



Regaining Our Freshwater Mussel Heritage



Biologists with the Virginia Department of Game and Inland Fisheries embark on a unique recovery program to reverse the decline of freshwater mussels in southwestern Virginia.

by Michael J. Pinder

Peering through the microscope, Virginia Department of Game and Inland Fisheries biologist assistant Joe Ferraro examines half-dozen larval freshwater mussels. Known as glochidia by biologists, each glochidium when magnified 200x can appear as a pair of castanets. When a salt grain is added to the sample, the glochidia, like little mousetraps, snap shut in rapid succession. Joe turns, and giving a look of eager anticipation remarks, "They're ready." Thus with such a seemingly small step begins the sizeable task of recovering Virginia's freshwater mussels.

Around the world, mussels live in a variety of freshwater habitats but are most prevalent in streams and

ivers. Similar to their marine clam and oyster cousins, freshwater mussels are bivalves and have two shells connected by a hinge-like ligament. Mussels vary in their adult sizes from species as small as a thumbnail to others as big as a pie plate. The wide variety of shapes and colors are reflected in species like purple

Dr. Richard Neves (right) and Steven Sklarew examine freshwater mussels collected from the Clinch River. Dr. Neves and his students at Virginia Tech have conducted research over the last 25 years to restore the unique species in the upper Tennessee River drainage of Virginia. Previous page: Biologists are using a new and innovative program of cultivating freshwater mussels to help increase their numbers and chances of survival.



Emily Pels

Michael J. Pinder

wartyback, pink heelsplitter, and three ridge just to name a few. On the stream bottom, mussels are often only noticeable by their two small siphons, which are used to draw and expel water. When quickly dislodged, a large muscular foot that is used to move amongst the stream gravel and pebble can be readily seen.

The life cycle of a freshwater mussel is one of the most complex and interesting in the animal world. Unlike other animals that can actively search for a mate, the sedentary mussel depends on the river current to reproduce. The process begins with the male releasing sperm, and the female located downstream, drawling it in through her incurrent siphon. Numbering in the 100s to 1000s the fertilized eggs develop into glochidia within her gills. Once mature, they are released into the water column to begin the second part of their lives—attaching to the gills, fins or scales of freshwater fishes. At this point, the process is further complicated because not only do glochidia have to find a fish, but it has to be one of several fish species for the life cycle to continue. If by chance a glochidium attaches to the correct fish species, it encysts into the fish's tissues and undergoes a short life as a parasite. Over several weeks, it begins to develop gills, a foot, and other internal structures to become a juvenile mussel. The now fully transformed, but still microscopic juvenile will drop off the fish and begin its life on the stream bottom. Unbeknownst to the fish, it has just served as a taxi transporting the young mussel into new habitat far away from its parent. If the mussel is lucky enough to grow into an adult, it may live 50-100 years or more depending on the species.

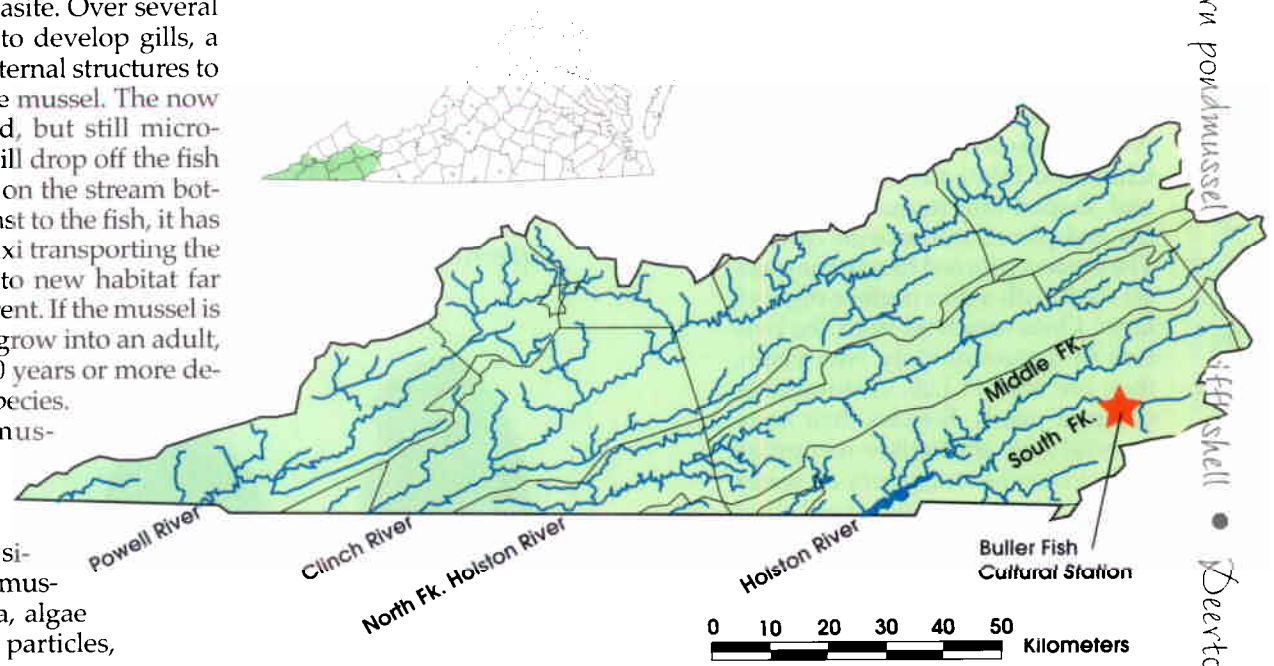
Freshwater mussels are an essential component of our rivers and streams. By their siphoning actions, mussels filter bacteria, algae and other small particles,



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which make them one of the few animals that improve water quality. Mussels also serve as a food source to many species of fish, reptiles, birds and mammals. Walking along the riverbank, piles of empty mussel shells called middens are clear evidence of a muskrat. The muskrat, using its hand-like paws, holds the mussel and carefully inserts its incisors between the shells. After the

Department biologist assistant Joe Ferraro begins the process of mussel cultivation by examining larval mussels, known as glochidia, under the microscope. Below: The Powell, Clinch, and tributaries (North, Middle, and South Forks) of the Holston River comprise the upper Tennessee drainage of Virginia. This drainage contains some of the highest mussel diversity in the U.S.



de pearl mussel • Eastern pond mussel • Haffshell • Deertoe

Water • Green blossom • Purple wartyback • Pistolgrip • Acornshell • Eastern lampmussel



Left to right: The mussel serves as an attachment area for aquatic plants and insects. Here a mussel, covered in aquatic vegetation, is only noticeable by a small slit on the river bottom. Even when dead, the remaining mussel shells serve as habitat for fish that use them for shelter and egg laying sites. Photos by Michael Pinder.

Below: Life cycle of a mussel (left to right). Sperm released by the male fertilizes the eggs of a female mussel. Young develop into larval mussels, called glochidia, in the gills of the female. Microscopic glochidia are released into the water and attach to the gills of a suitable host fish. Glochidia encyst into gill tissues and develop into juvenile mussels. After several weeks, mussels drop off the fish and begin life on the stream bottom. Illustration by Spike Knuth.

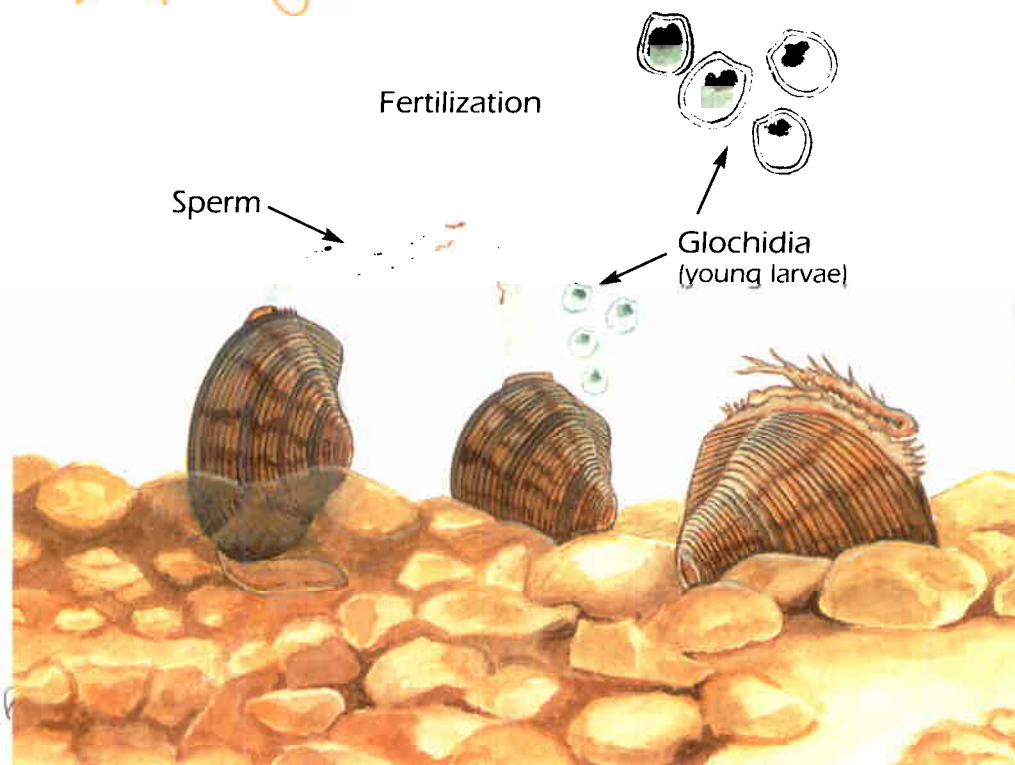
mussel is opened and eaten, the shell is discarded into a pile with others from previous meals. In addition to functioning as a food source, mussels serve as habitat for many organisms. The outer shell of a live mussel is usually covered by aquatic insects, algae and plants. Even when the mussel is dead, the empty shell functions as an egg laying site for fish like madtoms and darters.

People have a long history of benefiting from mussels. Native Americans used mussels as a ready food source, implements for tools, and as jewelry. Before the advent of plastics in the 1930s, most buttons were made from freshwater mussels. Modern day buttons retain the luster of those found from earlier times. Today, freshwater mussels are a key ingredient in the pearl industry. Mussels are collected in several areas of the United States and sold to Asian markets. In the pearl farms of China and Tahiti, these shells are cut and shaped into round pearl replicas and placed into marine oysters. The oysters proceed to coat the mussel shell with a thin mother-of-pearl layer. Once removed from the oysters in approximately two years, they are sold to U.S. customers as cultured pearls. Besides their commercial use, biologists recognize their value as indicators of water quality. Since mussels spend their entire lives in the water, they are a useful tool in gauging the long-term health of our rivers and streams. A person can be assured that a river

containing an abundant and diverse mussel fauna has good water quality and is a safe area to fish, swim and enjoy.

The diversity of freshwater mussels in the United States is unmatched by any other place on Earth. Of the estimated 1,000 species worldwide, the U.S. historically contained 297, about one-third of the total world's fauna. In comparison to other countries and continents like Africa with 96 species, China with 60 species, and Europe with a paltry 12

Mussel Life Cycle



Carolina lance • Rough pigtoe • Flat acornshell • River herring • Pearlfishing mussel • Darter

face • Tennessee heelsplitter •

vel • Atlantic pigtoe • Fragile • shell • Snuffbox • Oyster mussel

species, the wealth of the U.S. becomes truly impressive. The lion's share of this diversity is found in the southeastern drainages of the Ohio, Tennessee, Cumberland and Mobile rivers. One of the most diverse drainages, the Tennessee River Basin contains 102 species nearly one-third of the country's fauna! Virginia becomes a part of the equation because the headwaters are within the southwestern region of the state. Virginia's portion of the Tennessee River drainage includes the Powell, Clinch and Forks of Holston (North, Middle and South) rivers. Within these rivers, there are over 45 mussel species, several of which are found nowhere else but the upper Tennessee drainage.

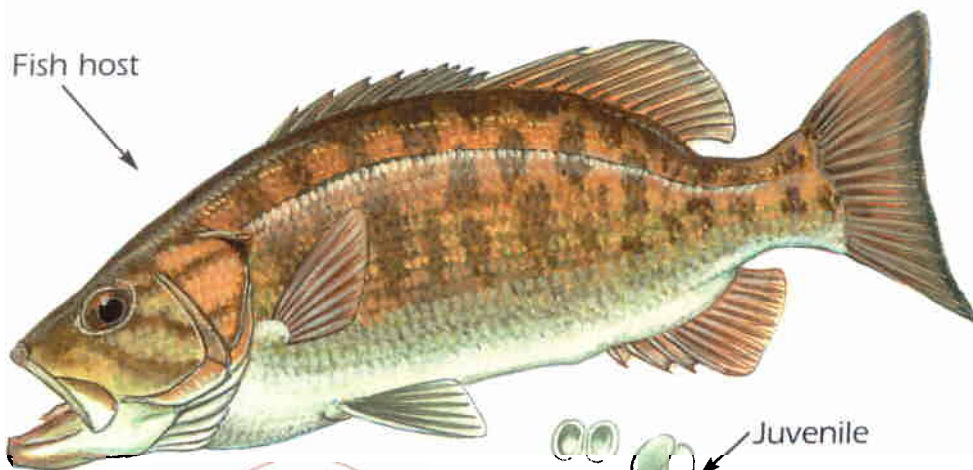
When settlers first arrived on these shores, they were astonished to discover river bottoms practically paved in freshwater mussels. Unfortunately, over the proceeding 400 years, water pollution, dams and in-

People have a long history of benefiting from freshwater mussels. Before the advent of plastics, freshwater mussels were commercially harvested to make buttons. Today, they are legally collected in other states for the cultured pearl industry. Photo by Dwight Dyke.

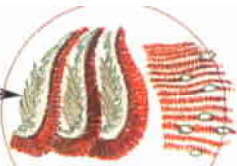
roduction of exotic organisms has taken its toll on many species. It is estimated that 70 percent of the mussel fauna in the U.S. is in peril. Over seven percent have gone extinct, and another 50 percent are receiving special protection under the U.S. Endangered Species Act. The situation does not get much better for Virginia. Of the 81 species in the Commonwealth, only 30 percent are considered stable with the remaining in decline. In Virginia's Tennessee drainage, 31 species are listed as either state or federally threatened and endangered. Certain species are so rare that completion of the life cycle is unlikely to occur under natural conditions. In fact, there are so many rare mussels in southwestern Virginia that it is illegal to collect any mussel species whether or not it is live, dead, common or endangered.

Alarmed by the decline of an entire group of animals, biologists realized that freshwater mussels needed urgent measures to recover their numbers. However, it was just as quickly realized that any effort to recover them was hampered by the lack of even the most basic biological and ecological information. In order to fill this void, Dr. Richard Neves has committed himself to discover-

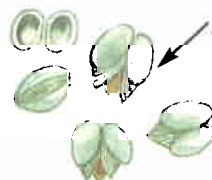
Fish host



Glochidia on gills



Juvenile



Finerayed pigtoe • Rayed bean • Flutedshell • Pimpleback • Brook floater • Kidneyshell • Pink

• Florida pondhorn • mucket

• Dromedary pearlymussel • Pheasantshell • Threeridge • Triangle floater • Pyramid pigtoe

• Spike • Purple lilliput • Yellow lampmussel • Rainbow • Northern lance • Ohio pigtoe • Green floater

1000 Species of

Freshwater Mussel Worldwide

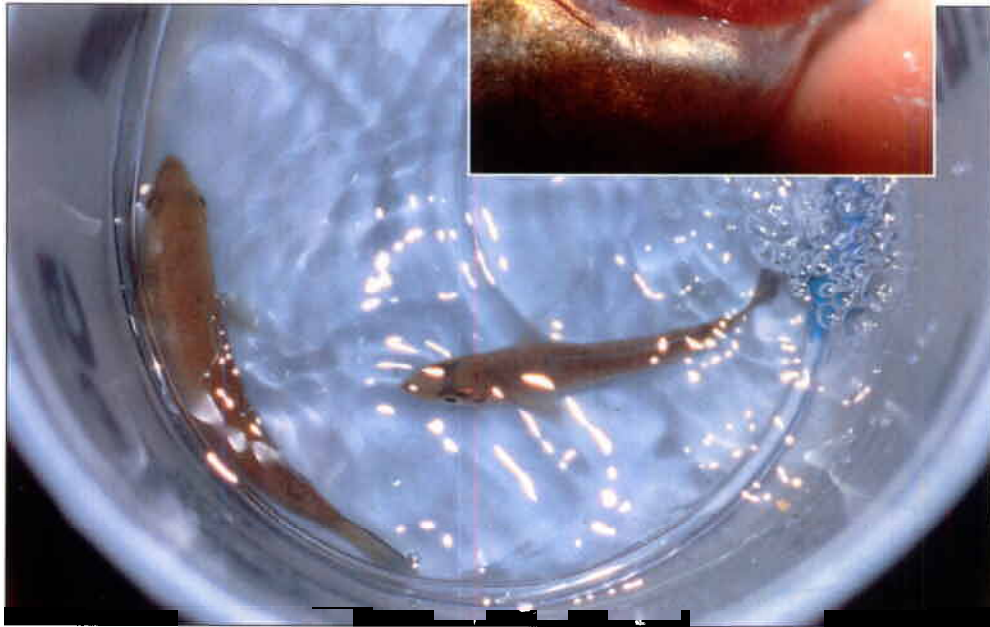


Above: Of the estimated 1,000 species of freshwater mussels found worldwide, an astonishing 297 species are historically identified to live here in the United States.

ing the secret lives of these unique animals for the past 25 years. Through funding provided in part by the Virginia Department of Game and Inland Fisheries, Dr. Neves and his students at Virginia Tech have investigated species status, host fishes, habitat use, genetics, diets, water quality requirements, reproductive strategies, and other topics too numerous to mention. The culmination of this research has led to the development of techniques to cultivate many mussel species. Through dedication and hard work, there is now hope that species on the brink of extinction can be captively-propagated to recover populations in the wild.

The cultivation of freshwater mussels allows biologists to increase the chances of survival at each step of their life cycle. The process begins with checking glochidia viability. A few glochidia are removed from the gill of a female mussel and salt grains, used to simulate the chloride found in fish blood, are placed alongside the larvae in a small water dish. Mature or viable glochidia rapidly close, while immature glochidia will react slowly or not at all. If the glochidia are determined to be vi-

Below: Fish are placed in a confined aerated container and glochidia are added. Fish are then examined to determine the proper level of infestation. Right: White specs representing hundreds of individual glochidia are attached to the gills of a smallmouth bass. Each glochidium will soon encyst into the gill tissues and begin changing into a juvenile mussel. Glochidia, no bigger than the period on the end of this sentence, live for a short time with the sole purpose to attach to a host fish.



able, several 100s to 1000s are removed from the female and placed into an aerated bucket containing the known host fish. Under natural conditions, the number of glochidia that infest a fish is so low that it

rarely causes damage to its host; however, care must be taken in the laboratory to avoid over infestation, which can cause the fish undue stress or death. Fish are infested over a short period and checked to deter-



Above: Glochidia are gently removed from the female mussel. Photos by Michael Pinder.

• Sheepnose • Longsolid • Stipppershell mussel • Pink heelsplitter • Faushell • Deertoe

• Carolina slabshell • Cumberland bean • Eastern floater Littlewing pearly mussel • Cumberland



Top: Glochidia, young mussel larvae. Above: A week-old, juvenile mussel after dropping off the host fish to feed brings in food particles by moving its ciliated foot through the water. Photos by Michael Pinder.

mine the degree of infestation. After the procedure is complete, the fish are transferred to tanks, which are carefully inspected over the next two weeks for juvenile mussels. While these techniques are known for a few species, many more require additional research before laboratory cultivation is possible.

Because of mussel cultivation advances and water quality improvements in many waterways, the Department initiated a program to reverse the decline and actively recover Virginia's freshwater mussels. The first step in accomplishing this task was creating the Aquatic Wildlife Conservation Center (AWCC), a facility located at the Department's Buller Fish Cultural Station near Marion, Virginia. Established in 1998, the AWCC is used to hold, propagate and grow mussels. Adult mussels at the facility are housed in a long raceway that contains a mix of gravel and pebble similar to that found on the stream bottom. The purpose of the stone is to act as a substrate so mussels can burrow, feed and respire naturally. Before entering the raceway, water from the South Fork Holston River passes through a one-quarter acre

pond, which increases algae and temperature, both necessary components for mussel survival and good health. Currently, over 300 adult mussels representing 22 species are held at the AWCC. We also hold an assortment of fish, from bass, darters and minnows, which serve as hosts for many mussel species. Because of the facility's river-like conditions, mussels spawn and produce viable glochidia as they would in the wild. In turn, these glochidia are used to infest host fishes and cultivate young mussels. Thousands of juvenile mussels ranging in ages from one month to five years old have been cultivated at the AWCC.

The second step in freshwater mussel recovery is determining where to release propagated species. In partnership with government, business and the public, six target reaches were developed to augment mussel populations in the Tennessee drainage of Virginia. These reaches were selected because they still have good species diversity and water quality. Within each reach, a monitoring site was selected to gauge suc-



Above: Adult mussels held at the Aquatic Wildlife Conservation Center maintain their position in gravel and pebble in the bottom of the facility raceway. Below: The Aquatic Wildlife Conservation Center, established in 1998, is used to cultivate and recover freshwater mussels of the upper Tennessee River drainage. Photos by Michael Pinder.



cess and develop a baseline of our overall recovery efforts. The monitoring sites are then sampled to determine the diversity and abundance of the mussel fauna. To date, three sites have been surveyed with

many more planned in the future. Using mussels from the AWCC and Virginia Tech, the Department began its first release of propagated mussels on August 28, 2001, into the Clinch River. By introducing propa-

spiny mussel • Navyrayed lampmussel • Alewife floater • Atlantic spike • Paper pondshell

Indian combshell • Appalachian monkeyface • Purple bean • Elephant ear • Subside • Cracking pearly mussel • James



Above: As part of its monitoring program, the Virginia Department of Game and Inland Fisheries in partnership with the U.S. Fish and Wildlife Service, The Nature Conservancy, Virginia Tech and other private, public and governmental organizations assist in monitoring mussels on the Clinch River. While snorkeling, biologists place a flag next to each live mussel on the river bottom. Photo by Michael Pinder.

gated mussels on an annual basis, it is hoped that the additional numbers will help increase and eventually produce self-sustaining populations of endangered species.

Just as China is expected to protect its pandas or India its tigers, the United States has a responsibility to protect its wildlife resources, be it bald eagles, grizzly bears or fresh-

water mussels. By actively working for their recovery, Virginia is one of only a few states doing its part to fulfill an obligation for future generations. With continued support and dedication, citizens can be assured that their freshwater heritage will once again regain its natural prominence in the rivers and streams of the Old Dominion. □

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Above: Mussels raised in captivity are marked with a small plastic tag before being released into the wild. After a year in the Clinch River, they have shown high survival and good growth. Virginia is working hard to recover its diversity of freshwater mussels for future generations. Photo by Michael Pinder.



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