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EXPERT REVIEWED

Publication 420-523

Sustaining America's Aquatic Biodiversity
Freshwater Mussel Biodiversity and Conservation

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Nearly 300 species of mussels inhabit fresh-water rivers, streams, and lakes in the United States. This is the richest diversity of mussels found in the world and an extraordinary natural heritage that needs protection. Because of the lustrous, pearl-like interior of the shells, some of these pearly mussels have important commercial value in the cultured pearl and jewelry industry. Our pearly mussels are of unique ecological value as natural biological filters, food for fish and wildlife, and indicators of good water quality.

The abundance and variety of mussels have declined sharply over the past century. At the turn of the twentieth century, the shallow, swift-flowing shoal areas of many of the streams and rivers within the Ohio River basin were filled with millions of living mussels. Today, many of these areas harbor only remnant populations of mussels. Dam construction, siltation, water pollution, mining and industrial wastes, and the introduction of exotic shellfish seriously threaten their continued existence. At present, 38 mussel species are presumed extinct, 120 are listed as endangered or threatened, and 72 are considered to be of special conservation concern. No other widespread animal group in North America has been jeopardized to this extent.

Conservation and recovery projects to artificially culture, reintroduce, and improve the habitats of pearly mussels are underway. However, water pollution continues to threaten streams crucial to their survival. Your help is needed to support mussel conservation efforts and safeguard their habitats. Why not adopt a local stream and clean it up? Also, promptly report water pollution problems to the natural resources agency in your state.

Introduction

This publication will provide you with a brief look at freshwater mussels—what they look like, where they live, what they eat, why they are valuable, how they are used, why some are in trouble, and how to protect these simple, but important, aquatic animals.

What Is a Mussel?

Submerged below clear, clean waters on the bottoms of streams, rivers, lakes, and ponds throughout the United States is a little-known but important group of aquatic animals called freshwater mussels. Mussels belong to a larger group of animals with shells called mollusks.

Freshwater mussels are similar in appearance to their saltwater cousins—the oysters and clams—from which they originated. They have adapted completely to freshwater and now are widespread in the rivers, streams, lakes, and ponds of North America. Freshwater clams, such as the small fingernail clam, also live in the freshwaters of the United States.

The freshwater mussels inhabiting our rivers sport colorful common names, based largely on their shell appearance, such as the monkeyface, shiny pigtoe, elephantear, pink heelsplitter, rabbitsfoot, purple wartyback, and black sandshell.

Structure and appearance

A mussel is a simple, soft-bodied animal enclosed by two shells (hence bivalves or shellfish) connected by a ligament. The shells are formed out of dissolved minerals, largely calcium carbonate (limestone),

extracted from their watery environment and secreted in successive layers in the shell. The shell provides some protection from predators such as muskrats, raccoons, herons, and fish.

The size, shape, color, and markings on the shell are used by biologists to identify the numerous species. Shell surfaces (periostracum) vary in color from yellow or green to brown or black; they also may contain distinctive ridges, rays, bumps, and textures. Many species have colored rays or chevron marks on their shells. The interior of the shell is composed of a pearly nacre that varies in color from pure white to shades of pink, salmon, gray, and purple. Males and females sometimes can be distinguished by their shell size and shape.

Internally, the soft body consists of gills for breathing, a digestive tract for processing food, a large muscular foot for locomotion, and mantle tissue that produces the shell. The enlarged gills of a gravid (pregnant) female act as a brood pouch or nursery for developing young before they are released into the water.

How do they reproduce?

The freshwater mussel has a unique life cycle that includes a short parasitic stage attached to fish. The life of a mussel can be partitioned into five distinct life stages:

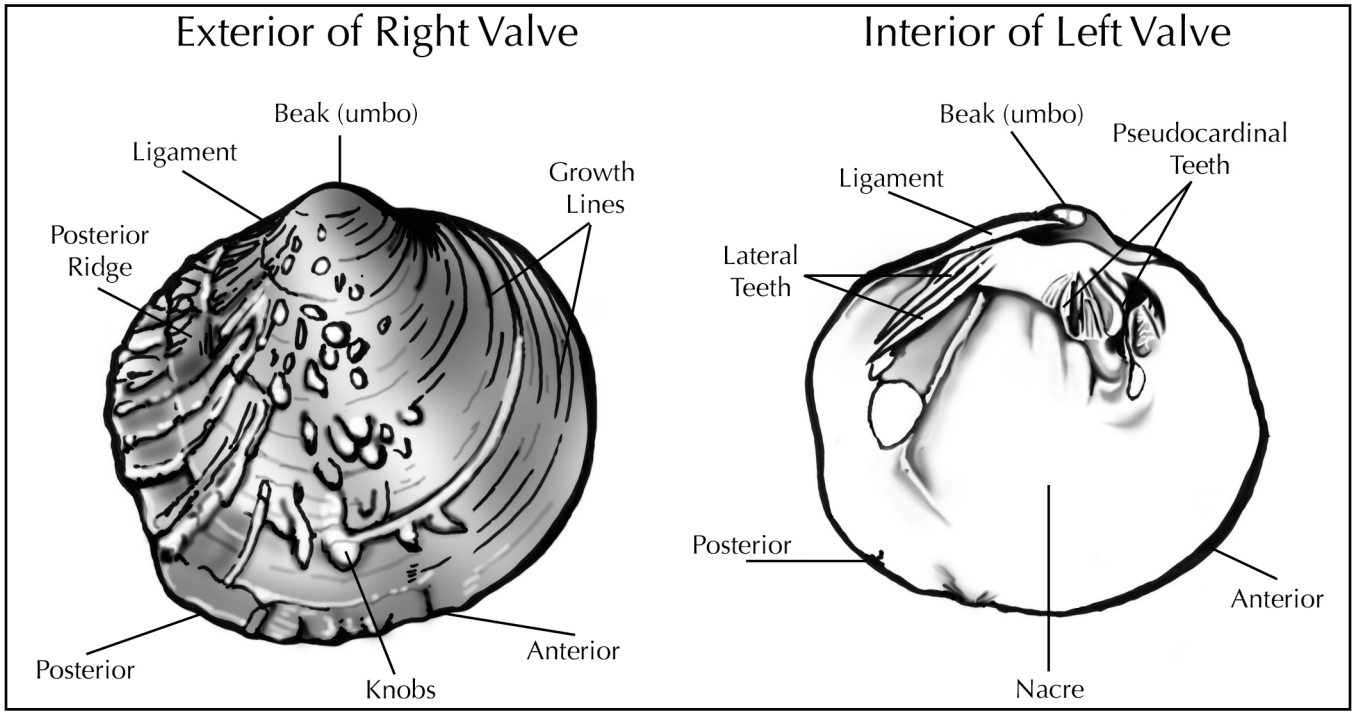
- a larva (called glochidium, plural glochidia) developing in the gill of a female mussel,
- a free-drifting glochidium expelled from the female mussel,
- a parasitic glochidium attached to the gills or fins of a living host fish,
- a free-living juvenile mussel, and
- an adult mussel.

Reproduction occurs when the male mussel releases sperm into the water column from which they are siphoned into the female mussel to fertilize the eggs. Reproduction may be triggered by increasing water temperatures and day length. Development and retention of larvae (smaller than a pinhead in size) within the female may last from one to ten months.

Glochidia generally are released from the female in spring and early summer (April to July). These tiny creatures drift in the water current seeking a suitable fish host. Timing is critical for these larvae, for they cannot survive long outside of the female mussel without a host fish.

Unlike oysters and clams, freshwater mussels require a fish host in order to complete their life cycle. As parasites, glochidia are dependent on fish for their nutrition at this part of their life. Some mussels may depend on a single fish species, whereas others can parasitize many different fishes. The attachment of glochidia causes no problems for the host fish. If they find a host fish, they clamp onto the gills or fins and remain attached for one to four weeks while transforming into juvenile mussels. As juveniles, they drop off the fish and begin their free-living life.

If glochidia do not find a suitable fish host within a few days of drifting in the water column, they die. To help ensure that they find a host fish, some species of mussels have developed special adaptations. Some



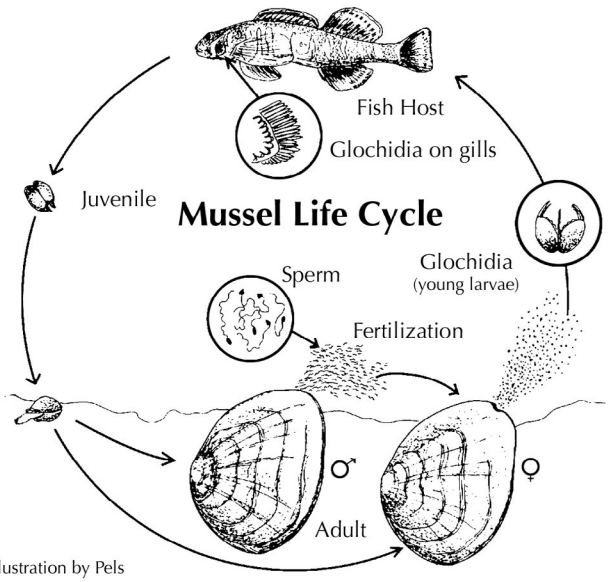


Illustration by Pels

adult female mussels have enlarged mantle tissue called mantle flaps that look like prey (worms, insect larva, or small fish) to attract a fish looking for food. When fish nip at these structures, resembling potential food items, the female releases glochidia into the water column and they clamp onto the gills or fins of the host fish.

What do they eat?

Mussels are filter feeders. Most mussels consume a variety of microscopic particles (e.g., algae, bacteria, and organic particles) suspended in the water column. They feed by taking in water through an incurrent siphon and passing it over their mucous-covered gills where small food items are collected and then transferred to the mouth. Unpalatable items and waste particles are flushed out through an excurrent siphon. By filtering out suspended particles, including impurities, mussels improve water quality and cleanse lakes and streams.

How long do they live?

Mussels can live to a ripe old age, but they grow rather slowly. Age and growth of individual mussels can be determined by microscopic examination of annual growth rings laid down on the shell, similar to the growth rings on tree trunks. As the mussel grows, the shell increases in thickness and length. Young mussels grow much more quickly than older ones. Depending on the species, mussels can live nearly as long as humans—60 years or more. Large species, like the washboard mussel, can weigh as much as 4 pounds and measure nearly 12 inches in length.

Distribution and Diversity

Freshwater mussels live on the bottoms of lakes and streams throughout the world. About 1,000 species have been identified worldwide, and 300 (nearly 30 percent) of these occur in North America. Early pioneers to this continent were surprised by the richness of mussel species. Individual rivers contained more than five times the number of mussel species as found in all of Europe. Considering the fact that fewer than 20 mussel species are found in most other countries of the world, our streams are truly "mussel rich."

The Ohio River basin

Rivers and streams of the Ohio River basin (which includes streams in Virginia, Tennessee, West Virginia, Pennsylvania, Ohio, Indiana, Illinois, New York, North Carolina, Georgia, Mississippi, Kentucky, and Alabama) are inhabited by the richest and most diverse assemblage of freshwater mussel species found anywhere on earth. The Ohio River basin supports an extraordinary variety of these shellfish, nearly 127 different species, or 42 percent of the 300 species found in North America. This includes 21 species that have become extinct since 1850, and 46 other species that are classified as endangered, threatened, or species of concern. Some species are reduced to a single population, and others may no longer be breeding.

The major rivers of the Ohio River basin include the Ohio, Tennessee, Cumberland, Kentucky, Allegheny, Monogahela, Scioto, Wabash, Big Sandy, and Kanawha. The United States is a "mussel treasure chest," considered by malacologists (shellfish experts) to be the finest remaining stronghold for freshwater mussels on the planet. These animals can occur in abundance in certain areas called "mussel beds," which may contain more than 20 mussels per square foot of stream bottom.

Where are they found?

Mussels lead a passive life. They lie burrowed in the sand and gravel substrates of streams and lakes, usually leaving only a small part of their shells and siphons exposed. Mussels move slowly by extending and contracting the foot, and only for short distances during their lifetime. If disturbed by flooding, drought, poor water quality, or predators, they move. Their footprints or tracks appear as furrows in soft mud or sand along the margins of shallow streams or in lake bottoms.

Mussels typically inhabit unpolluted, standing or flowing waters that are rich in oxygen, calcium, and suspended food particles. Most commonly, they are

found in large river systems like the Tennessee, Ohio, and Mississippi, but they also occur in medium-sized and small streams that have suitable water quality, bottom substrate, and food. Certain species of mussels have adapted to living in standing water (e.g., lakes, ponds, and reservoirs), but most are suited to living in rivers and streams where water currents supply abundant oxygen and suspended food particles favorable for growth and reproduction.

What Good Are They?

Historically, freshwater mussels provided food for early man and Native Americans, but their relative tastelessness and rubbery consistency did not make them a preferred food like their saltwater counterparts, oysters and clams. Mussel shells were used for jewelry, for making pottery and utensils, as currency, and for trading by certain Native American tribes.

Today, mussels are not recommended as food for humans or domestic animals because they accumulate and store toxic metals and other water pollutants in their tissues. Although they provide an important service to us, mussels from polluted waters could pose a health risk if consumed.

Pearl buttons

After the turn of the last century (the early 1900s), millions of mussels were harvested from rivers in North America to make pearl buttons out of the shells. Because of their color and luster, pearl buttons became widely popular in the clothing industry, which supported a thriving industry to harvest mussels. In 1912, nearly 200 factories were manufacturing buttons by grinding and polishing the circular blanks cut from the shells with a saw or drill.

Thousands of tons of mussels were gathered by mussel hunters, loaded on barges, and transported to button factories conveniently located along major rivers. With the advent of cheaper and more durable plastic buttons, the mussel mother-of-pearl button industry died. However, since the late 1950s mussel shells are again in demand—to supply the Japanese cultured pearl industry.

Mussels are harvested in a number of ways. Many harvesters still collect mussels by fishing for them with metal bead-tipped hooks attached to wires on a metal bar that is lowered to the river bottom by a rope. Using this old technique, called brailing, the hooks are dragged along the bottom until they contact an open mussel which promptly "hooks itself" by closing securely on the hook. Periodically, the brail is lifted to the water surface, and all the hooked mussels are removed. Some mussel harvesters simply hand-pick mussels from shallow waters in river shoals or lake bays as they wade, snorkel, or dive using scuba gear. The commercial harvest of freshwater mussels provides jobs for many people living along these rivers.

Today in the United States, wild mussels can still be harvested for their shells in some states; however, many states forbid the commercial harvest of freshwater mussels. Each year thousands of tons of live mussels are taken from our river bottoms and steamed open to remove the meat, and the shells are sacked for export to other countries, including Japan, for the cultured pearl industry.

Cultured pearl industry

Pearls are concretions—layers of calcium carbonate and organic materials created by both freshwater and saltwater shellfish (e.g., mussels and oysters). Pearls come in a variety of shapes, sizes, and colors. Natural pearls are rare, usually misshapen, and not as widely desirable as the high-luster, spherical cultured pearls. The largest natural pearl found in a freshwater mussel came from the Arkansas River, was 20 mm (4/5 inch), in diameter and sold for about $3,000.

Cultured (manmade) pearls are formed by shellfish, as are natural pearls. However, the difference is that they are created by "implanting" a small bead into a live oyster or mussel and waiting (sometimes for as long as seven years) for the animal to cover this bead with nacre. Because of their large size, spherical shape, color, and high demand, cultured pearls are sold worldwide. Globally, the production of cultured pearls has become a multi-billion dollar industry.

In Japan, the shells of our freshwater mussels are cut and ground into small round beads which are inserted into live Japanese pearl oysters suspended in saltwater embayments. The pellet irritates the oyster, causing it to secrete a mother-of-pearl layer (nacre) over the circular bead, thereby soothing the irritation and creating a cultured pearl.

Pearls, then, are the product of a shellfish self-defense system that either expels the foreign bead particle or coats it with nacre. In this manner, shell from an American mussel forms the center of nearly every Japanese cultured pearl.

Ecological Value

Although mussels have little value as human food, they hold immense ecological value. As a vital link in the food chain, they are a major food item for valuable wildlife such as muskrats, otters, and raccoons. Young mussels are eaten by ducks, herons, and sport fish. As important natural filterers in the riverbed, they improve water quality by straining out suspended particles and pollutants. Large mussels can filter several gallons of water in a day, and they help to remove and store contaminants, making the water more fit for human uses. Because of their filtering capacity, mussels are an integral part of the natural purification process in rivers and lakes. They are particularly useful in removing algae and suspended particles from turbid and organically enriched waters near wastewater facilities and in fish farm effluents.

Mussels have great scientific value as indicators of environmental health. They are used by biologists as "biological monitors" to indicate past and present water quality conditions in rivers and lakes. A sudden kill of freshwater mussels is a reliable indicator of toxic contamination in flowing and standing waters. The gradual disappearance of freshwater mussels usually indicates chronic water pollution problems. Moreover, biologists can measure the amount of pollutants found in mussel tissue to determine the type and extent of water pollution in streams and lakes. Biomedical uses of mussels are presently being studied. Evidence from cancer research suggests that some mussels may be resistant to certain types of cancer and that the extraction of cancer-curing drugs from mollusks may be feasible in the future.

Mussel Killers

The sharp decline in the numbers and diversity of mussels in the rivers, streams, and reservoirs of the Ohio River basin is attributed to a variety of human disturbances. Major factors contributing to the loss of mussel species and the degradation of their habitat include:

- dams and impoundments;
- channelization and dredging;
- water pollution, especially spills of toxic wastes (e.g., oil and petroleum products, industrial acids, pesticides, and fertilizers);
- sedimentation from agricultural land, construction projects, and logging and mining operations;
- fish kills that eliminate host fish for mussel glochidia; and
- introduction of invasive species, especially the Asian clam and the zebra mussel.

Disease and overharvesting by commercial shellers are only minor contributing factors to the mussel decline. In the future, competition with the invasive zebra mussel, accidently introduced to waters of the United States from Europe, will cause further declines of our native mussels. Many of these threats, acting singly or in combination, have resulted in the significant depletion of freshwater mussel populations nationally.

Dams and dredging

As dams transformed rivers and streams into lakes and reservoirs, the accompanying changes of increased water depths, reduced water currents and temperatures, and restructured algal and fish communities negatively impacted mussels. These habitat changes generally are not favorable to most mussel species that inhabit free-flowing rivers. Most cannot adapt to the alien environment and the loss of fish hosts that accompany dam construction. Dams are effective barriers to fish and mussel migration; they isolate upstream communities from those downstream.

Mussels are directly killed when they are crushed or removed from the stream channel, as happens when dredging for stream gravel and sand or channeling to straighten streams occur. Mussels are indirectly destroyed when their stream-bottom habitat is removed or altered. All stream and river bottoms in many states are public property. Dam building, gravel dredging, stream channeling, wetland filling, and other alterations to rivers or streams require permits from the U.S. Army Corps of Engineers and other federal and state agencies.

Water pollution

The contamination of rivers and streams with toxic chemicals is a serious and growing problem for adult and young mussels and their host fish. Deadly chemicals, including heavy metals (e.g., copper and mercury), coal-mine acids, pesticides, chlorine, gasoline, and oil, flushed daily into tributary streams of the Ohio River system, threaten mussels and other aquatic animals.

Although adult mussels have the ability to "clam up" for a limited time and avoid poisonous chemicals

that flow downstream, young mussels are often killed immediately. Multiple spills or the long-term, chronic leaching of toxins into streams will eventually kill the entire population. Water pollution is "double trouble" for mussels. It can either kill mussels directly or kill the fish hosts on which they depend for successful reproduction, ultimately eliminating the mussels.

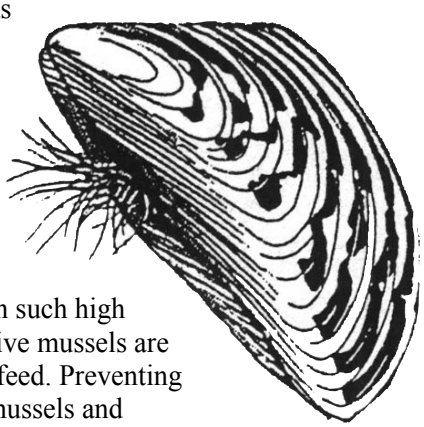
Loss of host fish

The successful reproduction of freshwater mussels is dependent on an abundance of the right species of host fish. Young freshwater mussels are parasitic on fish during their early life stage (glochidia stage). To obtain nourishment (from fish blood) for survival, glochidia must find and clamp onto the gills or fins of the right species of fish. If the right species of fish is not present in sufficient abundance at the proper time (spawning season) and place (mussel beds) in the river, then reproductive success will be low.

Because of this strong mussel/fish interdependence, any threat to host fish also jeopardizes mussel survival. If suitable host fish disappear, due to fish community changes, fish migration blockades such as dams, water pollution, or other causes, mussel populations cannot survive in the long term. If fish are killed by water pollution, even though mussels may survive by "clamming up," no mussel reproduction will occur in the absence of host fish. If the host fish population becomes too small, it could endanger mussel reproduction. In streams with few or no host fish, it may be necessary to restock suitable hosts to promote mussel reproduction.

Aquatic invasive animals

The introduction of aquatic invasive animals from Europe, Asia, and elsewhere in the world into waters in the United States poses a great threat to our native mussels. The zebra mussel is a small shellfish native to Europe that has invaded our Great Lakes and is spreading rapidly throughout the United States. Zebra mussels are voracious feeders and reproduce quickly, outcompeting our native mussels for food and space. They also attach themselves to the shells of our freshwater mussels in such high densities that the native mussels are unable to breathe or feed. Preventing the spread of zebra mussels and preventing the introduction of other invasive animals is essential for the survival of our native mussels.



What Can You Do?

The involvement of concerned local people, youth and adults, is critical to protecting rivers and streams with freshwater mussels. Water laws help, but pollution control agencies often do not have sufficient personnel or funding to locate and stop water polluters. It is up to the public to keep watch on their local streams, identify problems, and report suspected water pollution to the authorities. Be aware of changing water- and land-use practices near your local rivers and streams, especially farming, grazing, mining, irrigation, industry discharge, and sewage disposal activities. Participate in the review of plans for erosion control at stream-side construction sites for housing developments, bridges, and roads.

Be alert to the following symptoms of water pollution:

- muddy water,
- oil slicks,
- fish and mussel kills,
- algae and weed problems,
- odor and gas,
- unusual flows,
- discolored water,
- foaming water, and
- litter.

Organize or join a local "river watchers" group to keep an eye on your streams and conduct stream improvement projects. If we help mussel populations to remain healthy and abundant, then we help ourselves by maintaining clean, fresh water for human consumption and recreation.

Mussel Websites

- America's Freshwater Mussels Are Going Extinct—Here's Why That Sucks: https://blogs.scientificamerican.com/extinction-countdown/americas-freshwater-mussels-are-going-extinct-heres-why-that-sucks/.
- Freshwater Mussels, Virginia Department of Wildlife Resources: https://dwr.virginia.gov/wildlife/freshwater-mussels/.
- U. S. Fish and Wildlife Service, Listed U.S. Species by Taxonomic Group - Clams: https://ecos.fws.gov/ecp/report/species-listings-by-tax-group?statusCategory=Listed&groupName=Clams&total=124.

- Freshwater Mollusk Conservation Center: https://www.mussellab.fishwild.vt.edu/mussel/index.html.
- Freshwater Mollusk Conservation Society: https://molluskconservation.org.

Acknowledgments

Earlier versions of this publication were reviewed and edited by Nancy Templeman (Virginia Cooperative Extension) and Michelle Davis (Virginia Tech Department of Fish and Wildlife Conservation.) Additional support was provided by Randy Rutan and Hilary Chapman, National Conservation Training Center, U.S. Fish and Wildlife Service. Virginia Master Naturalist volunteers Daphne Cole, Joella Killian, and Pat Klima edited and reviewed the current version.

Art illustrations by Sally Bensusen, Mark Chorba, and Karen Couch.

Reviewed by Michelle Prysby, Virginia Master Naturalist Program Director, Virginia Tech

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Produced by Virginia Cooperative Extension, Virginia Tech, 2025

VT/0525/420-523 (CNRE-193P)