

FRESHWATER MUSSELS OF CAHABA RIVER NATIONAL WILDLIFE REFUGE



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Introduction

Freshwater mussels are one of the most imperiled groups of animals in North America. Currently 70 mussel species are listed as endangered or threatened under the Endangered Species Act, and a number of others are candidates or potential candidates for protection. Affected by siltation, erosion, polluted runoff, impoundment, channelization, habitat fragmentation, and population isolation, even common and widespread species have declined dramatically from historic levels.

Mussels have been economically tied to the southeastern drainages since prehistoric times. Native Americans not only ate mussels, but also used their shells for tools, containers, utensils, and jewelry. Early European settlers also consumed them during hard times, and often harvested natural pearls from them. During the late 1800's and early 1900's, mussel shells were harvested to make highly prized pearl buttons, which were shipped throughout the world and became a multi-million dollar industry. During the 1940's the pearl button industry collapsed due to the invention and wide-spread use of plastics. However, about the same time the Japanese cultured pearl industry was coming into its own.

Mussels continue to contribute to the economy today. Few Americans realize that freshwater mussel shells are the primary source of nuclei for the world-wide cultured pearl industry. Shells are still collected and shipped to Japan, China, the Pacific Islands, and Australia where they are cut and rounded into beads for insertion into oysters as nuclei for cultured pearls.

Mussels are important to the ecology of the Cahaba River. As filter feeders they remove sediments and detritus from the water. Their partially digested excretion is food for many aquatic invertebrates and fishes. Mussels are also consumed by some fish, turtles, muskrats, mink, otter, and raccoon.

Mussels are important indicators of aquatic ecosystem health. Their complex life cycle requires a healthy fish community, stable substrates, and relatively clean water. Changes in water quality, channel stability, or fish density and diversity are usually reflected by a decline in abundance or a loss of species within the mussel community. Monitoring the health and diversity of the mussels within a drainage system is an important tool in aquatic ecosystem management.

With a length of about 200 miles, the Cahaba River is Alabama's longest free-flowing stream. Although more than 40 species of mussels were historically known from the drainage, only 27 species have been collected from the Cahaba River during the past decade (McGregor *et al.*, 2000). The decline in mussel abundance and diversity in the Cahaba River during the past century has been attributed to discharge and runoff from mines, industrial sites, and urban growth in the watershed. Environmental laws and regulations have resulted in improved water quality, however, mussels remain relatively uncommon throughout the system.

The Cahaba River National Wildlife Refuge (Figure 1) was established for the purpose of protecting and managing a unique section of the Cahaba River and the lands adjacent to it. Within the Refuge a series of bedrock shoals are extremely productive, supporting a variety of fish, mussels, snails, as well as a dense stand of the Cahaba lily. A recent survey of select sites on the Refuge, and reports by others, indicate that at least 17 species of native mussels continue to survive on the Refuge (Appendix 1).

Figure 1

Mussel Identification

The most obvious and persistent feature of the freshwater mussel is its shell. Features used to differentiate species include the thickness of the shell, presence or absence of teeth inside the shell, presence or absence of pustules and/or ridges, color of the inside and outside of the shell, etc. It is important to realize that features of the shell can be highly similar between different species, as well as variable within a single species. Figure 1 shows the basic anatomy of a mussel's shell. The anterior end of a mussel can be determined by the location of the umbo (or beak) and the pseudocardinal teeth. These are both located anteriorly. In living mussels the more elongate end is usually the posterior end. When replacing a living mussel back into the substrate, it is very important to place the anterior end down, leaving the posterior end exposed to the water.

Important characters inside the shell include the nacre color, length and shape of the lateral and pseudocardinal teeth, and depth of the beak cavity. External characters include the color of the periostracum (external skin), the presence or absence of colored rays, the shape, number, and arrangement of pustules or ridges, the presence or absence of a sulcus (shallow depression running from the break to the ventral margin of the shell), and the presence/prominence of a posterior ridge.

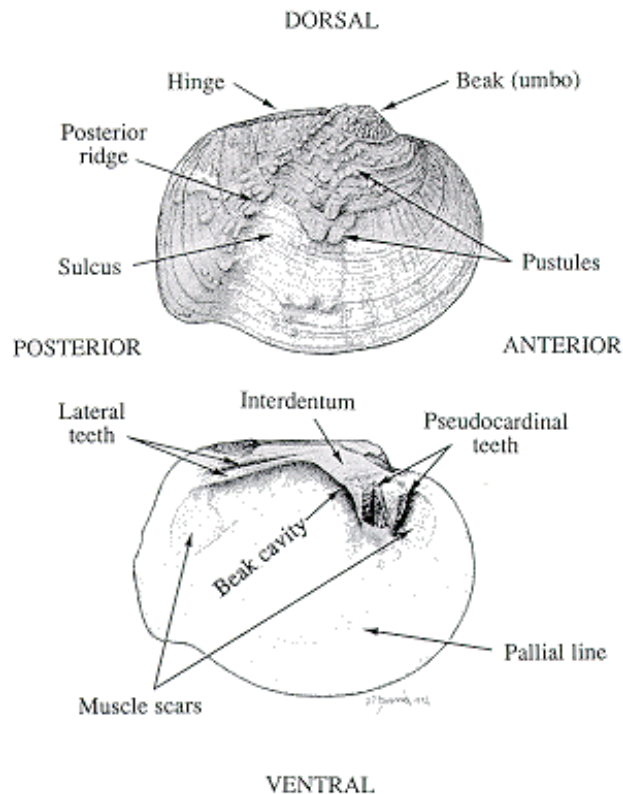
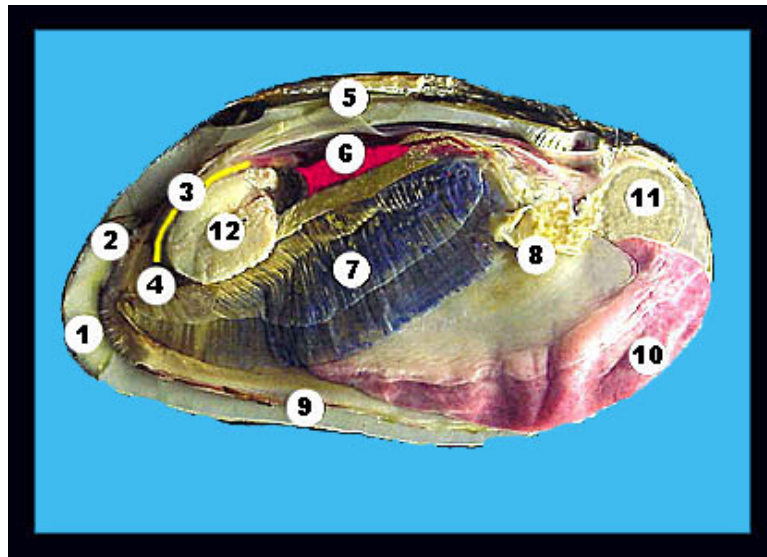


Figure 1: The Shell of a Freshwater Mussel

Internal anatomy, or “soft part” characters (Figure 2), are used in classification of mussels into families, genera, and species. The most prominent of these include the number of gills used as marsupia for the larvae, the size and shape of the marsupium, the anatomy of the larvae (glochidia), labial palps, siphons, and mantle characters.



- Key:
- 1: Incurrent siphon
 - 2: Excurrent siphon
 - 3: Intestine
 - 4: Anus
 - 5: Hinge ligament
 - 6: Heart
 - 7: Gills
 - 8: Labial palps
 - 9: Mantle
 - 10: Foot
 - 11: Ant. adductor muscle
 - 12: Post adductor muscle

Figure 2: The Body of a Freshwater Mussel

Freshwater Mussel Life History and Reproduction

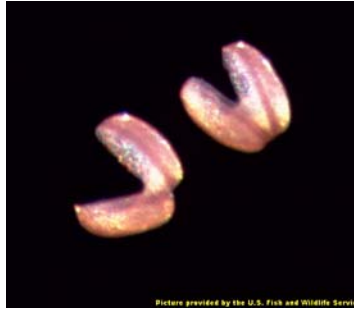


Figure 3: Mussel Glochidia

Most fresh water mussels have two separate sexes. A few, however, such as the paper pondshell (*Utterbackia imbecillis*) and the lilliput (*Toxolasma parvus*), are hermaphroditic, with both male and female sex organs. Typically, the males release sperm into the water. The females take in the sperm through the incurrent siphon. Eggs are kept in the water tubes of the female's gills. As water is pumped into the gills, the eggs are fertilized and then develop into larvae, called glochidia (Figure 3). The glochidia lack several of the organs of the adult mussels, and must go through metamorphosis before they can live independently.

In the southeastern United States, native mussels are parasitic during their larval stage (Figure 4). The glochidia of these mussel species use fish as hosts, but some have been known to occasionally use other aquatic vertebrates like bullfrogs or eels. For some mussels, only one or a few species of fish can host the glochidia; for other mussels, the glochidia can attach to many different kinds of fish. If successful, the larval mussels attach to the gills or fins (depending on the species of mussel) of a host fish where they undergo metamorphosis. If the glochidia do not attach to an appropriate host, they cannot survive.

There are many ways in which a female mussel attracts a host fish for her young glochidia. A few species of fresh water mussels simply release their larvae as bundles of free floating glochidia. These glochidia must wait to float into a fish by chance and can usually use multiple species of fish as hosts.

Some species of mussels build a structure of mucus and glochidia, called a conglutinate. The female mussel uses the conglutinate as a "fishing lure" to attract a host fish. When a fish attempts to eat the bait, the conglutinate breaks apart releasing many glochidia in the fish's mouth. The glochidia are then able to attach to the gills. The conglutinates of some species are extremely specialized, and have a close resemblance to a small fish or aquatic invertebrate.

Some species of mussel, such as the southern pocketbook (*Lampsilis ornata*), can use their mantle as bait for a passing fish. These mussels wave their specialized mantles, which resemble minnows, crawfish, worms or other small aquatic animals. When a fish is attracted, the female mussel retracts her mantle and releases her glochidia. The fish receives a mouth full of larvae which attach themselves to the gills of the host fish.

Other species of mussel build a “net” or “web” of mucus and glochidia. When a host fish swims through the trap, the web breaks apart, freeing the glochidia which attach to the fish’s fins.

Mussels such as the exotic *Corbicula fluminea*, or the Asian Clam, do not require a host fish. Instead, their larvae are planktonic and develop into adults as tiny free-floating animals.

Once attached to a host fish, a cyst or small abscess forms around the glochidium. There the larval mussels undergo metamorphosis and become juvenile mussels. Some fish can build up a resistance to glochidia, and can only be parasitized once. Glochidia that become attached to resistant fish fall off the fish and die. The parasitic stage of mussel glochidia lasts from a week to several months. This extreme variation is believed to be affected by mussel species and water temperature. Once metamorphosis is complete, the new juvenile mussel drops off of its host, leaving the fish unharmed. The juvenile mussel will take at least a year to reach sexual maturity, and some species are known to take as long as four years.

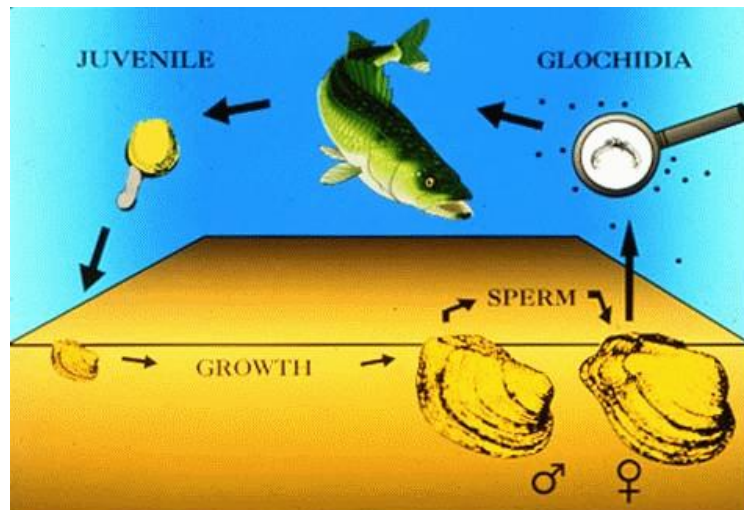


Figure 4: The Freshwater Mussel Life Cycle

Cahaba River National Wildlife Refuge Species Accounts

Amblema plicata
Threeridge



This photograph shows threeridges of all ages including an immature mussel that is about one inch in length and a mature mussel that is about three inches in length.

Description: The threeridge has a thick shell, with large teeth and a low beak. There are large folds or ridges on these shells, extending from the beak to the posterior end. Its color varies from light brown or green in juveniles, to dark brown, dark green, or black in older adults. The nacre of the shell is bright white, and sometimes. The mussel can reach seven inches in length.

The threeridge looks similar to the washboard (*Megalonaias nervosa*), but lacks the pustules on the beak of the shell, which characterize the washboard. This mussel is also sometimes mistaken for the rock pocketbook (*Arcidens confragosus*), but the threeridge has thicker teeth than the rock pocketbook.

Host Fish include several species of bass, pike, gar, sunfish, pumpkinseeds, warmouth bluegill, perch, crappie, catfish, and sauger.

Habitat: The threeridge requires some current. Though the mussel is found in rivers and streams of all sizes, it is mostly a large river species. The mussel can live in sand, mud, or gravel.

Distribution: The threeridge occurs from Alabama to Texas, and from the gulf coast, north into Maine and Canada.

On the Cahaba National Wildlife Refuge, the threeridge is present in the riffles and shoals where there is a sand substrate. During this survey, the threeridge was found at sites 15 and 16.

The threeridge is a commercially valuable species.

Elliptio arctata
Delicate Spike



Description: The delicate spike reaches about four inches when mature. It has an elongated shell with somewhat of an arc shape. The periostracum is a dull yellow in young animals and becomes dark brown to black with age. The beak is low and does not extend past the hinge. The teeth are thin and the nacre is a dull white, often with a blue or pink tint.

Host Fish for this species are unknown.

Habitat: The delicate spike is most often found in shallow water with strong to moderate current. It is usually found in substrate consisting of coarse sand and gravel.

Distribution: The delicate spike ranges from western Georgia to central Mississippi.

The delicate spike is not common in the Cahaba river, it was found during this survey only at site 16.

Elliptio crassidens
Elephantear



Description: The elephantear has a thick shell, which can reach six or seven inches in length. The anterior end is rounded and blunt, while the posterior end is usually pointed with a sharp posterior ridge. The periostracum is light brown to black. The beak is flat and shallow. The teeth are short and wide. The nacre is variable and may be white, pink, or purple.

Host Fish for this species is the skipjack herring.

Habitat: The elephantear is most common in larger rivers, but is found in smaller streams as well. It is usually found in strong to moderate currents and sand and gravel substrates.

Distribution: The elephantear occurs from southern Mississippi and Alabama to Minnesota and Ohio.

This was the most abundant mussel found on the Cahaba River Refuge during this survey. They were found at survey sites 15, 16, and 17.

Fusconaia cerina
Southern Pigtoe



Description: The southern pigtoe has a thick, inflated shell, with a rhomboid shape. The periostracum is brown or reddish brown. The beak is high, extending beyond the hinge, and the beak cavity is fairly deep. The teeth are thick and heavy. The nacre is white, sometimes with a pink or purple tint.

Host Fish for the southern pigtoe include the largescale stoneroller, the Alabama, blacktail, pretty, golden, orange fin, emerald, silverstripe, and stripped shiners, the clear and bluehead chubs, and the bluntnose minnow.

Habitat: The southern pigtoe resides in small streams to large rivers, and requires a firm mud or sand substrate.

Distribution: This mussel is found in coastal streams east of the Mississippi River and west of the Mobile Basin,

During this survey, the southern pigtoe was found at site 15 and dead shells were found at site 16, but not in abundance.

Lampsilis altilis
Fine-lined Pocketbook



Description: The fine-lined pocketbook is a thin shelled, ovate mussel. Adults are typically three to four inches in length. The periostracum is dark yellow, and most have rays, though they are often faint. The beak is low, and barely extends beyond the hinge. The teeth are small. The nacre is usually bluish white sometimes with a pink tint.

Host Fish include the blackspotted topminnow, the green sunfish, and the redeye, spotted, and largemouth bass.

Habitat: The fine-lined pocketbook is usually found in shallow, fast water, and in muddy sand often with some gravel.

Distribution: The fine-lined pocketbook ranges across Alabama (excluding the southeast corner of the state).

A single fine-lined pocketbook fresh dead shell was found at site 16 during this survey.

The fine-lined pocketbook is a federally threatened species.

Lampsilis ornata
Southern Pocketbook



Description: The southern pocketbook has an inflated shell with a high posterior ridge. The periostracum is a greenish yellow or tan, and some have rays. The beak is high, extending beyond the hinge. The teeth are fairly thin, and the nacre is white, sometimes with a blue tint.

Host Fish for the southern pocketbook include the largemouth bass.

Habitat: This mussel is usually found in shallow water with a moderate current. It typically resides in a mixture of mud, sand, and gravel.

Distribution: The southern pocketbook occurs across Alabama, into western Georgia and eastern Mississippi.

This mussel was found at sites 15 and 16 on the Cahaba River during this survey.

Lampsilis teres
Yellow Sandshell



Description: The yellow sandshell is smooth, elongated, and moderately thick shelled. Yellow sandshells are often rayed and are yellow, greenish-yellow, or dark yellow. The inside of the shell is white. The mussel has long thin lateral teeth, and fairly well pronounced pseudocardinal teeth. The beak is not high, and extends just above the hinge. The mussel can reach up to six inches in length.

Host Fish include the alligator, the longnose, and shortnose gar, the greenthroat darter, the warmouth, the bluegill, the largemouth bass, the yellow perch, the white and black crappie, the roach, the shovelnose sturgeon, and the redbreast, green, and orangespotted sunfish.

Habitat: The yellow sandshell is found in slow to fast moving water in rivers, streams, creeks, and sometimes lakes and oxbows. Yellow sandshells are typically found in sand or fine gravel, but are not uncommon in muddy areas.

Distribution: The yellow sandshell ranges from central Texas to northern Florida and into Minnesota and Wisconsin.

The yellow sandshell was found only at site 15 during this survey, and was not abundant.

Lasmigona alabamensis
Alabama Heelsplitter



Description: This shell is flat and thin. The beak is not particularly tall, and the dorsal end is flat. The nacre is white, or an iridescent blue-white. The periostracum is green or greenish-brown in younger mussels, and brown to black in older ones. The Alabama heelsplitter can reach approximately eight inches in length.

Host Fish include the largemouth bass, the orangespotted sunfish, the green sunfish, the white crappie, the common carp, and the banded killfish.

Habitat: The Alabama heelsplitter is found in slow rivers or streams in areas with a mud, sand, or fine gravel bottom.

Distribution: A single live Alabama heelsplitter was found at site 15 during this survey.

Leptodea fragilis

Fragile Papershell



Description: The fragile papershell has, as its name suggests, a thin, fragile shell with a smooth and glossy periostracum. The shell is yellow, sometimes with green or brown rays. The beak of this mussel is even with the hinge, which includes small, delicate teeth. The nacre is usually light pink, and iridescent. The mussel can reach up to six inches in length once mature.

The fragile papershell is sometimes confused with the pink papershell (*Potamilus ohiensis*) because the shapes are similar, and both have thin shells. The pink papershell, however, has a high wing on the posterior end of the hinge. When the pink papershell is missing its wings, the two species can be differentiated by nacre color. The pink papershell usually has dark pink nacre, while the fragile papershell has light pink or white nacre.

The **Host Fish** is the freshwater drum.

Habitat: The fragile papershell requires a medium to fast current and typically resides in streams and rivers. Mud, sand, or gravel is a good substrate for the mussel. The fragile papershell often buries deep into the substrate.

Distribution: The fragile papershell ranges from the Gulf Coast north to Minnesota and east to New Hampshire.

Only one live mussel was found during this survey, at site 16, but dead shells were found at sites 15 and 17.

Megaloniaias nervosa

Washboard



This photograph depicts two washboards on the right, and, for comparison, a rock pocketbook on the left. Note the thick teeth of the washboard in comparison to those of the rock pocketbook.

Description: The washboard has a thick, heavy, dark brown shell. The beak does not extend past the hinge. The shell is extremely bumpy and has folds that extend from the beak to the posterior end. This mussel has dark brown or black periostracum, and white nacre with spots of purple or copper. The washboard is one of the larger mussels and can reach eleven inches in length.

The washboard resembles the threeridge (*Amblyma plicata*), but it can be differentiated by the presence of pustules usually on the beak. The threeridge lacks these pustules, and has a smooth beak. The washboard also looks similar to the rock pocketbook (*Arcidens confragosus*), but the washboard has thicker teeth.

Host Fish include the longnose gar, the bluegill, the longear sunfish, the largemouth bass, the logperch, the yellow perch, and the slenderhead darter.

Habitat: The washboard needs some current to survive and is found in large streams, rivers, and bayous. It lives in a mud, sand, or gravel substrate.

Distribution: The washboard can be found from Texas to western Florida and from the Gulf Coast to Canada.

Only two live washboard were found on the Cahaba River during this survey, both at site 15.

The washboard is a commercially valuable species.

Obliquaria reflexa

Threehorn Wartyback



Description: The threehorn wartyback has a fairly thick, rounded shell. The posterior end is pointed, and there are two or three distinct nodules in a row going down the center of the shell. In younger mussels, there may only be one or two nodules present. The rest of the shell is smooth. Threehorn wartybacks can range in color from yellow to green to light or dark brown. The beaks extend above the hinge line. The nacre is bright white, and the teeth are thick and well developed. The mussel reaches three inches in length.

Host Fish include the silverjaw minnow, the common shiner, and the longnose dace.

Habitat: The threehorn wartyback prefers rivers and streams with a considerable amount of flow and a sand or gravel bottom.

Distribution: The threehorn wartyback can be found from Texas to western Florida and from the Gulf Coast to Canada.

Only one dead shell was found on the Cahaba River during this survey at site 15.

Potamilus purpuratus
Bleufer



Description: The bleufer has a fairly thick, inflated shell, with a rounded anterior end. The periostracum can be dark brown, dark green, or black. The beak extends just above the hinge line, and the teeth, though thin, are well developed. The nacre is typically dark pink to dark purple in color. The bleufer is a fairly large mussel, and can reach up to eight inches in length.

Host Fish include the freshwater drum, the warmouth, and the golden shiner.

Habitat: Bleufers are typically found in large streams and rivers in a firm mud or mud and gravel substrate. The mussel is often difficult to remove from the substrate, as it buries itself deep into the mud and is able to hold on to the substrate with its extremely muscular foot.

Distribution: The bleufer is widespread in Mississippi and Louisiana, and is found in parts of Arkansas, Texas, Alabama, Missouri, Illinois, Tennessee, and Kentucky.

This mussel was common at sites 15, 16, and 17. It is reasonable to assume that bleufers occur in shoals and riffles all along the Cahaba River.

The shell of the bleufer is used in the jewelry industry.

Ptychobranchus greeni
Triangular Kidneyshell



Description: The triangular kidneyshell has an elongate, triangular shell. Adults grow to about three inches in length. The periostracum ranges from yellow to light brown, sometimes with rays. The beak is high, but does not extend beyond the hinge. The teeth are fairly thin. The nacre is white, often with a blue tint.

Host Fish include the blackbanded, warrior, redfin, river and tuskaloosa darters.

Habitat: The triangular kidneyshell is a shallow water species, usually found in strong to moderate current and a gravel and sand substrate.

Distribution: The range of the triangular kidneyshell extends through most of Alabama, eastern Mississippi, and northwest Georgia.

No kidneyshells were found during this survey, but they have been found in past surveys both above and below the Cahaba River Refuge.

The triangular kidneyshell is federally listed as endangered.

Quadrula asperata
Alabama Orb



Description: The Alabama orb's shell is thick, usually covered with small bumps on the posterior end. The periostracum is brown to yellow in color. Their beaks are high, and extend well past their hinges. The teeth are heavy, and the nacre is white, often iridescent. Mature Alabama orbs can grow to three inches.

Host Fish for the Alabama orb include the speckled madtom and the channel catfish.

Habitat: The Alabama orb is found in a variety of habitats, with current ranging from fast to slow. Mud, sand, or gravel is the preferred substrate of the Alabama orb.

Distribution: This mussel occurs in Gulf Coast drainages east of the Mississippi River and west of the Mobile basin.

The Alabama orb was found live in the Cahaba River only at site 15 during this survey.

Tritogonia verrucosa
Pistolgrip



The female pistolgrip can be distinguished from the male by the elongated posterior end. The males tend to have a less elongated posterior end. This is a *sexually dimorphic* species. In this photograph, the mussels to the far left and middle are females.

Description: This mussel has a thick, elongated, bumpy shell. The pustules on the posterior end of the mussel are larger and more pronounced, and the ventral edge has a sharp concave curve. The periostracum is brown, or black, and the nacre is bright white and often iridescent. The hinge of the pistolgrip consists of large teeth, and the beak extends just over the hinge. The mussel can reach eight inches in length.

The pistolgrip is sometimes confused with the bankclimber (*Plectomerus dombeyanus*), but can be differentiated by the deep sulcus of the pistolgrip, and the more rounded dorsal end. This mussel's bright white nacre contrasts with the dark purple nacre of the bankclimber. The pistolgrip also lacks the high posterior ridge of the bankclimber.

Host Fish include the yellow and brown bullheads and the flathead catfish.

Habitat: The pistolgrip occurs in moving water and is found in creeks, streams, and rivers with fast to medium currents. Pistolgrips are found in mud, sand, or gravel.

Distribution: The pistolgrip is found from the Texas, Louisiana, Mississippi, and Alabama Gulf Coast north into Minnesota, Wisconsin, Michigan, and Pennsylvania.

Only a few dead pistolgrip shells were found on the Cahaba River during this survey, at site 15.

Villosa lienosa
Little Spectaclecase



Description: The little spectaclecase has a thin shell, which grows to about three inches in length. While both males and females are inflated, the females are much more so. The periostracum ranges in color from dark yellow to green to brown, often with very faint rays. The beak is broad, but low, extending just beyond the hinge line. The teeth are thin and small. The nacre can be white, pink, or even deep purple.

Host Fish for this mussel are unknown.

Habitat: The little spectaclecase occurs in the slow moving water of shallow creeks and small rivers. This mussel is usually found in a mud substrate.

Distribution: The Little Spectaclecase is found throughout the Gulf Coast region, and north to Missouri, Illinois, Indiana, and Ohio.

The little spectaclecase was not found during this survey, but has been found during previous surveys of the Cahaba River.

Villosa vibex
Southern Rainbow



Description: The southern rainbow has a fairly thin shell with rounded posterior and anterior ends. Adults have been known to reach four inches in length. The periostracum varies from brown to greenish yellow, sometimes with green rays. The beak reaches just beyond the hinge. The teeth are long and fairly thin. The nacre is white with a blue tint, often iridescent.

Host Fish for the southern rainbow include the blackspotted topminnow, the green and longear sunfish, and the redeye, spotted, and largemouth bass.

Habitat: The southern rainbow is found in shallow water with moderate current, usually in mud or soft sand.

Distribution: The southern rainbow is found in Mississippi, Alabama, Georgia, Florida, and South Carolina.

The southern rainbow was found during this survey at site 15.

Corbicula fluminea
Asian Clam



Asian clams are an introduced species. They are known to form dense single species beds containing thousands of mussels per square meter.

Description: The Asian clam is small with a slightly rounded or triangular shape. The beak is high and located in the center of the shell. The periostracum is yellow to brown or black. The teeth are small, and the nacre is white, purple, or pink. The mussel only reaches about 1 ½ inches.

The glochidia of the Asian clam go through a planktonic stage rather than a parasitic phase. Therefore, these mussels do not require a host fish. Also, the Asian clam is a hermaphrodite, and is capable of self fertilization.

Habitat: The Asian clam resides in rivers, streams, creeks, lakes, ponds, sloughs, and oxbows and can live in silt, sand, mud, or gravel.

Distribution: The Asian Clam is native to Asia, but can now be found in rivers, streams, lakes, ponds, etc. throughout the continental United States.

This introduced species is very abundant throughout the Cahaba River.

References

- Cummings, K. S., and C. A. Mayer. 1992. *Field Guide to Freshwater Mussels of the Midwest*. Illinois Natural History Survey Manual 5.
- Hartfield, P. 1987. Status of Selected Freshwater Mussels [Unionidae] in Mississippi. *Journal of the Mississippi Academy of Sciences*. 32:133-141.
- McGregor S. W., O'Neil, P. E., and Pierson, J. M., 2000, Status of the freshwater mussel (Bivalvia: Unionidae) fauna in the Cahaba River system, Alabama: Walkerana, v. 11, no. 26, p. 215-239.
- Parmalee, P. W., and A. E. Bogan. 1998. *The Freshwater Mussels of Tennessee*. University of Tennessee Press. Knoxville.
- van der Shalie, H. 1970. Hermaphroditism among North American freshwater mussels. *Malacologia* 10(1):93-112.

http://bioweb.uwlax.edu/zoolab/Table_of_Contents/Lab-5b/Mussel_Mount/mussel_mount.htm

<http://www.dcnr.state.al.us/agfd/mussel.html>

<http://www.uvm.edu/~pass/tignor/mussels/>

<http://news.fws.gov/mussels.html>

<http://members.aol.com/mkohl1/FWshells.html>

<http://www.museum.state.il.us/RiverWeb/harvesting/harvest/mussels/>

<http://dnr.state.il.us/lands/education/mussels/anatomy.htm>

<http://www.nps.gov/miss/features/mussels/aboutmussel.html>

<http://fly.hiwaay.net/~dwills/nasc.html>

http://outdoorplace.org/shells/local_shells.html

http://www.umesc.usgs.gov/reports_publications/psrs/psr_2000_04.html

http://www.inhs.uiuc.edu/chf/pub/mussel_man/cover.html

<http://courses.smsu.edu/mcb095f/gallery/Default.htm>

For host fish information, go to:

<http://ellipse.inhs.uiuc.edu/fmcs/>

Appendix I:
12-16 July 2004
Cahaba River National Wildlife Refuge
Mussel Survey Sites and Species Collected

Survey Sites

- 15CR: Cahaba River (Bibb Co., AL)
July 12, July 13, and July 15, 2004
First shoal below Piper Bridge (0.7 miles below)
Shallow water with moderate to fast current; vegetated; bedrock bottom with areas of sand; mussels found under and between rocks; snails abundant on tops of rocks and under rocks.
- 16CR: Cahaba River (Bibb Co., AL)
July 13 and July 15, 2004
Second shoal below Piper Bridge (1.7 mile below)
Shallow water with moderate to fast current; vegetated; bedrock bottom with sand and smaller rocks; mussels found under and between rocks; snails abundant on tops of rocks and under rocks.
- 17CR: Cahaba River (Bibb Co., AL)
July 16, 2004
Third shoal below Piper Bridge; first shoal below Caffee Creek.
Fast current; bedrock bottom with little sand; shallow water; few mussels.
- 18CR: Caffee Creek (Bibb Co., AL)
July 16, 2004
Rocky, sandy bottom; moderate current; vegetated; snails abundant on tops of rocks.

Mussel and Snail Species Collected 12-15 July 2004 CAHABA RIVER NWR

<u>Scientific Name</u>	<u>Site</u>
Mussels	
<i>Amblema plicata</i>	15, 16
<i>Eliptio arctata</i>	15, 16
<i>Eliptio crassidens</i>	15, 16, 17
<i>Fusconaia cerina</i>	15, 16
<i>Lampsilis altilis</i> (Threatened)	16
<i>Lampsilis ornata</i>	15, 16
<i>Lampsilis teres</i>	15
<i>Lasmigonia complanata alabamensis</i>	15
<i>Leptodea fragilis</i>	15, 16, 17
<i>Megaloniaias nervosa</i>	15
<i>Obliquaria reflexa</i>	15
<i>Potamilus purpuratus</i>	15, 16, 17
<i>Ptychobranchus greeni</i> (Endangered)	Not found
<i>Quadrula asperata</i>	15
<i>Tritigonia verucosa</i>	15
<i>Villosa vibex</i>	15
<i>Corbicula fluminea</i>	15, 16, 17, 18
Snails	
<i>Elimia ampla</i>	15
<i>Elimia annettae</i>	15, 16
<i>Elimia clara</i>	15, 16
<i>Elimia cahawbensis</i>	18
<i>Elimia showalteri</i>	15, 16
<i>Leptoxis ampla</i> (Threatened)	15, 16
<i>Lepyrium showalteri</i> (Endangered)	Not found
<i>Lioplax cyclostomaformis</i> (Endangered)	15, 16
<i>Pleurocera prasinata</i>	15, 16

(Italics indicates that only dead shells were found at these sites)

Bold indicates Federally listed species (status)

Appendix II:
Endangered and Threatened Snails of the Cahaba River Refuge

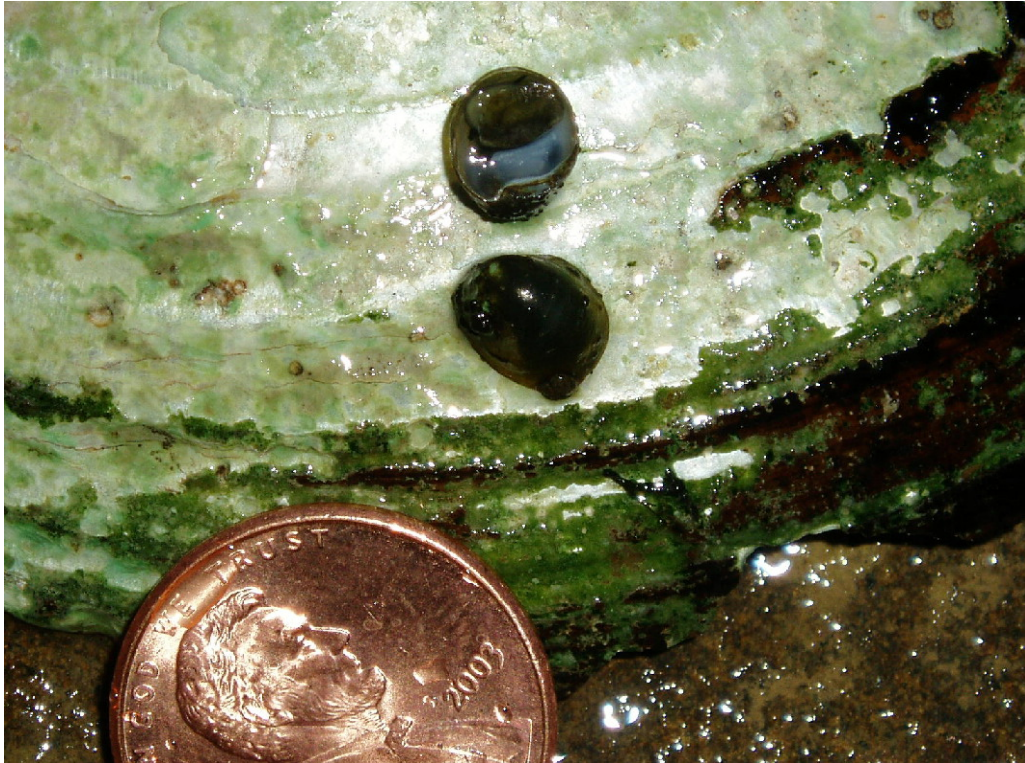
Lioplax cyclostomaformis
Cylindrical lioplax



Endangered

The cylindrical lioplax is found in the Lily Shoals in sandy mud under large rocks in rapid currents. It is uncommon, requiring some effort and time to find.

Lepyrium showalteri
Flat Pebblesnail



Endangered

The flat pebblesnail is found attached to clean, smooth stones in rapid currents of the shoals. Only a few individuals have been found on the refuge.

Leptoxis ampla
Round Rocksnail



Threatened

Round rocksnails are attached to cobble, gravel, or other hard substrates in the strong currents of the shoals. It is the most abundant species found in the shoals.