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**Glochidial Host of *Alasmidonta atropurpurea*  
(Bivalvia: Unionoidea, Unionidae)<sup>1</sup>**

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*Abstract.* Hosts for the glochidia of *Alasmidonta atropurpurea* were identified through examination of fish collected from the vicinity of mussel beds and by laboratory-induced infestations of fish. Five species of cypriniform and perciform fish collected during March 1990 harbored glochidia of *A. atropurpurea*. However, only on *Hypentelium nigricans* did glochidia occur consistently or were encysted. Of 12 fish species known to occur sympatrically with *A. atropurpurea*, induced infestations of glochidia resulted in the metamorphosis of juvenile mussels only on *H. nigricans*, confirming its role as a host.

Glochidia of unionoid mussels are ectoparasites on aquatic poikilotherms, usually fish. Although early host determination studies (e.g., Howard, 1914) were concerned primarily with commercial mussel species (i.e., pearl button shells), recent investigations have been more general in scope or directed toward rare or endangered taxa (e.g., Kitchel, 1985; Trdan & Hoeh, 1982; Weaver et al., 1991; Yeager & Neves, 1986). Glochidial hosts have been identified for only about 20% of the mussel fauna of the United States (Fuller, 1974; Gordon & Layzer, 1989); however, many purported host relationships have been based on observations of glochidia encysted on naturally infested fish without confirmation of successful metamorphosis to the juvenile stage (e.g., Lefevre & Curtis, 1910; Stern & Felder, 1978; Surber, 1913). Our investigation combined field observations and laboratory studies to assess regionally occurring fish as potential glochidial hosts for *Alasmidonta atropurpurea* (Rafinesque, 1831), a mussel endemic to the upper Cumberland River basin, Tennessee and Kentucky.

MATERIALS AND METHODS

Fish populations were assessed for natural glochidial infestations at sites within the Clear Fork River basin, Tennessee (Clear Fork River, 10 km SE of Allardt, Fentress Co.; North Prong Clear Fork River, 2 km E of Grimsley, Fentress Co.; Bone Camp Creek, 4 km E of Burrville, Morgan Co.). Mussel assemblages at these sites were composed exclusively of *Alasmidonta atropurpurea* or contained no other anodontine species (i.e., mussels with triangular, terminally hooked glochidia). Specimens were electrofished during the autumn

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(October 1988, November 1989), early spring (March 1990), and late spring (May 1989), preserved in 10% formalin, and examined microscopically for glochidial infestations in the laboratory.

To confirm field observations, fish were subjected to induced infestations of glochidia. Because fish may develop an immunological resistance subsequent to glochidial exposure (Arey, 1923; Reuling, 1919; Young et al., 1987), test species were collected from streams either devoid of or supporting very low densities of mussels (Roaring River basin, Jackson, Overton, and Putnam counties, Tennessee). Specimens were collected by electrofishing, maintained singly or in monospecific groups in aerated all-glass aquaria, held for one week prior to infestation, and fed daily.

Gravid *Alasmidonta atropurpurea* were obtained (11 October 1989) from the Clear Fork River, approximately 10 km southeast of Allardt, Fentress Co., Tennessee. Glochidia were prepared for infestation by rupturing water-tubes of excised marsupia and disassociating glochidial masses by mild agitation into a watchglass of clean aquarium water. Glochidial activity was assessed by exposure to a weak saline solution; infective glochidia closed quickly when stimulated. Representative species of the cypriniform and perciform faunae known to occur sympatrically with *A. atropurpurea* were infested experimentally. Fifty to 100 glochidia were pipetted into the left branchial chamber and onto fins of fish anaesthetized with tricaine methanesulfonate, *ad libitum*. Following exposure, fish were returned to clean aerated water and revived. Bottom contents of all aquaria were siphoned daily. The siphonate was passed through an 80- $\mu$ m mesh net to retrieve particulate matter. This material was then washed from the net into a watchglass and examined microscopically for sloughed glochidia and metamorphosed juveniles.

## RESULTS

As a relative assessment of community structure and temporal availability of potential glochidial hosts, qualitative sampling yielded 442 individuals and 24 species of fish (Table I). Glochidial infestations were observed on March-collected specimens of five species: *Cyprinella galactura* (Cope, 1868), *Hyphantelium nigricans* (Lesueur, 1817), *Ambloplites rupestris* (Rafinesque, 1817), *Lepomis megalotis* (Rafinesque, 1820), and *Etheostoma caeruleum* Storer, 1845. An infestation rate of 77% was observed for *H. nigricans* during this month; each infested specimen carried numerous glochidia in well-developed cysts on both fin and gill surfaces. The few specimens of *H. nigricans* not infested during March were all less than 4 cm in length. Infestations on other species were occasional; typically they consisted of one or two glochidia along the lower edges of fins, were not encysted, and appeared to be empty valves.

Twelve species of fish were tested for suitability as glochidial hosts (Table II). Following induced infestations, all fish sloughed large numbers of glochidia. *Rhinichthys atratulus* (Hermann, 1804) and two centrarchid species had lost all glochidia after eight days; other species retained glochidia for 13–41 days (water temperatures =  $19 \pm 3^\circ\text{C}$ ). By the end of the trials, valves of sloughed glochidia were broken or eroded, reflecting a tendency to remain attached to

TABLE I

Fish examined for natural infestations (number of fish infested in parentheses) of glochidia of *Alasmidonta atropurpurea*, Clear Fork River basin, Tennessee

Species	Number examined			
	October	November	March	May
Cyprinidae				
<i>Campostoma anomalum</i>	19	6	15	
<i>Cyprinella galactura</i>	9	12	18 (1)	
<i>Lythrurus ardens</i>	33			
<i>Nocomis micropogon</i>	1			
<i>Notropis rubellus</i>			2	
<i>Notropis stramineus</i>	34			
<i>Notropis volucellus</i>			16	
<i>Phenacobius crassilabrum</i>	8			
<i>Pimephales notatus</i>			1	
<i>Semotilus atromaculatus</i>	17	4	2	
Catostomidae				
<i>Hypentelium nigricans</i>	17	7	13 (10)	
Centrarchidae				
<i>Ambloplites rupestris</i>	10		4 (2)	1
<i>Lepomis cyanellus</i>	20		1	1
<i>Lepomis gulosus</i>				1
<i>Lepomis macrochirus</i>	30	2	10	8
<i>Lepomis megalotis</i>	14		7 (2)	
<i>Micropterus dolomieu</i>	2	5		
<i>Micropterus salmoides</i>	7			1
Percidae				
<i>Etheostoma blennioides</i>	19	7	17	1
<i>Etheostoma caeruleum</i>	4	3	23 (5)	2
<i>Etheostoma camurum</i>			2	
<i>Etheostoma rufilineatum</i>			1	1
<i>Etheostoma zonale</i>	2			
<i>Percina evides</i>			2	

fish despite unsuccessful infestations. Metamorphosed juvenile mussels (as evidenced by the presence of anterior and posterior adductor muscles, an enlarged visceral mass, an actively moving foot, and shell deposition along the lateral margins of the valves) were recovered from *Hypentelium nigricans* following 24 days of encystment. Examination of specimens of *H. nigricans* during trials indicated that glochidia remained encysted on fins and gills, apparently developing equally well on either surface; no glochidia remained attached following recovery of juveniles.

#### DISCUSSION

As a consequence of its recent recognition as a valid species (see Call & Parmalee, 1982; Clarke, 1981), little information has been available on the biology of *Alasmidonta atropurpurea* (see Gordon & Layzer, 1989). The pres-

TABLE II

Synopsis of laboratory-induced glochidial infestations of *Alasmidonta atropurpurea* on fish

Species	Period of glochidial sloughing (days)	Period of metamorphosis (days)
<i>Campostoma anomalum</i> (n = 7)	30	
<i>Notropis volucellus</i> (n = 2)	38	
<i>Rhinichthys atratulus</i> (n = 9)	8	
<i>Semotilus atromaculatus</i> (n = 2)	13	
<i>Hypentelium nigricans</i> (n = 3)	24	24
<i>Ambloplites rupestris</i> (n = 12)	41	
<i>Lepomis cyanellus</i> (n = 1)	8	
<i>Lepomis macrochirus</i> (n = 1)	8	
<i>Lepomis megalotis</i> (n = 2)	29	
<i>Etheostoma blennioides</i> (n = 9)	29	
<i>Etheostoma caeruleum</i> (n = 7)	13	
<i>Cottus carolinae</i> (n = 11)	20	

ence of infective glochidia in October but absence of parasitized fish until March indicates that temporal release of glochidia is a behaviorally, rather than a developmentally, mediated response. Brooding periodicity appears to be similar to that of the closely related *A. marginata* (Say, 1818) (Gordon, unpublished data; Gordon & Layzer, 1989), as is the use of a catostomid as a glochidial host. Unlike those of *A. marginata*, glochidia of *A. atropurpurea* did not metamorphose on any of the perciform species tested. Although anodontine mussels parasitize a broad spectrum of fishes, host specificity in *A. atropurpurea* appears to be more restricted than that of its more widely distributed congener (see Gordon & Layzer, 1989).

The triangular hooked glochidia of anodontine species generally have been reported as fin parasites, whereas other glochidial forms typically attach to gill filaments (e.g., Lefevre & Curtis, 1910, 1912; Pennak, 1989). In this study, glochidia developed successfully on gills and fins during laboratory infestations and were distributed on both of these surfaces on each of the naturally infected specimens of *Hypentelium nigricans* examined. Previous investigators (e.g., d'Eliscu, 1972; Howard, 1914; Lefevre & Curtis, 1910, 1912; Neves & Widlak, 1988; Young, 1911; Zale & Neves, 1982a) also noted glochidial infestations divergent from the purportedly typical location with respect to morphology. Rather than strictly a function of morphology, the site of glochidial attachment appears to be related to the method of glochidial release employed by the mussel species and the behavior of the host at the time of infestation (Gordon & Layzer, 1989). The absence of glochidia on the smallest specimens of *H. nigricans* (<4 cm) also suggests that behavior as related to the life stage of the host may be a factor. The eroded condition of sloughed glochidia near the end of the testing period and the empty, non-encysted valves observed on naturally infested, non-catostomid fish indicates a tenacity by hooked forms to remain attached for considerable periods following rejection.

Despite the limited geographic ranges of some species of unionoids, many

species utilize fairly common, widely-distributed fishes as glochidial hosts (e.g., Bruenderman, 1989; Gordon et al., 1993; Hill, 1986; Kitchel, 1985; Neves et al., 1985; Weaver et al., 1991; Zale & Neves, 1982b). With opportunistic (i.e., *r*-selected; see Pianka, 1983) species such as freshwater mussels, these relationships may increase the potential for successful parasitism and subsequent recruitment. Because the host functions as the primary dispersal agent for unionoids (Gordon & Layzer, 1989), a highly motile species of fish (e.g., *Hypentelium nigricans*; see Lee et al., 1980) also would increase the potential for range extension. However, the restriction of *A. atropurpurea* to the Cumberland River basin on the Cumberland Plateau indicates that another mechanism other than the range of the host is limiting the geographic distribution of this species. Reflecting causal factors for endemism of fishes in this region (see Burr & Warren, 1986), *A. atropurpurea* probably evolved as a result of geographic isolation by Cumberland Falls and subsequent adaptation to the poorly buffered sandstone lithology of the plateau. Downstream from the plateau, this species does not inhabit the adjacent calcareous Highland Rim physiographic province, but is replaced by *A. marginata*. However, recession of the falls upstream 72 km from its original location attributable to differential erosion of underlying strata (see McGrain, 1966) has resulted in the distribution of *A. atropurpurea* above and below the falls.

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