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A DIET FOR REARING JUVENILE FRESHWATER MUSSELS

Nearly 60 species of freshwater mussels (Unionidae) are listed as endangered in the United States, and many other species are declining because of habitat degradation and the invading zebra mussel (*Dreissena polymorpha*). We studied ways to develop a diet for rearing juvenile mussels, with the goal of long-term propagation of rare species. The published literature on mariculture of bivalves listed algae as the principal food, and polyunsaturated fatty acids (PUFA) as essential to larval and juvenile life stages. Similarly, Hudson and Isom reported that growth was enhanced and that survival increased for juvenile freshwater mussels with the addition of silt to aquaria. Our objectives were to determine the role of fine sediment in culturing juvenile mussels and develop a suitable diet for rearing juvenile mussels.

METHODS

The influence of river sediment and different foods on recently metamorphosed rainbow mussels (*Villosa iris*) and giant floaters (*Pyganodon grandis*) was investigated by culturing juvenile mussels on various combinations of algae, a live-cultured bacterium, a commercial suspension of several species of bacteria (Aqua-Bacta Aid, ABA), yeast, kaolin, and sediment, including autoclave-sterilized sediment. Two trials focused on determining the value of a substratum to juvenile mussels; a third trial tested various food sources to establish a suitable diet for rearing juvenile mussels (Table).

FEEDING TRIALS ONE AND TWO

After 45 days postmetamorphosis in fine sediment, juvenile *V. iris* fed algae exhibited a twofold increase in shell length (532 µm), and 63.5% mean survival. Juvenile *P. grandis* exhibited similar growth after 45 days postmetamorphosis with greater than a 2.2-fold increase in average shell length (806 µm) and 52.0% survival. In comparison, all juvenile mussels fed algae without sediment and algae plus bacteria (ABA), without sediment, exhibited no increase in shell length after 45 days postmetamorphosis.

Shell lengths of *P. grandis* juveniles fed algae in the kaolin substratum, in sterilized sediment, in sterilized sediment plus ABA, and in bacteria-colonized sediment were not significantly different. Shell lengths of *V. iris* juveniles fed algae with kaolin, or fed algae with colonized sediment also were similar after 60 days. Ingestion of bacteria was seemingly inconsequential to juvenile digestion and nutrition during this period. Juvenile mussels were observed to pedal-feed for about 120 ± 30 days; hence, sediment served as a physical substratum for pedal-feeding juveniles to collect food particles. Survival varied among mussels fed only algae without sediment. After 45 days, *V. iris* had 5.0% survival, whereas *P. grandis* exhibited 43.3% survival. Analysis of covariance indicated that growth rates of *P. grandis* and *V. iris* after 120 days were significantly different, with

P. grandis exhibiting a growth rate about twice that of *V. iris*.

After 272 days postmetamorphosis, *V. iris* fed *Chlorella*, *Ankistrodesmus*, and *Chlamydomonas* (CAC) with sediment achieved a mean shell length of 2,968 ± 405 µm (11-fold increase in length) and about 5% survival. After 195 days postmetamorphosis, *P. grandis* achieved a mean shell length of 4,877 ± 1,099 µm (13-fold increase in length) and about 12% survival. At 9 months postmetamorphosis, juvenile *P. grandis* were seen positioned with anterior end in the sediment and posterior end visible at the sediment–water interface with apertures visible.

Feeding Trial Three

Subsequent diet tests indicated that greater growth was correlated with algae high in oils containing PUFA. After 60 days, shell lengths of juveniles were similar among treatments, indicating that fine sediment provides some nutritional value. However, analysis of covariance indicated that *V. iris* juveniles in sediment, fed a tri-algal diet consisting of *Neochloris oleoabundans*, *Phaeodactylum tricornutum*, and *Bracteacoccus grandis* (NPB), showed the best growth over time (Figure). Shell lengths of juveniles fed NPB were significantly greater than those of juveniles fed other tested diets($P < 0.02$). Individuals fed NPB achieved a mean shell length of 1,747 ± 301 µm, and had 30.0% survival after 140 days postmetamorphosis. The oil-rich NPE and NNiC enhanced growth over the commonly used oil-poor green tri-algal mix of CAC, whereas commercial yeast diets did not support growth.

Conclusions

Results of this study indicated that juvenile freshwater mussels pedal-feed for about 4 months postmetamorphosis. A fine substratum associated with organic and inorganic materials is required presumably for pedal-feeding juveniles to collect food particles. Juveniles may begin filter-feeding in conjunction with pedal-feeding before 140 days postmetamorphosis as gill development occurs. By 9 months postmetamorphosis, they are filter-feeders. A substratum may also provide grit or a grinding surface for the crystalline style, thus enhancing digestion of algae. Algae are a suitable food source for rearing juvenile mussels, especially species high in polyunsaturated fatty acids. A tri-algal mixture of *Neochloris oleoabundans*, *Bracteacoccus grandis*, and *Phaeodactylum tricornutum* enhanced growth better than all other diets tested. Bacteria did not seem to contribute appreciably to juvenile growth and survival. Diet studies should be conducted for at least 60 days—and preferably 100 days—as juvenile mussels probably have fatty acid reserves that allow them to survive without food for several weeks postmetamorphosis.

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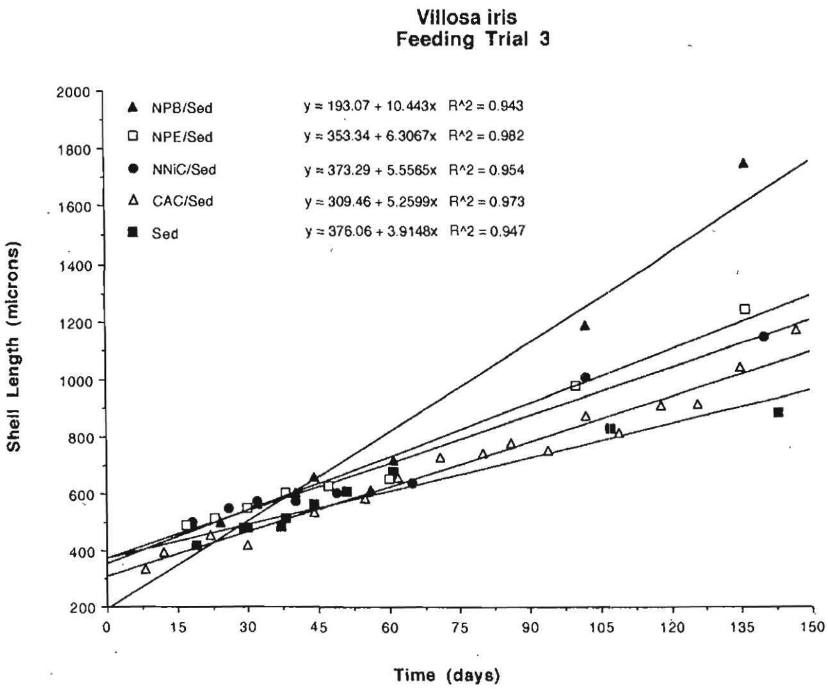

Figure. Comparison of growth equations of *Villosa iris* fed various diets for 140 days postmetamorphosis.

Table. Summary of experimental treatments to determine a suitable diet for rearing juvenile freshwater mussels. CAC = *Chlorella vulgaris, Ankistrodesmus falcatus,* and *Chlamydomonas reinhardtii.* NOC = *Neochloris oleoabundans, Oocystis marsonii,* and *Cyclotella menenghiana.* NNiC = *Neochloris oleoabundans, Nitszchia acicularis,* and *Cyclotella menenghiana.* NPB = *Neochloris oleoabundans, Phaeodactylum tricornutum,* and *Bracteacoccus grandis.* NPE = *Neochloris oleoabundans, Phaeodactylum tricornutum,* and *Enterobacter aerogenes.* Sed = fine sediment. StSed = autoclave-sterilized fine sediment.

Trial	Mussel	Host fish	Treatment (replicates)	Number of juveniles
1	*Villosa iris* (rainbow mussel)	*Ambloplites rupestris* (rock bass)	CAC (3)	200, 206, 205
		Micropterus salmoides (largemouth bass)	CAC/ABA (3)	200, 200, 200
			CAC/Sed (3)	200, 200, 215
2	*Pyganodon grandis* (giant floater)	*Ambloplites rupestris* (rock bass)	CAC only (3)	150, 153, 200
		Lepomis macrochirus (bluegill)	CAC/Kaolin(3)	100, 100, 100
		Micropterus salmoides (largemouth bass)	CAC/Sed (3)	201, 256, 258
		Carassuis auratus (goldfish)	CAC/StSed(3)	204, 205, 205
			CAC/StSed/ABA (3)	200, 206, 202
3	*Villosa iris* (rainbow mussel)	*Amploplites rupestris* (rock bass)	Unfed (1)	45
		Micropterus salmoides (largemouth bass)	Kaolin only (3)	50, 50, 50
			Sed only (2)	71, 70
			Yeast/Sed (3)	100, 100, 100
			CAC/Kaolin(2)	92, 100
			NOC/Sed (3)	100, 100, 100
			NNiC/Sed (3)	111, 100, 103
			NPB/Sed (3)	100, 101, 108
			NPE/Sed (3)	100, 103, 100