The great pond experiment: Pond communities bear lasting imprint of random events in their past

May 27 2010

Students sample the more than 100 species of plants and animals that made a home in the ponds set in a field at Washington University's Tyson Research Center in the second half of a seven-year-long experiment. Credit: Jon Chase/WUSTL

(PhysOrg.com) -- A seven-year experiment shows that pond communities bear the imprint of random events in their past, such as the order in which species were introduced into the ponds. This finding locates one of the wellsprings of biodiversity but also suggests that it may not be possible to restore ecosystems whose history we cannot recreate.

In graduate school, Jon Chase worked in a lab that set up small pond ecosystems in order to run experiments on species interactions and food webs. "And because this was an experimental science, we tried to replicate each pond system," Chase says.

"We would try really, really hard to duplicate pond communities with a given experimental treatment," he says, "putting 10 of this species in each pond, and five of these species, and eight of the other species, and 15 milliliters of this nutrient and 5 grams of that and SPROING, every replicate would do its own thing and nothing would be like anything else. "

"That made me curious. What if, instead of trying to eliminate the messiness, I tried to figure out where it was coming from."

On May 27, the results of his investigation were published on the *Science* Express web site. The seven-year experiment isolated one reason experimental ponds go wild.

History.

If the ponds have enough nutrients, the pond community that emerges depends on the order in which species were introduced into the pond, says Chase, PhD., professor of biology in Arts & Sciences at Washington University and director of the university's Tyson Research Center.

The discovery has broad implications for highly productive ecosystems such as tropical rainforests and coral reefs and for attempts to restore these ecosystems. Restoration can fail if the original ecosystem bears the imprint or memory of its past in ways that were not understood.

Setting up the Ponds

In the summer of 2002, Chase embarked on a long-term pond experiment at the Tyson Research Center, a 2000-acre field station owned by Washington University on the outskirts of St. Louis.

He set out 45 Rubbermaid cattle tanks in an old field, added a bit of dirt to each and filled them with well water.

The 300-gallon tanks are not as big as regular ponds, he says, but they're "decent sized. "I've even had herons come and try to hang out in them, although they're a bit small for that."

He dosed the ponds with nutrients in the form of nitrogen- or phosphorus-containing chemicals. Each pond received either low, medium or high levels of nutrients throughout the experiment.

And then he began inoculating the ponds with species. The species pool for inoculation consisted of zooplankton from each of 15 ponds, 30 insects and small invertebrates such as snails, 9 vascular aquatic plants and 12 kinds of filamentous green algae.

"Cladophora, Oedogonium, Zygnema and Mougeotia . . ." intones Chase, the sonorous genus names rolling smoothly off his tongue.

The first year each pond was innoculated with a randomly selected third of the species in the species pool. The following year, half of the remaining species, again randomly selected, were put in that pond. And third year, the pond got a soup containing the remaining third of the species pool. So each pond received species in a different order but in the end, every pond got exactly the same species.

"Then we let nature take over," Chase says. "The plankton moved around in the wind and on frogs' backs, and dragonflies flitted over and laid their eggs, and beetles buzzed by, and everybody was acting like a big happy wetland community."

Tramea lacerata, black saddlebags

Taking the Census

Beginning in the summer of 2004 Chase and a team of students and other helpers sampled the ponds each summer to see how the pond communities were getting on.

They'd plunge bottomless garbage cans into the sediments of the pond and then sweep the water column in the can to capture insects and larval amphibians. Or they'd partially submerge bottomless buckets and count every species of plant or algae within them.

"The garbage cans were purchased from Bed Bath and Beyond," Chase says, "because they had the straightest ones we could find."

Since there were nearly 100 species in the ponds by this time, many having colonized on their own, it wasn't easy to identify all of the species correctly.

"Several of the larval dragonflies look nearly identical," says Chase, "except for differences in small traits like hooks on their abdomens. The differences among the small beetle species are similarly cryptic (and, man, a lot of beetle species live in ponds). And the zooplankton—especially the rotifers—can look like tiny little blobs under the microscope until you get an eye for their structure."

"So when we found a student with a penchant for identifications," Chase says, "we tried to keep them as long as we could. In the final years of the experiment we had two exceptional students, one with an eye for zooplankton and the other with an eye for macroinvertebrates such as insects and snails. "

Both received National Science Foundation graduate research fellowships and are off to do PhDs at top universities starting next fall, he says.

What the census revealed

The low-productivity ponds all looked the same. "No matter where you started, you ended up in the same place," says Chase. "But each high productivity pond looked different. In that case, where you started determined where you ended up."

"The low productivity ponds were very predictable, very deterministic," he says. "The high productivity ponds were more stochastic. History mattered more."

There were no big differences among the ponds when it came to number of species. The low productivity ones had roughly as many as the high productivity ponds. The biodiversity arose at a different scale, not within a pond but within the group of high-productivity ponds.

This kind of diversity is called beta diversity to distinguish it from local, or alpha diversity.

The term is an old one, invented by American plant ecologist Robert Whittaker, to describe biodiversity that becomes apparent ascending a mountain, as species of suited to clement conditions give way to hose able to survive harsher ones.

"In the mountain's case, beta diversity is driven by changes in the physical environment," says Chase. "In our pond study we eliminated physical variations and so the beta diversity that emerged was most likely a result of priority effects.

Priority effects are probably most important in productive environments such as tropical rainforests and coral reefs, says Chase, and less important in low productivity ones such as grasslands and intertidal habitats. "

Ecosystems, not carbon copies

Chase's finding has both theoretical and practical implications. It directs our attention to structure that only emerges at a certain scale. Like the Nazca lines, the ancient geogylphs in the desert of Peru that can be seen to be birds or spiders only from an airplane, beta diversity may emerge clearly only if we look regionally rather than locally.

The importance of his findings also emerges clearly in the field of restoration ecology. Restorationists strive to recreate complex ecosystems by following simplified guiding principles, an endeavor that often exposes gaps in ecological understanding.

Restorationists say ecology is plagued by the myth of the carbon copy. This is the idea that we can easily make an identical copy of an ecosystem because community assembly is predictable and always ends up in the same place. So degrading an ecosystem resets it to an earlier stage from which it will develop in a predictable fashion to a predictable end point.

Many of us encountered this idea in school in the form of forest succession and the climax forest, ideas popularized by Frederic Clements, a botanist active in the first half of the 20th century.

But experience show that the replacement ecosystems often fall short of the original ones.

Chase's pond experiment suggests why. Far from being carbon copies, ecosystems, are historical artifacts, their final form a sensitive record of their past.

Provided by Washington University in St. Louis

Citation: The great pond experiment: Pond communities bear lasting imprint of random events in their past (2010, May 27) retrieved 25 March 2023 from https://phys.org/news/2010-05-great-pond-imprint-random-events.html