Learning to Live with WHIRLING DISEASE

This trout killer may not be as deadly as once feared, but it's still a potential threat to Montana's coldwater fisheries.

By Brian Maffly and Tom Dickson

Whirling disease has defied expectations ever since biologists fingered a European parasite as the culprit in Montana's Madison River rainbow trout decline 13 years ago. In the mid-1990s, many western state conservation agencies warned that whirling disease could have catastrophic effects on wild rainbow trout populations. And indeed that has been the case in some waters of some states, notably Colorado, where severe infestations have hit most major river drainages and wild trout in many popular streams have been nearly wiped out. In Montana, the waterborne parasite has spread to at least 150 rivers, including the world-class upper Missouri, Gallatin, and upper Bitterroot. And it is considered a dire threat to isolated populations of westslope and Yellowstone cutthroat trout.

Yet whirling disease has not damaged Montana trout populations as badly as some media reports had predicted. The Madison River, once the disease's poster child, has made a remarkable recovery over the past decade after losing most of its rainbow trout to the disease. Trout 12 inches and longer have numbered roughly 530 per mile in recent years. Though less than half that of pre-epidemic levels, the population of catchable trout is still more than four times what it was in 1995, a rebound that has helped make the storied blue-ribbon river Montana's most popular fishing water.

M. cerebralis spore

The upper Missouri River also has fisheries experts scratching their heads. The extraordinary rainbow trout fishery below Holter Dam continues to hold its own, despite severe whirling disease levels in its

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SENDING MIXED SIGNALS A rainbow trout looks for aquatic insects beneath the surface of the storied Madison River, once the nation's poster child for whirling disease. In recent years, the Madison's rainbow population has rebounded, and now the river is the most heavily fished water in the state. However, rainbow numbers are still less than half what they were before whirling disease struck in the mid-1990s, providing a murky picture of what biologists and anglers can expect in the future on this and other infested waters.

two main spawning tributaries.

These and other developments may cause trout anglers to wonder if whirling disease is really a problem. The answer is yes, though not one as severe (so far) as some had feared. State fisheries officials note that even though many initial predictions haven't come to pass, the disease-causing parasite is firmly entrenched in an increasing number of Montana rivers, and some waters will likely see temporary or even permanent rainbow trout population declines.

"As we learn more about whirling disease, we're realizing it isn't the end of life as we know it," says Chris Hunter, fisheries chief for Montana Fish, Wildlife & Parks. "But we also know the disease can do some real damage and can't be taken lightly."

Hunter is especially concerned about threats to small, isolated populations of increasingly rare westslope and Yellowstone cutthroat trout. "With large trout populations like those in the Missouri River, you have more genetic diversity to help withstand the effects of disease," he says. "But whirling disease could easily wipe out a small population of native cutthroats living in a remote mountain stream."

JULIE ANDERSON

CROOKED TAIL The "whirling" refers to a trout's inability to swim straight due to spinal cartilage and nerve damage.

Hungry sporoplasm

Whirling disease originates in a foreign, microscopic parasite called *Myxobolus cerebralis* that can persist for years in trout streams in a dormant form known as a spore. After being eaten by native underwater tubifex worms, the spores turn into what are called triactinomyxons, or TAMs. When excreted by the worms, these buoyant forms of the parasite float downstream in the current and attach themselves to trout, injecting yet another version of themselves called sporoplasm. The hungry sporoplasm travel along the fish's nervous system to large areas of cartilage in the head and spine on which they feed. Because cartilage in young trout is still forming and soft, it's easy for the sporoplasm to damage the tissue and cause severe levels of disease. The "whirling" refers to a fish's inability to swim straight due to nerve and spinal column damage.

Dick Vincent knows better than anyone the harm that whirling disease can do to trout and trout populations. The FWP senior fisheries research biologist has devoted his 40-plus-year career to studying the Madison River trout fishery and has been conducting nationally known whirling disease research on the Madison since the early 1990s. In recent years, Vincent and other whirling disease researchers have focused much of their attention on what happens to fish that become infected with the disease. In several dozen infected streams, Montana biologists place young trout in "sentinel" cages for ten days to expose the fish to the *M. cerebralis* parasite. They take the fish to an aquarium lab for an additional 80 days, then kill the fish and send the heads to a pathology laboratory at Washington State University, where scientists look for indications of cranial cartilage damage. "In young fish, the disease can actually turn the head to mush," says Vincent.

Sometimes, however, there is no damage, which is what Vincent recently discovered on the Madison. He says the surviving rainbow trout have become genetically resistant to the parasite that still infests the river. In 1999, every rainbow trout that Vincent exposed to TAMs showed severe disease levels. But when he repeated the experiment five years later, fewer than half the fish showed severe disease, and 30 percent had little to none. "As far as we know, this is the only place in the country where rainbow trout have become resistant to the disease," says Vincent. (Brown trout are native to Europe, where whirling disease originated, and are much more resistant. The number of browns on the Madison has stayed constant over the past decade.)

Vincent explains that even though the initial whirling disease outbreak killed up to 90 percent of young rainbow trout between 1991 and 1997, enough survived to keep the population afloat. "Those survivors appear to have significant genetic resistance to whirling disease," he says. "And now they've been reproducing and passing the resistance to new generations of rainbows in the Madison."

According to Vincent, the findings have surprised genetic scientists, who just a few years ago believed that genetic adaptation could not happen in such a short time. "Their theory was that it would take hundreds of years or even longer, because the assumption was that there was no inherent resistance," Vincent says. "But obviously there was some, which is why the genetic adaptation could occur so quickly."

Vincent, who grew up fishing the Madison and knows the river intimately, says he's pleased the famous trout fishery has shown some recovery. "This is good news, because the way things looked back in the mid-1990s, we thought the river was in real trouble," he says.

Nevertheless, the veteran research scientist

"As we learn more about whirling disease, we realize it isn't the end of life as we know it."

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STILL A MYSTERY Though the Missouri River's main spawning tributaries are infected with whirling disease, the river's trout population has remained strong. Biologists are still not sure why.

JEFF ERICKSON

still has concerns. The Madison's rainbow trout population has not fully recovered, and the population may never reach pre–whirling disease levels. "There aren't as many adult fish as we'd expect to see in a recovering population, and it appears that growth rates are down," says Vincent.

The inexplicable Missouri

The Missouri River between Holter Dam and Cascade, one of Montana's top rainbow trout fisheries, is another puzzle. In 1998 biologists found severe levels of whirling disease in Little Prickly Pear Creek, one of the river's major rainbow trout spawning tributaries. Three years later, they discovered the disease-causing parasite in the Dearborn River, an even larger tributary; in 2004, they recorded major disease levels there. Inexplicably, however, rainbow trout populations on the Missouri have remained among the strongest in the state, today numbering over 2,500 per mile in the popular Craig section.

Travis Horton, an FWP fisheries biologist who has monitored the Missouri for years, says rainbow "recruitment"—the number of young fish added to the overall trout population each year—is down 33 percent from pre–whirling disease years. "Some of that decline is likely due to the drought in recent years, but there have been a few years of decent water since 1998, so some is no doubt also due to whirling disease."

Yet Horton says the one-third recruitment reduction has not translated into a similar decline in adult rainbow numbers. In fact, numbers have increased. Before whirling disease struck, the upper Missouri around Craig averaged about 500 trophy trout per mile. In the past two years, the number has been roughly 1,500. "The average number of mid-sized adult rainbows (14 to 17 inches) is right at the pre–whirling disease average," Horton says. "But the average number of trophy rainbows (over 17 inches) is well above what we saw in the years before whirling disease."

The findings are baffling. "Our best explanation is that anglers were killing far more large rainbows before 1998 than we thought," he says. "It could be that more trophy trout are now being returned to the water than before."

The Missouri has seen a recruitment decline farther downstream in the Pelican Point section near Cascade. Sixty percent of those trout come from the heavily infected Dearborn River. But 30 percent of the Pelican Point trout come from Sheep Creek, which so far has remained free of the disease. "It looks like recruitment in the Pelican Point section is about 80 percent of average over the past two years," Horton says. "We thought it would be worse, so this is encouraging. It could be that Sheep Creek, which is still clean, mitigates some of the effects from the Dearborn."

Vincent also is puzzled by the Missouri. "The life cycle of the *M. cerebralis* parasite is extremely complicated," he says. "Conditions have to be just right for the disease to take hold. The window of disease development is narrow—only when fish are about 1 to 2 inches long. After that, they are safe from the disease."

Other factors affect the incidence of infection in Missouri River trout, such as water flows, water temperature, fish density, time of fry emergence, and TAM infestation rates when young fish are developing. "We're learning a lot," says Vincent, "but we've got a ways to go before we understand what's happening on the Missouri."

Brook trout not immune after all

Vincent and fellow scientists have also been monitoring whirling disease on more than 30 other Montana streams. Recently, Montana researchers found whirling disease in brook trout, a species long thought to be immune. For years, scientists had wondered why brook trout living in infected waters did not become sick. It turns out that brookies, a non-native species, aren't immune at all; most avoid infestation

ERIC ENGBRETSON

ANOTHER REASON WILD TROUT MATTER Senior fisheries scientist Dick Vincent says Montana trout populations are fortunate the state stopped stocking rivers more than 30 years ago: "That led to the establishment of genetically diverse wild trout populations better able to adjust to changes such as whirling disease. And it switched our focus to habitat protection, which is critical for maintaining healthy wild trout populations.

because they spawn in the fall. The fry emerge from eggs in February, when many streams are still too cold for the infected tubifex worms to release their lethal bounty of TAMs. Rainbows, on the other hand, spawn in the spring. Their fry hatch in early summer, when most streams have warmed to the 45- to 55-degree temperatures that trigger TAM dispersal.

Where researchers recently discovered infected brook trout was in spring creeks. These groundwater-fed streams stay at roughly 45 to 50 degrees throughout the year, meaning that TAM plumes are released throughout the winter—including in February when the brook trout eggs hatch. "This is a problem for brook trout in spring creeks, but it's good news for rainbows and cutthroats [in those waters]," says Vincent. "Spring creeks have pretty much exhausted their TAM output for the year by the time the eggs of cutthroats and rainbows hatch and the fry emerge in early summer."

Another recent finding is that North American trout may have some inherent resistance to whirling disease. Vincent learned this from a serendipitous discovery of resistance in a specific strain of rainbows. In the late 1800s, rainbow trout from somewhere in California were transplanted in waters throughout the interior West to establish sport fisheries. Now called the DeSmet strain, the rainbow trout were planted in Wyoming's DeSmet Lake and later stocked in some Utah and Montana waters, including Harrison Lake (also known as Willow Creek Reservoir), an impoundment of Willow Creek roughly 40 miles east of Butte.

"It's a case of all the eggs being in one basket, and when the basket gets hit by something like whirling disease, the whole thing is wiped out."

Willow Creek has severe levels of whirling disease. Yet recently, when Vincent conducted experiments on progeny of Harrison Lake rainbows at FWP's aquarium at Pony, he found that half of those fish did not become diseased, even though the rest were wiped out.

"We still don't know much about rainbow genetics, but one well-documented theory is that these DeSmet-Harrison fish do have some genetic resistance to the disease," he says. "Unfortunately, we don't know where on the West Coast these rainbows originally came from more than a century ago. If we did, we could go there and study them and learn why they have this resistance, because they developed it long before whirling disease ever got to North America."

Wild and diverse

Despite these recent discoveries, Vincent isn't banking on a resistance gene to keep rainbow trout safe from whirling disease. But he is counting on the inherent genetic strength of wild trout to prevent the disease from ravaging rainbow populations.

"I think there's no question that our wild trout are key," Vincent says, noting that Montana has not stocked hatchery trout in its rivers and streams for more than 30 years. "In populations you need diversity so that fish can respond to changing conditions, so that no matter what gets thrown at the population, there are some members that can survive and keep the population going. Stocked trout don't have the genetic variability to survive those changes."

Spawning habitat diversity is also crucial, he adds. "Rainbow trout in rivers that have many spawning tributaries seem to withstand whirling disease better than those where spawning occurs only in the river mainstem," says Vincent. "When the parasite emerges in spring in a river, it spreads throughout the mainstem at one time, and if all the small fish are in the mainstem, they can get hammered. But if you also have spawning occurring in various tributaries, where there's a greater diversity of water temperature and the parasites emerge at different times, then there's a greater chance that at least some of these areas will not get hit with the disease, and then you can have at least some natural reproduction. That could be what's happening on the Missouri with Sheep Creek."

Vincent believes that Colorado's vulnerability to whirling disease is due in large part to the state's lack of river spawning diversity. "Almost all the spawning in their main trout rivers takes place in the mainstem," he says. "It's a case of all the eggs being in one basket, and when the basket gets hit by something like whirling disease, the whole thing is wiped out."

Vincent says that when FWP discontinued stocking trout, it changed its focus to habitat conservation. "We've spent a lot of time and money protecting and improving stream habitat, including spawning tributaries and mainstem spawning sites," he says. "We probably wouldn't have done that if we were still stocking fish in our major rivers."

The research scientist adds that keeping tributaries clean will be critical if Montana hopes to keep whirling disease under control. "If Montanans can reduce sewage, agricultural runoff, and bank erosion on spawning streams, then we can reduce the silt and organic matter that foster tubifex worm productivity," Vincent says.

Another way to reduce the spread of whirling disease, says Eileen Ryce, FWP's Aquatic Nuisance Species Program coordinator, is for anglers to keep their fishing boats and gear clean. Ryce urges anglers to remove mud from their boat hulls and wading boots, especially after fishing the Madison, Missouri, and other infected rivers. "We know we can't stop 100 percent of the spread, but we can reduce the problem," she says.

Bob Wiltshire agrees. The president of the Federation of Fly Fishers points out that by keeping boats and fishing gear clean, anglers can also reduce the spread of other waterborne threats. "Whirling disease is part of a larger problem, which is invasive species in general," says Wiltshire. "All aquatic invasives—New Zealand mud snails, zebra mussels, whirling disease—are threats to Montana's fisheries, and we need a concerted effort to keep our rivers free of those threats."

Despite the best efforts of anglers to keep Montana waters clean, it's likely new infestations will continue (though more slowly than if no preventive measures were taken). Scientists continue to study whirling disease and learn how to slow the inevitable spread. But it may be Montana's genetically fit wild trout themselves, along with diverse and healthy spawning habitat, that provide the best line of defense against this and other biological threats to the state's cherished blue ribbon trout fisheries.

For more information on whirling disease, visit the Bozeman-based Whirling Disease Foundation at whirling-disease.org or Montana State University's Whirling Disease Initiative at whirlingdisease.montana.edu.

A whirling disease researcher at Montana State University sorts tubifex worm samples on the Madison River.

WHIRLING DISEASE

How the disease kills trout

Whirling disease is caused by an exotic parasite that originated in Europe. *M. cerebralis* is a two-host parasite that first began damaging rainbow trout populations in the decades following its introduction into the United States in the 1950s. The parasite's spores can lurk for years on river bottoms, where they are ingested by native tubifex worms, which prefer organically enriched environments containing abundant fine sediments. Inside the worms' digestive tracts, the spores take on a new form: triactinomyxons (TAMs). These spindly creatures are equipped with three long arms that make them buoyant and easily dispersed in the water column. TAMs emerge from the worms in search of a host. They latch onto a trout and inject the disease-causing sporoplasm into the fish.

A trout's susceptibility to the disease diminishes as its bones age and harden. Its first nine weeks of life are particularly perilous. A young trout's bones are still primarily made of soft cartilage, and its immune system is not fully developed. The parasite eats the cartilage in the head, neck, and back, resulting in deformities that can hamper a young trout's ability to swim straight and compete with other fish. Whirling disease doesn't necessarily cause death, but severely diseased fish have a harder time competing for food and space. If it dies, a diseased fish decomposes and releases fresh *M. cerebralis* spores into the stream, continuing the cycle.

M. cerebralis TAM

The "whirling" refers to the circular swimming route made by some severely infected trout. Not all diseased fish show signs of whirling, however. And not all streams infected with the *M. cerebralis* parasite have rainbow trout population reductions.

Unlike imported brown trout, which co-evolved with the parasite in Europe, North American salmonids had never been exposed to *M. cerebralis* before its introduction here. As a result, the salmonids on this continent have little genetic resistance to the disease. Species most at risk are rainbow, cutthroat, bull, and redband trout, as well as mountain whitefish and sockeye salmon.