TRANSACTIONS OF THE KANSAS ACADEMY OF SCIENCE
105(3–4), 2002, pp. 232–240

Effects of Lowhead Dams on Freshwater Mussels in the Neosho River, Kansas

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Freshwater mussels are declining rapidly in many parts of their range throughout North America, primarily as a result of anthropogenic alterations of their habitat, including damming of rivers. To assess the effects of lowhead dams on freshwater mussel assemblages in the Neosho River, Kansas, we sampled mussels by groping along transects and searching haphazardly along a 100-m stretch at eight sites of four site types (i.e., upstream reference, upstream treatment, downstream treatment, and downstream reference) centered around two lowhead dams. We collected from four to 11 species of mussels at each site, and a total of 13 species. Analysis of variance indicated a significant difference in mean species richness and evenness, but not abundance, among site types, consistent with the hypothesis that lowhead dams affect freshwater mussel assemblage composition in the Neosho River.

INTRODUCTION

Freshwater mussels (Mollusca: Unionidae) are one of the most imperiled groups of organisms in North America (Williams and others, 1993). Of the approximately 300 taxa on the continent, nearly two-thirds are considered endangered, threatened, or in need of special conservation (Williams and Fuller, 1992; Parmalee and Hughes, 1993; Vaughn and Taylor, 1999). Anthropogenic habitat alteration is one of the leading causes of unionid mussel decline (Vaughn and Taylor, 1999).

Freshwater mussels in North America have been devastated by the impoundment of rivers (Obermeyer and others, 1997; Vaughn and Taylor, 1999). There are an estimated 2 million dams in the United States, including 75,000 high enough (more than 2 m in height) to be catalogued as dams by the United States Army Corps of Engineers (Maclin and Sicchio, 1999). Among states with the most dams, Kansas ranks second (behind Texas) with

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5,699 (Shuman, 1995). Dams alter the physical, chemical, and biological attributes of rivers by blocking the movement of fishes, converting lotic habitats to lentic habitats, altering the flow regime, and increasing siltation upstream from and scouring downstream from the dam (Baxter, 1977; Blalock and Sickel, 1996; Obermeyer and others, 1997). Mussel dispersal is inhibited by habitat fragmentation caused by dams, which can alter fish assemblages by preventing longitudinal migration of host fishes and associated glochidia (Baxter, 1977; Watters, 1996).

Many studies have documented the effects of large dams on freshwater ecosystems (e.g., Baxter, 1977; Chessman, Robinson, and Hortle, 1987; Vaughn and Taylor, 1999), but few studies have addressed the effects of lowhead (low-water) dams (0.4 to 3 m in height). Most of these studies assessed fish assemblages and habitat, and suggest results similar to, but smaller in magnitude than, those reported for larger dams (Kanehl, Lyons, and Nelson, 1997; Helfrich and others, 1999; Porto, McLaughlin, and Noakes, 1999). Only Watters (1996) has addressed the effects of lowhead dams on freshwater mussel assemblages. He concluded that lowhead dams act as physical obstacles that might affect mussels by restricting the dispersal and distribution of their hosts.

Historically, the Neosho River in Kansas was inhabited by at least 35 species of freshwater mussels, of which three are considered extirpated, four are endangered, three are threatened, and 10 are listed as species in need of conservation (SINC) by the State of Kansas (Obermeyer, Edds, and Prophet, 1995). During the past century, the Neosho River has undergone many anthropogenic changes, including construction of two federal reservoirs and 16 lowhead dams (Eberle and Stark, 1995; Obermeyer and others, 1997).

The objective of this study was to investigate whether lowhead dams affect freshwater mussel assemblages in the Neosho River. We predicted that freshwater mussel abundance, species richness, and evenness (equitability) would be lower immediately upstream and downstream from lowhead dams compared to relatively unaffected reference sites. To test this hypothesis, we conducted timed searches for mussels at eight sites around two lowhead dams in the Neosho River between Americus and Emporia in Lyon County, Kansas.

METHODS

To test for effects of two lowhead dams (Correll Dam and Emporia City Dam) on freshwater mussel assemblages, we sampled eight sites in the Neosho River, Lyon County, Kansas, during August and September 2001 (Fig. 1). We sampled four site types, consisting of two sites upstream from and two sites downstream from each dam (i.e., upstream reference, upstream treatment, downstream treatment, and downstream reference). Upstream reference and downstream reference sites were assumed to be affected mini-

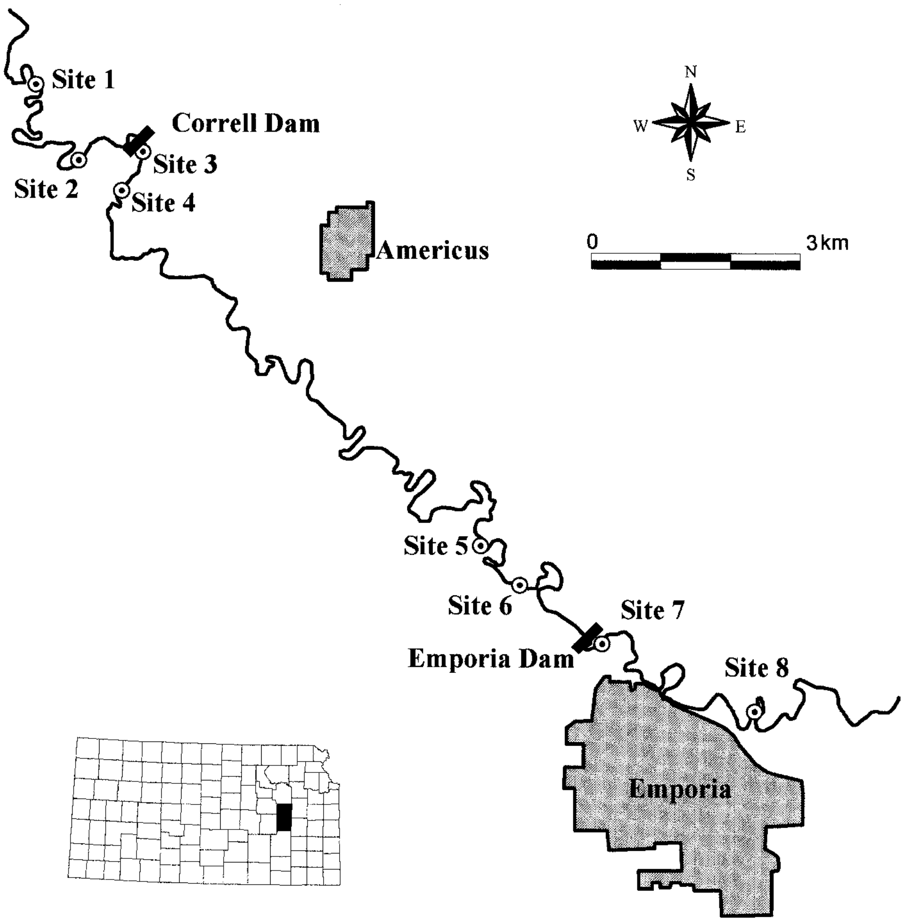

Figure 1. Study area along Neosho River in Lyon County, Kansas.

mally by the dams. They were free-flowing and had gravel and pebble substrates. Upstream treatment sites were inundated; they had no obvious flow and had silt substrates. Downstream treatment sites had variable flow regimes, and substrate comprised mainly of cobble, boulder, and bedrock.

Sites were 100 m long, ranged in width from 13.8 m to 35.4 m (Table 1), and were centered along a gravel bar. Global positioning system coordinates were obtained at each site with a Garmin GPS 12 XL (Garmin International, Romsey, Hampshire) (Table 1). At each site, we sampled six transects, spaced 20 m apart, by groping the substrate from bank to bank for 68 to 202 minutes. Upon completion of transects, we sampled the site in a haphazard manner by groping the substrate for 4 to 75 minutes. Vari-

Table 1. GPS coordinates for site locations along the Neosho River, Lyon County, Kansas, with mean width of transects and minutes sampled (total of timed search, including transect and haphazard timed searches).

Site	North latitude–West longitude	Mean width ± SD (m)	Minutes sampled
1	38° 32′ 06.7″–96° 19′ 40.3″	13.8 ± 7.7	154
2	38° 31′ 19.0″–96° 19′ 05.3″	14.5 ± 7.4	72
3	38° 31′ 25.8″–96° 18′ 16.7″	23.2 ± 2.5	180
4	38° 30′ 58.7″–96° 18′ 36.1″	14.3 ± 4.5	247
5	38° 27′ 15.3″–96° 13′ 55.4″	15.5 ± 3.7	149
6	38° 27′ 02.2″–96° 13′ 44.9″	35.4 ± 2.9	93
7	38° 26′ 11.7″–96° 12′ 28.8″	25.7 ± 4.1	108
8	38° 25′ 35.5″–96° 10′ 19.1″	18.6 ± 4.3	173

ation in sampling effort was because of variability in site width and depth and ease of groping for mussels in silt versus rock substrate. For both transect and haphazard searches, we used a hookah rig (Pioneer 275, Brownie's Third Lung, Ft. Lauderdale, Florida) to sample depths greater than 1 m. We kept mussels in mesh bags until the end of the search and then identified, counted, and returned the mussels to the river.

We analyzed data at the level of site type (two replicates per four site types) by combining transect and haphazard search data; we standardized abundance for all searches by minutes sampled (Table 1). We calculated one-way analyses of variance by site type to test for effects of lowhead dams on mussel abundance, species richness (number of species), and evenness (Shannon diversity divided by maximum possible diversity) (Pielou, 1966). Tukey's studentized range test was used for pairwise comparisons among site types. *A priori*, we set our α level at 0.10, because of our small number of replicates per site type, to reduce Type II error (Dayton, 1998). We conducted all statistical tests with the Statistical Analysis System, Version 8.1 (SAS Institute, Inc., Cary, North Carolina).

Results

We collected 13 mussel species at the eight sites (Table 2). Abundance ranged from 0.03 mussels per minute at Site 3 and Site 7 (both downstream treatment sites) to 0.54 mussels per minute at Site 5 (an upstream reference site) (Table 3). Species richness ranged from two at Site 7 to nine at Site 5 (Table 3). Evenness ranged from 0.72 at Sites 2 and 6 to 0.97 at Site 3 (Table 3).

Analysis of variance revealed a significant difference in species richness ($F_{3,4} = 5.86$, $P = 0.06$) and evenness ($F_{3,4} = 38.47$, $P = 0.002$) among site types, whereas mussel abundance ($F_{3,4} = 1.42$, $P = 0.36$) did not differ

Table 2. Freshwater mussel species abundance per site type during lowhead dam study in the Neosho River, Lyon County, Kansas, August and September 2001.

Species	Upstream reference	Upstream treatment	Downstream treatment	Downstream reference
Amblema plicata	24	1		2
Fusconaia flava	2			
Lampsilis cardium	5			1
Lampsilis teres			1	
Lasmigona complanata	5	18		4
Leptodea fragilis	1		2	4
Obliquaria reflexa	4			1
Potamilus purpuratus	9	1	3	2
Quadrula pustulosa	10		1	7
Quadrula quadrula	28	7	1	8
Strophitus undulatus				1
Tritogonia verrucosa	7		1	7
Truncilla donaciformis	1			2

significantly among site types (Fig. 2). Tukey's test for species richness revealed that upstream treatment and upstream reference sites were significantly different from one another. Species richness ranged from a total of 11 at upstream reference sites and four at upstream treatment sites to six at downstream treatment sites and 11 at downstream reference sites (Table 2). Evenness at the upstream treatment sites was significantly lower than at all other site types, and evenness at upstream reference sites was significantly lower than at downstream treatment sites (Fig. 2).

Table 3. Freshwater mussel abundance, species richness, and evenness at eight study sites (UR= upstream reference, UT= upstream treatment, DT= downstream treatment, and DR= downstream reference) during lowhead dam study in the Neosho River, Lyon County, Kansas, August and September 2001.

Site (site type)	Number per minute	Species richness	Evenness
1 (UR)	0.10	7	0.86
5 (UR)	0.54	9	0.88
2 (UT)	0.28	3	0.72
6 (UT)	0.08	3	0.72
3 (DT)	0.03	5	0.97
7 (DT)	0.03	2	0.92
4 (DR)	0.10	6	0.90
8 (DR)	0.08	8	0.94

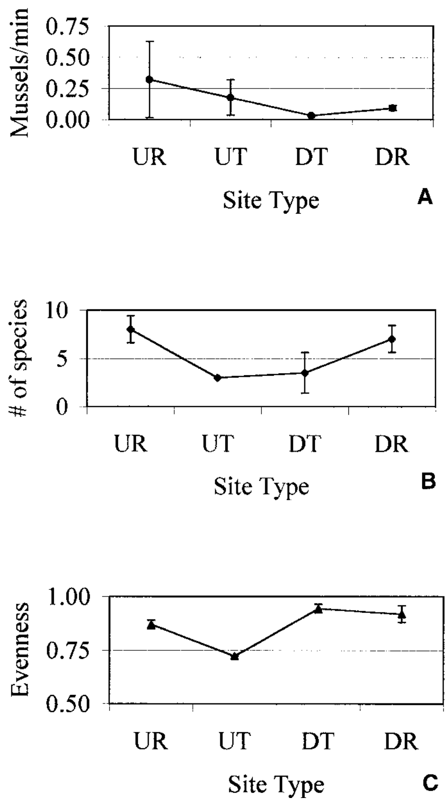

Figure 2. Mean freshwater mussel A, abundance; B, species richness; and C, evenness, with standard deviation, by site type (UR = upstream reference; UT = upstream treatment; DT = downstream treatment; DR = downstream reference) in the Neosho River, Lyon County, Kansas, August and September 2001.

Discussion

Upstream treatment sites (inundated areas) had significantly fewer species than upstream reference sites. This is likely because of the ponded conditions created by the dams, with deeper water, lower current velocity, and silty substrates observed at these sites (Site 2 and Site 6). These sites had only four species: *Amblema plicata, Lasmigona complanata, Potamilus purpuratus,* and *Quadrula quadrula.* All of these usually occur in lentic habitats (Bates, 1962; Murray and Leonard, 1962; Cummings and Mayer, 1992).

Mean abundance was not significantly lower at treatment sites, despite a decrease in *Fusconaia flava, Strophitus undulatus,* and *Truncilla donaciformis,* known from the literature as sensitive species (Murray and Leonard, 1962; Cummings and Mayer, 1992). This was the result of an increase in abundance of *L. complanata* (Table 2), known to be silt tolerant (Murray and Leonard, 1962; Cummings and Mayer, 1992). These three sensitive species, listed as SINC by the State of Kansas (Obermeyer, Edds, and Prophet, 1995), were present only at reference sites (Table 2). Evenness was significantly lower at the upstream treatment sites than at all other site types. The increase in the number of silt tolerant species, such as *L. complanata*, coupled with the reduction in sensitive species resulted in significant evenness differences. That upstream reference sites had significantly lower evenness values than downstream treatment sites could be a result of these lowhead dams acting as barriers to upstream movements of fish hosts (Watters, 1996). Abundance, richness, and evenness all showed a trend of lower values at treatment sites relative to their respective reference sites (Fig. 2). All three parameters might have been significant statistically had the power of these tests not been reduced by our small sample size and for the fact that evenness was so high at Site 3, where we collected six individuals of five species.

The effects of large dams on freshwater mussels (i.e., habitat degradation and decreased species richness) have been well established (Bates, 1962; Blalock and Sickel, 1996; Vaughn and Taylor, 1999). However, the effects of lowhead dams on mussels are poorly known (Watters, 1996). Our results suggest that lowhead dams and large dams have similar effects on mussels. Despite the relatively small number of sample sites in this preliminary study, these data indicate a negative impact of lowhead dams on these freshwater mussel assemblages, and that additional investigation is warranted. Given the large number of lowhead dams in the Neosho River, their effects on freshwater mussels could be widespread.

Acknowledgments

This research was part of a larger project investigating possible impacts of these lowhead dams on fishes and benthic invertebrates, and was supported by the U.S. Geological Survey, Department of Interior, under USGS Cooperative Agreement No. 00CRAG0025. Additional support was provided by an ESU Faculty Research and Creativity grant and by the ESU Department of Biological Sciences. We thank the landowners (G. Gulde, W. and M. Leffler, P. and D. Matile, L. Schlesener, the Girl Scout Flint Hills Council, the City of Emporia, and ESU Natural Areas) for allowing access to the river on their property. We also thank M. Wildhaber of the Columbia Environmental Research Center, USGS, for assistance in locating sites. L. Westerman of ESU helped create the map of the study area, L. Lehnhoff assisted in the field, and B. Loveless of Western Resources loaned us the hookah rig.

This paper is part of a Stream Ecology class project at ESU, and is dedicated to the life and work of Frank B. Cross. Dr. Cross' classes at KU were involved in many such projects, and his years of instruction, both formal

and informal, serve as an outstanding model for teaching and research on Kansas' aquatic resources. He was a true naturalist, and on field trips he would point out all types of organisms and their preferred habitats, including mussels, insects, herps, and plants, as well as fishes. Dr. Cross' commitment to teaching and research demonstrated his love for students and his concerns about the impacts of anthropogenic activities on our rivers and streams and their faunas, including mussels (and their hosts).

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