Post Oak & Prairie Journal
A Regional Journal of the Cross Timbers and Prairies
Summer, 2021

Natural History Notes on Texas' Freshwater Mussels

David Ford

When someone asks me what I'm doing when they see me digging around in pitch black water full of alligators and snapping turtles, or when I'm face down in a river full of cottonmouths (because every snake in the river is a cottonmouth or so I have been told repeatedly), my response is usually that I'm looking for mussels. Typically, the person immediately thinks of the tasty little critters you can get at a restaurant, often with a nice butter sauce. These are, without exception, marine mussels, and these are what most people think of anytime they hear the word mussel. This makes sense as the vast majority of class Bivalvia are marine. However, mussels are also a conspicuous and important element of our freshwater systems, and about 1,000 species live strictly in freshwaters. Of the approximately 1,000 freshwater mussel species, the vast majority occur in the order Unionida which contains approximately 850 species and encompasses almost every freshwater family. Unionid mussels (mussels) are the species that I and many of my colleagues study as malacologists, especially given the dramatic declines of freshwater mussels around the world.

Almost inevitably the next question I'm asked is, "Can you eat 'em?" While technically edible (you can eat almost anything if you're hungry enough), and prehistoric people around the world have eaten them, it's not something I recommend. Here's why: 1) they build up levels of many undesirable contaminants in their tissues (more on this later); and 2) they contain

A group of mussels awaiting processing and being returned to the river. Several endangered species are present in this group. (Photo by Mitchell Kriege)

high levels of putrescine, an intermediate compound formed in amino acid metabolism that makes decaying flesh smell so foul. Despite their lack of culinary uses, freshwater mussels are a vital component of an aquatic ecosystem and are keystone species and ecosystem engineers. However, with a lack of fur, feathers or big brown eyes, freshwater mussels don't get a lot of attention.

A filtering Pink Heelsplitter (*Potamilus alatus*) encrusted with Zebra Mussels (*Dreissena polymorpha*). (Photo by David Foltz II)

Admittedly, mussels aren't the most exciting animals in the world at first glance. They are primarily filter feeders and so have no need to dramatically pursue and catch prey. Males do not compete for females in massive flashy courtship rituals, and they do not undertake any grand migrations around the world. Instead, they tend to remain buried at the bottom of waterbodies, rarely moving. The most obvious (and often beautiful) feature of a mussel is its shell. This is their main defense against the world, supports the amorphous body, and provides a record of growth and life events. Mussel shells are highly variable and greatly influence how the mussel interacts with the world. The shape and ornamentation of the shell can help reduce scouring effects, hold a mussel in place during a high flow event or allow it to more easily move and right itself if it becomes dislodged. Shell shape also varies between habitat types and can vary within the same species based on its position within a waterbody. Many species will have compressed shells in small streams to progressively inflated shells in larger rivers.

Shells consist of two valves, held together by a pair of muscles known as adductors, and a hinge ligament along the dorsal margin. The shell opens by relaxing the adductors, allowing the hinge to pull the valves slightly apart. Many species have hinge "teeth" which interlock to hold the valves together. Shell material is secreted by the mantle, a thin extension of the body wall unique to mussels. Mussel shells consist of three layers: the periostracum, the prismatic layer, and the nacre. The majority of the shell is composed of nacre, which is the lustrous shiny layer seen in many shells and is overlaid by a thin prismatic layer. The periostracum is a thin protein layer

on the outside of the shell. Pearls (yes freshwater mussels make pearls too) form when a foreign object becomes trapped between the mantle and the shell. As mussels grow, rings form in their shells representing seasonal deposition of shell material. These can be counted (typically) like tree rings to get an estimate a mussel's age, though the rings become harder to count the older the mussel becomes. Mussels can also create false/disturbance rings if a stressful event occurs. Shell size varies extensively between species, with the smallest approximately 35 mm (about 1.5 inches) to more than 250 mm (just shy of a football).

Internally the mantle lines the shell and encloses the mussel's body. In addition to secreting the shell, the mantle contains sensory organs, aids in reproduction and feeding, and forms the incurrent and excurrent siphons, though these are not true siphons as in marine bivalves. Under the mantle are gills. Water brought in via the incurrent siphon passes over the gills where food and other particles are trapped in mucus, and gas exchange occurs. Eventually water and non-edible material is excreted via the excurrent siphon but collected material on the gills is transported to the labial palps and mouth. The digestive system consists of a mouth, esophagus, digestive gland, intestine, rectum, and anus. Another large structure is the foot, a muscular organ that the mussel uses in movement, burrowing, and orientation, and can extend and retract between the valves. They have a three-chambered heart within a pericardial cavity in addition to numerous arteries and veins. Their blood is nearly clear and lacks most typical blood cells. The nervous system consists of two cerebral ganglia alongside the esophagus and minor nerves. Their primary sensory organs consist of an otocyst for balance, chemoreceptors in the mouth and labial palps to detect food, and light sensitivity in the mantle tissues.

Mussels are omnivores which feed on a wide variety of particles including phytoplankton, zooplankton, bacteria, and other organic detritus. A large amount of their time is spent filter feeding, though the factors governing this activity are poorly known. Light may play a role, as it can influence if a mussel is open or closed. Feeding occurs via either inhaling materials or via deposit feeding. Deposit feeding occurs either via the uptake of material through the shell gap by suction created by the foot, or via pedal feeding where material is moved into the shell directly by cilia on the foot. Juvenile mussels pedal feed much more actively than adult individuals. Despite some ability for movement, they tend to be highly sessile once adults, remaining in largely the same spot the majority of their adult lives, typically moving only if water levels decline or they are dislodged by a flood event. In many places mussels can be found in dense, multi-species aggregations called "beds". Historically, mussel beds could contain thousands of individuals sometimes representing dozens of species. Mussel lifespans can vary considerably and can range from just a few years to almost 100, though most species live around 10 to 15 years.

A displaying female Plain Pocketbook (*Lampsilis cardium*). (Photo by David Foltz II)

Despite their lack of charm to most people, they are incredibly interesting and important creatures. Mussels can be an abundant and conspicuous component of a freshwater ecosystem, and they often comprise more than 50% of the total benthic biomass because of their large size compared to other benthic organisms. Their functional role in these habitats was largely ignored for many years, but recent research has shown that mussels are keystone species and ecosystem engineers with a large impact on other organisms. Dense mussel assemblages can filter large amounts of water that can exceed the daily stream discharge, and they act much like water treatment plants. Such heavy filtering can reduce phytoplankton and increase water clarity, and the material that is filtered from the water is deposited in the substrate as feces. This links the pelagic and benthic food webs by biodeposition of filtered material and excretion of dissolved nutrients. They also serve as a food source for several fish, and mammal species, and were historically utilized as food by Native Americans. Their burrowing mixes sediments, which increases the sediment oxygen content and releases additional nutrients. These behaviors can stimulate production across multiple trophic levels. Dense mussel beds can stabilize loose substrates, and actively provide habitat for additional mussels. Their shells, both living and dead, increase habitat for many organisms, and

their dead shells represent an important source of calcium. The magnitude of these ecosystem services can vary widely according to environmental factors such as temperature and flow rates and is also dependent on the structure and composition of the mussel bed itself. Ecological roles vary between species and are important drivers of ecological processes. For humans, mussels act as indicator species, and give us an idea as to the health of a water body. Healthy mussels, healthy system.

With their beautiful and varied shells, a diversity of shapes and adornments such as ridges, pustules and spikes, freshwater mussels have earned some intriguing common names like Elephantear (*Elliptio crassidens*), Yellow Sandshell (*Lampsilis teres*), Clubshell (*Pleurobema clava*), Louisiana Pigtoe (*Pleurobema riddellii*), and Giant Floater (*Pyganodon grandis*). They are widely distributed, with species found around the world (except Antarctica). North America is considered the "mussel Mecca" of the world, with more species than anywhere else. Currently there are approximately 300 species found here, though this changes regularly as scientists identify new species or remove/reclassify old species based on genetic studies and other methods. The greatest diversity of mussels is found within the southeastern US. Alabama and Georgia lead the country with 180 and 120 species, respectively.

Currently Texas has approximately 50 species, depending on which geneticist you are talking to that day. A lot of work is currently ongoing to verify that Texas' mussel species are valid, and many new species are being described when older species are revised based on genetic discoveries. Four species, Guadalupe Orb (*Cyclonaias necki*), Balcones Spike (*Fusconaia iheringi*), Brazos Heelsplitter (*Potamilus streckersoni*), and Guadalupe Fatmucket (*Lampsilis bergmanni*) were described within the last few years. These species have yet to be officially approved by the scientific community, but that will likely happen in 2021. Of the 50 or so mussel species, several are endemic to Texas. Those endemics tend to be located in central Texas, but many other Texas species are endemic to the southeastern US.

Mussels can be found in nearly all aquatic habitats from small ponds in your backyard to the mighty Mississippi River or the Rio Grande. In fact, you may have seen them or even stepped on them if you have ever wandered around in a stream. The only thing they really need is enough flow to ensure that food is brought to them and waste taken away. The habitat also needs to contain enough water that a mussel will not become completely desiccated. With their limited movement, they will often attempt to follow water as it moves, but only if it recedes slowly enough that they do not dry and die first. They can survive in nearly every type of substrate from mud and muck to pristine gravel beds. As long as it is loose enough that they can burrow down into it, but not so loose they will get washed away, mussels will likely be there. Mussels live most of their

A displaying female Plain Pocketbook (*Lampsilis cardium*) attempting to draw in a host fish for its glochidia. (Photo by Aaron Prewitt)

lives burrowed in the substrate of a waterbody with the anterior end oriented downward and the foot anchored in the sediments. Remaining buried keeps the mussel from becoming dislodged and potentially transported to unsuitable habitats or vulnerable to predators. Portions of the mussel may remain above the substrate but often mussels are flush with the bottom, only showing the siphons for filtration. Vertical burrowing behaviors are often seasonally dependent, influenced by both water temperature and light, and many species will remain nearer the surface during warmer months. These behaviors also vary by species and may have some links to reproductive behaviors. Mussels are also capable of horizontal movements, which is often cued by receding water levels.

Mussels have an incredibly complex and fascinating form of reproduction, which includes a brief, obligatory stage as a parasite on a fish. The host acts as a floating fortress, moving and protecting the growing offspring. Reproduction begins when the male releases sperm into the water and the female siphons it in. She then fertilizes her eggs, and broods them in a special gill pouch called a marsupia. Inside the marsupia, eggs develop into microscopic larvae, called glochidia. This is where the fish host comes in and things get really interesting. The female mussel needs to

"infect" the host with the glochidia. Once attached, the glochidia forms a cyst on the fish, remaining and growing for several weeks. It then drops off the host as a juvenile (which looks like a very small adult), ready to begin the rest of its life. The glochidia is generally harmless to the host, though large enough numbers can harm the host, and they do elicit an immune response in the host. If a glochidia attaches to the incorrect host it will latch on but fail to grow, eventually dying and falling off.

Host infection methods can vary greatly between mussel species. Some species simply release glochidia into the water column, where they must randomly come into contact with the correct host. Others will make a web of glochidia that floats from the female through the water until it hits a host. For other species the process is more intricate and direct. Some species utilize an extension of the mantle tissue that strikingly resembles a small fish. This is displayed outside the shell and is twitched repeatedly to attract a fish interested in the "fake" prey item, like a fishing lure. When the fish tries to eat the lure, the marsupial gills are ruptured, and the glochidia are released and attach themselves to the gills and fins of the host. Members of the genus *Epioblasma* will actively attach themselves to the head of their host as they release their glochidia. Lures can vary in size, shape, color and the way they are displayed, depending on the host that is being sought. Still other species release small structures called conglutinates, which are attached to the mussel by a long strand of tissue. These structures contain glochidia, are shaped like prey items such as insect egg masses, and rupture when the host tries to eat them, releasing the glochidia. Conglutinates can also vary in size and shape and remain either on the substrate of the river or float in the water column. Members of the genera *Ellipsaria*, *Leptodea*, *Potamilus*, and *Truncilla* lack any of these methods. Instead, females seem to sacrifice themselves to their host, freshwater drum (*Aplodinotus grunniens*) a known mussel eating specialist. The exact infection strategy for this is poorly understood, however, the mussel likely releases her glochidia when the fish

A close up look at the lure of a Plain Pocketbook (*Lampsilis cardium*). Note the eye spot to mimic a minnow. (Photo by Aaron Prewitt)

bites/grabs her. One species, Paper Pondshell, *Utterbackia imbecillis*, is thought to be able to reproduce without a host. Some mussel species can only utilize a few or a single fish species as a host and are called specialists, while others can utilize multiple fish species, and are known as generalists. One species, aptly named the Salamander Mussel (*Simpsonaias ambigua*), utilizes Mudpuppies as its host.

A mussel displaying a packet of glochidia to entice its fish host into attempting to eat it. (Photo by David Foltz II)

Unfortunately, this unique life cycle is one of the reasons that mussels are considered one of the most endangered animal groups on the planet. Dams and impoundments have created barriers that mussel hosts are often unable to cross, and invasive fish species have altered fish communities and changed the number of available fish hosts. In addition, dams, channelization, and physical dredging alter mussel habitats, resulting in severe erosion, which can bury mussels, or result in reduced/changed flows, such as changing a river to a lake, such that many species cannot survive. Dams will sometimes release thermally altered water which can result in altered behaviors such as coming up to breed at incorrect times. The large releases from dams can also blow mussels out or result in desiccation if water is being held back during a drought. As sedentary filter feeders, mussels are highly susceptible to pollutants and toxins, unable to move away from the source. As they filter feed mussels build these contaminants within their tissues. Human harvest has also been a factor. Freshwater mussels will form pearls and there have been several pearl rushes throughout North America's history. Additionally, shells of freshwater mussels have been used as buttons prior to the invention of plastics, and thousands of animals were removed for these industries. More recently, mussels were harvested for their shells which were ground up to be used as part of the manufactured pearl industry (thankfully this is now done synthetically). Invasive species have also taken a toll. For instance, Zebra Mussels (*Dreissena polymorpha*), will outcompete mussels for food and habitat, and will attach themselves to mussel shells, smothering them. Though Zebra Mussels are relatively new to Texas' waters, another invasive species, the Asian Clam (*Corbicula fluminea*) has been in the state since the 1940s and competes with native mussels for food and habitat much like Zebra Mussels. Finally, fairly large-scale mussel die-offs are occurring across the nation. Though these

A female Wavyrayed Lampmussel (*Lampsilis fasciola*) using its lure to draw in a host fish. (Photo by David Foltz II)

die-offs remain mostly unexplained, evidence is pointing towards a novel densovirus as the culprit. Due to these factors approximately 70% of mussels in North America are imperiled to some degree. Here in Texas, 15 species are currently listed as threatened at the state level, and one is currently listed as endangered at the state and federal levels. Several more of these species have been petitioned for federal listing. Sadly, many of these problems are expected to get worse as the human population continues to increase and climatic impacts worsen.

Now with all this doom and gloom you might be thinking that mussels are done for, and you would not be entirely wrong. Between their complicated life histories, which forces any conservation efforts to include both the host and the mussel, and the continuing alteration and pollution of waterways by humans, mussels are in some trouble. However, all is not yet lost. Many mussels can survive in less than pristine conditions, and even waters in urban centers such as Dallas-Fort Worth still harbor mussel populations including some rarer species. Despite the declines, there are still lots of mussels, and the current estimated mussel population in the Mississippi River alone exceeds the human population of the US, even with commercial harvests, waterway alterations, pollution, and invasive species. Conservation efforts for mussels began in the early 1900s but really took off after the passage of the Endangered Species Act in 1973. Since then, numerous states, including Texas, have instituted regulations to protect mussels, and mussel conservation is now a high priority for many federal, state, and other agencies. Typically, this involves survey efforts to identify mussel populations, relocation of mussels prior to any instream construction efforts, and limits to, if not a ban

on any type of harvesting, among others. Additionally, various groups including zoos and fish hatcheries have begun captive propagation of many rare and declining species which are being reintroduced into wild populations to augment and support them. Many other conservation efforts, such as habitat restoration efforts, are also taking place across the country by federal, state, and corporate entities. Any prognosis on the fate of the mussels of North America must include a mixture of optimism and realism but given the building momentum towards mussel conservation it is possible that the darkest days are past. Mussels are a unique part of our natural heritage, and we must actively continue to preserve them both for future generations and the health of our rivers and ourselves.

David Ford is a senior malacologist/aquatic biologist with EDGE Engineering and Science, LLC based in Houston, Texas. Mr. Ford has worked with mussels since 2011 and publishes mussel research in scientific journals. He can be reached at dfford@edge-es.com

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