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FINAL REPORT

FEDERAL AID GRANT NO. T-14-P-1

THE FRESHWATER MUSSELS OF OKLAHOMA

OKLAHOMA DEPARTMENT OF WILDLIFE CONSERVATION

OCTOBER 1, 2003 through SEPTEMBER 30, 2005

FINAL REPORT

STATE: Oklahoma GRANT NUMBER: T-14-P

GRANT PROGRAM: State Wildlife Grant

GRANT PERIOD: October 1, 2003 – September 30, 2005

ABSTRACT:

This report summarizes the known species of freshwater mussels existing in Oklahoma. Included in each species account are:

Current scientific name
Photo of the species
Synonymy of names for the species used in Oklahoma in the past
Description of the species
General distribution of the species
Table of shell characters
Oklahoma distribution map
List of specimen locations in Oklahoma
Comments

Also included in the report are sections on:

Anatomy and physiology of freshwater mussels
Literature
Mussel conservation
Zoogeography

Finally at the end of the report are included:

Questionable and uncertain species that may occur in Oklahoma
Exotic species
Species list for major river systems in Oklahoma
An expanded list of unionid literature
Glossary of terms

OBJECTIVE:

Summarize historical and recent literature and collections with descriptions, distributions and photographs of the native and introduced freshwater mussels of Oklahoma.

NEED:

Oklahoma is host to approximately 57 species of native Unionid mussels, and several populations with uncertain taxonomic status. Native freshwater mussels are found throughout the state, but species richness declines from east to west across the state. The greatest diversity of mussels occurs in several southeastern rivers such as the

Kiamichi and Little Rivers. Oklahoma's mussels include many widespread species (e.g. *Pyganodon grandis, Strophitus undulatus*) but also several regionally endemic species restricted to the Ozark and/or Ouachita Highlands (e.g. *Ptychobranchus occidentalis, Lampsilis rafinesqueana*) or the Gulf Coastal Plain (e.g. *Obovaria jacksoniana*). Live specimens of at least one species, the Western Fanshell (*Cyprogenia aberti*), have not been collected in several decades suggesting that this species may be extirpated from Oklahoma. Of the approximately 57 possible species of native freshwater mussels in Oklahoma, 19 of these have Natural Heritage Inventory global ranks of G3, G2 or G1. Additionally, 23 species have been nominated for inclusion on Oklahoma's list of Species of Greatest Conservation Need that was developed as part of the Oklahoma Comprehensive Wildlife Conservation Plan.

Several publications have been written regarding freshwater mussels in Oklahoma. The first of these by Isely (1925) was based on major collections conducted during the early twentieth century and this provided the basis for understanding Oklahoma's freshwater mussel fauna. Valentine and Stansbery (1971) published a report also based on extensive collections but this was largely restricted to the Red River and Lake Texoma region. Finally, a series of three publications by Branley A. Branson (1982, 1983 and 1984) summarized many literature records regarding Oklahoma unionids and provided black and white photographs of the species covered. Judging from records provided by Isely and Valentine and Stansbery, many drainage systems within the state have suffered drastic reductions in populations and species diversity since the early part of the twentieth century. At least one species, and possibly several, have been extirpated from the state and many species have been extirpated from one or more of the drainage systems in which they once occurred. Historically, the major factors that have dealt severe blows to mussel populations and species in Oklahoma were similar to those that have devastated mussels throughout North America. These include pollution (agricultural, industrial and municipal), siltation (agricultural, forestry and construction) and reservoir construction.

While there has been a history of research regarding freshwater mussels in Oklahoma, this information has never been compiled into a single, comprehensive reference document. Additionally, there are mussel collections, particularly during the past 20 years, which have not been published and need to be documented in the literature. Finally, there has been little effort to compare historic and recent mussel distributions to examine geographic range and/or population changes over time.

Recently, two biological factors have been introduced that may further devastate native mussels. First, the Asiatic clam (*Corbicula fluminea*) invaded the state in the early 1970's. This small bivalve can spread easily because of its planktonic, non-parasitic larvae and reaches tremendous populations in a variety of habitats. It is feared that the Asiatic clam may out-compete native species for food filtered from the water column. There have been some serious economic problems with the Asiatic clam clogging water intakes and circulating systems in municipal and industrial water systems.

A second more recent invader is the zebra mussel (*Dreissena polymorpha*), a native of eastern Europe and western Asia. It was introduced into the Great Lakes about 1986 and was discovered in the McClellan-Kerr Arkansas River Navigation System at Kerr Lake and Webber Falls in January of 1993. This species also has non-parasitic, planktonic larvae but possibly more important, large numbers can colonize any hard substrate by attaching with a byssal thread. This habit can be fatal for native mussels if exposed parts of the shell are colonized. Some populations of unionids in the Great Lakes region have been totally annihilated since 1988.

Because of the precarious position of native mussels in Oklahoma, and the relatively large proportion of species which have been identified as species of greatest conservation need in Oklahoma, there is a need for a document which summarizes the current status and distribution of each native and exotic species in the state to serve as a baseline for understanding future changes in the fauna due to the factors mentioned above. This is especially needed for the preparation of the Oklahoma Comprehensive Wildlife Conservation Plan. In addition to its use as a conservation planning reference, this document would be a useful identification manual for the increasing number of biologists being drawn into studies involving mussels and managing the aquatic systems that harbor native unionids. Hard copies or CD versions could be provided to biologists and agencies across the state.

APPROACH:

1. Existing literature and existing unpublished data will be compiled to write status accounts for each species of freshwater mussel (native and exotic) known to occur in Oklahoma.
2. Where questionable data exist, museum collections and voucher specimens will be analyzed to determine the accuracy of species identifications and site locations. Travel to several museums will be necessary to clarify some taxonomic questions that exits concerning several populations of Oklahoma mussels and to gather further information regarding the distributions of some species within the state.
3. Professional quality photographs and/or illustrations will be obtained by employing the services of individuals with the necessary talents.
4. A manuscript will be produced complete with descriptions, state and total distributions and photographs of all species of freshwater unionid mussels known to exist in the state of Oklahoma.

RESULTS AND DISCUSSION:

The document consisting of 200+ pages had been produced with all objectives met.

SIGNIFICANT DEVIATIONS:

There were no significant deviations from the original objectives of the project. The document turned out to be about twice as long as originally projected and several

sections of additional information was included (Conservation, Zoogeography, Oklahoma Rivers species lists, Anatomy and Physiology, additional literature and a glossary of terms).

COSTS:

Total Project Cost	=	$52,887
Federal Share (75%)	=	$39,665
State Share (25%)	=	$13,221

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The Freshwater Mussels of Oklahoma

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INTRODUCTION

My first realization that freshwater mussels even existed came about as a consequence of my Great Aunt Genie. She lived in Greene, Iowa near the banks of the Shellrock River. On her gnarled, wrinkled, arthritic hand she wore a pearl ring. She told me that the pearl had come from a local river clam collected many years ago. She also told me that the pearl was imperfect, that it had a flaw on the unexposed surface. However, to me, it was beautiful, it was perfect and it was worth at least a fortune, or as much as the price of ten comic books. My Aunt Genie's brother-in-law was my Grandpa. Grandpa Dayton (Dayton Webster Mather) recognized my interest and in 1951 took me "musseling" on the Shellrock River. My recollections of the event includes wading in shallow water below a low water dam pulling out large mussels, taking them into Grandma Gertrude's kitchen and cooking them out to look for pearls. I can't imagine what trouble my Grandpa stirred up by stinking up the house but that part of the memory evades me. We also didn't find any pearls. That probably disappointed Grandpa but I recall the beautiful lustrous nacre we found on the insides of those extremely ugly, black shells.

In 1957, while in the eighth grade in Crockett, Texas, I hooked up with a character named Jerry Wayne Davis. Jerry and I thought that hunting and fishing were the only reasons for existence (we hadn't discovered girls at that time). One of our favorite hangouts was the Big Slough area of the Neches River. We occasionally stumbled across a live mussel and it was always quickly converted to catfish bait. Who needed a mussel? The important things were catfish, black bass, deer and squirrels.

In 1959, my Uncle Dick Pletka died. It was suicide. He never recovered from his experiences in the Pacific Theater of World War II. He had shared my passion for fishing. A few months after his death, Aunt Doris brought me his tackle box. She said that he would want me to have it. During the past 45 years, most of the treasures in that box have been lost to fish, snags, stolen, or that well known phenomenon "tackle box melt down." The two items I still have are the tackle box itself and a marvelous lure made into a spoon from a freshwater mussel shell. For some reason, I thought that it was too precious to ever be thrown into a body of murky water on the end of a tiny line.

In 1970, while in the U. S. Navy, and stationed in San Diego, California, I made the acquaintance of a fellow Texan, Joseph Anthony Michael Bergmann. He made the mistake of showing me a box of beautiful shells found at La Jolla Beach. He was excited about the variety of species he had found and so was I. For the next three years, we scoured the beaches, mudflats and rocky shorelines of Southern California in an effort to learn every species that existed there. But all good things must come to an end. The U. S. got out of Viet Nam and Joe and I both went home to Texas. He went to San Antonio and I went to Texas A & M to pursue my other passion, lizards. Eventually we got our families together for a picnic at Lake Somerville. We naturally went back to our old habit of beachcombing. Among our findings were an assortment of mussel shells. That was all it took. I was finally hooked. Even though I continued to chase lizards for the next several years, I eventually attained a position where I could continue my interest in the clam world.

This publication is the result of my interest in these organisms since coming to Oklahoma in 1976. I hope that those of you who use its contents will have the joy of discovery that I have had and the pleasure of sharing that joy with others.

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ACKNOWLEDGMENTS

This project was supported by the Oklahoma Department of Wildlife Conservation, the U. S. Fish and Wildlife Service and the University of Science and Arts of Oklahoma. In addition, I would like to express my deep gratitude to Mr. Joseph Bergmann without whose help in both field and academic pursuits, this manuscript would not have been possible. Robert Howells, Caryn Vaughn and Tom Watters also have contributed in a variety of ways to my understanding of freshwater mussels in general and to Oklahoma's fauna in particular. A special thanks goes out to Kelly Brown and Mitzi Cook of the Nash Library. Their help in locating obscure literature has been phenomenal.

ANATOMY AND PHYSIOLOGY

Many of us are at first attracted to mussels by the beauty of the nacre and in some cases the external color, patterns or sculpture. Most people react to the internal parts of the same animal much as they would something that had been coughed and left on the sidewalk. And, you must admit, it is a little strange to work with an animal that has its heart wrapped around its rectum, carries its babies in its gills and buries itself in the mud with its head down! The following is a short summary of the anatomy and physiology of the freshwater mussels.

The Shell

Although most classification of the unionids is based upon anatomy of soft parts, the shell is the most commonly encountered structure. Either the shell is all you have, or the animal is alive and you may not be inclined to sacrifice the animal to look at the internal structures. Therefore, for live material you may only have external shell structures to go by.

The structure responsible for growth and maintenance of the shell is the **mantle**. The mantle is a thin membranous structure that completely encloses the other soft structures and is interposed between the soft anatomy and the shell. It is attached to the shell along the periphery and contains specialized cells that secrete the shell material. There are basically three recognizable layers in the shell, the outer **periostracum** (= **epidermis**), the middle **prismatic layer** (calcite) and the innermost **nacreous layer** (calcite and/or aragonite). The periphery of the mantle is responsible for the shell growing larger in external surface area (height and length). The entire mantle continuously adds layers of shell on the inside surface and is responsible for adding to the thickness of the shell.

The periostracum is a proteinaceous material that is tough, impermeable and resistant to acids and alkaline reactions. It provides some mechanical protection for the shell but most importantly, in areas of low pH, it protects the shell from being slowly dissolved in the acidic environment. Many mollusks in southeastern Oklahoma, where acidic conditions prevail, may have difficulty producing shell material faster than it is being eroded away. This is particularly evident in areas with rock substrates where the periostracum becomes abraded or damage, exposing the calcium carbonate materials of the prismatic and nacreous layers to the action of acids. The periostracum also adds some color and texture to the external shell. It may be black, brown, yellow or even green. Usually the younger specimens show the best color and patterns and they become progressively darker with age. Color patterns are present in some species and may consist of rays, spots, blotches, chevrons, etc. The surface texture also varies and can be very rough, ragged and flaky or extremely smooth and shiny. The bulk of the shell is composed of the prismatic and nacreous layers. These are both calcium carbonate materials and can easily be eroded. The inner nacreous layer is also called **mother-of-pearl** and usually gives the interior parts of the shell a luster or iridescence. The nacre may vary in color from white, bluish, purple, pink or salmon. The function of color in the nacre is unknown since it is not visible until the mollusk dies and opens.

The external shell surface may also exhibit considerable variation. Many species are rather smooth but others show various sculpture consisting of pustules, knobs, ridges, fluting, wrinkles, folds, etc. The size, location and arrangement of these are often useful in identification. Special sculpture may also be present on the embryonic or early juvenile umbos and is called **beak sculpture**. This is also a useful identifying character if present, but is usually eroded away while the individual is fairly young. Another surface character that may be present is concentric rings of color or texture irregularities that may represent changes in growth rate. In some areas these are useful in aging a specimen but must be used carefully because other environmental or physiological disturbances may cause the formation of false annual rings.

The external shell surface may have one or more angular or rounded ridges that often radiate from the umbonal region to some part of the margin of the shell. If the ridge extends posteriorly, it is called a **posterior ridge** and the area between the ridge and the posterior margin is the **posterior slope**. If other ridges are present, there is often a depressed area between the ridges called a **sulcus**.

The two shells or valves are connected by a **hinge ligament**. This tough, flexible structure and the presence of the embryonic growth area, usually characterized by a bump or raised area called the **umbo**, define the dorsal margin of the valves. On the interior surface of the shell below the ligament and posterior to the umbo area are usually one or two elongate, blade-like ridges called **lateral teeth**. Posterior to the lateral teeth are usually one or more short peg-like projections called **pseudocardinal teeth**. All of these teeth apparently help to keep the two valves in proper alignment by preventing any slippage either in a dorsal/ventral or anterior/posterior plane. There are some species of unionids in which the teeth are reduced or even absent. In others, the size, position, number and form of the teeth vary widely and are often useful characters in identifying shells.

Other internal shell characters include scars where muscles are attached. At the anterior end of the shell (the end with the pseudocardinal teeth) are several of these scars. The largest is the **anterior adductor scar**. Adjacent to it are usually two smaller scars, the **anterior retractor scar** and the **anterior protractor scar**. At the posterior end of the shell usually just below the end of the lateral teeth are two scars, a large **posterior adductor scar** and a smaller **posterior retractor scar**. A series of small scars may be present in the umbonal cavity area. These are the **dorsal muscle scars**. An impressed line is usually visible extending from the region of the posterior adductor scar to the region of the anterior adductor scar and running parallel to the ventral margin (the margin opposite the ligament). This impressed line is the **pallial line** and is where the mantle is attached to the shell. In some shells, there is a flattened area present between the lateral and pseudocardinal teeth. This is called a **hinge plate** or **interdentum**. It may be absent in some species. In some shells there may be one or two projections of shell on the dorsal side. If the projection is posterior to the umbo it is a **posterior wing**. It is an **anterior wing** if it occurs anterior to the umbo.

This discussion of the shell is a summary of the skeletal system of the mussel. Obviously it is an exoskeleton and serves several functions. First of all it protects the soft structures of the animal from mechanical injury due to predators, water currents, abrasion, etc. Second, it provides support for the soft tissues. Third, its weight and

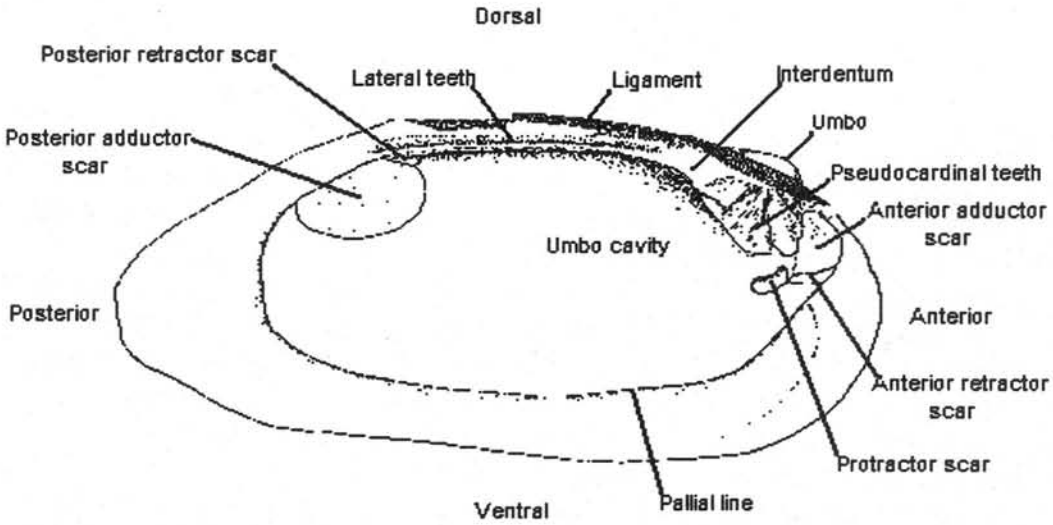


Figure 2. Internal anatomy of mussel shel..

sculpture may help to anchor the individual in the substrate, an especially important function when wave action or currents are involved. And, fourth, in some species it closes so efficiently that it can seal the animal shut when out of the water and allow survival during periods of possible dehydration.

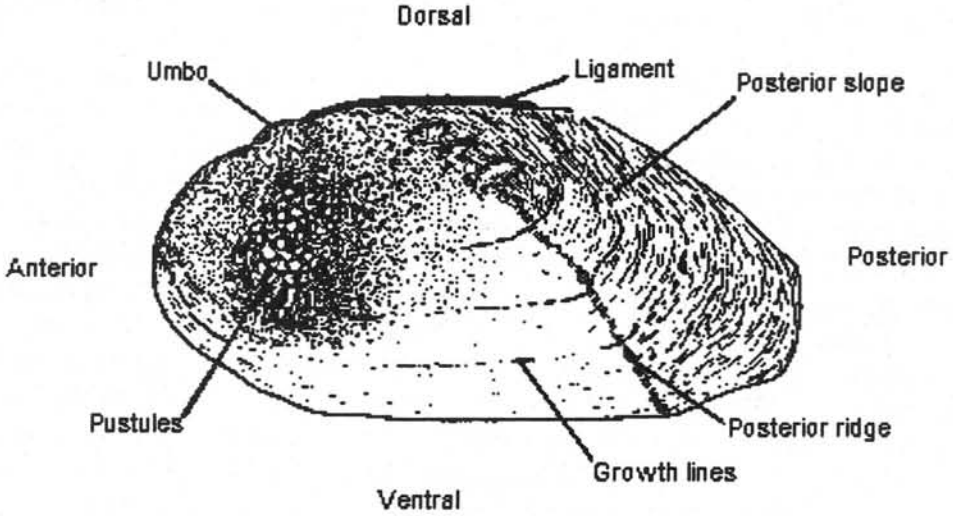


Figure 1. External anatomy of freshwater mussel shell.

Muscles

The principle organized muscles in the unionids are those associated with the muscle scars of the shell previously discussed. The adductor muscles extend directly from shell to shell and are responsible for holding the valves tightly shut. The retractor muscles pull the soft parts into the shell so it can close. The protractor muscles help to extend the soft "foot" out of the shell. Muscle fibers are also present in the mantle margins. These along with the dorsal muscles, help to pull the mantle within the shell for closure. Additional muscle fibers in the mantle margin may control movement of the mantle flaps during reproductive processes and control of the siphons used in feeding and respiration.

The foot is also highly muscular and can be extended for some distance out of the shell, between the valves. In many cases it acts as an anchor in the substrate. If the animal needs to move, it can be used for locomotion in conjunction with the protractor and retractor muscles.

Digestive System

The digestive tract of a freshwater mussel is relatively simple. Its structure allows filtering of small matter (such as microorganisms and organic debris) from the water. Water is brought into the mantle cavity through the **incurrent siphon** at the posterior end of the body. The posterior end usually protrudes into the water column whereas the anterior end is normally imbedded in the substrate. The epidermal surfaces on the inner mantle and surface of the gills are ciliated and produce sticky mucous. Particles stick to the mucous and are swept by ciliary action toward the mouth located between the **labial palps** at the anterior end of the body. The mucous, along with food particles, passes through the short esophagus and into the stomach. Digestive enzymes are added from the surrounding digestive glands. The elongate intestine then loops down through the gonads and into the foot region. It then returns to the dorsal region of the body and extends posteriorly surrounded by the heart, a **rectum** then passes over the posterior adductor muscle and exits at the anus in the region of the **excurrent siphon**.

Respiratory System

The **gills** are the principle respiratory organs. These consist of two flaps located on either side of the body. The **outer gills** are adjacent to the mantle and the **inner gills** are adjacent to the foot. The gills receive water coming into the **mantle cavity** and water passes through tiny **ostia** by way of ciliary action and enters the water tubes. From here the water moves up the tubes and into the **suprabranchial chamber** and ultimately out of the **excurrent siphon**. Gas exchange occurs in the gills. The gills also function in feeding (see section on the digestive system) and in reproduction (see section on the reproductive system).

Excretory System

The **kidney** is the principle organ of excretion. It is located below the heart and is connected to the **pericardial chamber**. Pericardial fluid passes through the kidney and waste materials are removed. Wastes eventually pass into the suprabranchial chamber and out the excurrent siphon.

Circulatory System

The **blood** is basically a clear fluid with only a few **amoebocytes** being the only cellular elements present. The **heart** consists of two **auricles** and one **ventricle** . The ventricle surrounds the lower intestine just anterior to the rectum. Blood collects in the auricles and passes into the ventricles. From the ventricles, blood passes through the body through the anterior and posterior **aortae** and their branches. Blood collects in **venus sinuses** (large veins) and returns to the heart.

Nervous System

There is no concentrated "brain" present. There are several nerve centers called **ganglia** located in various regions. There are two **cerebral ganglia** near the mouth that are in turn connected to two **pedal ganglia** in the foot and also with two visceral ganglia in the posterior region below the posterior adductor muscle.

Sensory System

Since cephalization (an organized head) is not well developed in mussels, there are no organized sensory organs present. However, there are at least chemoreceptors, thermoreceptors and photoreceptors present so the animal is capable of responding to a variety of stimuli.

Reproductive System

The reproductive process in the unionids is a very complex and interesting process. Typically, there are separate sexes (dioecious). However, monoecious individuals have been reported in the genus *Anodonta* (*Utterbackia*). The gonads are located in the region above the foot and tend to surround much of the intestine. In the male, sperm pass into the surabranchial chamber and are discharged into the water via the excurrent siphon. The sperm must then be taken into the incurrent siphon of a female for fertilization to occur. In females, the eggs are transferred to the water tubes in various regions of the gills. Fertilization occurs in the gills of the female and the fertilized eggs are retained in the gills for further development into a tiny bivalve called a **glochidium**. The glochidium must be discharged from the gills and at this point must attach to a fish

(or in some cases a salamander) host for a parasitic stage that lasts several weeks. There are a few cases where development can occur without the parasitic stage but these are exceptions. The glochidium encysts in the gills or fins of the host and utilizes nutrients from its host to further develop its organ systems. This parasitic stage is also an important dispersal mechanism for an animal with very limited locomotion. It insures distribution into suitable habitats and also allows a mechanism for upstream migration. Eventually, the glochidium will drop from its host (hopefully into a suitable substrate) and begin its free-living existence. There are many strategies involved in attracting and becoming attached to a host.

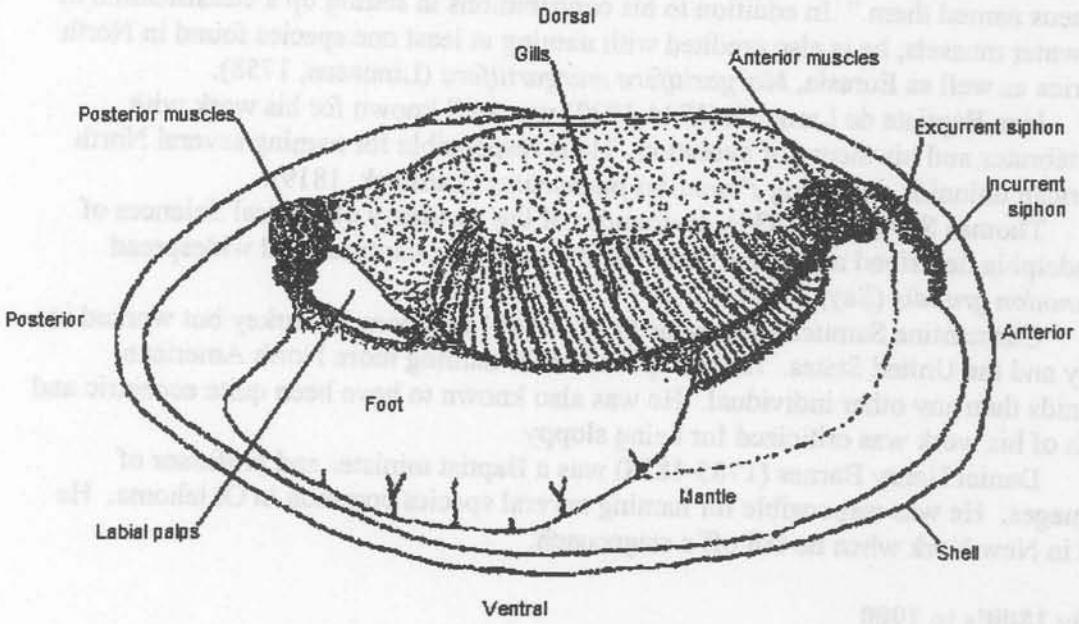


Figure 3. Internal anatomy of freshwater mussel.

UNIONID LITERATURE

This is a brief overview of the literature on unonids and information about some of the authors. In general, there have been trends in interests and activities that can be identified in looking at the available literature over the years.

Early Period – 1758 to Early 1800's

As with most taxonomic studies, we begin with Carolus Linnaeus (1707-1778) Swedish naturalist and responsible for our basic system of classification and use of scientific names. The Swedish people say that "God made the plants and animals, Linnaeus named them." In addition to his contributions in setting up a classification of freshwater mussels, he is also credited with naming at least one species found in North America as well as Eurasia, *Margaritifera margaritifera* (Linnaeus, 1758).

Jean Baptiste de Lamarck (1744-1829) was well known for his work with invertebrates and his theory of evolution. He is responsible for naming several North American unionids, including *Potamilus purpuratus* (Lamarck, 1819).

Thomas Say (1787-1834), co-founder of the Academy of Natural Sciences of Philadelphia described numerous unionids, including the common and widespread *Pyganodon grandis* (Say, 1829).

Constantine Samuel Rafinesque (1783-1840) was born in Turkey but worked in Sicily and the United States. He is responsible for naming more North American unionids than any other individual. He was also known to have been quite eccentric and much of his work was criticized for being sloppy.

Daniel Henry Barnes (1785-1828) was a Baptist minister and professor of languages. He was responsible for naming several species common in Oklahoma. He died in New York when he fell off a stagecoach.

Early 1800's to 1900

By the end of the first quarter of the 19th century, many unionid species had been named and described, but many more, especially in the South, were yet to be discovered. During this period there were a number of workers that diligently searched for new mussels and published descriptions. Unfortunately, the species concept was rather weak at this time and many of these men named and described every minor variation in shell shape, color or sculpture. Most of these were local variants or often differences due to growing in different substrates. The result was an avalanche of synonyms that are yet to be completely sorted out. Among the more productive writers of the times were:

Isaac Lea (1792-1886) left his collections to the U. S. National Museum and the Academy of Natural Sciences of Philadelphia. He was probably the most prolific author of freshwater mollusks of the period.

Timothy A. Conrad (1803-1877) worked with the Smithsonian Institute and was responsible for describing many species of living and fossil mollusks.

Berlin Hart Wright (1851-1940) of New York and Florida, described many new species of unionids, almost all of which were already described and named. His collection was sold to Bryant Walker and eventually became part of the University of Michigan Collections.

Early 1900's

During the late 1800's and early 1900's, much of the writing about unionids dealt with surveys of the mussel faunas of geographical regions, usually states. Needless to say, some states received a great deal of attention while the faunas of others remained virtually unknown until recent times. Some important individuals during this period include:

Bryant Walker (1856-1936), a Michigan lawyer who amassed a huge collection of unionids that were ultimately left to the University of Michigan. He published 155 papers on freshwater and land mollusks.

Charles Torrey Simpson (1846-1932) of the U. S. National Museum, made very important contributions in his 1900 "Synopsis of the Naiades" and his 1914 "Catalogue." These publications summarized all the known species at the time and attempted to develop complete synonomies. This was a very useful first step in clearing up some of the taxonomic chaos that went on up until this time.

Richard Ellsworth Call (1856-1917) produced important surveys of mid-western states, including Kansas (1885, 1887a and 1887b), Arkansas (1895) and Indiana (1900).

Loraine Screven Frierson (1861-1933) was a Louisiana cotton plantation owner and published many papers on unionids, not only of the U. S. but worldwide.

John Kern Strecker (1875-1933) was a librarian and curator at Baylor University, Waco, Texas. He published "The distribution of the naiads or pearly fresh-water mussels of Texas" (1931).

F. B. Isely worked in Kansas, Oklahoma and Texas. He published "The fresh-water mussel fauna of eastern Oklahoma" (1925) based on surveys of the eastern Oklahoma rivers and streams carried out around 1910 to 1912.

Frank Collins Baker (1867-1942) produced the monumental work "The fresh water mollusca of Wisconsin. Part II. Pelecypoda" (1928).

W. I. Utterback (1872-1949) wrote "The naiads of Missouri" (1915-1916).

Arnold Edward Ortmann (1863-1927) was born in Germany and was a student of Ernst Haeckel. He worked at the Carnegie Museum and published the "Monograph of the naiads of Pennsylvania" (1911 and 1919).

Other important names during this period include W. J. Clench, Calvin Goodrich, Henry van der Schalie, R. E. Scammon, M. L. Winslow, V. Sterki and others.

During the early 1900's there was also a great interest in mussel shell as a source of buttons. Through much of the upper Mississippi drainage, button factories flourished and along with it, the commercial harvest of mussel shell. Mussel beds were drastically depleted in some areas and the government sponsored research (through fisheries) in an

effort toward propagation of the commercially valuable species. Two of the resulting studies include:

Robert Ervin Coker (1897-1967) who worked with others at the U. S. Biological Station, Fairport, Iowa and published studies on the reproduction and artificial propagation of unionids.

G. Lefevre and W. C. Curtis also published "Studies on the reproduction and artificial propagation of fresh-water mussels" (1912).

1970's Through 1990's

With the development of plastics in the 1930's and 1940's, the shell button industry collapsed. Plastics were easier to deal with, easily molded to any shape and at least as durable as mussel shell. Little interest was shown for freshwater mussels during the next couple of decades. Eventually, there began a movement toward a re-evaluation of the taxonomy and systematics of unionids. A better understanding of the distributions of the many species in North America was sought. Among the principle authors during this period are:

Arthur H. Clarke was with the National Museum of Natural Sciences, Ottawa, Canada and Associate Curator, Smithsonian Institution before creating a private mollusk research consultation service.

John B. Burch of the Department of Mollusks, Museum of Zoology, University of Michigan is responsible for the Environmental Protection Agency Identification Manual "Freshwater Unionacean Clams (Mollusca: Pelecypoda) of North America." This was later revised and re-published.

Richard I. Johnson is with the Museum of Comparative Zoology, Harvard University and contributed primarily to the history of the Unionidae and zoogeography.

David Honor Stansbery has retired from the Museum of Zoology, Ohio State University and has written extensively on zoogeography, ecology and evolution of freshwater mussels.

Recent Studies

During the past couple of decades, and even extending back to the 1960's, and especially since the organization of the EPA and the passage of the Endangered Species Act, there has been a renewed interest in the ecology of unionids and methods of conservation. This has come about as the scientific world began to realize that unionid populations were rapidly declining and many species and populations were already extinct. The effects of an expanding human population in North America and the environmental degradation associated with their activities, has resulted in devastation of mussel faunas. In the meantime, a resurgence in harvesting mussel shell has occurred as the Japanese market for "seed shell" for cultured pearls has expanded. As a result of these problems, the expanding unionid literature now is focused primarily on the recovery and maintenance of mussel populations. Much of this interest is reflected in publications

appearing in such journals as The Nautilus, The Bulletin of the American Malacological Union, Malacological Review, Malacology Data Net, Walkerana and others. There is also a tremendous volume of "grey" literature being produced by state and federal agencies as well as some private groups and organizations.

ZOOGEOGRAPHY

Although there is a lot of data on the distributions of unionids, many of their distributions are difficult to explain. Strayer (1987) summarized generalizations made by Ortmann (1913) and gave some of his own opinions primarily on the Hudson River basin of northeastern United States. Ortmann's conclusions (in Strayer, 1987)include:

1. The Appalachian Mountains have formed an effective barrier for unionids and the result are distinct Atlantic Slope and Interior Basin faunas.
2. The Atlantic Slope fauna is depauperate and derived mostly from Interior Basin species. Very little evolutionary radiation on the Atlantic Slope. Most unionids apparently dispersed to the Atlantic Slope around the northern and southern ends of the Appalachians.

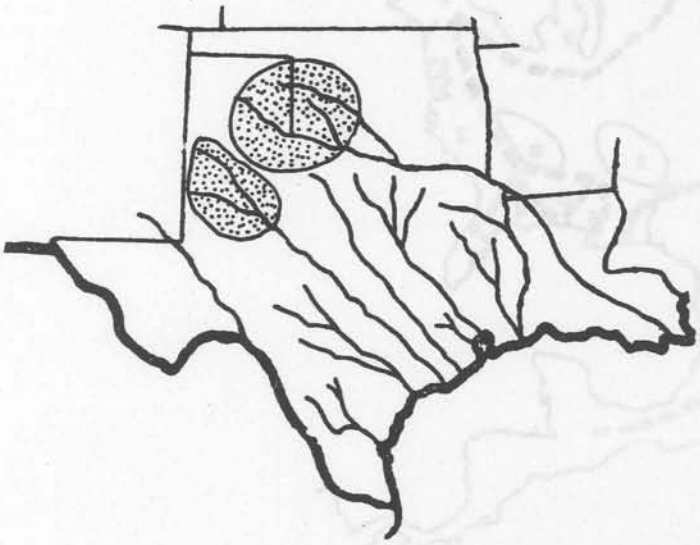
In general, species richness tends to diminish from lower to upper (or headwater) areas of drainage systems. Large river species then tend to be widespread. That is, river systems like the Mississippi have numerous large tributaries that are spread over a large area and species adapted to those large rivers can disperse through those continuous waterways. On the other hand, headwater species tend to be fairly well isolated from the headwaters of other tributaries. The large rivers themselves may function as barriers to these species.

Unionids are perhaps victims of their own ecological niche and reproductive processes. By their very nature, they are relatively immobile. The fact that they are mostly dioecious means that a male can only reproduce if there is a female downstream to receive sperm and a female can only reproduce if there is a male sperm source upstream. If it weren't for the parasitic stage on relatively mobile fish hosts, the population would, through time march irreversibly downstream. Fish parasitism is obviously a great solution to this problem and many fish hosts for the glochidia tend to be anadromous to some extent. This allows a continuous re-seeding of a population upstream as far as habitats suitable for the mussel species or its fish host. There is a great deal to learn about the fish host/mussel glochidium relationship. It appears that in many cases hosts are fairly specific. This then ties the mussel to the successes or failures of its host fish. If a fish is capable of dispersing from river system to river system, headwater to headwater, over mountain barriers, through saline barriers, etc. then its parasitic hitchhiker also has a chance of making the trip. However, if a mussel is tied to an endemic headwater fish species (like a darter) then it may have little or no chance of dispersal.

These factors together with the complicated changes in patterns of stream flow through geological time can really paint a complex picture. Stream capture in headwater areas and confluence and separation in coastal areas due to tectonic processes of rising and sinking land masses or increases and decreases in sea level, also due to tectonic forces or climatic changes (glacial and interglacial periods) make it extremely difficult to decipher current distributions.

The following is an example of a problem in the Oklahoma and Texas region (see Map 1). *Quadrula apiculata* occurs though much of Texas and it has its variant in the

numerous river systems that drain into the Gulf of Mexico. Through much of the Mississippi River system, *Q. quadrula* is the widespread *Quadrula* species. In the upper



Map 1. Shaded areas showing distribution of one form of *Quadrula apiculata* in Oklahoma and Texas (upper Red River and Colorado River drainages).

Red River system the form of *Quadrula* differs considerably from that in the lower Red River and its tributaries. The Washita River (from the Texas Panhandle through western Oklahoma) joins the Red River at Lake Texoma has a form of *Quadrula* that appears to be *Q. apiculata*. In fact, it is most similar to the form of *Q. apiculata* that occurs in the Colorado River system! Is this a case of convergent evolution? Or, is this a case of dispersal from the headwaters of one system to the headwaters of another? Or, perhaps this is the result of stream capture! Was the Washita River drainage once a part of the Colorado River system but was captured by the Red River system? Geologic literature does give some credence to some of the more eastern Red River tributaries having been once part of some of the more eastern Texas rivers. Electrophoretic studies of these two populations may shed some light on this zoogeographic problem or at least narrow the possibilities. There are several other mussels that show similar distribution problems in this region (*Truncilla* and *Potamilus*). In addition, there may be similar distribution patterns present in crayfish (Rollin Reimer, pers. comm.) and possibly other aquatic invertebrates and vertebrates. This is just an example of a zoogeographical problem and some of its possible explanations for one small region. Every area has numerous examples of their own problems to solve with their own unique set of drainage patterns, geology, etc.

Based on faunal affinities, Roback, Bereza and Vidrine (1980) illustrated their concept of unionid faunal zones and provinces (see Map 2).

Map 2. Unionid faunal zones and provinces: 1. North Atlantic; 2. South Atlantic; 3. Peninsula Florida; 4. Apalachicolan; 5. Mobile Basin; 6. Central Gulf Coast; 7. Western Gulf Coast; 8. Interior Basin; 9. Great Lakes—St. Lawrence; 10. Pacific; 11. Mexican Pacific; 12. Mexican Gulf Coast; 8A. Ozarkian Province; 8B. Cumberlandian Province. Redrawn from Roback, et al., 1980.

CONSERVATION

The freshwater mussels of North America are one of the richest species groups of aquatic animals. There are approximately 300 recognized species in the continental United States and with the advent of DNA technology, more will probably be added to the list. However, the same ecological, anatomical, behavioral and reproductive factors that have resulted in this diversity of species have also contributed to their dramatic decline. Almost one in four species is considered endangered or threatened. In Oklahoma, populations are not as bad as most other states but there are some major concerns. Of the 55 species that have historically occurred in the state, only one species is extirpated (*Cyprogenia aberti*) and two others (*Ligumia recta* and *Alasmidonta marginata*) are probably extirpated. All three species still exist in other states. Two other species (*Arcidens wheeleri* and *Lampsilis rafinesqueana*) are species of very restricted range and pose special problems in trying to maintain populations within the state. These and all the other species within Oklahoma are subject to a variety of threats to their success, some of which are unique to being a mussel and others imposed upon them by the vagaries of man and nature. Factors affecting freshwater mussel populations in Oklahoma fall within several categories, including the following:

Immobility: Because of the relatively stationary life style of freshwater mussels, this requires that for a female to reproduce, there must be a male source of sperm either nearby or upstream. This relative immobility also makes it difficult or impossible to escape events that may impinge on their health, well-being or reproduction.

Parasitism: Because freshwater mussels require a period of parasitism on a fish host, this means that in order to successfully transfer glochidia from the stationary gravid female to a proper fish host, she must attract the fish in some manner and release the glochidia at the proper time. Success of this part of the reproductive process is also dependent on the presence of the proper fish host species. Changing fish faunas in our lakes and rivers are potentially serious impediments to the reproductive potential of some mussel species.

Location: Mussels are benthis organisms, that is they live in the bottom substrate of aquatic ecosystems. The most favorable substrates are gravel or stable sand or mud. Shifting sand, fine silt, soft mud or organic debris are generally unfavorable for all but the most mobile species. Numerous factors to be discussed further on have dramatic effects on benthic substrates. Also, the substrate itself may become the repository of toxic substances such as heavy metals, pesticides and herbicides that remain in the substrate more or less permanently long after its deposition.

Feeding: Mussels are filter feeders. Water along with organic nutrients are siphoned through the mantle cavity and gills thus exposing these delicate and permeable tissues to anything present in the water column. Chemicals that may be concentrated in plankton and organic particles and taken in by mussels may be further concentrated.

Anoxia: During periods of drought or low water levels, especially during high summer temperatures, oxygen levels may plunge to dangerously low levels. This can be exacerbated by eutrophic conditions due to evaporative concentration of nutrients or the

addition of organic nutrients from some outside source. The most severe anoxia conditions occur on the bottoms of aquatic systems. Fish and other aquatic organisms can often move to the surface or other areas where oxygen levels are more favorable. Mussels are unable to escape. Common sources of nutrients that result in anoxic conditions include poultry wastes, cattle and hog feedlot wastes, municipal sewage treatment overflow and fertilizer runoff.

Toxins: The variety of possible toxins that might pollute an aquatic system are impossible to enumerate. Everything from pesticides and herbicides to heavy metals, solvents, oil spills, salts and others. Just as in conditions of anoxia, the immobility of mussels make it difficulty for them to escape or survive these events.

Sediments: Although erosion and deposition are natural processes that have served to shape Oklahoma's topography, any alteration in the process can have significant effects on mussel species not adapted to the change. Most often the problem is with increased erosion and deposition. This is usually associated with human activities such as agriculture, logging, construction and overgrazing. Increased sediment loads in our lakes and rivers can bury and smother mussels or perhaps alter the substrate say from gravel to silt and thus making the habitat unsuitable for species adapted to gravel substrates. Increased sediments can also alter the stability of a stream forcing channels to constantly shift and meander. This creates conditions in which mussel populations have great difficulty in establishing and also maintaining themselves.

Dams: Impounding rivers and streams have probably been the leading cause of mussel declines in North America and in Oklahoma. Rivers contain the greatest diversity of species and most of these species are adapted to flow regimes and temperature cycles for their nutrient and reproductive needs. Impoundments obviously alter large stretches of flowing river habitat into lakes. This restricts the number of species that can survive lake conditions to only a few but also has drastic effects in the river both above and below the lake. The dam itself is a barrier to the movement of anadromous fish that may be required as hosts for mussel glochidia. If the proper fish hosts can't reach those areas of the river, the mussels can't reproduce. Below the dams, a number of factors may come into play. If water is released from the surface of the lake (hyperlimnetic discharge) then it may follow fairly normal seasonal changes in temperature and nutrients. However, if water is released from the bottom of the lake (hypolimnetic discharge) then the water temperature will be much below normal and contain fewer nutrients. Both of these factors can dramatically affect the mussel's ability to survive and reproduce. Another factor involves man's control of the rate of discharge. If the discharge is too low, stagnation and anoxia may result in damage to mussel populations. If the discharge is too great, scouring of the streambed may result, thus removing the substrate needed for mussel survival. This is almost inevitable because the dam itself blocks the passage of any sediments from upstream and that can only mean that there will be a gradual loss of substrate downstream.

Channelization: Channelization of rivers and streams is commonly done to straighten a segment to shorten its length or to increase the rate of flow. It is also used to deepen natural channels for the passage of large boats and barges. The channelization

process itself may destroy mussel beds and once it is done, it alters the flow patterns and sedimentation processes.

Watercraft: The passage of boats, barges and ships along rivers creates wave action along the banks that is an unnatural phenomenon for flowing systems. This wave action increases bank erosion, alters substrate composition and prevents establishment of stabilizing vegetation. All of these limit the mussel composition to only a few relatively adaptable species.

Headcuts: An interesting phenomenon occurs when the substrate in a river or stream is disturbed. Disturbance is commonly caused by removal of sand, gravel or cobble. Once substrate is removed, the current overflowing the upstream edge of the disturbance begins to undercut the site and the undercutting process begins to move upstream. As the process moves upstream, it can disturb and possibly bury mussel beds and it also tends to spread laterally. Repeated headcut events can gradually alter a deep, well-channelized stream or river into a wide, shallow, unstable system that is unfavorable for all but a few mussel species.

Scouring: Any factor that increases flow in a stream or river can have either one of two seemingly opposite results. If increased runoff increases the input of sediments into the system such as in disturbed agricultural lands it can result in a "choking" of the stream, thus burying mussels and creating a high sediment-load system. On the other hand, if increased runoff is not associated with the inflow of sediments, then the result is to move sediment substrates already in the river downstream, often resulting in exposure of cobble, boulder or bedrock unsuitable for mussel habitat.

Predators: Mussels provide an important food source for a variety of animals including muskrats, raccoons and otters. Under normal circumstances these are not expected to have a significant impact on mussel populations. However, when populations are reduced or imperiled then predation must be considered a possible detriment.

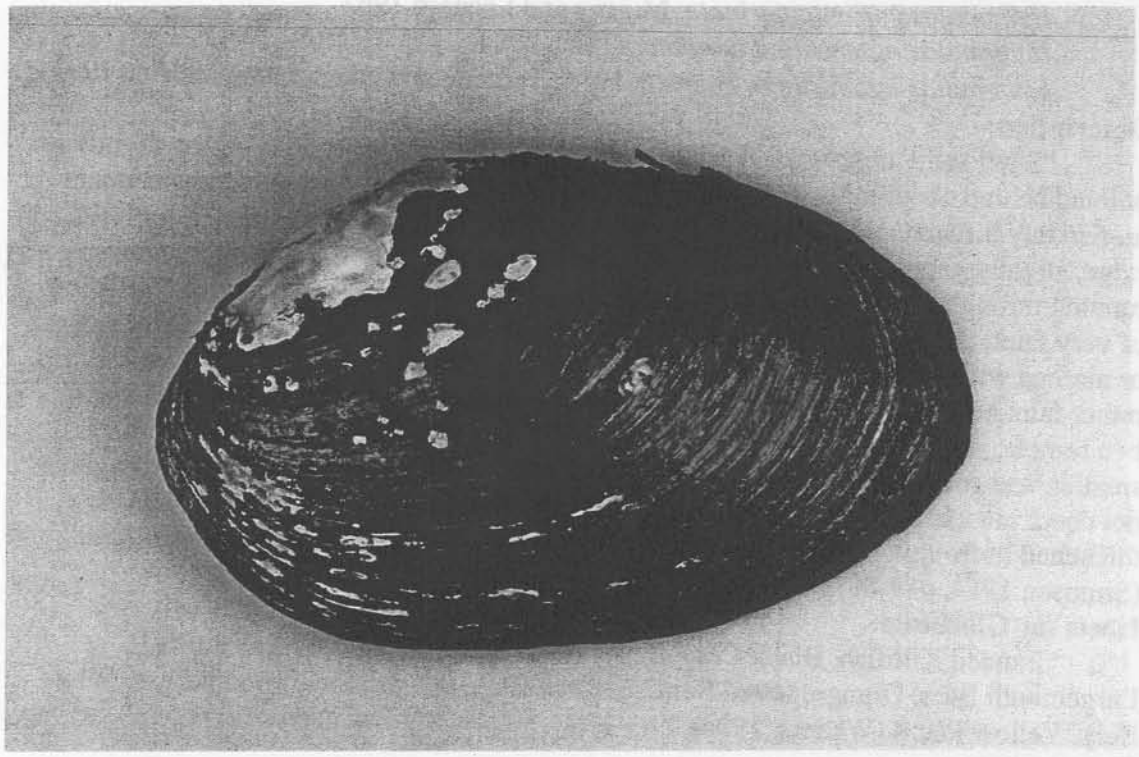
Commercial Harvest: The massive harvest of mussels can obviously have a great impact on the species of commercial value. Because most of the commercial species are common and widespread, their populations tend to recover with time. However, the association of rare, uncommon or endemic species in the mussel beds associated with the more common and abundant commercial species, they are subject to the disturbance of the mussel bed substrate. Also, misidentification and harvest of rare or protected species by harvesters is also a distinct possibility.

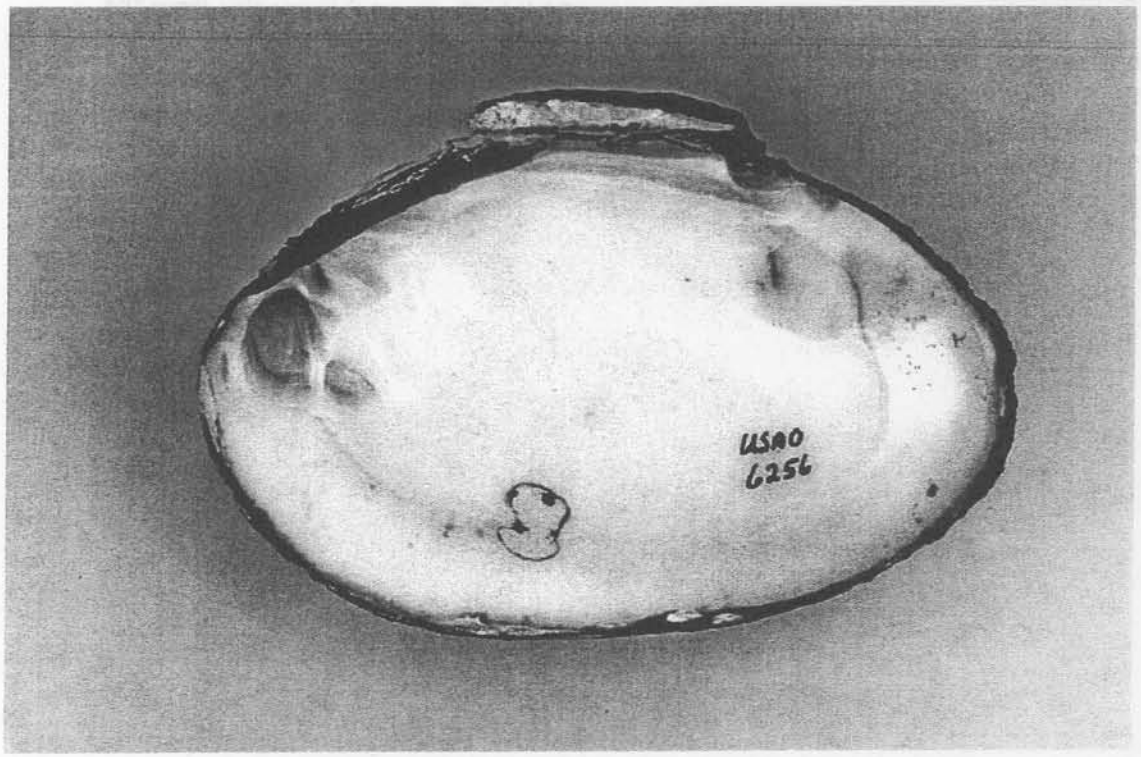
Competition: Since about 1970, Oklahoma has seen the invasion of two exotic species, the Asian clam (*Corbicula fluminea*) and the zebra mussel (*Dreissena polymorpha*). Both species can attain huge populations that because they are also filer feeders, can greatly reduce the nutrients available to native species. Reduced nutrients obviously can affect native species' ability to survive, grow and, possibly most importantly, to reproduce. Furthermore, the zebra mussel attaches to any hard substrate in the water, often in tremendously dense numbers. This includes the exposed shells of living mussels. This colonization of the living mussel shells has a heavy impact on native mussels.

Isolation: In recent years it has become clear that fragmentation of ecosystems results in loss of diversity. Fragmentation creates isolated "islands" of habitat that quickly

lose species that are high in the food chain. This, in turn, has a trickle down effect that ultimately results in a system with a drastically diminished diversity. Consequently, low diversity means less stability and increases the likelihood of extinction within the system. Freshwater aquatic systems function much like islands or fragmented ecosystems. Lakes tend to be isolated from other lakes. Rivers, especially second and third order tributaries, function as "islands" by being cut off from one another by mainstem rivers and the surrounding terrestrial ecosystems. Second and third order tributaries tend to contain endemic species that have evolved in these streams and are adapted to the specific water chemistry, flow regimes, substrates and fish hosts. These populations are particularly susceptible to any or all of the previously discussed factors.

Actinonaias ligamentina (Lamarck 1819)
Mucket





Partial Synonymy:

Lampsilis ligamentina, Simpson 1914
Lampsilis ligamentina gibba, Isely 1925
Actinonaia carinata gibba, Isely 1925
Actinonaias carinata carinata, Murray and Leonard 1962
Actinonaias ligamentina carinata, Oesch 1984
Actinonaias ligamentina, Branson 1984; Turgeon and others 1988; Vidrine 1993

Description:

"Shell solid, almost regularly long elliptical, rounded in front, rounded slightly or pointed behind about midway up from the base of the shell, young and adult specimens moderately inflated, old specimens decidedly swollen, having a low, rounded posterior ridge, slightly gaping at the anterior base; old shell having a well-developed lunule running through under the beaks; beaks scarcely inflated, low, their sculpture consisting of very faint, doubly-looped, irregular ridges; ligament large, long; surface nearly smooth or marked with rude, irregular, low, concentric ridges, tawny to pale greenish with broad, rather faint and somewhat broken rays; left valve with two small pseudocardinals and two remote, rather small laterals; right valve with two pseudocardinals, the anterior smaller, and sometimes a small posterior third tooth, with one high lateral; beak cavities not deep; muscle scars large, well impressed and smooth; nacre white or pink, much thickened in front in old shells; female shells very slightly produced at posterior base" (Simpson 1914, p79-80).

Hosts for Glochidia:

Banded Killifish, Black Crappie, White Crappie, Bluegill, Green Sunfish, Largemouth Bass, Orangespotted Sunfish, Rock Bass, Sauger, Smallmouth Bass, White Bass, Yellow Perch (Watters, 1994).

Comments:

Although Isely (1925) and Branson (1984) both report this species from the northeastern part of Oklahoma (Neosho River and Fourteenmile Creek), I believe all of these records are of male *Lampsilis rafinesqueana* (Frierson 1927). The shells of *L. rafinesqueana* are remarkably similar to *A. ligamentina* and can be easily misidentified. The specimen illustrated by Murray and Leonard (1962) from the Neosho River in Kansas is almost certainly *L. rafinesqueana.*

Table 1 . Summary of *A. ligamentina* shell characters.

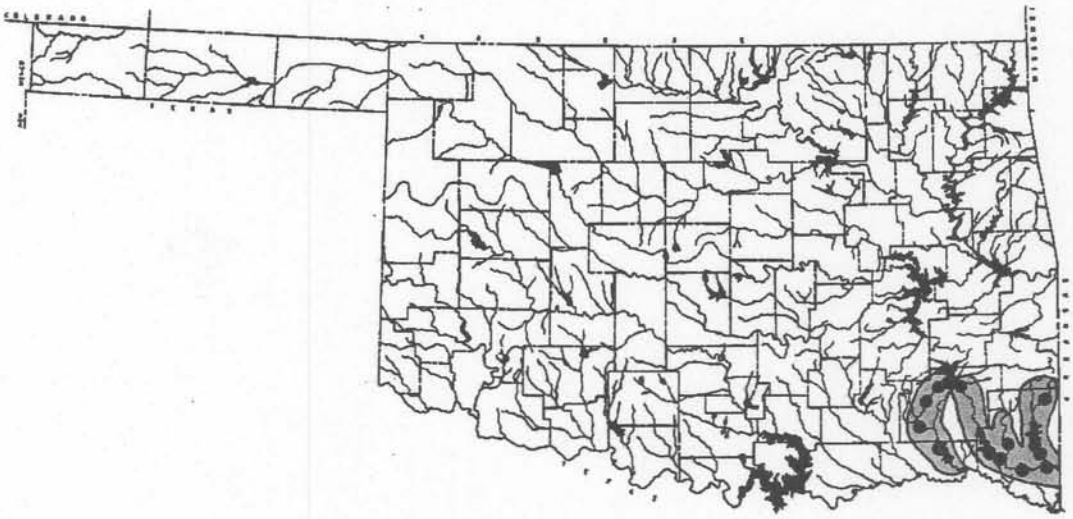
Location	N	H/L Range (%)	Mean H/L (%)	Max. Length (mm)	W/L Range (%)	Mean H/L (%)	Remarks
Red River System							
Kiamichi River	59	55.6-72.2	64.7	122	34.7-52.5	42.3	9 of 65 rayed 8 of 60 colored(pink to yellowish salmon nacre
Little River	17	54.2-70.8	64.5	131	36.6-56.3	45.4	2 of 17 rayed All white to bluish white nacre
Glover River	10	61.7-70.6	64.5	116	37.5-48.4	43.0	1 of 10 rayed All white to bluish white nacre
Mountain Fork River	13	61.3-72.6	66.4	128	37.5-48.6	43.1	2 of 13 rayed All White to bluish white nacre
Lukfata Creek	1	-	65.3	98	-	46.9	

General Distribution:

Mississippi River drainage of central and northeastern United States and parts of the St. Lawrence River and Great Lakes drainage.

Oklahoma Distribution:

Little River drainage (including the Mountain Fork River, Glover River and Lukfata Creek), Kiamichi River and Poteau drainages of eastern Oklahoma.



Map 3. Distribution of *A. ligamentina* in Oklahoma.

Red River System:

Kiamichi River:

Pushmataha Co.: At Stanley; South of Clayton; 14.9 mi. NNE of Antlers, Hwy 2; 0.9 mi. SE of Clayton; At St.Hwy 2, N. of Antlers, S. crossing; At St.Hwy 2, N. of Antlers, N. crossing; U.S.Hwy. 271 at Antlers.

Choctaw County: Spencerville Crossing, 8.5 mi. NE of Hugo.

Little River:

McCurtain Co.: At RR crossing, 1.5mi.SW of Wright City; S6&7-T6S-R22E; 1.5 mi. N. of Garvin; S6-T7S-R23E; 7 mi. N. of Idabel at mouth of Lukfata Ck.,Hwy. 70; About 0.5 mi.E. and 2.5 mi. N. of Goodwater; 1.5 mi. S and 1.5 mi. E of Wright City.

Black Fork Creek:

Pushmataha Co.: Black Fork Creek, _ mi. S. of Nashoba.

Glover River:

McCurtain Co.: 10.5 mi. W of Broken Bow on St. Hwy 3 and 7; At Glover, S33-T5S-R23E; 0.25 mi. W of Glover.

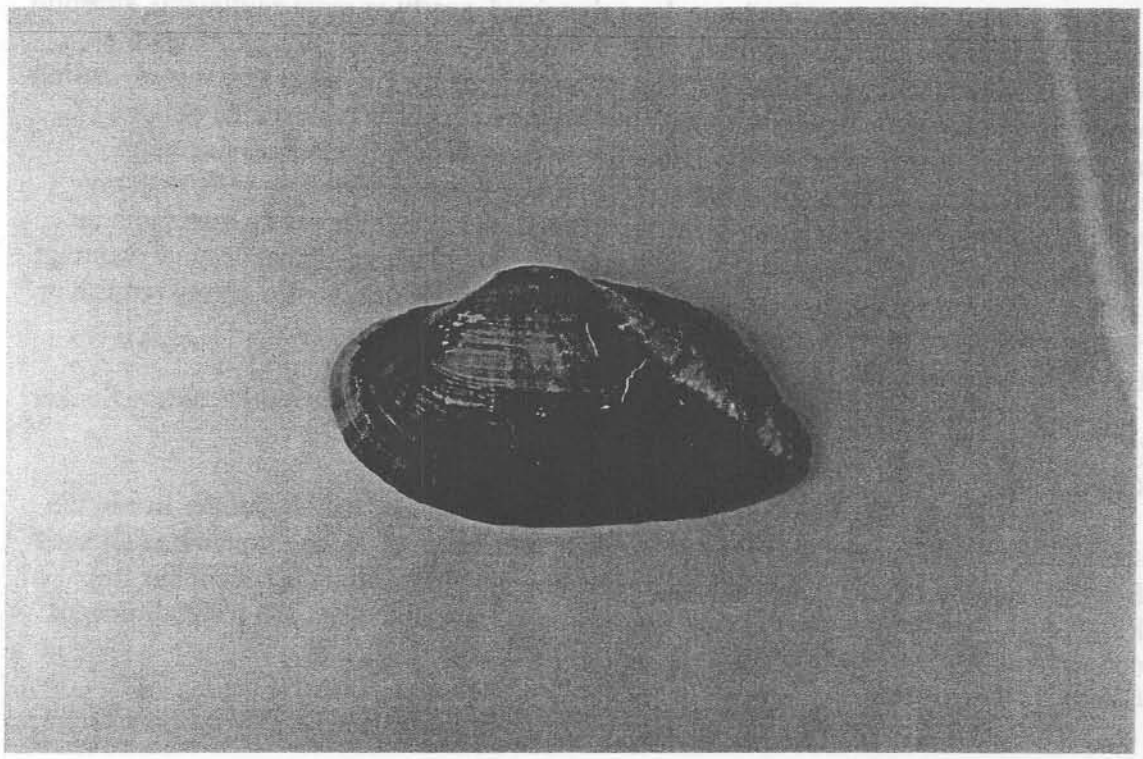
Lukfata Creek:

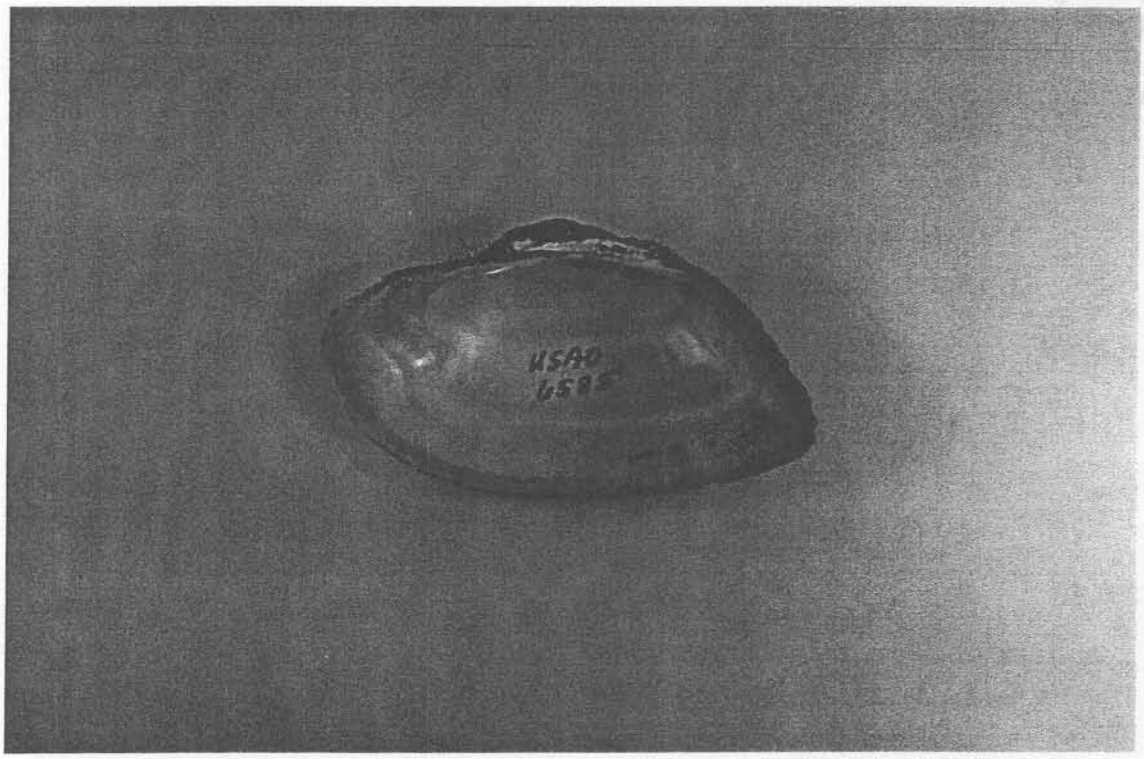
McCurtain Co.: 2 mi. N of Little River bridge on US Hwy. 259/70 and 1 mi. W.

Mountain Fork River:

McCurtain Co.: At US Hwy. 70, about 7 mi. E. of Broken Bow, S7&8-T6S-R22E; 8.4 mi. NE of Smithville; Beavers Bend St. Pk.; Broken Bow Lake, Stephens Gap.

Alasmidonta marginata Say 1818
Elktoe





Partial Synonymy:

Alasmidonta marginata Say 1818; Simpson 1914; Isely 1925; Clarke 1981; Branson 1983; Oesch 1984; Turgeon and others 1988; Vidrine 1993

Description:

"Shell medium to rather large, long rhomboid, nearly or quite equilateral, subsolid to solid, subinflated; beaks very full, high, sculptured with a few strong corrugations, which show a tendency to be doubly looped; posterior ridge very high and angled, ending behind in a point at the base of the shell, behind the ridge there is a decided oblique truncation and the truncated area is rather finely corrugated; growth lines uneven; epidermis smooth, shining, greenish, ashy or smoky-green with narrow yellowish rays and broken, clouded green ones; left valve with one small, compressed, sharp tooth in front of the beak; right valve with a small anterior tooth; laterals almost or quite wanting; beak cavities rather deep; nacre white or bluish, sometimes straw-color, rarely reddish or purple; prismatic border distinct" (Simpson 1914, p 504-505).

Hosts for Glochidia:

Northern Hog Sucker, Rock Bass, Shorthead Redhorse, Warmouth, White Sucker (Watters, 1994).

Comments:

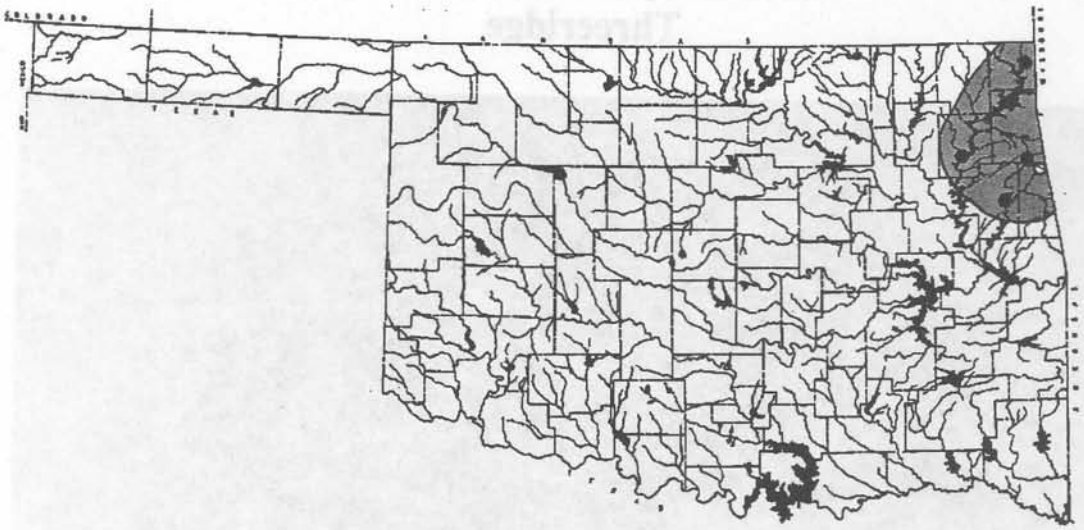
This species has been extremely rare in Oklahoma and may no longer live in the state. The most recent records for this species include a single living specimen collected from the Neosho River in 1978 (Shepard and Covich 1982) and three specimens from Flint Creek (a tributary of the Spring River which is part of the Neosho River drainage) collected in 1955 (Branson 1966).

General Distribution:

Upper Mississippi River and parts of the Great Lakes and St. Lawrence River drainage.

Oklahoma Distribution:

Illinois and Neosho (= Grand) Rivers. This species has always been very rare in Oklahoma and the most recent record of fresh or living specimens date back to 1982. This species may no longer live in the state.



Map 4. Distribution of *A. marginata* in Oklahoma.

Arkansas River System:

Flint Creek:

Ottawa County: Tributary of Spring River, below St. Hwy. 10 bridge (Branson, 1966).

Neosho (Grand) River:

Mayes County: Just upstream from low-water dam, immediately below Hwy. 69 bridge (Shepard and Covich, 1982)

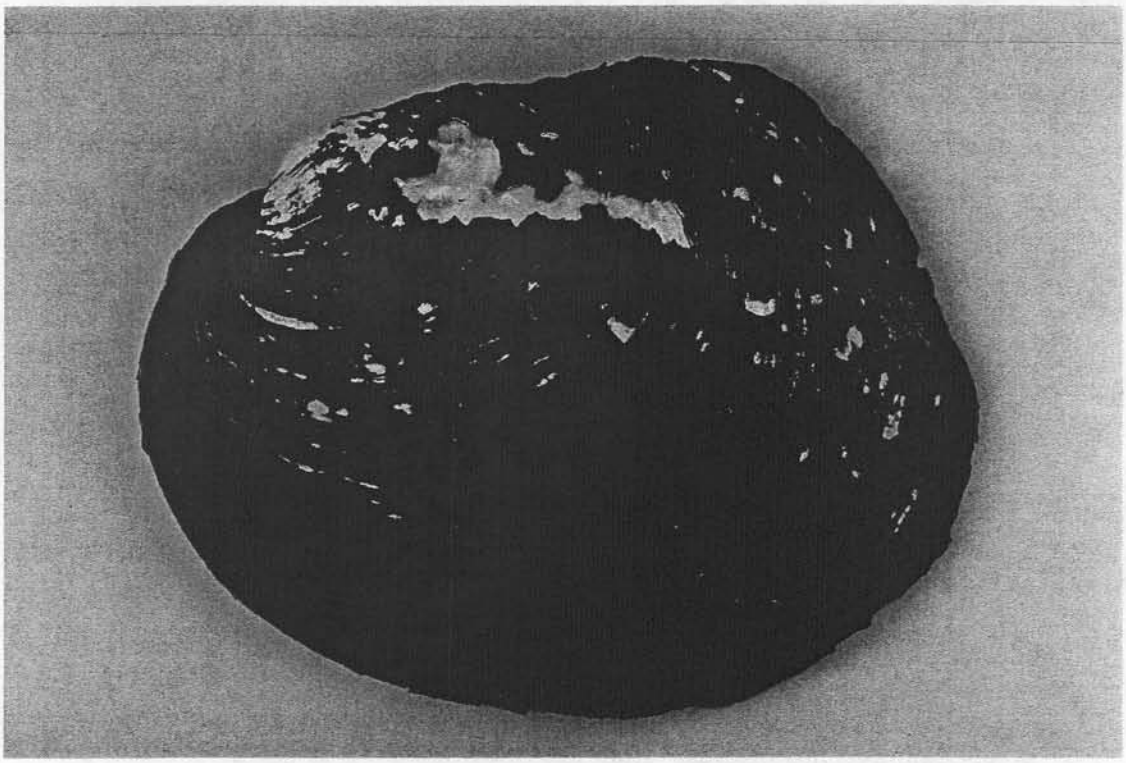
Illinois River:

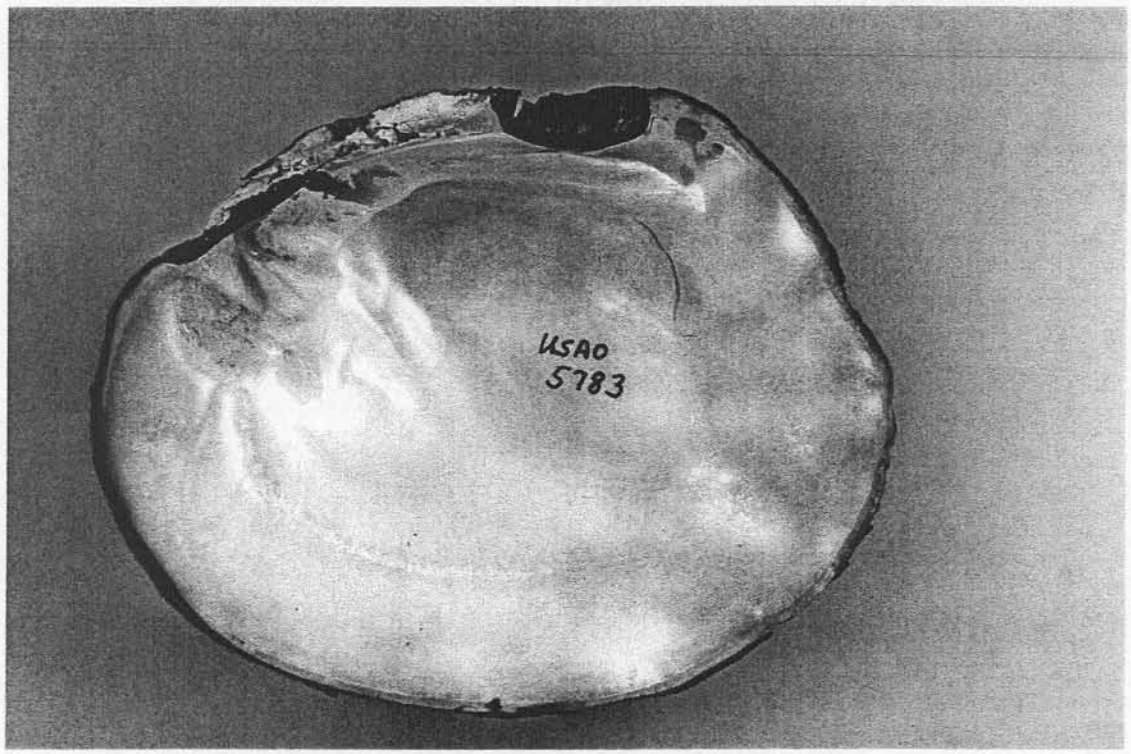
Adair County: 1 mi. downstream from Lake Frances Dam (extremely weathered/subfossil specimen).

Delaware County: Just above mouth of Flint Creek, 1.3 mi. SSW of Flint,

Cherokee County: At Tahlequah (Isely, 1925).

Amblema plicata (Say 1817)
Threeridge





Partial Synonymy:

Amblema costata Rafinesque, 1820, Isely 1925
Quadrula undulata (Barnes, 1823), Isely 1925
Quadrula perplicata (Conrad, 1841), Isely 1925
Amblema perplicata (Conrad, 1841), Isely 1925
Quadrula plicata (Say, 1817), Isely 1925
Amblema peruviana (Lamarck, 1819), Murray and Leonard 1962
Crenodonta peruviana peruviana (Lamarck, 1819), Murray and Leonard 1962
Crenodonta peruviana costata (Rafinesque, 1820), Murray and Leonard 1962
Amblema plicata (Say, 1817), Valentine and Stansbery 1971; Branson 1982; Oesch 1984; Turgeon and others 1988; Vidrine 1993; Howells and others 1996

Description:

"Shell quadrate; dorsal margin long and nearly straight, ventral margin gently rounded; anterior end uniformly rounded; posterior end truncated, ending in a squarish point. Shell thick and solid even in young specimens; size to 18cm; moderately inflated, becoming compressed posteriorly; posterior ridge prominent; four to six prominent ridges roughly parallel the posterior ridge; a few to many curved ridges extend from the posterior ridge to the posterior and dorsal margins. Beaks low, only slightly raised above the hinge line, inequipartite; beak sculpture, usually seen on only very young shells, consists of three or four concentric double-looped ridges. Concentric growth-rest periods form prominent ridges and grooves. Epidermis light brown or yellowish-green becoming dark brown to black on old shells.

Left valve has two large, triangular, grooved pseudocardinal teeth; the lateral teeth are long, slightly curved and finely striated. Right valve has a stout, elevated, triangular, grooved pseudocardinal tooth, having a small lamellar denticle anteriorly; the lateral tooth is high, slightly curved and striated. Interdentum broad; beak cavity deep; nacre white, often tinged with pink or purple posteriorly; local infections often stain the nacre a golden amber color, iridescent posteriorly" (Oesch 1984, p102).

Hosts for Glochidia:

Black Crappie, White Crappie, Bluegill, Flathead Catfish, Green Sunfish, Largemouth Bass, Northern Pike, Pumpkinseed, Rock Bass, Sauger, Shortnse Gar, White Bass, Yellow Perch (Watters, 1994).

Comments:

A highly variable species that varies in outline, size, inflation, sculpture and external color. Because of this, it has accumulated many synonyms over the years. It is widespread in the state and in many mussel beds is the predominant species.

Table 2. Summary of *A. plicata* shell characters.

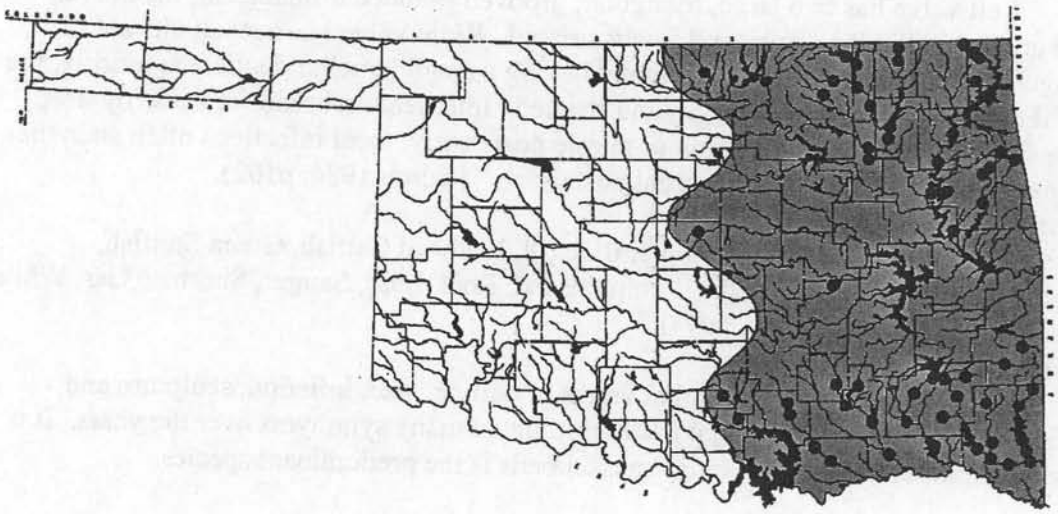
Location	N	H/L Range (%)	Mean H/L (%)	Maximum Length (mm)	W/L Range (%)	Mean H/L (%)
Red River Drainage						
Kiamichi River	55	64.3-85.2	74.7	119	34.1-57.1	44.7
Little River (+ tributaries)	50	63.7-87.2	74.8	118	40.9-56.4	47.6
Mountain Fork River	28	64.2-82.4	74.2	92	38.5-55.8	44.6
Glover River	35	66.3-85.7	74.4	92	38.8-55.3	45.8
Boggy Rivers	13	66.1-85.7	73.7	115	37.7-53.2	47.1
Blue River	23	59.6-76.4	70.1	136	36.9-49.5	43.5
Washita River	1	-	77.0	35	-	-
Arkansas River Drainage						
Illinois River	8	65.0-78.1	70.9	163	41.8-47.9	44.6
Poteau River	13	62.2-77.4	68.5	134	26.8-46.2	37.9
Caney River	5	60.7-74.6	69.6	135	37.0-46.1	41.1
Neosho River	24	62.1-79.2	73.5	158	41.4-55.6	46.6
Verdigris River(+tributaries)	23	62.5-81.8	71.7	144	34.7-56.4	44.3
Bird Creek	21	65.2-77.8	73.3	135	33.3-40.0	36.6

General Distribution:

Mississippi and adjacent Gulf of Mexico drainages. Also some areas of the Hudson Bay and Great Lakes drainage systems.

Oklahoma Distribution:

Found in most river systems throughout the eastern half of Oklahoma.



Map 5. Distribution of *A. plicata* in Oklahoma.

Arkansas River System

Chickaskia River:

Kay County: 3mi. S, 2mi. E and 1 mi. W of Blackwell; SE of Blackwell; Below Lake Blackwell.

Salt Creek:

Osage County: 3.1 mi. SW of Shidler.

Verdigris River:

Rogers County: 0.8 mi. W of Claremore Mound; Below Oologah Dam; 2.29 mi. SE of Oologah.

Nowata County: At St. Hwy. 10, 2.8 mi. E of Lenapah; 4 mi. N of Childers, Hancock Bridge; 2 mi. SE of South Coffeyville.

Bird Creek:

Osage County: At Nelagoney.

Tulsa County: 3 mi. E and 4 mi. N of Lake Yahola.

Mingo Creek:

Tulsa County: 2 mi. S of Owasso.

Caney River:

Washington County: 6.2 mi. NW of Dewey; At Bartlesville; 4.8 mi. E of Ramona; 4.6 mi. NE of Dewey; NE of Bartlesville on old Hwy. 75.

Osage County: Below Hulah Reservoir Dam; 4.8 mi. SE of Hulah Dam.

Sand Creek:

Osage County: NE _ S15-T26N-R10E; Osage Hills St. Pk.

Neosho River:

Ottawa County: Miami, city park.

Craig County: 4.5 mi. NW of Miami, Stepps Ford Bridge; 3 mi. WNW of Miami; 9.5 mi. NW of Miami (Craig/Ottawa county line); 2.9 mi. E of USHwy. 59.

Mayes County: Lake Hudson at Salina boat ramp; W side of Ft. Gibson Lake at Three Finger Bay.

Wagoner County: Ft. Gibson Lake; Ft. Gibson Lake, 3 mi. S and 4 mi. E of Wagoner.

Cherokee County: Ft. Gibson Lake; Ft. Gibson Lake, Hulbert Landing area, 2 mi. E and 1 mi. S of Sequoyah St. Pk.

Fort Gibson Reservoir:

Wagoner County: 9 mi. N of Okay.

Horse Creek:

Ottawa County: At Afton.

Illinois River:

Adair County: 1 mi. downstream from Lake Frances Dam.

Cherokee County: Round Hollow Public Access Area, 1 mi. ENE of Scraper off St. Hwy 10; Peavine Hollow Public Access Area, 2.6 mi. SE of Scraper on St. Hwy. 10; Public Access Area, downriver from Hwy. 51 bridge.

Delaware County: Just above the mouth of Flint Creek, 1.3 mi. SSW of Flint.

Greenleaf Lake:

Muskogee County: Greenleaf Lake.

Poteau River:

LeFlore County: 7 mi.S. of Heavener, S35-T5N-R25E.

North Canadian River:

Hughes County: NE of Wetumka on Hwy. 75.

Deep Fork River:

Oklahoma County: W. of Arcadia.

Red River System

Washita River:

Murray County: W of Davis.

Carter County: E of Gene Autry on St. Hwy. 53.

Blue River:

Johnston County: 2.9 mi. E of Jct. of SH 99 and 7 on St. Hwy. 7; At St. Hwy. 48, 1 mi. N of Milburn, S34&35-T3S-R7E; 2.8 mi. NNW of Milburn, old low water crossing, S21-T3S-R7E; 5 mi. NE of Tishomingo;
10 mi. NE of Tishomingo; 7.5 mi. E of Reagan; 6.2 mi. S of Connerville; 4.3 mi. S of Connerville.

Bryan County: 5 mi. W of Blue on US Hwy. 70; At Blue (weathered specimen); At Armstrong, below dam; 1 mi. SSW of Blue on county road.

Muddy Boggy River:

Coal County: 2 mi. N of Coalgate.

Atoka County: 7 mi. E of Atoka; 3 mi. W of Lane; Atoka Reservoir, 5 mi. N of Stringtown.

Choctaw County: Hwy 70 W of Soper; At Jasper on US Hwy. 70.

Clear Boggy River:

Atoka County: At US Hwy. 75 between Caney and Tushka.

Kiamichi River:

LeFlore County: 1 mi. SSW of Muse, S10-T2N-R24E.

Pushmataha County: 2 mi. S of Clayton on US Hwy 271; 14,9 mi. NNE of Antlers on Hwy 2; Low water crossing at Stanley; US Hwy 271 at Antlers.

Choctaw County: Spencerville Crossing, 8.5 mi. NE of Hugo.

Little River:

Pushmataha County: Near Fewell; County Road E of Cloudy (4.5 mi. E and 1.5 mi. W); 5.2 mi. ENE of Cloudy.

McCurtain County: N of Idabel on US Hwy. 70, S19-T7S-R24E; 1 mi. N of Goodwater; At railroad crossing, 1.5 mi. SW of Wright City, S6 and 7-T6S-R22E; 1.5 mi. N of Garvin, S6-T7S-R23E; Lukfata Creek, 2 mi. N of Little River bridge on US Hwy 259/70 and 1 mi. W.

Cloudy Creek:

Pushmataha County: 3 mi. SE of Cloudy at low water crossing.

Black Fork Creek:

Pushmataha County: _ mi. S of Nashoba.

Glover River:

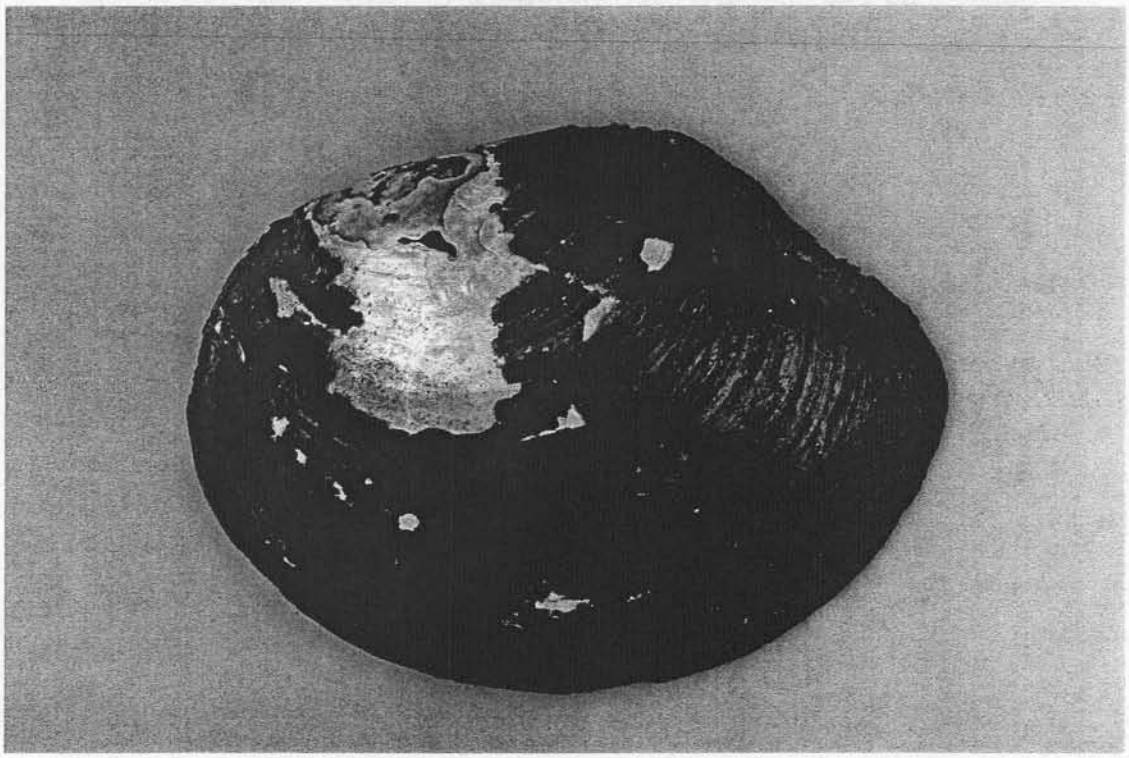
McCurtain County: 10.7 mi. W of Broken Bow on St. Hwy. 3 and 7; 14 mi. SE of New Ringold on St. Hwy. 3 and 7; At Glover, S33-T5S-R23E; 2 mi. N of Glover; 0.25 mi. W of Glover.

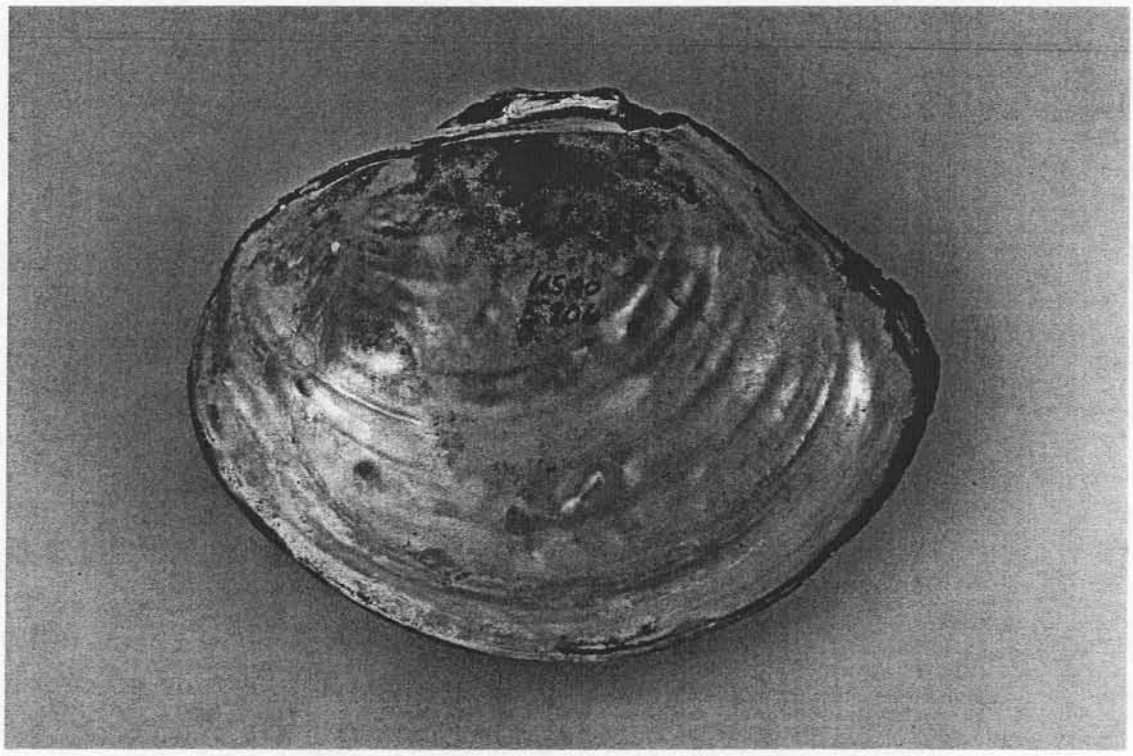
West Fork of Glover River: 1.4 mi. W and 0.2 mi. N of Battiest.

Mountain Fork River:

McCurtain County: At US Hwy. 70 E of Broken Bow; 8.4 mi. NE of Smithville; 10 mi. S of Smithville, S9-T2S-R25E; 5 mi. S of Smithville; Beavers Bend St. Pk.; about 3 mi. E of Beachton, S7-T1S-R27E; At the "Narrows", S9-T2S-R25E; Off US Hwy. 259, about 8 mi. S of Smithville; 6.5 mi. SW of Smithville.

Anodonta suborbiculata Say 1831
Flat Floater





Partial Synonymy:

Anodonta suborbiculata Say, 1831, Simpson 1914; Murray and Leonard 1962; Branson 1983; Oesch 1984; Turgeon and others 1988; Vidrine 1993; Howells and others 1996

Description:

"Shell large, irregularly short ovate, thin but strong, gaping in front and behind, subinflated, with low beaks, which are compressed in young shells but fuller in old ones, their sculpture a few irregular, feeble undulations, each bar usually having small, sharp tubercles, these tubercles form two imperfectly radiating rows; dorsal line somewhat curved, ending in front and behind in a small wing or angle; dorsal slope truncated, its outline incurved just above the low posterior ridge; the rounded posterior point about at the median line; base line rounded; anterior end rounded, sometimes cut away a little below; surface smooth and shining in young shells, pale, yellow-green, beautifully and delicately rayed, with three broad rays behind; in old shells the outer growth is concentrically sculptured and the epidermis is smoky or ashy, often banded and nearly or quite rayless; nacre silvery and iridescent, tinted bluish or purplish" (Simpson 1914, p400).

Comments:

An uncommon species in the state and records are probably the result of accidental introduction.

Table 3. Summary of *A. suborbiculata* shell characters.

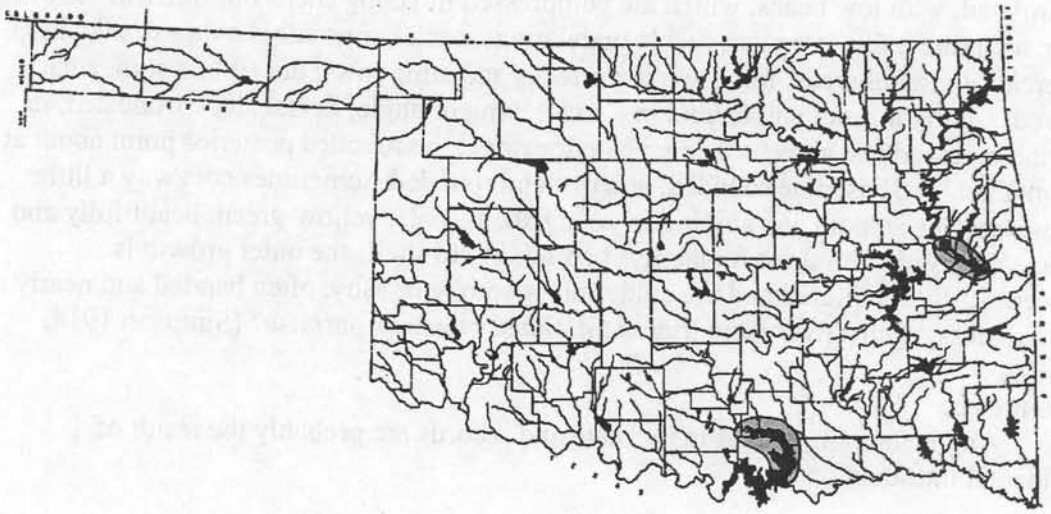
Location	N	H/L Range (%)	Mean H/L (%)	Maximum Length (mm)	W/L Range (%)	Mean W/L (%)	Remarks
Lake Texoma	5	69.2-77.8	72.1	81.0	23.8-40.7	29.0	4 of these 5 were early juvenile shells

General Distribution:

Upper Mississippi and Great Lakes drainages and some Gulf of Mexico drainages.

Oklahoma Distribution:

Currently known only from Lake Texoma and Robert S. Kerr Reservoir but can be expected to be introduced into almost any lake or river backwater within the state.



Map 6. Distribution of *A. suborbiculata* in Oklahoma.

Arkansas River System

Arkansas River:

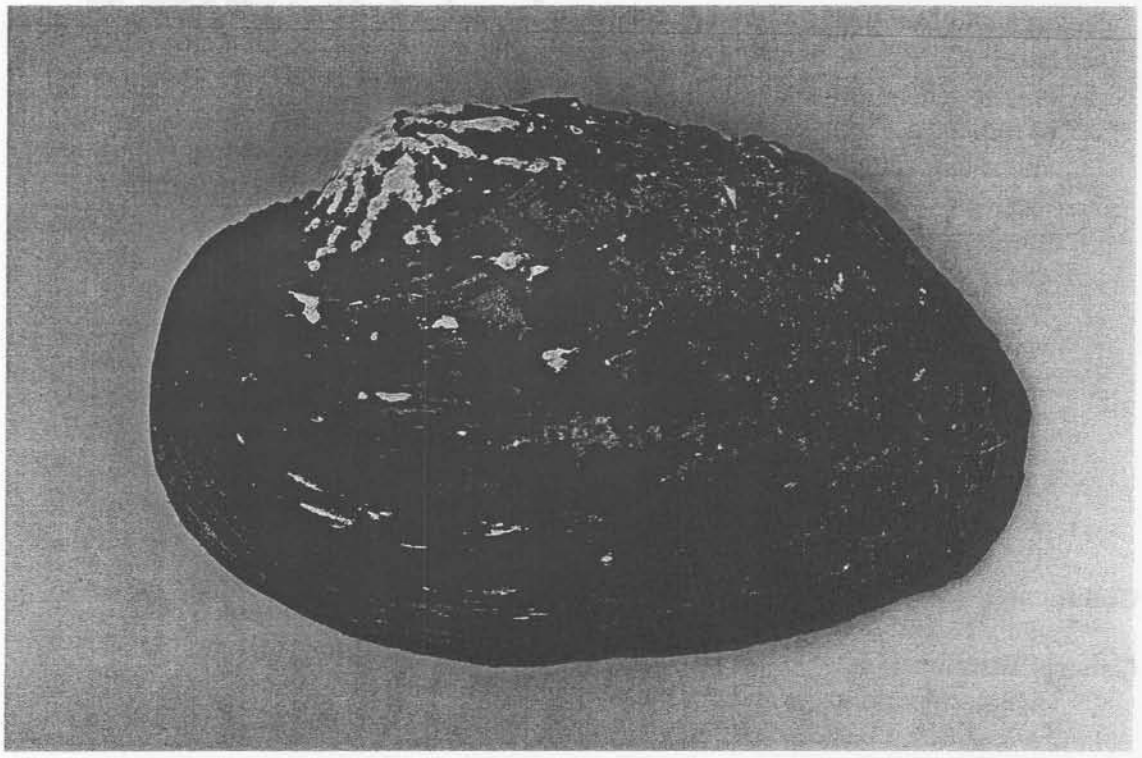
Muskogee County: Webber Falls at Hwy. 10, Robert S. Kerr Lake.

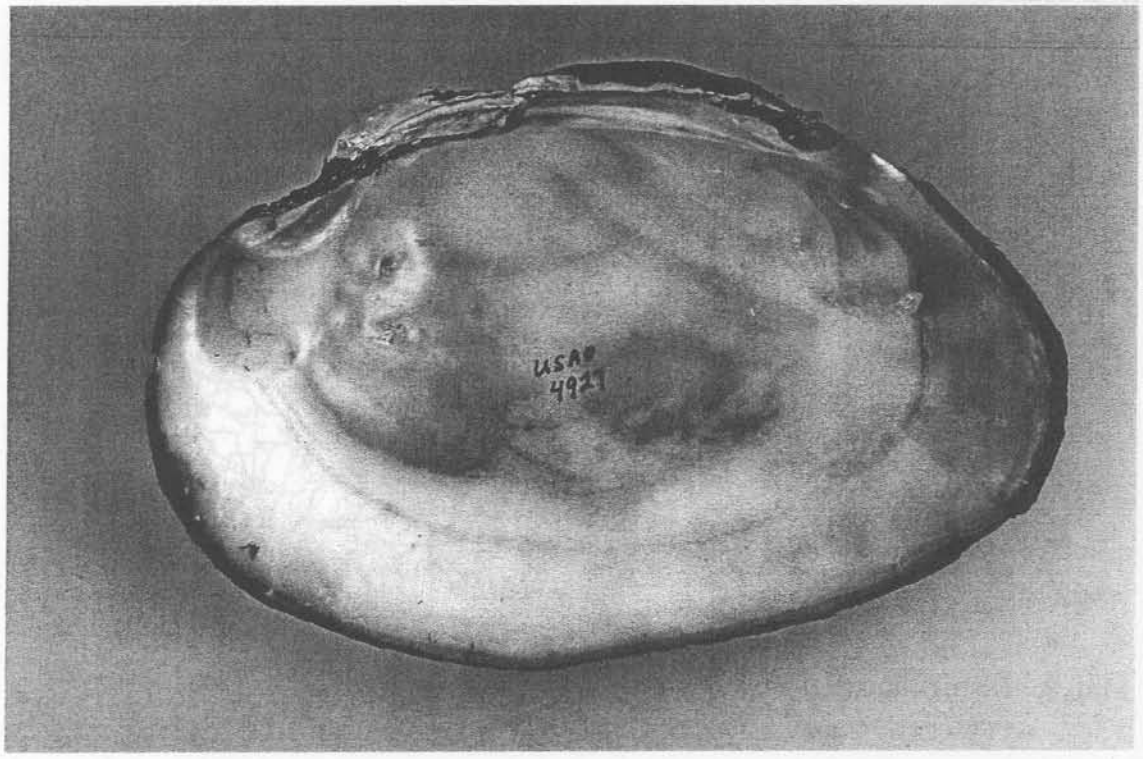
Red River System

Lake Texoma:

Bryan County: Lake Texoma, a cove SE of Roosevelt Bridge, W of Durant, S33-T6S-R7E.

Arcidens confragosus (Say 1829)
Rock-Pocketbook





Partial Synonymy:

Arcidens confragosus (Say, 1829)

Description:

"Shell rhomboid, inflated, subsolid, or solid, slightly inequilateral; beaks high and full, their sculpture consisting of irregular, doubly-looped ridges, the bases of the loops being developed into strong, pinched-up nodules, which extend out on to the disk of the shell; in front of and behind the loops there are a number of radiating, wavy, subnodulous lirae or small ridges; from the anterior row of knobs extending backwards and downwards there is a series of strong folds and these are crossed by wrinkled, radiating, sometimes zigzagged, threads; the posterior slope has radial, wrinkled sculpture, while the anterior base has usually merely concentric striae; posterior ridge rather high; post-dorsal region almost winged; epidermis brownish-green with dark bands, sometimes clouded; left valve with an arched, somewhat elongated tooth under the beak, which often curves upward; in front of this there is a compressed tooth; right valve with a strong, subcompressed tooth in front of the beak; at the beak the hinge plate is cut away for the reception of the tooth in the left valve; laterals reduced to blurred, uneven vestiges; beak cavities deep; muscle scars shallow; nacre bluish-white, dull, often with uneven radial sculpture, with a wide prismatic border" (Simpson, 1914, p. 475-476).

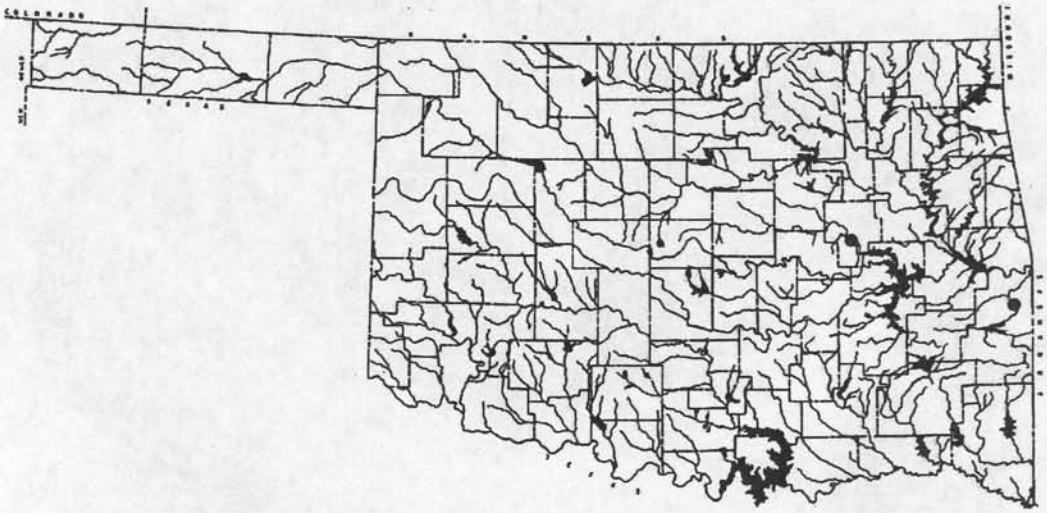
Comments:

Only recently confirmed in Oklahoma.

General Distribution:

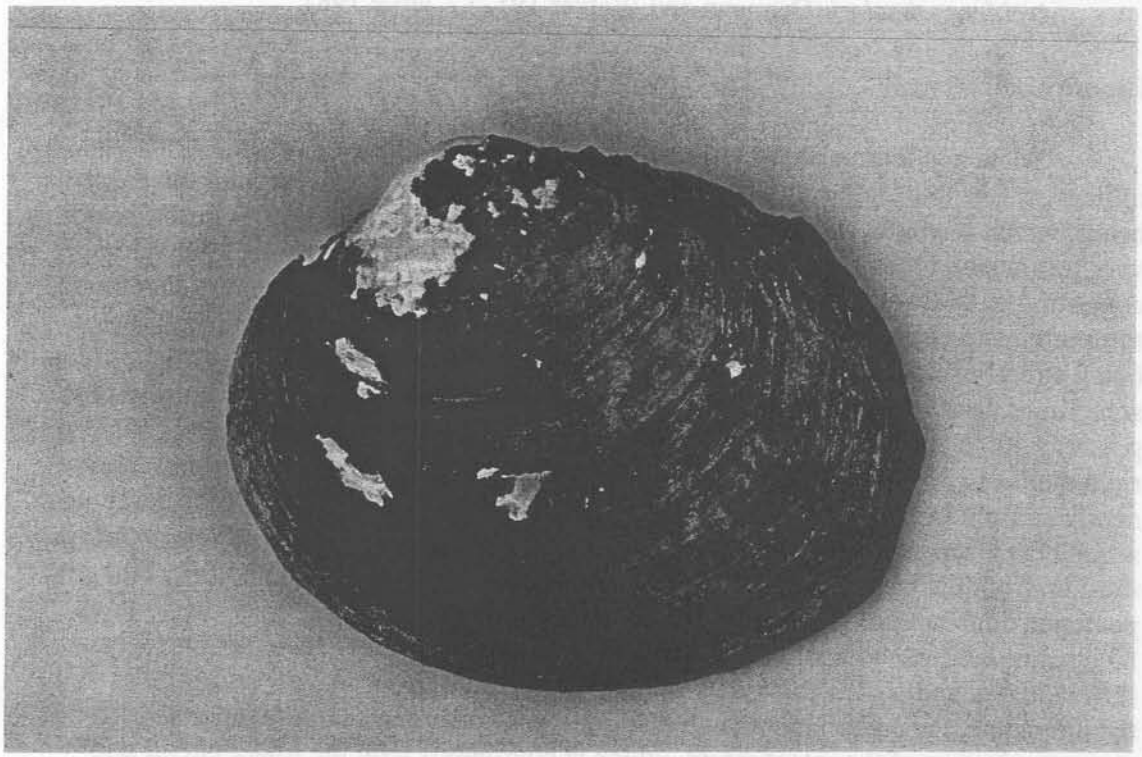
Mississippi drainage and Gulf of Mexico rivers west into Texas.

Oklahoma Distribution:



Map 7. Distribution of *A. confragosus* in Oklahoma.

Arcidens wheeleri (Ortmann and Walker 1912)
Ouachita Rock-Pocketbook



Partial Synonymy:

Arkansia wheeleri Ortmann and Walker 1912, Simpson 1914; Isely 1925; Johnson1980; Branson 1983; Turgeon and others 1988; Howells and others 1996

Arcidens wheeleri (Ortmann and Walker 1912), Clarke 1981

Description:

"Male and female shells alike. Shell subrotund to subovate or subrhomboidal, inflated, rather thick and solid; dark reddish-brown or black, usually lighter toward the beaks, which in young shells are chestnut-colored; epidermis with a silky luster; beaks very prominent, projecting anteriorly and incurved over the large lunule, their sculpture consisting of two or three double-looped bars, the loops slightly swollen or tubercular; sculpture restricted to the extremity of the beaks, the remainder of the umbonal region being entirely smooth; posterior half of the disk sculptured with irregular, oblique folds, sometimes nearly obsolete, which on the dorsal slope curve upwards, and in front of the posterior ridge are crossed by numerous, irregular, radiating, small folds or wrinkles at right angles to the lines of growth; anterior portion of the disk smooth; anterior margin nearly straight in front of the beaks, then projecting in a regular curve, which continues around the basal margin until it meets the posterior margin at an obtuse angle about one-third up from the base; Hinge margin nearly straight; posterior margin slightly curved; posterior ridge not prominent, usually rounded, but sometimes obscurely biangulate; hinge complete; pseudocardinals strong, ragged, in the left valve, two, not strongly differentiated and coalescing along the hinge line, the anterior narrow and parallel with the hinge line, the posterior somewhat wider and heavier and scarcely separated from a strong projection of the interdentum, which is continuous with the lower lateral and slopes gradually to its extremity; upper lateral low, the groove between them deep and extending nearly to the beak; a single, strong pseudocardinal in the right valve with a deep pit behind it to receive the anterior pseudocardinal of the left valve, interdentum cut away to make room for the interdental projection in the left valve; a single strong, but rather short lateral; ligament dark brown; muscle scars not very deep, those of the anterior adductor and posterior adductor large, those of the anterior retractor and pedal protractor rather small and inconspicuous; Cavity of the beaks very deep; nacre usually salmon-colored above the pallial line, bluish-white below (sometimes entirely white) and rather thin, slightly iridescent with a wide, dark prismatic border" (Ortmann and Walker 1912, p98-99).

Comments:

Considered rare and endangered on the Federal and State level. Small populations confined to parts of Arkansas (mostly extirpated), the Kiamichi River and Little River in Oklahoma and possibly small tributaries of the Red River in Northeast Texas.

Table 4. Summary of *A. wheeleri* shell characters.

Location	N	H/L Range (%)	Mean H/L (%)	Maximum Length (mm)	W/L Range (%)	Mean W/L (%)
Red River Drainage						
Kiamichi River	14	73.8-85.4	78.0	93.0	46.2-57.1	54.5

General Distribution:

Found only in the Ozarkian region of southeastern Arkansas (mostly extirpated) and the Kiamichi and Little Rivers of Oklahoma and possibly some small tributaries of the Red River in northeastern Texas.

Oklahoma Distribution:

Map 8. Distribution of *A. wheeleri* in Oklahoma.

Red River System

Kiamichi River:

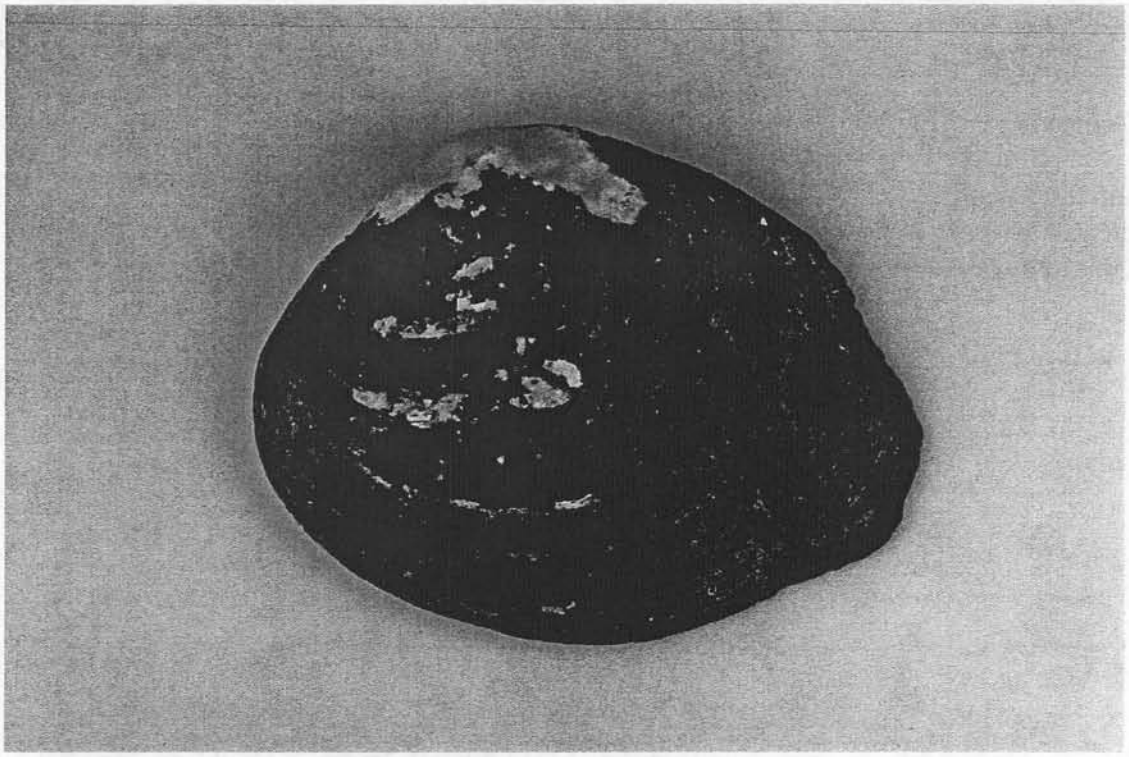
Pushmataha County: 14.9 mi. NNE of Antlers on St. Hwy. 2; 16.3 mi. SW of Clayton on St. Hwy. 2; 0.9 mi. S of Clayton on US Hwy. 271; At Eubanks crossing on St. Hwy. 2; At Stanley.

Choctaw County: Spencerville Crossing, 8.5 mi. NE of Hugo.

Little River:

McCurtain County: 1.5 mi. N of Garvin, S6-T7S-R23E; At railroad crossing, 2 mi. W of Wright City.

Cyprogenia aberti (Conrad 1850)
Western Fanshell



Partial Synonymy:

Cyprogenia aberti (Conrad, 1850), Simpson 1914; Isely 1925; Murray and Leonard 1962; Johnson 1980; Branson 1984; Turgeon and others 1988

Description:

"Shell of medium size, seldom exceeding 80mm in length. Outline usually rhomboidal, occasionally rounded triangular. Valves slightly inflated, thick and heavy. Anterior end regularly rounded; posterior end subtruncate. Ventral margin more or less rounded, tending to be straight or slightly concave posteriorly. Dorsal margin slightly convex forming a more or less distinct angle with the almost vertical, sometimes concave, posterior margin. Hinge ligament rather long. Posterior ridge well developed, high and narrow at the umbonal region, becoming flattened and somewhat double, with a wide shallow groove before it. Posterior slope with a radial furrow, very narrow. Umbos low and compressed, curved forward over the lunule, located at the middle of the shell or somewhat anteriorly. Surface of the shell with strong, low, more or less numerous, concentric ridges; in addition it is sometimes subvertically wrinkled and nodulous. Periostracum scarcely shining, yellowish green, with dots and flecks of dark green which fall into broad broken rays. Hinge very broad and flat. Left valve with two heavy, triangular, blunt and ragged, pseudocardinal teeth of about equal height; also with two short, very low lateral teeth.

Right valve with one large pseudocardinal, sometimes with a feeble one on each side of it. Interdentum is very broad. One low double or triple lateral tooth. Umbonal cavities are very shallow and compressed. Anterior and posterior adductor muscle scars and pallial line are all well impressed. Nacre is white, thinner and somewhat iridescent anteriorly" (Johnson 1980, p 134).

Hosts for Glochidia:

Goldfish (Watters, 1994).

Comments:

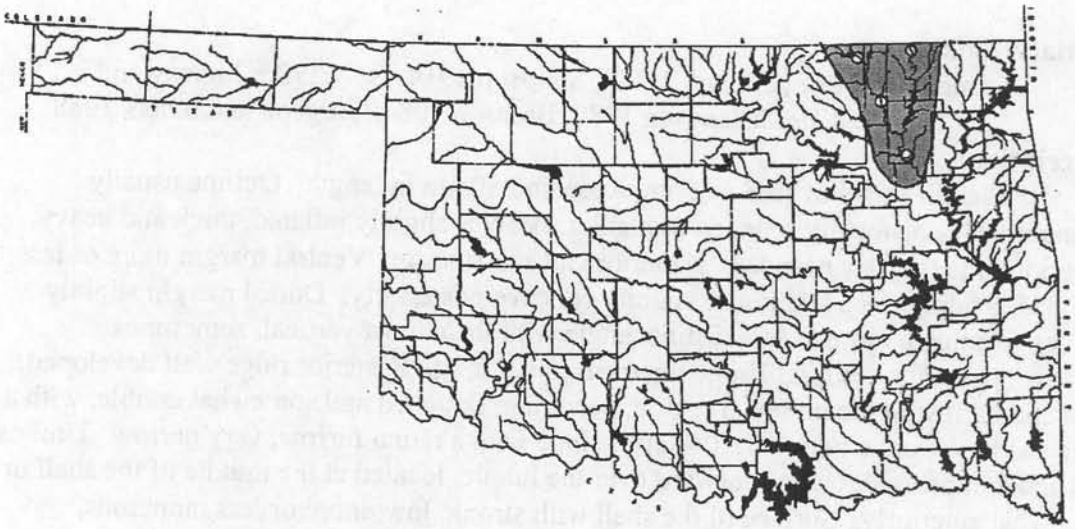
Probably extirpated from Oklahoma.

General Distribution:

Black River, White River, Arkansas River, St. Francis River and Meramec River systems of Arkansas, southern Missouri, southeastern Kansas and northeastern Oklahoma.

Oklahoma Distribution:

This species was originally described from a specimen collected at Chambers Ford on the Verdigris River in 1849 by Dr. Samuel Woodhouse. There are no recent records for the species in the state and is presumed extirpated from Oklahoma's part of its range.



Map 9. Distribution of *C. aberti* in Oklahoma. Yellow dots represent old literature records and subfossil specimens. The open (white) dot is "Chambers Ford" on the Verdigris River from which the species was described in 1850 by Timothy Conrad.

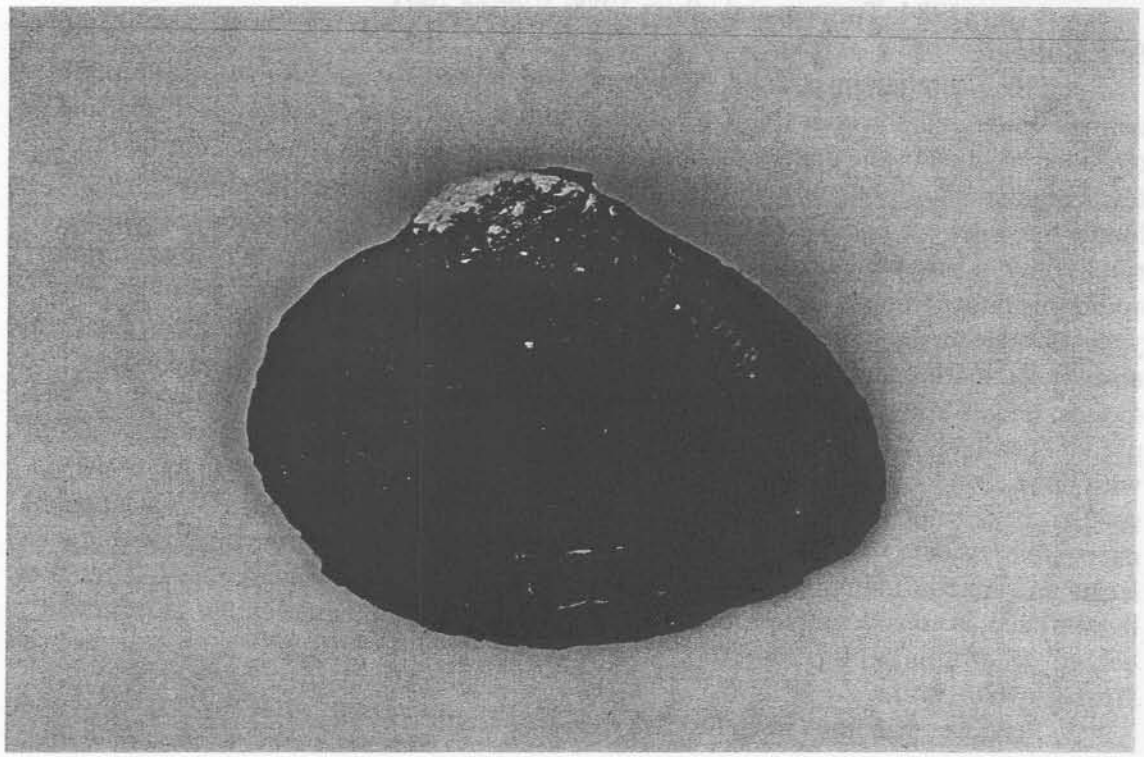
Arkansas River System

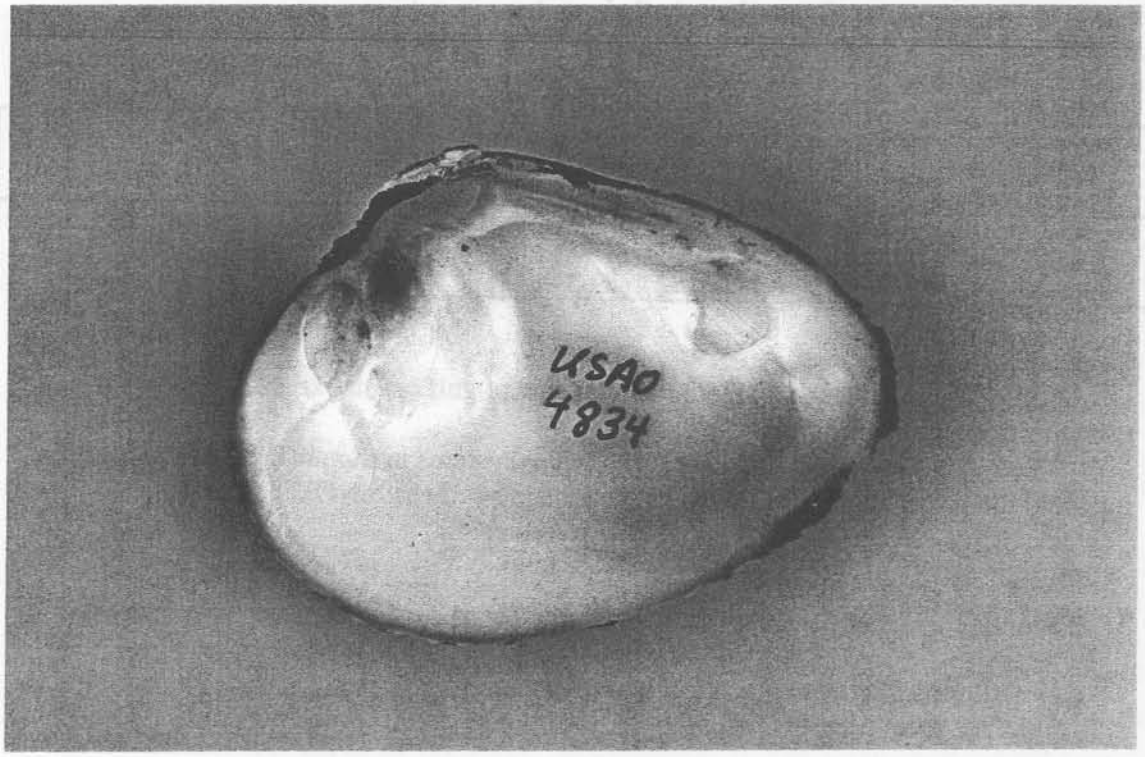
Caney River:

Osage County: 4.8 mi. SE of Hulah Lake Dam (subfossil).

Washington County: Bridge 635 (subfossil).

Ellipsaria lineolata (Rafinesque 1920)
Butterfly





Partial Synonymy:

Plagiola securis (Lea, 1829), Simpson 1914

Plagiola lineolata (Rafinesque, 1820), Murray and Leonard 1962

Ellipsaria lineolata (Rafinesque, 1820), Johnson 1980; Branson 1984; Oesch 1984; Turgeon and others 1988; Vidrine 1993

Description:

"Shell subtriangular, solid, subcompressed or scarcely inflated, with a sharply defined up-curved posterior ridge, behind which it is truncated; region of the beaks and a considerable area of the upper part of the shell compressed; beak sculpture consisting of a few irregular, slightly doubly-looped ridges; beaks curved forward over a small, wide lunule passing back under the hinge, where it is filled with epidermal matter; ligament small, brown; surface with irregular, often rude, sometimes almost sulcate, growth lines; epidermis rather smooth, but showing fine, wrinkled loops under a glass, tawny or yellowish-green, generally with faint, broken rays, which are made up of dots or lunate or arrow-head markings; they are sometimes composed of alternately lighter and darker dashes; hinge strong, the plate often flattened; left valve with two triangular, ragged pseudodcardinals, a faint anterior third one, and two slightly curved laterals; right valve with three pseudocardinals, the middle one the largest, and two laterals, the lower the smaller; beak cavities moderately deep; muscle scars impressed, the anterior ones ragged; nacre silvery-white. The male and female shell differ widely, the former are much the larger and are considerably compressed; the female shell is somewhat humped, is more or less inflated, is considerably produced at the posterior base and gaps a little in front and behind" (Simpson 1914, p 304-305).

Hosts for Glochidia:

Freshwater Drum, Green Sunfish, Sauger (Watters, 1994).

Table 5. Summary of *E. lineolata* shell characters.

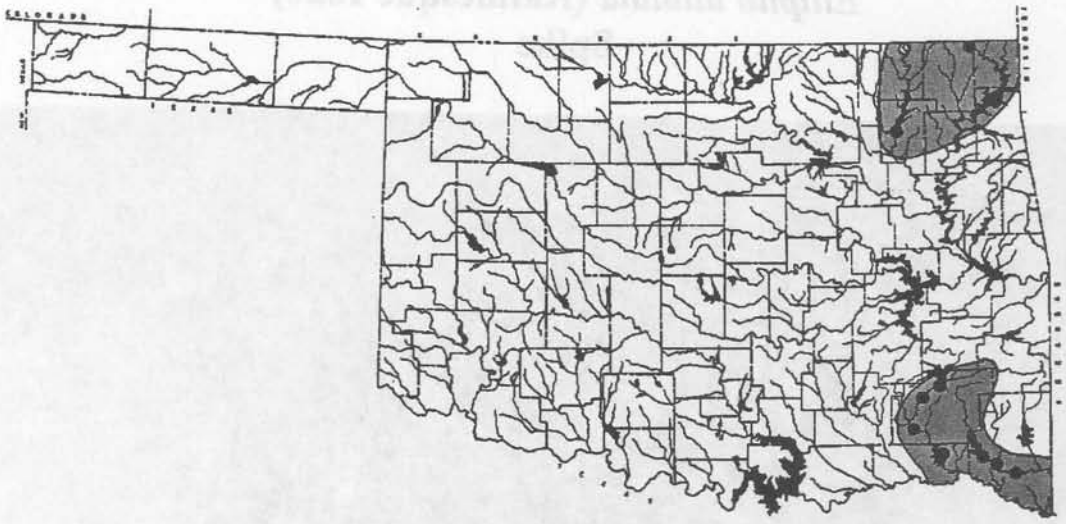
Location	N	Mean H/L (%)	H/L Range (%)	Maximum Length (mm)	Mean W/L (%)	W/L Range (%)
Arkansas River Drainage						
Verdigris River	4	74.0	71.7-75.6	99	-	37.8
Neosho River	5	75.5	71.7-78.9	134	-	-
Red River Drainage						
Kiamichi River	1	74.8	66.3-88.6	101	43.0	32.3-57.1
Little River	9	73.8	68.1-79.2	91	45.8	44.4-46.9

General Distribution:

Mississippi River drainage in general except gulf coastal areas.

Oklahoma Distribution:

Found in the Verdigris and Neosho River systems in the northeastern part of the state and the Kiamichi and Little River systems in southeastern Oklahoma.



Map 10. Distribution of *E. lineolata* in Oklahoma.

Arkansas River System

Verdigris River:

Nowata County: 2 mi. SE of South Coffeyville (weathered/subfossil).

Rogers County: 0.8 mi. W of Claremore Mound; Below Oologah Dam (weathered).

Neosho (Grand) River:

Craig County: 9.5 mi. NW of Miami, Craig/Ottawa county line (weathered); 2.9 mi. E of US Hwy. 59, Craig/Cherokee,KS county line (weathered).

Red River System

Kiamichi River:

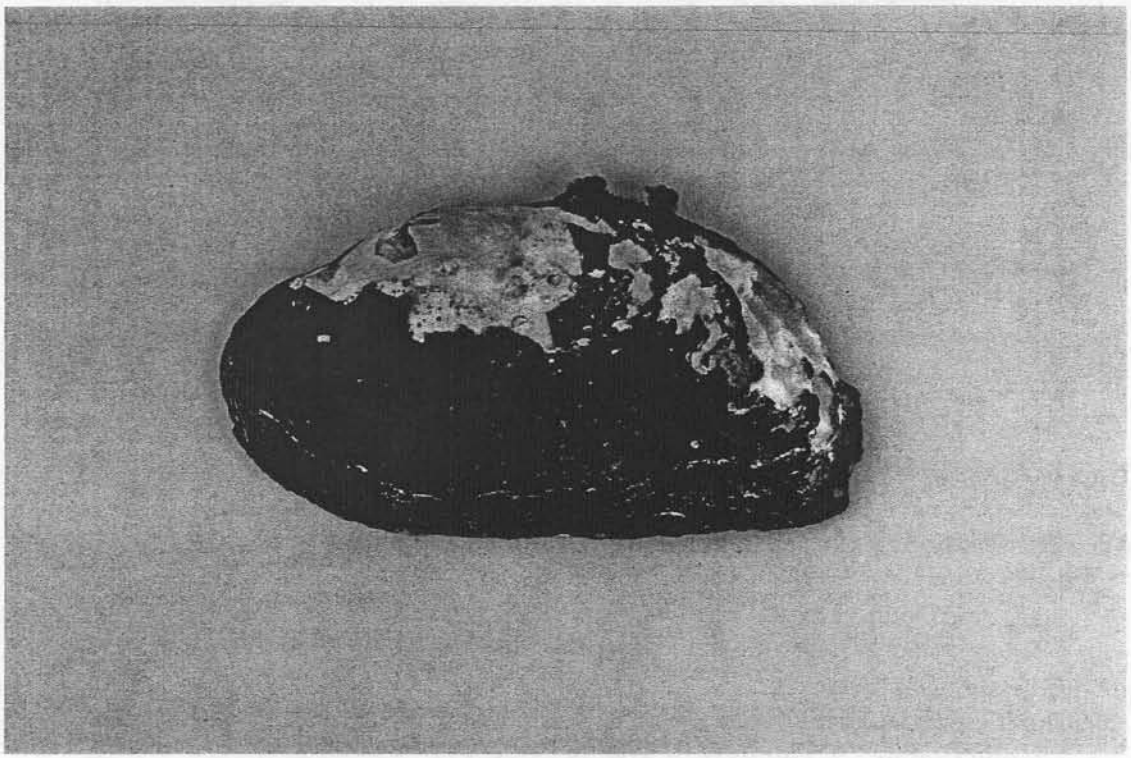
Pushmataha County: 14.9mi. NNE of Antlers on St. Hwy. 2; 0.9 mi. S of Clayton at US Hwy 271; At Stanley, low water crossing; US Hwy. 271 at Antlers.

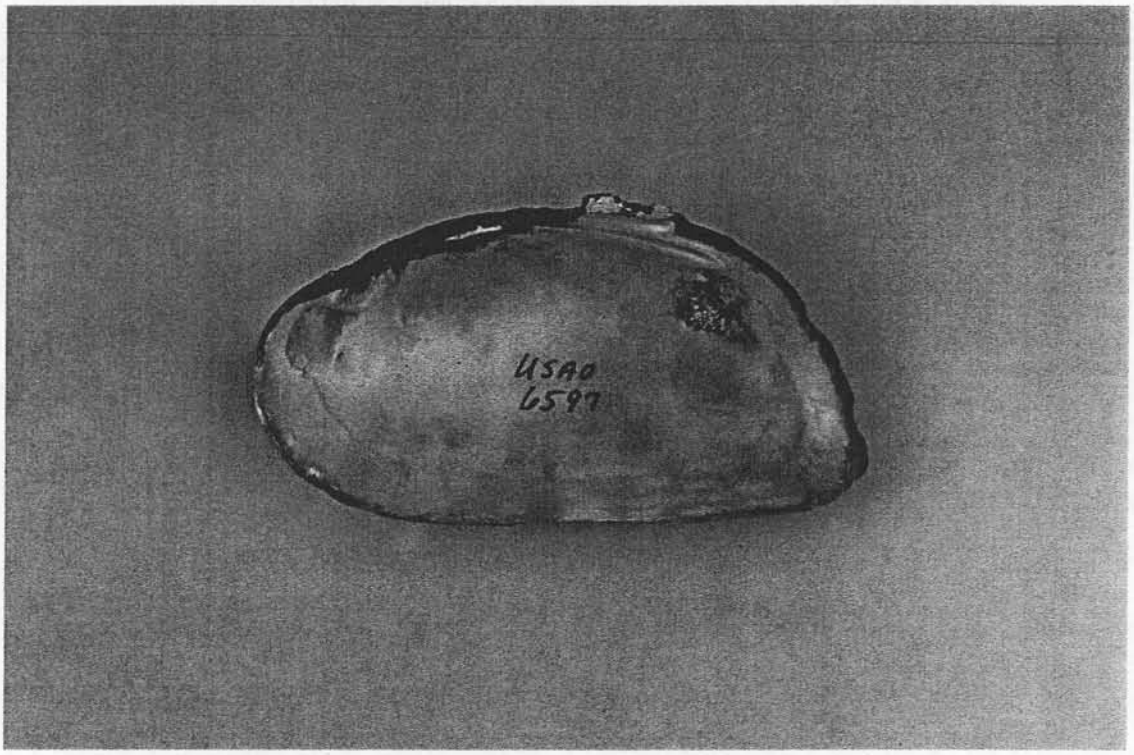
Choctaw County: Spencerville Crossing, 8.5 mi. NE of Hugo.

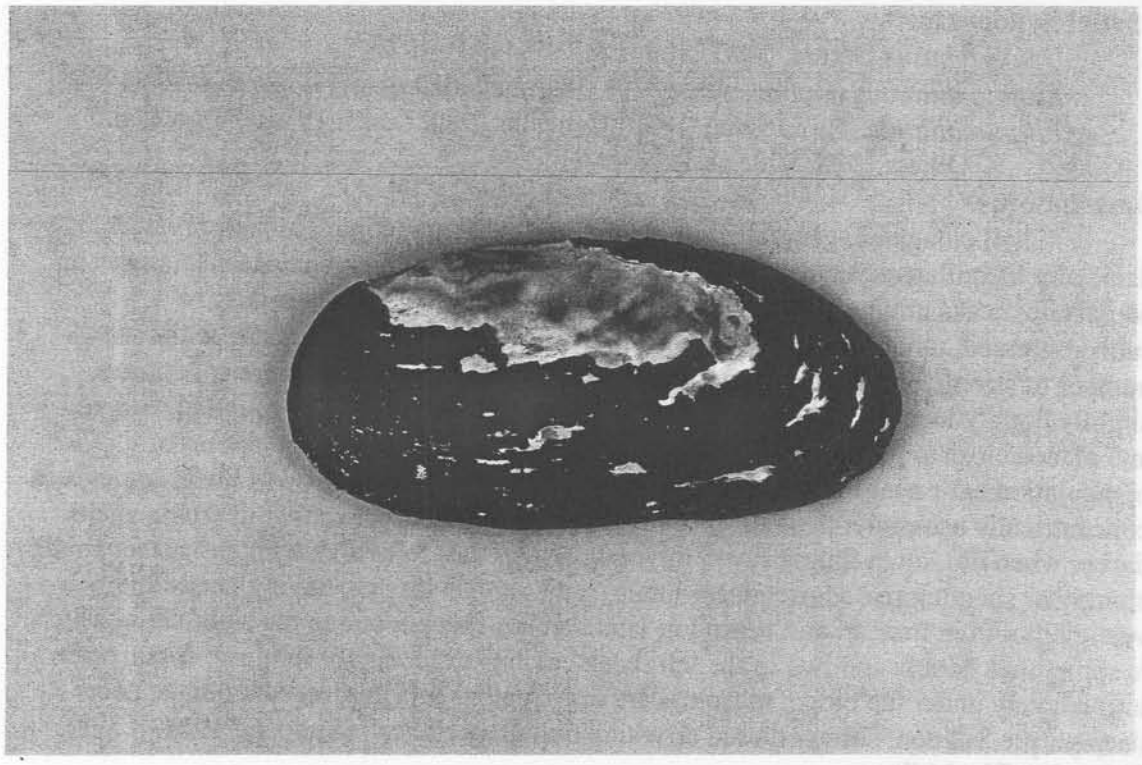
Little River:

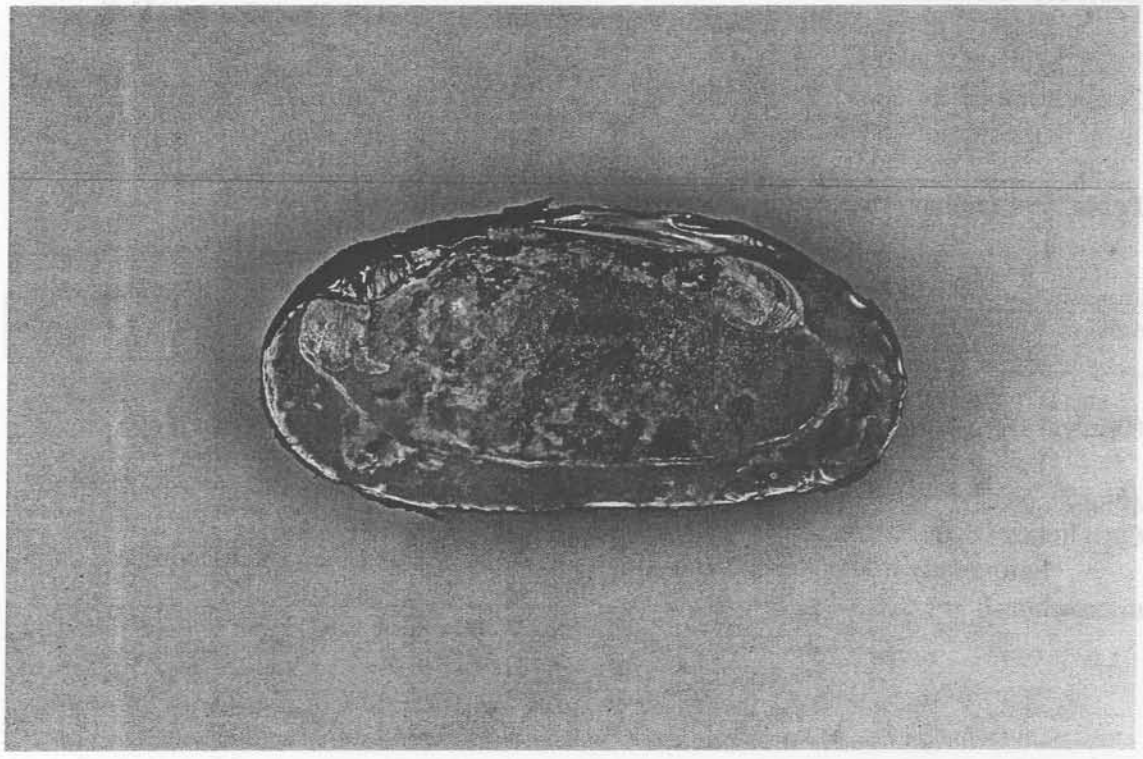
McCurtain County: N of Idabel, S19-T7S-R24E; At railroad crossing, 1.5 mi. SW of Wright City, S6 and 7-T6S-R22E; 1.5 mi. N of Garvin, S6-T7S-R23E.

Elliptio dilatata (Rafinesque 1820)
Spike









Partial Synonymy:

Unio gibbosus Barnes, 1823, Simpson 1914; Isely 1925

Elliptio dilatatus (Rafinesque, 1820), Murray and Leonard 1962; Branson 1983

Elliptio dilatata (Rafinesque, 1820), Johnson 1980; Oesch 1984; Turgeon and Others 1988; Vidrine 1993

Description:

"Shell elongated, generally solid, rarely inflated, sometimes subcompressed, decidedly inequilateral, usually a little higher in front and often arcuate, especially in an adult state; beaks not much elevated above the curved dorsal line, generally subcompressed, turned a little forward over a well-developed lunule, their sculpture a number of strong, often rude, subcorrugated, longitudinal bars, which are sometimes slightly doubly looped; posterior ridge well developed, subangular or rounded, curved and placed close to the dorsal line, rarely double and ending behind in a point of biangulation at or near the base of the shell; surface with uneven growth lines, sometimes concentrically sculptured; epidermis dull, greenish or yellowish-brown in young shells, darker when old, often faintly rayed in young specimens; left valve with two rather small, stumpy or subcompressed pseudocardinals; right valve with one, having occasionally a vestigial tooth in front of and behind it; laterals club-shaped, one in the right valve which is sometimes double and two in the left; beak cavities exceedingly shallow; dorsal scars immediately under the hinge; muscle scars deep; pallial line impressed, crenate; nacre deep purple, salmon, straw-colored or white, obliquely ribbed" (Simpson 1914, p 597).

Hosts for Glochidia:

Black Crappie, White Crappie, Flathead Catfish, Gizzard Shad, Sauger, Yellow Perch (Watters, 1994).

Comments:

Uncommon in Oklahoma.

Table 6. Summary of *E. dilatata* shell characters.

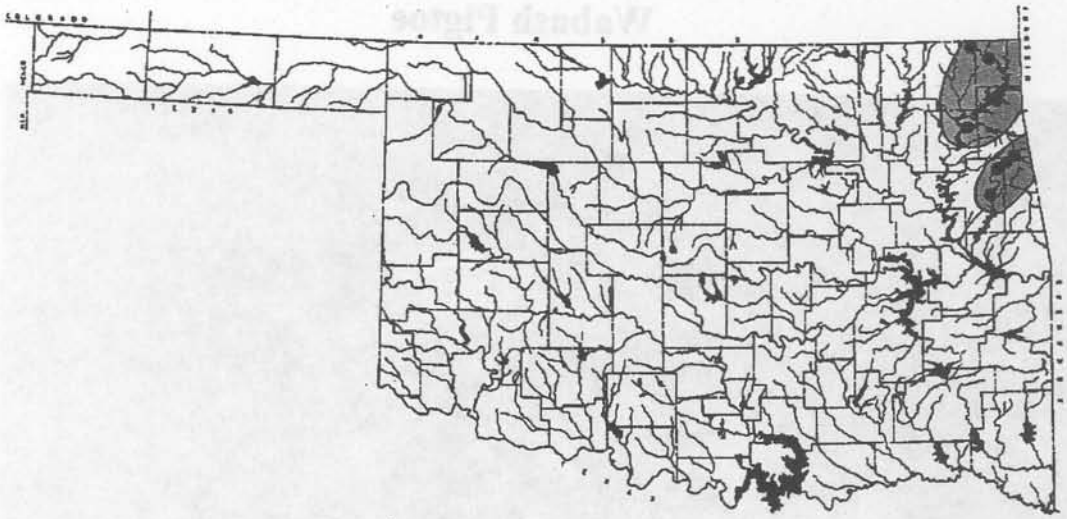
Location	N	Mean H/L (%)	H/L Range (%)	Maximum Length (mm)	Mean W/L (%)	W/L Range (%)
Arkansas River Drainage						
Illinois River	3	48.6	46.2-52.0	93	26.7	25.3-28.0

General Distribution:

This species occurs throughout most of the eastern United States except the Atlantic coastal region.

Oklahoma Distribution:

Found only in the Neosho and Illinois River systems. Live specimens are uncommon.



Map 11. Distribution of *E. dilatata* in Oklahoma.

Arkansas River System

Neosho (Grand) River:

Ottawa County: Miami, city park.

Craig County: 4.5 mi. NW of Miami, Stepps Ford Bridge (weathered); 3 mi. WNW of Miami (weathered); 9.5 mi. NW of Miami, Craig/Ottawa county line (weathered).

Spavinaw Creek:

Mayes County: Below Spavinaw Lake Dam, 15.5 mi. ENE of Pryor.

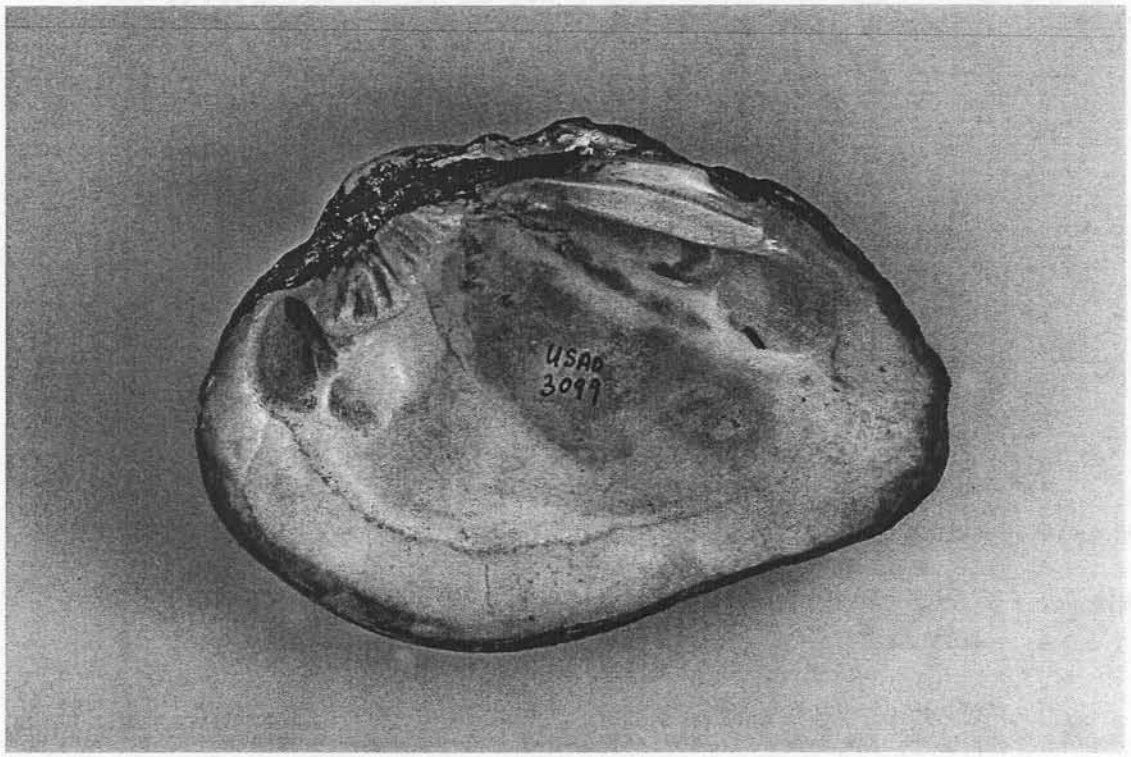
Illinois River:

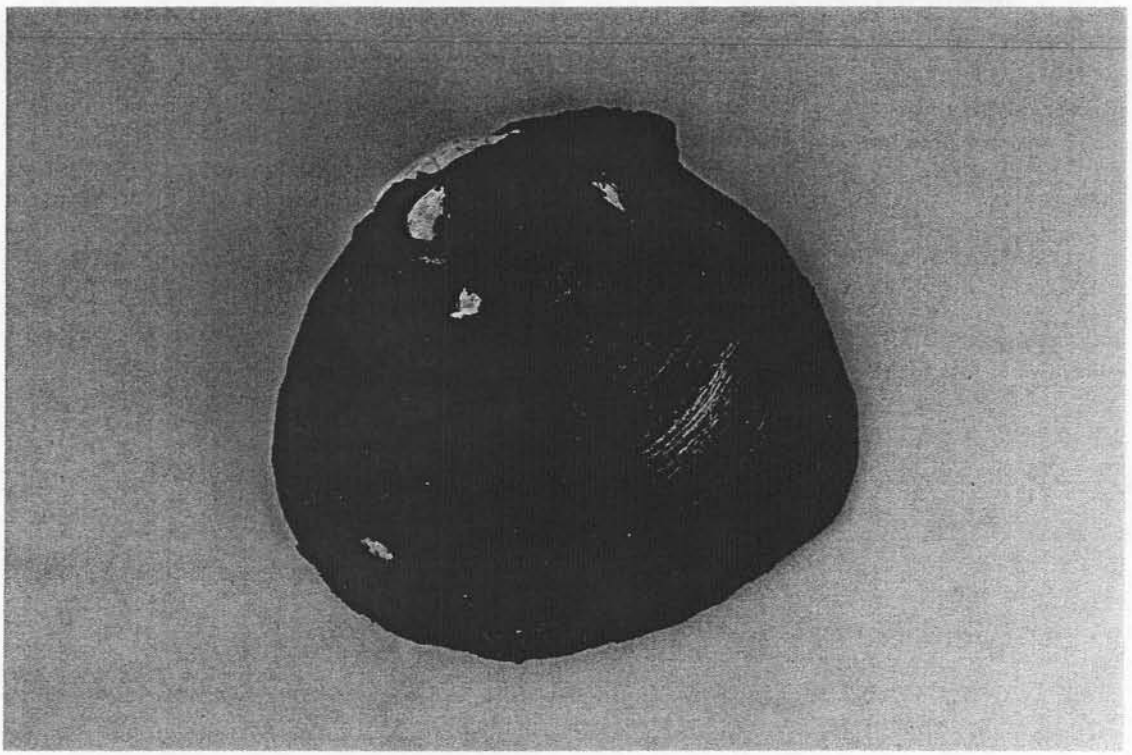
Adair County: At Hampton's Bridge, 0.8 mi. W of Chewey (weathered).

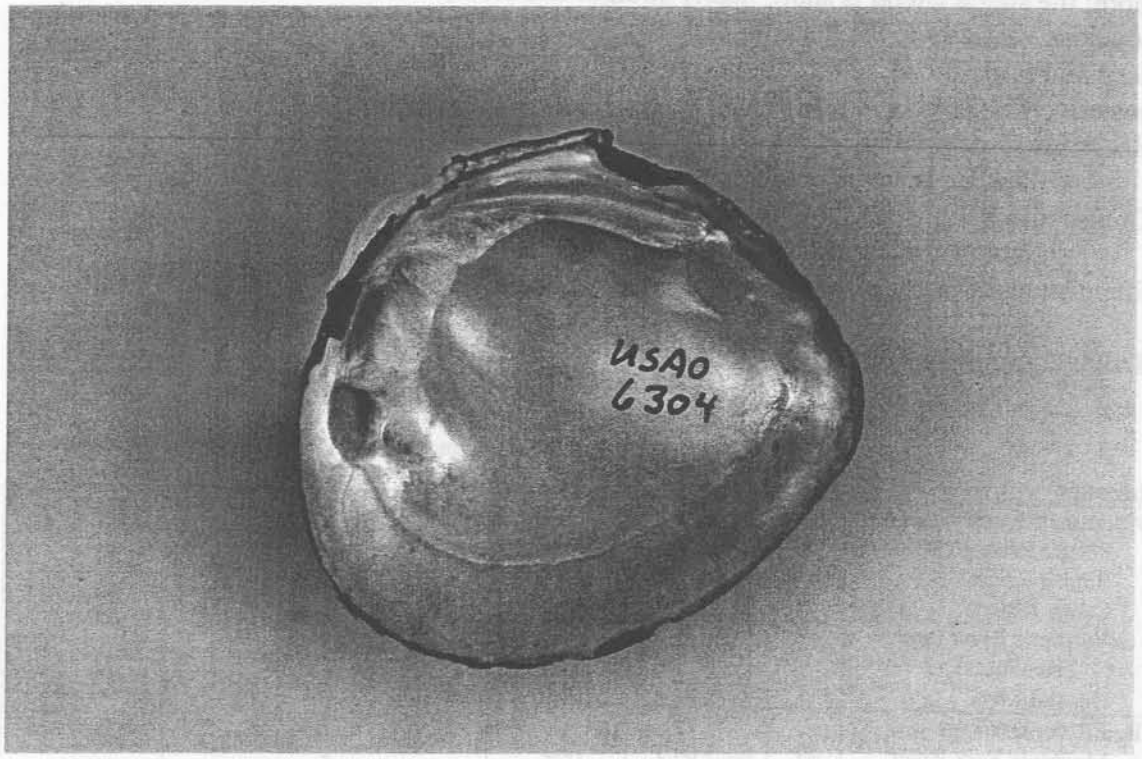
Cherokee County: Round Hollow Public Access Area, 1 mi. ENE of Scaper on St. Hwy. 10 (weathered); Echota Public Access Area.

Delaware County: Just above mouth of Flint Creek, 1.3 mi. SSW of Flint.

Fusconaia flava (Rafinesque 1820)
Wabash Pigtoe







Partial Synonymy:

Fusconaia rubiginosa (Lea, 1829), Isely 1925

Fusconaia flava (Rafinesque, 1820), Murray and Leonard 1962; Valentine and Stansbery 1972; Johnson 1980; Branson 1982; Oesch 1984; Turgeon and Others 1988; Vidrine 1993; Howells and others 1996

Description:

"Shell quadrate to triangular; dorsal line short, straight only at the hinge; sharply angled posteriorly; ventral line straight, anterior end with a straight face dorsally, gently rounded ventrally; posterior end sharply truncated above, sharply rounded below. A broad, shallow sulcus anterior to the posterior ridge; shell is strong and heavy even in small shells; in old shells the valves usually become quite thick in the anterior half; size to 9.5cm; moderately inflated, posterior ridge prominent, sometimes sharply angled dorsally, often flattening ventrally and causing a double angle on the postero-ventral margin. Beaks broad, raised above the hinge line, inequipartite; beak sculpture consists of three to five faint concentric bars that become sharp-angled on the posterior slope and may form slight tubercles there. Growth lines often prominent, forming raised concentric ridges which are dark-stained at rest periods. Epidermis yellow-brown in young, becoming chestnut brown to black when old; small valves may have faint green rays on the umbones.

Left valve has two dissimilar pseudocardinal teeth; the anterior one is narrow and elongate, the posterior one heavy and triangular, both are rough and serrated; the two lateral teeth are short and straight. Right valve has one heavy, serrate pseudocardinal

tooth; the single lateral is short, nearly straight and stout; sometimes a smaller tooth develops ventrally to the main tooth. Interdentum well to poorly developed; beak cavities deep and fairly broad; nacre white, sometimes tinged with salmon or pink, iridescent posteriorly" (Oesch 1984, p109-111).

Hosts for Glochidia:

Black Crappie, White Crappie, Bluegill (Watters, 1994).

Comments:

Highly variable in shape, size and color. Some populations resemble *F. askewi* found south of the Red River. Others closely resemble forms described as *F. undata.*

Table 7. Summary of *F. flava* shell characters.

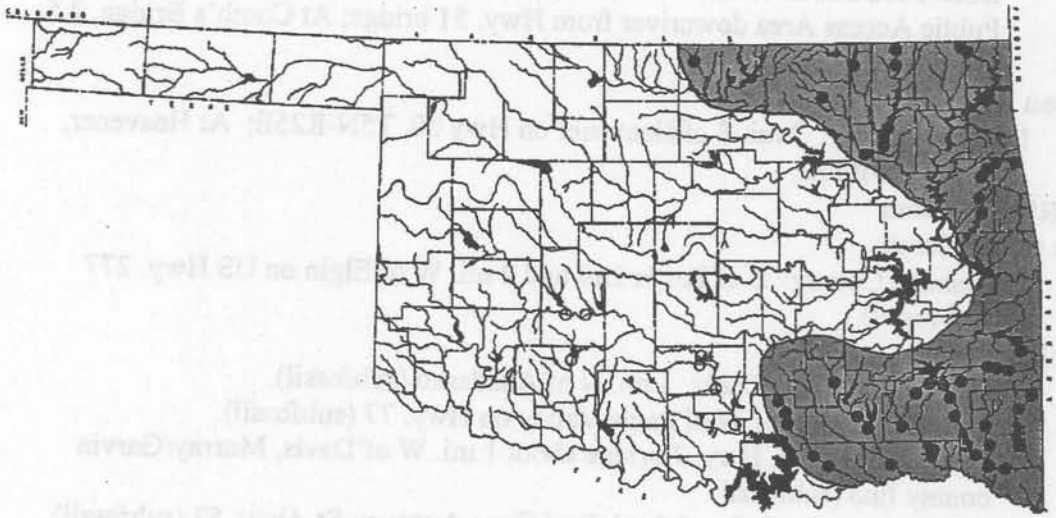
Location	N	Mean H/L (%)	H/L Range (%)	Maximum Length (mm)	Mean W/L (%)	W/L Range (%)
Arkansas River Drainage						
Poteau River	2	71.3-72.6	72.0	94	48.8-51.1	50.0
Illinois River	18	61.1-79.5	69.9	112	37.9-56.9	46.7
Caney River	9	70.2-82.2	76.1	101	41.7-55.6	46.9
Verdigris River (and Tributaries)	39	67.6-84.6	76.5	108	35.4-58.2	48.4
Neosho River	7	71.4-87.3	76.8	112	44.6-58.2	50.3
Red River Drainage						
Mountain Fork River	49	68.3-84.1	75.3	79	39.7-62.7	49.2
Glover River	63	64.6-97.5	80.4	71	41.5-66.7	54.4
Little River	55	69.5-94.1	82.3	73	42.1-72.2	57.0
Kiamichi River	42	66.7-91.1	76.9	88	42.1-70.6	54.0
Muddy Boggy River	4	74.4-79.6	77.2	90	52.2-55.9	54.0
Blue River (upper)	21	62.0-71.4	67.8	79	35.7-44.2	41.3
Blue River (lower)	8	68.7-77.1	72.4	92	45.8-56.6	48.7
Washita River	7	65.6-76.2	70.7	52	-	-

General Distribution:

Mississippi River system, Great Lakes and St. Lawrence drainages.

Oklahoma Distribution:

Generally distributed throughout the river systems in the northeastern and southeastern thirds of the state.



Map 12. Distribution of *F. flava* in Oklahoma. Yellow dots represent subfossil localities outside the current distributional limits.

Arkansas River System

Chickaskia River:

Kay County: 3 mi. S, 2 mi. E and 1 mi. W of Blackwell (weathered).

Verdigris River:

Nowata County: At St. Hwy. 10, 2.8 mi. E of Lenapah; 4 mi. N of Childers, Hancock Bridge; 2 mi. SE of South Coffeyville.

Rogers County: 5 mi. N of Catoosa; 4.5 mi. W of Claremore, S of Hwy 20; 0.8 mi. W of Claremore Mound; Below Oologah Dam.

Mingo Creek:

Tulsa County: 2 mi. S of Owasso (weathered).

Bird Creek:

Osage County: At Nelagoney.

Caney River:

Washington County: 6.2 mi. NW of Dewey; 4.6 mi. NE of Dewey.

Neosho (Grand) River:

Craig County: 4.5 miles NW of Miami, Stepps Ford Bridge; 3 mi. WNW of Miami; 9.5 mi. NW of Miami, Craig/Ottawa county line (weathered).

Illinois River:

Adair County: At Hampton's Bridge, 0.8 mi. W of Chewey; 1 mi. downstream from Lake Frances dam; 1.2 mi. N of Watts.

Cherokee County: At No Head Hollow Public Access Area, 1 mi. SE of McSpadden Falls; At Sequoyah Boat Club, 3 mi. S of mouth of Baron Fork Creek (weathered); At Tahlequah; 5.5 mi. E and 3 mi. N of Tahlequah; Round Hollow Public Access Area, 1 mi. ENE of Scraper on St. Hwy. 10; Peavine Hollow Public Access Area, 2.6 miles SE of Scraper on St. Hwy. 10;

Buck Ford Public Access Area, 1 mi. S of Scraper; Echota Public Access Area; Public Access Area downriver from Hwy. 51 bridge; At Comb's Bridge, 2.5 mi. E of Moodys.

Poteau River:

LeFlore County: 7 mi. S of Heavener on Hwy 59, T5N-R25E; At Heavener, S35-T5N-R25E.

Red River System

East Cache Creek:

Comanche County: E of Porter Hill and 2 mi. W of Elgin on US Hwy. 277 (subfossil) .

Washita River:

Caddo County: Fort Cobb; 1 mi. N of Anadarko (subfossil).

Garvin County: 2 mi. N of Pauls Valley on Hwy. 77 (subfossil).

Murray County: St. Hwy. 7 bridge about 1 mi. W of Davis, Murray/Garvin county line (subfossil).

Carter County: 1 mi. S and 2 mi. E of Gene Autry on St. Hwy. 53 (subfossil).

Rush Creek:

Garvin County: Rush Creek at Pauls Valley (subfossil).

Blue River:

Johnston County: 2.9 mi. E of junction of St. Hwy. 99 and 7 on St. Hwy. 7, public hunting area; At St. Hwy. 48A, 1 mi. N of Milburn, S34&35-T3S-R7E; 2.8 mi. NNW of Milburn, old low water crossing, S21-T3S-R7E; Hwy. 7 Public Access Area; 5 mi. NE of Tishomingo (weathered); 0.5 mi. S of Connerville (weathered); 0.5 mi. E of Connerville; 7.5 mi. E of Reagan; 10 mi. N of Tishomingo; 3 mi. N of Milburn; 6.2 mi. S of Connerville; 4.3 mi. S of Connerville.

Bryan County: At Blue Hwy. 70; 1 mi. SSW of Blue on county road (weathered); At Armstrong, below dam.

West Fork of Blue River:

Johnston County: 0.8 mi. E of Connerville.

Muddy Boggy River:

Coal County: 2 mi. E of Coalgate at St. Hwy. 43.

Atoka County: Near Farris, S26-T3S-R13E; 7 mi. S and 6 mi. E of Atoka at crossing; 7 mi. E of Atoka.

Choctaw County: At Jasper on US Hwy. 270.

Kiamichi River:

LeFlore County: 0.7 mi. S of Big Cedar on US Hwy. 259, S14&23-T2N-R25E; 0.6 mi. S of Whitesboro, S33-34-T3N-R23E; 1 mi. SSW of Muse, S10-T2N-R24E.

Pushmataha County: At St. Hwy. 2, N of Antlers, N crossing; 0.9 mi. S of Clayton at US Hwy. 271; Between Clayton and Antlers on St. Hwy. 2, S crossing; At Stanley; US Hwy 271 crossing at Antlers; Above the mouth of Dry Creek.

Choctaw County: Spencerville Crossing, 8.5 mi. NE of Hugo.

Little River:

Pushmataha County: Near Fewell, S35&36-T1N-R21E; Bridge on St. Hwy. 144; 5 mi. S and 2 mi. E of Nashoba; 4.5 mi. E and 1.5 mi. N of Cloudy on County Road; 5 mi. E and 1 mi. N of Cloudy on Weyerhauser road, S2&11-T3S-R20E; 5.2 mi. ENE of Cloudy.

McCurtain County: Little River National Wildlife Refuge; At railroad crossing, 1.5 mi. SW of Wright City, S6&7-T6S-R22E; 2 mi. Nof Garvin, S5&6-T7S-R23E; N of Idabel on Hwy. 70, S14-T7S-R24E; N of Idabel, S19-T7S-R24E.

Black Fork Creek:

Pushmataha County: 0.5 mi. S of Nashoba.

Lukfata Creek:

McCurtain County: 2 mi. N of Little River Bridge on US Hwy. 257 and 70 and 1 mi. W.

Glover River:

McCurtain County: 10.7 mi. W of Broken Bow on St. Hwy. 3 & 7; 14 mi. SE of New Ringold on St. Hwy. 3 & 7; About 8 mi. S of Battiest (7 mi. S and 1.5 mi. W), S13-T3S-R22E; At Glover, S33-T5S-R23E; 0.25 mi. W of Glover; 2 mi. N of Glover.

West Fork of Glover River:

McCurtain County; 1.4 mi. W and 0.2 mi. N of Battiest.

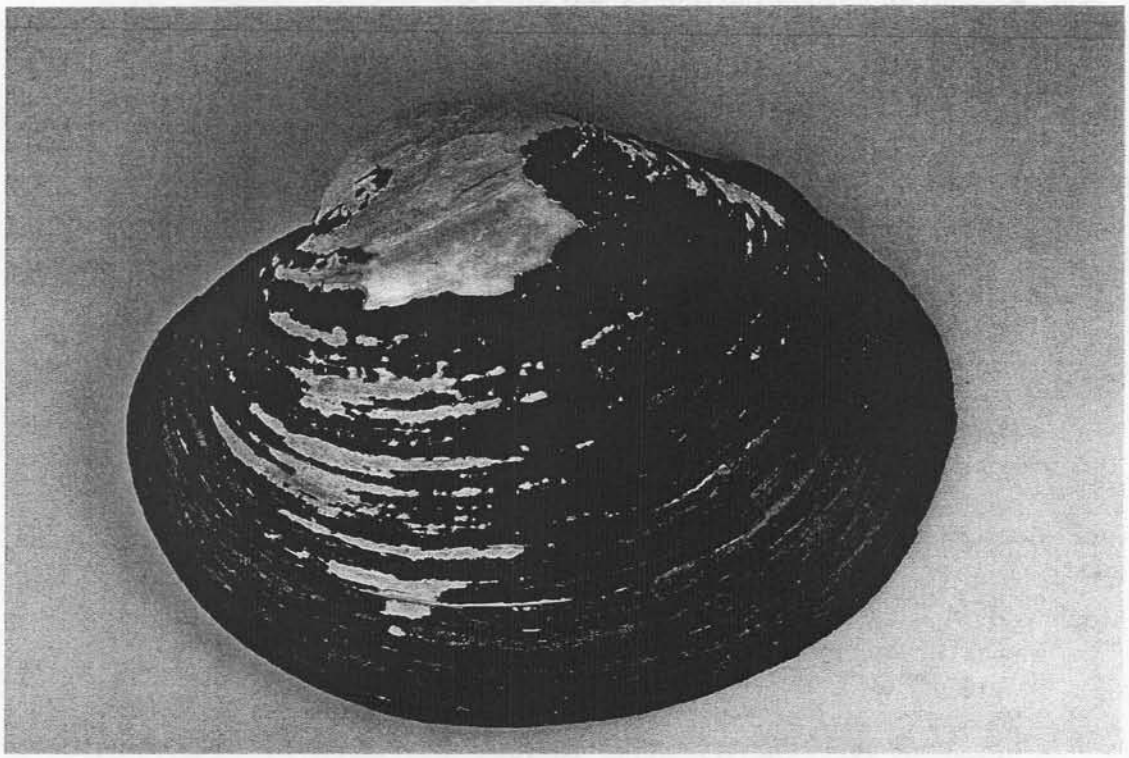
Mountain Fork River;

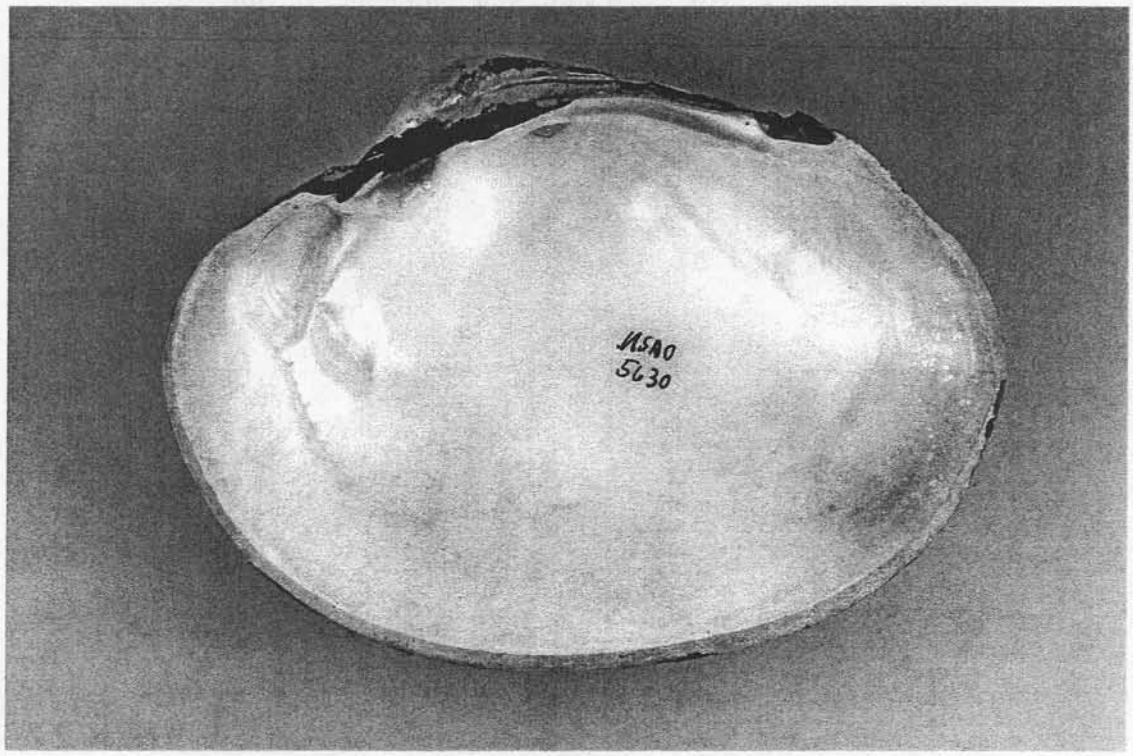
McCurtain County: 8.4 mi. NE of Smithville; _ mi. E of Smithville; Below Broken Bow Lake; Beavers Bend State Park, 7 mi. NE of Broken Bow; At US Hwy. 70, 7 mi.E of Broken Bow, S7&8-T6S-R26E; About 3 mi. E of Beachton, S7-T1S-R27E; At the "Narrows" S9-T2S-R25E; 4 mi. S of Smithville; Off Hwy. 259, about 8 mi. S of Smithville; 6.5 mi. SW of Smithville.

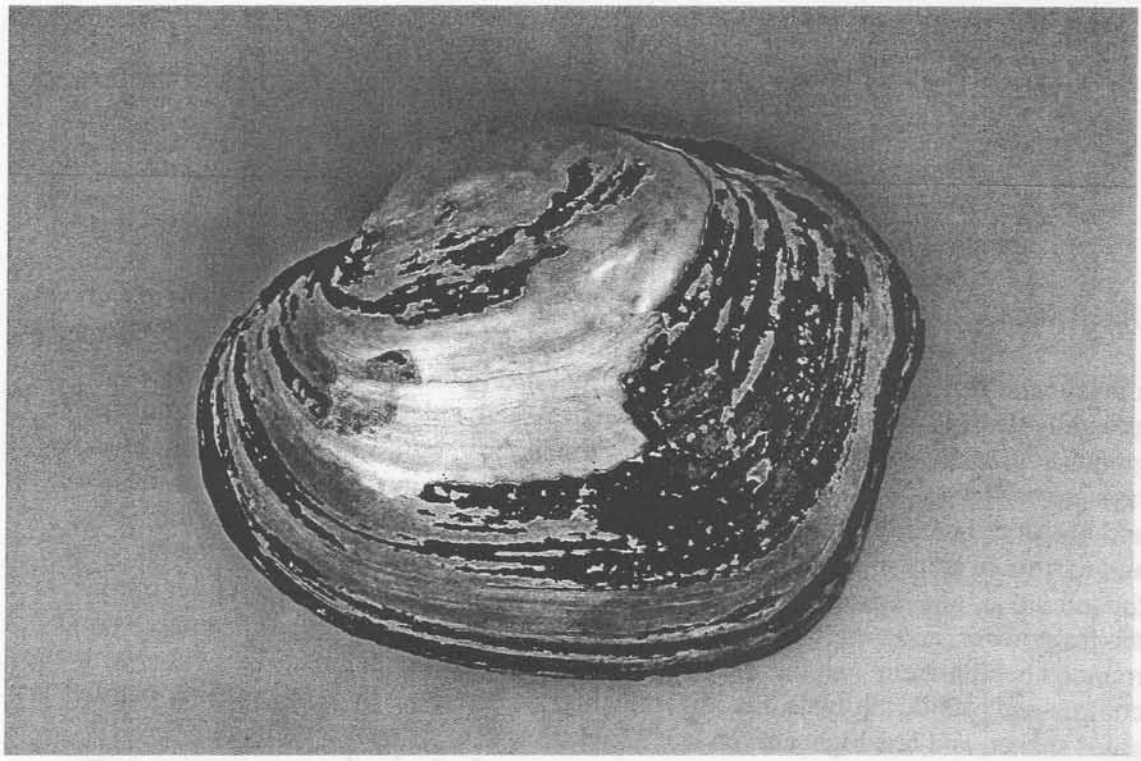
Cypress Creek:

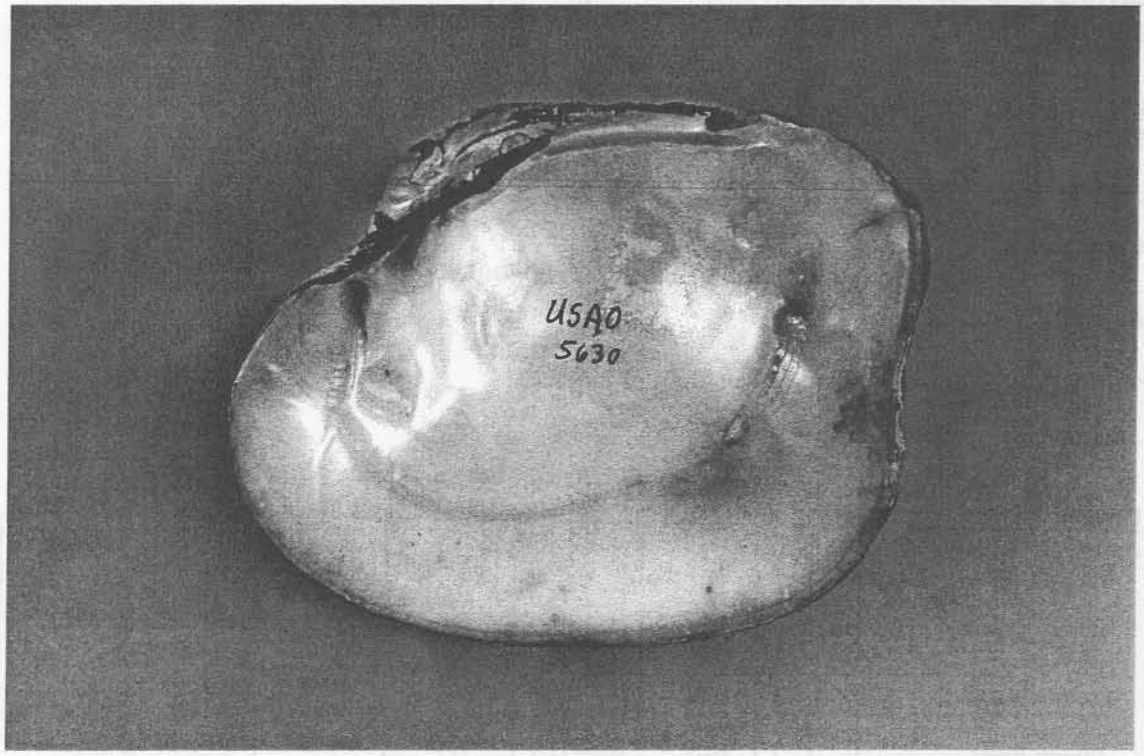
McCurtain County: About 3 mi. NE of Valliant.

Lampsilis cardium (Rafinesque 1820)
Plain Pocketbook





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Partial Synonymy:

Lampsilis ventricosa (Barnes, 1823), Isely 1925; Oesch 1984
Lampsilis ovata ventricosa (Barnes, 1823), Murray and Leonard 1962
Lampsilis ovata form *ventricosa* (Barnes, 1823), Valentine and Stansbery 1971
Lampsilis ventricosa satura (Lea, 1852), Isely 1925
Lampsilis ovata (Say, 1817), Johnson 1970; Branson 1984
Lampsilis cardium (Rafinesque, 1820), Turgeon and others 1988; Vidrine 1993; Watters 1995; Howells and others 1996

Description:

"Shell large, rather solid, obovate, inflated, with very full, high beaks, which have a few coarse, irregular corrugations that are inclined to be doubly looped; surface generally nearly smooth, the rest periods well marked; epidermis normally shining, greenish, greenish-yellow or brownish with broad, bright green rays. In old shells the rays are often nearly or quite wanting. Hinge line usually incurved in front of the beaks and outcurved behind them; ligament large and prominent, extending under the beaks, and narrow in front of them. There are two, somewhat compressed pseudocardinals in the left valve, one in front of the other, the hinder high and having a triangular outline, the front lower, and both of these are in front of the beak; the hinge plate is narrow and rounded behind them, and there are two rather short, slender laterals; right valve with two compressed pseudocardinals, the lower the higher, separated by a deep, nearly parallel-sided socket, and one high, curved lateral, which is sharply truncated behind; beak cavities deep and wide; muscle scars not deep, smooth, the hinder semicircular; nacre brilliant, silvery, bluish-white or sometimes a beautiful pink.

In the female shell the marsupial swelling is pronounced, and the shell is generally higher than that of the male" (Simpson 1914, p 38-39).

Hosts for Glochidia:

Bluegill, Largemouth Bass, Sauger, Smallmouth Bass, Walleye, White Crappie, Yellow Perch (Watters, 1994).

Comments:

Variable in size, color and inflation in Oklahoma but should all be considered as *L. cardium*.

Table 8. Summary of *L. cardium* shell characters.

Location	Sex	N	Mean H/L (%)	H/L Range (%)	Maximim Length (mm)	Mean W/L (%)	W/L Range (%)	Remarks
Arkansas River Drainage								
Caney River	_	10	67.2	65.0-70.8	137	46.9	45.3-48.5	
	_	3	70.9	67.7-74.0	100	54.4	50.8-58.0	
Verdigris River	_	10	69.5	63.3-74.2	139	49.5	46.9-50.8	
	_	7	74.7	69.9-80.0	120	60.6	49.5-70.0	
Neosho River	_	13	70.7	67.1-74.6	152	49.8	45.2-54.6	
	_	9	72.9	67.2-77.1	136	55.0	48.9-58.4	
Illinois River	_	7	67.9	63.9-71.7	151	45.8	43.0-49.5	
	_	4	71.1	69.1-73.4	106	56.6	53.8-60.4	
Poteau River	_	5	67.6	62.5-71.6	136	52.9	51.1-54.8	
	_	2	69.8	69.5-70.1	105	64.7	59.8-69.5	

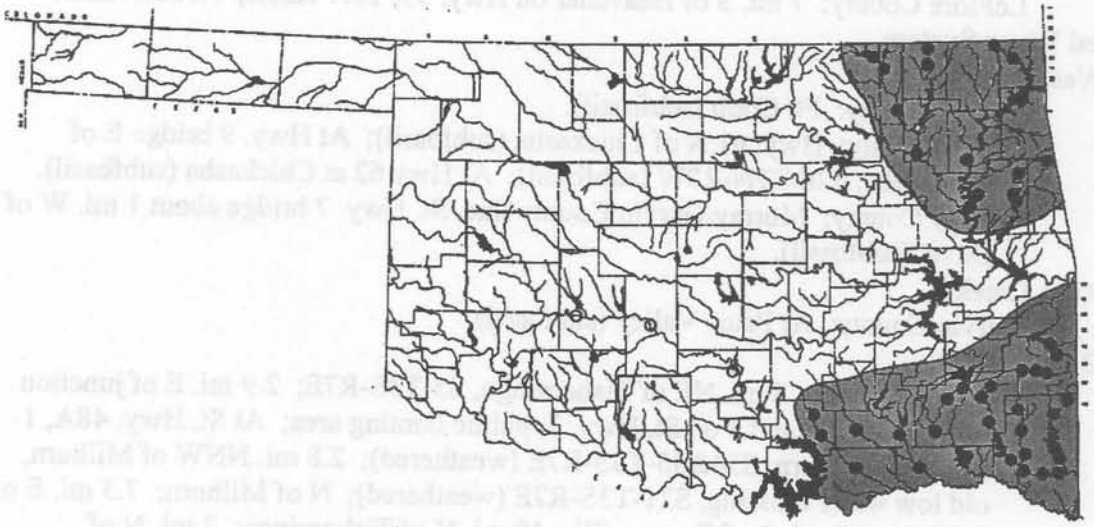
Red River Drainage	_	7	68.1	64.0-71.4	111	-	-	subfossil
Washita River	_	6	71.7	69.0-75.4	95	-	-	subfossil
	_	7	69.2	66.3-73.0	111	50.4	48.0-52.4	
Blue River	_	6	70.3	66.7-74.1	95	-	53.5	
	_	2	69.1	67.6-70.6	111	55.2	51.8-58.6	
Boggy River	_	4	71.7	69.4-73.8	107	56.5	54.1-61.5	
	_	18	68.3	63.1-75.2	117	52.0	45.8-56.4	
Kiamichi River	_	33	74.1	68.3-80.8	98	57.7	47.7-64.8	
	_	12	66.3	62.8-70.7	114	47.7	40.8-52.1	
Little River	_	12	72.4	67.9-77.1	94	52.7	42.9-58.9	
	_	8	66.7	61.8-70.2	102	48.5	45.5-53.2	
Glover River	_	6	70.7	68.2-73.2	85	54.3	50.6-58.8	
	_	29	67.1	62.8-72.7	128	47.5	41.5-55.6	
Mountain Fork River	_	26	71.2	65.4-75.4	112	53.1	46.4-64.3	

General Distribution:

Upper Mississippi River drainage, Hudson Bay, Great Lakes and St. Lawrence drainages. Introduced into several east coast Atlantic drainages.

Oklahoma Distribution:

Found generally in all the river systems of northeastern and southeastern Oklahoma.



Map 13. Distribution of *L. cardium* in Oklahoma. Yellow dots represent subfossil localities outside the current range of the species.

Arkansas River System

Verdigris River:

Nowata County: At St. Hwy. 10, 2.8 mi. E of Lenapah; 4 mi. N of Childers, Hancock Bridge; 2 mi. SE of South Coffeyville.

Rogers County: 0.8 mi. W of Claremore Mound; Below Oologah dam (subfossil); 5 mi. N of Catoosa; 4.5 mi. W of Claremore, S of Hwy. 20.

Caney River:

Osage County: 4.8 mi. SE of Hulah Lake Dam, S28-T28N-R12E; Below Hulah

Reservoir.

Washington County: 6.2 mi. NW of Dewey; 4.8 mi. E of Ramona (weathered); Bridge 635 (subfossil); 4.6 mi. NE of Dewey.

Neosho (Grand) River:

Ottawa County: Miami, city park.

Craig County: 4.5 mi. NW of Miami, Stepps Ford Bridge; 3 mi. WNW of Miami; 9.5 mi. NW of Miami, Craig/Ottawa county line; 2.9 mi. E of US Hwy. 59, Craig County, OK/Cherokee County, KS line.

Mayes County: 4.6 mi. WNW of Locust Grove.

Cherokee County: 0.5 mi. below dam of Ft. Gibson Lake.

Fort Gibson Lake:

Cherokee County: Hulbert Landing area, Sequoyah St. Pk.

Illinois River:

Adair County: 1 mi. downstream from Lake Frances Dam.

Cherokee County: Peavine Hollow Public Access Area, 2.6 mi. SE of Scraper on St. Hwy. 10; Echota Public Access Area; Public Access Area downriver from Hwy. 51 bridge; 5.5 mi. E and 3 mi. N of Tahlequah; SE of Tahlequah at mouth of Barron Fork Ck.

Delaware County: Just above the mouth of Flint Creek, 1.3 mi. SSW of Flint.

Poteau River:

LeFlore County: 7 mi. S of Heavener on Hwy. 59, T5N-R25E; At Heavener.

Red River System

Washita River:

Caddo County: Ft. Cobb (subfossil).

Grady County; Hwy. 81 N of Chickasha (subfossil); At Hwy. 9 bridge E of Chickasha, S26-T7N-R7W (subfossil); At Hwy 62 at Chickasha (subfossil).

Murray County; Murray/Garvin County line, St. Hwy. 7 bridge about 1 mi. W of Davis (subfossil).

Rush Creek:

Garvin County: At Pauls Valley (subfossil).

Blue River:

Johnston County: 8 mi. NE of Tishomingo, S5-T3S-R7E; 2.9 mi. E of junction of St. Hwys 99 and 7 on St. Hwy. 7, public hunting area; At St. Hwy. 48A, 1 mi. N of Milburn, S34&35-T3S-R7E (weathered); 2.8 mi. NNW of Milburn, old low water crossing, S21-T3S-R7E (weathered); N of Milburn; 7.5 mi. E of Reagan; 4.3 mi. S of Connerville; 10 mi. N of Tishomingo; 2 mi. N of Milburn.

Bryan County: W of Blue on old highway (weathered); 0.5 mi. W of Blue on US Hwy. 70.

Muddy Boggy River:

Atoka County: SE of Atoka (weathered); N of Lane; 7 mi. NE of Atoka (weathered).

Choctaw County: At Jasper on US Hwy. 70.

Clear Boggy River;

Atoka County: At US Hwy. 75 between Caney and Tushka.

Kiamichi River:

LeFlore County: 0.6 mi. S of Whitesboro, S33-34-T3N-R23E; 1 mi. SSW of Muse, S10-T2N-R24E; 0.7 mi. S of Big Cedar on US Hwy. 259, S14&23-T2N-R25E; 11.78 mi. SE of Daisy.

Pushmataha County: On St. Hwy. 2 N of Antlers, S crossing; 0.9 mi. S of Clayton on US Hwy. 271; At Stanley; US Hwy. 271 crossing at Antlers; 14.9 mi. NNE of Antlers on St. Hwy. 2.

Choctaw County: Spencerville Crossing, 8.5 mi. NE of Hugo.

Little River:

Pushmataha County: Near Fewell; 4.5 mi. E and 1.5 mi. N of Cloudy on County Road; 5 mi. S and 2.5 mi. E of Nashoba; Bridge on St. Hwy. 144; 5.2 mi. ENE of Cloudy.

McCurtain County: N of Idabel, S19-T7S-R24E; 1 mi. N of Goodwater; At railroad crossing, 1.5 mi. SW of Wright City, S6&7-T6S-R22E; 1.5 mi. N of Garvin, S6-T7S-R23E; 1.5 mi. S and 1.5 mi. E of Wright City.

Lukfata Creek:

McCurtain County: 2 mi. N of Little River Bridge on US Hwy. 259/70 and 1 mi. W.

Glover River:

McCurtain County: About 10 miles W of Broken Bow on St. Hwy. 3 & 7, S28-T5S-R23E; 14 mi. SE of New Ringold on St. Hwy. 3 & 7; About 8 mi. S of Battiest (7 mi. S and 1.5 mi. W) S13-T3S-R22E; At Glover, S33-T5S-R23E 2 mi. N of Glover; 0.25 mi. W of Glover.

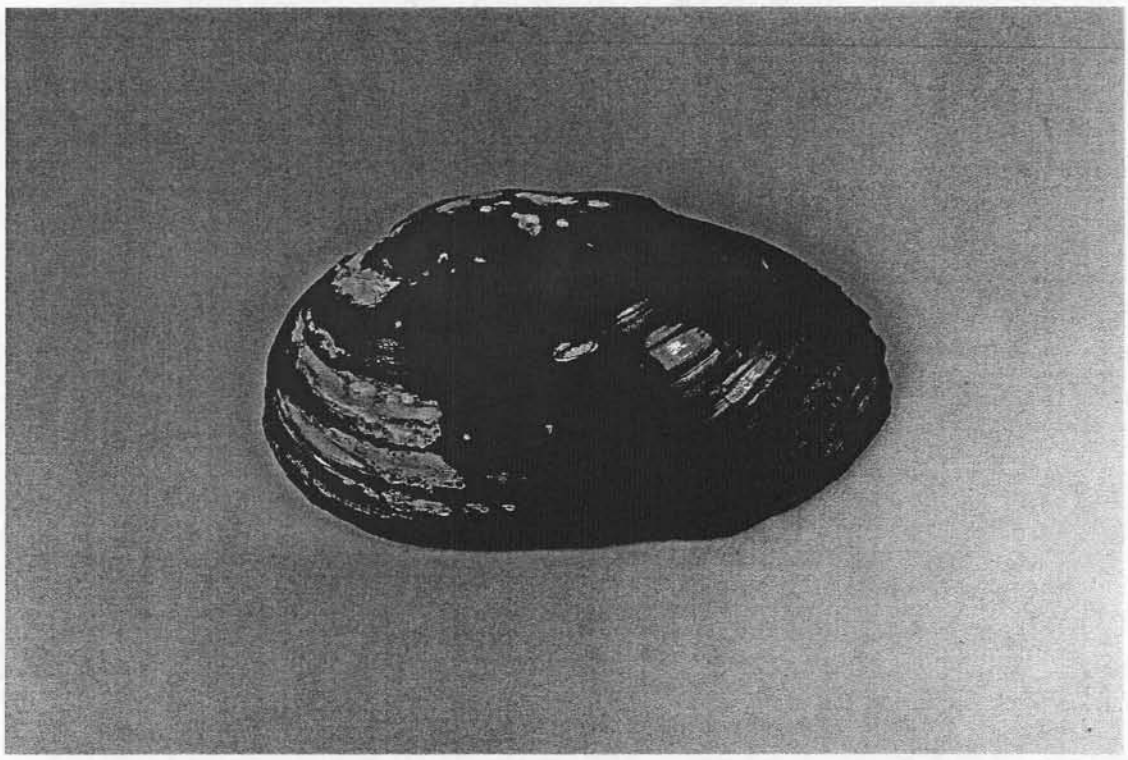
West Fork of Glover River:

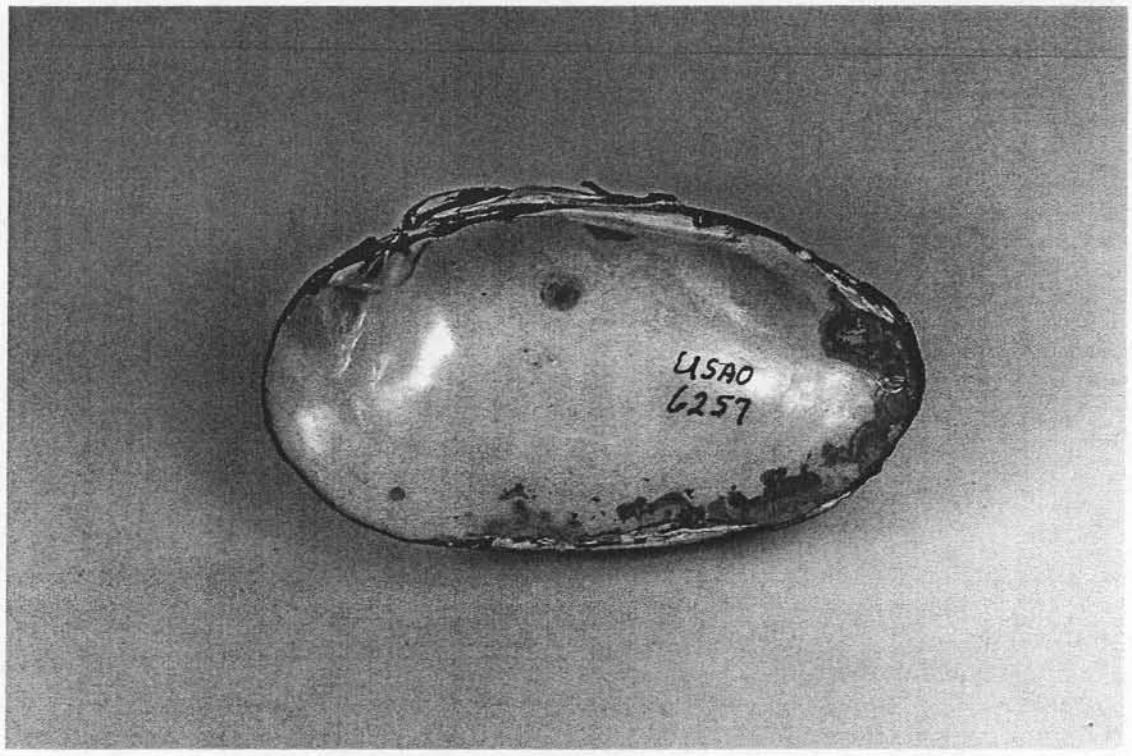
McCurtain County: 1.2 mi. W and 0.1 mi. N of Battiest.

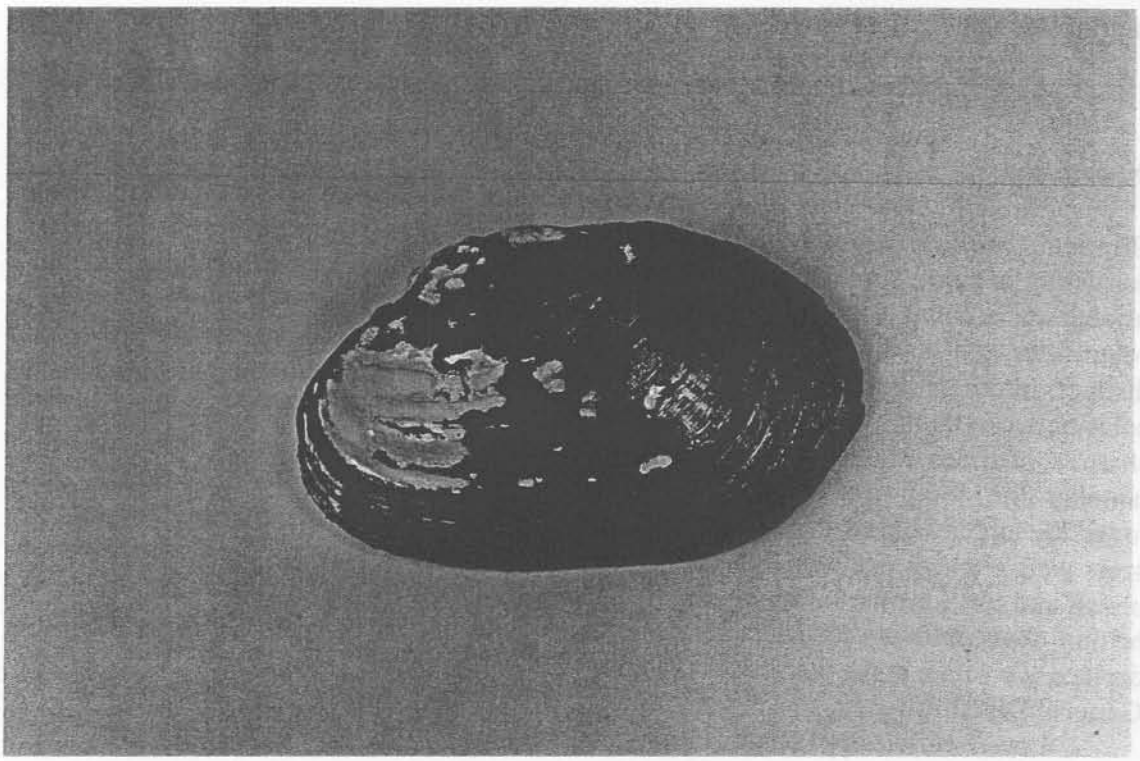
Mountain Fork River:

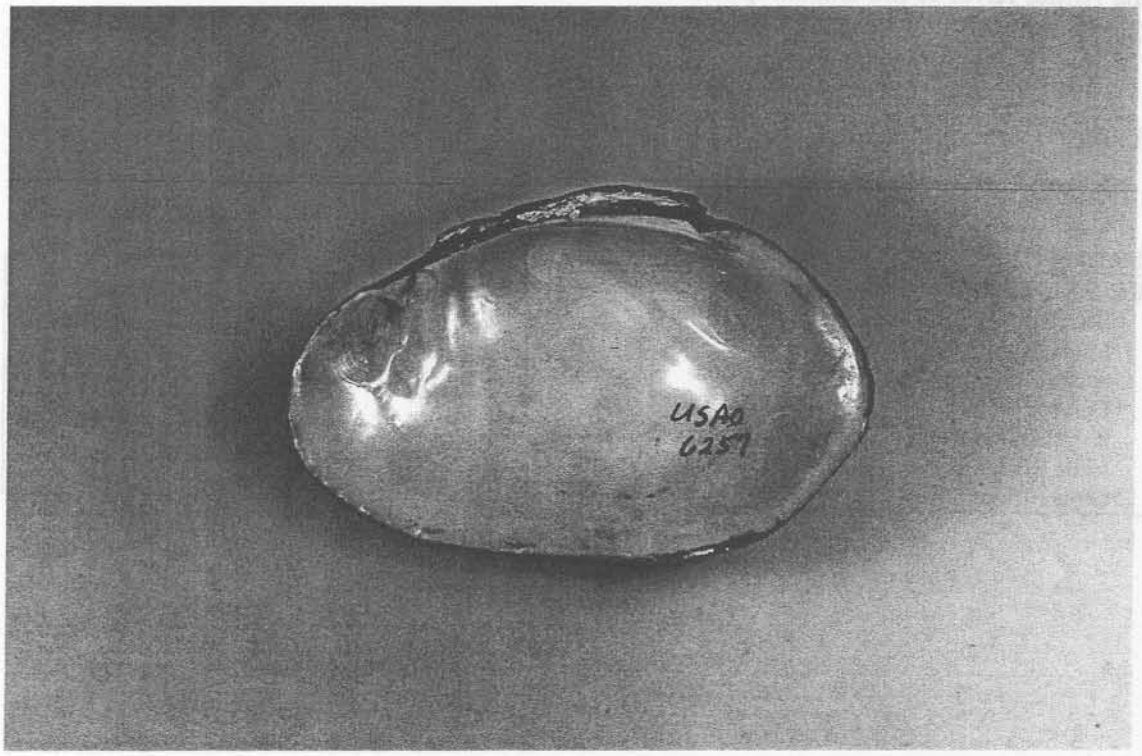
McCurtain County: At US Hwy. 70 E of Broken Bow; 8.2 mi. NE of Smithville; Beavers Bend St. Pk.; About 3 mi. E of Beachton, S7-T15S-R27E; S7-T1S-R27E; At the "Narrows", S9-T2S-R25E; 3 mi. W of Eagletown on Hwy. 70; 4 mi. W of Smithville; 8.4 mi. NE of Smithville.

Lampsilis hydiana (I. Lea 1838)
Louisiana Fatmucket





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6257

Partial Synonymy:

Lampsilis radiata luteola (Lamarck, 1819), Valentine and Stansbery 1971

Lampsilis hydiana (I. Lea, 1838), Simpson 1914; Isely 1925; Johnson 1980; Branson 1984; Turgeon and others 1988; Vidrine 1993

Description:

"Shell of moderate size, normally subsolid but sometimes rather thin, long elliptical, ordinarily much inflated; beaks full and high, their sculpture delicate, consisting of faint, somewhat corrugated double loops, the hinder open behind; surface smooth and shining, sometimes faintly concentrically sculptured, greenish, waxy-yellow, beautifully and boldly rayed with green. In some cases the rays are broad and very distinct, in others they are split into numerous fine rays with a wider ray of the ground color between them. Occasional shells are scarcely rayed at all. Left valve bearing two sharp, sometimes slightly compressed pseudocardinals, and after having a small anterior lamellar third tooth near the edge of the shell; right valve with two pseudocardinals, the lower the larger; laterals curved, one in the right valve and two in the left; anterior muscle scars well marked; posterior scars faint; nacre generally rich silvery, though sometimes bluish and lurid brown in the cavity of the beaks. The male shell is somewhat pointed behind about midway up from the base; that of the female is rather blunt behind and decidedly swollen at the post-base" (Simpson 1914, p66-67).

General Distribution:

Lower Mississippi River drainage and adjacent Gulf of Mexico drainages from the Amite River to the Guadalupe River.

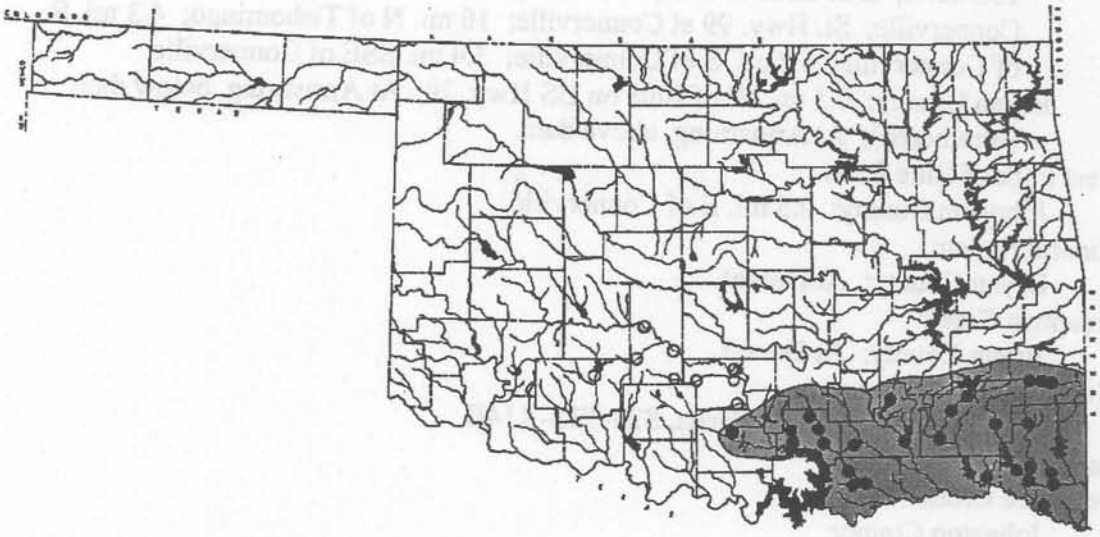
Comments:

Confined to SE Oklahoma. Blue River populations are distinct.

Table 9. Summary of *L. hydiana* shell characters.

Location	N	H/L Range (%)	Mean H/L (%)	Maximum Length (mm)	W/L Range (%)	Mean W/L (%)
Red River System						
Blue River	22	54.8-63.0	58.8	83	33.9-43.1	37.8
Muddy Boggy River	1	65.7	-	67	46.3	-
Atoka Reservoir	3	57.6-60.0	58.6	33	33.3-38.7	36.2
Delaware Creek	3	56.3-57.1	56.7	67	38.1-40.3	39.2
Kiamichi River	25	54.3-65.4	59.5	90	29.8-49.2	39.5
Little River	15	53.3-65.0	58.9	86	37.5-51.6	44.6
Glover River	7	51.2-61.2	56.3	84	33.3-45.6	39.6

Oklahoma Distribution:



Map 14. Distribution of *L. hydiana* in Oklahoma. Yellow dots represent subfossil localities outside the present range of the species.

Red River System

East Cache Creek:

Comanche County: E of Porter Hill and 2 mi. W of Elgin on US Hwy. 277 (subfossil).

Washita River:

Grady County: 3 mi. E of Alex (subfossil); Hwy. 81 N of Chickasha (subfossil).

Little Washita River:

Grady County: Between S23 & 24-T5N-R8W, about 11 mi. SSW of USAO Campus at Chickasha (subfossil).

Rush Creek:

Grady County: 0.5 mi. S of Cox City (subfossil).

Garvin County: At Pauls Valley (subfossil); 10.2 mi. S of Lindsay on St. Hwy. 76 (subfossil).

Wildhorse Creek:

Garvin County: 6.2 mi. S of Wynnewood, exit 17a on I-35 (subfossil).

Hickory Creek:

Carter County: About 1 mi. N of Woodford, near Mountain Lake (weathered).

Pennington Creek:

Johnston County: Tishomingo Golf Course (subfossil); About 3 mi. W of Connerville; About 1 mi. E of Reagan; 1 mi. S of Tishomingo.

Spring Creek:

Johnston County: Just below jct. with Pennington Creek.

Blue River:

Johnston County: 2.9 mi. E of jct. of St. Hwys. 99 and 7 on St. Hwy. 7, public hunting area; N of Connerville; 2 mi. N of Milburn; 12.3 mi. W of Wapanucka on St. Hwy. 7; At St. Hwy. 48A, 1 mi. N of Milburn, S34&35-

T3S-R7E (weathered); 2.8 mi. NNW of Milburn, old low water crossing, S21-T3S-R7E; E of Connerville (weathered); 7.5 mi. E of Reagan; 0.5 mi. E of Connerville; St. Hwy. 99 at Connerville; 10 mi. N of Tishomingo; 4.3 mi. S of Connerville; 6.2 mi. S of Connerville; 3.4 mi. SSE of Connerville.

Bryan County: 0.5 mi. W of Blue on US Hwy. 70; At Armstrong, below dam (weathered); At Armstrong, above dam.

West Fork of Blue River:

Johnston County: 0.8 mi. E of Connerville.

Mineral Bayou:

Bryan County: At Durant.

Chuckwa Creek:

Bryan County: At Durant.

Muddy Boggy River:

Atoka County: SW of Farris, S26-T3S-R14E.

Caney Creek: At Caney.

Delaware Creek:

Johnston County:

Atoka Reservoir:

Atoka County: 5 mi. N of Stringtown.

Kiamichi River:

LeFlore County: 0.6 mi. S of Whitesboro, S33-34-T3N-R23E; 1 mi. SSW of Muse, S10-T2N-R24E; 0.7 mi. S of Big Cedar on US Hwy. 259, S14&23-T2N-R25E.

Pushmataha County: At Eubanks crossing on St. Hwy. 2; 0.9 mi. SE of Clayton on US Hwy. 271; N crossing on St. Hwy. 2 N of Antlers; At Stanley, low water crossing; US Hwy. 271 crossing at Antlers.

Lake Raymond Gary:

Choctaw County:

Little River:

Pushmataha County: 5.2 mi. ENE of Cloudy.

McCurtain County: N of Idabel on US Hwy. 70; At railroad crossing, 1.5 mi. SW of Wright City, S6&7-T6S-R22E; 1.5 mi. N of Garvin, S6-T7S-R23E; S of Broken Bow on US Hwy. 259.

Lukfata Creek:

McCurtain County: 4.3 mi. W of Broken Bow on St. Hwy. 3 and 7; 2 mi. N of Little River Bridge on US Hwy. 259 and 70 and 1 mi. W.

Yashau Creek:

McCurtain County: S of Broken Bow.

Glover River:

McCurtain County: At Glover, S33-T5S-R23E; 14 mi. SE of New Ringold on St. Hwy. 3 and 7; On St. Hwy. 3 about 10 mi. W of Broken Bow, S28-T5S-R23E; 2 mi. N of Glover; 0.25 mi. W of Glover.

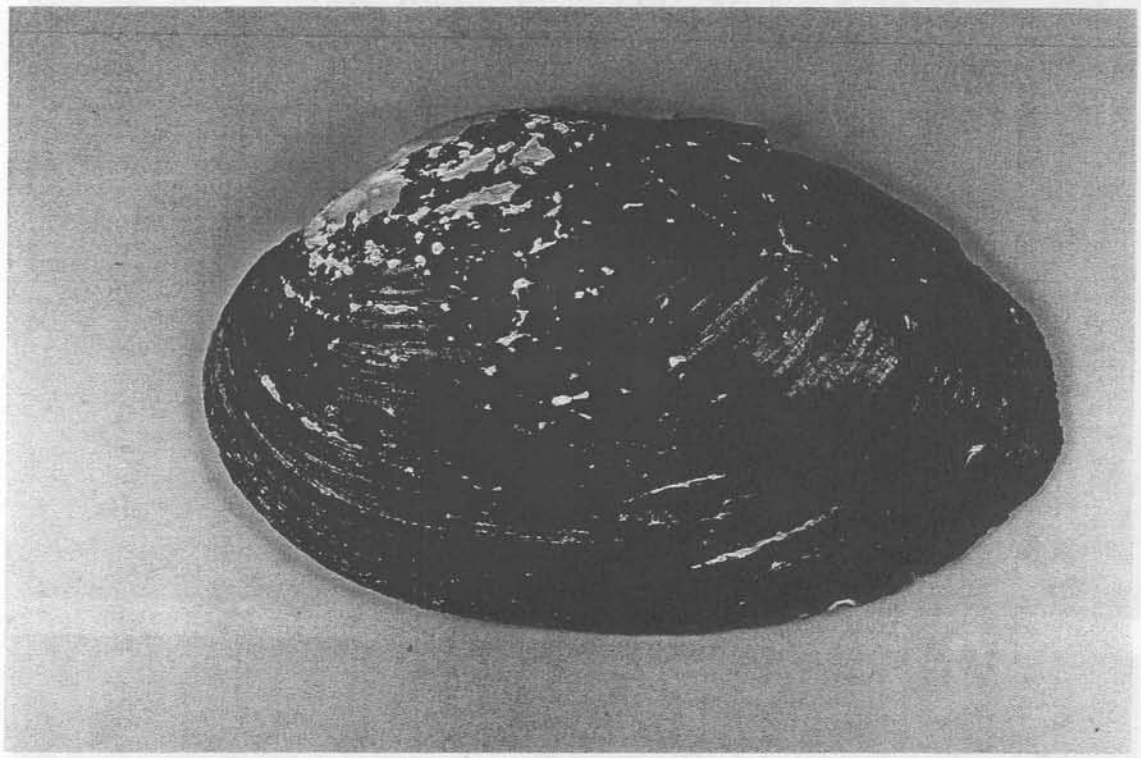
West Fork of Glover River:

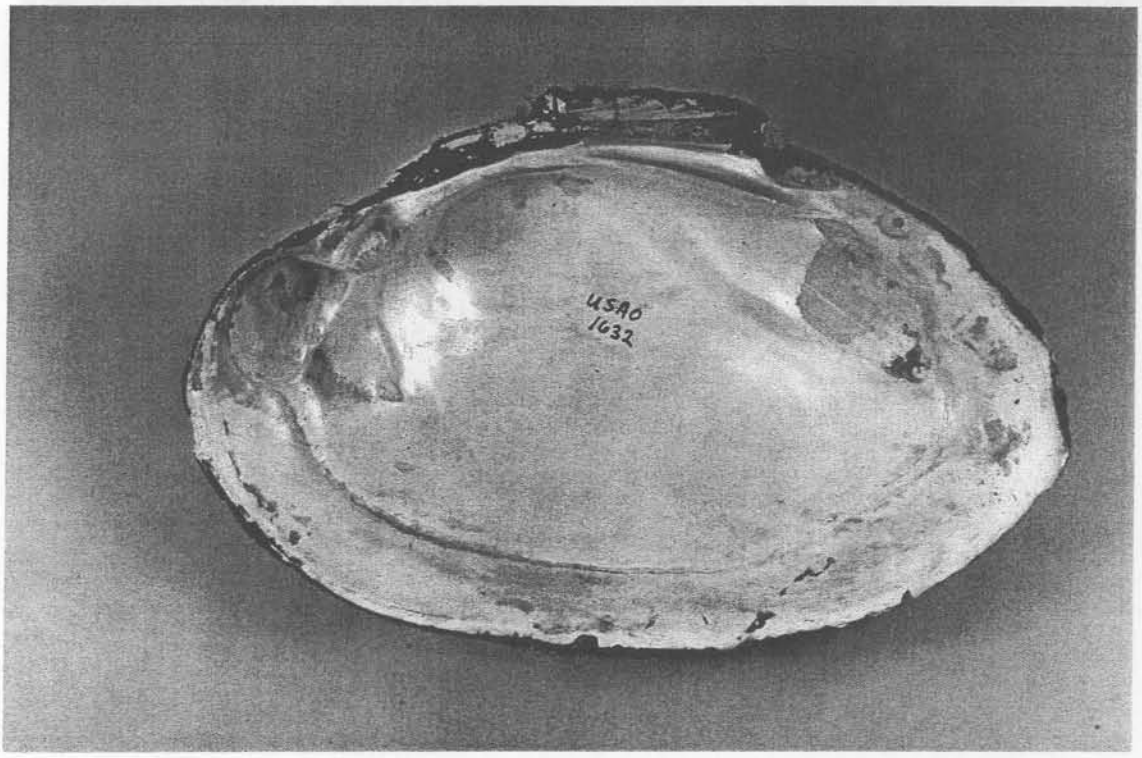
McCurtain County: 1.4 mi. W and 0.2 mi. N of Battiest.

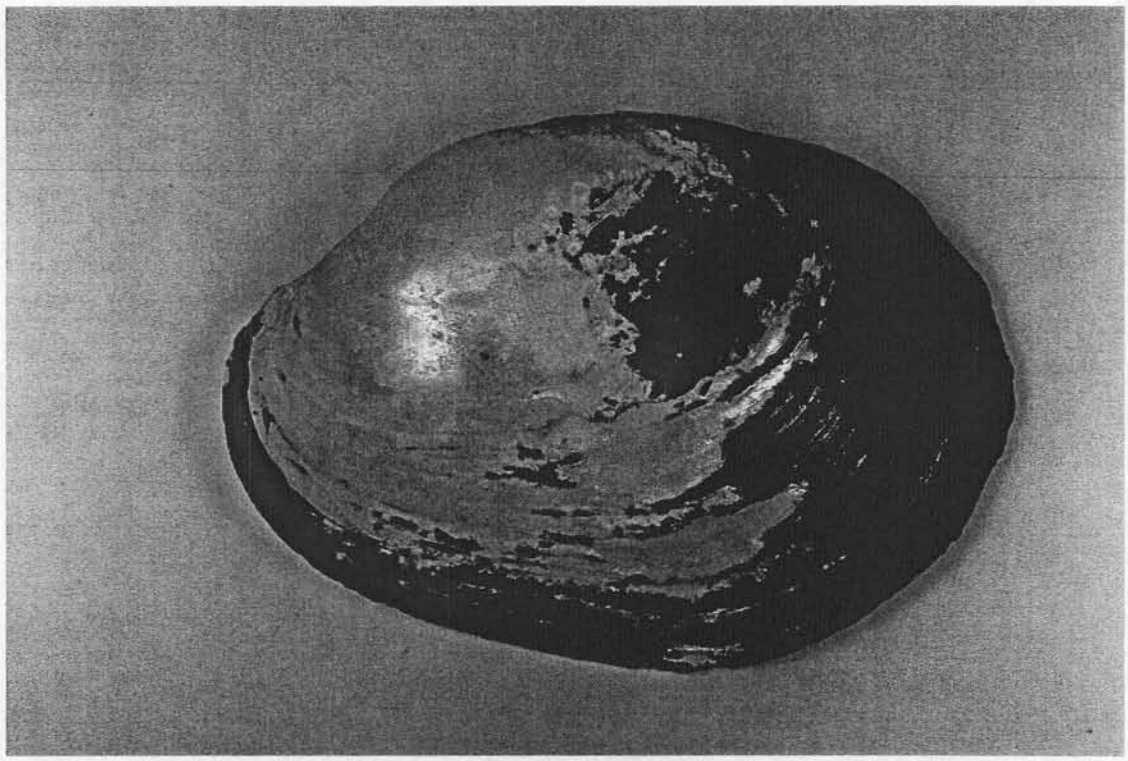
Waterfall Creek:

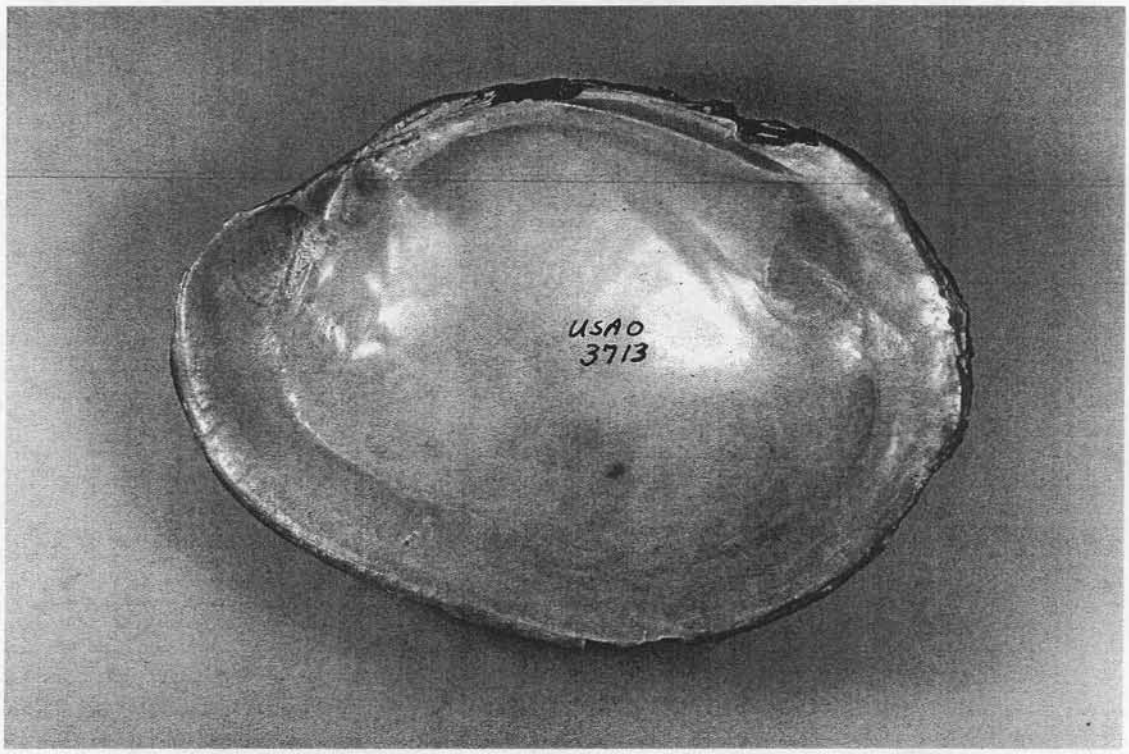
McCurtain County: 4.3 mi. NW of Harris.

Lampsils rafinesqueana Frierson 1927
Neosho Mucket





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Partial Synonymy:

Actinonaias rafinesqueana (Frierson, 1927), Johnson 1980

Lampsilis rafinesqueana Frierson, 1927, Branson 1984; Oesch 1984; Turgeon and others 1988

Description:

"Shell oblong, dorsal line gently rounded, ventral line straight to gently curved; anterior end uniformly rounded, posterior end truncated above and at the posterior ridge which usually gives it a biangulate appearance. Shell is strong although relatively thin; size to 9.5cm; compressed; posterior ridge broadly rounded dorsally becoming flattened and biangulate ventrally. Beaks low, only slightly raised above the hinge line; inequipartite; beak sculpture consists of a number of fine lines rounded up posteriorly; growth-rest lines prominent; the epidermis is usually darker colored in the grooves. Epidermis light brown and has a dull, waxy luster; it usually becomes dark brown with age; green rays usually cover the surface, rays are often discontinuous, especially during the second and third year of growth; during this period the shell usually exhibits chevron- and Y-shaped patterns.

Left valve has two stout, divergent, striated, triangular pseudocardinal teeth; the two lateral teeth are short, stout and slightly curved. Right valve has a tall, triangular to columnar, striated pseudocardinal; a low, lamellar tooth can be seen anteriorly; right lateral tooth is short, stout and slightly curved. Interdentum present but not broad; beak cavities relatively shallow; nacre bluish-white to white, slightly iridescent posteriorly" (Oesch 1984, p219-220).

Hosts for Glochidia:

Unknown

Comments:

Very similar in appearance to *Actinonaias ligamentina* and often confused with that species.

Table 10. Summary of *L. rafinesqueana* shell characters.

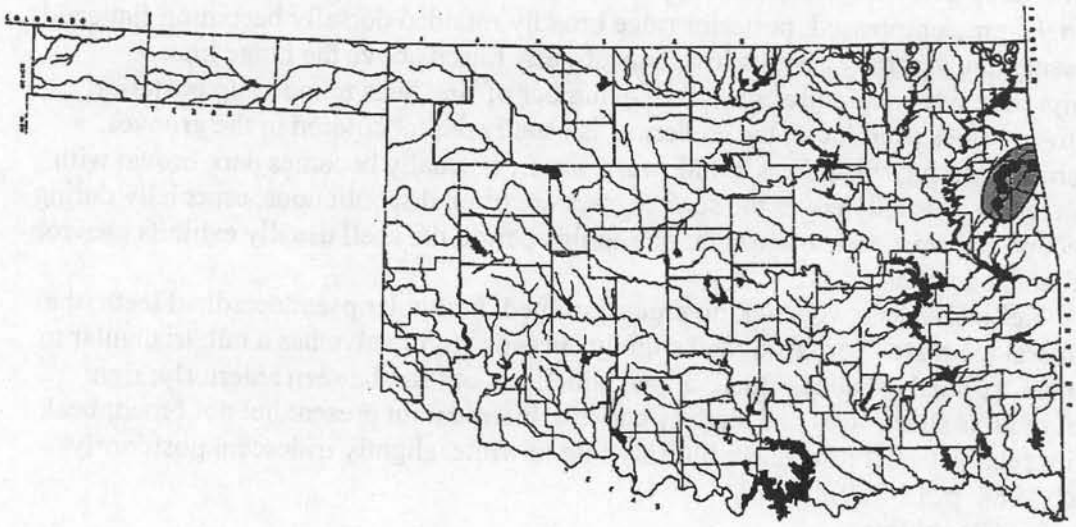
Location	Sex	N	Mean H/L (%)	H/L Range (%)	Max. Length (mm)	Mean W/L (%)	W/L Range (%)	Remarks
Arkansas River Drainage								
Caney River	_	2	62.3	61.9-62.6	115	-	-	subfossil
	_	1	-	68.4	114	-	-	subfossil
Verdigris River	_	2	64.4	63.0-65.8	119	-	41.2	subfossil
Neosho River	_	3	61.5	58.3-65.7	120	-	42.4	subfossil
	_	2	62.1	61.6-62.5	136	-	-	subfossil
Illinois River	_	23	61.7	56.3-66.4	135	38.5	31.3-45.7	1 with pinkish teeth
	_	26	65.1	59.2-69.5	150	41.6	35.4-46.1	

General Distribution:

Southwestern Missouri, southeastern Kansas, northwestern Arkansas and northeastern Oklahoma.

Oklahoma Distribution:

Currently found only in the Illinois River from the Arkansas State Line to Lake Tenkiller. Formerly found in the Spring, Neosho, Verdigris and Caney Rivers.



Map 15. Distribution of *L. rafinesqueana* in Oklahoma. Yellow dots represent subfossil localities outside the current range of the species.

Arkansas River System

Verdigris River:

Nowata County: 2 mi. SE of South Coffeyville (subfossil).

Caney River:

Osage County: 4.8 mi. SE of Hulah Dam (subfossil).

Washington County: 4.6 mi. NE of Dewey (subfossil).

Neosho (Grand) River:

Craig County: 4.5 mi. NW of Miami, Stepps Ford Bridge (subfossil); 3 mi. WNW of Miami (subfossil).

Ottawa County: Miami, city park (subfossil).

Illinois River:

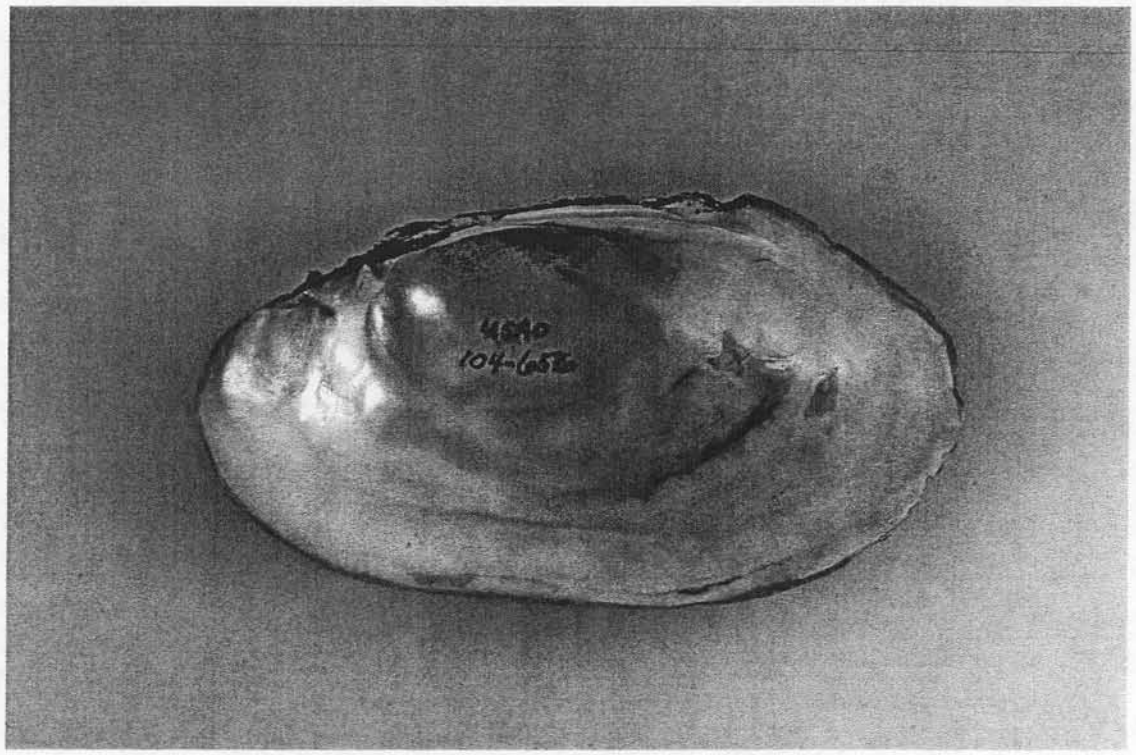
Adair County: 1 mi. downstream from Lake Frances Dam; 0.8 mi. W of Chewey, Hampton's Bridge; 0.5 mi. W of Chewey at Chewey Bridge.

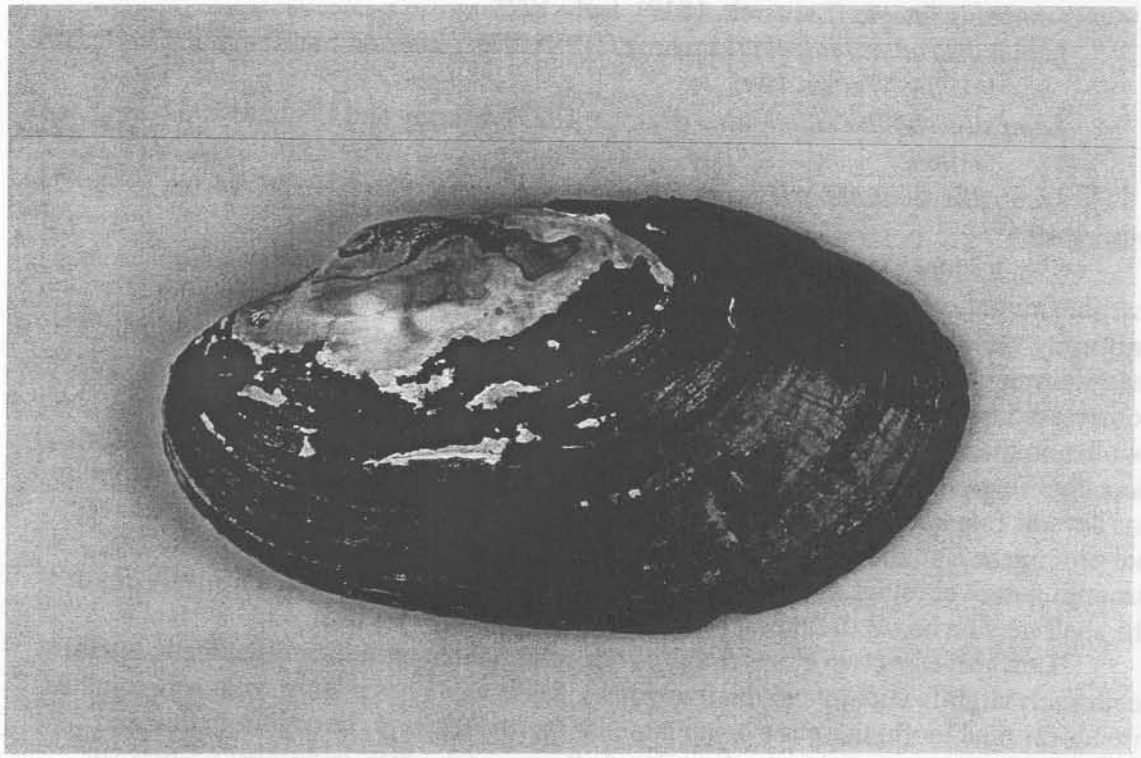
Cherokee County: SE of Tahlequah; 1 mi. ENE of Scraper off St. Hwy. 10, Round Hollow Public Access Area; 2.6 mi. SE of Scraper on St. Hwy. 10, Peavine Hollow Public Access Area; 1 mi. S of Scraper, Buck Ford Public Access Area; 0.7 mi. ESE of Scraper off St. Hwy. 10, Stunkard Public Access Area; 1 mi. SE of McSpadden Falls, No Head Hollow Public Access Area; Echota Public Access Area; Public access area, downriver from Hwy. 51 bridge; S of Tahlequah at mouth of Barron Fork, S22-T16N-R22E; At

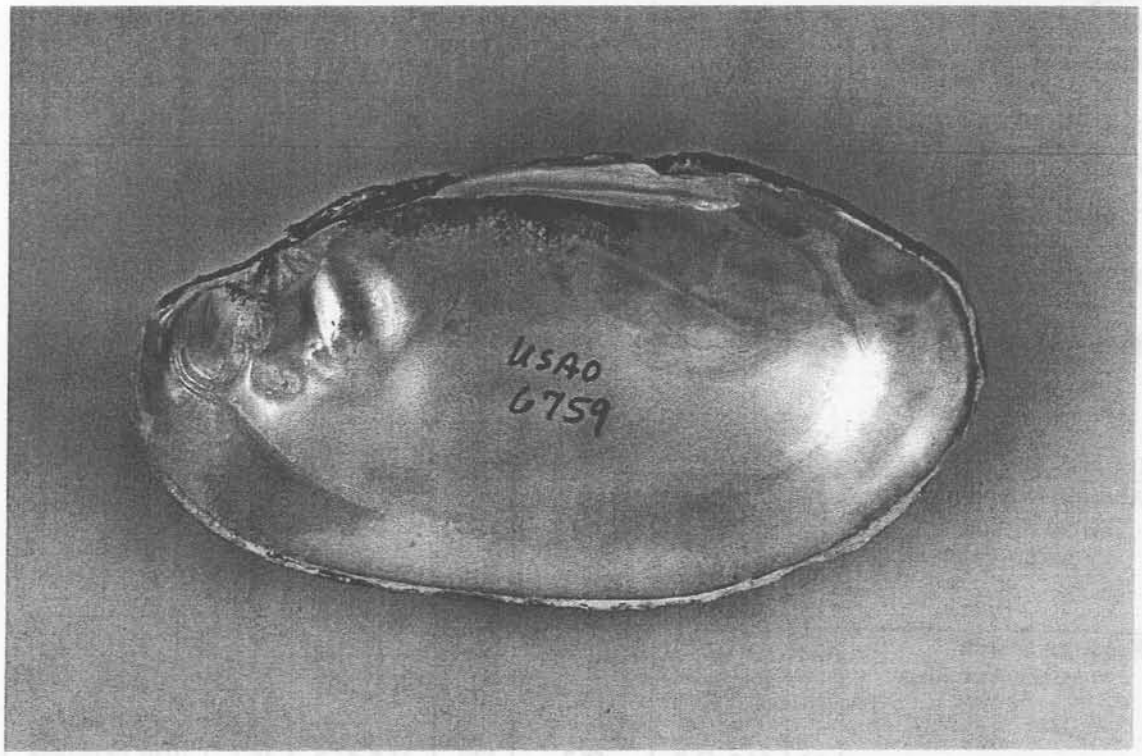
Tahlequah; 3 mi. E and 6 mi. N of Tahlequah; 5.5 mi. E and 3 mi. N of Tahlequah; Downstream from Sparrow Hawk; 8 mi. SE of Tahlequah; 2.5 mi. E of Moodys, Combs Bridge.

Delaware County: Just above mouth of Flint Creek, 1.3 mi. SSW of Flint.

Lampsilis siliquoidea (Barnes 1823)
Fatmucket



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Partial Synonymy:

Lampsilis luteola (Lamarck, 1819), Isely 1925

Lampsilis radiata luteola (Lamarck, 1819), Valentine and Stansbery 1971; Oesch 1984; Watters 1995

Lampsilis radiata siliquoidea (Barnes, 1823), Murray and Leonard 1962; Branson 1984

Lampsilis siliquoidea (Barnes, 1823), Turgeon and others 1988; Vidrine 1993

Description:

"Shell oblong, elongate, ovate; dorsal and ventral margins nearly parallel; dorsal margin straight, ventral margin straight, sometimes gently rounded; anterior end uniformly rounded, posterior end straight dorsally, angled where it meets the dorsal margin, rounded below. Shell thickness is uniform; size to 13.2cm; shell moderately compressed to moderately inflated, the later seen in females who become noticeably swollen in the postero-ventral region; Posterior ridge not prominent, gently rounded dorsally. Beaks broad, slightly raised above the hinge line; inequipartite; beak sculpture has several fine lines sharply drawn up in the middle. Growth-rest lines noticeable but not prominent features on the shell. Epidermis shiny, light yellow in young shells, becoming dark chestnut in some old specimens; bright green rays that uniformly cover the shell may be broad to fine capillary type rays; some are rayless.

Left valve has two erect, compressed, emarginated pseudocardinal teeth; lateral teeth short slightly curved and relatively low. Right valve has a large erect, emarginated pseudocardinal tooth; there is a small lamellar tooth anteriorly; lateral tooth thin and straight. Interdentum absent; beak cavity shallow; nacre white, iridescent posteriorly" (Oesch 1984, p 213-214).

Hosts for Glochidia:

Black Crappie, Bluegill, Common Shiner, Largemouth Bass, Orangespotted Sunfish, Pumpkinseed, Rock Bass, Sauger, Smallmouth Bass, Walleye, White Bass, White Crappie, White Sucker, Yellow Perch (Watters, 1994).

Comments:

Specimens in the upper Mountain Fork drainage tend to be compressed and often have pink/reddish nacre.

Table 11. Summary of *L. siliquoidea* shell characters.

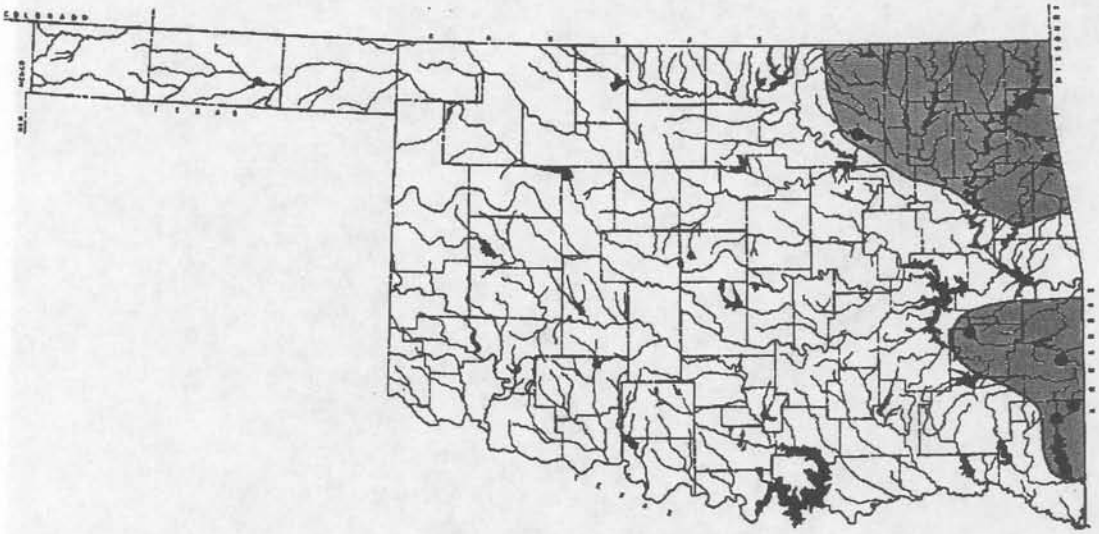
Location	N	H/L Range (%)	Mean H/L (%)	Maximum Length (mm)	W/L Range (%)	Mean W/L (%)	Remarks
Arkansas River System							
Poteau River and Fourche Maline Creek							
_	5	52.5-54.4	53.6	103	30.1-32.3	30.8	
_	2	57.8-58.5	58.2	94	51.1	-	
Red River System							
Mountain Fork River							
_	20	50.8-62.5	55.7	122	32.8-45.7	37.9	13 of 19 rayless 6 of 19 pinkish
_	19	54.2-63.9	58.2	120	31.6-42.5	38.7	10 of 19 rayless 5 of 19 pinkish

General Distribution:

Upper Mississippi River drainage northward through much of Canada.

Oklahoma Distribution:

Rare in the northeastern part of the state in the Arkansas River drainage. Also occurs in the Poteau River and Mountain Fork Rivers of southeastern Oklahoma.



Map 16. Distribution of *L. siliquoidea* in Oklahoma.

Arkansas River System

Hominy Creek:

Osage County: 3 mi. N of Wildhorse.

Illinois River:

Delaware County: Just above the mouth of Flint Creek, 1.3 mi. SSW of Flint.

Poteau River:

LeFlore County: 7 mi. S of Heavener on Hwy. 59.

Fourche Maline Creek:

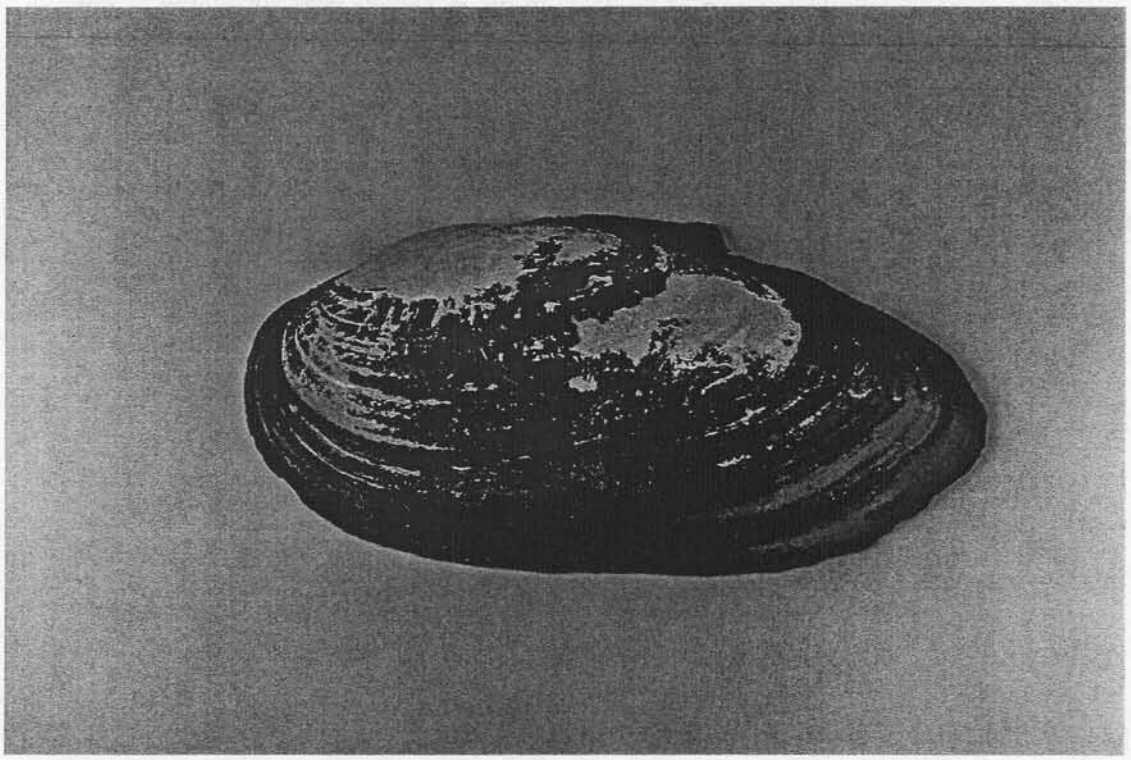
Latimer County: At Robbers Cave State Park.

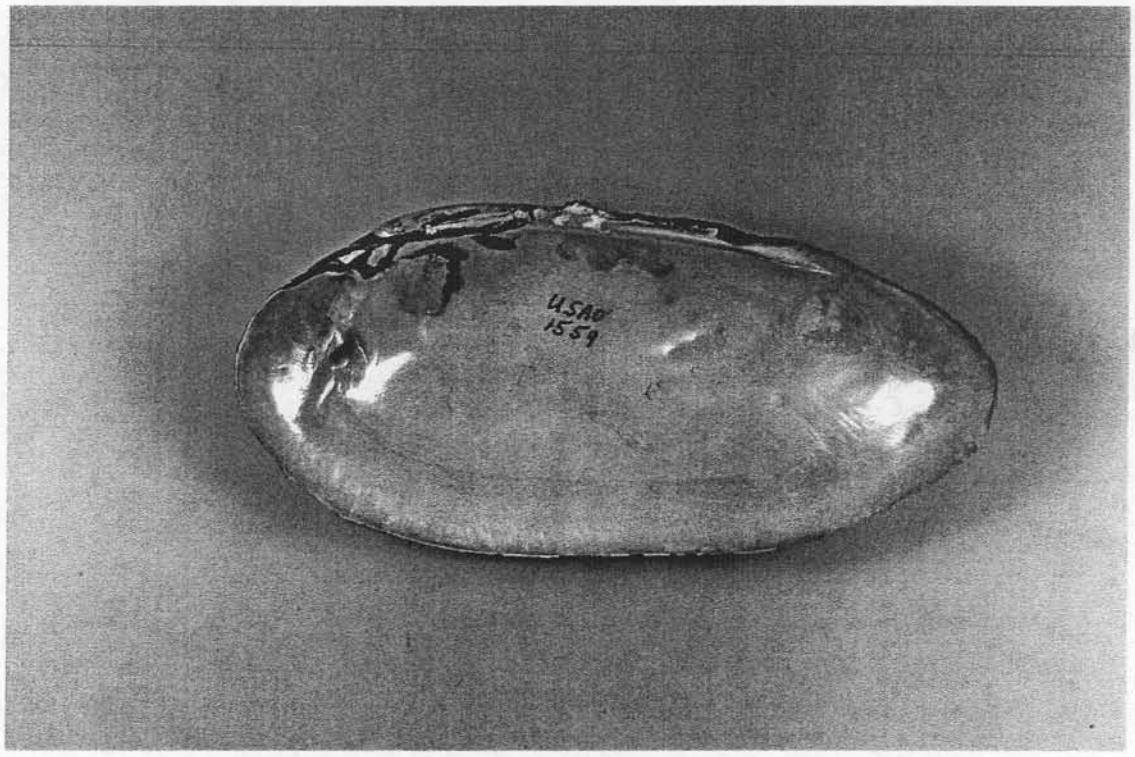
Red River System

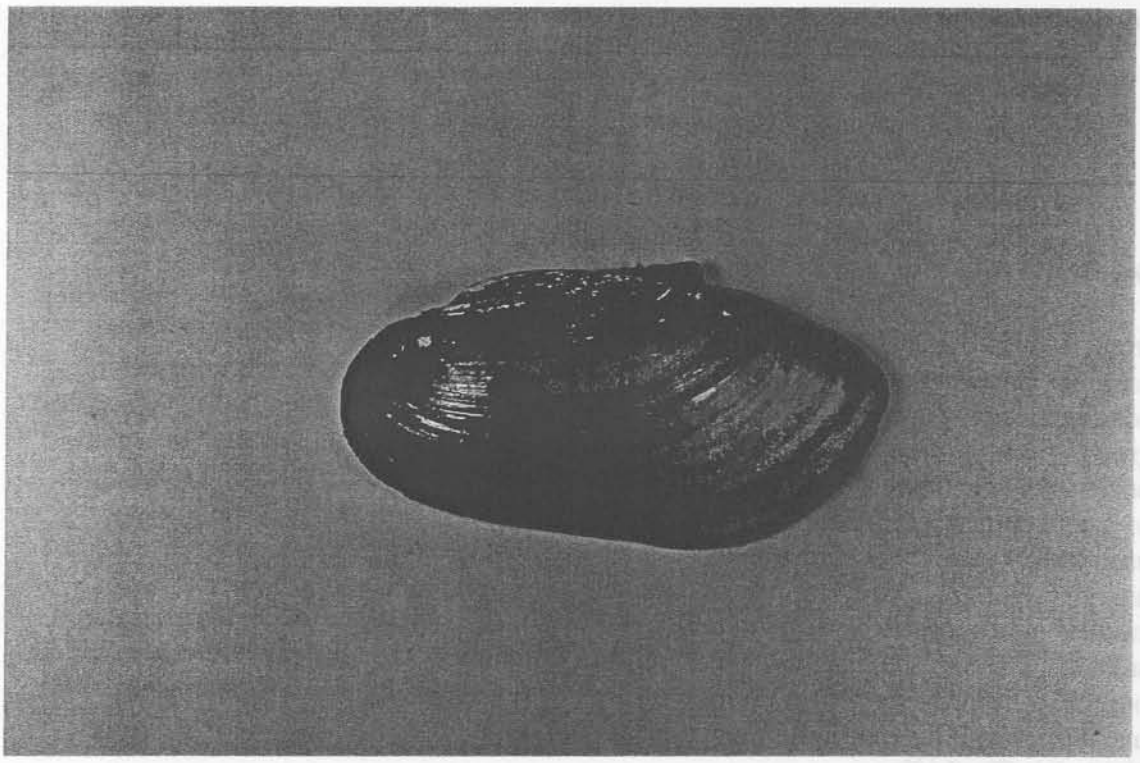
Mountain Fork River:

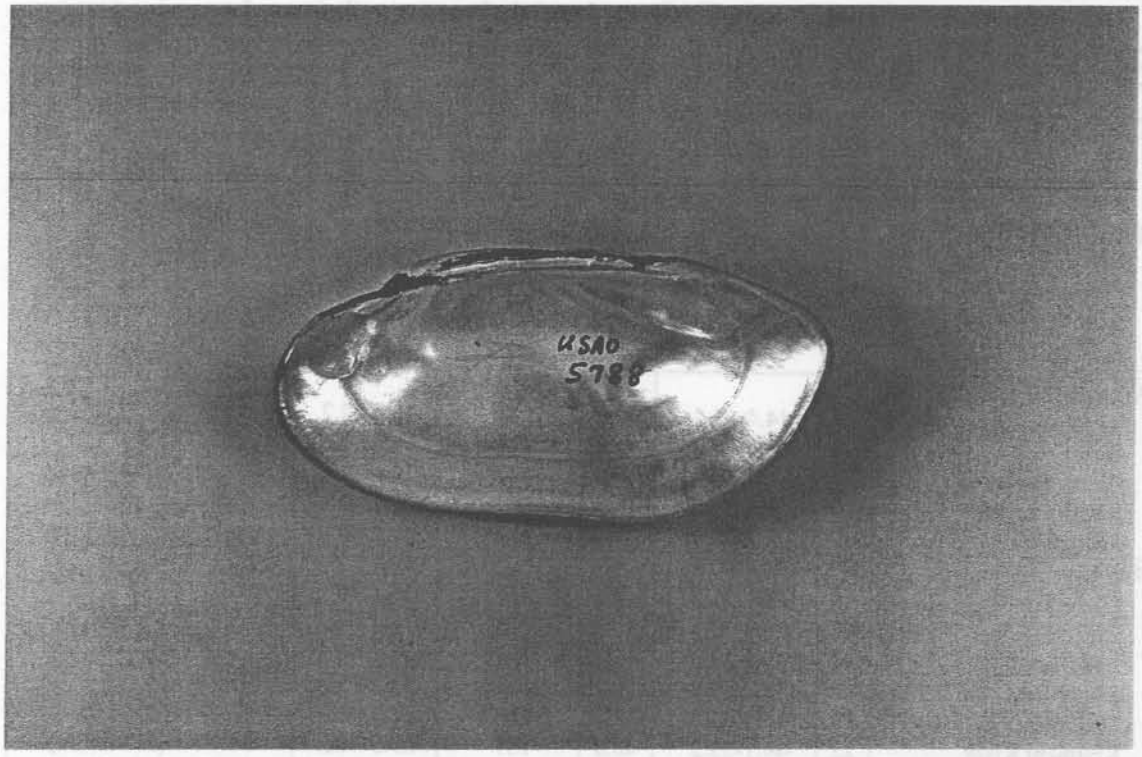
McCurtain County: Below Broken Bow Lake; At US Hwy. 70 E of Broken Bow; At Beavers Bend St. Pk.; About 3 mi. E of Beachton, S7-T1S-R27E; At the "Narrows", S9-T2S-R25E; E of Smithville; About 8.2 mi. NE of Smithville; At Smithville, S16-T2S-R25E; Off US Hwy. 259, about 8 mi. S of Smithville; 6.5 mi. SW of Smithville.

Lampsilis teres (Rafinesque 1820)
Yellow Sandshell





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Partial Synonymy:

Lampsilis anodontoides (Lea, 1831), Simpson 1914; Isely 1925; Valentine and Stansbery 1971

Lampsilis anodontoides anodontoides (Lea, 1831), Murray and Leonard 1962

Lampsilis fallaciosa Smith 1899, Isely 1925

Lampsilis teres (Rafinesque, 1820), Johnson 1980; Branson 1984; Turgeon and others 1988; Vidrine 1993; Watters 1995; Howells and others 1996

Description:

"Shell large, elongated, with dorsal and ventral lines nearly parallel, rounded in front, pointed behind, more or less inflated, solid; beaks rather full but not high, their sculpture consisting of numerous, distinct ridges looped in the middle but open behind; posterior ridge low and rounded; surface smooth and shining, but often having concentric growth ridges in front, tawny to pale straw-color, sometimes with a few rays on the posterior slope, the rest of the shell generally rayless; there is often a large, brown flush in the umbonal region; ligament large and long; left valve with two subcompressed pseudocardinals, the hinder somewhat elongated, and two long, nearly straight, delicate laterals; right valve with two pseudocardinals, the upper faint, and one lateral; beak cavities not deep; muscle scars rather large, well impressed; nacre white, cream-colored, salmon-tinted or pink, slightly thicker in front. Both male and female shell end behind in a point two-thirds of the way up from the base; the female shell has a large rounded marsupial swelling and slightly incurved at the central base" (Simpson 1914, p 90).

Hosts for Glochidia:

Alligator Gar, Black Crappie, Green Sunfish, Largemouth Bass, Longnose Gar, Orangespotted Sunfish, Shortnose Gar, Shovelnose Sturgeon, Warmouth, White Crappie (Watters, 1994).

Comments:

Very common and widespread in the eastern part of the state.

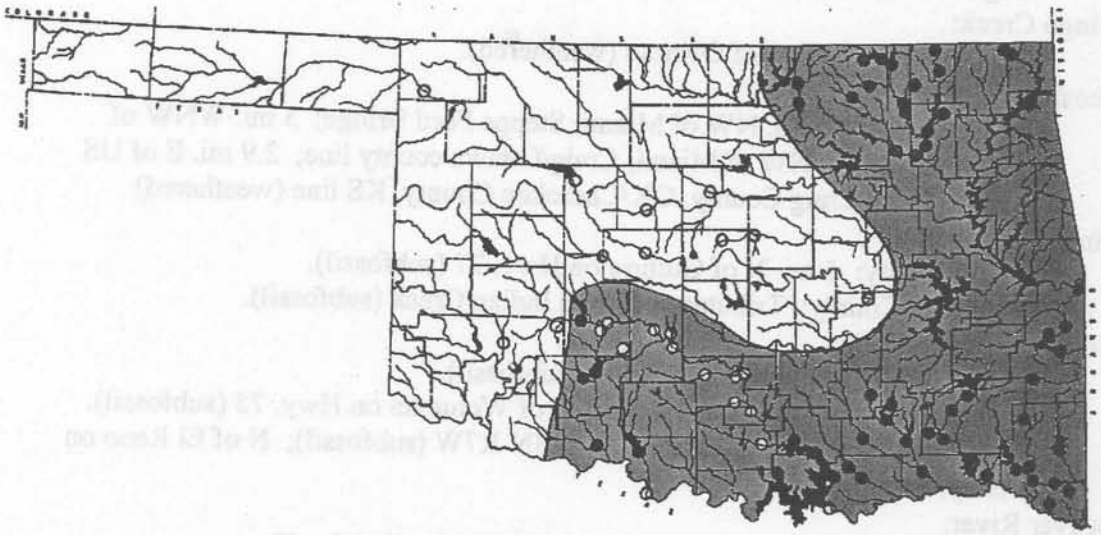
Table 12. Summary of *L. teres* shell characters.

Location	N	H/L Range %	Mean H/L %	Maximum Length (mm)	W/L Range %	Mean W/L %	Remarks
Arkansas River System							
Verdigris River	12	44.4-57.3	49.9	119	31.9-42.7	39.0	
Bird Creek	5	42.6-48.2	46.2	122	30.3-38.6	34.1	
Caney River	22	44.2-51.5	49.0	122	25.6-44.2	36.9	5 with rays
Neosho River	10	46.3-53.6	49.9	112	29.7-42.9	36.4	
Poteau River	5	44.9-53.1	48.8	113	30.6-46.0	36.9	1 with rays
Red River System							
Cache Creek	6	46.7-51.2	49.2	120	37.5-46.1	40.5	
Bitter Creek	12	48.8-53.7	50.5	112	31.6-43.2	35.5	1 with rays
Lake Texoma	4	45.6-52.2	49.3	137	33.8-47.4	39.9	
Blue River	5	43.0-49.5	46.2	111	33.0-39.6	36.6	
Muddy Boggy River	14	46.5-52.6	49.3	116	32.4-42.0	36.8	
Kiamichi River	22	44.1-53.2	48.6	105	29.0-40.2	34.7	1 with rays
Little River	29	42.4-52.2	47.3	110	31.1-39.0	35.4	4 with rays
Glover River	4	45.1-48.4	46.5	93	28.2-34.4	31.6	1 with rays

General Distribution:

Most of the eastern United States except Atlantic drainages through the Florida peninsula.

Oklahoma Distribution:



Map 17. Distribution of *L. teres* in Oklahoma. Yellow dots represent subfossil sites.

Arkansas River System

Salt Creek:

Osage County: 3.1 mi. SW of Shidler; 2.2 mi. NW of Fairfax.

Verdigris River:

Nowata County: At St. Hwy. 10, 2.8 mi. E of Lenapah; 4 mi. N of Childers, Hancock Bridge; 2 mi. SE of South Coffeyville.

Rogers County: 0.8 mi. W of Claremore Mound; Below Oologah dam (weathered); 5 mi. N of Catoosa; 4.5 mi. W of Claremore, S of Hwy 20.

Oologah Lake:

Rogers County: 5 mi. W of Chelsea; 1 mi. SW of Winganon.

Caney River:

Osage County: 4.8 mi. SE of Hulah Dam, S28-T28N-R12E (weathered); Below Hulah Lake (weathered).

Washington County: 4.8 mi. E of Ramona; Bridge 635; 4.6 mi. NE of Dewey; 6.2 mi. NW of Dewey; NE of Bartlesville on old Hwy. 75 (weathered).

Lake Hulah:

Osage County: Near E end of dam, S1-T28N-R11E (weathered).

Sand Creek:

Osage County: NE _ S15-T26N-R10E; Osage Hills State Park.

Little Caney River:

Washington County: 2.1 mi. NW of Copan.

Curl Creek:

Nowata County: 1.5 mi. E of Nowata/Washington County line on US Hwy. 60.

Bird Creek:

Osage County: 0.25 mi. N of Nelagoney (weathered).

Rogers County: On Hwy. 167; At Catoosa, S18-T20N-R15E (weathered).

Tulsa County: 2 mi. ENE of Sperry.

Hominy Creek:

Osage County: 3 mi. N of Wildhorse; 5.7 mi. ENE of Wildhorse.

Mingo Creek:

Tulsa County: 2 mi. S of Owasso (weathered).

Neosho (Grand) River:

Craig County: 4.5 mi. NW of Miami, Stepps Ford Bridge; 3 mi. WNW of Miami; 9.5 mi. NW of Miami, Craig/Ottawa county line; 2.9 mi. E of US Hwy. 59 on Craig County, OK/Cherokee County, KS line (weathered).

Cimarron River:

Logan County: 5 mi. N of Guthrie on Hwy. 77 (subfossil).

Kingfisher County: Tributary of Dead Indian Creek (subfossil).

North Canadian River:

Blaine County: Below Canton Lake (subfossil).

Hughes County: 3 mi. N and 0.5 mi. E of Wetumka on Hwy. 75 (subfossil).

Canadian County: At El Reno, S32-T13N-R7W (subfossil); N of El Reno on Hwy. 81 (subfossil).

Beaver River:

Harper County: 0.5 mi. N of May, wooden bridge (subfossil).

Deep Fork River:

Lincoln County: SW of Wellston, S10-T14N-R2E (subfossil).

Oklahoma County: W of Arcadia (subfossil).

Canadian River (South);

Caddo County: Hwy. 281 bridge E of Bridgeport (subfossil).

Poteau River:

LeFlore County: Old Hwy. 59 S of Poteau; At Arkoma, S9-T10N-R27E; At Heavener.

Caston Creek:

LeFlore County: 1 km SSE ofWister on US Hwy. 270, S36-T6N-R24E.

Red River System

Red River:

Jefferson County: S of Terral on US Hwy. 81 (subfossil).

Bryan County: At US Hwy. 75 S of Colbert (subfossil).

Elk Creek:

Kiowa County: 7 mi. S of Hobart (subfossil).

West Cache Creek:

Cotton County: 2.5 mi. N of Taylor.

East Cache Creek:

Comanche County: E of Porter Hill and 2 mi. W of Elgin on US Hwy. 277.

Lake Lawtonka:

Comanche County: About 2.5 mi. N of Mount Scott.

Beaver Creek:

Jefferson County: About 2.4 mi. E of Hastings on St. Hwy. 5, S17-T4S-R8W.

Washita River:

Caddo County: Fort Cobb (weathered); Randlett Park, Anadarko (subfossil); 1 mi. N of Anadarko (weathered).

Grady County: At Hwy. 9 bridge E of Chickasha, S26-T7N-R7W; Hwy. 62 at Chickasha; 3 mi. E of Alex (subfossil); Hwy. 81 N of Chickasha (subfossil).

Garvin County: 2 mi. N of Pauls Valley on Hwy. 77 (subfossil).

Murray County: St. Hwy. 7 bridge about 1 mi. W of Davis, Murray/Garvin County line (subfossil).

Stinking Creek:

Kiowa County: 4.7 mi. E of Mountain View on St. Hwy. 9.

Rush Creek:

Garvin County: At Pauls Valley (subfossil); 5 mi. S of Maysville on St. Hwy. 74 (subfossil).

West Bills Creek:

Caddo County: 2 mi. E of Cement (subfossil).

Hog Creek:

Caddo County: 4 mi, W of Anadarko on Hwy. 9 (subfossil).

Wildhorse Creek:

Garvin County: 6.2 mi. S of Wynnewood, exit 17a on I-35 (subfossil); About 13 mi. S of Pauls Valley, S27-T1N-R2E (subfossil).

Bitter Creek:

Grady County: About 2 mi. S and 6 mi. E of USAO campus.

Caddo Creek:

Carter County: 1 mi. E of Hwy. 77 (subfossil) ; At I-35, S35-T3S-R1E (weathered); At Hwy. 77, N of Ardmore, S31-T3S-R2E.

Sandy Creek:

Johnston County: Mouth of creek in Tishomingo National Wildlife Refuge.

Pennington Creek:

Johnston County: 1 mi. S of Tishomingo; 1 mi. S of Murray State College.

Lake Texoma:

Marshall County: At Lebanon (weathered).

Bryan County: SE of Roosevelt Bridge, W of Durant, S33-T6S-R7E; Willow Springs, S of US Hwy. 70 (weathered).

Blue River:

Bryan County: W of Blue on old highway (weathered); 1 mi. SSW of Blue on county road; 0.5 mi. W of Blue on US Hwy. 70 (weathered); At Blue, S27-T6S-R10E (weathered); At Armstrong, below dam.

Muddy Boggy River:

Atoka County: 5 mi. E of Lane; N of Lane; Near Farris, S26-T3S-R13E; 3 mi. NE of Lane.

Coal County: 2 mi. N of Coalgate.

Choctaw County: At Jasper on US Hwy. 70.

Atoka Reservoir:

Atoka County: Below Spillway; 5 mi. N of Stringtown.

Clear Boggy River:

Atoka County: At US Hwy. 75, between Caney and Tushka.

Gates Creek:

Choctaw County: Below Lake Raymond Gary dam.

Kiamichi River:

LeFlore County: 0.6 mi. S of Whitesboro, S33-34-T3N-R23E.

Pushmataha County: 0.9 mi. SE of Clayton on US Hwy. 271; 14.9 mi. NNE of Antlers on St. Hwy. 2; At Stanley; US Hwy. 271 at Antlers.

Choctaw County: Spencerville Crossing, 8.5 mi. NE of Hugo.

Ten Mile Creek:

Pushmataha County: 1.5 mi. S of Moyers.

Little River:

McCurtain County: N of Idabel on Hwy. 70; W of Wright City on St. Hwy. 98, S6-T6S-R22E; At Railroad Crossing, 1.5 mi. SW of Wright City, S6&7-T6S-R22E; 1.5 mi. N of Garvin, S6-T7S-R23E.

Lukfata Creek:

McCurtain County: 2 mi. N of Little River Bridge on US Hwy. 259 (weathered).

Mud Creek:

McCurtain County: 5 mi. E of Idabel on St. Hwy. 3.

Glover River:

McCurtain County: At Glover, S33-T5S-R23E.

West Fork of Glover River:

McCurtain County: 1.4 mi. W and 0.2 mi. N of Battiest; 2 mi. N of Glover; 0.25 mi. W of Glover.

Waterfall Creek:

McCurtain County: 4.3 mi. NW of Harris.