COPE

Triannual Unionid Report

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A forum for the informal exchange of information
on the status of
North American unionid research, management, and conservation

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NOTE: The intent of this report is to expedite the exchange of information in an informal format. Report submissions were solicited from individuals and agencies involved in unionid conservation. The submissions were not edited. They were copied as received and assembled into the report.

Update on Zebra Mussels/Native Unionids in the Illinois River

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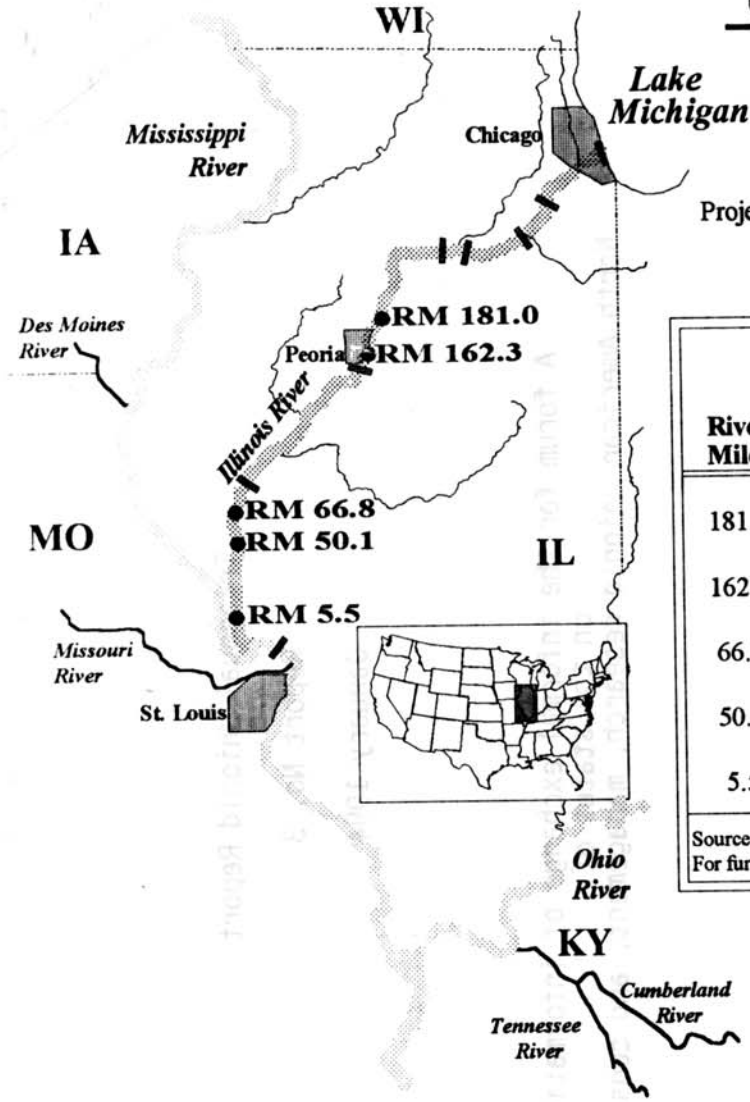
Project funded by: National Fish & Wildlife Foundation, Tennessee Shell Company, Mussel Mitigation Trust, Upper Mississippi River Conservation Committee, Long Term Resource Monitoring Program, and Illinois Natural History Survey.



River Mile	Site	Collection Date	Zebra Mussels: Densities Mean /m²	Zebra Mussels: Densities min./max. /m²	Zebra Mussels: Size < 15mm %	Zebra Mussels: Size > 15mm %	Native Unionids: Densities /m²	Native Unionids: Infestation %
181.0	Chillicothe	08/03/93	< 1	--- / ---	---	---	0.3	03
162.3	Peoria	08/10/93	1,793	588 / 3,572	61.6	38.5	5.2	88
66.8	Meredosia	07/20/93	10,905	4,948 / 25,988	99.5	0.5	11.0	95
50.1	Montezuma	10/01/93	Analysis Pending					
5.5	Grafton	08/18/93	60,956	27,936 / 94,504	99.7	0.3	12.2	99

Source: Illinois Natural History Survey (11/01/93). Unpublished data.
For further information contact K.D. Blodgett or S.D. Whitney.

The exotic zebra mussel (*Dreissena polymorpha*) probably invaded the Mississippi Basin via canals linking Lake Michigan to the Illinois River, a major tributary of the Mississippi River. First reports in the basin were from these canals in 1989 and 1990, so it is not surprising the densest and most extensive populations in the basin are from the Illinois (up to 94,504/m^2 at river mile [RM] 5.5). What is surprising is zebra mussels occur in such high densities downriver--average numbers increase from less than 1/m^2 at RM 181 (our upper-most sample site) to 60,956/m^2 at RM 5.5. The percentage of native mussels infested with zebras likewise increases from only 3% upriver to 99% downriver. The most likely explanation for the upriver-downriver gradient is that rvae from populations in southern Lake Michigan or the upper Illinois River were released during the "Great Flood of 1993" and carried far downriver before settling. This hypothesis supported by the size distribution of the zebras: most (99%) of them downriver were less than 15mm long, indicating they settled in the spring or early summer of 1993, whereas wer (62%) small zebras occurred at our upriver sites. It is highly likely the Illinois seeded the Mississippi with larvae downriver of the confluence. The upriver-downriver gradient of itive mussels densities, from 0.3/m^2 at RM 181 to a maximum of 12.2/m^2 at RM 5.5, is attributable to a long-existing gradient in sediment and water quality (due to pollution from e Chicago area), rather than to effects of the newly arrived zebras on the native mussels. However, judging from our observations, the zebras threaten the 23 species of native mussels tant in the Illinois River. We found freshly dead native mussels (with meats inside) so heavily infested with zebras that their shells could not be forced closed. Others were held shut tufts of byssal threads attached to both shells. Action should be taken now to cryogenically preserve gametes or fertilized eggs of native riverine mussels or to move adults into itcheries where they can be maintained and perhaps propagated. Native mussels might be restocked in their big river habitats in the future if the zebra mussel populations ever crash. wo observations from October 1993 offer a ray of hope: (1) zebra mussels suffered 51% mortality at RM 66.8 (mortality rates appeared to be lower at other sites), and (2) some native ussels had no zebras, but did have numerous byssal threads attached--zebras may have released or been scoured off when native mussels burrowed into the substrate for winter.

ZEBRA MUSSELS IN THE TENNESSEE RIVER SYSTEM

The first zebra mussel (*Dreissena polymorpha*) found in the Tennessee River was collected by a commercial musseler at Tennessee River Mile 30, Kentucky Reservoir, in September 1991. Since then, adult zebra mussels have been found with increasing frequency along the length of the mainstem Tennessee River. Mussel fishermen have reported zebra mussels as far upstream as upper Wheeler Reservoir and a recreational boater found a zebra mussel in Nickajack Reservoir, in eastern Tennessee. TVA divers have found varying numbers of zebra mussels in all of the navigation locks on the mainstem Tennessee River (from Kentucky through Ft. Loudoun). Zebra mussels have not yet been found in any Tennessee River tributary.

TVA zebra mussel monitoring began in March 1992 with the placement of settlement monitors at 42 TVA dams and power plants located on Tennessee River basin streams as well as sites on the Cumberland, Ohio, Green, and Mississippi rivers. These monitors are being examined biweekly or monthly throughout the warmer months of the year. Slides and, more recently, "bridal veil" nets from these monitors are collected on each visit and sent to the TVA Zebra Mussel Laboratory in Chattanooga for examination. Once adult zebra mussels are known to exist in the vicinity of a power plant, weekly qualitative plankton sampling is begun in the plant intake. When zebra mussel veligers are encountered in the qualitative samples, quantitative plankton sampling is conducted on a biweekly basis. All plankton samples are examined in the Zebra Mussel Laboratory, from where the results are reported to the affected plants and to a TVA-wide zebra mussel interest group.

Zebra mussel veligers were first detected at TVA facilities in June 1993. Since then, veligers have been found rather consistently in the plankton at Shawnee, Allen, and Cumberland Steam Plants (on the Ohio, Mississippi, and Cumberland rivers, respectively). Veliger densities have been consistently highest at Shawnee Steam Plant, reaching an average of 50,000 per cubic meter in August 1993. Settled small zebra mussels were first found at Shawnee and Allen Steam Plants in September 1993.

A variety of control measures have been and are being investigated by TVA staff to prevent zebra mussels from disrupting plant operations. ClamTrol has been used once as a zebra mussel control measure at Shawnee Steam Plant, largely to gain experience in using this approach. At the moment, ClamTrol treatment is proposed to be used during the initial invasion of a plant by zebra mussels. A control plan for all TVA generating facilities is now being prepared and various research projects are being conducted or monitored to evaluate the potential uses of thermal, chemical, and mechanical control techniques.

So far, TVA has started or funded only one project on potential zebra mussel impacts to aquatic communities. Under contract, Dr. Terry Richardson, University of North Alabama, is now starting to gather a second year of baseline information intended to help document zebra mussel effects on specific native mussel communities.

For further information about TVA zebra mussel activities, contact **Bennie Kerley** (615/632-1773), **John Jenkinson** (615/751-6903), or **Neil Woomer** (615/751-7307). TVA also maintains a toll-free telephone number (**800/538-2526**) to receive zebra mussel siting reports and take zebra mussel information requests.

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SURVEY OF UNIONIDS OF RICHARDSON CREEK, UNION COUNTY, NC - PEE DEE DRAINAGE BASIN.

Survey was requested by the North Carolina Wildlife Resources Commission in response to a proposed upgrading of the city of Monroe's waste water treatment plant. Funding was through McKim and Creed Engineers, Wilmington, NC. All field sampling occurred between June 23 and July 2, 1992. Sampling methods are similar to those I report for the Bearskin and Stewarts Creeks survey. Area sampled at each station varied between 100 and 300 ft. stream length. Location of station sites and aid in getting to and from sites was greatly aided by Mr. Dick Gambill, a field engineer for McKim and Creed Engineers; Dr. E. P. Keferl, Brunswick Jr. College, Brunswick, GA made available his unpublished collection notes on Richardson Creek.

Only known prior molluscan collections from Richardson Creek are those by Dr. E. P. Keferl [seven sites in August, 1987]. Our uppermost site was at NC Road #39 crossing [Lat. 34° 53.5'N; Long. 80° 33.5'W]; the most downstream site was at NC Roads #1645 & 1649 crossing [Lat. 35° 4.1'N; Long. 80° 24.4'W - total sampling distance was approximately 20 running miles.

Area included: Semiurban segment upstream of Lake Lee; Lake Lee; Urban and industrialized area between Lake Lee dam and upstream of Monroe sewage treatment plant; Just above and just downstream of sewage treatment plant; Downstream of latter.

The upstream segment [two collection sites] contained no unionids, living or dead. Some snail and non-unionid bivalve species were recorded. Keferl's 1987 notes recorded only snail species from here.

Recent storms prevented sampling of Lake Lee.

Downstream of Lake Lee dam to near the sewage treatment plant [eight sites] contained moderate numbers of the following unionids: Eastern floater, Anodonta cataracta Say; paper pondshell, Anodonta imbecillis Say; Eastern elliptio, Elliptio complanata (Lightfoot); variable spike, E. icterina (Gould) - one shell only; Southern pondhorn, Uniomerus obesus (I. Lea); and Eastern creekshell, Villosa delumbis (Conrad). Proposed NCWC "Threatened" and "Special Concern" status unionids found were: Eastern fatmucket, Lampsilis radiata (Gmelin) - one fresh dead and two dead shell; squawfoot, Strophitus undulatus (Say) - one dead shell; Savannah lilliput, Toxolasma pullus (Conrad) - one recent living and one dead shell. Snail species and Asian clams were common.

Waters just above/downstream of the sewage treatment plant [two sites] contained no mollusca and were highly contaminated.

Downstream of above [three sites], no unionids were found. Keferl's 1987 notes from this area recorded finding several specimens of Elliptio complanata (Lightfoot), Uniomerus sp., and Villosa delumbis Conrad. Recent storms possibly made these downstream waters difficult to sample in.

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developed. This work was carried out to develop such reagents. Host and non-host fish were immunized with killed bacteria (Brucella abortus) to study their humoral immune response to an antigen. All fish were able to respond well, as measured by agglutination and Western Blot assays. Antibodies produced by the Brucella injections were used to stimulate anti-fish immunoglobulins in goats, and the antisera were tested for their ability to recognize immunoglobulins from different host fish species. The specificities of these reactions were compared to the reactivity of Protein A. Goat antisera were able to cross-react with different fish antibodies, but it was found that Protein A was a more suitable reagent. Protein A is seemingly suitable to identify the host-fish species and could be used as a reagent for the serological diagnosis of various fish diseases.

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ABSTRACT

Cryopreservation studies were conducted to assess the feasibility of conserving the genetic material and early life stages of freshwater mussels (family: Unionidae). Objectives of the study were to 1) conduct a literature review on cryopreservation of mollusks; 2) extract and cryophilize the DNA from mussel tissue; and 3) attempt to cryopreserve the embryos of asian clams (Corbicula fluminea) and glochidia of freshwater mussels. The few studies conducted on mollusks have been exclusively with marine mussels and oysters; no information on freshwater species was available prior to this project. Mussel DNA was extracted from foot tissue with a high degree of purification; the wave length ratio of A_{260}:A_{280} exceeded 1.80, as measured in an ultraviolet spectrophotometer. The purified, lyophilized DNA was stored at -70°C and can be kept in that state until needed. Glochidia tolerated cooling conditions above 0°C, but they did not tolerate 0°C for 24 hr. Cryoprotectant agents were effective in allowing glochidia to survive at -6°C and -20°C for 20 min, but not at -197°C (liquid nitrogen) for 20 min. Glochidia of mussels and embryos of asian clams survived over 8 days after thawing from -197°C using organic solutions for water extraction and the B.D. 20 vitrification solution. However, because only partial success was achieved in experiments, cryopreservation of multi-cellular embryos of mollusks will require considerably more research by cryobiologists.

Table 6. The percent viability of glochidia of freshwater mussels after cryopreservation at -197°C.

	Time (days)							
Treatment	1	2	3	4	5	6	7	8
Anodonta grandis	56	49	42	36	29	20	12	5
Ligumia nasuta	52	42	36	28	19	9	<5	<5
Villosa iris	56	38	29	17	9	7	<5	<5

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Use of Ponds to Protect Native Freshwater Mussels

The exotic zebra mussel (Dreissena polymorpha) is spreading rapidly throughout the Interior Basin rivers of the U.S. Since its introduction into Lake St. Clair in 1986, it has eliminated the native freshwater mussel fauna from Lake St. Clair, much of Lake Erie, the Detroit River, and other localized areas in this region. Zebra populations now infest native mussel beds in the upper Mississippi River, Illinois River, lower Ohio River, Tennessee River, Hudson River, and numerous other mainstem rivers throughout the central U.S. Our prognosis for native mussel populations is decimation, with widespread extirpations and some extinctions expected before the year 2000. This project is evaluating the use of ponds as refugia for mussel species in large rivers at greatest risk of extirpation or extinction.

Ponds as Refugia

To protect native species at greatest risk from this hellhound mussel, a project was initiated in 1992 to test the feasibility of pond refugia for riverine mussel populations. A sample of adult mussels was collected from the Tennessee and New rivers and are being held in suspension within a 0.25 acre farm pond at Critz, Virginia. Mussels are held in 1 m x 1 m x 0.5 m plastic screen cages fastened to PVC float collars. Large species are held unrestricted on the cage bottoms. Small species are held within 100 mm mesh plastic sleeves hung horizontally from the cage tops.

In 1993, three ponds at the state fish hatchery in Marion, Virginia were made available to expand the project. Adult mussels collected from the Tennessee and Cumberland rivers in summer-fall, 1993 are being maintained at this hatchery. Because these mussels were collected within the known range of the zebra mussel, they were scrubbed at the collection site and transported to a small quarantine pond (36 m x 36 m) at Virginia Tech in Blacksburg, Virginia. This lined irrigation pond has no inlet or outlet, and a maximum depth of about 2 m. Mussels were quarantined for 1 month and then transported to the hatchery ponds for long-term monitoring.

Survival in Farm Pond

After 1 year, survival in the farm pond at Critz was 74% overall. There were significant differences in percent survival (Table 1). Elliptio spp. exhibited high survival, whereas survival of Pleurobema cordatum and Lampsilis ovata was lower. We suspect that low alkalinity (17 mg/L) of the pond may be a limiting factor for some species (Table 2). Dissolution of the umbonal region of valves of L. ovata was evident after several months, and perforations likely contributed to mortality of this species.

Survival in Hatchery and Quarantine Ponds

Survival of mussels has been high although only 1 month has elapsed (Table 3). We suspect that

alkalinity (154 mg/L) is better suited to mollusks in these ponds, and no shell dissolution has been observed.

Because many populations of federally listed and state protected freshwater mussels will be colonized by zebra mussels, we encourage natural resource agencies to consider ponds or other refugia as a means to protect native species from the impending impacts anticipated by the continuing spread of this prolific competitor and biofouler. We currently maintain about 1,500 mussels of 15 species and will continue to monitor survival and reproductive condition in 1994. Additional species will be collected in 1994 to expand our captive stocks. We anticipate that caged mussels will spawn and become gravid, so that glochidia will be available for ongoing propagation efforts in field and laboratory experiments.

Table 1. Survival of mussels being held in the farm pond after 1 year.

Species	No. Held	% Survival
Pleurobema cordatum (Ohio pigtoe)	39	74.3
Elliptio dilatata (spike)	29	100
Elliptio complanata (eastern elliptio)	53	90.5
Elliptio producta (Atlantic spike)	13	92.3
Cyclonaias tuberculata (purple wartyback)	33	96.9
Lampsilis ovata (pocketbook)	14	35.7

Table 2. Water chemistry of holding ponds in Virginia, summer 1993.

	Chemical Measurement		
Location	Alkalinity (mg/L)	pH	Dissolved Oxygen (mg/L)
Critz	17	8.0-8.5	10-12
Marion	154	8.5-9.0	10
Blacksburg	154-205	8.0	10-11

Table 3. Survival of mussels being held at the hatchery and quarantine ponds after 1 month.

Species	No. Held	% Survival
Pleurobema cordatum (Ohio pigtoe)	333	99.1
Quadrula pustulosa (pimpleback)	264	97.7
Megalonaias nervosa (washboard)	192	97.9
Ellipsaria lineolata (butterfly)	94	79.8
Elliptio crassidens (elephant-ear)	240	100
Quadrula metanevra (monkeyface)	36	100
Ptychobranchus fasciolaris (kidneyshell)	14	100
Cyclonaias tuberculata (purple wartyback)	12	100

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Using Physiological Measurements to Establish Water Quality Criteria for Freshwater Mussels

The primary objective of this study is to determine dissolved oxygen levels below which normal physiological function begins to fail in adult mussels. For this purpose, oxygen consumption and heart rate is measured over a range of dissolved oxygen levels. Oxygen consumption is measured by placing single mussels in plastic respirometer chambers equipped with an oxygen probe in the lid, and screen above the floor, and a magnetic stirring bar on the floor. The lid also has ports through which water can flow during acclimation to the chamber. As the animal lowers the dissolved oxygen in the sealed chamber, the oxygen probe records the dissolved oxygen, and these data are then used to generate oxygen consumption rate at different levels of oxygen availability.

Heart rate is detected using electronic means. For this purpose, a small hole is drilled in each valve in the vicinity of the heart. Small insulated wires (with the ends bared) are inserted through the holes and sealed in with "super glue". The heart activity is detected with an impedance converter and the sine wave pattern displayed on a polygraph. Heart rate can then be determined by counting the number of beats in a measured period of time.

Preliminary tests were performed on several species including pocketbook, butterfly, pheasant shell, fluted shell, spike, and pistolgrip. Considerable differences were noted in their ability to regulate oxygen consumption under hypoxia. For example, the butterfly mussel behaved more like an oxygen regulator whereas the pistolgrip was a conformer (i.e. oxygen consumption declined with dissolved oxygen level). But these preliminary measurements also showed there is marked variability within a species. Extensive work on *Anodonta grandis* may help us to understand the sources of some of that variability.

The effect of photoperiod on heart rate and shell opening was examined. Mussels (*Anodonta grandis*) from Calytor Lake were maintained under a photoperiod of 12:12, while heart rate was electronically recorded and shell opening visually recorded. There was a marked diurnal pattern; the mussels opened more frequently in the dark and had higher heart beat rates then, Generally speaking, the heart beat (and rate of oxygen consumption) are low when the shell is closed. From this, it is obvious that measurements are very different if the animals are in the dark as opposed to light.

Those animals that showed relatively good ability to regulate oxygen consumption under a declining dissolved oxygen have a relatively low rate of oxygen consumption at the beginning of the experimental run. Those that act more like conformers, on the other hand, have a higher rate of oxygen consumption when the chamber is first sealed. The cause of this difference is not obvious at this time.

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Cont:

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Experiments were run on *Anodonta* that has been just captured and on other specimens that had been kept in the aquaculture center at Virginia Tech for at least one month. No obvious differences were seen between these two groups in their responses to low oxygen. Thus, at least for this species, duration of acclimation to laboratory conditions does not appear to be an important variable. *Anodonta* over a range of body weights of 30 to 190g were run at different levels of dissolved oxygen. No statistical differences were detected in their ability to regulate based on body size over this range.

The heart beat of mussels under declining dissolved oxygen was measured in both the closed respirometer system and in an open aquarium. For the open system, compressed nitrogen was used to lower the dissolved oxygen level in a step-wise fashion while the heart rate was electronically monitored. In some of the animals, an increase in heart rate was detected at the lower levels on DO, but then as the DO got even lower, the heart rate began to decline. As with the oxygen consumption work, the ability to regulate was often associated with a low rate of heart beat under normoxic conditions. It was further found that if the same animals in the open system were exposed to the same experimental protocol the next day, they exhibited somewhat less ability to regulate on the second day.

Specimens of eastern elliptio were captured in the Nottaway River in September 1993. The patterns of opening and closing of the valves were examined over a week, and it was found that this species showed no diurnal rhythm. There was also no diurnal rhythm in oxygen consumption when this was measured over a period of 96 hours in normoxic water. Surgery to detect the heart activity was tried on five of the mussels and it was learned that they are rather sensitive to it. All five died within a month of drilling the holes. Therefore, no further heart rate experiments are to be done on this species. Experiments have been run on heart beat changes under declining dissolved oxygen, oxygen consumption rate and their relationships to body weight, The raw data are currently being analyzed,

Overall, we have gotten a good solid start on this research project. Unanticipated variables, both environmental and intrinsic to the individual specimens, are being explored so we have a better idea of the overall biology of these animals, and how that affects physiological measurements. For example, the effect of the amount of algae in the water on oxygen consumption rate is currently being measured.

Add

TVA CONDUCTS TWO LARGE MUSSEL RELOCATION PROJECTS

Kentucky Mooring Cells Project

During June 1993, TVA divers relocated native mussels out of two 16x16 meter squares just downstream from Kentucky Dam (TRM 21) where new mooring cells are to be built. Each square was divided into 256 one square meter areas, each of which was individually searched for live native mussels. Results from each square meter search were maintained separately. In eight field days, the divers removed a total of over 18,300 live mussels representing 23 species, none of which is listed as endangered by the U.S. Fish and Wildlife Service. Average density from both squares was near 35 animals per square meter. Almost all animals encountered were transplanted into suitable habitat in the Tennessee River just downstream from the I-24 bridge. Animals not transplanted by TVA were transferred to Dr. David Berg, Miami University, for genetic studies or to Dr. James Sickel, Murray State University, for use in a transplantation experiment. Three adult zebra mussels were encountered during this work, two in the upstream square and one at the relocation site. Two of the zebra mussels were attached to rocks and the third was attached to a relict shell.

No Marking or Follow-up

Pickwick Channel Widening Project

In September and October, TVA divers relocated native mussels from much of the area to be affected when a two-mile reach of the navigation channel just downstream from Pickwick Landing Dam is widened (TRM 204 - 206). For this project, the search area was laid out in a set of 469 20x20 meter squares. Each of these squares was (or is to be) searched by divers swimming along movable lines between anchored baselines. Before cold air and water temperatures forced the work into a winter recess, 72 percent of the squares had been searched and 7,300 native mussels had been collected. Within the nearly 120,000 square meters of area searched (about 30 acres), mussel density averaged 0.07 animals per square meter. Only a few of the 20+ species encountered were represented by anything other than very old, eroded individuals. Notable finds included nearly 50 specimens of the orange-foot pearly mussel, Plethobasus cooperianus, a federal endangered species; and two specimens of the spectaclecase, Cumberlandia monodonta, a candidate for federal endangered or threatened status. All mussels recovered from the project site were transplanted to suitable habitats within the Pickwick tailwater mussel sanctuary except for 20 orange-foot specimens which are being held in the TVA mussel channel on the Browns Ferry Nuclear Plant reservation. In spite of a reward for their recovery, only three zebra mussels were found during this project (all attached to rocks). The status of this mussel relocation project will be reviewed with the U.S. Fish and Wildlife Service and the Tennessee Wildlife Resources Agency this winter, and the mussel relocation is likely to be completed during Summer 1994.

Old and Decrepid No - Follow up

Contact John Jenkinson (615/751-6903) for more information about either of these projects.

WMC2239R

Some reproduction there

Duck River still being monitored. Few left at transplant site

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Table 1. Unioidae collected from the Walhonding River, Coshocton County, Ohio, 1991-1993.

		live	dead	old-dead
1.	*Anodonta imbecillis*	3	1	0
2.	*Anodonta grandis grandis*	111	9	4
3.	*Strophitus undulatus undulatus*	164	36	4
4.	*Alasmidonta marginata*	47	5	8
5.	*Lasmigona complanata complanata*	1056	18	2
6.	*Lasmigona costata*	501	9	14
7.	*Lasmigona compressa*	10	2	3
8.	*Tritogonia verrucosa*	145	2	10
9.	*Quadrula quadrula*	14	0	2
10.	*Quadrula cylindrica cylindrica*	20	0	15
11.	*Quadrula pustulosa pustulosa*	90	5	17
12.	*Amblema plicata plicata*	1909	16	6
13.	*Fusconaia maculata maculata*	7	0	16
14.	*Fusconaia flava*	37	9	3
15.	*Cyclonaias tuberculata*	123	4	5
16.	*Plethobasus cyphyus*	5	0	7
17.	*Pleurobema clava*	0	1	14
18.	*Pleurobema sintoxia*	1	0	4
19.	*Elliptio dilatata*	16	1	20
20.	*Ptychobranchus fasciolaris*	10	3	11
21.	*Cyprogenia stegaria*	0	0	13
22.	*Actinonaias ligamentina carinata*	3187	27	6
23.	*Obovaria subrotunda*	7	1	12
24.	*Leptodea fragilis*	25	9	2
25.	*Potamilus alatus*	2	0	0
26.	*Ligumia recta*	24	1	8
27.	*Villosa fabalis*	1	1	4
28.	*Villosa iris iris*	31	2	2
29.	*Lampsilis radiata luteola*	515	20	1
30.	*Lampsilis ventricosa*	180	8	6
31.	*Lampsilis ovata*	8	0	3
32.	*Lampsilis fasciola*	42	1	7
33.	*Epioblasma triquetra*	8	1	5
34.	*Epioblasma obliquata obliquata*	0	1	0
	Total	7999	193	234

Hoggarth Cont.

The Unionidae of the Walhonding River, Coshocton County, Ohio.

The Walhonding River supports a rich unionid fauna. Table 1 lists the number of live, dead, and old-dead specimens collected from 1991-1993. All living specimens were returned, while the dead shells were retained as vouchers. Historically, three species listed as endangered by the federal government, have lived in the river: *Pleurobema clava*, *Cyprogenia stegaria*, and *Epioblasma obliquata obliquata*. None of these were found alive during this study, although a very fresh-dead shell of *P. clava*, and a fairly fresh-dead shell of *E. o. obliquata* were found. State endangered species found living in the river included *Quadrula cylindrica cylindrica, Fusconaia maculata maculata, Plethobasus cyphyus, Villosa fabalis*, and *Lampsilis ovata*. Two of these species, *V. fabalis* and *E. triquetra*, are Category 2 species currently being considered for federal protection. All of the data relative to this project will be available soon as a report to the Ohio Department of Natural Resources, Division of Natural Areas and Preserves (see below).

Recent Publications

Hoggarth, Michael A. in prep. The Unionidae of the Walhonding River, Coshocton County, Ohio. Final Report to the Ohio Department of Natural Resources, Division of Natural Areas and Preserves.

Hoggarth, Michael A. 1993. Population Status of Ohio Endangered Species, 1993. U.S. Fish and Wildlife Service, Reynoldsburg Field Office, 6950-H Americana Parkway, Reynoldsburg, Ohio 43068-4115. 33 p.

Hoggarth, Michael A. 1993. Glochidial functional morphology and rarity in the Unionidae. Pages 76-80 *in* K.S. Cummings, A.C. Buchanan, and L.M. Koch, eds. Conservation and Management of freshwater mussels. Proceedings of a UMRCC symposium, 12-14 October 1992, St. Lewis, Missouri. Upper Mississippi River Conservation Committee, Rock Island, Illinois.

Robert S. Butler, U.S. Fish and Wildlife Service, 6620 Southpoint Drive South, Jacksonville FL 32216 (904/232-2580)

The following abstracts are for presentations at the annual meetings of the Association of Southeastern Biologists and North American Benthological Society, respectively, both this spring in Orlando, Florida. The former is part of a special session on the "Zoogeography of Florida", while the latter will be given in a "Status of Native Freshwater Mussels of North America" special session.

SUPERCONGLUTINATES: AN EXTRAORDINARY METHOD OF GLOCHIDIAL EXPULSION/HOST FISH ATTRACTANT IN FRESHWATER MUSSELS. Robert S. Butler, U.S. Fish and Wildlife Service (FWS), 6620 Southpoint Drive South, Jacksonville FL 32216; Paul D. Hartfield, FWS, 6578 Dogwood View Parkway, Jackson MS 39213; and Wendell R. Haag, U.S. Forest Service, Forest Hydrology Lab, P.O. Box 947, Oxford MS 38655.

Female unionids incubate larvae (glochidia) in their gills. Glochidial expulsion is either as individual glochidia, or as packets (conglutinates) representing contents of individual water tubes of marsupialized gills. Most glochidia must complete a parasitic stage on a fish host prior to juvenile transformation. Female unionid mantle modifications resembling small fish, worms, or aquatic insects, or conglutinates resembling worms or grubs may be utilized as potential host fish attractants. A new method of glochidial expulsion/fish host attractant is described for the orange-nacre mucket, *Lampsilis perovalis* (Conrad, 1834), a federally threatened Mobile Basin endemic. The marsupium in this species represents the posterior-ventral portion of the outer gills. Both gills' conglutinates are packaged as a unit (superconglutinate), expelled, and suspended at the end of a gelatinous strand up to 2.4 m long. Superconglutinates are 2.5-3.5 cm long, pisciform in shape, cream colored, with black stripes and eyespots, and when suspended resemble distressed minnows. Other Gulf Slope species may produce superconglutinates based on marsupium shape or observations of old superconglutinates.

DISTRIBUTION PATTERNS OF THE FRESHWATER MUSSELS (FAMILY UNIONIDAE) OF FLORIDA. James D. Williams, National Biological Survey, 7920 NW 71st Street, Gainesville FL 32606, and Robert S. Butler, U.S. Fish and Wildlife Service, 6620 Southpoint Drive South, Suite 310, Jacksonville FL 32216.

The river systems of Florida harbor a unionid fauna of more than 60 species belonging to 22 genera. Within this geographic area there are two major faunal regions with a total of 41 endemic species. The Apalachicolan Region, encompassing drainages from the Escambia River to and including the Suwannee River, and the Peninsular Region which includes the St. Marys River southward on the Atlantic Slope and the Waccasassa River southward on the Gulf Slope. There are 58 species of mussels in the Apalachicolan Region of which 31 are endemic. In the Peninsular Region there are 17 species of which five are endemic. In the two regions 18 species are endemic to a single river system. There are only 11 species that occur in both regions. Two additional species, *Elliptoideus sloatianus* and *Elliptio crassidens*, occur as fossils in the Peninsular Region but are found living in the Apalachicolan Region today. Most of this relatively diverse mussel fauna was derived from western Gulf drainages with the remainder originating from south Atlantic Slope systems.

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TVA CONDUCTS TWO LARGE MUSSEL RELOCATION PROJECTS

During June 1993, TVA divers relocated native mussels out of two 16x16 meter squares just downstream from Kentucky Dam (Tennessee River Mile 21) where new mooring cells are to be built. Each square was divided into 256 one square meter areas, each of which was individually searched for live native mussels. Results from each square meter search area were maintained separately. In eight field days, the divers removed a total of over 18,300 live mussels representing 23 species, none of which is listed as endangered by the U.S. Fish and Wildlife Service. Average density from both squares was near 35 animals per square meter. Almost all animals encountered were transplanted into suitable habitat in the Tennessee river just downstream from the I-24 bridge. Animals not transplanted by TVA were transferred to Dr. David Berg, Miami University, for genetic studies or to Dr. James Sickel, Murray State University, for use in a transplantation experiment. Three adult zebra mussels were encountered during this work, two in the upstream square and one at the relocation site. Two of the zebra mussels were attached to rocks and the third was attached to a relict mussel shell.

In September and October, TVA divers relocated native mussels from much of the area to be affected when a two-mile reach of the navigation channel just downstream from Pickwick Landing Dam is widened (Tennessee River Miles 204-206). For this project, the search area was laid out in a set of 469 20x20 meter squares. Each of these squares was (or is to be) searched by divers swimming along movable lines between anchored baselines. Before cold air and water temperatures forced the work into a winter recess, 72 percent of the squares had been searched and 7,300 native mussels had been collected. Within the nearly 120,000 square meters of area searched (about 30 acres), mussel density averaged 0.07 animals per square meter. Only a few of the 20+ species encountered were represented by anything other than very old, eroded individuals. Notable finds included nearly 50 specimens of the orange-foot pearly mussel, *Plethobasus cooperianus*, a federal endangered species; and two specimens of the spectaclecase, *Cumberlandia monodonta*, a candidate for federal endangered or threatened status. All mussels recovered from the project site were transplanted to suitable habitats within the Pickwick tailwater mussel sanctuary except for 20 orange-foot specimens which are being held in the TVA mussel channel on the Browns Ferry Nuclear Plant reservation. In spite of a reward for their recovery, only three zebra mussels were found during this project (all attached to rocks). The status of this mussel relocation project will be reviewed with the U.S. Fish and Wildlife Service and the Tennessee Wildlife Resources Agency this winter and the mussel relocation is likely to be completed during Summer 1994.

Mussel survey of the Lillard Mill site, Duck River, Marshall Co., Tennessee.

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In October of 1993, a survey for freshwater mussels was conducted at the Lillard Mill site, Duck River mile 179, Marshall Co., Tennessee. The Lillard Mill site is the home of a diverse mussel assemblage, including the largest known population of *Lemiox rimosus*. The intent of the survey is to initiate a time series of quantitative data. In this manner, the health of the population can be monitored with less disturbance to the site than would be caused by an intensive survey every few years. Thus, a relatively small number of replicate quadrat excavations were used (N=116).

An area of good mussel habitat was defined at the site, using substrata characteristics and the presence or absence of mussels as criteria. Within what was considered to be good mussel habitat, the mean mussel density was 17.8/m^2. When data both inside and outside of the good habitat is considered, the mean density was 3.1 mussels/m^2. Twenty-three species were encountered during the survey. *Lemiox rimosus* was the fifth most abundant species at the site, with a mean density of 1.5/m^2 within the good habitat. Species more abundant that *L. rimosus* were *Cyclonaias tuberculata* (4 mussels/m^2), *Truncilla truncata* (2.6 mussels/m^2), *Amblema plicata* (1.9 mussels/m^2) and *Quadrula pustulosa* (1.8 mussels/m^2). Two of the species, *Lexingtonia dolabelloides* and *Epioblasma capsaeformis*, are being considered for addition to the federal list of protected species. Within what was considered good habitat, *L. dolabelloides* had a mean density of 0.7 mussels/m^2 and *E. capsaeformis* averaged 0.05 mussels/m^2. *Lemiox rimosus* were aged and measured. Length measurements for *L. rimosus* ranged from 24.0 to 60.8 mm, with a mean of 42 mm (N=78). The age curve for *L. rimosus* peaked at approximately 7 years.

The overall perception was that the population at the site was healthy. Juveniles of several species, including *L. rimosus*, *C. tuberculata*, *Q. pustulosa*, *Tritogonia verrucosa*, *E. dilatata* and *Fusconaia barnesiana* were encountered. Many of the lampsiline species encountered were gravid. Continuation of surveys such as this on an annual basis should make any changes in the population apparent.

This project was funded by Tennessee Valley Authority. State and federal permission was obtained to survey for *L. rimosus*. We would like to thank Don Hubbs and Freddie Couch (Tennessee Wildlife Resources Agency) and Dr. Barry Payne (U.S. Army Corps of Engineers, Waterways Experiment Station) for their assistance with the field work on this project.

DEVELOPMENT OF A DIET FOR REARING EARLY JUVENILE FRESHWATER PEARLY MUSSELS. Catherine M. Gatenby, Richard J. Neves, and Bruce C. Parker. VA Tech, Blacksburg, VA 24061. 703/231-5921

Because of significant declines in native mussel populations, a study was undertaken to develop a diet for rearing juvenile mussels, with the goal of long-term propagation of rare species. Three trials were conducted to test various tri-algal and commercial diets and to determine the influence of silt in survival and growth of the rainbow mussel (*Villosa iris*) and giant floater (*Pyganodon grandis*).

Overall, growth and survival required the presence of a substratum (silt). At 45 days post-metamorphosis, juvenile rainbow mussels in silt and fed algae exhibited a 2-fold increase in shell length, and 63.5% survival. In comparison, juveniles fed algae without silt exhibited no increase in shell length, and only 5.0% survival. Giant floater juveniles exhibited similar results at 45 days post-metamorphosis. After 60 days, growth of the giant floater fed on an algal diet and reared in various substratum which included kaolin, sterlized silt with ABA (bacteria), and sterilized silt only was similar to growth of juveniles fed algae in silt with natural associated bacterial flora. Maximum shell length of the giant floater after 60 days was 1.1mm with 59% survival. Juveniles of both the rainbow mussel and the giant floater appear to be pedal-feeding for about 140 days post-metamorphosis; hence, silt provides a substrate for juveniles to collect food particles.

Subsequent tests indicated that growth was significantly correlated with the quality of the diet (algae high in oils). Juveniles fed a tri-algal diet, consisting of *Neochloris oleoabundans, Phaeodactylum tricornutum, and Bracteacoccus grandis* (NPB), with silt substratum showed the best growth over time (140 days), with a 9-fold increase in shell length (mean = 2968µm; maximum = 4520µm) and 30.0% survival at 140 days post-metamorphosis. Commercial yeast diets did not support growth.

Rainbow mussels juveniles from Trial 1 were monitored for 272 days and had 10 survivors, representing 5% survival. Giant floater juveniles were monitored for 192 days and exhibited 12% survival.

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Commercial Mussel Survey

The Indiana DNR closed the state's mussel harvest in September 1991 and has completed the second year of a three year study to evaluate this resource. Sites surveyed in 1992 were revisited in 1993. Specimens marked in 1992 were recovered at all sites although recapture success was variable ranging from 13% to 37.4%. Thin sectioning the shells of recaptured mussels indicates that internal shells rings are formed annually, although ring clarity is variable between species. Our estimates show that threeridge, *Amblema plicata plicata*, the fastest growing species aged, reaches 2 1/2 inches in height between age 9 and 10 years. The pimpleback, *Quadrula pustulosa*, the slowest growing species reaches 2 1/2 inch height at age 23 years. Ages of the largest shells aged are variable, ranging from age 27 - 32 for mapleleaf, *Quadrula quadrula*, to age 24 - 60 for pimplebacks.

Population density, based on transect sampling, ranges from 0.92 mussels/m^2 to 2.38 mussels/m_2 in the 11 river segments,(3 rivers). Several rare and endangered species were encountered during 1993 sampling including 3 federally listed endangered species the fanshell, rough pigtoe, and clubshell. Additionally, an apparently large but highly localized population of the snuffbox was found.

Fish Creek Oil Spill

Fish Creek in northeast Indiana and northwest Ohio is inhabited by the only known population of the white catspaw, *Epioblasma obliquata perobliqua*. This small stream has a total of 30 mussels species including 6 others that are rare and endangered. A diesel fuel spill into Fish Creek occurred in October 1993. The effects of this spill on the mussel community in the impacted area is being evaluated. *If anyone knows of other oil spills in streams harboring freshwater mussels I would be interested in discussing the circumstance and outcome.*

Sheepnose (*Plethobasis cyphyus*) reintroduction

The sheepnose, and Indiana endangered species has been eliminated from most streams that once support it. In 1994, we plan to infect sauger fingerlings with glochidia from Tippecanoe River or Ohio River populations. The infected sauger will be released soon after inoculation into potential habitat. We plan to repeat the stocking for at least 3 years and implement ongoing monitoring for sheepnose recruitment. Hopefully, the overall sauger population and sport fishery will also be augmented.

Life history research on *Cyclonaias tuberculata*, the purple wartyback

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Research on the life history of *Cyclonaias tuberculata* was continued this summer at the St. Croix River, Minnesota and at laboratories at the University of Minnesota. Gravid *C. tuberculata* were observed from mid-May through late-July in 1992, and on 25 July and 8 August in 1993. Fish naturally infested with glochidia were collected from the St. Croix River and are being analyzed to determine the species of glochidia infesting them.

Laboratory tests were conducted on a variety of fish species to determine/verify suitable hosts for *C. tuberculata* glochidia. Of 8 fish species tested this summer, yellow bullheads were found to be suitable hosts.

n	positive	n	negative
2	yellow bullhead	1	common carp
		1	black bullhead
		2	channel catfish*
		4	tadpole madtom
		1	burbot
		4	banded killifish
		1	freshwater drum

* - Fish died before end of test.

Average water temperature was 19 °C and juveniles were collected on average 33 after glochidia were exposed to the fish.

Channel catfish and yellow bullheads were identified as suitable hosts for *C. tuberculata* glochidia in 1992. Fish species with fewer than three individuals tested will be retested. Life history studies will continue this winter and next summer on *C. tuberculata* and other mussel species.

If you would like further information or would like to share information please contact Mark Hove at: University of Minnesota; 1980 Folwell Ave.; St. Paul, MN 55108; (612) 624-3019; FAX (612) 625-5299; or at mh@finsandfur.fw.umn.edu.

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Title: **Mitochondrial DNA variation of *Anodonta grandis grandis* Say in Colorado**

The distribution of *Anodonta grandis grandis* Say in Colorado has changed with increasing levels of habitat disturbance and reintroduction into restored habitats. Brandauer & Wu (1979) listed two sites for *A. g. grandis* in Colorado. Herrmann & Fajt (1985) revisited these two sites and they believed that *A. g. grandis* is extinct in these sites. However, they reported four new records of *A. g. grandis* (Flagler Reservoir, Mayham Lake, C.F. & I. Reservoir No. 2, and 3). In 1986, two more Colorado sites of *A. g. grandis* were discovered by the Colorado Division of Wildlife (Washington Park and Cherry Creek Reservoir). In 1989, Wu reported one more site (Ft. Morgan) in Colorado. However, Wu also reported that the *A. g. grandis* fauna of Colorado is in critical condition because of industrial effluent and agricultural impounding of river water. Herrmann and Fajt transferred 412 *Anodonta grandis grandis* adults from C.F. & I. Reservoir No. 3 to the newly formed Pueblo Reservoir. Their goal is to restore the mussels to its entire native habitat in eastern Colorado.

To guide conservation efforts, we need baseline data describing genetic variation and population structure to make wise decision concerning the management and reintroduction of the mussels. For this reason, we examined the genetic diversity within and among populations of *Anodonta grandis grandis* in Colorado with mitochondrial DNA Restriction Fragment Length Polymorphisms (RFLPs). Our initial results show that there are several distinct mitochondrial DNA patterns within Pueblo and Cherry Creek populations. In each of these localities, all mussels with glochidia (at the time of collecting) had the same type of mitochondrial DNA. Mussels without glochidia had other forms of mitochondrial DNA, and the frequencies of these forms varied among localities.

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SURVEY of the UNIONID MUSSELS of the ELKHORN RIVER BASIN: NEBRASKA.

A survey consisting of 55 stations in the Elkhorn River basin in northeastern Nebraska documented a unionid fauna of twenty-nine taxa for the region. In the only previously published work on the Elkhorn River, Aughey (1877) reported a total of only twenty species. The present study confirmed nine of his identifications, but could not locate evidence of the remaining eleven taxa. Nineteen previously unreported species and one additional subspecies were confirmed for the Elkhorn basin. Three of these additions, Arcidens confragosus (Say, 1829), Obovaria olivaria (Rafinesque, 1820) and Lampsilis teres teres (Rafinesque, 1820) are especially important in that they have not previously been reported for Nebraska.

Unfortunately, most of the species recovered were represented by weathered or eroded valves. Factors contributing to the decline of the unionid populations of the basin include grazing, channelization, siltation, and pollution. A manuscript on this study is currently in progress.

Aughey, Samuel. 1877. Catalogue of the land and freshwater shells of Nebraska. *Bulletin of the U.S. Geological and Geographical Survey of the Territories 3(3):697-704.*

EARLY DYNAMICS OF THE ZEBRA MUSSEL INVASION OF THE HUDSON RIVER ESTUARY, NEW YORK. **David L. Strayer, Institute of Ecosystem Studies, Box AB, Millbrook, NY 12545.** (914) 677-5343

The zebra mussel, Dreissena polymorpha, was first seen in the Hudson River estuary in the spring of 1991. The population originated from two sources: a human introduction in the center of the estuary and fluvial transport into the head of the estuary. The population in the estuary now exceeds 200 billion animals (>1000 per m^2, estuary-wide), reaches into the oligohaline part of the estuary, and forms over half of the biomass of benthic invertebrates in the estuary. Despite these high densities, fouling of unionid clams still is relatively minor (mean = 0.4 zebra mussels per clam). In the middle 65 km of the estuary, I estimate that zebra mussels filter the entire water column in less than a day during the summer. Probably because of intense adult-larval interactions caused by these high filtration rates, the 1993 year class of zebra mussels was very poor. I predict that the future trajectory of the zebra mussel population in the estuary (and in similar ecosystems) will be erratic.

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SURVEY of the UNIONID MUSSELS of the UPPER REPUBLICAN RIVER BASIN: NEBRASKA, KANSAS, COLORADO.

A survey of 103 stations in the Republican River Basin above the Harlan County Dam in south central Nebraska documented a unionid fauna of twelve species for the region. Extant populations were located for eight species, however, the remaining four species were represented solely by eroded valves suggesting their extirpation from the region. Of particular interest was the recovery of an eroded valve of Obovaria olivaria (Rafinesque, 1820). O. olivaria was not reported by Aughey (1877), and the record from this study represents an addition to the known unionid taxa of Nebraska.

Analysis of distributional data indicates unionid populations are concentrated in and immediately below area reservoirs, and in tributaries to the Republican River. With the exception of reservoirs on the Republican River, and a one mile stretch immediately below the Trenton dam, no living mussels were found in the Republican River. Unionid shells obtained from non-reservoir associated stations on the Republican River were limited to a total of one identifiable valve and two unidentifiable fragments, indicating a general absense of unionids in the Republican River proper. A manuscript on this study is currently in progress.

Aughey, Samuel. 1877. Catalogue of the land and freshwater shells of Nebraska. *Bulletin of the U.S. Geological and Geographical Survey of the Territories 3(3):697-704.*

AN ABSTRACT OF A THESIS

HOST FISHES OF FOUR SPECIES OF FRESHWATER MUSSELS, AND DEVELOPMENT OF AN IMMUNE RESPONSE

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Host fishes were identified for *Medionidus conradicus, Lasmigona costata, Elliptio dilatata,* and *Ptychobranchus subtentum.* Twenty fish species representing seven families were infected with glochidia in the laboratory to enable positive identification of host species. Transformation periods varied among species and ranged from 10-40 days. *Medionidus conradicus* transformed on rainbow darters (*Etheostoma caeruleum*) and striped darters (*E. virgatum*). Hosts identified for *P. subtentum* were rainbow darters, redline darters (*E. rufilineatum*), fantail darters (*E. flabellare*), barcheek darters (*E. obeyense*), and banded sculpin (*Cottus carolinae*). *Lasmigona costata* glochidia metamorphosed on 11 fish species. Few glochidia of *E. dilatata* were available for infecting fish, but metamorphosis occurred on rainbow darters, banded sculpins, and rockbass (*Ambloplites rupestris*).

To determine if fish developed immunity to glochidia, six redline darters and seven rainbow darters were subjected to three infections of glochidia of *M. conradicus.* Metamorphosis occurred on 100% of the rainbow darters during the first two infections but declined to 83% in the third infection. Although transformation occurred on 100% of redline darters after the first infection, metamorphosis occurred on 83% of the fish after the second infection and on only 50% of the fish after the third infection.

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A survey of the unionid fauna of the Susquehanna River Basin in Pennsylvania.

The Pennsylvania Wild Resource Conservation Fund has just funded the first year of a two year survey of the unionid fauna of the Susquehanna River Basin in Pennsylvania. This portion of the Susquehanna Basin coveres 26,988 square miles. This is the first survey of the basin since the monographic work on the unionid fauna of Pennsylvania by Ortmann (1919). There is evidence that some portions of the basin are impacted by acid mine drainage, but other portions appear to remain in good condition. The historic fauna was composed of approximately nine species (Ortmann 1919). Sepkoski and Rex (1974, Sys. Zoo.) reported 11 species based on information from R.I. Johnson.

AN ABSTRACT OF A THESIS

EFFECTS OF COMMERCIAL EXPLOITATION ON UNIONID DENSITY AND HABITAT USE IN THE GREEN AND BARREN RIVERS, KENTUCKY

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Master of Science in Biology

Unionid populations were monitored over a three-year period in two rivers in southcentral Kentucky to determine the effects of commercial exploitation on density and habitat use. Densities of unionids were estimated at five permanently marked sites on the Green and Barren Rivers, Kentucky. Commercial harvest by brailing was legal on four sites; one site on the Green River was closed to all unionid harvest. A stratified random sampling design was used and twenty-five 0.25-m^2 quadrat samples were taken from each 100 m^2 stratum. Estimated unionid densities ranged from 3.1 to 3.8 individuals/m^2 among sites in 1990. The greatest density occurred on the site closed to commercial harvest. Densities decreased by 0.4 to 1.1/m^2 among the four sites open to commercial harvest over the three year study. However, not all differences were significant. Density of commercially valuable species at the site closed to harvest was significantly lower in 1991. Legal and illegal harvest activities are suggested as causative factors for decreases in unionid densities at some sites.

Habitat variables were measured at 2.5-m intervals along transects established perpendicular to the stream flow in the center of each 20-m-long sampling site. These habitat availability data along with results from the 1990 and 1991 quantitative survey were used to determine unionid habitat use. Hydraulic models were constructed to describe unionid habitat use in each 2.5-m by 20-m cell for normal low flow conditions. Habitat use varied among areas; these differences seem to be related to the amount of commercial harvest activity in each area rather than to differences in habitat preference.

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AN ABSTRACT OF A THESIS

FACTORS INFLUENCING THE DISTRIBUTION AND ABUNDANCE OF FRESHWATER MUSSELS IN THE BARREN RIVER, KENTUCKY, WITH EMPHASIS ON THE ROLE OF HOST FISHES

Jeffrey L. Weiss

Master of Science in Biology

Five 150-m-long sampling sites were established within a 5 km reach of the Barren River. Twenty-seven species of mussels were collected including the federally endangered *Pleurobema plenum*. Mussel densities range from 1.0/m^2 to 6.3/m^2 and varied significantly. Species richness was similar among sites. *Amblema plicata* most frequently utilized sand and small gravel substrate in water 40 to 100 cm deep and velocities from 5 to 15 cm/s; the other 26 species, as a group, occurred over a somewhat broader range of habitats. Differences in mussel abundance among sites may be due to habitat requirements of juvenile mussels and host fishes. Mussels were most abundant on sites with high fish abundance.

Of 2,510 fish (43 species) examined, 4.1% were infected with glochidia. Infection rates were similar (4.0% to 5.5%) among four of the five sites. Only 1.5% of fish examined from the fifth site were infected. The number of fish infected on each site was significantly correlated ($P<0.05$) with fish species richness on each site. Amblemine glochidia were present on fish from December through July due to an extended period of infections by glochidia of *Megalonaias nervosa*. Seasonality of glochidial infections by anodontines and lampsilines generally agrees with reported periods.

Glochidial infections were observed on 25 fish species (11 families). Fourteen of these species have not been identified as a host for any of the mussel species collected. Amblemine glochidia infected the most species (19); anodontine and lampsiline glochidia infected eight and four fish species, respectively. Differences in host specificity occurred among species within subfamilies. Potential new hosts were identified for five mussel species and *Pleurobema* spp.

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