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First Record of *Helisoma trivolvis trivolvis* (Say, 1816) from Newfoundland, Canada

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ABSTRACT

Helisoma trivolvis trivolvis (Say, 1816) is reported from the province of Newfoundland and Labrador, Canada, for the first time. The subspecies is apparently restricted to a single locality on the west coast of the island of Newfoundland. Specimens and habitat are typical.

INTRODUCTION

Helisoma trivolvis trivolvis (Say, 1816), the most abundant of the large eastern Canadian helisomas, occurs throughout the boreal and deciduous forest regions from Nova Scotia to southwestern Manitoba, with a small occurrence in central Saskatchewan. It is characteristic of well-vegetated perennial-water lakes, ponds, and slow-moving streams, and prefers mud as a substrate (Clarke, 1981).

From 1924 to 1929, American botanist Bayard Long collected molluscs while botanizing in western and northern Newfoundland. The results of these efforts were published by E.G. Vanatta in 1925, 1927, and 1930. In 1934, S.T. Brooks collected on the northwest coast as well, mainly in the Bonne Bay area (Brooks, 1936; Brooks and Brooks, 1940). Neither Vanatta nor Brooks reported *H. trivolvis*.

DISCUSSION

During the past four years, both authors of the present paper have carried out extensive field surveys of the land and freshwater molluscs of Newfoundland and parts of Labrador. These surveys are preliminary to the compiling of a field guide to the land and freshwater molluscs of the Province.

On July 15, 1983 the senior author collected eighty-six live specimens (65 adults, 21 juveniles) of a large helisoma from a small (2 ha.) pond on the west coast of the Island of Newfoundland. The pond is situated on the west side of Route430, at the hamlet of Three Mile Rock, approximately 3 km south of Parson's Pond, Great Northern Peninsula (50°00'30"N 57°44'00"W).

The specimens from the pond at Three Mile Rock were determined to be Helisoma trivolvis trivolvis, and thus constitute a range extension for both the species and the sub-species to the province of Newfoundland and Labrador.

The specimens were found mostly on and under muddy, algae-covered rocks in shallow water near the eastern shoreline of the pond. One juvenile specimen was obtained from the underside of a water lily pad (Nuphar variegatum Engelmann) in shallow water near the western shoreline of the pond. The dominant submergent vegetation was the watermilfoil Myriophyllum exalbescens Fernald; less common was a stonewort (Chara sp.). The substrate of muddy, algae-covered rocks is similar to that reported as a preference of H. trivolvis trivolvis (Clarke, 1973).

On August 5, 1985 additional specimens were collected from the same locality by the junior author. However, a search of the ponds and streams in the surrounding area at that time failed to locate other populations of the species. It appears to be restricted to a single locality.

The Newfoundland specimens appear typical of the subspecies *trivolvis*, although they are slightly smaller, with a size range for adult specimens from 17 to 25.2 mm in width, and from 9 to 12.6 mm in height. The periostracal color is yellowish-brown to dark olive-brown, and the apertural band is reddish-brown to purplish-brown.

The planorbid *Gyraulus deflectus* (Say, 1834) and an unidentified pisidiid clam, were also obtained from Three Mile Rock. Clarke (1973) notes that other planorbids are often found in association with *H. trivolvis trivolvis*.

It was a great surprise to find such a large and obvious species occuring at such a singular and restricted locality in the province. There is no apparent inlet or outlet to the pond, and apart from its close proximity to the coastal hamlet of Three Mile Rock, there is no obvious explanation for its introduction to the site. Its status as a relict species is undetermined.

Specimens from the original site have been deposited in the collections of the Newfoundland Museum (NFM MO-246), of the senior author (RGN G887L205), and of Dr. A.H. Clarke, ECOSEARCH, Inc., Portland, Texas.

ACKNOWLEDGEMENTS

We appreciate the assistance of Dr. Arthur H. Clarke, who verified the identification of the above subspecies and helped us with identification of other species of freshwater molluscs from Newfoundland.

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Notes

Occasional Papers on Mollusks is published at irregular intervals by the Department of Mollusks, Museum of Comparative Zoology, Harvard University, Cambridge, Mass. 02138. All mollusk workers who do not receive this important series containing diverse articles in malacology are urged to write the Editor for a price list.

A useful publication, "Effects of Contaminants on Naiad Mollusks (Unionidae) : A Review" by Marian E. Havlik and Leif L. Marking, has recently been published.

A copy may be obtained without charge by writing to Publications Unit, U.S. Fish and Wildlife Service, Matomic Building, Room 148, Washington, D.C. 20240.

A First Account of the Marine Mollusks of La Blanquilla Island, Venezuela

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ABSTRACT

A preliminary list of marine molluscs from Isla La Blanquilla off northeastern Venezuela is presented. It is based principally on three independent collection made between 1972 and 1985, but it also includes other species cited in the previous literature from this island but not found during this investigation. A brief description of the island is also given.

INTRODUCTION

The taxonomy and distribution of the molluscan fauna of venezuelan waters have been studied in a systematic manner during the last three decades. Several productive localities have not been yet sampled exhaustively, especially those of difficult access. This is the case in regard to some small islands off the venezuelan continental coast, viz. Los Monjes, Los Frailes, La Tortuga, Los Testigos, Los Hermanos, and La Blanquilla.

The identifications of the marine molluscs of the insular territory of central and eastern Venezuela have been done principally by Buisonje et a (1957), Coomans (1958), Rodriguez (1959), Rehder (1962), Flores (1968, 1973), Princz (1973, 1978, 1982), Flores & Caceres (1980), 1981), Princz & Gonzalez de Pacheco (1981), and Talavera & Princz (1984). It is also important to mention three

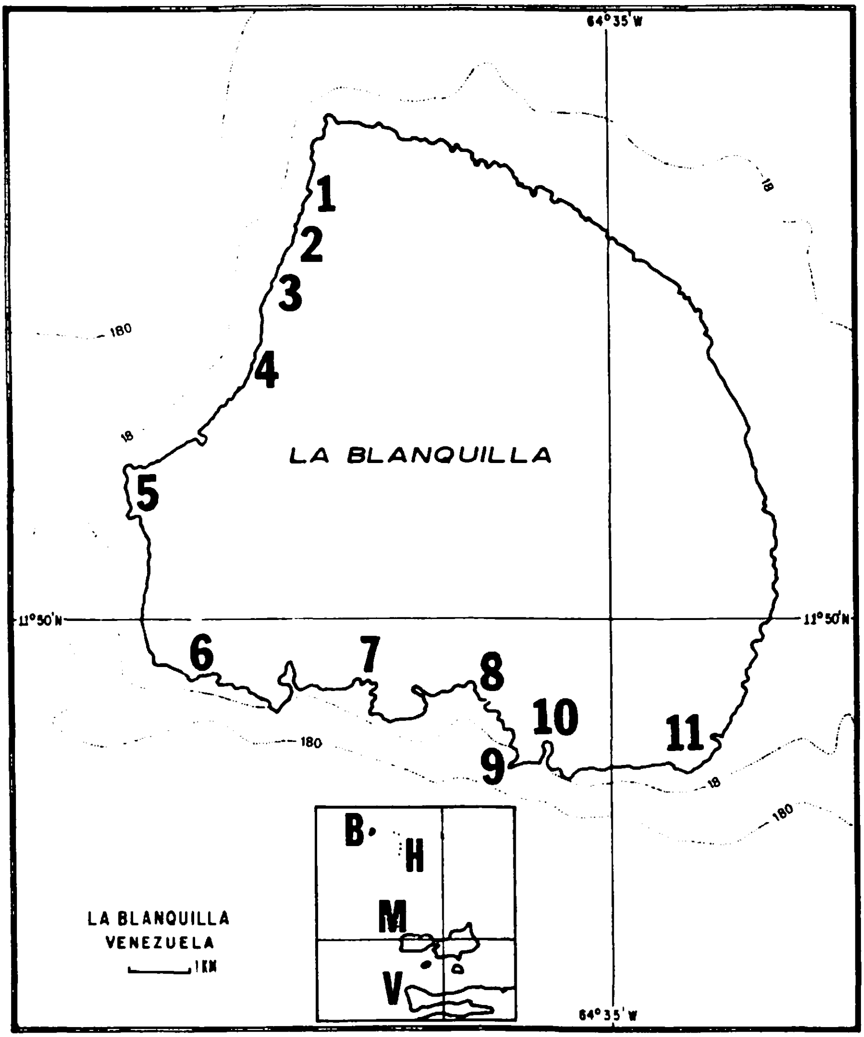

FIG. 1. SAMPLING SITES: 1) Manzanillo Largo 2) La Laja 3) La Muerta 4) Manzanillo 5) La Aguada 6) Punta Bobos 7) Las Tres Playas 8) Falucho 9) Punta La Langosta 10) No Martin 11) Cabecera
GEOGRAPHICAL REFERENCES: B La Blanquilla. H- Los Hermanos. M- Margarita Island. V-Venezuela.

scientific cruises that sampled molluscs in this area: the "Chazalie" (Dautzenberg, 1900), the "Pillsbury" (Bayer, 1974), and the "Velero III" (Garth, 1945; McLean & Poorman, 1970).

In this context, the objective of this work is to present a preliminary inventory of the coastal molluscs of one of those unattended islands, La Blanquilla. To my knowledge, only five references exist concerning the malacology of the island: Dautzenberg (1900), who reported 26 different species; Zuloaga (1953), who listed some fossil species; Flores (1973), who recorded six species in his revision of the Littorinidae of Venezuela; and Flores & Caceres (1980, 1981), who recorded the presence of *Cittarium pica* and *Astraea tuber*. In addition to this, a general natural history description of the island was written by Varela & Cardenas (1984).

The list of species herein is the result of three independent samplings organized by the Estacion de Investigaciones Marinas de Margarita (EDIMAR) between 1972 and 1985. In all cases, molluscs were collected manually from the supra-littoral level down to a depth of five meters. The sites of sampling were located on the western and southern coasts of the islands.

I sincerely appreciate Drs. Donald Moore (Rosenstiel School of Marine and Atmospheric Sciences, Miami) and Francisco Garcia Talavera (Museo Insular de Ciencias Naturales, Canary Islands) for their comments on the manuscript of this article. My deepest appreciation is also extended to the staff of EDIMAR and to the students of the Instituto Universitario de Tecnologia del Mar for their support.

GEOGRAPHY & GENERAL COMMENTS

La Blanquilla, also known by Isla Blanca (and not to be confused with La Blanquilla Reef in the Gulf of Mexico), is one of the external members of the insular territory of Venezuela. The island is located at approximatively 87 km northwest of Margarita Island. With a surface of 52.5 km , and a perimeter of 25 km, La Blanquilla is formed by three Quaternary terraces over a shallow shelf. The highest point above sea level is of 30 m (Shubert & Moticska, 1973; Williams, 1980). The island is triangular in shape and most of its coasts are mainly abrupt. Its eastern margin is constituted by relatively high cliffs which are practically inaccessible because of their exposure to strong currents and winds. The southern coast is low and indented. The sites Caranton, Las Tres Playas, and Falucho are muddy sand beaches surrounded by mangroves. The locality of No Martin presents the same features but is particularly narrow and deep. Punta La Langosta is a rocky point with tidal pools on its exposed margin and a long sandy beach on the protected side. The subtidal level at Falucho and Punta Bobos shows important coral communities. Finally, the western coast is formed by a sequence of very clean sandy beaches (Manzanillo Largo, La Laja, La Muerta, Manzanillo, and La Aguada), devoid of mangroves and skirted by scattered rocks. The submerged shelf is more conspicuous on the windward margin of the island, otherwise, the other coasts slope steeply. During one of the trips to the island, a 24-hour gale swept the region (August 16-17, 1978), possibly related to the path of hurricane Cora. Certain localities were visited afterwards and the collections were rewarded by a great diversity of fauna and flora displaced over the supralittoral level.

CLASS GASTROPODA

Fissurellidae
Emarginula pumila (A Adams, 1851)
Hemitoma octoradiata (Gmelin, 1791)
Diodora cayennensis (Lamarck, 1822)
Diodora minuta (Lamarck, 1822)
Lucapina suffusa (Reeve, 1850)
Fissurella nodosa (Born, 1778)
Fissurella angusta Gmelin, 1791
Acmaeidae
Acmaea leucopleura (Gmelin, 1791)
Acmaea pustulata (Helbling, 1779)
Trochidae
Cittarium pica (Linnaeus, 1767)
Turbinidae
Astraea tecta americana (Gmelin, 1781)
Astraea caelata (Gmelin, 1791)
Cyclostrematidae
Arene tricarinata (Stearns, 1872)
Neritidae
Nerita peloronta Linnaeus, 1758
Nerita versicolor Gmelin, 1758
Phenacolepidae
Phenacolepas hamillei (Fischer, 1857)
Littorinidae
Littorina meleagris (Potiez & Michaud, 1838)
Littorina ziczac (Gmelin, 1791)
Littorina lineolata d'Orbigny, 1840
Echininus nodulosus (Pfeiffer, 1839)
Nodilittorina tuberculata (Menke, 1828)
Tectarius muricatus (Linnaeus, 1758)
Turritellidae
Turritella variegata (Linnaeus, 1758)
Caecidae
Caecum pulchellum Stimpson, 1851
Vermetidae
Petaloconchus erectus (Dall, 1888)
Serpulorbis decussatus (Gmelin, 1791)
Spiroglyphus irregularis d'Orbigny, 1791
Planaxidae
Planaxis nucleus (Bruguiere, 1789)
Planaxis lineatus (Da Costa, 1778)
Potamididae
Batillaria minima (Gmelin, 1791)
Cerithidae
Cerithium litteratum (Born, 1778)
Cerithium lutosum Menke, 1828
Seila adamsi H C Lea, 1845
Hipponicidae
Hipponix antiquatus (Linnaeus, 1767)
Hipponix subrufus subrufus (Lamarck, 1819)
Capulidae
Capulus incurvatus Gmelin, 1791
Crepidulidae
Cheilea equestris (Linnaeus, 1758)
Strombidae
Strombus gigas Linnaeus, 1758
Strombus pugilis Linnaeus, 1758
Strombus gallus Linnaeus, 1758
Strombus costatus Linnaeus, 1791
Eratoidae
Trivia pediculus (Linnaeus, 1758)
Cypraeidae
Cypraea zebra Linnaeus, 1758
Cypraea cinerea Gmelin, 1791
Ovulidae
Simnia uniplicata (Soverby, 1848)
Cyphoma gibbosum (Linnaeus, 1758)
Cassidae
Cassis madagascariensis Lamarck, 1822
Cymatiidae
Cymatium pileare (Linnaeus, 1758)
Cymatium nicobaricum (Roding, 1789)

Muricidae
Purpura patula (Linnaeus, 1758)
Coralliophilidae
Coralliophila caribaea Abbott, 1958

Columbellidae
Columbella mercatoria (Linnaeus, 1758)
Nitidella laevigata (Linnaeus, 1758)
Mitrella argus (d'Orbigny, 1758)
Buccinidae
Pisania pusio (Linnaeus, 1758)
Fasciolariidae
Leucozonia nassa (Gmelin, 1791)
Latirus mcgintyi Pilsbry, 1939
Olividae
Ancilla tankervillei (Swainson, 1825)
Turbinellidae
Vasum capitellus (Linnaeus, 1758)
Volutidae
Voluta musica Linnaeus, 1758
Marginellidae
Marginella lavalleeana d'Orbigny, 1842
Marginella catenata (Montagu, 1803)
Persicula pulcherrima (Gaskoin, 1849)
Gibberulina ovuliformis (d'Orbigny, 1842)
Retusidae
Pyrunculus caelatus (Bush, 1885)
Acteocinidae
Acteocina candei (d'Orbigny, 1842)
Acteocina bullata (Kiener, 1834)
Melampidae
Melampus monile (Bruguiere, 1789)
Detracia bullaoides (Montagu, 1833)
Pedipes mirabilis (Muhlfeld, 1816)

CLASS BIVALVIA
Arcidae
Arca zebra (Swainson, 1833)
Barbatia cancellaria (Lamarck, 1851)
Anadara chemnitzi (Philippi, 1851)
Arcopsis adamsi (Dall, 1886)
Glycymeridae
Glycymeris decussata (Linnaeus, 1758)
Mytilidae
Brachidontes dominguensis (Lamarck, 1819
Pectinidae
Chlamys ornata (Lamarck, 1819)
Plicatulidae
Plicatula gibbosa Lamarck, 1801
Spondylidae
Spondylus americanus Hermann, 1781
Ostreidae
Ostrea frons Linnaeus, 1758
Chamidae
Chama macerophylla (Gmelin, 1791)
Arcinella arcinella (Linnaeus, 1767)
Lucinidae
Linga pennsylvanica (Linnaeus, 1758)
Lucina nassula (Conrad, 1846)
Divaricella quadrisulcata (d'Orbigny, 1842)
Cardiidae
Americardia media (Linnaeus, 1758)
Laevicardium laevigatum (Linnaeus, 1758)
Tellinidae
Tellina laevigata Linnaeus, 1758
Tellina fausta Pulteney, 1799
Tellina listeri Roding, 1798
Donacidae
Donax striatum Linnaeus, 1767
Psammobidae
Asaphis deflorata (Linnaeus, 1758)
Veneridae
Chione cancellata (Linnaeus, 1767)

CLASS SCAPHOPODA
Siphonodentaliidae
Polyschides tetraschistus Dall, 1881

CLASS AMPHINEURA
Chitonidae
Chiton marmoratus Gmelin, 1791
Acanthopleura granulata (Gmelin, 1791)

Within the species recorded by Dautzenberg (1900), Zuloaga (1953) and Flores (1973), several were not found in our collections. These original records permit to increase this inventory by 23 additional species:

Dautzenberg (1900): Diodora listeri (d'Orbigny, 1842); Fissurella barbadensis (Gmelin, 1791); Fissurella nimbosa (Linnaeus, 1758); Littorina angustior (Morch, 1876) [=Littorina (Melarhaphe) carinata d'Orbigny, 1842]; Thais haemastoma floridana (Conrad, 1837) [=Purpura (S.) floridana Conrad, 1837]; Anadara notabilis (Roding, 1798) [=Arca (Anadara) deshayesi Hanley, 1843]; Brachidontes exustus (Linnaeus, 1758) [=Mytilus (Hormomya) lavalleanus d'Orbigny, 1842]; Lima lima (Linnaeus, 1758) [=Radula caribaea d'Orbigny, 1842]; Lima scabra (Born, 1778); Cardita gracilis (Shuttleworth, 1856); Trachycardium muricatum (Linnaeus, 1758); Pedalium isognomon Linnaeus, 1758 [=Perna lamarckeana d'Orbigny, 1853]; Codakia imbricatula CB Adams, 1851 [=Lucina (C.) occidentalis Reeve, 1850]; Donax denticulatus Linnaeus, 1758.

Zuloaga (1953): Atys caribaea (d'Orbigny, 1841) [=Atys sharpi Vanatta, 1901]; Conus sp.; Liotia sp.; Natica sp.; Olivella floralia Duclos, 1853; Olivella rotunda Dall, 1889; Strigilla pisiformis (Linnaeus, 1758); Transenella sp.

Flores (1973): Littorina angulifera (Lamarck, 1822)

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Notes on the Anatomy of Neopilina (Vema) ewingi Clarke & Menzies, 1959 (Monoplacophora).

Henning Lemche and Karl G. Wingstrand

Editor's Note. Shortly after Neopilina ewingi was discovered, two of the original 4 specimens, i.e. those from R/V Vema Station 151, were sent to Professors Lemche and Wingstrand for anatomical study. These paratype specimens were 9.2 and 12.5 mm long and were dredged from a depth of 3195-3201 fathoms off northern Peru at 7°30'S, 81°25'W. The findings, described in this letter, were received too late for inclusion in the original description (Science 129 (3355): 1026-1027) and constitute the only existing information about the anatomy of this important relict species.

Copenhagen, March 6th, 1959

Dear Dr. Clarke,

I have just sectioned the two specimens of Neopilina from the "Vema". The small one was cut in 8 u paraffin sections, the big one in 30 u celloidin sections. Sectioning was difficult in both cases, for the intestine of the small animal was full of stones and other hard things, and the periostracum of the big specimen caused trouble with the 30 u sections, which are rather thin for colloidin material. However, no sections were lost, but some were somewhat disarranged. I did my best, and I hope you will not feel that I have dealt carelessly with this valuable material.

The small specimen. The very delicate tissues of the small specimen were not so well preserved except for the anterior end and the ventral parts which are fairly good. It has 6 pairs of gills but is in all other respects like the big, 30-mm. Neopilinas of the Galathea expedition. However, nothing can be said about the coelom and the nephridia and the heart, which all were damaged or destroyed when the back of the animal was crushed. But the entire radula apparatus with all the complicated muscle strings is the same as in N. galatheae, and the radula vesicles are not collapsed as in our specimens but can be studied in their proper position in detail. The teeth of the radula are - as far as observed-exactly as in N. galatheae, although in a miniature issue: a rod-like median, a rod-shaped 1st lateral, big, hook-like 2nd and 3rd laterals, a comb-like thin plate representing the 4th lateral, and a plate-like 5th lateral with a small, little prominent, hook. The nervous system, the statocysts and the mouth appendages, like the entire musculature show interesting details and confirms beautifully previous observations on N. galatheae. Differentiation of the outer epithelia is slight as compared with our specimens. The animal is not sexually mature. No gonads whatever can be detected, but this may in part depend on a somewhat incomplete preservation of the region, which makes it impossible to recognize gonads in an embryonic state.

The big specimen is well preserved in many details, e.g. in the digestive system, in the outer epithelia, the nervous system (which is beautiful in comparison with our material), in the musculature and in the appendages. However, the nephridia and the coelom like the pericard and the heart are poorly preserved. One gets the idea that some of these fluid-filled cavities "exploded" when the animal contracted vigorously at death. The buccal apparatus is well-preserved with beautiful, non-collapsed radula vesicles and the entire complicated musculature in situ. The periostracum is in places intact from the periostracum gland on the ventral side to the shell edge, where it turns over into the shell.

There are 6 pairs of nephridial openings at the base of the 6 pairs of gills. The extra gill is thus situated as we guessed at the place where N. galatheae has a nephridium but no gill, just behind the oral region. The specimen is not sexually mature. It has two pairs of gonoducts in the proper place, connected with gonoducts to the 3rd and 4th nephridium on each side. But the gonad rudiments are very small (a few percent of the adult gonad) and do not show any formation of germ cells. It is not even possible to tell the sex of the specimen. The outer epithelia are only slightly differentiated as compared with our specimens. The exit of the intestine from the stomach is asymmetrical, not sub-median as in our specimens. There is a crystalline style pouch but no crystalline style is preserved.

The radula could not be studied in all details, but the 2nd and 3rd lateral look more complicated than in N. galatheae, where they are fairly simple, Chiton-like hooks. I am not really sure, however. Could you possibly make a total preparation of the radula from some damaged specimen, if there is one. I can send you a figure of N. galatheae's radula.

Some anterior cavities, described by us as anterior extensions of the dorsal coelom, seem to be connected with the pharyngeal diverticula. This was a real shock to me and made my sleep bad last night. For this was clearly a misinterpretation. The region was severly damaged in both our specimens, and we thought all cavities with pigment-containing cells of the characteristic type were coelomic cavities. Now we must reconsider all this again, and the character of the "dorsal coelom" should depend on the connections with the nephridia. Unfortunately this region is completely exploded in the Vema specimens. The question must be left open, and we shall introduce a note in our report, now with the printer, to the effect that the interpretation of the dorsal coelomic cavities is made less catagorical.

No larval shell was found in any of the two specimen, but a spiral-shaped surface structure on the apex might indicate that there has been one. How about the other specimens? The larval shell is very small (o,15 mm.) and is difficult to see even in a binocular dissecting microscope.

Altogether, it was marvelous to see the new material and to be able to confirm so many obscure points. And even if a few questions will remain unsolved, the report on the Vema material will increase our knowledge of these interesting animals considerably.

With many kind regards from Dr. Lemche and myself,

Karl G. Wingstrand

A New Location for the Federally-Listed Endangered Unionid Lampsilis abrupta (Say, 1831) (="Lampsilis orbiculata (Hildreth, 1828)"), The Pink Mucket, in the Upper Ohio River Bordering West Virginia.

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MacArthur, WV 25873

Besides the upper free-flowing 3.5 miles of the Kanawha River in West Virginia, L. abrupta was thought to have been extirpated from the entire Ohio River Basin in the Ohio River and its tributaries above the mouth of the Green River. Recently, on August 13, 1987, biologists with the U.S. Fish and Wildlife Service and the West Virginia Department of Natural Resources discovered a population in the mainstem of the Ohio River in the upper Navigation pool.

Two adult L. abrupta, a male and a female, were collected by dovetail brail. These specimens were located in 16 to 18 feet of water in a substrate of clean-swept sand, gravel, and cobbles. Sixteen species of mussels were collected from the site. Of these, two species, Elliptio crassidens and Actinonaias ligamentina carinata, were thought to have been extirpated, in the region and three species, Quadrula metanevra, Pleurobema cordatum, and Plethobasus cyphyus, are considered rare in Ohio by state agencies there. This site is also the farthest upriver site for Fusconaia ebena.

A comprehensive survey of the mussel bed will be conducted in the future to determine the extent of this valuable natural resource. All appropriate Federal, State, and private resource agencies have been notified of this important discovery.

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The Freshwater Naiads of Ohio, Part V
Wabash River Drainage of Ohio

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ABSTRACT

Sixteen freshwater naiad collections were made in the upper Wabash drainage of Ohio, a casual collections not a part of a planned project, in the years 1938 through 1942. Calvin Goodrich had encouraged the author to give attention to the area he had collected in 1913, to determine what naiads he had missed on his "excursion".

Goodrich took 14 species from the Wabash (Brooks) 1943), to which the author added _Quadrula quadrula_, _Alasmidonta marginata_, _Lasmigona complanata_, _L. costata_, and _Lampsilis ovata ventricosa_. Goodrich had found _Pleurobema cordatum coccineum_, _P. clava_, _Alasmidonta calceolus_, and _Ptychobranchus fasciolare_, which were not found by the author. _Lasmigona complanata_ showed a greater change in distribution and abundance in the upper Wabash than any other species since Goodrich's time. The 43 forms, subspecies, and species reported by Clark (1987) from the Maumee drainage had equal opportunity to colonize the upper Wabash; but were probably impeded by the heavy silt loads there.

INTRODUCTION

The lower end of the Wabash River probably received more attention from early malacologists than any other midwestern stream, in part because Thomas Say, Gerard Troost, and other eminent naturalists lived near its banks in the "utopian" community of New Harmony, Indiana. Call (1900) appropriately referred to Say as the "father of American conchology". Many studies have been made of the naiads of the Wabash, but only the paper by Ortmann (1919) gives any information about the mussels of its headwaters in Ohio.

At our first meeting, Calvin Goodrich encouraged the author to give attention to that area of the upper Wabash which he had collected in 1913. Environmental concerns, as indicated by the activities of the Natural Heritage Program, and the general requirement for environmental impact statements prior to implementation of water projects, emphasize the desirability to make available all existing information about the fauna and flora of the past and present. It is hoped that the data presented here will be useful in meeting some of those needs.

METHODS AND MATERIALS

This paper is based on collections of naiads made during the years 1938 through 1942 when the author had the time and opportunity to make them.

Sixteen sites were collected over the four years; four of which were collected twice at intervals of from one to four years. Most of the collecting was done during the summer, when the stream was at its lowest level, and the visibility was at its greatest. Most of the specimens were taken by muddling or by the use of a garden rake because the water transparency seldom permitted visual collecting. The collecting effort at each station was never less than one hour and seldom more than two hours.

Collections of 20 or less of each species were retained. Specimens in excess of 20 from each site were identified, sometimes measured, and replaced in the substrata. Specimens were deposited in the University of Michigan Museum of Zoology and the Museum of Comparative Zoology at Harvard University.

ACKNOWLEDGEMENTS

Calvin Goodrich fostered the author's desire to collect the Wabash River in Ohio, and Henry van der Schalie was a stimulus and constant guide in all the molluscan work the author has done in the last 45 or more years. Dr. van der Schalie also verified the identifications of all the specimens retained.

Dr. Arthur Brooks, former Curator of Recent Invertebrates at the Carnegie Museum of Pittsburg, provided the author with a list of the mussels collected in the Wabash in Ohio by Goodrich and with data based on these collections.

PHYSIOGRAPHY

The Wabash is one of the major tributaries of the Ohio River. It drains most of the state of Indiana, a large area of Illinois, and a very small portion of Ohio. In Ohio small tributaries from Dark County flow northward into Mercer County where they combine to form the headwaters of the Wabash River. From there the river is diverted westward by the St. John's moraine, through which it cuts near Ft. Recovery, Ohio. It then flows northward for 12 or 13 miles where it is again diverted westward, into Indiana, by the Wabash moraine.

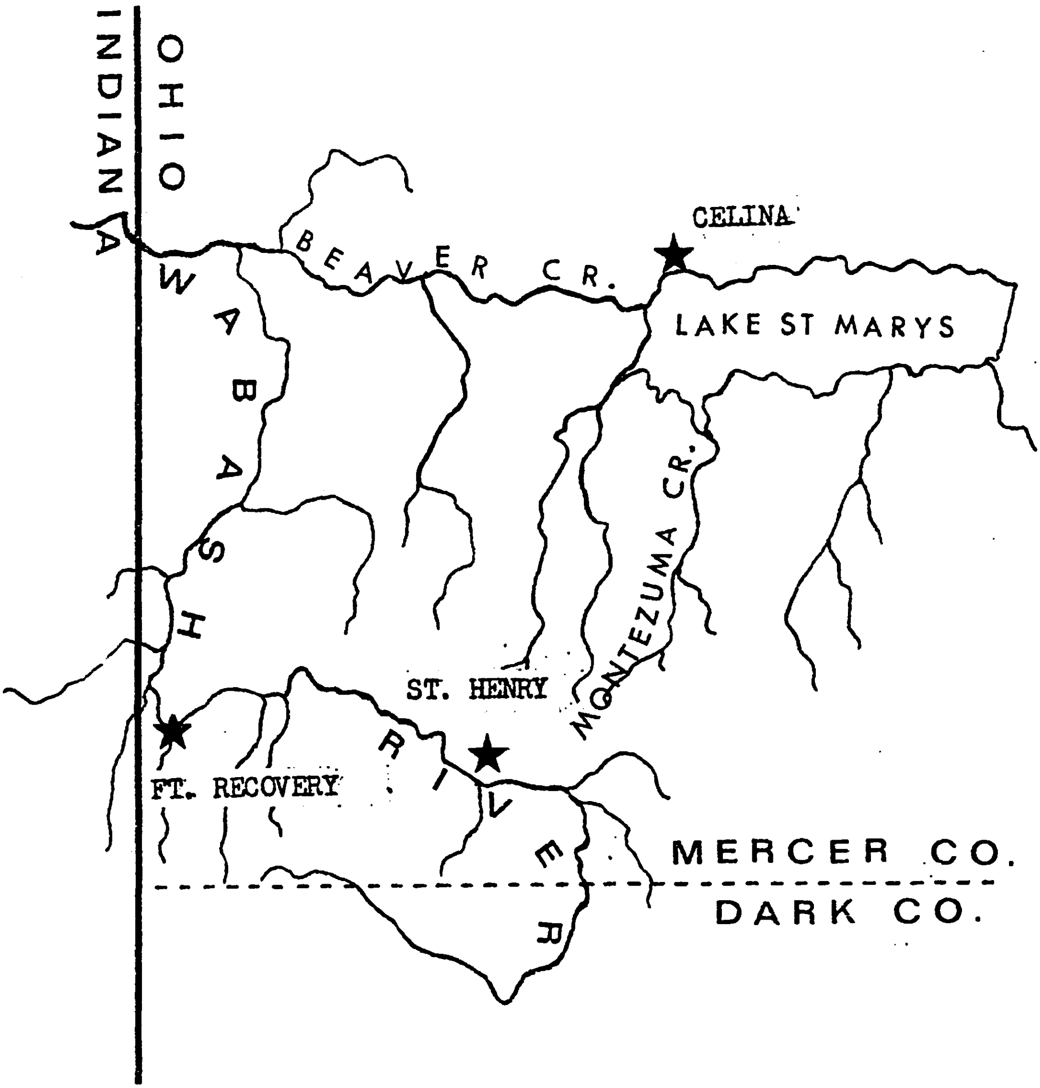

Figure 1, Wabash River Drainage in Ohio.

Ohio's Wabash lies chiefly in Mercer County, the bulk of which is a continuous plan lying between the St. John's and Wabash moraines. These moraines reach heights of 10 to 30 feet above the interlying plain and are composed of stratified gravel and sand capped with some clay. The underlying rock comes close to the surface in several areas of the county, and is exposed in several locations in the river bed north of Ft. Recovery. The county is covered with glacial drift containing layers of blue clay of 10 to 15 feet in depth. Howe (1904) stated, "Much of the county is still covered with forest, while the soil of that which has been occupied by farmers is not infrequently too damp and cold to bear a high market price". This swamp forest deposited a thick layer of humus over the clays. The sand and gravel ridges, underlying layers of blue clay, a minimum of gradient, and a heavy coating of humus collectively contribute to poor drainage and provided a slow but rather stable water supply for the streams, during summer, prior to settlement.

In recent historical time, several large areas south of the St. John's moraine were mostly occupied by cranberry marshes or bogs which were flooded in the spring and remained wet throughout the remainder of the year. The largest was nearly 1,000 acres in size. They contained deposits of peat four or more feet in thickness. Their location in the headwaters of the Wabash added to the stability of the stream flow in summer. Small areas of these bogs existed at the time of the author's collecting in the basin.

The Wabash River arises in terrain of an altitude of 1050 feet above sea level and flows into Indiana at an altitude of 838 feet. It has an average fall of slightly over five feet per mile; but one of its tributaries is listed as having 27.3 feet fall in 4.6 miles of stream (Krolosyk 1954). The fairly rapid run-off from the intensively cultivated farmland provides heavy silt loads in the main stream. Leverett (1897) reported that this upper portion of the Wabash Valley had been formed entirely by the parent stream and was a shallow, narrow trench.

As could be expected in such an area, beds are largely mixtures of gravel, sand and silt, the proportions of these sediments varying in response to local rates of stream flow, particularly during spring floods. The riffles are largely gravel with a few boulders; they also have some exposures of bedrock. Wherever the current slackens the substrate is covered with silt. Most of the small tributaries are either ditches or ditch-like in nature, dredged, and often contain eight to 12 inches of silt.

Also of significance is Lake St. Marys, a large, man-made lake which was formed by damming headwater streams of both the Wabash River and part of the Maumee River System, the St. Marys River. Before the lake was formed, Beaver Creek, the largest tributary of the Wabash in Ohio, arose south of the lake, flowed in a northwestern direction across what is now the west end of the lake, and down the channel which is now the outlet at the spillway. That part of the stream above (south of) the lake has now been named Montezuma Creek and only the portion below (west of) the spillway retains the name Beaver Creek. The original outlet of Lake St. Marys was at the east end through a lock into the canal feeder which led into the Miami-Erie Canal, but that lock was closed near the beginning of this century. The present outlet is at the west end of the lake over a spillway, which was completed about 1940. Thus Lake St. Marys provided direct opportunity for faunal migrations between the Wabash River (Ohio River System) and the Maumee River and the Miami-Erie Canal (both Great Lakes-St. Lawrence System) until barriers were created in this century.

When the author first became acquainted with the Wabash in 1937 it had a history of fish kills downstream from Ft. Recovery and in Beaver Creek below the spillway. These were caused by oxygen depleating wastes, with both sewage and milk wastes in the Wabash, and sewage and cannery wastes in Beaver Creek. The fish kills in the Wabash usually affected only a few miles of the stream and the recovery was rapid. As many as 22 species of fishes were taken from the affected area within a few weeks after some of the fish kills.

SPECIES DATA

Amblema costata Rafinesque, 1820

Brooks (1943) reported *A. costata* as taken by Goodrich in the Wabash three miles below Ft. Recovery, near St. Henry, and in the lower end of Beaver Creek. Six is the largest number found by the author at any one location in the stream. These were near Ft. Recovery. It was found at nine of the 16 sites collected.

Fusconaia flava (Rafinesque, 1820)

This species was collected by Goodrich three miles below Ft. Recovery. It was found by the author in the headwaters, in the central part of the stream in Mercer County, and near the Indiana State Line. Eleven specimens were collected from the three areas.

Table 1. Distribution of naiads in the Ohio portion of the Wabash River.

Locality	Date	Amblema costata Raf. 1820	Fusconaia flava (Raf. 1820)	Quadrula quadrula (Raf. 1920)	Uniomerus tetralasmus (Say 1831)	Alasmidonta marginata Say 1819	Anodonta grandis Say 1819	Anodonta imbecillis Say 1829	Anodontoides ferussacianus (Lea 1834)	Lasmigona complanata (Barnes 1823)	Lasmigona costata (Raf. 1820)	Strophitus undulatus (Say 1817)	Carunculina parva (Barnes 1822)	Dysnomia triquetra (Raf. 1820)	Lampsilis siliquoidea (Barnes 1823)	Lampsilis ovata ventricosa (Barnes 1823)
Bear Creek-Mercer Co.-Granville Twp.-Sec. 30	9/19/38						39		1		8				27	
Wabash River-Mercer Co.-Granville Twp.-Sec. 30-	6/20/40	6	1				2			3						
Wabash River-Mercer Co.-Granville Twp.-Sec. 35	9/1938	1									1					
Wabash River-Mercer Co.-Granville Twp.-Sec. 25	9/19/38	1					4		4				1			
Wabash River-Mercer Co.-Granville Twp.-Sec. 22	9/19/38	1	1				3		2							
Wabash River-Mercer Co.-Recovery Twp.-Sec. 21	8/21/40								.3	1				12		
Three Mile Creek-Mercer Co.-Liberty Twp.-Sec 22	9/19/38						7									
Wabash River-Mercer Co.-Washington Twp.-Sec. 28	8/31/40									4	1	1			5	4
Wabash River-Mercer Co.-Washington Twp.-Sec. 10	9/10/39					2	23		3	5	3	4		2	5	4
Wabash River-Mercer Co.-Washington Twp.-Sec. 3	9/19/38	1					6			3	2				2	4
Wabash River-Mercer Co.-Washington Twp.-Sec. 3	9/19/38						5		1	2	1	1				
Wabash River-Mercer Co.-Liberty Twp.-Sec. 33	6/28/41	1					2			1	1				1	1
Wabash River-Mercer Co.-Liberty Twp.-Sec. 32	6/15/41		5				1		2	2	1				3	
Wabash River-Mercer Co.-Liberty Twp.-Sec. 31	9/26/39						10		2	10					1	4
Wabash River-Mercer Co.-Liberty Twp.-Sec. 31	9/23/41	1					2			4						
Lake St. Marys-Auglaize Co.- St. Marys Twp.-Sec. 18	4/3/43				?		5	14								
Lake St. Marys-Mercer Co.-Jefferesen Twp.-Sec. 3	11/2/38			7	2		3						11			
Lake St. Marys-Mercer Co.-Jefferson Twp.-Sec. 3	5/9/41			2			1						2			
Lake St. Marys-Mercer Co.-Jefferson Twp.-Sec. 5	10/41		o		2								17			
Beaver Creek-Mercer Co.-Liberty Twp.-Sec. 35	8/14/42	2					4						1	1		

Quadrula quadrula (Rafinesque, 1820)

This species was not found by Goodrich during his 1913 collecting trip in the Wabash Basin. The author's specimens were found on the wave-swept beaches on the north shore of Lake St. Marys, where they had been thrown by heavy wave action of storms. Its presence in the reservoir at the extreme upper end of the headwaters of both the Wabash and St. Marys Rivers would permit its entry from either of the streams, or at a later date from the Miami-Erie Canal. It was reported from the St. Marys River in Mercer County by Ortmann (1919), and from the Miami-Erie Canal by Clark (1944), but not from the Wabash in Ohio.

Megalonaias gigantea (Barnes, 1823)

Goodrich (1914) wrote, "In a rather hurried collecting excursion along the main stream of the Wabash from St. Henry, Ohio to Bluffton, Ind., last fall, Unio crassidens Lam. and Quadrula heros (Say) possibly were the only species found which were unknown in the Great Lakes drainage". The author has been unable to locate any other information which suggests that these species were collected by Goodrich, and no specimens have been located.

Pleurobema clava (Lamarck, 1819)

Pleurobema, a highly disputed genus of variable forms, seems to be best represented in northwestern Ohio and northeastern Indiana by this form. Brooks (1943) reported that Goodrich collected this mussel in the Wabash three miles downstream from Ft. Recovery.

None were collected by the author from the Wabash in Ohio.

Uniomerus tetralasmus (Say, 1831)

Goodrich collected *Uniomerus* from Lake St. Marys in 1913 (Brooks 1943). Its presence there, and its absence downstream in the Ohio portion of the Wabash, suggests that its occurrence may be accounted for by the same theory as that for *Q. quadrula*. It was not only found by the author in the quiet backwaters and dredged channels of the lake, but on wave swept beaches, where it was cast up by heavy wave action. During the cleaning of the channels in St. Marys with a dipper dredge many "semi-fossils" were removed with the silt. They were at depths of eight to twelve inches.

Alasmidonta calceolus (Lea, 1830)

Goodrich found this small stream species in the main stream of the Wabash River, three miles downstream from Ft. Recovery, in 1913 (Brooks 1943). It normally is not found in such silty streams with very turbid waters. It may represent an accidental occurrence and not a population of consequence as discussed by Clark (1987) under History of the fauna.

Alasmidonta marginata Say, 1819

This species was not taken by Goodrich in 1913 (Brooks, 1943). The author found only two, both in an area of clean gravel, sand and boulder habitat in the Wabash about three miles above the entrance of Beaver Creek.

Anodonta grandis Say, 1829

Goodrich found "*A. g. footiana*" in the Wabash, Beaver Creek, and Lake St. Marys (Brooks, 1943). The author collected *A. grandis* at 13 of his 16 stations in the Wabash Basin. It was the most abundant species found. Thirty-nine specimens were found at the upstream station, where they were practically floating in the deep, soft silt, in a ditch-like situation. The variations in shell thickness, from the downstream gravel and rubble riffles and those of the upstream silty substrate were very obvious. The softer the bottom, the thinner the shell, seemed to be the rule.

Anodonta imbecilis Say, 1829

This "floater" was collected by Goodrich in Lake St. Marys in 1913 (Brooks,1943). Ortmann (1919) also credited him with finding it in the Wabash near Bluffton, Indiana, just west of the Ohio-Indiana State Line. The author found it to be rather common in the backwaters and channels of Lake St. Marys. It could have been in the small tributary streams of the Wabash and St. Marys when the lake was impounded, or it could have moved into the lake via the Miami-Erie Canal to which its distribution in southwestern Ohio is closely related (Clark, 1987).

Anodontoides ferussacianus (Lea, 1834)

Goodrich collected this mussel from the Wabash River near St. Henry in 1913 (Brooks, 1943). Eighteen specimens were found by the author at seven sites in the Ohio portion of the Wabash, in which it was rather uniformly distributed.

Lasmigona complanata (Barnes, 1823)

This mussel was considered by Goodrich (1914) as a late-comer to the Maumee Basin, to which it came via the Wabash-Erie Canal. His theory becomes more credible when we consider that he did not find it in his collecting from Ohio's Wabash in 1913 (Brooks 1943).

It was taken at eight of the author's 16 sites from 1938-1942. Ten were collected at one site. It was distributed throughout the main stream. It is difficult to explain why Goodrich did not find this large species if it had reached this area at the time of of his collecting.

<u>Lasmigona costata</u> (Rafinesque, 1820)

This mussel was not collected by Goodrich in 1913 (Brooks,1943). Yet, its widespread distribution in this part of the midwest indicates that it must have been in the watershed, if not in the upper Wabash in Ohio, 1913.

The author collected it at seven of his collecting stations during 1938-1942. It was distributed throughout the main stream of the river. Eight were taken at one site east of Ft. Recovery and a total of 16 were found at the seven stations where it was collected.

<u>Strophitus undulatus</u> (Say, 1817)

Goodrich collected this naiad three miles downstream from Ft. Recovery in 1913 and Brooks (1943) indicated that he also found it in the Wabash near St. Henry, Ohio.

<u>Carunculina parva</u> (Barnes, 1823)

This is the smallest of the mussels collected in the Ohio portion of the Wabash River. Goodrich found it in the main stream, near St. Henry, and in Lake St. Marys in 1913.

The author found only one specimen in the upper part of the river, but numerous ones were collected from Lake St. Marys. Eleven were found at one site, where they were thrown up on the beach by heavy wave action.

<u>Dysnomia triquetra</u> (Rafinesque, 1820)

Goodrich's collections of this species from Ohio's Wabash were listed by Brooks (1943) and cited by Johnson as coming from the river three miles north of Ft. Recovery and from Beaver Creek about one mile upstream from its mouth.

The author found *D. triquetra* at three different sites, two of which were very close to the sites at which Goodrich took it in 1913. The largest number of this species taken by the author in four decades of mussel collecting was from the main stream east of Ft. Recovery. Twelve were found in this riffle, one of the best in the Wabash in Ohio.

Lampsilis siliquoidea Barnes, 1823

This *Lampsilis* was the second most abundant mussel found in the Wabash by the author. Goodrich found it three miles north of Ft. Recovery and near St. Henry in 1913. The nomenclature conforms with Clark's discussion of the Maumee River naiads (1987).

Although this naiad ranked second numerically, it was found at only seven of the 16 stations collected in the Ohio portion of the Wabash. These sites were in the central portion of the stream in Mercer County.

Lampsilis ovata ventricosa (Barnes, 1822)

The name *ventricosa* is used by Burch (1975) in Figure 234 in the combination *Lampsilis ovata* form *ventricosa*. Fuller (1978) uses *L. o. ventricosa* and opens his discussion with, "This subspecies..." Johnson (1980) considered *L. o. ventricosa* as synonymous with both *L. ovata* and *L. ventricosa*. Goodrich and van der Schalie (1944) wrote, "...as one progresses into the headwaters, the sharp posterior ridge of the true *ovata* is seen to round off and we pass gradually to the more common form of the species in Indiana known as *Lampsilis ovata ventricosa* (Barnes)."

Ortmann (1919) credited Goodrich as finding this naiad in the Wabash River at Bluffton, Indiana close to the Ohio-Indiana State Line. The author found twenty at five sites in the central portion of the Wabash in Ohio. One specimen, which met the description of Lampsilis ventricosa (Barnes), recognized as a true species by Havlik and Stansbery (1978), was found in the central portion of the main stream.

Ptychobranchus fasciolare (Rafinesque, 1820)
This species was collected by Goodrich in the river three miles downstream from Ft. Recovery (Brooks,1943) but was not found by the author.

DISCUSSION

At our first meeting, Goodrich asked me to compare what he had found in the Wabash in Ohio in 1913 with what I could find 25 years later. He was of the opinion that more species might have extended their distribution and crossed the low divide between the Wabash and Maumee drainages since he had collected the upper Wabash. The author's collections from the Maumee River side of the divide are discussed by Clark (1987).

Goodrich collected both Pleurobema clava and P. cordatum coccineum in the Wabash. The rarity of the former was indicated by Wilson and Clark (1912) and varified by Clark (1987) for the streams of northwestern Ohio. Nevertheless it is difficult to understand why P. cordatum coccineum was not found by the author. Its habitat varies almost as much as its shell form, and it has found in most northwestern Ohio streams.

Alasmidonta calceolus would normally be expected to be present in the upper Wabash, but the turbid waters and heavy silt deposits are not its favorite habitat.

Goodrich (1914) seemed to anticipate that *Elliptio crassidens* and *Megalonaias gigantea* might someday enter the Maumee drainage from the Wabash. Clark (1987) failed to find either in the Maumee drainage, and no other suggestion of their occurrence other than Goodrich's 1914 comment given under *M. gigantea*.

Lasmigona complanata probably shows a greater change in distribution and abundance, from Goodrich's time of collecting to the author's, than any other species. Goodrich (1914) reported the lowermost station for this species, in the Maumee, as New Haven, Indiana, and did not find any in the Ohio portion of the Wabash. Five years previous to Goodrich's 1913 collecting, Wilson and Clark (1912) reported a few *complanata* at Maumee Center bridge, about seven miles below New Haven. Clark (1987) reported it from the Maumee almost to Lake Erie, and Table 1 indicates its presence up the Wabash almost to the source.

Lasmigona costata was found throughout the length of the Maumee by Wilson and Clark (1912) but it was not found by Goodrich in his 1913 excursion along the upper Wabash in Ohio (Brooks, 1943). The author collected it at nine sites scattered throughout the Wabash in Ohio. It is the author's opinion that neither of these *Lasmigona* were present, in the Wabash in Ohio, at the time Goodrich collected the area.

Otherwise the mussel communities found by Goodrich in 1913 (Brooks 1943) were not materially different from those found by the author 25-30 years later.

The species found by Goodrich, but not the author, are ones generally considered as requiring stable stream beds of sand and gravel, and clearer water than found in the Wabash at the time of the author's collecting.

Although Johnson (1980) reported 43 species as colonizing the Maumee drainage from the Wabash, only 19 are known to have colonized the upper Wabash in Ohio, and four of these have not been collected since those collected by Goodrich in 1913.

If Leverett's 1897 theory is correct, the upper Wabash was probably forming at the time the Maumee-Wabash outlet acted as a passageway for the lower Wabash River contributions of mussels to the Lake Erie drainage. In cutting its channel and tributaries through the colloidal clays laid down by the glacial lake, the Wabash headwaters must have been loaded with sediment, and characterized by high turbidities and soft mud substrate. Such conditions would not have been attractive to fish or conducive to the survival of mussel glochidia.

Ellis (1931) attributed the almost complete lack of mussels in the lower Mississippi to the tons of silt carried downstream and deposited in the stream bed. The upper Wabash must have presented a similar set of conditions while extending its channel.

Early descriptions of Mercer County, Ohio suggest that the water-laden soils could hold little additional moisture, and that heavy rains created many flood accompanied by heavy silt loads in the Wabash River. If the coils were too cold to be highly productive (Howe 1904), the seepage from them produce cold water streams, probably acid from the swamp and bog drainage, and thick layers of humus in the forests. If most of the county was forested at the time of Howe's visit (1904), a tremendous change in the water quality and habitat conditions in the Wabash must have taken place with the reduction of the forest to only 5.6 percent of the county by 1942 (Diller 1944). Yet, only four species of naiads were taken by Goodrich in 1913 that were not taken by the author in 1938 through 1942.

In general, the upper Wabash River mussel fauna is comprised of species tolerant to turbid waters and silted bottoms, conditions which seemingly have been characteristic of this portion of the stream for centuries.

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Occurrence of the Asiatic Clam, *Corbicula fluminea*, in the Canadian River and upper Red River drainage, Texas

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The first record of the Asiatic clam, *Corbicula fluminea* (Müller, 1774), in Texas was in agricultural canals in the El Paso area (Metcalf, 1966). Subsequently, *C. fluminea* has spread throughout the state except for the Trans-Pecos region (which has extremely limited water resources suitable for this clam), the Canadian River in the Texas Panhandle, and the upper Red River drainage upstream of Lake Texoma (Britton, 1982; McMahon, 1982; Counts, 1986). This report records the results of field surveys in the Canadian River and the upper Red River drainage of Texas.

Populations of *Corbicula fluminea* have been discovered at the following localities:

1) Lake Arrowhead, Clay County, is a 5468-hectare reservoir that was created in 1966 when a dam was constructed on the Little Wichita River. A survey of the freshwater bivalves of Lake Arrowhead on 29 August 1984 revealed populations of *Corbicula fluminea* at five of seven sample sites. Largest specimen measured only 25.4 mm in shell length, but presence of small individuals (less than 5 mm shell length) indicates that reproduction occurs in this lake. *C. fluminea* lives on rock riprap and soft substrates (clay loam to silty sand) but was noticeably less common to absent on hard clay substrates.

2) Lake Copper Breaks, Hardeman County, is a 4.1 hectare lake which formed behind a dam constructed in 1972 in Copper Breaks State Park. This population originated when sand from an unspecified source was placed along the shoreline of a swimming area in 1984. Some park visitors complained of

discomfort to feet while wading in the shallow lake water at the site. Comments by park visitors have decreased, but the population was still viable on 29 March 1987. Largest specimen recovered had a shell length of 29.1 mm. Clams are found in the unvegetated beach area where human foot traffic prevents growth of cattails. No clams were found in cattail marshes. Examination of the stream below the dam and the Pease River revealed no sign of Corbicula fluminea. An extensive population of this species does not exist in this portion of the Pease River; most likely no living clams occur in this portion of the river which consists of massive shifting beds of sand. Survey of a small, 0.3 hectare pond (originally a livestock pond) revealed a single valve well above the water line. This shell may represent an individual which was transported by a fisherman as bait or by a child as a curiosity. Populations are less likely to develop in this pond than the lake, because of colder winter water temperatures (see below) and lack of high energy, sandy beaches which are prime habitats (Neck, 1986).

3) Greenbelt Reservoir, Donley Co., is a 805-hectare reservoir which formed behind Greenbelt Dam which was constructed on the Salt Fork of the Red River in 1966. The shells were collected on the west side of a point of land about 300 meters west of the dam on a sandy clay and clayey sand substrate. Largest valve had a shell length of 29.55 mm. This collection was made by S. C. Caran on 27 March 1986.

4) Bugbee Canyon, Lake Meredith, Hutchinson Co., is a narrow inlet on the 8757-hectare reservoir with initial impoundment of the Canadian River in October 1964. Adult shells (up to 33.9 mm shell length) were common, in wet vegetative matter at the strand line. This population is the first record of Corbicula fluminea (or any bivalve species) in the Canadian River of Texas. Clench (1971) rported C. fluminea from the Canandian River in the Oklahoma City area. The Bugbee Canyon collection was made on 5 October 1987.

DISCUSSION

Paucity of permanent water bodies, tremendous variation in water flows in streams, relatively cold winter weather, and presence of substantial levels of salts (both halite and gypsum) provide limitations on the survival probabilities of newly established populations of *Corbicula fluminea* in the upper Red River drainage of northern Texas. Extended periods of winter cold appear to limit assimilation of nutrients and storage of sufficient lipid reserves to allow successful reproduction and increase winter survival probabilities (Joy, 1985). *C. fluminea* is absent from all of the midcontinent region northward of the Canadian River drainage (Counts, 1986). Most northern records are in thermal plumes associated with industrial or power generation plants. All four populations reported herein are composed of individuals which can be referred to the white morph of Hillis and Patton (1982).

ACKNOWLEDGEMENT

I thank S.C. Caran for shells collected at locality #3 and for field assistance at locality #4.

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New Prehistoric Distribution Records of Io fluvialis (Say, 1825) (Gastropoda, Pleuroceridae) in Tennessee with Comments on Form Variation

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ABSTRACT

Archaeological specimens of the Spiny River Snail, Io fluvialis, recovered in aboriginal sites along the Little Tennessee, Tellico and West Prong Little Pigeon rivers represent the first records of viable prehistoric populations of this aquatic gastropod from these rivers. Measurements of the most complete shells, including shell length and width, aperture length, height of spines and distance between spines were taken in an effort to arrive at the several forms represented through comparisons with metrical data presented by Adams (1915). Shells from the Little Tennessee and Tellico rivers exhibited characteristics typical of the big river forms; three distinct forms, ranging from headwaters to large river forms, comprised the Io material from the West Prong Little Pigeon River.

INTRODUCTION

Probably no other freshwater gastropod found in North America has invoked such interest, both from an aesthetic point of view and taxonomically, than has the Spiny River Snail, Io fluvialis (Say, 1925). A representative of the family Pleuroceridae, it is restricted in distribution to the Tennessee River system, especially the major tributaries of upper East Tennessee and southwestern Virginia. Changes in many of these streams, including the main Tennessee River, brought about as a result of

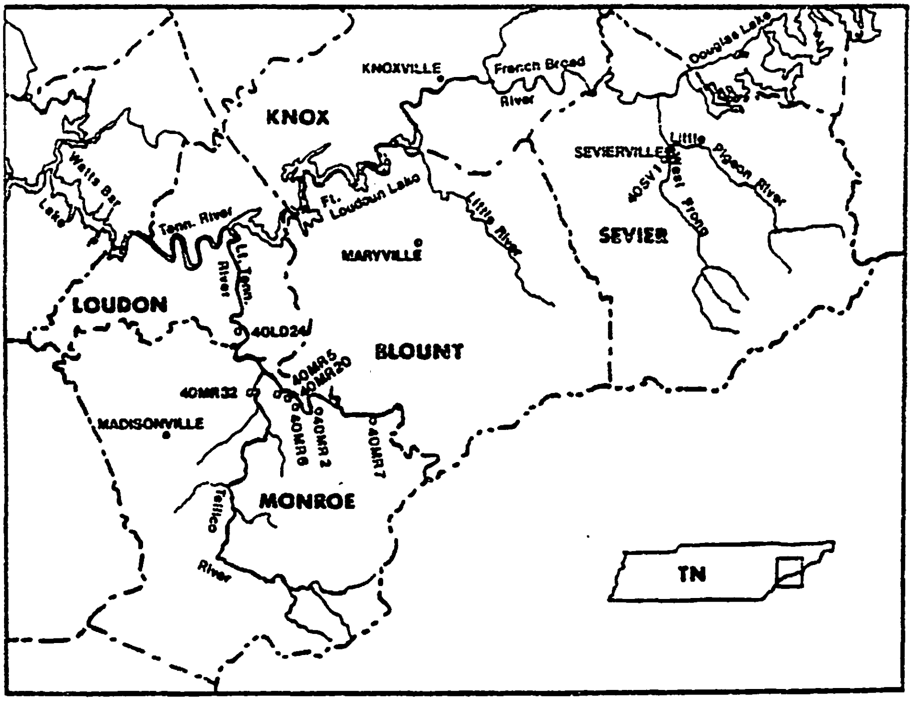


Figure 1. — Map showing the Little Tennessee, Tellico and West Prong Little Pigeon rivers and location of aboriginal sites from which Io fluvialis specimens were recovered.

impoundment, siltation and various forms of pollution have caused either total extirpation of or major reduction in populations throughout its former range. Shells of Io associated with aboriginal sites along the larger rivers in East Tennessee attest to its prehistoric distribution and probable local abundance.

Adams (1900, 1915) provided the most definitive work on Io fluvialis up to that time, and even today the latter reference stands as the most comprehensive single treatment of this species and its diverse forms. In light of the variation in shell size and morphological characteristics, Adams (1915:10) made the following observation: "There are so many variations and degrees of intergradation, and in so many directions, that it is very difficult to distinguish them; and probably few persons would agree as to where the lines of demarcation should be drawn." More recent studies by Lutz (1951), Lutz and Weese (1951), McLeod (1973), and McLeod and Moore (1978) have updated ecological, distributional and abundance data on this unique species, but their investigations have added little toward resolving taxonomic problems involving what appears to be a multitude of forms. However, the authors should not be faulted since they made every effort within the scope of their research designs to evaluate and compare shell morphology with that proposed by Adams (1915), and in light of changes resulting in alteration of river habitat during the period of ca. 50-60 years since the work of Adams.

METHODS

Construction of the Tellico Dam by the Tennessee Valley Authority, a 12 year project (1967-1979) that included major archaeological investigations in the Little Tennessee River valley, established the 16,500 acre Tellico Lake by inundating the lower 33 miles of the Little Tennessee River and the lower 22 miles of the Tellico River (Chapman,1985). Archaeological field crews from The University of Tennessee, Knoxville investigated literally hundreds of aboriginal sites that would be inundated by the proposed lake. Major excavations involving between 25 and 30 of the larger village and mound sites, or smaller aboriginal occupation areas of special significance, were carried out in as intensive a manner as time and funds would permit. Great quantities of both vertebrate and molluscan remains were recovered at many of these sites; the variety and numbers of animals represented in these middens attest to the dependency of these people on the local fauna in their subsistence (e.g. Bogan, 1980, 1983;

Table 1. Archaeological specimens of _Io fluvialis_ examined for this study.

Site Name	Site Designation	River	Total No. Specimens	Number Measured
Tomotley	40MR5	Little Tennessee	4	2
Toqua	40MR6	Little Tennessee	93	26
Citico	40MR7	Little Tennessee	11	8
Martin Farm	40MR20	Little Tennessee	1	
Bat Creek	40MR24	Little Tennessee	32	22
Starnes	40MR32	Tellico	1	1
McMahan	40SVI	West Prong Little Pigeon	261	84

Bogan and Bogan, 1985). Numerous shells of both freshwater mussels and gastropods were encountered at sites where the soil pH was neutral to sightly alkaline so as to prevent disintegration. Preservation of shell varied from fair (chalky, some erosion/breakage) to good (not chalky, hard, minimal breakage and flaking). Specimens of Io fluvialis were recovered at five sites along the Little Tennessee River and one on the Tellico River (Table 1, Figure 1). Cultural affiliation of people occupying sites from which specimens of Io were recovered were, for the most part, either Late Mississippian (Dallas), ca. A.D. 1300-1600 or historic Overhill Cherokee, ca. A.D. 1700-1820.

Of special interest is a series of I. fluvialis that was recovered at a Late Mississippian village and mound complex located along the West Prong Little Pigeon River, Sevierville, Sevier County (Figure #1). A large portion of the village lying adjacent to the south side of the mound was to be removed for topsoil, so during this soil removal operation that lasted from June through December 1985 the senior author was able to salvage a large sample of vertebrate and molluscan remains. For an open village site such as this, the McMahan Site (40SVI), shell was remarkedly well preserved; 45 species of freshwater mussels and six species of aquatic gastropods were represented.

Five measurements, in mm using a vernier caliper, were taken on the spinose forms of I. fluvialis, three on the smooth forms (Table 2).Specimens selected for measurement were complete or nearly so. In some individuals, the apex or tip of the anterior canal exhibited slight erosion and the total length (and length of aperture) was estimated, but all were judged to be within a 1.0 - 1.5 mm limit of correction. Measurements include: (1) length or height of shell, measured from the tip of the apex to the tip of the anterior canal; (2) aperture length, measured from the tip of the anterior canal to the posterior end of the aperture; (3) width of the shell, measured from the periphery of the last whorl just behind the outer lip of the aperture to a point on the opposite side of the shell; (4) height of spines, using the last or second-to-last spine nearest the aperture; (5) distance between the tips of the first and second, or second and third spines. Measurement (4) was perhaps the most variable because the spines project outward from a gradually sloping whorl that does not allow a consistant or distinct sharp-angled base for placement of the caliper.

Table 2. Measurements (mm) of Io fluvialis from aboriginal sites along the Little Tennessee, Tellico and West Prong Little Pigeon rivers, Tennessee

River (site) Io fluvialis form	Shell Length				Shell Width				Aperture Length				Spine Height			Distance Between Spines		
	N	R	$\bar{x}$	SD	N	R	$\bar{x}$	SD	N	R	$\bar{x}$	SD	N	R	$\bar{x}$	N	R	$\bar{x}$
Little Tennessee (Toqua: 40MR6) Io fluvialis form angitremoides	26	33.5 – 63.0	54.2	5.99	26	15.7 – 28.1	23.5	3.08	26	19.0 – 33.0	27.2	3.09	25	3.8 – 7.2	5.3	26	9.8 – 22.6	15.9
Little Tennessee (Bat Creek: 40LD24) Io fluvialis form angitremoides	22	33.0 – 63.5	45.8	8.17	22	13.2 – 24.0	19.1	3.23	22	17.0 – 30.6	23.3	3.57	22	3.0 – 7.0	5.3	22	9.8 – 17.3	13.1
Little Tennessee (Tomotley: 40MR5) Io fluvialis form angitremoides	2	47.5 – 55.0	51.3	5.30	2	17.5 – 23.7	20.6	4.38	2	24.0 – 26.5	25.3	1.77	2	4.4 – 6.6	5.5	2	14.2 – 16.0	15.1
Little Tennessee (Citico: 40MR7) Io fluvialis form angitremoides	8	41.8 – 60.0	53.0	5.63	8	18.5 – 24.8	21.5	1.97	8	22.0 – 32.0	25.9	3.38	8	4.3 – 7.1	5.4	8	13.2 – 16.5	14.8
Tellico (Sternes: 40MR32) Io fluvialis form angitremoides	1	53.0			1	24.3			1	25.5			1	4.4		1	12.5	
Little Pigeon (McMahan: 40SV1) Io fluvialis form ?fluvialis	29	19.7 – 36.5	28.7	3.81	29	9.1 – 15.9	12.5	1.53	29	11.8 – 19.0	15.6	1.86						
Io fluvialis form ?paulensis	30	25.4 – 38.4	32.6	5.47	30	11.7 – 16.4	14.3	1.28	30	13.8 – 20.6	17.9	1.47						
Io fluvialis form spinosa	25	31.5 – 56.7	45.5	6.95	25	12.9 – 23.8	18.2	2.82	25	14.5 – 27.4	22.4	3.26	25	2.9 – 7.8	5.3	25	10.2 – 20.00	14.2

RESULTS AND DISCUSSION

In preparation for his detailed treatise of Io from the upper Tennessee River system, Adams (1915) had collections of the Spiny River Snail available to him for study from all major tributaries of the Tennessee (Powell, Clinch, Holston, Nolichucky, French Broad) except the Little Tennessee River. Whether he or others who made collections of Io for him had never collected in the Little Tennessee River, or did so and failed to encounter specimens, is not mentioned (Adams, 1915). Both Lutz and Weese (1951) and McLeod and Moore (1978) also made no comment as to recent collections of Io from or their attempts to collect in the Little Tennessee River.

However, in his comparative study of Io obtained from the same rivers from which Adams obtained his specimens, Lutz (1951) did include measurement data taken from 44 specimens obtained from six archaeological sites along the Tennessee River. Of special interest is the following comment by Lutz (1951:51): "Shells were also examined from the Chote Site[Chota, 40MR2], Monroe County, Tennessee, on the Little Tennessee River." These specimens (number ?), recovered during 1939 excavations at the Chota Site, were reportedly in the collections of the Department of Anthropology (Frank H. McClung Museum), The University of Tennessee, Knoxville, but we were unable to locate them. If Lutz realized that these specimens from the Chota Site comprised the first and apparently only record of Io fluvialis from the Little Tennessee River, he made no mention of it. In addition, measurements (range for aperture length, shell width, shell-index, height of spines: Table 1, p.54, Lutz, 1951) taken on these shells and those from other archaeological specimens recovered from the six sites along the Tennessee River were combined so that it was not possible to differentiate among populations.

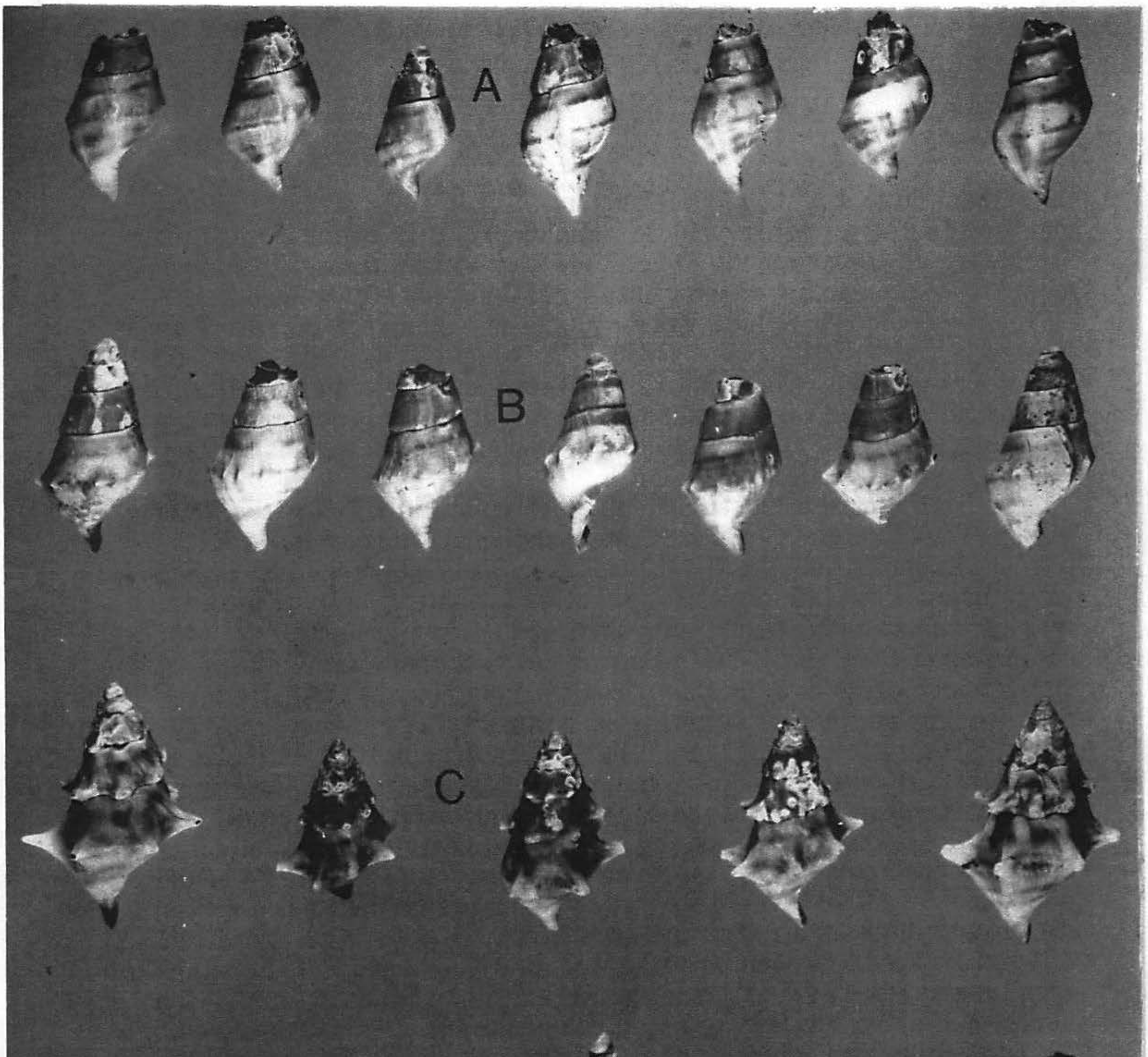
Specimens of I. fluvialis reported here from the Little Tennessee and Tellico rivers are noteworthy because they represent the first published records of this species for this major tributary of the Tennessee River (the Tellico River is a tributary of the Little Tennessee: see Figure 1), they provide evidence for what appears to have been viable populations in lengthy stretches of at least the Little Tennessee River, and their measurements enable comparisions with other populations from the Tennessee River and its tributaries. All measurable 58 archaeological specimens from the five Little Tennessee River sites and the one specimen from the Tellico River site are spinose, heavy and globose and, with the exception of two or three specimens that are more elongated and may reflect the form turrita (Anthony, 1860), suggest populations composed of a form identified by Adams (1915: Plate 1) as I.f. form loudonensis C.C. Adams 1915 and/or I.f. form angitremoides C.C. Adams 1915. The illustration of the form angitremoides by Burch (1980, p. 147, Fig. 430) compares closely with the shell morphology found in our Little Tennessee and Tellico River specimens. Although thousands of shells of smaller pleurocerid species such as Leptoxis praerosa (Say, 1821), Lithasia verrucosa (Rafinesque, 1820), and Pleurocera canaliculatum (Say, 1821) were recovered at these sites, no small or juvenile Io were encountered. Possibly the presence of only large, mature specimens of Io fluvialis in the archaeological samples is indicative of selective gathering on the part of the Indians, but in most instances they probably reflect the establishment of adults only in certain shoal areas searched by the site inhabitants.

The collection of Io from the McMahan Site is particularly noteworthy for two reasons. First, it documents a once viable and abundant late prehistoric Io population in this small tributary of the French Broad River. Although Holmes (1884:452) recorded Io spinosa and three other aquatic gastropods from the McMahan Site as "provisionally determined," no quantified data were give and it can only be assumed that these shells were collected during excavation of the mound and were, therefore, from a Late Mississippian context. During his collecting trips in search of the Spiny River Snail, Adams (1915:23) commented that "The Little Pigeon River was examined about Catlettsburg, Tennessee, and also about its mouth, but no Io were found." Catlettsburg was located at River Mile 2, ca. two miles below Sevierville. One might speculate as to whether Adams would have encountered living Io fluvialis had he ventured upstream to Sevierville; in light of no historic evidence of its presence since the Adams study and the pollution generated by Sevierville and the cities of Pigeon Forge and Gatlinburg upstream, it seems unlikely.

Secondly, there appears to be three distinct forms represented at the McMahan Site. The first (Plate1:A) are not unlike the forms powellensis C.C. Adams, 1915 and fluvialis (Say, 1825), particularly the former, described by Adams (1915:11) as "... smooth or slightly undulated or carinated shells ...", the shell being relatively thin in powellensis. Both of these, along with I.f. form clinchensis C.C. Adams, 1915 described by Adams (1915), are headwaters forms. The second (Plate 1:B) is similar to the first except its mean shell length and width and aperture length are slightly larger (Table 1), and the last whorl possesses a series of low to slightly developed nodules or spines. This latter shell characteristic appears consistent and is diagnostic in distinguishing this form. Adams (1915:12) described a new form I.f. form paulensis C.C. Adams, 1915 from the Clinch River and characterized it as "... generally spinose on the last whorl only ... This shell represents the transitional stage between smooth and spinose shells in the Clinch." He also mentioned that "The maximum for shell width is very narrow, at 14.5 and 16.5 mm; " 30 specimens from the McMahan Site exhibiting shell characteristics of this form had a mean shell width of 14.3 mm with a range of 11.7-16.4 mm (Table 1). The third and largest, most spinose form from 40SVI is referable to I.f. form spinosa (Lea, 1837) (Plate 1:C), a shell possessing well developed spines on the last two whorls, even in juvenile specimens. Adams (1915) considered this form an inhabitant of the Holston River from near Morristown and at other localities above Knoxville and below Kingsport (Adams 1915: map, Plate 1). Forms he reported from the French Broad River were angitremoides, loudonensis and turrita; although the Little Pigeon River specimens suggest the form spinosa, it is possible they may be a small river expression of one or more of the large river spinose forms. Regardless, it appears that at least three distinct forms once inhabited the same stretch of the West Prong Little Pigeon River ca. four miles above its confluence with the French Broad River.

The necessary data for comparison of archaeological specimens of *Io* from the West Prong Little Pigeon, Tellico and Little Tennessee rivers with the data presented by Adams (1915) are summarized in Table 2. Adams (1915) defined shell index as aperture length/shell diameter, with the resulting figure as a percentage. By some fortuitous error, the shell index definition was inverted from what Adams subsequently used in his analyses, but this did not effect his correct use of this method of measurement . The Toqua Site sample shell index (86.4) is much greater than that for the Bat Creek Site (81.97), Tomotley Site (81.42) and the Citico Site (79.93) specimens, as well as the spinose form from the McMahan Site (81.25). The two other forms from the McMahan Site were also noticeably less (80.13, 80.05). Adams (1915) defined the spine index as height of spines/distance between spines. The spine indices for the Bat Creek Site (40.46), Tomotley Site (36.4) and Citico Site (36.49) specimens, and the spinose form from the McMahan Site (37.3), all fall at the extreme far right of the distribution Adams plotted for the Tennessee River shells and beyond the spine index for the other rivers (Adams, 1915: plates 25, 27). The Toqua Site sample spine index (33.33) does not fall as

Plate 1. — A series of three forms of *Io fluvialis* recovered at the McMahan Site, West Prong Little Pigeon River, Sevier County, TN. (A) *I. f.* form ?*fluvialis*, (B) *I.f.* form ?*paulensis*, (C) *I.f.* form *spinosa*.


A
B
C
C

far to the right in Adams' plot of spine index. The globosity (shell index) and the spine index of the spinose samples exclusive of the Toqua Site sample are all comparable to Tennessee River Io specimens. Specimens from the Toqua Site are distinguished by a higher shell index which falls even further out to the right side of the plotted distributions of Adams' shell indices (Adams, 1915: plates 10-13). This high shell index, compared with those of shells from other Little Tennessee River Valley sites, is interpreted as an indication that the Toqua Site Io series is not random but represents a selected sample, specimens procured by the Indians for their large size and globosity.

The two largest shell samples of Io from the Little Tennessee River Valley (Toqua and Bat Creek sites) were combined and compared with the combined samples from the McMahan Site on the West Prong Little Pigeon River using a simple ANOVA (Sokal and Rohlf, 1969). The three measurements - total shell length, shell width and aperture length were compared in each test. The means of the two combined samples are significantly different at $p< 0.001$ level for total length, shell width and aperture length. Further comparisons revealed that the Bat Creek and Toqua Site samples are also significantly different at $p<0.001$ for the same three measurements. However, a comparison of the Bat Creek Site sample and the spinose form from the McMahan Site revealed no significant differences between the two for any of the three measurements. The series of Io from the Toqua Site was recovered primarily from Structure 3 on the north slope of Mound A. This structure has been interpreted as a special function or high status structure (see Bogan, 1980). The significant difference in shell measurements between the Toqua and Bat Creek Site samples may reflect the difference between a general midden sample (Bat Creek Site) and a specially or specifically selected sample (Toqua Site). These analyses confirm the close similarities between the shells of Io fluvialis from the Little Tennessee and the West Prong Little Pigeon rivers, and that there are significant differences between what appear to be three distinct forms in the McMahan Site sample. Assuming that specimens of these three distinct forms were gathered in close proximity to the McMahan site, their apparent differences in shell structure might be attributable to a local river habitat that varied from shallow riffles to intermittent deep pools.

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Endangered Species News [1]

A program is now underway by the Fish and Wildlife Service, U.S. Department of the Interior, to re-examine the official status of endangerment of all species listed in 1976, 1977, 1981, and 1982 (see Federal Register, 52 (129) : 25522-25528, July 7, 1987). Comments from the public are solicited. The mollusks under review were listed as follows:

Snails: Achatinella spp. (all species).
Clams: Lampsilis virescens, Quadrula sparsa, Conradila caelata, Villosa (=Micromya) trabalis, Quadrula intermedia, Epioblasma (=Dysnomia) florentina curtisi, Dromus dromas, Epioblasma (=Dysnomia) torulosa gubernaculum, Lampsilis higginsi, Megalonaias nicklineana, Plethobasus cooperianus, Toxolasma (=Carunculina) cylindrellus, Lampsilis orbiculata, Cyrtonaias tampicoensis, Epioblasma (=Dysnomia) turgidula, Epioblasma (=Dysnomia) sulcata delicata, Plethobasus cicatricosus, Epioblasma (=Dysnomia) florentina florentina, Fusconaia cuneolus, Pleurobema plenum, Fusconaia edgariana, Potamilus (=Proptera) capax, Epioblasma walkeri.

More recently the Fish and Wildlife Service has proposed the James River Spiny Mussel, under the name "Pleurobema collina" [= Canthyria collina (Conrad)], for addition to the federal List of Endangered Species (Federal Register, 52 (169), 32539-42, Sept. 1, 1987). The major threat to its survival is believed to be Corbicula fluminea.

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[1] Endangered Species News will continue as a regular feature of Malacology Data Net. Its purpose is to inform malacologists about important activities which affect the survival of endangered species. Previous recent activities were described in Malacology Data Net, 1 (6) ; 144.

ANNOUNCEMENT

Malacology Data Net continues to evolve. The following beneficial changes will begin with this issue.

The text pages of Volume 1 were printed on good quality paper (20 lb. bond, 25% cotton) but the paper was not acid-free. We will continue to use paper of the same weight and composition but henceforth it will be acid-free and of archival quality. Plates will continue to be printed on slightly alkaline, coated paper.

Peer-review of all manuscripts has been a policy of this journal since its inception. That process has now been formalized by the formation of an Editorial Advisory Board. Its members are listed on the inside front cover.

Although Malacology Data Net was scheduled to appear six times a year, it has become apparent that acceptable manuscripts cannot be expected with such regularity. Our publication schedule must therefore be explicitly linked to the receipt of enough good manuscripts to fill an issue. Frequent publication is still anticipated, however, and a complete volume will still consist of about 150 to 175 pages.

INFORMATION FOR CONTRIBUTORS

Malacology Data Net (Ecosearch Series) seeks to enhance progress in malacology by facilitating rapid publication of significant new information about all aspects of marine, freshwater, and terrestrial mollusks. All scholarly contributions are welcome, but manuscripts dealing with timely issues such as current threats to the survival of molluscan species or communities, descriptions of new taxa, opportunities for participation in ongoing research programs, etc. are particularly appropriate.

Editorial style used in this journal follows the Style Manual for Biological Journals available from the American Institute of Biological Sciences, 1401 Wilson Boulevard, Arlington, VA. 22209. Manuscripts should be submitted (in duplicate) as camera ready copy, using "letter quality" type, with text in blocks 5 inches wide and 6½ inches high. Use of a word processor is recommended. Each manuscript will be reviewed by at least two professional malacologists and, if necessary, will be returned to the author for revision. After final acceptance publication will proceed rapidly, normally within about 8 weeks.

Although Malacology Data Net is without grant or institutional support no author page charges to subscribers will be assessed. If half-tone illustrations (i.e. photographs) are included in the manuscript, however, authors will be charged at cost for plate preparation and reproduction.