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Robert A. Krebs
Cleveland State University, r.krebs@csuohio.edu

Heather M. Griffith
Cleveland State University

Michael J. S. Tevesz
Cleveland State University

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A STUDY OF THE UNIONIDAE OF TINKERS CREEK, OHIO

ROBERT A. KREBS, HEATHER M. GRIFFITH, AND MICHAEL J. S. TEVESZ
Department of Biological, Geological, and Environmental Sciences
Cleveland State University, Cleveland Ohio 44115-2406
r.krebs@csuohio.edu

ABSTRACT

We present data on freshwater mussel (Mollusca: Bivalvia: Unionidae) distributions for Tinkers Creek, a small Ohio stream that previously had not been surveyed for its unionid fauna. The distribution of these mussels was mapped against the changing habitat of the stream, with special attention paid to two zones of human manipulation, a wastewater treatment plant and a stretch of the river where the bed was relocated to enable development. At least five unionid species live in Tinkers Creek. These are *Pyganodon grandis*, *Lampsilis radiata luteola*, *Fusconaia flava*, *Lasmigona costata*, and *Lasmigona compressa*. Fresh shells suggested the presence of three others: *Strophitus undulatus*, *Toxolasma parvus*, and *Alasmidonta marginata*. The region of Tinkers Creek where the mussels are most common extends through Twinsburg, Ohio, and upstream to a waterfall just below the confluence with Pond Brook. Relocation of the river channel eliminated mussels from a 0.5 km stretch in eastern Twinsburg. Furthermore, the impact of effluent from a wastewater treatment plant was minor, at most. Mussel diversity diminished from five to three species commonly found below this facility. A change in river habitat to faster flow, however, provided an alternate explanation for this faunal change. The most striking difference was the replacement of *Lasmigona costata*, a species usually found in medium and large rivers, by *L. compressa*, a species common in small streams and headwaters.

Introduction

Freshwater mussels (Mollusca: Bivalvia), particularly the family Unionidae, are in steady decline in diversity worldwide, but they remain an important component of freshwater ecosystems. Freshwater mussels live infaunally to semi-faunally in bottom sediments and sustain themselves by suspension feeding. Their methods of feeding and burrowing serve not only to remove seston from the water column and to transfer it to the sediment-water interface, but also to mix and to irrigate bottom sediments significantly. These activities have a major impact on nutrient cycling in the environment (McCall et al., 1986).

Because freshwater mussels routinely take in water while feeding and are sensitive to pollutants during different stages of their complex life cycle, unionids are good indicators of water quality (Ortman, 1909, p. 94). Common contaminants that affect mussels include heavy metals, pesticides and herbicides, nitrogen, phosphorus, and trace metals (Havlik and Marking, 1987). Eastern North America has been home to the richest freshwater mussel fauna in the world (Cummings and Mayer, 1992, p. 1), but like the abundance of many aquatic organisms, unionid numbers have declined due to habitat alteration, pollution, isolation and impoundments, sedimentation, and competition from nonnative species (National Native Mussel Conservation Committee, 1998).

As a consequence of environmental degradation, mussels receive statewide protection in Ohio. This protection, however, is not fully effective unless faunal studies are kept up-to-date. In addition, no data exist for many streams. A diverse mussel population in a lake or stream may be an indication of good water quality; contrastingly, the absence or decline of mussels above or below regions where diverse populations exist may be an indicator of habitat degradation. As a result, a mussel survey may be a very cost-effective way to initially identify a potential pollution problem, or to clear a suspected source from suspicion of environmental impact.

We investigated species composition of freshwater mussels in Tinkers Creek, a fifth order stream located in northeast Ohio (Figure 1). Tinkers Creek became an area of interest for several reasons. First, no comprehensive data set has yet been assembled on the number and species of mussels inhabiting this important tributary of the Cuyahoga River. For example, a previous study (Smith, 2000; Smith et al., 2002) found no mussels in the lower region of Tinkers Creek within the Cuyahoga Valley National Park. Second, a number of wastewater treatment plants (WWTP) occur along the stream, and one outflow occurs in the middle of the city of Twinsburg, Ohio, an area largely passed over in a recent EPA analysis (Ohio EPA, 1994). Nevertheless, the section of the stream in and near Twinsburg remains one of the best maintained regions of the stream for recreational use. We compared species composition upstream and downstream of this recreational area. Lastly, a 500 m section of the streambed was relocated to facilitate development in eastern Twinsburg (Army Corp of Engineers permit 9451210), and we were interested to see if this change affected mussel diversity.

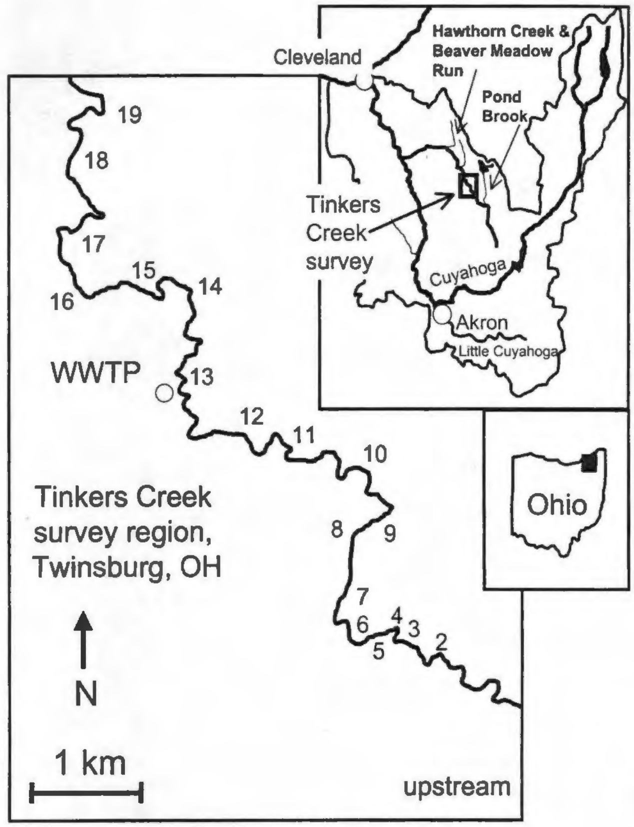

Figure 1. Map showing sampling sites 2–19 along 10 km of Tinkers Creek. This stream is the largest tributary of the Cuyahoga River (inset). The stretch of the Tinkers Creek shown flows through the city of Twinsburg, Ohio, which lies between the confluence of Tinkers Creek and Pond Brook upstream, and the confluence with Beaver Meadow Run downstream. Site 1 is located off the map to the east.

Materials and Methods

A field study was conducted from May through July of 2000. Field collection was performed visually (sites 15–17), as well as by brailling with feet or hands (all other sites) where either turbidity or depth prevented a visual search of the stream bottom. Search sites were concentrated near (but not restricted to) areas below riffles, where the water is most highly oxygenated, enhancing living conditions for mussels. We also assessed dissolved oxygen levels, pH, conductivity, water temperature and substratum composition.

The search method was determined at each site. In areas where water was above 1 m (high water), searching was restricted to feeling along the bottom with soft rubber shoes; at less than 1 m, we also felt along the bottom with our hands, while in very shallow water, mussels could be visually identified. Visibility was usually at best about 15 cm. The total survey time spent at each location surveyed by brailling averaged 35 minutes (range 30–40 minutes). When live specimens were found, they were arranged on the bank by species, identified preliminarily and counted, and photographs were taken to confirm identifications. Mussels then were gently placed back where they had been found. Empty shells were collected, numbered (37–131; 174–236; 244–349), and identified. These are presently stored in the Department of Biological, Geological, and Environmental Sciences at Cleveland State University.

Results and Discussion

A total of 138 living mussels of five different species were found in Tinkers Creek (Table 1). *Pyganodon grandis* (Say, 1817) comprised 65 percent of the living specimens found, *Fusconaia flava* (Rafinesque, 1820) 15 percent, *Lasmigona costata* (Rafinesque, 1820) 11 percent, *Lasmigona compressa* (Lea, 1829) eight percent, and *Lampsilis radiata luteola* (Lamark, 1819) one percent (a single female specimen, although shells of this species were common). The apparent rarity of live specimens of this latter species may perhaps be explained by its life position, which is approximately 2/3 buried (Tevesz et al., 1985, p. 31), while the other species often were

Table 1. The distribution and abundance of unionid mussels in Tinkers Creek based on collections of both shells and live mussels. The frequency of each species in the collections is indicated in parentheses to the right of the total number of individuals.

Species in Tinkers Creek	Above outflow Live mussels	Above outflow Shells	Below outflow Live mussels	Below outflow Shells	Tinkers Creek[1] Live mussels	Tinkers Creek[1] Shells
Alasmidonta marginata		1 (0.01)		2 (0.02)		4 (0.01)
Fusconaia flava	18 (0.19)	13 (0.07)	1 (0.03)	3 (0.03)	21 (0.15)	23 (0.06)
Lampsilis radiata luteola	1 (0.01)	18 (0.10)		12 (0.10)	1 (0.01)	35 (0.09)
Lasmigona compressa	5 (0.05)	2 (0.01)	5 (0.16)	8 (0.07)	11 (0.08)	11 (0.03)
Lasmigona costata	15 (0.16)	6 (0.03)		8 (0.07)	15 (0.11)	18 (0.05)
Pyganodon grandis	57 (0.59)	141 (0.76)	26 (0.81)	76 (0.66)	90 (0.65)	280 (0.73)
Strophitus undulatus		2 (0.01)		5 (0.04)		9 (0.02)
Toxolasma parvus		3 (0.02)		1 (0.01)		4 (0.01)
Total specimens	96	186	32	115	138	384

[1]Totals for Tinkers Creek include data from a preliminary survey (1999) that did not distinguish locality with respect to the WWTP. The data presented here also include additional material to that summarized in Tevesz et al. (2002).

well exposed on firm substrate. Alternatively, this species, which Watters (1995, p. 59) describes as the most widespread and common in Ohio, may be in decline within this stream. *L. costata* and *F. flava* frequently were found in close proximity to each other, and *P. grandis* co-occurred with all other species.

The primary area inhabited by mussels is restricted to a region of the stream within Twinsburg, Ohio, and the upstream limit is just below the confluence of Tinkers Creek with Pond Brook (Figure 1). At Pond Brook, the stream appears more as a riverine wetland; it slows and the Ohio EPA (1994, p. 18) reports a minimum dissolved oxygen (DO) concentration of 3.0 mg/l just upstream of Pond Brook, which may approach the threshold for survival of some mussel species (Vaughn and Taylor, 1999; Chen et al., 2001). No living mussels or even shells were found in this region, nor in surveys of the stream within Tinkers Creek State Park, east of Twinsburg and further upstream of Pond Brook. About 500 meters below the confluence with Pond Brook, Tinkers Creek broadens, runs across a lengthy riffle bed, and drops about a meter over a small natural waterfall. Below this fall, DO approached saturation, and a 2 h survey produced one live *L. costata* (site 1, Table 2) and a half valve from *L. r. luteola*. Thus, this region may be the upper limit for the distribution of unionids in Tinkers Creek. The downstream limit is at least 3 km above the confluence of Tinkers Creek with the Cuyahoga River. Neither we nor Smith (2000) found live mussels, possibly because water conditions degrade rapidly below Twinsburg where Beaver Meadow Run brings effluent from the Solon wastewater treatment plant, as does Hawthorn Creek from Bedford Heights (Ohio EPA, 1994, p. 144–147). However, surveys in this industrial region have yet to be performed.

Across the survey area, changes in the presence, absence and distribution of mussels indicate their usefulness as a water quality indicator. The distribution of mussels along rivers often can be nearly continuous where impoundment does not degrade conditions, and the communities of mussels present may correlate with the habitat (Morey and Crothers, 1998; Hughes and Parmalee, 1999). Our assessment of a 10 km stretch of Tinkers Creek was facilitated by its shallow (1 m) depth (Table 2), which enabled replicate sampling across short distances. Some mussels were found in almost every search, and where the water was sufficiently clear and shallow to see the stream bed of Tinkers Creek, mussels appeared to be distributed uniformly and crawling semi-infaunally (see also McCall et al., 1986, p. 96). Dissolved oxygen levels approached saturation throughout the summer, probably due to a high frequency of riffle beds.

The occasional absence of freshwater mussels within our survey of Tinkers Creek was restricted to areas of high levels of detritus on the stream bottom, or regions of bare rock (Table 2). Soft, muddy substrata also yielded few or no mussels (two sites, with one mussel). That 114 of 128 mussels inhabited firmer substrates of mixed sand, gravel and small rocks, but only 13 inhabited rocky areas support the importance of substrate to levels of abundance (Metcalf-Smith et al., 2000). The changes in the nature of the substrate also may slow the reestablishment of mussels in the newly created stream bed, which was rerouted in eastern Twinsburg by simply digging a two-meter deep trench. After two years, the substrate has firmed sufficiently for wading, but no mussels were found despite a diverse fauna both above and below this section (Table 2).

Mussels also thrived both above and below the WWTP located between sites 12 and 13 (Figure 2), although the relative abundance of some species shifted at or above this point in the stream (Figure 3). The Shannon-Weaver Index for mussels declined from only 1.07 above this site to 0.58 below the plant; both values suggest low diversity. Most of the mussels downstream were *P. grandis* followed in frequency by *L. compressa*. Only one other live specimen, a *F. flava*, was found downstream. Neither the significant decline in *L. costata* ($X^2 = 5.28$, $P < 0.05$) nor the comparative

Table 2. Site locations, habitat, species present and the number of unionid individuals found alive along a 10 km stretch of Tinkers Creek.

Location	Site no. (Fig. 1)	Latitude/Longitude	Bottom type	Living mussels found	Species present
Tinkers State Park, above Pond Brook		41°17.08′ 81°23.58′	heavy detritus, soft mud	0	
Tinkers State Park, above Pond Brook			sand/rock/gravel	0	
Old Mill Rd., below falls	1	41°17.12′ 81°24.37′	very rocky (small rocks)	1	*L. costata*
Above the altered site	2	41°18.40′ 81°25.91′	sand/gravel	11	*Fusconaia flava* *L. costata* *P. grandis*
Above the altered site	3	41°18.45′ 81°26.00′	sand/silt/gravel	4	*Fusconaia flava* *P. grandis*
Just above the altered site	4	41°18.48′ 81°26.06′	sand/silt	2	*P. grandis*
Altered river site		41°18.48′ 81°26.06′	sand/gravel	0	
Altered river site		41°18.51′ 81°26.22′	rock/sand	0	
Just below the altered river site	5	41°18.51′ 81°26.22′	mixed gravel/silt	8	*Fusconaia flava* *L. costata* *P. grandis*
Below the altered river site	6	41°18.56′ 81°26.25′	sand/gravel	11	*Fusconaia flava* *L. costata* *P. grandis*
Just upstream of the Ravenna Rd. bridge	7	41°18.60′ 81°26.48′	firm gravel/sand	13	*Fusconaia flava* *L. costata* *P. grandis*
Begin recreational zone Cannon Park	8	41°18.86′ 81°26.23′	rock/gravel, shallow water – 18"	12	*Fusconaia flava* *L. costata* *P. grandis*
Cannon Park recreational zone	9	41°18.88′ 81°26.19′	rocky	12	*Fusconaia flava* *L. costata* *P. grandis* *Lampsilis radiata luteola*
Recreational zone	10	41°18.88′ 81°26.10′	sandy	8	*Fusconaia flava* *L. costata* *L. compressa* *P. grandis*
Recreational zone			soft mud, abundant detritus	0	
Just below Darrow Rd. bridge (State Rt. 91)	11	41°19.17′ 81°26.50′	mixed/soft, some detritus	3	*Fusconaia flava* *P. grandis*
Recreational zone	12	41°19.20′ 81°26.67′	sand/gravel	11	*L. costata* *L. compressa* *P. grandis*
Just downstream of outflow	13	41°19.45′ 81°26.93′	soft and firm sand	7	*L. compressa* *P. grandis*
Specimen found on bank. None nearby			rock, muddy, no loose sand	1	*P. grandis*
Recreational zone	14	41°19.70′ 81°26.90′	sand/gravel	6	*P. grandis*
Recreational zone			rocky	0	
Recreational zone	15	41°19.73′ 81°27.09′	sand/gravel	8	*Fusconaia flava* *L. compressa* *P. grandis*

Table 2. Continued.

Location	Site no. (Fig. 1)	Latitude/Longitude	Bottom type	Living mussels found	Species present
Recreational zone	16	41°19.73′ 81°27.30′	rock/sand, very shallow water	2	*P. grandis*
Center Valley Park, south end	17	41°19.96′ 81°27.39′	sand/gravel	1	*P. grandis*
Recreational zone	18	41°20.28′ 81°27.36′	rock/sand	5	*P. grandis*
Recreational zone			rock/gravel	0	
North end of Center Valley Park	19	41°20.37′ 81°27.29′	sand/gravel	2	*P. grandis*
Bedford Reservation, east of 271		41°23.02′ 81°30.37′	rock/gravel	0	0
Brecksville,west of 271		41°23.16′ 81°32.27′	rocky	0	0
Confluence with the Cuyahoga		41°21.51′ 81°36.35′	rock/gravel	0	0

decline in *F. flava* ($X^2 = 3.76$, $P < 0.10$), however, are sufficient to implicate the WWTP as a detriment to the stream.

Instead, change in the diversity of species may follow clearly visible shifts in the natural characteristics of Tinkers Creek. Just above the WWTP, near sites 10 and 11 along the survey (Figure 1), the stream changes depth and flow. Upstream of the plant depth is greater (1–2 m deep) and flow slower than downstream, where depth is less than one meter and the flow faster as the stream descends the escarpment east and southeast of Cleveland. *Lasmigona costata* prefers medium and large rivers, while *L. compressa* is a small stream species, but both require clean water (Watters, 1995, p. 62–63). Possibly as a consequence of structural change, the comparative frequency of *L. compressa* increased ($X^2 = 3.42$, $P < 0.10$).

In contrast to variation in live individuals, the relative frequency of shells of the different species provided no hint of change in conditions upstream or downstream of the WWTP. Of a total of 384 shells collected in the search region (Table 1), *P. grandis* was the most common, followed by *L. r. luteola*, *F. flava*, *L. costata*, and *L. compressa*. A few complete shells or valves were found for each of the following: *Strophitus undulatus* (Say, 1817), *Toxolasma parvus* (Barnes, 1823) and *Alasmidonta marginata* (Say, 1818). A single worn valve of *Actinonaias ligamentina* (Barnes, 1823) was found, but this species has probably disappeared from the entire watershed since its observance by Dean (1890) in the lower Cuyahoga. Therefore, while the river and its molluscan fauna have changed as the area developed (Tevesz et al., 2002), the only change in rank order of abundance when we considered extant species was the collection of fewer *F. flava* shells below the WWTP, a difference that was not significant. Thus the fauna may, at present, have stabilized.

Therefore, our use of mussels to identify changing conditions along Tinkers Creek fairly supports the presence of the Twinsburg, Ohio, WWTP as a small factor or nonfactor to Tinkers Creek. Substrate and stream dynamics probably affect mussel populations more (Miller and Payne, 1998; Hardison and Layzer, 2001), as suggested by the shift to a shallower and faster current just above the plant that can explain why *L. costata* and *F. flava* make up a greater proportion of the fauna upstream rather than downstream, and why *L. compressa* increased in frequency downstream. That the shift is between these two *Lasmigona* species is very important, because each of the other three species found alive, particularly *P. grandis* and *F. flava* (Metcalfe-Smith et al., 2000), are more tolerant of impoundment and moderate pollution.

Chemical analysis similarly supported this conclusion, as we found that water samples from the immediate area of the stream into which the WWTP drained differed only marginally from those downstream for dissolved oxygen and for pH. For example, the effluent region was more basic (pH 7.93), but the dissolved oxygen concentration (10.15 ppm) was higher than the average for all downstream sites (7.24 ppm). Also, EPA data show no exceedences of coliform bacteria, and the quantity of many chemical pollutants entering the Cuyahoga from Tinkers Creek has declined between 1984 and 1996 (Ohio EPA, 1994; 1999). Finally, the Invertebrate Community Index for this region of the stream met or exceeded requirements for recreational use after 1991, and stream quality remains good above the confluence with Beaver Meadow Run and Hawthorn Creek to the north (Ohio EPA, 1994).

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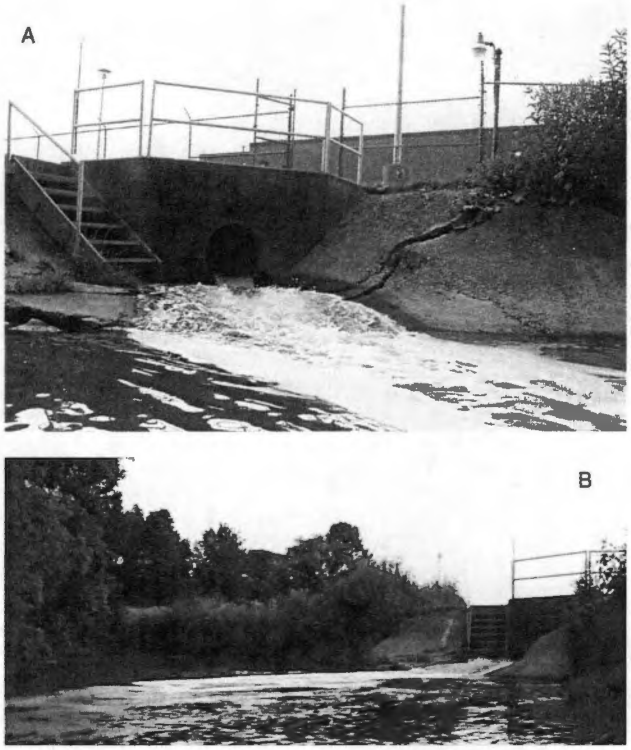

Figure 2. View of the Twinsburg wastewater treatment plant from the river (A) showing effluent and (B) a visual image of the proportional contribution that can be obtained from treatment plants when river water levels are low (photo taken looking upstream). Photos taken July 26, 2000.

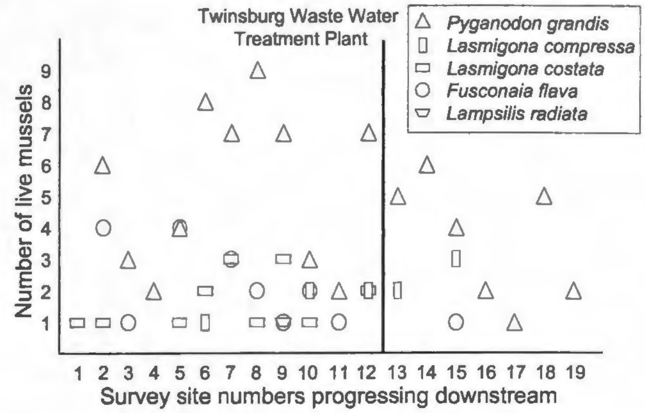

Figure 3. Diversity of mussels and number of each species collected in the survey of Tinkers Creek progressing downstream through a recreation preserve, past the Twinsburg wastewater treatment plant, and down to Center Valley Park in north Twinsburg.

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