RICHARD J. NEVES

Fish hosts

~~STENOTOPIC HOST REQUIREMENTS~~ FOR GLOCHIDIA OF *EPIOBLASMA* (=*DYSONOMIA* = *PLAGIOLA*) *CAPSAEFORMIS*, *E. INTERRUPTA* AND *E. TRIQUIETRA* (PELECYPODA: UNIONIDAE)

in the ~~Powell River~~, upper Tennessee River drainage

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This needs major work

who uses *E. interrupta*?

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ABSTRACT

In May and June of 1984, gravid females of *Epioblasma capsaeformis* *E. interrupta* and *E. triquetra* were collected from the Powell River in Tennessee. Laboratory Induced infestations of the parasitic glochidial stage of these mussels on fishes resulted in the identification of the following suitable hosts for *Epioblasma capsaeformis*: *Etheostoma maculatum*, *E. rufilineatum*, *Percina sciera* and *Cottus carolinae*. Six species of fish: *Etheostoma blennioides*, *E. maculatum*, *E. rufilineatum*, *E. simoterum*, *Pr caprodes* and *C. carolinae* yielded juveniles of *Epioblasma interrupta* in infestation trials. Juveniles of *Epioblasma triquetra* transformed from *P. caprodes* and *C. carolinae*. Stenotopic requirements for perciform hosts inhabiting riffles may be contributary to the historical decline of the genus *Epioblasma*.

Rewrite badly needed

The freshwater mussel genus Epioblasma is comprised of seventeen species, all but one of which occurred historically in the Tennessee River system. The pattern of distribution for the genus indicates that all members are of Tennessee-Cumberland river origin, either belonging to the ancient Cumberlandian fauna (Ortman 1924, 1925) or being of descent from it (Johnson 1978). Species of Epioblasma are characteristic inhabitants of riffles in areas of swift current in medium and large rivers. The majority of species in Epioblasma are either presumed extinct (Johnson 1978) or are endangered from activities of man such as pollution and construction of impoundments, which impact or destroy these shoal habitats of larger rivers. All species of mussels extirpated from the Ohio River drainage (Stansberry 1970) are members of Epioblasma.

Of the surviving members of the genus, E. capsaeformis and E. interrupta are restricted in distribution to the Tennessee and Cumberland River systems. Both species are absent from the mainstream Tennessee River, rare in tributaries to the Cumberland River, and locally common or abundant in the tributaries of the Tennessee River. Occurring in the upper White, Missouri, Mississippi, Illinois, Tennessee, Cumberland, Ohio, Green and St. Lawrence river systems and Lakes Michigan and Erie, E. triquetra is the most widely distributed and abundant member of the genus.

Incidental to life history studies on the endangered dromedary mussel (Dromas dromas) and the Cumberland monkeyface (Quadrula intermedia) in the Powell River of Tennessee, gravid females of the three species, E. capsaeformis, E. interrupta and E. triquetra were collected by biologists of the Tennessee Valley Authority. Knowledge of the reproductive biology of species from the Cumberlandian mussel fauna (Zales and Neves 1982, Yeager and Neves 1985) and particularly Epioblasma is limited. Investigations of mussel-fish host relationships in unionid life cycles are imperative for any effective conservation efforts. The objectives of this report are to provide information on the period when gravid female Epioblasma contain mature glochidia; to identify suitable fish hosts for the glochidia; and to provide description of the early life history stages of the mussels.

METHODS

All specimens of Epioblasma were collected by snorklers between river miles 106.8 and 117.4 on the Powell River in the upper Tennessee River drainage. Gravid females were aged by the external growth ring method (Chamberlain 1931; Crowley, 1957). The mussels were opened slightly by hand or with modified O-ring expanders to check for gravidity. Gravid mussels were placed in small mesh cloth bags and transported in insulated coolers containing river water to a laboratory in Norris, Tennessee. Until utilized, mussels were held in Living Streams (Frigid Units Inc., Toledo OH) with flow-through spring water at a mean temperature of 17.8 C.

When possible, fish were collected from mussel-free sites to reduce incidences of prior infestations of glochidia. Prior to testing, fish were also maintained in Living Stream Units with flow-through spring water. Numbers of fish in each trial depended on species availability. Fish were fed frozen brine shrimp before and during infestation trials.

Mature glochidia were obtained by excision of the marsupial gills from gravid female mussels and rupturing the ovisacs with a probe. Glochidia were tested for maturity by exposing a subsample to salt crystals and observing for a strong closing response (Zale and Neves 1982).

Experimental fish were anesthesized with tricaine methanesulfonate (MS-222) and the gills and fins inspected for current infestations of contaminant glochidia. Fishes so infested were excluded from experimental infestation trials. Individual fish were infested by pipetting several hundred glochidia into the right branchial chamber. Each fish was exposed to glochidia only once. Mixed species assemblages of fish, infected with a species of mussel, were held in Living Stream units for ten days post-infestation. At five and ten days post-infestation fish were anesthesized and inspected for retention of glochidia. Fish not found to have retained glochidia were preserved in 10 percent formalin and re-examined. Fish retaining glochidia at ten days were sequestered by individual species in 38 L aquaria containing spring water filtered through a bag seive of five micron aperature.

Beginning 11 days post-infestion and every other day thereafter material from the bottoms of aquaria was siphoned through a 35 micron aperature, nylon mesh sieve. Sloughed glochidia and juvenile mussels were examined with a stereomicroscope. Juveniles were placed in gridded 9x9x1.5 cm square petri dishes for observation. Intermittantly specimens were preserved in five percent formalin buffered to pH 7.0 with ammonium hydroxide. The methods of Castanaga and Kraeuter (1981), as modified by Hudson and Isom (1984), were used to culture juveniles. Juvenile cohorts of mussels were placed in separate 2 L Nalgene trays containing about 1.5 L of feed consisting of a mixed culture of several species of single-celled algae and diatoms obtained from a nearby pond. The pondwater had been filtered through a five micron bag sieve. Feed supply was changed daily by filtering the media through a sieve of 35 micron aperature, returning any mussels poured off from the culture media and adding the filtered pondwater. Measurements of glochidia and juveniles were obtained under a stereomicroscope equipped with an ocular micrometer.

RESULTS

Adults of the three species of Epioblasma were usually found lying on the substrate surface or only partially buried. All three species were collected from the swifter currents of large riffles in firm, gravel-cobble substrate. Sites and numbers of females of each species collected appear in Table 1.

Gravid specimens of E. interrupta and E. triquetra were found from May 1 to June 5, in water temperatures ranging from 15.0 to 17.8 C. During this period 58 percent E. capsaeformis, 45 percent of E. interrupta and 31 percent of E. triquetra females were gravid. Gravid E. capsaeformis were collected only until May 18. Unlike the two other species, females of E. capsaeformis lay partially open, displaying a brilliant "electric blue" mantle that was often observable by collectors without the aid of a viewing box or snorklers mask.

Ages of the gravid females collected were as follows for each species: E. capsaeformis, 7 to 10 years; E. interrupta 8 to 13 years; and E. triquetra 5 to 10 years. For all three species only the outer demibranches served as marsupia. Water tubes containing mature glochidia were swollen, whitish and granular in appearance. Unfertilized eggs accounted for less than one percent of conglutinates.

Fully mature glochidia (Fig. 1 a-c) were nearly transparent and were subcircular with a truncated dorsal hinge line. A single adductor muscle was visible. Glochidia are apparently released individually as conglutinates disintegrate, since intact conglutinates could not be teased from water tubes. Only glochidia exhibiting a strong, immediate closing response when exposed to salt crystals were deemed satisfactory for infestation trials. Mean dimensions of 100 mature glochidia from two females of each species were: E. capsaeformis, length 0.25 mm (SE=.06), depth (dorsal to ventral) 0.23 mm (SE=.05), hinge length 0.17 mm (SE=.05); E. interrupta, length 0.24 (SE=.01), depth 0.23 (SE=.05), hinge length 0.17 (SE=.04); E. triquetra, length 0.22 mm (SE=.03), depth 0.22 mm (SE=.02), hinge length 0.16 mm (SE=.03).

Glochidia typically attached to the distal portion of gill lamellae on experimental fish. ~~An exception was that on specimens of~~ the banded sculpin, Cottus carolinae, most glochidia attached and encysted in the epithelial tissue lining the branchial cavity. Degrees of infestation were light to moderate depending on relative size or species of fish. Immediately after infestation as few as six to ten glochidia were observed on some species of percids or cyprinids and as many as several hundred on centrachids or larger percids.

Eighteen species of fish (Table 2) were exposed to glochidia of E. capsaeformis in laboratory trials. Thirteen species of fish sloughed all glochidia by ten days post-infestation. Of the remaining five species, Etheostoma maculatum, E. rufilineatum, Percina sciera and Cottus carolinae were identified as hosts for glochidia of E. capsaeformis. Periods for transformation (Table 2) varied from nineteen to thirty-four days. The Tennessee snubnose darter, Etheostoma simoterum retained glochidia for fourteen days but produced only unviable, partially transformed glochidia.

Twenty-six species of fish (Table 3) were exposed to glochidia of E. interrupta. By 10 days post-infestation, twenty species of fish sloughed all glochidia. Mussels transformed on six species of fish: Etheostoma blennioides, E. maculatum, E. rufilineatum, E. simoterum, Percina caprodes and Cottus carolinae. Transformation occurred in 16 to 45 days. Juveniles from the log perch, P. caprodes were initially more vigorous and exhibited a greater amount of foot activity and movement than juveniles transformed on other species of fish. Of the 25 fish (Table 4) exposed to glochidia of E. triquetra, six species retained glochidia for ten days. Only two suitable hosts, P. caprodes, the log perch, and Cottus carolinae, the banded sculpin, were identified. Juveniles, equally vigorous from both these fish species, transformed in 24 to 44 days.

In size and shape, newly metamorphosed juveniles (Fig. 2 a,b,d) of Epioblasma spp. were nearly identical to glochidia. However two adductor muscles, gill lamellae, functioning cilia, and other internal organs were apparent. Juveniles moved by extending the extremely adhesive foot, then drawing the body to the foot. By one to three days after dropping off host fish (Fig. 2c) juveniles showed evidence of shell growth. Twenty-seven day old juveniles of E. interrupta had the characteristic "hatchet" shaped foot of adult mussels. Culturing of E. capsaeformis and E. interrupta was ended at 30 days. When all culturing activities were terminated at 67 days (Fig. 2e), juveniles of E. triquetra were surviving in the food culture and continued to show growth.

DISCUSSION

Field investigations from the Powell River support the status of Epioblasma as a genus of long-term or bradytictic breeders (Ortman 1919). In our study all three species of Epioblasma were gravid with mature glochidia in May or June and were nongravid by mid-July. Seven females of *E. triquetra* reported from the Ohio River in September and October were gravid (Ortman 1912). In the Powell River, females of *E. capsaeformis* ceased displaying the "electric blue" mantle, a feature not shown by the other two species; buried deeper; and were nongravid sooner, indicating a cessation of spawning earlier than either *E. interrupta* or *E. triquetra*.

Laboratory-induced infestations ~~of~~ glochidia ~~with~~ the three species of *Epioblasma* indicated a relatively high degree of host specificity, restricted to ~~a narrow range of~~ perciform fishes. Within the family Percidae, encompassing hosts, three congeneric, sympatric species of *Percina* and two of *Etheostoma* produced no juveniles in infestation trials of *Epioblasma capsaeformis*. None of the six species of *Etheostoma* and a congeneric *Percina* ~~also of the family Percidae~~ yielded juveniles of *Epioblasma triquetra*. Transforming on six perciform species, *Epioblasma interrupta* was only slightly less fastidious in required host species than the other two mussel species. Two darters congeneric with demonstrated hosts of *E. interrupta* were unsuitable as hosts. Species of *Percina* (3) and *Etheostoma* (2) congeneric with demonstrated hosts of *E. capsaeformis* produced no juveniles in laboratory tests. Several percid species, e.g. *Etheostoma jessiae*, *E. caeruleum* and *E. simoterum* however did retain glochidia of *Epioblasma capsaeformis* and *triquetra* for longer periods than other nonhost fish. As suggested for other lampsiline mussels (Zale and Neves, 1982) retention of glochidia by these nonhost fish species ~~may~~ be related to biochemical or physiological similarities ~~within~~ taxa ~~containing hosts~~.

Explanations for the ranging fish host specificity required by mussel species are at present speculative. Whatever the etiology, the degree of host specificity may affect the chances of survival for mussel species in the face of largescale alterations of aquatic habitats by man. *Anodonta grandis*, a characteristic, successful member of the subfamily Anodontinae, has a broad tolerance (Parmalee 1967, Clark 1973, Mathiak 1979) of both lentic and lotic habitats and exhibits eurytopic use of fish hosts, exceeding 30 species in number (Fuller 1974, Trdn and Hoeh 1982). Neves et al (1985) recognized that mussels of the subfamily Ambleminae have a less generalist life history, i.e. glochidia exhibit a greater degree of host specificity and are more habitat specific in requirements. Fish hosts per mussel species in this subfamily are fewer in number and are more closely related phylogentically. Zale and Neves (1982) reported two species of *Villosa*, a genus of ambleminae, to parasitize only 3 of 24 fish species in their area of study. Narrow spectrum host requirements were also reported by these authors for *Medionidus conradicus* and *Lampsilis fasciola*. Similarly, stenotopic use of hosts was found for the three species of *Epioblasma*, herein reported.

A general decline of unionid mussel species in the last century has been well documented (Stansbery 1970, van der Schalie 1975). Many species of the subfamily Ambleminae, particularly those of the unique Cumberlandian fauna, including *Epioblasma*, have declined in abundance and distribution. Undoubtedly direct destruction and alteration of mussel habitats are major contributors (Stansbery 1970) to declines in commercially valuables, riffle dwelling populations of mussels.

However, success or decline of various taxa within the Unionidae has also been influenced by the varied reproductive strategies of mussels. Narrow spectrum host requirements by the mussel and use of only those fish hosts occupying riffles, both factors limiting diversity of occurrence and dispersal of juveniles make populations of *Epioblasma* even more vulnerable

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to disturbance. The close stenotopic relationship between the species of Epioblasma and their fish hosts was advantageous and successful in undisturbed environments as evidenced by historical records. But decline or loss of even a single host ~~fish~~ species may severely reduce or eliminate recruitment for some species of Epioblasma. As more riffle habitat has been altered by activities of man, the high degree of host specificity exhibited by the three Epioblasma, investigated may have served at least an ancillary role in the historical decline of the genus in general.

Awkward

Discussion needs major rewrite

It jumps all over, has questionable taxonomic terms, and doesn't make a strong case

ACKNOWLEDGEMENTS

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Table 1. Collections of ~~female~~ *Epioblasma* females from the Powell River in 1984 (Numbers gravid in parentheses).

Date	Site	Water Temperature °C	Number Females Collected (Number Gravid) *E. capsaeformis*	*E. interrupta*	*E. triquetra*
May 1-2	Bales Ford Island PRM 111.8	15	4(3)	6(4)	8(3)
May 17-18	Fletcher Ford PRM 117.5	16.1	7(4)	2(0)	3(1)
May 19	McDowell Ford PRM 106.5	16.1	1(0)	-	3(0)
June 5	Bales Ford Island PRM 111.8	17.8	-	3(1)	2(1)
July 19	Bales Ford Island PRM 111.8	23.3	1(0)	4(0)	4(0)
Total Number Inspected			13	15	20

Table 2. Results of laboratory infestations with glochidia of *Epioblasma capsaeformis*.

Fish Species	No. of Fish Infested	Glochidia Attached 5 Days	10 Days	Total Number Juveniles Produced	Period For Transformation (Days)	Mean Holding Temperature °C
Campostoma anomalum	2	–				
Hybopsis amblops	4	–				
H. dissimilis	2	–				
Notropis coccogenis	1	–				
N. galacturus	3	–				
N. rubellus	1	–				
N. spilopterus	1	–				
Pimephales notatus	2	–				
Hypentelium nigricans	2	–				
Etheostoma jessiae	3	–				
E. maculatum	1	x	x	10	19-31	16.2
E. rufilineatum	5	x	x	1	25	15.8
E. simoterum	1	x	x			
Percina caprodes	1	x	–			
P. copelandi	1	x	–			
P. evides	4	x	–			
P. sciera	1	x	x	4	25	15.8
Cottus carolinae	1	x	x	14	20-34	16.9

Table 3. Results of laboratory infestations with glochidia of *Epioblasma interrupta* (≠ *brevidens*).

Finally you cite this ?

Fish Species	No. of Fish Infested	Glochidia Attached 5 Days	10 Days	Total Number Juveniles Produced	Period For Transformation (Days)	Mean Holding Temperature °C
Campostoma anomalum	1	–				
Hybopsis amblops	1	–				
H. dissimilis	2	–				
Nocomis micropogon	1	–				
Notropis ariomus	3	–				
N. chrysocephalus	1	–				
N. coccogenis	3	–				
N. galacturus	2	–				
N. leuciodus	2	–				
N. rubellus	2	–				
N. spilopterus	2	–				
N. telescopus	1	–				
Phenacobius uranops	1	–				
Pimephales notatus	4	–				
Hypentelium nigricans	2	–				
Moxostoma erythrurum	1	–				
Lepomis auritus	2	–				
L. machrochirus	2	x	–			
Etheostoma blennioides	2	x	x	9	34–37	17.0
E. jessiae	3	x	–			
E. maculatum	2	x	x	2	17	15.4
E. rufilineatum	12	x	x	28	16–33	16.3
E. simoterum	10	x	x	3	25–34	16.9
Percina caprodes	1	x	x	104	28–45	16.7
P. evides	3	–				
Cottus carolinae	13	x	x	123	20–48	17.2

Table 4. Results of laboratory infestations with glochidia of *Epioblasma triquetra* .

Fish Species	No. of Fish Infested	Glochidia Attached 5 Days	Glochidia Attached 10 Days	Total Number Juveniles Produced	Period of Transformation (Days)	Mean Holding Temperature °C
Campostoma anomalum	4	–				
Hybopsis amblops	1	–				
H. dissimilis	2	–				
Nocomis micropogon	1	–				
Notropis ariomus	1	–				
N. coccogenis	2	–				
N. chrysocephalus	1	–				
N. galacturus	1	–				
N. leuciodus	2	–				
N. rubellus	2	–				
N. spilopterus	2	–				
N. telescopus	1	–				
Pimephales notatus	2	–				
Hypentelium nigricans	3	–				
Lepomis auritus	2	x	–			
L. machrochirus	3	x	–			
Etheostoma blennioides	2	x	x			
E. caeruleum	2	x	x			
E. jessiae	1	–				
E. maculatum	1	x	–			
E. rufilineatum	9	x	x			
E. simoterum	15	x	x			
Percina caprodes	3	x	x	804	24-33	17.1
P. copelandi	3	x	–			
Cottus carolinae	4	x	x	26	25-44	17.2

LIST OF FIGURES