

HOW A STATE-WIDE STREAM SURVEY CAN AID IN UNDERSTANDING
FRESHWATER MUSSEL (BIVALVIA: UNIONIDAE) ECOLOGY: EXAMPLES OF
UTILITY AND LIMITATIONS FROM MARYLAND

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ABSTRACT: Gaps in our knowledge of freshwater mussel life history, distribution, and ecology remain even though their study has increased considerably over the past few decades. These studies have traditionally taken place within a population, river, or larger drainage unit, but rarely across a broad landscape, such as a state. Given the imperiled status of a majority of unionid species alternative opportunities to collect valuable data cannot be overlooked. We present results from a statewide biological monitoring program (Maryland Biological Stream Survey) that has incorporated a visual survey for mussels, several example analyses using mussel-bioassessment data, and discuss the utility and limitations of incorporating freshwater mussels into stream assessments. Since 2007, we encountered 11 of the 16 mussel species extant in Maryland during assessments of wadeable streams by using an informal visual survey and recording incidental observations. On several occasions, we have discovered new populations of imperiled mussels or extended a species distribution. The biological and physiochemical data collected at sites coincident with freshwater mussels have allowed us to hypothesize factors potentially limiting species distribution, such as fish-host dynamics, habitat quality, nutrient concentration, and catchment land use. We feel that the addition of a survey effort into a biological monitoring program, invaluable data can be collected that can assist resource managers, malacologists, and researchers answer a variety of questions. Further investigation into the cost-benefits of an appropriate level of sampling effort is needed as this could vary markedly among molluscan faunal regions and by objectives.

REPRODUCTIVE BIOLOGY AND HOST FISHES OF FOUR UNIONIDS FROM THE LAKE PONTCHARTRAIN BASIN, LOUISIANA, U.S.A.

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ABSTRACT: Host fishes, fecundity estimates, and gravid periods were identified for four species of freshwater mussels from the Lake Pontchartrain basin, Louisiana. Two of the mussel species have broad distributions both in the Mississippi River and elsewhere in Louisiana: *Villosa lienosa* (Conrad, 1834) and *Lampsilis teres* (Rafinesque, 1820). The other two species have more restricted distributions: *Quadrula refulgens* (Lea, 1868) and *Lampsilis ornata* (Conrad, 1835). *Lampsilis ornata* is listed as a species of concern in Louisiana. Of the 23 species of fishes tested as potential hosts, we found 4 previously unknown hosts for *Villosa lienosa*: *Lepomis megalotis*, *Lepomis humilis*, *Lepomis microlophus* and *Lepomis cyanellus*, and confirmed 2 previously documented: *Lepomis macrochirus* and *Micropterus salmoides*. *Villosa lienosa* was gravid from April until June and had an estimated fecundity of $38,562 \pm 3,073$ glochidia/female. For *Lampsilis ornata* we established a host relationship with *Luxilus chrysocephalus*, and confirmed *Micropterus salmoides* as a host. *Lampsilis ornata* was gravid from February until April and had a fecundity estimate of $451,214 \pm 27,239$ glochidia/female. *Lampsilis teres* was gravid from April until September and had a fecundity estimate of $407,333 \pm 24,727$ glochidia/female. We confirmed three hosts for *L. teres*: *Micropterus salmoides*, *Pomoxis annularis*, and *Lepomis humilis*, and identified two new hosts: *Lepomis microlophus* and *Notropis venustus*. Only a single *Quadrula refulgens* was found gravid in late June and its fecundity was estimated at 32,450 glochidia and a host was identified as *Pylodictis olivaris*.

POPULATION PERFORMANCE CRITERIA TO EVALUATE REINTRODUCTION AND
RECOVERY OF TWO ENDANGERED MUSSEL SPECIES, *EPIOBLASMA BREVIDENS*
AND *EPIOBLASMA CAPSAEFORMIS* (BIVALVIA: UNIONIDAE)

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ABSTRACT: Genetic and demographic modeling of two endangered mussel species, *Epioblasma brevidens* and *E. capsaeformis*, in the Clinch River, U.S.A., was conducted to determine quantitative criteria to evaluate performance of extant and reintroduced populations. Reintroduction modeling indicated that the initial population size created during a 5 y build-up phase greatly affected final population size at 25 y, being similar to the population size at the end of the build-up phase, especially when expected growth rate was low (e.g., 1-2%). Excluding age-0 individuals, age-1 juveniles or recruits on average comprised approximately 11% and 15% of a stable population of each species, respectively. Age-class distribution of a stable or growing population was characterized by multiple cohorts, including juvenile recruits, sub-adults, and adults. Molecular genetic and demographic data indicated that the ratio of N_e/N_c was ~5% for both species. Based on this ratio and predicted declines of genetic variation at different population sizes, target total sizes for reintroduced or recovered populations of each species should be $\geq 10,000$ individuals ($N_e=500$), respectively, and ideally should be comprised of multiple smaller demes spread throughout a river. Because of current barriers to dispersal and the low dispersal capability of some mussel species, reintroductions will play a prominent role in restoring populations in the United States.

A QUALITATIVE FRESHWATER MUSSEL (BIVALVIA: UNIONIDAE) SURVEY OF THE LAMINE AND BLACKWATER RIVER BASINS, MISSOURI

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Abstract: From 2003 to 2006 freshwater mussels (Bivalvia: Unionidae) were qualitatively surveyed in the Lamine River basin, a Missouri River tributary in west central Missouri. Timed searches (average time/site = 1.9 hr) were conducted to ascertain the distribution, diversity and abundance of unionids in the basin. A total of 45 sites were sampled and 5287 individuals from 27 species were observed, including *Ligumia recta*, a Missouri Species of Conservation Concern. The invasive *Corbicula fluminea* was observed live at nearly all sampling locations throughout the basin. Overall average Catch per Unit Effort (CPUE, live individuals/person hr) was 54.7 and ranged from 0 to 417.6. *Amblema plicata* was the most abundant species, with 2989 individuals recovered at 34 sites, representing 56.5% of the live mussels collected. *Leptodea fragilis* and *Potamilus alatus* were the most widely distributed species, each occurring at 36 sites. The Lamine basin unionid fauna (30 historic, 27 extant species) is more diverse than that of prairie streams in the Missouri River system and is similar to Ozark rivers. Given the anthropogenic impacts occurring in the basin, the Lamine River basin has a diverse freshwater mussel fauna. A number of species rich mussel assemblages were observed in the mainstem Lamine River. Continuing with management objectives to maintain water quality, improve aquatic habitat, and work with private landowners to stabilize streambanks and improve riparian zones will be necessary to maintain the diversity of freshwater mussels in the Lamine River basin.

ASSESSING ACCUMULATION AND SUBLETHAL EFFECTS OF LEAD IN A UNIONID MUSSEL

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ABSTRACT: Lead (Pb) contamination of the environment remains a global problem. Previous studies have demonstrated that Pb deposited onto roadside sediments from the past use of leaded gasoline in vehicles may be mobilized into rivers and streams, thereby resulting in exposure to aquatic biota. The aims of this study were to conduct a 28 day laboratory toxicity test with Pb and adult Eastern Elliptio (*Elliptio complanata* (Lightfoot, 1786); family Unionidae) mussels to determine uptake kinetics and to assess several potential non-lethal biomarkers of Pb exposure. Mussels were collected from a relatively uncontaminated reference site and exposed to a control and eight concentrations of Pb (as lead nitrate) ranging from 1 to 251 µg/L, as a static renewal test. There were five replicates per treatment with one mussel per replicate. The hemolymph of mussels from four of the replicates were repeatedly sampled (days 7, 14, 21, and 28) for analysis of Pb and ion (Na⁺, K⁺, Cl⁻, Ca²⁺) concentrations. The mussels in the fifth replicate per treatment were only sampled on day 28 and served as a comparison to the repeatedly sampled mussels. The accumulation of Pb in mussel tissue was also evaluated during the study. We found that measured concentrations of Pb in mussel hemolymph suggested regulation of the heavy metal up to 66 µg/L by day 14, whereas concentrations in tissue proved to be strongly correlated ($R^2 = 0.98$; $p < 0.0001$) throughout the 28-day exposure, displaying concentration dependent uptake. The concentration of Pb in mussel hemolymph, which can be sampled and measured non-lethally, is a suitable marker of recent Pb exposure in mussels. In contrast, none of the ion concentrations measured in the hemolymph from the repeatedly sampled mussels was significantly changed with increasing concentrations of Pb, whereas the mussels from the fifth replicate sampled only on day 28 showed altered calcium concentrations. The activity of δ-aminolevulinic acid dehydratase (ALAD), a demonstrated Pb-specific biomarker in vertebrates and some invertebrates, which was also evaluated as a potential endpoint in an initial evaluation for this study, proved to be an unsuitable biomarker in *Elliptio complanata*, with no detectable activity observed. This finding was in contrast to a second freshwater, but non-unionid bivalve tested, the Asian clam *Corbicula fluminea*, which had detectable ALAD activity.

THERMAL TOLERANCES OF FRESHWATER MUSSELS AND THEIR HOST FISHES: SPECIES INTERACTIONS IN A CHANGING CLIMATE

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Abstract: Rising environmental temperatures result from changes in land use and global climate and can cause significant shifts in the composition and distribution of species within communities. In freshwater systems, the larval life stage, glochidia, of Unionida mussels develops as an obligate parasite on host fish gills or fins before transforming into the juvenile stage and dropping to the sediment to complete the life cycle. Because of the relationship between freshwater mussels and their often specific host fish species, mussels are not only limited by their own variable thermal tolerances, but also by those of their host fish. Our intent was to compile data from available literature regarding thermal sensitivities of eight species of freshwater mussels and their host fish, to determine if the community structure of these systems is at risk from rising environmental temperatures. Mussels were both more and less thermally sensitive than specific host fish species (2.9 °C mean absolute difference between mussel and host; range = 0 - 6.8 °C). In 62% of mussel-host fish comparisons, freshwater mussels were more thermally tolerant than their hosts (3.4 °C mean difference; range = 0.2 - 6.8 °C), suggesting that some mussels are effectively more stenothermic than tolerance criteria indicate, which may pose additional environmental risk. Further analysis revealed that variation in mussel thermal tolerance could not be attributed to mussel acclimation temperature, species, life stage, or mean fish host thermal tolerance, suggesting that mussel thermal tolerance is controlled by multiple interacting and complex factors. Our findings in this meta-analysis suggest that thermal effects of anthropogenic landscape alteration and climate change may be compounded for freshwater mussels via their obligate life cycle interaction with fish and highlight the importance of considering global change effects in a community context.

RECENT MONITORING OF THE FRESHWATER MOLLUSKS OF KINNICONICK
CREEK, KENTUCKY, WITH COMMENTS ON POTENTIAL THREATS

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ABSTRACT: This study was conducted to gain a better understanding of the current status of freshwater mollusks in the mainstem of Kinniconick Creek, a small tributary to the Ohio River. Qualitative and quantitative sampling documented 17 species of freshwater mussels and 8 species of freshwater gastropods from mainstem Kinniconick Creek. Declines in freshwater mussel species richness have been observed at several sites since 1983 as well as declines in densities. I discuss potential threats to the mussel fauna posed by excessive particle movement from historical channel alteration, human perturbation, and from changes in precipitation patterns.