

Shell shock

Saving America's freshwater mussels requires some oddball interventions, finds Jason Bittel

SHINY pigtoes, elephant ears, winged spikes, snuffboxes, monkeyfaces and heelsplitters. If the names call to mind fantastical creatures from the world of Harry Potter, think again. These are all freshwater mussels, inconspicuous filter-feeders that have kept our rivers and lakes clean for millions of years, only to now find themselves at the sharp end of a little-known ecological crisis.

You probably don't give them a second thought, even on the occasions you are tucking into their saltwater cousins in a white-wine sauce. But these unsung riverkeepers aren't without their charms: some can live to be upwards of 100 years old, for starters, with shells that grow rings over time like trees.

The problem is that these days, many of them are growing old and dying without producing any offspring. In fact, freshwater mussels are some of the most imperilled lifeforms on the planet. One-third of all species hail from the US and of these, more than 70 per cent are listed as threatened, endangered or potentially extinct. Just last year, the known global population of golden riffleshell mussels was down to only five individuals.

They are never going to be a conservation priority. So it is down to the underdog efforts of a handful of biologists strung across the US to halt the collapse before it is too late. Their strategy? To hand-rear species on the brink – a task rendered all the more difficult by the mussels' exceedingly peculiar reproductive habits.

Freshwater mussels are part of the mollusc family, a large group of invertebrates that

includes fellow bivalves like oysters and clams as well as octopuses, squid, slugs and snails. At first blush, theirs is a simple lifestyle. They anchor themselves in the sediment at the bottom of lakes, streams and rivers, where they make a living by filtering water for algae and other microscopic morsels. But they do have a few tricks up their shells.

To overcome their lack of mobility, freshwater mussels deceive fish into serving as roaming nurseries for their young – and it is quite the show. Evolution has equipped the females with fleshy lures that mimic worms, minnows or even crayfish to tempt predators like the largemouth bass down to the riverbed for a nibble. When the fish attacks, the bait explodes into a cloud of parasitic spawn, which latch on to the fish's gills to gorge



RACHEL MARCUS/USFWS

Mussels mimic tasty morsels to attract fish that then nourish and carry their young

on blood and other nutrients. Several weeks later, the larval mussels metamorphose into juveniles and finally drop off the fish to colonise new territories (See "Masters of disguise", page 41).

It is a good job they do, because mussels are the overlooked guardians of freshwater ecosystems. Not only do they stabilise riverbeds and provide food for all sorts of creatures, they also clean the water, filtering out toxic substances including heavy metals and bacteria such as *E. coli*. One adult mussel can process up to a litre of water per hour, which means that a healthy mussel bed of around 100,000 animals can purify enough water to fill an Olympic-sized swimming pool each day. "That's the kind of a service we're obtaining for free just from these organisms existing," says Carla Atkinson, an ecologist at the University of Alabama.

Even mussels have their limits, though. We have spent the last 300 years polluting and damming our rivers, and the results for freshwater mussels have been catastrophic.

When the Wilson dam was built on the Tennessee river in Florence, Alabama, for example, it put the most diverse mussel bed on the planet under vast amounts of standing water, says Paul Johnson, a malacologist, or mollusc specialist, at the Alabama Aquatic Biodiversity Center. Some of the 75 or so species in this area adapted and got on with their lives but more than half disappeared. And that is just one spot. There are similar stories all over the place, leading the US Geological Survey to declare freshwater mussels the most endangered group in the country. ➤



JOEL SARTORE/PHOTARKINGS

INVASION OF THE SHELL SNATCHERS

While many freshwater mussel species native to the US are barely scraping by (see main story), invasive species such as zebra mussels and quagga mussels are making a killing.

“There’s a big difference in life cycle,” says Monte McGregor, a mollusc specialist at the Kentucky Department of Fish & Wildlife Resources. For starters, zebra and quagga mussels don’t require a fish host to nourish and transport their offspring, which means one mussel can pump out millions of free-swimming larvae every spawning season. And once those larvae turn into adults, they ruthlessly outcompete native species.

In extreme cases, 10,000 tiny zebra mussels have been seen locking onto a single native. This starves natives of food and oxygen, and can stop them from closing their shells, making them vulnerable to predators. Death by 10,000 anchors, if you will.

FASHION VICTIMS

The current crisis isn’t the first time North America’s rich array of freshwater mussels have been taken to the brink of extinction.

For about two decades around the turn of the 20th century, freshwater mussels were hauled out of the water by the tonne to make buttons with a fashionable pearly shimmer. Not even the species with shells too thin to make buttons from were spared, says G. Thomas Watters, who studies molluscs at Ohio State University: “The idea was if you threw them back, you were just going to waste time recollecting them. Better to just kill them all.”

Then someone invented plastic buttons, and the industry went down the tubes overnight. The problem was that the nascent science of how to make sure there would always be enough mussels went with it - at least until the Endangered Species Act became law in 1973. Suddenly there was a mandate for states to save their most vulnerable creatures, and a new generation of mussel breeders was born.

Mussels in the US aren’t the only molluscs under threat. We are living through a global mollusc crisis, though you aren’t likely to see a bumper sticker decrying it. In 2007, the International Union for the Conservation of Nature (IUCN) listed this as the group most affected by extinction, with 302 species and 11 subspecies officially extinct. A study published two years later found that the true scope of the crisis was being under-reported: the number of extinct molluscs was close to double the earlier figures. That means more than 600 species of mollusc have gone the way of the dodo in the last century or so - that is twice as many lost as there are primate species known to exist.

Some are not giving up hope. Bernard Sietman, a malacologist at the Minnesota Department of Natural Resources, is one of those dedicated conservationists who spend much of the year face-down in frigid waterways. In recent years, Sietman has focused on the spectaclecase mussel. Growing oblong shells large enough to stow a pair of glasses, this species used to inhabit 44 rivers and streams across the Midwest. Today, it can be found in just 20, and the remaining populations are severely fragmented.

Because of this, the spectaclecase was added to the US Fish and Wildlife Service’s endangered list in 2012. But it has been in trouble for a while. In 1907, the St Croix river that divides Minnesota and Wisconsin was dammed for hydroelectricity at St Croix Falls. As a result, there are places above the dam where barely a mussel can be found, Sietman says, and those that remain are all senior citizens that have not been reproducing.

Below the dam, however, the mussels were doing the business. This led Sietman to scour all the information he could find about the fishes that used to inhabit the St. Croix, and to identify the ones that had disappeared from the river’s upper reaches. At the same time,



When it comes to saving hopeless mussels, the secret ingredient is rabbit blood



JOEL SARTORE/PHOTOARK/ANGS

he and his colleagues started taking every candidate fish species he could find and squirting them in the face with spectaclecase larvae taken from the lower-river mussels. River shiner? Nope. Gizzard shad? Nope. Sauger, white bass, logperch and channel catfish? Nothing.

At least one mussel species is known to parasitise salamanders called mudpuppies, so the team tested similarly outside-the-box species, including tiger salamanders, American eels, crayfish and even turtles. All told, Sietman and his team tested more than 70 species, and all of them were busts.

Finally, Sietman zeroed in on two migratory fish known for their iridescent peepers: the mooneye and the goldeye. The trouble is that they are notoriously difficult to catch and keep alive. “The mooneye would just rub their eyes along the tank wall and one or both eyes would eventually get infected, start swelling and then sort of rupture,” he says.

Having installed bubble curtains in the tanks to keep the fish from grinding off their own eyes, Sietman’s careful fish husbandry was eventually rewarded when he saw a mooneye’s gills heavy with mussel larvae. Today, his team have about 200 baby spectaclecase mussels growing in the lab, as well as containers full of lab-raised juveniles growing au naturel in the St Croix river. Some may be mature enough for release this year,

North America’s rich diversity of freshwater mussels is in danger

but Sietman says that is probably a long shot. For the time being, he can only watch and wait: “It’s a 365-day-a-year monitoring process.”

Even in cases where the host is known or discovered quickly, it can still take several years before you start churning out mussels, says Tyler Hern, a biologist at the White Sulphur Springs National Fish Hatchery in West Virginia. Hern has spent the past few years working with the purple cat’s paw mussel, named for the colour of its inner shell

and a feline-finger-shaped divot on its exterior. This species isn’t so picky: it parasitises several fish. But for Hern and his colleagues that came as little consolation when it was discovered in 2012 that there were just 10 females left, all of them languishing in a drought-scorched stream in Ohio.

The following year, experts from three facilities were given permission to extract larvae from these females to grow in the lab. Several weeks later, Hern announced that 13 of his larvae had successfully metamorphosed, making them the first purple cat’s paw mussels born in captivity. However, even with two other facilities dedicated to the same species, just 48 almost-adult mussels were reintroduced to the wild in October. That’s not a bad haul given how few remain, but it illustrates the glacial pace at which freshwater-mussel conservation moves.

In many cases, it seems hopeless. What is a malacologist to do when they simply can’t find the host fish or they suspect that it is extinct? It turns out that even then, all is not lost. Some researchers have come up with a way to bypass the host altogether.

At the Freshwater Mussel Conservation and Research Center at Columbus Zoo, home to around 700 rare mussels, researchers from Ohio State University are raising thousands of mussel larvae in dishes filled with warm, red goo. This is designed as a proxy for fish gills and the secret ingredient is rabbit blood - a cheaper, more readily available alternative to fish blood. “The benefit is that you can transform thousands of larvae in one petri dish,” says team member Jacquelyn Halmbacher.

Elsewhere, it has already helped to push the pause button on extinction for the golden riffleshell mussel. Monte McGregor, a malacologist at the Kentucky Department of Fish & Wildlife Resources, has successfully

grown more than 70 species of freshwater mussel in vitro. But the golden riffleshell stands out as a striking story of redemption.

Once found in droves across the southern section of the Appalachian mountains, the entire population had dwindled to just five. Nobody knows the riffleshell’s host fish, but McGregor and his team coaxed larvae from those last remaining adults and, thanks to the in vitro method, brought them to adulthood in the lab. In September last year, he and his

“This gruesome strategy has helped to save the golden riffleshell from extinction”

colleagues distributed some of those individuals across three sites in Virginia, boosting the population to 700. “If we hadn’t raised these, I think they may have gone extinct,” he says

If nothing else, such dogged efforts buy time to better understand what is laying mussels low. In addition to dams, dredging and reduced water quality, there is evidence that run-off from fertilisers can affect mussel health, says G. Thomas Watters, a malacologist also at Ohio State University. The rock salt used in the US to melt ice on winter roads could also be neutralising mussel sperm before it can reach the females. Nowadays, mussels are even occasionally targeted by poachers, since their shells can be broken up and inserted into oysters to encourage the growth of cultured pearls - a throwback to an earlier era when mussels’ pearly innards made them a target (see “Fashion victims”, left).

The true test of whether it is possible to return North America’s mussels back to their former glories is whether recovered populations can go on to produce new generations on their own. Hern, for one, sees reasons for optimism: a single female can generate hundreds of thousands of larvae, he says, so a species can recover rapidly if we can get enough individuals back into the water with their host fish.

And Watters, who wades into Ohio’s Darby river every year to check the endangered northern riffleshell mussels he helped to reintroduce, insists that such efforts are more important than they might appear: “I would like to think that by protecting a very rare and intolerant species we are protecting everything else as well”. ■

Jason Bittel is a writer based in Pittsburgh, Pennsylvania

Masters of disguise

Freshwater mussels use a fleshy lure to mimic minnows, worms and other tasty morsels to trick unsuspecting fish into carrying their young and carrying them upstream

