NOTES ON HABITS AND DEVELOPMENT OF EGGS AND LARVÆ OF THE SILVERSIDES MENIDIA MENIDIA AND MENIDIA BERYLLINA.

By SAMUEL F. HILDEBRAND,
Assistant, U. S. Bureau of Fisheries.

Contribution from the U. S. Fisheries Biological Station, Beaufort, N. C.

INTRODUCTION.

The present paper embodies the results of observations made on eggs, larvæ, and adults of the silversides *Menidia menidia* and *Menidia beryllina*. All observations were made on living or fresh material, in the immediate vicinity of the Fisheries Biological Station, Beaufort, N. C., and they extend over a period beginning in April, 1914, and ending in August, 1916.

The eggs used in this work were artificially spawned and hatched in the laboratory. The descriptions and drawings are offered with the view of affording means of identifying the eggs and larvæ with the adult. The two closely related species under consideration are compared and contrasted in order to show likenesses and differences in their habits and development.

Menidia menidia, SILVERSIDE.

ADULTS.

This fish belongs to the family Atherinidæ, the silversides, which are elongate shapely fishes with a silvery lateral stripe. Most of them are of small size, inhabiting fresh or salt water of temperate or tropical latitudes, and they usually run in large schools. The genus Menidia may be distinguished from related genera by the strongly curved premaxillary, the narrow bands of teeth on the jaws, the short lower jaw, which is included in the upper when the mouth is closed, the rounded abdomen, and the smooth, firm scales. There are only two species of the genus known from North Carolina waters. The present species may be distinguished from *Menidia beryllina*, the other species, by the larger size, by the longer anal fin, which consists of one spine and 21 to 26 soft rays, by the more posterior position of the dorsal fins, and by the black peritoneum.

This species is exceedingly abundant in the vicinity of Beaufort, N. C., inhabiting both salt and brackish water, and it is the only fish which occurs in large numbers in the shallow waters throughout the winter. Large schools may be seen along the shores of Pivers Island during the coldest days, when practically all other fishes have migrated to deeper water or to a warmer latitude.

It was learned from the examination of large collections that the ratio of males to females is about equal. It so happens, however, for unknown reasons, that at times a school which consists almost wholly of females is taken, and again the reverse is true. The females are constantly somewhat larger than the males, their average length being about 100 millimeters, with a maximum length of 123 millimeters. The average length of the males is about 89 millimeters, with a maximum length of 112 millimeters. The food of this species consists of small fish, crustaceans, algæ, and diatoms.

SPAWNING.

Spawning occurs from early spring to late summer, ripe or nearly ripe fish having been taken by the writer during March, April, May, June, July, and August. Eggs of several sizes are present in the ovaries at one time. When one lot is spawned, the eggs of the next lot are large enough to be seen with the unaided eye. The presence in the ovaries of several different sizes of eggs at one time strongly suggests that spawning occurs more than once and perhaps several times during the season. An average-sized female produces as many as 500 eggs at one time, and the eggs can easily be hatched artificially. The writer has hatched them during cool weather by merely placing them in a shallow glass dish at the time of fertilization and leaving them undisturbed and without change of water until the young fish appeared; but when the weather is warm an occasional change of water is essential.

The eggs are deposited in shallow water along grassy shores, where large schools of fish collect for this purpose. Capt. Charles Willis,[1] a resident of Morehead City, N. C., found a very large school of silversides spawning among eelgrass, in shallow water near Morehead City in May, 1915. The eggs were attached to the vegetation in clusters and became exposed at ebb tide. He then collected and preserved about a quart of the eggs, together with several specimens of the fish which he later exhibited to the author.

EGGS.

The eggs of this species are approximately 1¼ millimeters in diameter and are slightly heavier than sea water. Their form is spherical when spawned, and they remain so until hatched. The eggs to the unaided eye appear to be separate when first spawned, but as soon as exposed to water, opaque threads of considerable length become visible at the upper pole of the egg. If the water is agitated, the threads become visible more quickly than they do in quiet water; likewise the eggs appear to become attached to objects in the water or to each other more quickly. The addition of the sperm, too, seems to hasten the formation of the opaque threads. A microscopic examination, however, showed that the eggs are delivered in a transparent gelatinous mass, consisting of more or less definite strands, but, as already indicated, the mass does not become opaque and definitely threadlike until exposed to the elements. The strands again become transparent after they have been exposed for a somewhat variable period of time, and then they are elastic like rubber and of very remarkable strength. It was necessary to use glassware and glass apparatus for incubating and handling the eggs, as they readily adhered to all other materials with which they were placed in contact.

[1] Capt. Willis was employed for several seasons by Mr. Russell J. Coles in the latter's investigations of the fishes of Cape Lookout. It was through this employment that Capt. Willis's interest in the natural history of fishes was stimulated.

It is obvious, then, that the purpose of these gelatinous strands is to afford ready means by which the eggs may attach themselves to vegetation or other objects in the water. It is likewise apparent that because of this provision the parents spawn in places where there is an abundance of vegetation.

The eggs are yellowish green, as seen in a mass with the unaided eye, but when seen singly under magnification they are semitransparent, and the slight greenish pigment appears to be in the individual granules of the yolk. It is also seen that what appeared to the unaided eye to be a single thread by means of which the egg becomes attached is really a bundle of very fine strands of uniform size. A large fat globule, occupying a central position, is always present, and smaller globules, from a few to several in number, are variously distributed. There is a perceptible space between the egg membrane and the vitelline membrane which varies in width. It is broadest at the germ disk and narrowest opposite this point; that is, the yolk sphere occupies the upper part of the egg sphere (fig. 85).

EMBRYOLOGY.

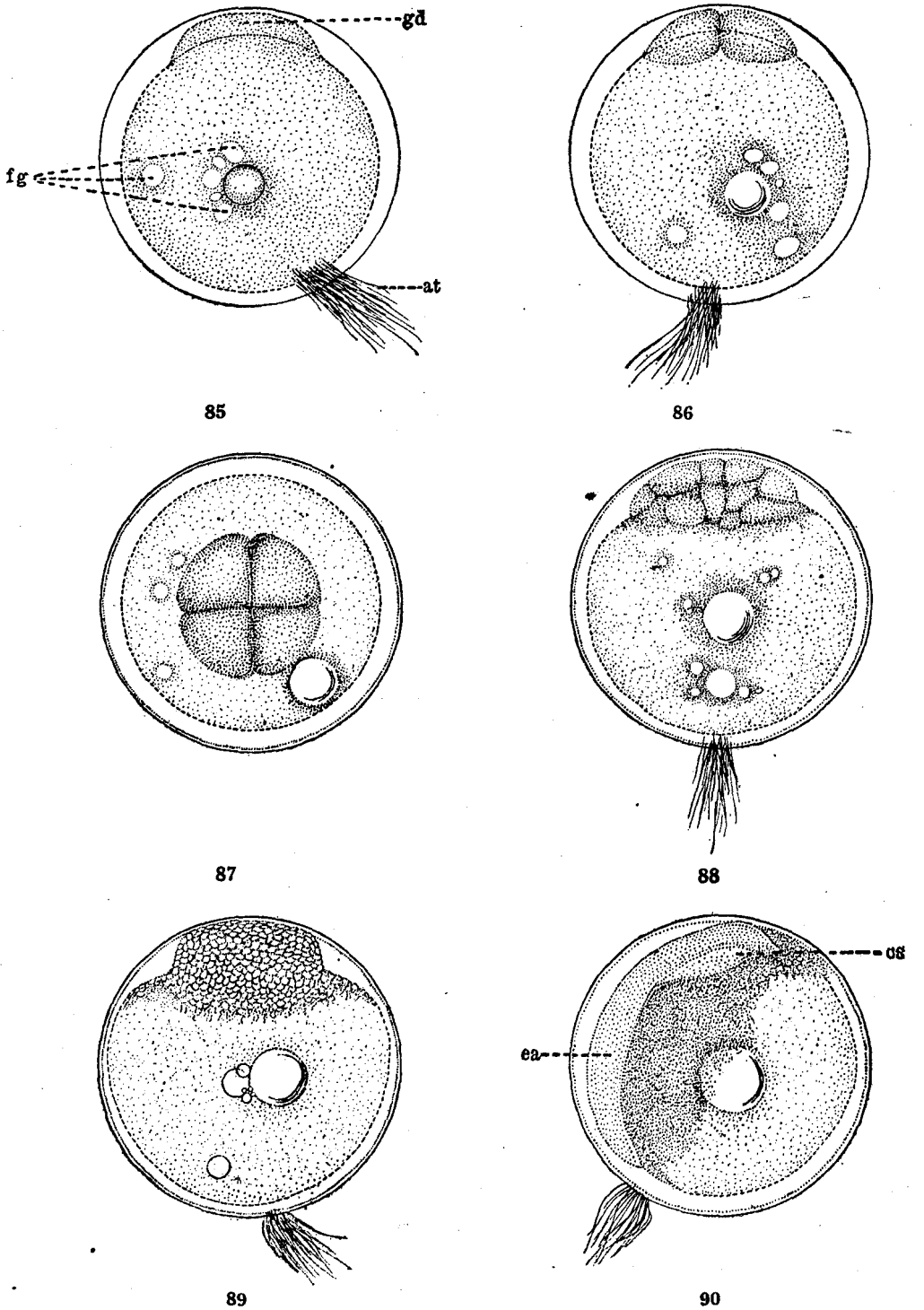
The protoplasm becomes concentrated after fertilization has taken place at the lower pole of the egg, forming a cap on the yolk of the egg. This mass of protoplasm is the blastodisk. The first cleavage plane cuts the blastodisk parallel with the axis, passing through the upper and lower pole of the egg (fig. 86). The second is at right angles to the first (fig. 87). Cleavage in these eggs is quite regular (fig. 88) and proceeds rapidly in a relatively high temperature, but it is much retarded in a relatively low water temperature; for example, the stage represented in figure 89 was reached in about six hours in a water temperature of 84° F., but in a water temperature of about 40° F. the time required to reach the same stage was approximately 48 hours.

The outline of the blastoderm on the yolk after an advanced cleavage stage is reached is only indistinctly visible, and the development can not be clearly observed. Within 12 hours after fertilization with a water temperature of 84° F., or within about 60 hours with the temperature of the water at approximately 60° F., the outline of the embryo, however, may be seen (fig. 90).[2] It is curved with the periphery of the egg and is somewhat less opaque than the remainder of the blastoderm.

Within 24 hours after fertilization with a water temperature of about 84° F., or within approximately four days with a water temperature of about 60° F., the embryo is distinctly formed and has about 12 somites. It now extends at least half the distance around the periphery of the egg, and only one large fat globule remains (fig. 91).

Two days after fertilization with a water temperature of 84° F., or about seven days with a water temperature of 60° F., the heart begins to pulsate and large blood vessels may be seen traversing the yolk. The blood at first contains relatively few corpuscles, which flow slowly, but their number and speed increase rapidly with the development of the embryo (fig. 92). Soon after circulation is well established large dark-green or brownish chromatophores appear on the yolk and smaller ones on the embryo. The embryo by this time has fully encircled the egg and is segmented throughout and capable of considerable movement, the tail being partly free. The period of incubation is about 16 days in a water temperature varying from 40 to 60° F.

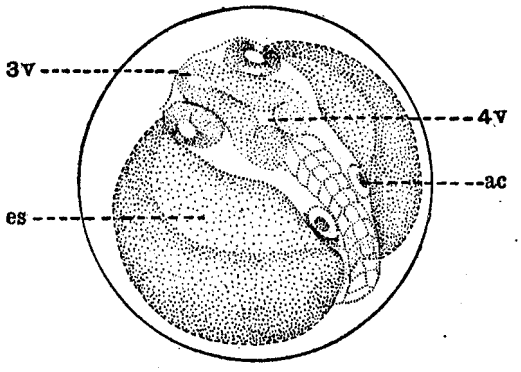
[2] The author's attention was called to an irregularity in this figure by Dr. Albert Kuntz, who kindly examined the illustrations and read the manuscript, suggesting that an abnormal egg was probably studied, as the outline of the advancing blastoderm should be regular and not broken as shown in the figure.



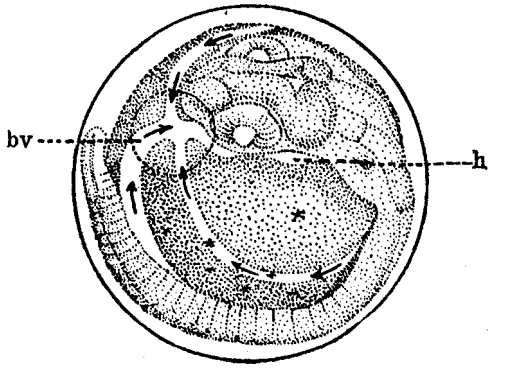
Egg of *Menidia menidia*. × 34. (Drawn by Mrs. E. B. Decker.)

FIG. 85.—Egg shortly after fertilization: at, adhesive threads; gd, germinal disk; fg, fat globules.
FIG. 86.—Egg in 2-cell stage.
FIG. 87.—Egg in 4-cell stage, surface view.
FIG. 88.—Egg in 32-cell stage, with 11 cells visible in side view.
FIG. 89.—Egg in advanced cleavage stage.
FIG. 90.—Egg in stage showing first outline of embryo:[3] ea, embryonic area; cs, cleavage space. (The blastoderm appears to project above the yolk of the egg more prominently in some eggs than in others.)

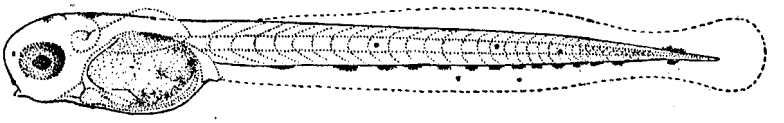
[3] See footnote on p. 115.



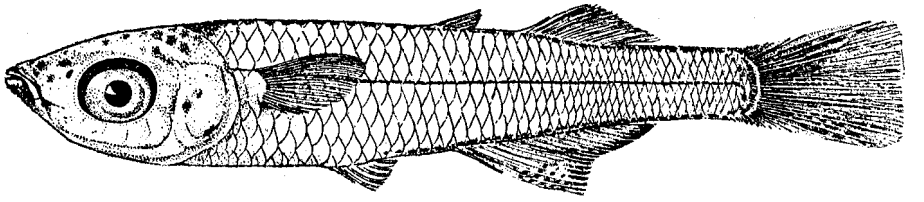
91



92



93



94

Menidia menidia. (Drawn by Mrs. E. B. Decker.)

FIG. 91.—Surface view of egg 2 days after fertilization, water temperature, 82° F.: es, embryonic shield; 3v, third ventricle of the brain; 4v, fourth ventricle; ac, auditory canal. × 37.

FIG. 92.—Egg slightly more advanced than fig. 91, showing large blood vessels (bv) transversing the yolk, arrows indicating the direction of the flow; h, heart. × 37.

FIG. 93.—Newly hatched larva. × 20.

FIG. 94.—Young fish, 13 mm. in length. × 9.

LARVÆ.

The newly hatched larva is approximately 5 millimeters in length. Considerable coiling, obviously, is necessary in order that a fish of this length may be contained within an egg only 1.25 millimeters in diameter. The larvæ are very slender, having an extremely long tail. They are very active, but for want of proper food or other causes they lived only a short time (usually about three days) in the aquarium after hatching. The yolk is completely absorbed by this time, but no important structural changes are evident. The newly hatched fry are highly transparent, only a few yellowish-green pigment spots being present. A few large spots occur on the upper surface of the head and a row of smaller ones along the base of the ventral fin fold. Circulation, due to the transparency of the newly hatched fish, can be nicely observed with a low power of the microscope. The blood may be seen flowing through the aorta to the tail, then curving sharply and returning through the caudal vein. One large blood vessel is still evident on the small yolk yet remaining. The vertical fins appear as continuous folds, surrounding the entire caudal portion of the body (fig. 93). Swimming appears to be accomplished by the very rapid vibration of the tail. The young fish has assumed practically all of the characters of the adult when it reaches a length of 13 millimeters, and it is then easily recognized (fig. 94).

Menidia beryllina, SILVERSIDE.

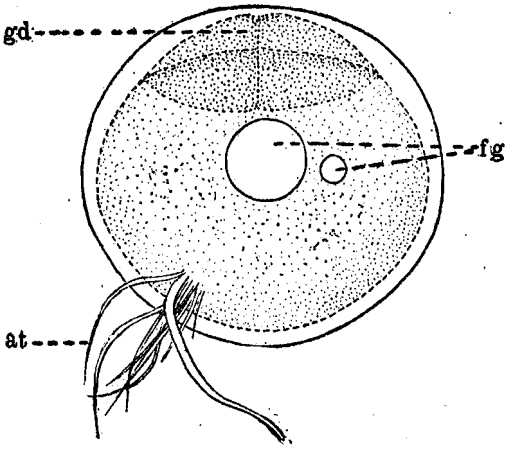
ADULTS.

This fish differs from *M. menidia* in the smaller size, in the shorter anal fin, which consists of 16 to 19 soft rays, in the more anterior position of the dorsal fins, and in the pale silvery peritoneum. It is much less abundant than *M. menidia*, and it inhabits only fresh and brackish water in the vicinity of Beaufort, N. C., although it is reported from salt water from other localities. It is fairly common in the mullet pond and in the fresh or brackish water creeks along the inland waterway and above the "narrows" in Newport River.

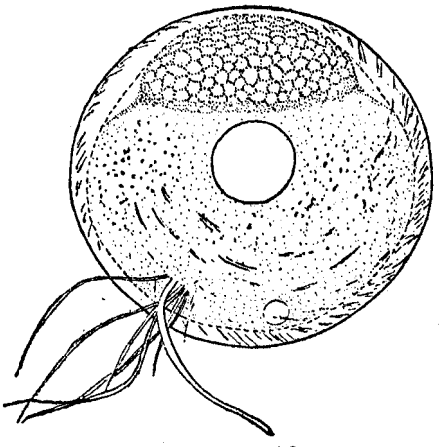
The females, as in the foregoing species, are somewhat larger than the males, reaching an average length of about 61 millimeters and a maximum length of 72 millimeters, while the males reach an average of only about 55 millimeters and a maximum length of 65 millimeters. The ratio of the males to the females appears to be about equal. The food of this species consists of small fish, small crustaceans, diatoms, and algæ.

SPAWNING.

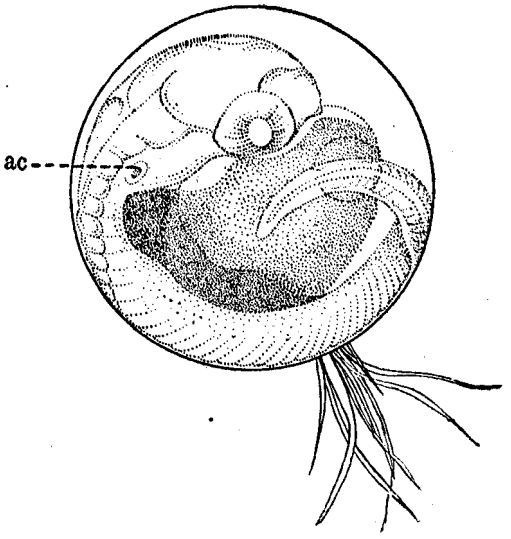
This fish, as does *M. menidia*, spawns throughout the summer, or from March to September. The author has taken ripe or nearly ripe fish during March, April, May, June, and July, but the small size of the young taken during October and November indicates that it spawns as late as September. This species also selects shallow water with an abundance of vegetation for its spawning ground. It is quite evident that this fish, as does *M. menidia*, spawns several times during one season, for it has ova of several sizes in the ovaries at one time, and when one lot of eggs is ripe those of the next largest size are big enough to be plainly visible with the unaided eye.



95



96



97

98

Menidia beryllina. (Drawn by Mrs. E. B. Decker.)

FIG. 95.—Egg in 2-cell stage: at, adhesive threads; gd, germinal disk; fg, fat globules. × 67.
FIG. 96.—Egg in advanced cleavage stage. × 67.
FIG. 97.—Egg 2½ days after fertilization, water temperature 82° F.: ac, auditory canal. × 67.
FIG. 98.—Newly hatched larva. × 22.

EGGS.

The eggs of this species are not quite spherical when first spawned, and they are somewhat smaller than those of *M. menidia*, their greatest diameter being approximately 0.75 millimeter. The action of the eggs after spawning, with respect to adhering to objects in the water, is identical in the two species; but under magnification it is seen that in the present species the gelatinous threads are comparatively few in number, and one of them is always much enlarged (fig. 95), while in *M. menidia*, as already shown, they are very numerous and of uniform size. The eggs of the two species appear to be identical in all other respects

EMBRYOLOGY.

Nothing essentially different from *M. menidia* in the embryology of this species was noted (figs. 95, 96, and 97). The eggs hatched in a water temperature varying from 78 to 82° F. on the eighth, ninth, and tenth day after fertilization.

LARVÆ.

The newly hatched larvæ are approximately 3.5 millimeters in length, or 1.5 millimeters shorter than the newly hatched larvæ of *M. menidia*, and it is only in size that they can be readily distinguished from the latter (fig. 98). Therefore, what was previously stated with respect to the larvæ of *M. menidia* also applies to the present species. The development of the young fry, too, appears to be identical, except that in the present smaller species the development with respect to size is proportionately slower, although from field observations it is evident that maturity is reached just as early.