EVOLUTION

Predator-Free Guppies Take An Evolutionary Leap Forward

For a small population of Trinidadian guppies, meeting evolutionary biologist David Reznick in 1981 was like winning the lotto of life. The University of California, Riverside, researcher scooped the lucky fish from a waterfall pool brimming with predators, then released them upstream in a pool where only one enemy species lurked. The guppies adjusted to the perks of life with few predators by growing bigger, living longer, and having fewer and bigger offspring. Now, a new analysis of this 11-year study offers intriguing insights into the speed of such evolutionary change.

Although natural selection is often thought of as a slow pruning process, Reznick and his colleagues find that it can shape a population as fast as a chain saw can rip through a sapling. On page 1934, they report that the guppies adapted to their new environment in a mere 4 years—a rate of change some 10,000 to 10 million times faster than the average rates determined from the fossil record. Although lab studies have shown similarly fast rates of natural selection, this is one of the few examples from a natural environment. "That's why this study is so marvelous," says Dolph Schluter, an evolutionary ecologist at Canada's University of British Columbia in Vancouver. Reznick has "brought his evolutionary experiment out of the lab and into the wild."

And Reznick claims that the work offers clues to larger evolutionary patterns such as that of stasis (a lengthy period when organisms don't appear to evolve) punctuated by rapid bursts of change. Not everyone agrees, but some biologists support the idea. "There's always that question," says Thomas B. Smith, an evolutionary biologist at San Francisco State University. "Can we get some inkling about what happened in the past by observing what's going on today? Microevolutionary studies such as this show that we can."

The current work starts with research that Reznick and other colleagues published in 1990, showing that guppies evolve in size, reproductive strategies, and other traits in response to predators in the wild. For example, in Trinidad's Aripo River, a species of cichlid fish feeds primarily on relatively large—2 to 3 centimeter—sexually mature guppies; in nearby tributaries, killifish prefer tender young fish. In response to these different pressures, the guppies have evolved two different life-history strategies. Those in the Aripo River reach sexual maturity at an early age and

Living in the fast lane. Guppies transplanted from this predator-filled pool rapidly evolved to larger sizes.

bear many young, while the guppies in the tributaries do just the opposite. Reznick's team proved that predation caused this pattern; he did so by transplanting guppies from the Aripo River to a tributary that happened to be empty of guppies and where killifish were the only predators. By 11 years later, the transplanted guppies had switched strategies, delaying their sexual maturity and living longer.

Building on that study, Reznick, Frank and Ruth Shaw from the University of Minnesota, and F. Helen Rodd from the University of California, Davis, now analyze their data to see just how fast those changes occurred. In as little as 4 years, male guppies in the predator-free tributary were already detectably larger and older at maturity when compared with the control population; 7 years later, females were also noticeably larger and older. The team then used standard quantitative genetics to determine the rate of evolution for these genetic changes.

Their analysis showed that in only 4 years, the male guppies increased 15% in weight—roughly, from that of a dime to that of a penny. Biologists estimate the speed of evolutionary change in darwins, or the proportional amount of change per unit of time, and the guppies evolved at a rate between 3700 and 45,000 darwins. For comparison, artificial selection experiments on mice show rates of up to 200,000 darwins, while most rates measured over millions of years in the fossil record are only one-tenth to 1.0 darwin. "It's further proof that evolution can be very, very fast and dynamic," says Philip Gingerich, a paleontologist at the University of Michigan, Ann Arbor, who has analyzed evolutionary rates. "It can happen on a time scale that's as short as one generation—from us to our kids."

Because the guppies evolved at rates four to seven orders of magnitude greater than those estimated from the fossil record, Reznick suggests that selection on such short time scales is powerful enough to be behind major evolutionary changes. Indeed, he says the study demonstrates that it is "possible to reconcile large-scale evolutionary phenomena, such as stasis, with what we can see in our lifetimes."

Reznick notes that his study and one by Princeton University's Peter and Rosemary Grant show two different ways that organisms can attain stasis. In their study, the Grants found that Galápagos Island finches also adapt rapidly to sudden changes in their environment, such as variations in rainfall. But because years of drought favor larger, big-billed finches while rainy weather favors smaller, small-beaked finches, the net long-term effect was that "nothing seemed to change," says Reznick. The guppies also quickly entered a new period of stasis, but in a different way: Because their new environment was constant, they stopped evolving when they reached a new optimum size and age. Unless faced with some fresh selective pressure, the transplanted guppy population will remain as it is now—in stasis.

To some, Reznick's study has implications for reading the fossil record. For example, paleontologists sometimes interpret dramatic changes in size as a sign of the birth of a new species. But, notes Brian Charlesworth, an evolutionary geneticist at the University of Chicago, "papers such as this demonstrate that is not [necessarily] true. As far as I know, these are still guppies."

Others aren't so sure that such short-term studies have any bearing on fossils. Particularly irksome, they say, is Reznick's comparison of his decade-long study with that of the millennia-long fossil record. Says Cornell University evolutionary biologist Amy McCune, "His study is fine, but his conclusions drive me crazy. He's overstepped the boundaries of what it means." Evolutionary rates from the fossil record are necessarily lowered because they average periods of rapid change with periods of slow change or stasis. So, it is not meaningful to compare these rates with the flash-in-the-pan 11 years of guppy changes, McCune says. The data also provide little understanding of such phenomena as bursts of new species, she notes. That would take studies of speciation itself, rather than research on change within an interbreeding group of guppies.

Still, this evolution-in-the-wild study has fired the imaginations of other biologists bent on studying evolution in action. British Columbia's Schluter, for one, is already designing a similar project. "We're entering a new age of these … experiments," he says, "and from them, we'll gain a deeper understanding of evolutionary patterns."

–Virginia Morell