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LARVAL DEVELOPMENT OF THE LARGE BLOOD CLAM, *NOETIA PONDEROSA* (SAY) ¹

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ABSTRACT

Larvae of *Noetia ponderosa* were raised from eggs in laboratory cultures. Lengths increased from 80 to 210 μ over a 4-week free-swimming period. Height is 15 μ less than length in small larvae but as much as 55 μ less than length when larvae are ready to metamorphose. Depth varies from 25 to 70 μ less than length over the same period. The straight-hinge line is 65 to 80 μ long. The umbo is first formed at a length of 150 to 160 μ and becomes long and broad. Umboned larvae are brown with the shell becoming reddish-brown at the anterior end. However, these typically arcid colors are not as dark as in other species of this family. The anterior end is more pointed than the posterior in umbo larvae. The hinge consists of a central undifferentiated area with a series of small taxodont teeth at both the anterior and the posterior end of the hinge line in both valves.

INTRODUCTION

Noetia ponderosa (Fig. 1), one of the common larger members of the family Arcidae, occurs in estuaries from Virginia to Florida and in the Gulf of Mexico (Abbott 1954). Its distribution is usually limited to high-salinity (above 25 ppt) subtidal areas where it is frequently attached to shells or other objects in a soft mud or sand substrate. This report describes the larval development of this species.

Adult *N. ponderosa*, collected periodically from the channels between the high-salinity marshes near Wachapreague, Virginia, contained gametes throughout most of the year, though they spawned in the laboratory on but three occasions during the fall and winter. Spawning was induced and the larvae were raised in the laboratory by the techniques described by Loosanoff and Davis (1963). Although some larvae were fed a variety of algae, only those receiving *Monochrysis lutheri* survived to metamorphosis. Water temperature ranged from 19 to 26°C in larval cultures.

Both male and female clams released a steady stream of gametes during spawning. Spermatozoan heads were triangular and 3.5 to 45 μ long. They were bluntly pointed anteriorly and 2.5 μ wide at the base of the tail which was about 60 μ long. Normal eggs were released either singly or

in clumps. They were coral-red and about 65 μ in diameter. The yolk appeared coarse and granular under the microscope. Sample counts indicated that two isolated females had released 11,314,000 and 11,034,000 eggs respectively within a few minutes during a single spawning.

LARVAL DEVELOPMENT

Larvae of *N. ponderosa* are similar in appearance to those of other Arcidae. They grew slowly in our cultures. Straight-hinge larvae have a minimum length (maximum anterior-posterior dimension) of 80 to 85 μ . The apical flagellum becomes inconspicuous and disappears while larvae are still less than 100 μ in length. The hinge line is 65 to 70 μ long in one-day-old larvae (80 to 90 μ in length) but increases to 75 to 80 μ long in two-day-old larvae (95 to 105 μ in length). There is no further increase in the length of the hinge line during larval development. In early stages length is usually 15 to 20 μ greater than height (the dimension perpendicular to length) but the difference increases to 25 to 30 μ by the time the umbo stage begins at 150 to 160 μ . The difference continues to increase until length usually exceeds height by 45 to 55 μ at a length of 200 μ . Depth (the maximum left-right dimension) is about 25 μ less than length in the smallest larvae. In larger straight-hinge larvae depth is 45 to 55 μ less than length but may be as much as 70 μ less in larvae at metamorphosis.

At a length of 130 μ the anterior end begins to

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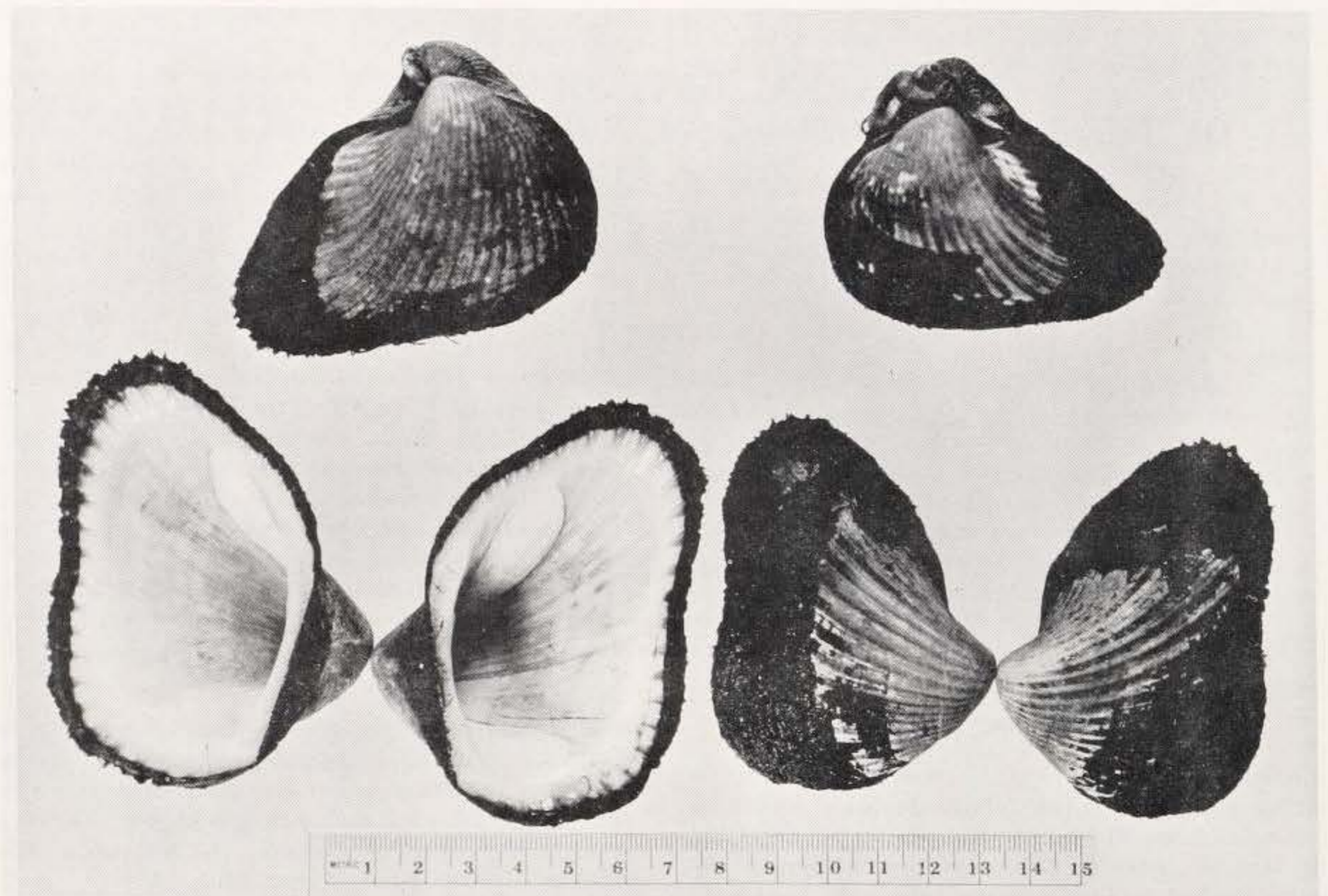


FIG. 1. Above, living *Noetia ponderosa*; lower left, internal view of opened valves; lower right, external view of opened valves.

develop a more pointed appearance than the posterior end. This difference becomes more noticeable as size increases. Nevertheless, the anterior and posterior ends are of nearly equal length. Shoulders are short and form a continuous line obscured by the umbo. They slope equally and gradually to the differently shaped ends.

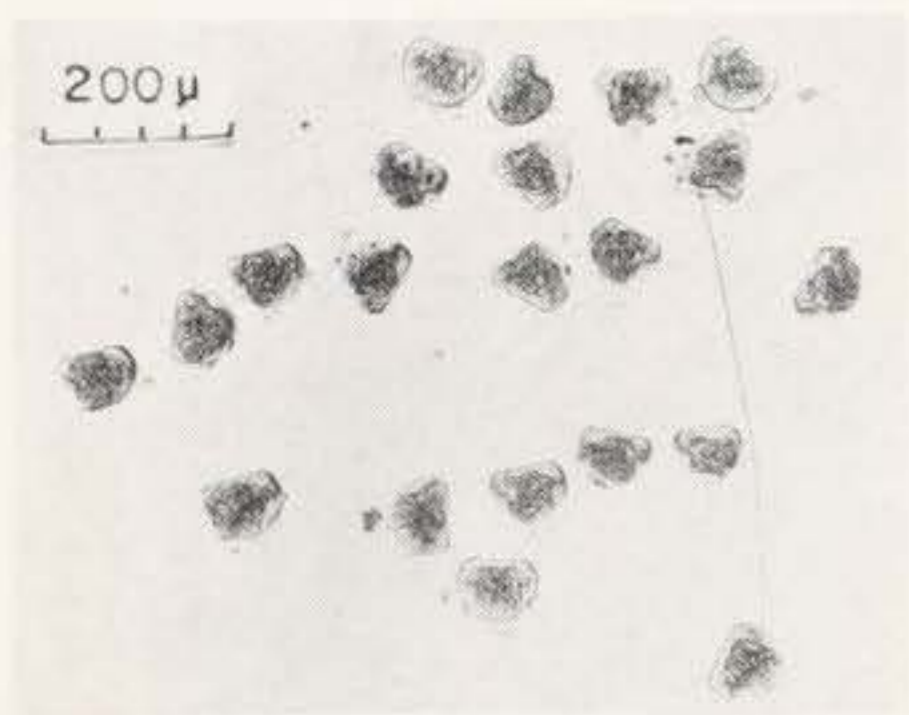
A broadly rounded umbo begins to project above the hinge line when larvae reach a length of 150 to 160 μ (2 to 4 weeks under our culture conditions). The umbo becomes increasingly conspicuous and somewhat flat. Eventually it appears as a long, broadly-rounded knob with a silhouette that is discontinuous with the shoulders (Fig. 2).

Shortly after the development of the umbo, the anterior end of the shell becomes a darker reddish-brown. This shell coloring may extend into the umbo region in larger larvae. Larvae are darker than most pelecypods, but are not as dark as larval *Anadara transversa*. The adductor muscles become prominent shortly after the formation of the umbo, and are more conspicuous than in most species of pelecypods. An indistinct eye spot forms in larvae about 180 to 185 μ in length. It

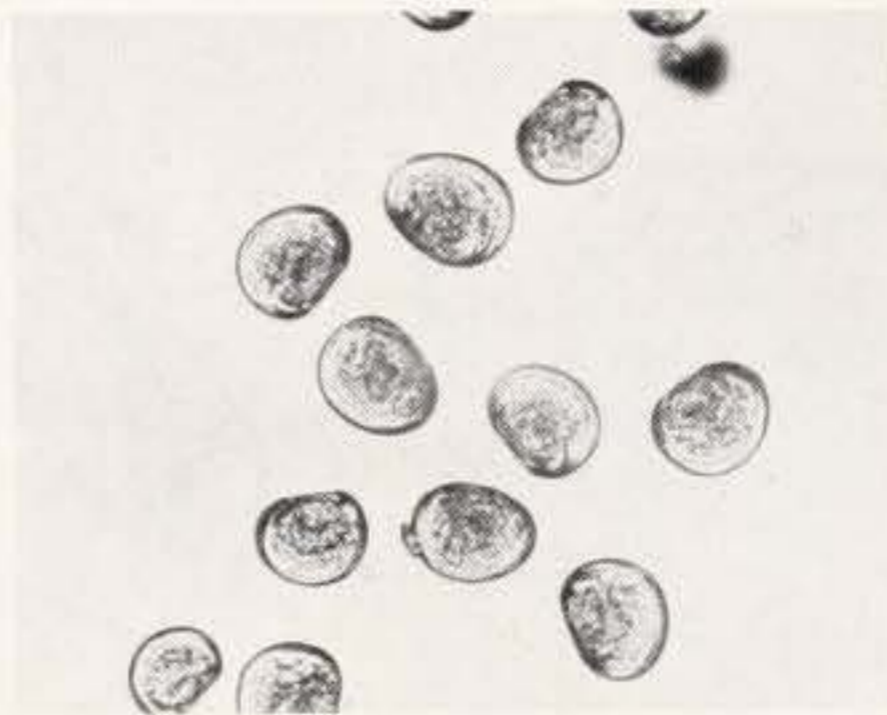
rapidly becomes conspicuous and is typically dark as metamorphosis proceeds. Larvae metamorphose at lengths ranging from 185 to 210 μ .

The foot is short and blunt. It is heavily ciliated at the distal end and has a large blunt heel that is used to apply the strong byssus threads with which this clam is capable of attachment at metamorphosis. The prominent features of the internal anatomy are illustrated in Figure 3.

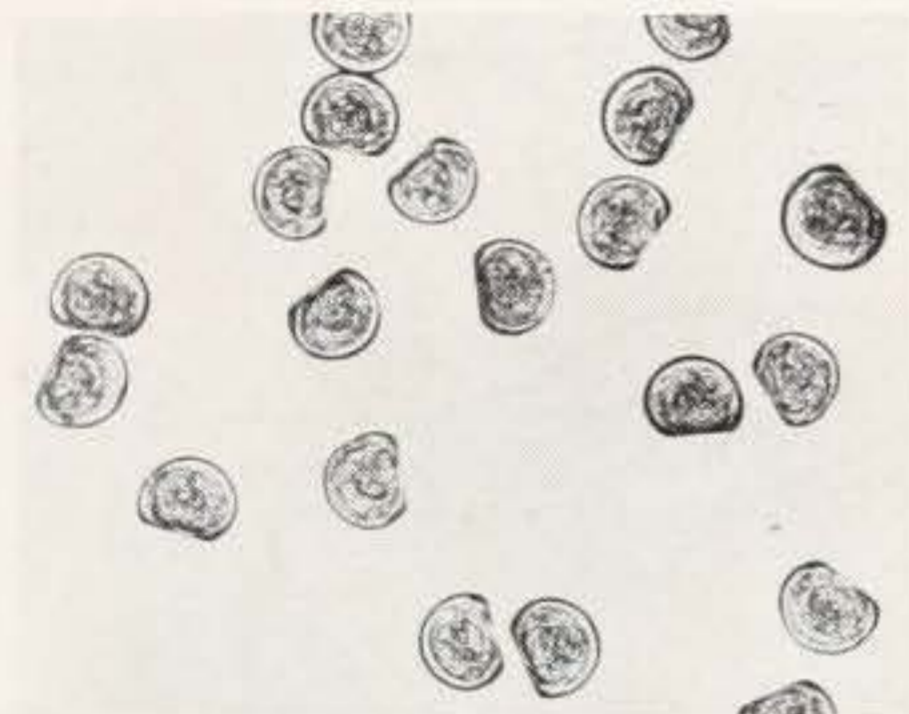
The distinctive hinge structure of the Arcidae is evident in larvae as small as 80 μ in length (Fig. 4A). At both the anterior and posterior ends of the hinge line of each valve are a series of small taxodont teeth. The number of readily identifiable teeth in each series increases from four to six during larval development. The teeth on one valve mesh with those on the opposite valve to form a toothed area about 25 μ long. The anterior toothed area is separated from the posterior area by an undifferentiated central area of the hinge 35 μ long. Frequently at least part of the hinge structure can be seen through the umbo when larvae are lying quietly. The development of the hinge can be seen in the photomicrographs in Figure 4.



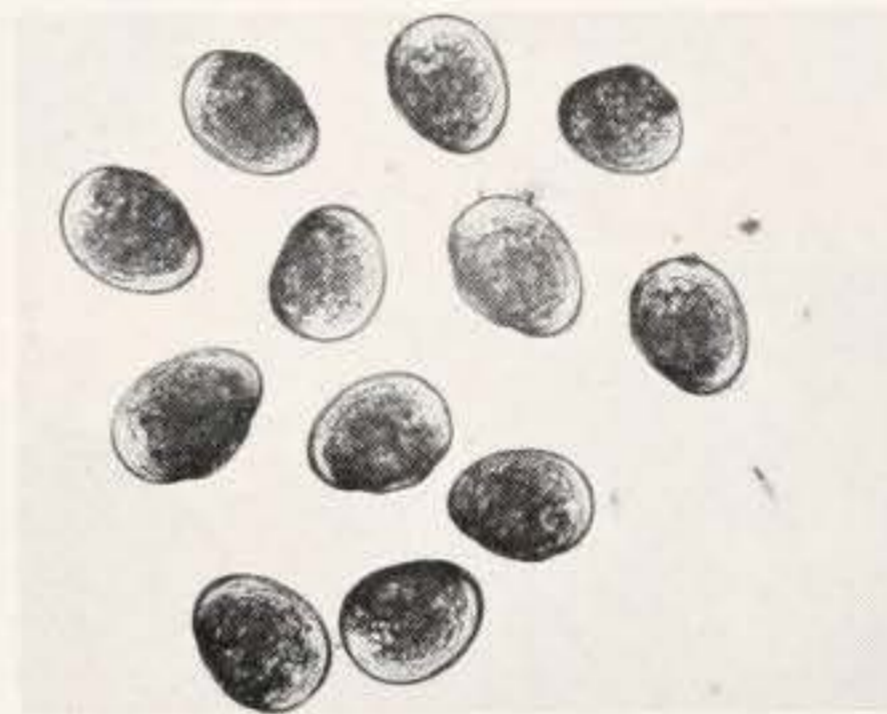
A



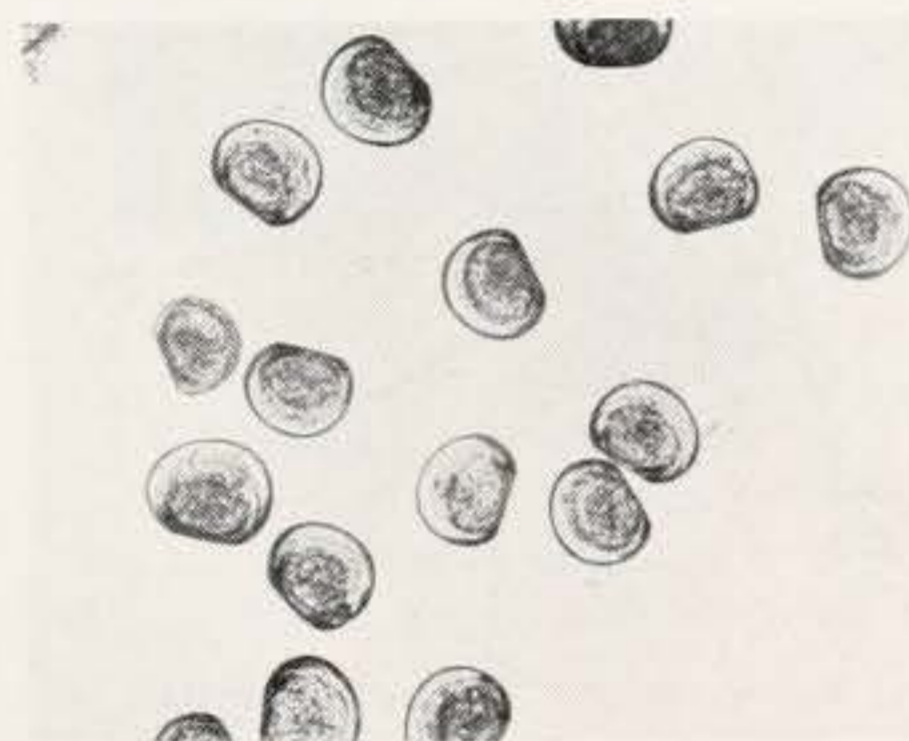
D



B



E



C



F

80 X 70

95 X 80

120 X 105

135 X 110

160 X 130

180 X 150

200 X 155

FIG. 2. A. One-day-old larvae. Many with shell still incompletely formed. B. 10-day-old larvae. C. 12-day-old larvae. D. 20-day-old larvae. E. 26-day-old larvae. F. 30-day-old larvae.

DISCUSSION

The Arcidae are common, widely-distributed clams. Some species are of commercial importance (Kan-no and Kikuchi, 1962; Pathansali, 1964), yet larval development of only five species has previously been described (Table 1). From descrip-

tions and illustrations accompanying them, several characteristics appear to be common to larvae of this family. Growth is relatively slow, and the larval period comparatively long (4 to 6 weeks). Length exceeds height by up to 70 μ; more than in most pelecypod larvae. Larvae have a distinct brown to reddish-brown color and become eyed and metamorphose at lengths between 200 and 300 μ.

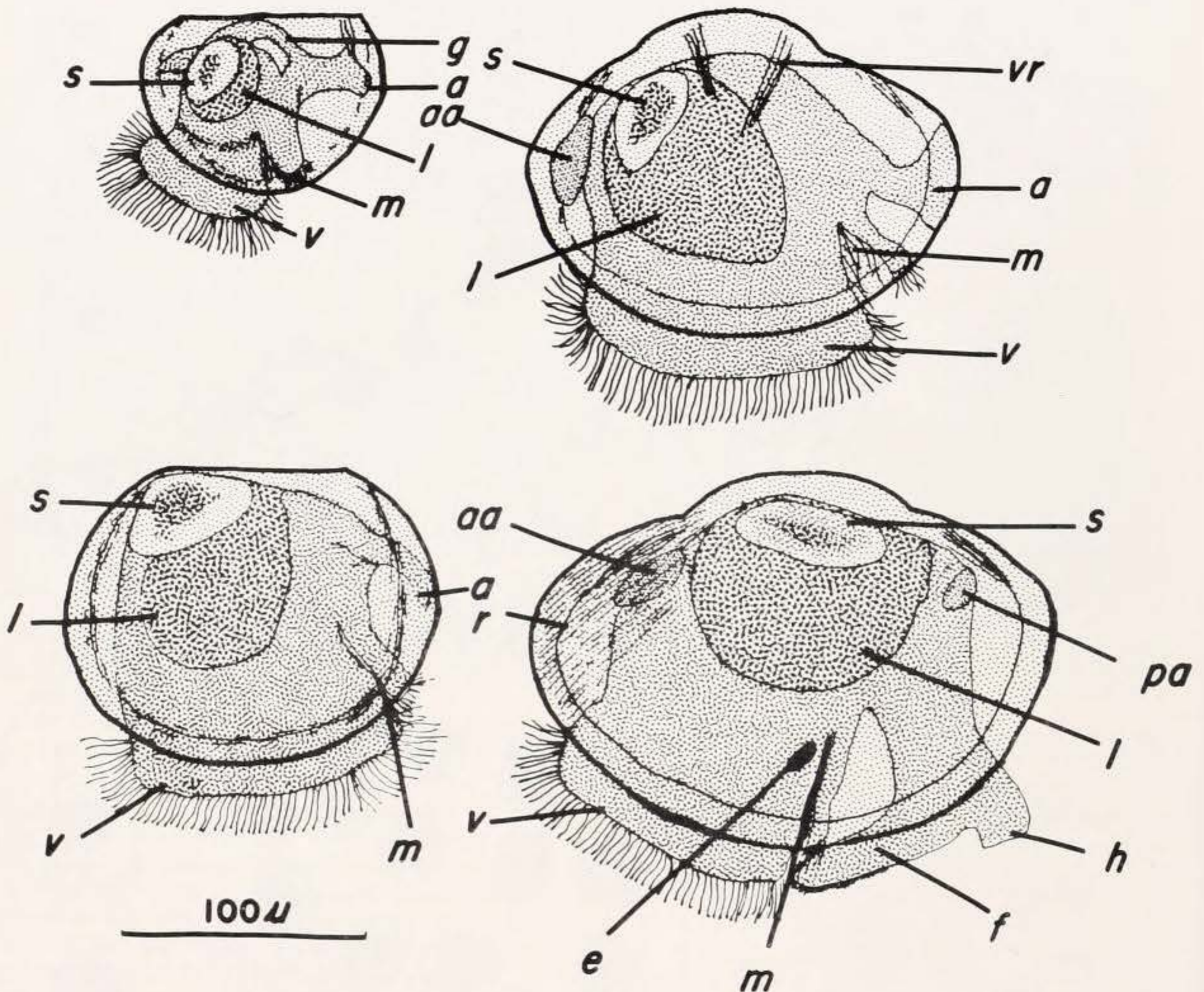


FIG. 3. Schematic drawing of development of the internal anatomy of larval *Noetia ponderosa*. *aa* — anterior adductor muscle, *a* — anus, *e* — pigmented eye spot, *f* — foot, *g* — gut, *h* — heel of foot, *l* — liver or digestive diverticula, *m* — mouth, *pa* — posterior adductor muscle, *r* — reddish-brown color, *s* — stomach, *v* — velum, and *vr* — velar retractor muscles.

Larvae of *N. ponderosa* have the shape, color, comparatively short height, and dentition typical of arcid larvae. In Virginia only larvae of the closely related blood clams, *Anadara transversa* and *Anadara ovalis*, could be confused with larval *N. ponderosa*. The umbo of *N. ponderosa* is broader, longer, and flatter than the umbo of *A. transversa* and the shoulders of the latter slope more steeply. In addition, the ventral margin of *N. ponderosa* slopes more steeply toward the an-

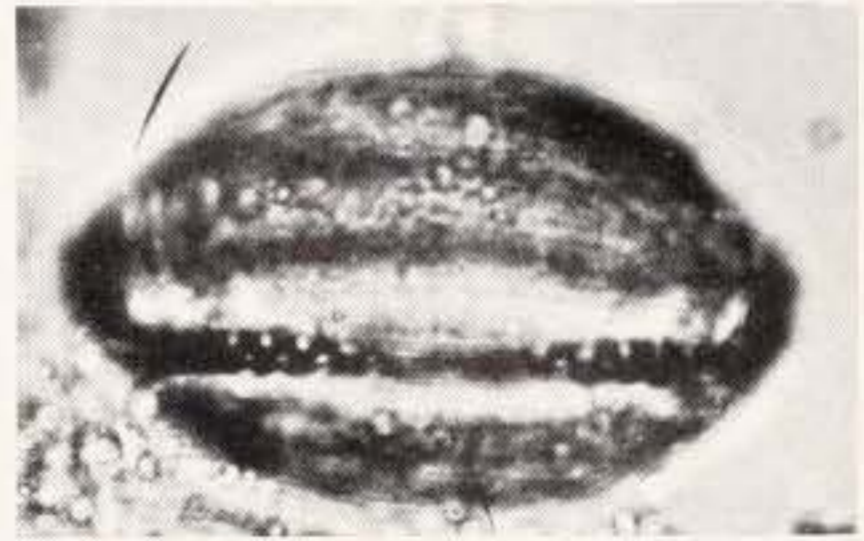
terior end than in larval *A. transversa*. Although the larval stages of *A. ovalis* have not been described, the similarity of other arcid larvae suggests that larval *A. ovalis* would resemble those of *N. ponderosa*.

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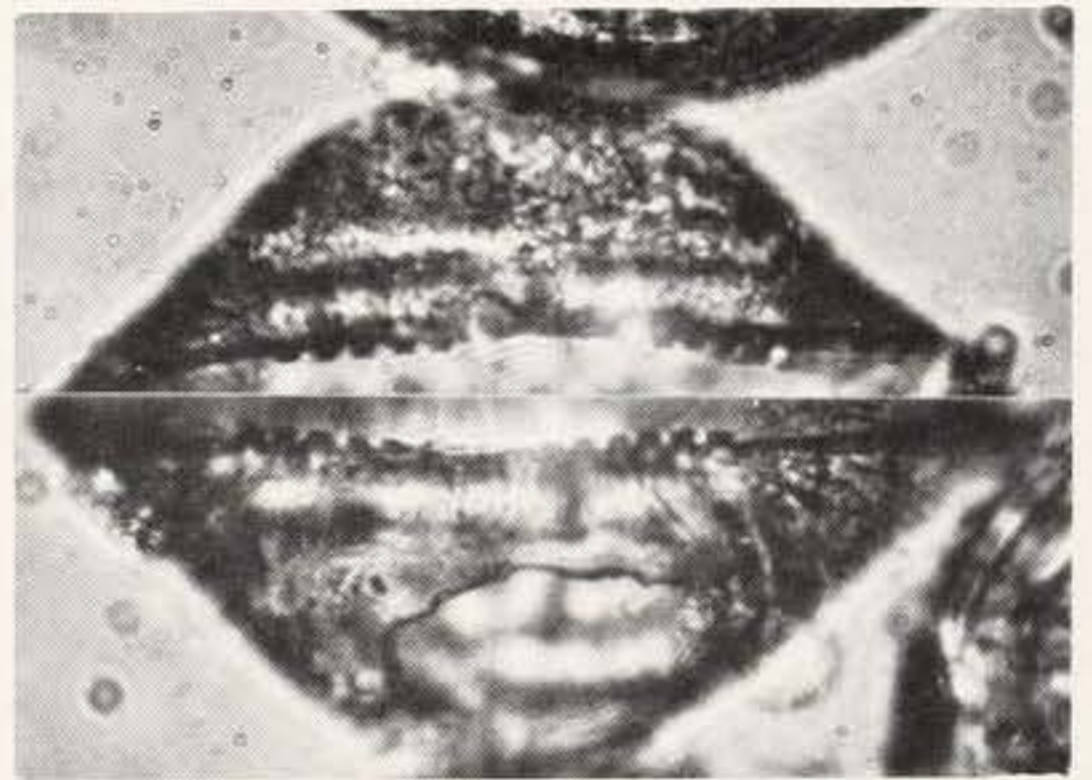
A



B



C



D

FIG. 4. Development of the hinge structure in *Noetia ponderosa* larvae. A. Larval shell 80 μ long. B. Larval shell 120 μ long. C. Larval shell 155 μ long. D. Separate valves of larval shell 175 μ long. Dorsal view with left valve on top. Anterior end to the right.

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TABLE 1. *Description of Larval Arcidae*

| Species | Author | Description |
|--|----------------------------|---|
| <i>Arca noae</i> Linnaeus | Odhner (1914) | Reddish-yellow, metamorphose at about 200 μ . Hinge line with 8 anterior and 8 posterior taxodont teeth. (Drawings) |
| <i>Anadara broughtonii</i> (Schrenk) | Yoshida (1953) | Recognizable at length of 150 μ . Metamorphose at about 250 μ . Height 120 to 190 μ . Both ends rounded. (Drawings) |
| <i>Anadara broughtonii</i> (Schrenk) | Kan-no (1963) | Minimum length 83 μ . Height 67-180 μ . Metamorphose at 230 μ after about 40 days. (Photomicrographs) |
| <i>Anadara broughtonii</i> (Schrenk) | Kan-no and Kikuchi (1962) | Minimum length 90 μ . Metamorphose at 190-230 μ in 4 weeks. (Photomicrographs) |
| <i>Anadara granosa</i> Linnaeus | Pathansali (1964) | Metamorphose at lengths from 187 to 208 μ . Height 21 to 28 μ less than length. Pale yellow; 16 large taxodont teeth with small gap in mid-provinculum. Concentric lines in shell. Narrow anterior end more darkly colored than more rounded posterior. |
| <i>Anadara granosa bienensis</i> (Schrenk and Reinhart) | Yoshida (1957) | Metamorphose at 231 μ . Elongated. Height 44-60 μ less than length. About 7 concentric lines on shell. |
| <i>Anadara transversa</i> (Say) | Loosanoff and Davis (1963) | Minimum length 70 μ . Metamorphose in 27 to 37 days at lengths of 215 and 310 μ but usually 240-260 μ . Umbo at 130-140 μ . Eye at 205 μ . (Photomicrograph) |
| <i>Anadara subcrenata</i> (Lischke) | Yoshida (1937; 1953) | Minimum length 110 μ . Metamorphose at about 280 μ . Height 90-200 μ . Knobby umbo. Yellow. (Drawings) |

