Dragonflies reveal how biodiversity changes in time and space

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Rice University's Volker Rudolf and his students collected more than 18,000 insects, amphibians and fish at remote ponds north of Houston. Credit: Brandon Martin/Rice University

An ecological filter in a pond, such as voracious fish that feed on dragonflies and damselflies, can help ecologists predict how biodiversity loss may impact specific habitats, according to Rice University researchers who spent four years studying seasonal changes in ponds

across East Texas.

In one of the first studies of its kind, the scientists show that strong environmental "filters"—in this case, predatory fish—cause dragonfly and damselfly communities to vary regularly from year to year and season to season in ponds across East Texas. The results, which appear online this week in the journal *Ecology Letters*, show how an ecological filter can help ecologists predict how biodiversity loss may impact specific habitats.

Thousands of Earth's species are becoming extinct each year and the rate is increasing. Scientists have struggled to predict consequences of biodiversity loss, in part because of the uncertainty about natural variations in composition of communities across time and space.

"Ecologists tend to think about biodiversity in space—we locate biodiversity hotspots and use maps to show how biodiversity varies in different habitats—but not in time," said Volker Rudolf, associate professor of biosciences at Rice and the lead scientist on the new study. "In reality, biodiversity changes over time just as much and in many different ways.

"There are ecological theories that suggest that community dynamics should be connected in both time and space, but we typically just infer the temporal dynamics from the spatial patterns," he said. "In a sense, people have sort of done this backward. They assume that if these dynamics happen over time, then here's what we should see in space. In our case, we don't assume. We actually show what happens."

More than 60 species of dragonfly live in East Texas. Rice University ecologists identified thousands of specimens. Credit: Jeff Fitlow/Rice University

In their study, Rudolf and his students collected and analyzed more than 18,000 insects, amphibians and fish in quarterly visits each year from 2011 to 2015 at 45 remote ponds in the Davy Crockett and Angelina national forests about 80 miles north of Houston.

Study co-author Nick Rasmussen said dragonflies—and their diminutive cousins, damselflies—were the perfect organisms to study biodiversity in East Texas because more than 60 species live there.

"We've got a lot of the tropical species, and a lot of the North American species, and if you go out and look at a specific pond, you'll see there is

a lot of variation in what species is where," said Rasmussen, a postdoctoral researcher at the University of California, Davis, who earned his Ph.D. at Rice in 2012. "There's a pretty good understanding that specific factors can influence what species show up in a given pond, and those could be things like fish, canopy cover, water temperature and how often the pond dries out. But on top of that, everything is seasonal. Species change with summer, winter and wet and dry seasons."

One of the main things the team wanted to investigate was the extent that each pond varied, not just from season to season but also from year to year during the same season. By returning each fall, winter, spring and summer to the same ponds for four years, they quantified four sets of season-by-season changes (i.e., spring to summer) as well as four sets of year-to-year changes (i.e. summer to summer) for each site.

In analyzing the differences, Rudolf's team found systematic differences in the temporal and spatial patterns of dragonfly diversity across ponds with different top predators. In ponds that were associated with the presence of predatory fish like bass, the top predators brought an order to both the type of dragonflies that were able to live in a pond and how dragonfly communities changed over the seasons and years.

Rice University graduate students Shannon Carter and Patrick Clay sort newly collected samples. Ongoing visits to the ponds will allow researchers to learn more about the mechanisms that govern biodiversity. Credit: Jeff Fitlow/Rice University

"If you look at any of the fish ponds, you can observe dramatic changes in the composition of communities from season to season, but the changes are pretty consistent among years for each pond with the same fish predators," said study lead author Benjamin Van Allen, a postdoctoral researcher at the University of California, San Diego, who earned his Ph.D. at Rice in 2014. "Looking at one fish pond throughout the year gives you a good idea of what happens in the rest of them."

In contrast, the ponds that lacked fish showed far more diversity from

pond to pond in the types of dragonfly species that were present. They also failed to change as consistently with seasons and years as ponds with strong top predators. Without a strong filter, the community of dragonflies in ponds that lacked fish "drifted" over time and did not go back to the same place each year, Van Allen said.

Co-author Chris Dibble, a postdoctoral researcher at Indiana University who earned his Ph.D. at Rice in 2014, said, "What this tells us is that if we want to get a sense of total biodiversity in habitats with strong filters, then we should pick a few example sites and measure them several times throughout the year. If no strong filter is present, then our study suggests that it would be more efficient to measure as many sites possible, but at fewer points in time. It's also important to note that strong filters can also include strong climatic or environmental conditions, in addition to biotic factors like predators."

Rudolf said the study suggests that ecological stress brought on by overfishing, overhunting, habitat loss and climate change could have very different effects on habitats with and without filters. He said the study shows how important it is for ecologists to account for such differences as they seek to quantify and conserve remaining biodiversity.

"These spatial and temporal components are really connected," he said. "A common mechanism can drive them. In a larger context, that means that we can use simple rules to infer something about biodiversity and how it changes over time and space in various habitats and patches."

More information: Benjamin G. Van Allen et al, Top predators determine how biodiversity is partitioned across time and space, *Ecology Letters* (2017). DOI: 10.1111/ele.12798

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