Evolution Impacts Environment, Challenging Traditionally Held View, Study Finds

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Biologist Ronald Bassar of UC Riverside hunts for guppies in a stream in Trinidad. Credit: Sonya Auer, UC Riverside.

(PhysOrg.com) -- Biologists have known for long that ecology, the interaction between organisms and their environment, plays a significant role in forming new species and in modifying living ones. The traditional view is that ecology shapes evolution. The environment defines a template and the process of evolution by natural selection shapes organisms to fit that template.

Some specialized theory, a few laboratory experiments and studies of natural populations suggest, however, that evolutionary processes reciprocate by influencing ecology in turn.

Now a team of biologists presents evidence that ecology and evolution

are indeed reciprocally interacting processes, presenting a fundamental shift in our understanding of the relationship between evolution and ecology.

"Ecology for the most part ignores evolution because organisms are treated as constants," said David Reznick, an evolutionary biologist at the University of California, Riverside, who led the study. "This does not mean that ecologists don't believe in evolution. It means the general assumption is that ecological interactions happen on such a short time scale in comparison to evolution that evolution can be ignored—similar to the way physicists can often safely ignore relativity in the majority of their experiments.

"Our results represent a first significant step in showing that evolution cannot be ignored when studying ecological interactions. In earlier work, we had shown that guppies, our study organism, can evolve very rapidly. In this new study we quantify the ecological consequences of such rapid adaptation."

Study results appear this week in the online early edition of the Proceedings of the National Academy of Sciences.

Reznick's team compared guppies - small freshwater fish that have been the subject of long-term studies - that had adapted to two different types of stream communities in Trinidad. One stream community had a diverse group of fish species, some of which were serious predators on guppies. The other type of community included guppies and just one or a few non-predatory species.

Previously, Reznick and colleagues had established that predators cause a substantial increase in guppy mortality rates, resulting in guppies that are younger at maturity, produce more babies, and display different behavior, escape abilities and body shapes.

In the new experiments, the researchers collected guppies from the two different types of communities, and quantified their impact on the stream ecosystem by placing them in replicate, artificial streams built alongside a natural stream. The researchers chose this location for the artificial streams so that they could divert water from a spring that normally flowed into the stream in such a way that it first flowed through the artificial streams, emptying later into the natural stream.

Next, they seeded the artificial streams with organisms such as insect larvae from the natural stream so that all artificial streams had similar ecosystems at the start of the experiment.

This photo shows the replicate, artificial streams used in the experiments. In total, 16 such streams were used. Credit: Ronald Bassar, UC Riverside.

They found that guppies from the two types of fish communities had substantially different impacts after only four weeks on the structure and function of their ecosystems.

"Guppies from the more diverse fish communities ate more insect larvae while the low-predation guppies - guppies from the simple fish

communities - ate more algae," said Ronald Bassar, a graduate student in Reznick's lab and the first author of the research paper. "These differences in diet resulted in the artificial streams with guppies from the diverse communities having substantially more algae and fewer invertebrates than streams stocked with guppies from the simple communities.

"There were corresponding differences in how and at what rate nutrients, like nitrogen or phosphorus, were recycled. The streams with high-predation guppies - guppies from the more diverse fish communities - had less plant production and oxygen consumption, a slower breakdown of leaves that had fallen into the water and a slower accumulation of detritus, the breakdown product of leaves."

The researchers found, too, that their findings from their experiments in the artificial streams mirrored their observations in guppies across natural stream communities in Trinidad.

"By doing our experiments in the artificial streams we are able to pin down guppies as a likely cause of what we see in the natural streams," Bassar said. "The experiments show that local adaptation causes the evolution of differences in diet, which, in turn, causes differences in ecosystem structure. Our next step is to characterize how this changed ecosystem, in turn, shapes how the guppies adapt to it."

Provided by University of California - Riverside