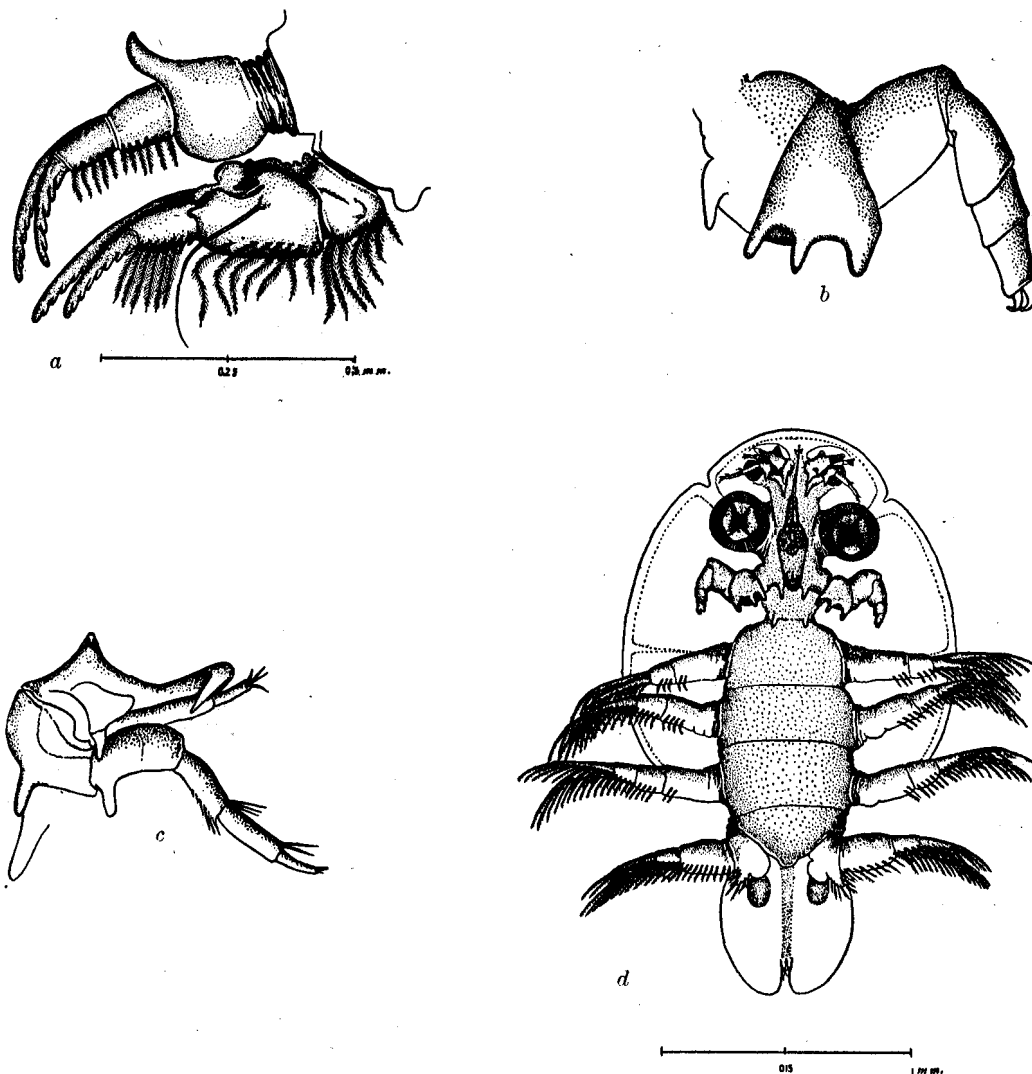
Argulus latus Smith. Female. a, Dorsal surface; b, ventral surface; c, posterior maxilliped; d, first and second antennæ.

narrow, elliptical, one-third as long as the carapace; anal sinus triangular, papillæ basal. Antennæ small but well-armed, widely separated; sucking discs very large and widely separated; posterior maxillipeds stout; basal plate uniformly papillated and prolonged backward as a whole without teeth or lobes. Swimming legs all reaching beyond the carapace, without flagella; lobes on the posterior legs small, rounded, triangular. Color yellowish-white, becoming brown in alcohol. Length 2.3 mm.; length of carapace 2.2 mm.; breadth of carapace 2.5 mm.; length of abdomen 0.7 mm.; breadth of abdomen 0.45 mm. (Description from alcoholic specimens.)

Has been taken only at the surface, one specimen at Woods Hole and one at Casco Bay, both females. Egg deposition and larvæ unknown.

Argulus megalops Smith. Male and female known.

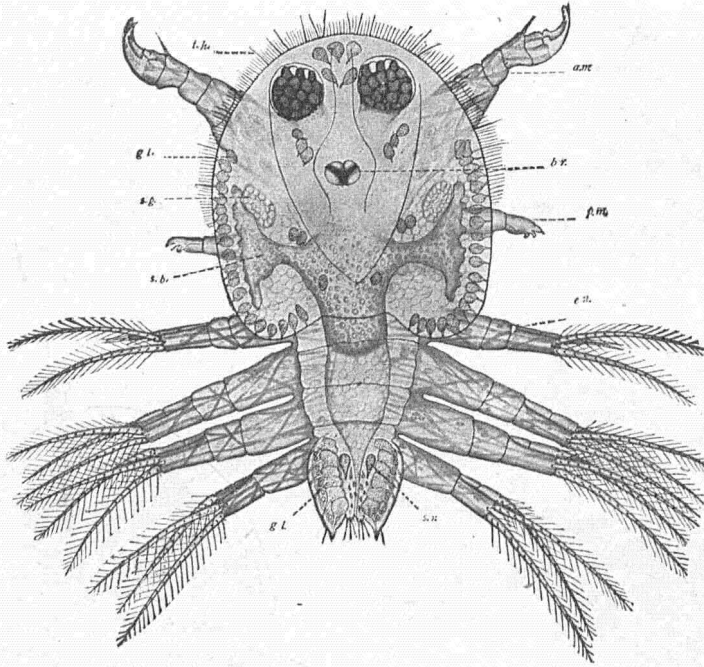
Carapace elliptical, longer than wide, scarcely covering the third pair of legs; posterior sinus triangular and shallow, lobes broadly rounded and free from the thorax. Eyes very large (one-tenth of the breadth of the carapace) and far forward; thorax partly uncovered, narrowing slightly posteriorly; abdomen broad elliptical, slightly longer than wide; anal sinus triangular (not more than



Argulus megalops Smith. a, Two posterior swimming legs of male; b, posterior maxilliped of male; c, antennæ of female; d, ventral surface of female.

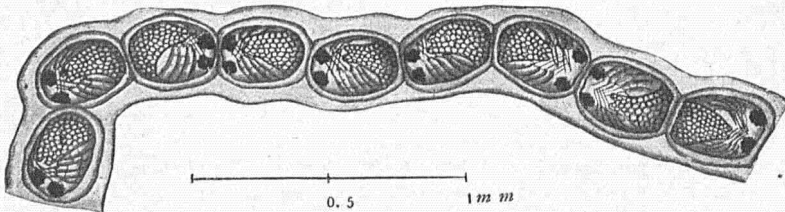
one-fifth the entire length); papillæ basal. Antennæ medium, closely approximated and well-armed; sucking discs small. Posterior maxillipeds large, well-armed; basal plate broad triangular, teeth rather widely separated, stout and blunt. Swimming legs long, projecting far beyond the edge of the carapace, without flagella; lobes on posterior legs narrow and sharply pointed posteriorly. Male with a large thumb-shaped projection on the anterior border of the basal joint of the third legs, in addition to the regular accessory organs.

Color yellowish-white with four delicate longitudinal bands of pale yellowish pigment; the entire upper surface of the abdomen and the thorax in ripe females is red-brown, inclining to pink, thickly sprinkled with minute black dots; the lateral areas are also ornamented with an arborescent design in black pigment. Upon death the females frequently become a bright pink color. Length 6 mm.; length of carapace 3.8 mm.; breadth of carapace 3.5 mm.; length of abdomen 2 mm.; breadth of abdomen 1.4 mm. (Description from living specimens.)



Newly hatched female larva of *Argulus megalops*, $\times 235$. *br.*, Brain; *en.*, endopod of first swimming foot; *gl.*, skin glands; *a. m.*, anterior maxilliped; *p. m.*, posterior maxilliped; *s. b.*, side branch of stomach; *s. g.*, shell gland; *s. r.*, semen receptacle; *t. h.*, tactile hairs.

Found most commonly upon the flounders (*Paralichthys dentatus*, *Pseudopleuronectes americanus*), upon or near the fins of which developmental stages may be secured in August and September. Has been found upon the common skate (*Raia erinacea*), the spotted sand flounder (*Lophopsetta maculata*), the sand dab (*Hippoglossoides platessoides*), and occasionally upon the sculpin (*Myoxocephalus octodecimospinosus*); upon the web-fingered sea-robin (*Prionotus carolinus*), the tomcod (*Microgadus tomcod*), the



Eggs of *Argulus megalops* about ready to hatch. Actual size of one egg, 0.35 mm. long, 0.28 mm. wide.

goose-fish (*Lophius piscatorius*), a species of minnow (*Fundulus*), and is frequently taken in tow. Deposits its eggs in August and September (August 31, September 1) and in October and November (October 14–November 2). Eggs placed end to end in single rows, 10 to 12 eggs in each row. Eggs yellowish-white, soon becoming dirty and brownish, 0.35 mm. long by 0.28 mm. wide; jelly covering perfectly smooth. Eggs require 60 days' incubation at a temperature of 72–75° F.

Emerging larva totally unlike that of *catostomi* and *foliaceus*, in a more advanced cyclops stage, with all the appendages except the first maxillipeds like those of the adult. Carapace elliptical, longer than wide, partly covering the base of the first pair of legs only; posterior sinus very wide and shallow; eyes one-fifth the width of the carapace, closely approximated, almost touching the anterior margin. Thorax narrowing gradually from in front backward; abdomen broad-elliptical, nearly as wide as long; anal sinus broadly triangular, papillæ basal; a very distinct row of small skin glands around the edge of the lateral areas of the carapace; five or six much larger ones along either margin of the abdomen. Antennæ thicker and stouter than in the adult, with the spines relatively larger; anterior maxillipeds four-jointed, terminating in two sickle-shaped hooks, the ventral one armed with barbs; there is also a stout spine on the anterior border of the terminal joint; posterior maxillipeds much smaller, five-jointed, each of the four basal joints armed on their ventral surface with a long curved spine and many shorter ones; basal plate with only two posterior teeth, but with a long spine on its outer margin. Swimming legs all perfectly developed; exopods one-jointed, with two long, plumose, rowing setæ; endopods of first pair three-jointed, first and second joints with sharp spines on their posterior border, third joint terminating in two similar spines, placed side by side; endopods of three posterior pairs of legs two-jointed with a single rowing seta.

The following is a list of the hosts upon which any species of *Argulus* has been found in the vicinity of Woods Hole:

- Common skate, *Raja erinacea* Mitchill.
A. laticauda, *A. megalops*.
- Brook sucker, *Catostomus commersonii* (Lacépède).
A. catostomi.
- Chub sucker, *Erimyzon sucetta oblongus* (Mitchill).
A. catostomi
- Common eel, *Anguilla chrisypa* Rafinesque.
A. laticauda.
- Alewife, *Pomolobus pseudoharengus* (Wilson).
A. alosæ.
- Smelt, *Osmerus mordax* (Mitchill).
A. alosæ.
- Killi-fish, *Fundulus majalis* (Walbaum).
A. fundulus, *A. megalops*.
- Killi-fish, *Fundulus heteroclitus* (Linnaeus).
A. fundulus, *A. megalops*.
- Sculpin, *Myoxocephalus weneus* (Mitchill).
A. laticauda, *A. megalops*.
- Sea robin, *Prionotus carolinus* (Linnaeus).
A. megalops.
- Blenny, sp.
A. laticauda.
- Tomcod, *Microgadus tomcod* (Walbaum).
A. laticauda, *A. megalops*.
- Sand-dab, *Hippoglossoides platessoides* (Fabricius).
A. megalops.
- Summer flounder, *Paralichthys dentatus* (Linnaeus).
A. laticauda, *A. megalops*, *A. alosæ*.
- Common flat-fish, *Pseudopleuronectes americanus* (Walbaum).
A. laticauda, *A. megalops*.
- Window pane, *Lophopsetta maculata* (Mitchill).
A. megalops.
- Goose-fish, *Lophius piscatorius* (Linnaeus).
A. megalops.