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Larval Mussel Parasitism of Fishes in the Potomac River Estuary, Fairfax County, Virginia

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Introduction

Freshwater mussels of the family Unionidae have a highly modified larva, the glochidium, which is an obligate parasite on the gills, fins, or skin of certain freshwater fishes. Glochidia are released into the water from the marsupia of the female mussel. After locating and attaching to a suitable fish host, the glochidium becomes encysted. While encysted, it metamorphoses to the juvenile stage (Zale and Neves 1982a). At the end of the parasitic phase the young mussel breaks out of its cyst, falls to the bottom, and enters a free-living juvenile stage (Pennak 1978). This combination of parasitic larva with free-living adult is unusual in parasitic organisms; this parasitism is also unusual in that the Unionidae are the only members of the Class Bivalvia known to have obligate parasitic larvae (Kat 1984).

The presence of a suitable host at the appropriate time is a critical factor in the life cycle of mussels. Host fishes have been identified for only 20 to 25 percent of the North American species of unionaceans (Fuller 1974; Hanek and Fernando 1978a, b; Stern and Felder 1978; Trdan and Hoeh 1982; Zale and Neves 1982b; Threlfall 1986). Fish hosts have been reported for only seven of the 19 species of Unionidae (six of which are endangered or of special concern) thought to occur in the Potomac and Rappahannock drainages in northern Virginia.

Materials and Methods

Fish were collected by trawling at five sites in the Potomac River estuary in Fairfax County, Virginia (Figure 1); two sites (1, 2) in Gunston Cove, one (3) in Dogue Creek, and two (4,5) in the Potomac River. Gunston Cove is located along the south side of the Potomac River approximately 18 miles SSW of central Washington D.C. Collections were made on 2 and 19 September, 19 October, and 16 November, 1988. One hundred twenty-six fish representing 13 species from eight families were examined (Table 1): Atherinidae (1 species), Centrarchidae (2), Clupeidae (2), Cyprinidae (3), Engraulidae (1), Percidae (2), Percicthyidae (1), Sciaenidae (1).

Fish were fixed in 10% formalin and transferred to 70% ethanol. Each was identified to species, measured, and examined under a zoom stereoscopic microscope for encysted glochidia on the gills, fins, and skin. Gills were excised for examination. To facilitate identification, encysted glochidia were removed from host tissue by placing small sections of infested tissue in 1-2 ml of 5.25% sodium hypochlorite solution for several minutes. Glochidia removed by this procedure were then examined and photographed under a compound microscope. General shell shape and the presence or absence of a hook were noted. Glochidial measurements, when possible, included length, the maximum anteroposterior dimension parallel to the hinge; breadth (or height), the maximum dorsoventral dimension perpendicular to the hinge; and hinge length.

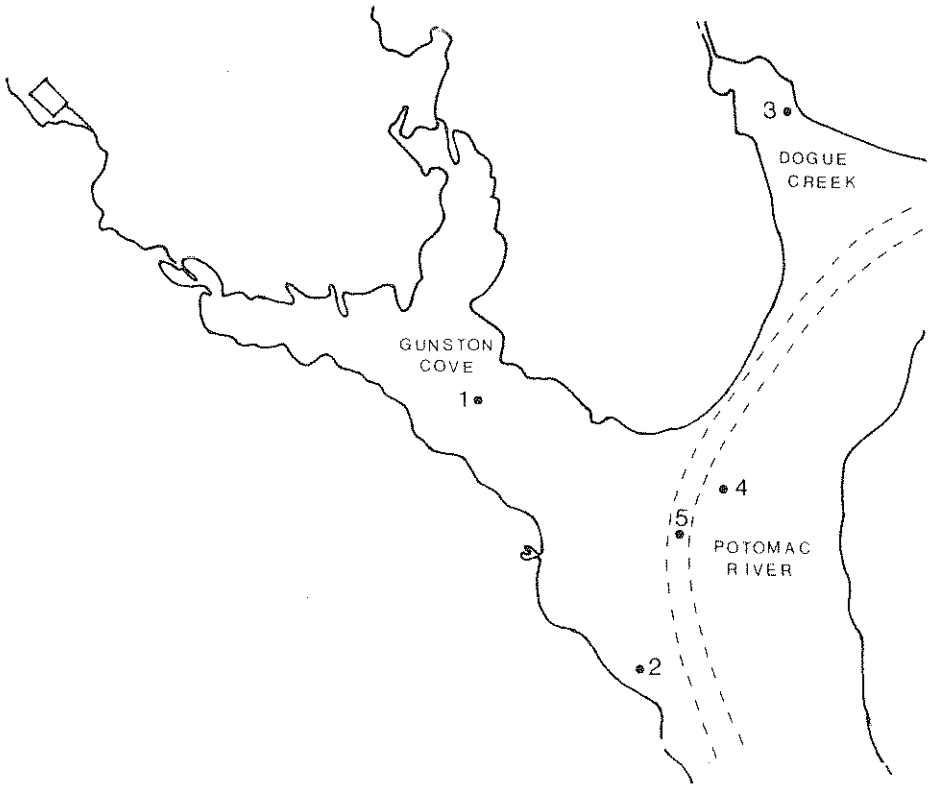


Figure 1. Study sites in the Potomac River estuary in Fairfax County, Virginia.

Prevalence of Parasitism

Encysted glochidia were found on 18 (14.3%) of the fish examined. Only two species, white perch, *Morone americana* (Percicthyidae) and spot, *Leiostomus xanthurus* (Sciaenidae), were parasitized. Both are new host records for natural glochidial infestations. Davenport and Warmuth (1965) exposed freshly excised pectoral and pelvic fins of white perch to glochidia of *Anodonta implicata* in an aquarium and observed glochidial attachment, but presented no quantitative data. This is the first record of either natural or experimental infestations of the spot, but a related species, the freshwater drum, *Aplodinotus grunniens*, is known to host at least 11 species of mussels (Fuller 1974).

Of 71 *M. americana* examined, 11 (15.5%) had encysted glochidia (Table 2). The numbers of infested *M. americana* were highest in early September (33%), declined through mid-September (17%), with no parasitized *M. americana* collected at the five study sites in October. However, in mid-November the prevalence of parasitism increased to 25%. Standard body lengths of infested *M. americana* ranged from 7.4 to 10.1 cm (mean, 8.45).

Of 13 *L. xanthurus* examined, seven (53.8%) contained encysted glochidia. Parasitism was more prevalent in spot than in white perch, with 67% parasitized in early September and 50% in mid-October. No spot were captured in November. The high percentages of parasitized individuals based on such small sample sizes suggest that this fish may be an important host

species in the study area. Standard body lengths of infested spot ranged from 7.9 to 10.0 cm (mean, 8.60).

Table 1. Prevalence of parasitism by glochidia of the Unionidae in fishes in the Potomac River watershed of Fairfax County, Virginia, 1988.

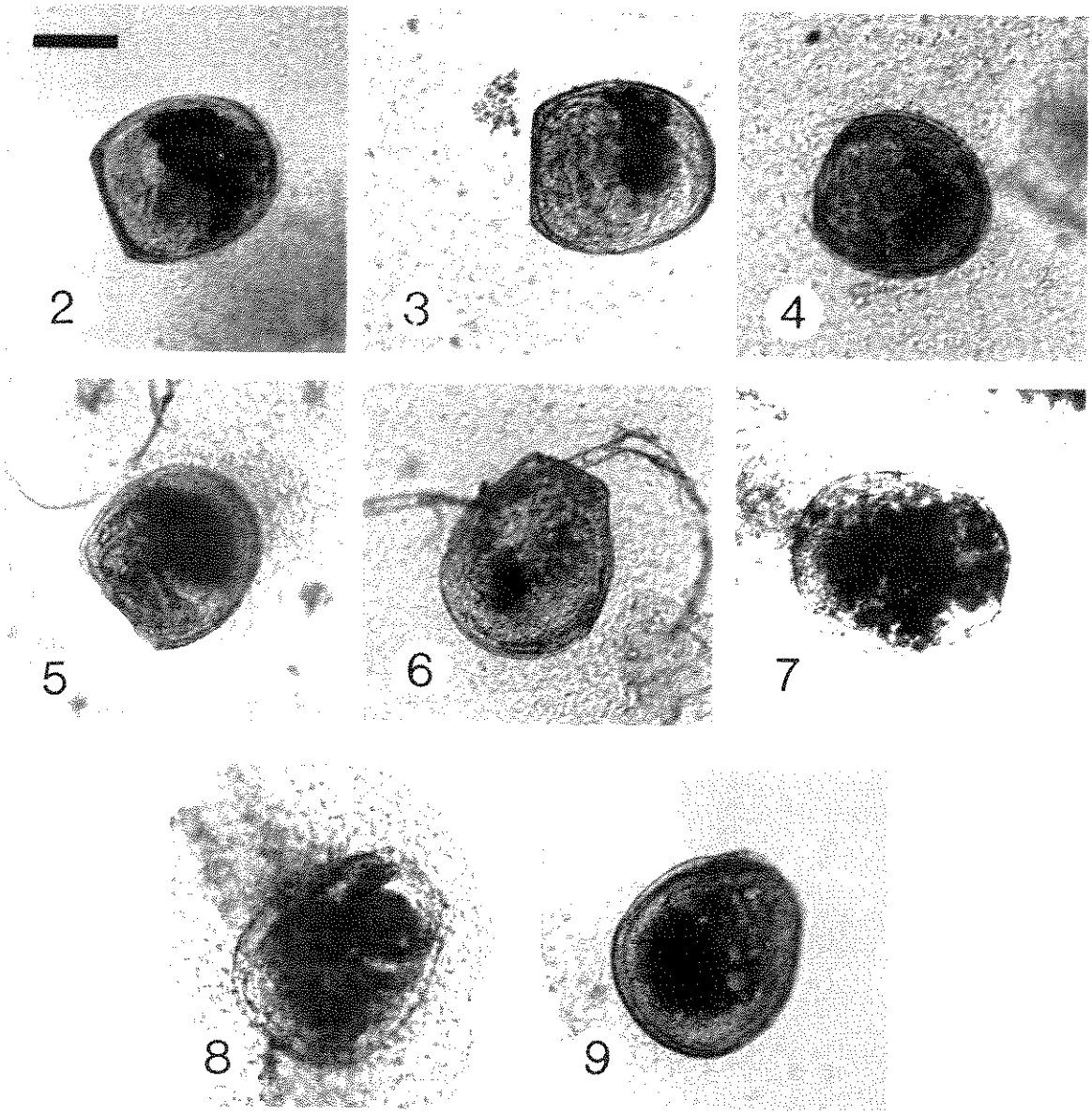
Fish species examined	Number parasitized (%)	Number
Atherinidae:		
Menidia beryliana	1	0
Centrarchidae:		
Lepomis gibbosus	1	0
Lepomis macrochirus	8	0
Clupeidae:		
Alosa pseudoharengus	10	0
Dorosoma cepedianum	11	0
Cyprinidae:		
Notropis sp.	1	0
Semotilus sp.	1	0
Semotilus corporalis	4	0
Engraulidae:		
Anchoa mitchelli	1	0
Percidae:		
Etheostoma flabellare	3	0
Etheostoma olmstedi	1	0
Percichthyidae:		
Morone americana	71	11(15.5)
Sciaenidae:		
Leiostomus xanthurus	13	7(53.8)
TOTALS	126	18(14.3)

The average numbers of encysted glochidia per fish were generally low, six (1-28) for *M. americana* and 11 (1-54) for *L. xanthurus*. With the exceptions of three glochidia encysted on gill rakers and one on a dorsal fin, all glochidia were located on the gill filaments. All glochidia examined under the compound microscope appeared to be hookless species of the subfamilies Lampsilinae and Ambleminae, some of which are probably species of *Elliptio* (See figures 2-9).

Table 2. Prevalence and intensity of parasitism of *Morone americana* and *Leiostomus xanthurus* by glochidia of the Unionidae in the Potomac River estuary, Fairfax County, Virginia, 1988.*

Locality	Collection Date 9/2	9/19	10/19	11/16
Morone americana				
Gunston Cove (site 1)	1/8(13) 1	-	0/6(0)	0/8(0)
Gunston Cove (site 2)	-	0/1(0)	0/11(0)	4/4(100) 3,5,6,2
Dogue Creek (site 3)	-+	-	-	0/2(0)
Potomac River (site 4)	2/4(50) 2,14	1/5(20) 3	0/11(0) 1	1/7(14)
Potomac River (site 5)	2/3(67) 1,3	-	-	-
TOTALS	5/15(33)	1/6(17)	0/28(0)	5/21(24)
Leiostomus xanthurus				
Gunston Cove (site 1)	-	-	-	-
Gunston Cove (site 2)	-	-	3/5(60) 1,2,3	-
Dogue Creek (site 3)	-	-	-	-
Potomac River (site 4)	-	1/2(50) 11	1/3(33) 2	-
Potomac River (site 5)	2/3(67) 6,54	-	-	-
TOTALS	2/3(67)	1/2(50)	4/8(50)	-

*Number of fish parasitized/number examined (% prevalence)
numbers of encysted glochidia per fish
+No fish examined.



Figures 2-9. Glochidia from naturally infested *Morone americana* and *Leiostomus xanthurus*. 2. Ambleminae from *Morone americana*. 3-5. Ambleminae from *Leiostomus xanthurus*. 6-8. Lampsilinae from *Morone americana*. 9. Lampsilinae from *Leiostomus xanthurus*. Bar equals 100 um. The spot, *L. xanthurus*, identified in this study, consumes mollusks, as well as crustaceans, annelids, fish, and vegetable debris. The white perch, *M. americana*, preys on fish and small invertebrates.

Discussion

The prevalence of glochidial infestations may vary by species, locality, season, abundance of mussels, or source of fish (Lefevre and Curtis 1910, Surber 1913, Stern and Felder 1978, Zale and Neves 1982b, Threlfall 1986, Neves and Widlak 1988). While the intensity of infestation is generally low (1-20 glochidia per fish), like those found in this study, certain fish species are

naturally parasitized by large numbers of glochidia. The drum, *Aplodinotus grunniens*, and the herring, *Alosa chrysochoris*, have been found with thousands of glochidia attached (Surber 1913, Howard 1914). Trdan (in Kat 1984) suggests that such great infestations may result from high levels of host specificity, necessitating concentration of glochidia on the available hosts. Factors such as the relative densities of mussel and host fishes and the levels of host immunity should also be considered as contributing to the rate of infestation (Stern and Felder 1978, Kat 1984).

The mean number of known host species per unionacean species is approximately four (Fuller 1974). Some mussels have only one known host, although there are probably other hosts which have not yet been identified. In contrast, *Anodonta grandis* has over 30 known host species. If host requirements are very specific, the loss of a single host species could have devastating effects on a mussel population. However, mussel species that utilize a variety of hosts have a greater probability of persistence.

Mechanisms which might reduce competition for available hosts are the concurrent use of different areas of the same fish (i.e. fins versus gills), and the parasitism of the same fish host but at different times of the year (Stern and Felder 1978).

The North American unionaceans exhibit a variety of adaptations which may increase the probability of contact with the correct host. One such mechanism is the timing of reproduction and glochidial release to correspond with periods of high host density and/or predictable host behaviors (Kat 1984).

One of the best-documented studies of the synchronization of glochidial release with a specific host behavior is that of *Anodonta implicata* and its anadromous host, the alewife (*Alosa pseudoharengus*). Even though the alewife spends only a short period of time in fresh water, the reproductive and developmental cycles of *A. implicata* are so well synchronized with the spawning run that they can infest, metamorphose, and drop off the alewife before it leaves the freshwater habitat (Davenport and Warmuth 1965).

Another adaptation which increases the probability of contact with the correct host species is mimicry of food items of the host. Glochidial conglutinates may resemble worms, leeches, or grubs (Chamberlain 1934, Kat 1984). Females of certain species of lampsiline have modifications of the mantle flap below the incurrent siphon which act as fish lures; the flaps resemble small, swimming fish with conspicuous eyespots and elaborate tails, and may attract piscivorous species.

The drum and catfish are molluscivorous, and may become heavily infected when they feed on gravid females. The drum, *Aplodinotus grunniens*, is a host to glochidia of at least 11 species of unionaceans (Fuller 1974). However, molluscivorous fish of the family Centrarchidae, such as the pumpkinseed (*Lepomis gibbosus*), are only known to host two species, while the largely vegetarian and insectivorous bluegill (*Lepomis macrochirus*) and green sunfish (*Lepomis cyanellus*) of the same family are host to 13 and 12 species, respectively. The five most commonly parasitized fish are omnivorous, insectivorous, and piscivorous (Kat 1984). The spot, *L. xanthurus*, identified in this study, consumes mollusks, as well as crustaceans, annelids, fish, and vegetable debris. The white perch, *M. americana*, preys on fish and small invertebrates.

Many species of freshwater fish have predictable cycles of migration and behavior. These may include movement from deep to shallow water in lakes, spawning migrations during the spring, aggregational behavior during reproductive cycles, and the movement of anadromous hosts such as the salmon into freshwater (Kat 1984). The release of glochidia by many short-term breeders (Ambleminae) corresponds with nesting behavior of the host. Hosts may construct nests in sandy patches within the mussel community, making the fish and its offspring susceptible to parasitism. The displacement of sediment with the fins during nest construction and maintenance may also promote attachment of glochidia lying on the sediment surface (Kat 1984).

The bottom-dwelling activities of darters and the nest-building behavior of centrarchids have been implicated in high rates and intensity of parasitism for these two groups in Michigan (Trdan and Hoeh 1982). The "lurking" predation strategy of pike, whose stomach contents may contain appreciable numbers of glochidia during natural feeding, may also provide opportunities for glochidial attack (Dartnall and Walkey 1979).

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