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EVIDENCE FOR DECLINE IN THE UNIONIDAE OF THE EAST BRANCH ROCKY RIVER, OHIO

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ABSTRACT

A survey of freshwater mussels (Mollusca: Bivalvia: Unionidae) was conducted for the East Branch Rocky River, Ohio, during the summer of 2006. Development in this watershed is moderate though rapidly expanding, particularly in the upstream reaches. Perhaps as a consequence, a preliminary search failed to reveal any live mussels in the river in 2003. The present report is of an extensive survey covering 21 two-hour timed searches for live mussels and shells combined with visual assessments of disturbance and tests for water quality at each site. All searches were visual or by feeling for mussels embedded in the stream bottom where visibility was poor. These surveys produced only 34 live animals and 287 empty shells, which included live specimens of *Lampsilis radiata luteola*, *Lasmigona costata*, *Lasmigona compressa*, and *Strophitus undulatus* as well as fresh shells of *Pyganodon grandis*. The few sites that contained live animals and fresh shells were isolated, while worn shells were distributed more evenly throughout the river, suggesting a wider distribution of mussels in the past. Present water quality appeared good, and, therefore, the relatively low density and spatial isolation of unionids may reflect local geomorphologic factors combined with historic and current land usage.

Introduction

Headwater streams often determine water quality downstream, yet these smaller tributaries tend to be neglected in surveys of mussels (Mollusca: Bivalvia: Unionidae) due to their predicted lower species diversity and absence of rare species. However, as development continues to expand outward from many Great Lakes coastal cities, the less disturbed headwater regions are coming under greater pressure from anthropogenic changes, including channeling and increased proportions of impervious surfaces in the watershed, that greatly alter the flow dynamics (Dunne and Leopold, 1978, p. 693–704). Streams with high levels of impervious surface-cover exhibit marked degradation in both biological (Yoder et al., 1999) and hydrological (Booth and Jackson, 1997) health and integrity. The East Branch Rocky River is one such small stream and contains some of the most rapidly expanding urban areas in all of northeastern Ohio (Clapham, 2003). It is the smaller of two main branches of the Rocky River, which drains 752 km^2 west and southwest of Cleveland, Ohio. The East Branch Rocky River drains 213 km^2 of the Rocky River's upper reaches.

Freshwater mussels play an important role in lotic ecosystems (Vaughn et al., 2004). As benthic, burrowing filter-feeders, unionids remove great quantities of suspended particulate organic matter from the water column. Mussels also directly influence benthic communities as they burrow through sediment, depositing feces and pseudo-feces (Vaughn et al., 2001), while enhancing the rate of nitrate release from the substrate (Matisoff et al., 1985). This trophic role makes mussels highly sensitive to pollutants and habitat destruction. As a consequence, unionid mussels are perhaps the most threatened family of organisms worldwide, with perhaps 70% of species extinct, endangered, or threatened (Bogan, 1993; Williams et al., 1993). With their depletion the characteristics of many small streams have surely changed.

Because high mussel abundance is a characteristic of clear, undisturbed streams, such as Ohio's Grand River (Huehner et al., 2005), stream quality can be assessed not only by the presence of unionid mussels, but by the proportion of pollution sensitive versus more tolerant species that compose the mussel community (Metcalfe-Smith et al., 2003; Staton et al., 2003; McRae et al., 2004). A marked reduction in unionid diversity is an early indication that water quality has been degraded, and as such, they make excellent biological indicators of long- and short-term stream health, especially where historical data on mussel populations are available. Here we provide a detailed survey of unionids in the East Branch Rocky River and compare the distribution and abundance of mussels to standard chemical assessments of water quality in the stream, to a site-specific analysis of anthropogenic alteration (Lyons et al., 2007), and to past and present diversity throughout the Rocky River (Krebs and Rundo, 2005).

Materials and Methods

To survey the East Branch Rocky River for the Unionidae, 21 sites were chosen based on access and spatial distribution throughout the watershed in order to cover as much of the river as extensively as possible. A semi-quantitative approach of timed searches was applied due to its cost-effectiveness when a stream is largely wadable (Strayer et al., 1996). All surveys were conducted visually where possible, and by feel in areas with low visibility. Effort was standardized at two hours per site, which also made results comparable to those completed in the Rocky River main stem and West Branch Rocky River (Krebs and Rundo, 2005).

Appropriate habitats within the stream as well as the immediate adjacent floodplain were searched for both live animals and dead (shell) specimens. Live unionids were identified using Watters (1995) and immediately returned to the stream substrate. No effort was made to "bury" or otherwise conceal the returned mussels. Large fragments, individual valves, and whole, recently dead, shell specimens were collected for identification and storage by site as voucher specimens at Cleveland State University.

To examine site-specific anthropogenic effects, we applied a simple urbanization rating scale from Lyons et al. (2007). At each site, seven visible factors typically associated with a human presence were recorded and assessed on a rating scale from 0 to 3, where a score of zero indicated little to no human effects and a score of three denoted extreme modification of the river: (1) the presence of buildings; (2) presence of roads visible through the riparian zone; (3) breadth and condition of the riparian zone; (4) condition of the stream bank; (5) presence of dams or spillways; (6) occurrence of erosion; and (7) the quantity of human litter in the river. This measure of urbanization, which ranges from 0–21, is largely qualitative across sites, but it is easily applied to describe relative site-specific changes along the length of a river. Site-specific characteristics appear to be more important for predicting the presence of mussels than are many regional scale analyses (Poole and Downing, 2004).

Water chemistry measurements were taken throughout the watershed on multiple dates that spanned low, moderate, and high flow regimes throughout the summer of 2006. These results were then averaged over the collection dates for comparison to the mussel survey results. At each site, measurements of water temperature, dissolved oxygen (DO) and oxygen saturation (O_2%), specific conductivity, pH, salinity, and oxidation-reduction potential (redox) were made using an Orion 250A pH/conductivity meter for pH and redox, a YSI Inc. model DO200 meter to estimate DO, O_2%, and temperature, and a YSI Inc. model 85 meter for specific conductivity and salinity. All measurements were taken via external probes suspended as near to the substrate as possible, taking care not to disturb the surrounding benthic sediment particularly upstream of the testing location. Each meter was calibrated according to manufacturer's instructions on each day that tests were performed. Before and after each measurement, the probes were thoroughly rinsed with de-ionized water.

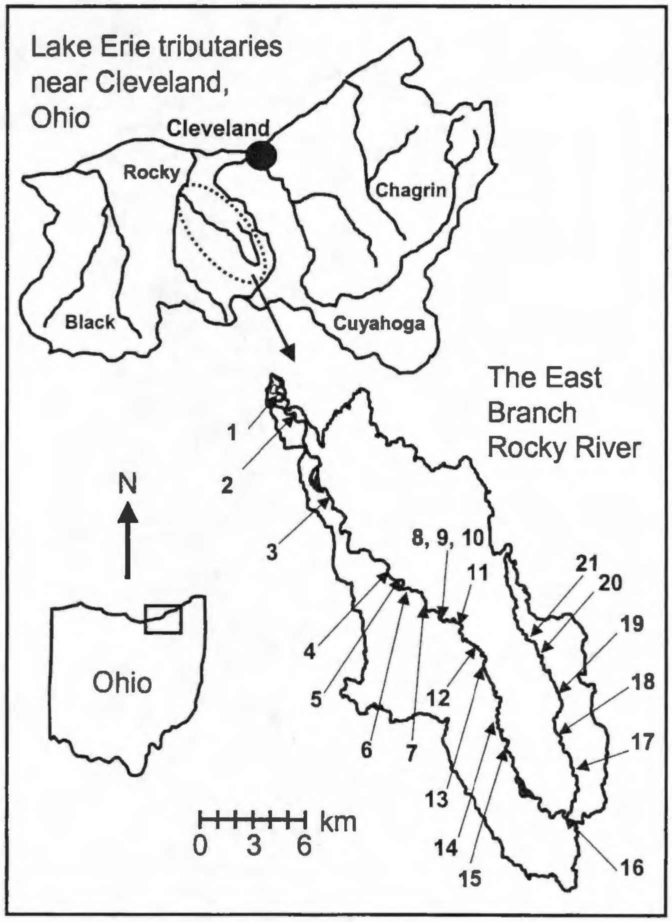

Figure 1. Map showing the larger streams around Cleveland, Ohio, and the location of the East Branch Rocky River watershed. Numerals indicate sampling sites for mussels.

Results

Surveys

The extensive surveys that spanned 21 sites yielded just 34 live individuals, although 287 shell specimens were collected. Four taxa were found alive in the stream: 26 *Lampsilis radiata luteola* (Lamarck, 1819), four *Lasmigona compressa* (Lea, 1829), three *Strophitus undulatus* (Say, 1817), and one *Lasmigona costata* (Rafinesque, 1820). A fifth species, *Pyganodon grandis* (Say, 1828), was represented only as shells in the river. As this species prefers lentic environments (Watters, 1995, p. 31), the 53 shells, many in fresh condition, may derive from impounded small tributary streams, as observed when a pond downstream of site 19 was purposely drained to reclaim land at a girl scout camp, Camp Jane Crowell. The pond was found to have been densely and apparently exclusively populated with *P. grandis*.

Suitable habitat for unionid mussels appeared limited in the East Branch Rocky River. Live individuals were found only at 5 sites: 8, 9, 10, 13, and 20 (Figure 1). Of these, sites 8–10 contained the most mussels ($n = 26$, with 21 in site 9 alone), and these sites composed a small continuous stretch of the stream such that the site-8 survey ended at the site-9 start point, and so on. Of the other eight individuals, five occurred at site 13 located within and below a public golf course in a stretch of the stream with major bank modification. Three live *S. undulatus* were found at site 20, a headwater region that was only recently developed.

Not only were live individuals very restricted in distribution, fresh shells were similarly found only where mussels occurred alive, with the exception of *P. grandis* already mentioned. Worn shells, however, were scattered along the river, but were not found at sites 19 and 21, the latter of which may be an ephemeral component of the headwaters. The frequency of shells basically followed that for live mussels in the stream, with 186 *Lampsilis radiata luteola*, 38 *Strophitus undulatus*, nine *Lasmigona compressa*, and a single fresh *Lasmigona costata* at the same site where one live individual was found. Weathered shells found per site more or less increased the further downstream we surveyed until

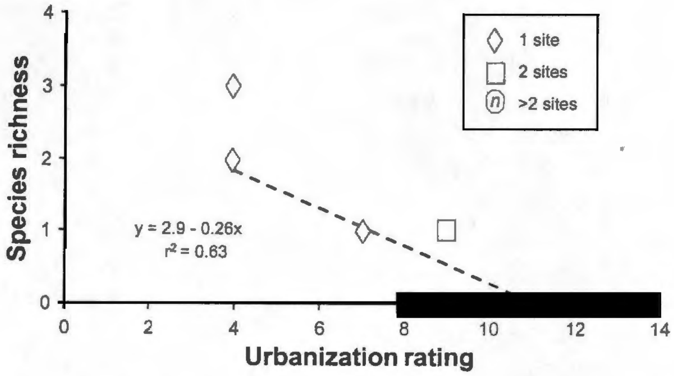

Figure 2. Simple linear regression for urbanization score versus species richness as indicated by the actual number of species observed living at a particular site. Species richness at each site was assumed to be an independent unit. Diamonds demarcate a single datum, squares are two overlapping data points, and octagons indicate overlapping data of three or six sites as labeled.

just below site 8, where the East Branch Rocky River becomes heavily urbanized, and shell numbers of any condition dropped off. The paucity of shells at site 7, when many were found in sites 8–10, suggests they are not washed far downstream, and therefore the number of mussels and their range has almost certainly declined.

Water quality and urbanization

Mean temperatures were generally moderate and stable for the length of the stream, which is characterized as a warm water habitat: the low temperature site (site 17) averaged 21.2 (SD ± 2.3) °C and the warmest (sites 1 and 2) were 24.1 (SD ± 3.1) °C, with a trend towards increasing temperatures as we sampled downstream. Salinity readings were virtually identical across sample locations (0.2–0.3 ppm), while relative conductivity ranged from a minimum of 349.5 μS/L at site 21 to a maximum of 567.5 μS/L at site 4. Oxygen redox potential ranged from −35.3 (site 13) to −78.3 (site 1), and measurements of the closely related pH ranged from 7.60 (site 13) to 8.23 (site 1). Oxygen levels were also generally good throughout, with a low of 5.9 ppm (67.2% saturation) at site 5 and a high of 8.3 ppm (93.6% saturation) at site 17.

While the condition of the water appeared good, visual assessments of each site suggested extensive urban impacts. The mean urbanization value was 9.5 using a site specific scale. Only at two sites were scores less than five, and overall, this simple metric explained over 60% of the variation in species diversity within the East Branch Rocky River (Figure 2).

Discussion

The extremely small population of unionids remaining in the East Branch Rocky River cannot be attributed to just the drainage area of this watershed. With extensive surveys covering 21 sites, only 34 live animals and 287 mostly worn shell specimens were recovered. These numbers are low when compared with similar efforts applied in the West Branch Rocky River (182 alive and nearly 600 shells of 11 different species), and even in the lower Rocky River, which has faced urbanization impacts longer than the East Branch, unionids within a short stretch of stream are more abundant (Krebs and Rundo, 2005). With the exception of *L. compressa*, the species present in the watershed all are common in the region, but because *Lasmigona* spp. may require clean habitat, their abundance may be dwindling regionally (Tevesz et al., 2002; Lyons et al., 2007). Oddly, one *L. costata* found constituted a new stream record, but of a remnant population.

Clearly, the fauna of the East Branch Rocky River is experiencing an unfortunate, but common, outcome of urban sprawl. With habitat declining, the extant unionid community is completely isolated and compressed to short stretches of the river. Any event that contributes to local extirpation will not be balanced by colonization, and changes to the fauna become unidirectional towards loss. Few previous collections were ever made for the East Branch Rocky River, limiting what can be said of change, although the Ohio State University Museum of Biological Diversity on-line data base (Watters and Cramer, 2008) lists three additional species from the East Branch Rocky River not found in the present survey: *Anodontoides ferussacianus* (Lea, 1834), *Toxolasma parvum* (Barnes, 1823), and *Utterbackia imbecillis* (Say, 1829). A shell of *U. imbecillis* was also found by Krebs and Rundo (2005), and *U. imbecillis* and *T. parvum* may persist within impounded tributaries (Smith et al., 2002). However, *A. ferussacianus*, which is regionally common in clean headwater streams, is probably extirpated from the East Branch Rocky River.

Even the much more diverse West Branch Rocky River has lost diversity within the last century. Specimens of *Alasmidonta marginata* (Say, 1818), *Amblema plicata* (Say, 1817), and *Pleurobema sintoxia* (Rafinesque, 1820), which are described as requiring clean-water (Watters, 1995; Metcalfe-Smith et al., 2000, 2003), are listed in the Cleveland Museum of Natural History holdings for the Rocky River (Heiser et al., 2002; an updated list of holdings is available from R. A. Krebs or from Tom Pucci, Cleveland Museum of Natural History).

The East Branch Rocky River changes both in chemistry and in velocity along its length, leading to conditions that destabilize the substrate and that create a chemical environment outside of that optimal for mussels. The headwaters are located in glaciated Appalachian highlands where they feed a stream flowing south, eventually to a drift filled pre-glacial valley (Hubbard and Champion, 1925). There, the stream makes a U-turn to the north, entering the lake and till plains of Lake Erie, and it generally follows the ancient river valley northwestward where it widens considerably in places as it cuts through glacial-valley and alluvial sediment, and in other places is bounded by steep shale and sandstone walls (Cushing and others, 1931, Plate 20; Ohio Environmental Protection Agency, 1993). Throughout this region, the East Branch Rocky River is considered a high-gradient stream, averaging 3.1 m of elevation loss per kilometer in length (Ohio Environmental Protection Agency, 1999). The geological setting explains the noticeable increase in pH and associated rise in redox potential, as shales tend to exhibit a high cation exchange and buffering capacity. In places the river flows over bedrock rather than buried-valley and alluvial sediment. Changes in gradient related to substrate composition can increase current velocity, creating conditions for higher shear stress, which reduce mussel abundance (Gangloff and Feminella, 2007).

Throughout the East Branch Rocky River, water quality appears not to be a prohibitive factor limiting unionid mussels (Ohio Environmental Protection Agency, 1993, 1999). Several wastewater treatment plants, which are potential sources of episodic water quality impairment, have been removed or upgraded, and only three plants continue to discharge treated effluent into the East Branch Rocky River or its tributaries (Ohio Environmental Protection Agency, 1999). However, as expected in an urban stream, there is a general trend towards human impacts downstream (Paul and Meyer, 2001), as indicated by site specific analyses. Mussels were present whenever impact scores were < 5, but no live mussels occurred when scores were > 10; higher scores tended to occur downstream. This trend corresponded with results for Ohio's Black River, just west of the Rocky River (Lyons et al., 2007).

Therefore, given a long stretch of sediment-poor bedrock in the lower stretches of the East Branch Rocky River, and several high dams creating man-made impoundments, the few areas of higher quality habitat will remain separated from other reaches of the watershed where mussels are abundant.

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