The Influence of Physical Factors on the Distribution and Abundance of Freshwater Mussels (Bivalvia: Unionidae) in the Lower Tennessee River

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ABSTRACT

Sixteen quantitative samples of mussels were taken by SCUBA divers at each of two inshore and two offshore sites from a mussel bed in the lower Tennessee River in July, 1987. Sedimentation (measured with *in situ* sediment traps), sediment type, and current velocity were measured at all sites. *Fusconaia ebena* (Lea, 1831) was the dominant mussel at both the inshore and offshore sites representing 72 and 53% of the community, respectively. Total mussel density, species diversity, and evenness were all greater at the inshore sites. Sedimentation rates were significantly greater and current velocities were approximately half as great (11 and 19 cm/sec, respectively) at the inshore *versus* the offshore sites. We hypothesize that physical factors are the dominant influence structuring this mussel community in the lower Tennessee River.

Key words: Mussels; Unionidae; sedimentation; lower Tennessee River.

INTRODUCTION

Freshwater mussels (Family Unionidae), being filter-feeders and essentially non-motile, have long been considered intolerant of poor water quality and sedimentation (Hynes, 1960, 1970; Pennak, 1978). Laboratory experiments conducted by Ellis (1933), in which he buried mussels in various types of substrates, provided early evidence on the negative effects of sediment deposition. In addition, Stansbery (1970) considered that sediment from agricultural practices, reservoir construction, maintenance dredging, and pollution eliminated many species of mussels. However, the distribution and abundance of many species of mussels is at least partly dependent upon low water velocities and low to moderate levels of sedimentation for the successful settlement of glochidia.

The objective of this study was to relate community composition and density of the dominant species (*Fusconaia ebena*) at a large mussel bed in the lower Tennessee River to water velocity, sedimentation, and substrate type.

STUDY AREA

Sampling sites were located on the left bank of the Tennessee River (RM 18.6), approximately 6 km below the Kentucky Lock and Dam. Sites 1 and 3 were 61 m apart and 31 m from shore (inshore sites); sites 2 and 4 were 61 m apart and 61 m from the shore (offshore sites). Sites 1 and 2 were located 200 m upstream of sites 3 and 4. Mussels have been collected from this bed, which appears to extend throughout most of the river between RM 18.6 and 11.0 (Sickle, 1985), since 1931 (van der Schalie, 1939). Current velocity at the sediment-water interface was 11.4 cm/sec ($s = 1.1$; $N = 8$) and 19.2 cm/sec ($s = 1.4$; $N = 8$), and water depth was 3–4 m and 5–6 m at the inshore and offshore sites, respectively.

MATERIALS AND METHODS

Sampling was conducted on July 22–23, 1987. Using SCUBA, a diver randomly placed and secured a 16-cell PVC grid (each cell 1 × 1 m) to the substrate at each sampling site. A 0.25 m^2 quadrat was placed in the lower left corner of a cell and all substrate was removed by the diver to a depth of 15 cm. Substrate was returned to the surface in a 20 liter bucket, sieved through a nested screen series (smallest mesh size = 6.4 mm), and all live mussels were removed and identified to species. Sixteen samples were taken from each of the four sites.

Sedimentation rates were measured by anchoring six PVC sediment traps (length : width = 25.4:2.5 cm; two collection pipes/trap) to steel cables. Sediment traps were placed at 3 m intervals along a 21 m transect at each of the four sites. Sediment traps were placed in the river by divers on July 10, 1986 and retrieved on July 23, 1986. In the laboratory, the trapped material was allowed to

Table 1. A summary of the biological and physical data from the lower Tennessee River, 1986. Means in a given row with the same letter (a, b, c) are not significantly different ($p < 0.05$). Densities are expressed as clams m^{-2}.

	Collection site			
	Inshore upstream	Inshore downstream	Offshore upstream	Offshore downstream
Total number of mussels	751	604	319	295
Total number of species	17	15	18	17
Total mussel density	187.7 a	151.0 a	79.7 b	73.7 b
(SD)	(16.3)	(27.4)	(12.6)	(5.6)
Total density of *Fusconaia*	133.3 a	111.0 a	41.0 b	40.0 b
(SD)	(14.5)	(21.1)	(6.9)	(3.9)
Density of *Fusconaia* adults	74.0 a	68.0 a	22.2 b	25.2 b
(SD)	(10.4)	(12.3)	(3.7)	(1.9)
Density of *Fusconaia* juveniles	59.2 a	43.0 b	18.7 c	19.0 c
(SD)	(7.1)	(9.5)	(4.4)	(2.5)
Species diversity (H′)	1.112 a	1.040 a	1.591 b	1.598 b
Evenness (J)	0.392	0.384	0.550	0.564
Sediment deposition (g cm^{-2} day^{-1})	0.055 a	0.060 a	0.031 b	0.033 b
(SD)	(0.003)	(0.003)	(0.002)	(0.002)
Current velocity (cm/sec)	11		19	
[1]% Sand/% gravel at 0–5 cm depth	60/32		35/61	
[1]% Sand/% gravel at 5–10 cm depth	35/20		57/37	

[1] Remaining percentage of substrate was made up of silt.

settle for 24 hr, decanted, and the remaining sediment dried for 24 hr at 100 °C and weighed.

Sediment composition was also determined at each of the four sampling sites. Eight 10 × 15 cm cores (Miller and Bingham, 1987) were randomly taken by divers at each site. Cores were brought to the surface and divided into three depth fractions (0–5, 5–10, and 10–15 cm) and subsequently analyzed for particle size distribution.

RESULTS

Total mussel density was significantly greater at the inshore sites, although there was no substantial difference in total number of species between the inshore and offshore sites (table 1). No significant differences in any of the remaining measured parameters were observed between upstream and downstream sites. *Fusconaia ebena* was the dominant mussel at both the inshore and offshore sites representing 72 and 53% of the community, respectively. Total mussel density was two times greater at inshore compared to offshore sites. This was due mainly to *F. ebena*, which was about three times as dense at inshore *versus* offshore sites. The difference in densities of *F. ebena* was significant for both large (≥ 30 mm shell length) and small (< 30 mm shell length) clams (table 1). Species diversity (Shannon-Weaver index, H′; Poole, 1974) and evenness (J; Poole, 1974) was greater at the offshore sites. The greater species diversity and evenness at the offshore sites was the result of a decrease in the densities of *F. ebena* relative to the other species in the community.

Sedimentation and substrate composition differed between the inshore and offshore sites. Sediment deposition over the 2 week period was significantly greater at the inshore sites than at the offshore sites. Particle size analysis of inshore sediments indicated the substrate consisted mainly of medium sand, whereas offshore sediments contained higher percentages of gravel (table 1). Current velocities at the offshore sites were approximately twice those at the inshore sites (table 1).

DISCUSSION

Salmon and Green (1983) reported that there was an increase in the frequency of occurrence of unionids associated with slow moving, shallow water with relatively coarse substrate. Strayer (1983) reported that stream size and surface geology determined the distribution of unionids in streams in southeastern Michigan. Although some unionids appear to be substrate specific, many are tolerant of a wide range of substrate types (Murray & Leonard, 1962; Parmalee, 1967; Strayer, 1981). Green (1971, 1972) found that the distribution of *Anodonta grandis* Say, 1829 and *Lampsilis radiata* (Gmelin, 1791) in 32 lakes was due more to water chemistry and to different geological conditions than to sediment characteristics. Previous workers have indicated that sedimentation negatively affects freshwater mussels (Ellis, 1933; Stansbery, 1970); however, their conclusions apply to abnormally high levels of sedimentation (sufficient to bury mussels) that often result from impoundment, channel modification, or disposal of dredged materials.

The various parameters that affect the distribution and abundance of unionids (suitable fish hosts, current velocity, substrate type, stream geomorphology, water chemistry, etc.) probably have varying levels of importance depending on the specific site studied. These factors are responsible for the lack of statistical correlations between microhabitat use and unionid abundance (Strayer, 1981), but favor statistical correlations between unionid abundance and geological conditions, water chemistry, and substrate type. Our data show that within a mussel bed in the lower Tennessee River, higher densities of mussels (especially the dominant species, *F. ebena*) may be associated with differences in sedimentation rate and water velocity. These physical effects act upon all species in the assemblage, but the resulting changes in community structure are due to a shift in the relative abundance of the dominant species, *F. ebena*. We hypothesize that physical factors are of paramount importance in structuring this mussel community in the lower Tennessee River.

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