Center for Limnology Ph.D. student Michael Spear casts a net to detect invasive species in Madison's Lake Mendota. Soon, however, nets could be replaced with test tubes and genetics machines.

KATHERINE SPEAR

CSI: MENDOTA

HOW SCIENTISTS ARE USING DNA TO DISCOVER INVASIVES.

Michael Spear

The sun rises over the skyline. A boat speeds across the open water. Music by The Who blasts in the background as a young scientist looks through an iridescent green test tube.

No, it's not the opening sequence of your favorite TV crime drama. It's just another day at the University of Wisconsin-Madison Center for Limnology, where professors and students are bringing crime scene investigation technology to the environmental crises that face our community, country and planet. They say nature mimics art, and for these intrepid scientists, nature has cooked up a Hollywood-caliber villain: invasive species.

Once invasive species establish in an ecosystem, it's nearly impossible to control their harmful effects. But there is a soft spot in their brute-force takeover, a chance to neutralize the threat.

When the invasion has just begun and one or two individuals are lurking beneath the water's surface, management actions could thwart a species' attempt to build its population for a total ecosystem overthrow. Invasive eradications have suffered some high-profile failures in recent history, bringing into question its feasibility. But with early detection and action, an eradication effort's probability of success increases exponentially.

When an invasive species becomes abundant enough to see, it's usually too late to eradicate it. The trouble is, these organisms are almost impossible to detect at low, manageable levels. Until now.

Faced with this daunting challenge, a few rogue scientists at the Center for Limnology are ditching their nets and traps for cutting-edge forensic science. Like sweeping a crime scene for a perpetrator's DNA, these limnologists can sample the water for genetic fingerprints of invasive species, potentially well before traditional surveillance would spot an invader.

They used to rely on dragging a small net through the vast lake, then picking by hand through algae and innocent animals to find one or two bad guys, a true needle-in-a-haystack scenario. But now, in a cup of water, they can pick up the genetic signal broadcast by secretive invaders through shed skin, feces and even sperm. It's called environmental DNA, or eDNA, and it's the smoking gun left behind by even the most scarce and secretive organisms.

These exotic organisms come in all shapes and sizes, arriving "undercover" from the four corners of the earth. There's the tiny spiny water flea, billions of which voraciously consume the life of Lake Mendota like hoards of zombie sea monkeys, triggering algae blooms in their wake. And the menacing lamprey, which literally suck the blood out of game fish in Lake Michigan with their circles of vampire teeth.

Of course, it's not these animals' fault. They were harmless, important parts of their home ecosystems before being accidently, or sometimes purposely brought here by humans. But now, in the absence of their natural predators, these invaders can wreak havoc on the delicate balance of life in Wisconsin, which is why researchers are scouring aquatic habitats for telltale genetic markers.

It works like this: instead of spending lots of time and money hauling nets through a huge lake, trying to capture an actual organism, the researchers rely on the natural diffusion of DNA in the water to disperse the signal of the invader throughout the lake.

That way, instead of looking for one tiny or elusive individual, they can target a much larger cloud of incriminating evidence as the animal constantly emits a DNA signal of its presence. Just by scooping water from the lake, they drastically improve their chances of collecting proof of an invasive species, with significantly less time, effort and money than traditional sampling methods.

After returning to the lab, they filter that water and extract the DNA that it contained. This includes DNA from anything nearby in the water: bacteria, fish, plants — even human swimmers who were having too much fun to get out of the water to find a bathroom.

But DNA is like a fingerprint, not only among individuals but among whole species. So the researchers can pick out the DNA of the invader, if it's there, by looking for genetic sequences unique to that species, just like a prosecutor pins a crime on a suspect with their personal DNA signature. They can even get an idea of the amount of DNA present, giving indications of how far along an invasion might be.

With advanced detection of an invasion, we can do more than assign blame for past ecological destruction, like forensic evidence incriminates a criminal. We can head off invasions before they happen, sparing thousands of ecosystems and billions of dollars.

We can even apply this technology beyond invasive species, monitoring low-level populations of concern like endangered species, or rapidly assessing the species composition of whole lakes based on the DNA instead of intensive, expensive and intrusive netting.

Advancing technology is often at odds with the environment, but the scientists at the Center for Limnology are showing how we can employ technology for conservation instead of exploitation. As with any new method, there are kinks to be worked out, but eDNA is a promising new part of the ecological toolbox used to answer questions about the environment.

So while they may lack the suave, tinted sunglasses and pithy one-liners of the TV detectives they evoke, these scientific investigators do use state-of-the-art forensic tools to fight these invaders, and eDNA might just be the leg up they need to help them bag the perp.

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