Fish evolve a longer lifespan by evolving a longer period during which they reproduce

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Image: The fish at the top is the pike cichlid, Crenicichla alta. It is one of the key predators in high-predation localities. The middle fish is the killifish Rivulus hartii. It is the only predator that co-occurs with guppies in low-predation sites. The fish on the bottom left is an adult male guppy while the one on the bottom right is an adult female guppy. Photo credit. D. Reznick.

A UC Riverside-led research team has found that as some populations of an organism evolve a longer lifespan, they do so by increasing only that segment of the lifespan that contributes to "fitness" – the relative ability of an individual to contribute offspring to the next generation.

Focusing on guppies, small fresh-water fish biologists have studied for long, the researchers found that guppies living in environments with a large number of predators have adapted to reproduce earlier in life than guppies from low-predation localities. Moreover, when reproduction ceases, guppies from high-predation localities are far older, on average, than guppies from low-predation localities, indicating that high-predation guppies enjoy a long "reproductive period" – the time between first and last reproduction.

"In earlier work, we showed that guppies from high predation environments have longer lifespans," said David Reznick, professor of biology. "Our new study explores how and why this happens. We found that fish from populations enjoying longer lifespans live longer because there is a selective increase in their reproductive lifespan. Indeed, theory predicts this result because only reproductive lifespan determines fitness."

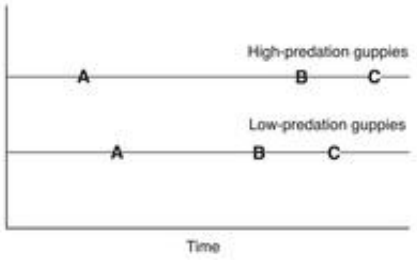

Image: Guppies in environments with a high number of predators live longer than low-predation guppies because the former have evolved a long reproductive period, a study led by David Reznick reports. In the above chart, "A" marks the time reproduction begins, "B" marks the time reproduction ceases, and "C" marks the time of death for guppies. The reproductive period is therefore AB.

Study results appear Dec. 27 in the online edition of the Public Library of *Science* – *Biology*.

The study supports the controversial hypothesis that natural selection – the process in nature by which only organisms best adapted to their environment tend to survive and pass on their genetic characters in increasing numbers to succeeding generations – introduces changes in only a specific segment of an organism's lifespan.

The researchers conducted their experiments by comparing life-history traits in 240 guppies they retrieved from high- and low-predation streams in

mountains in Trinidad. In their analysis, they divided the life history into three non-overlapping segments: the age at maturity (birth to first reproduction), the reproductive lifespan (first to last reproduction) and the post-reproductive lifespan (last reproduction to death). They also devised a statistical criterion for evaluating whether or not guppies had a post-reproductive lifespan, that is, did guppies live significantly past the end of their capacity to reproduce?

“We were exploring whether or not fish have the equivalent of mammalian menopause,” Reznick said. “We found that 60 percent of the fish had a significant post-reproductive lifespan, indicating that, yes, fish do have menopause. Indeed, their patterns of growing old are similar to those of mammals.”

The researchers’ statistical analysis also showed that regardless of which environments the guppies lived in, there were no differences among their populations in the probability of having a post-reproductive lifespan or in its duration.

“This is just what one might predict because these fish provide no care for their young,” explained Reznick. “The older fish, after they stop reproducing, do not contribute to the fitness of young fish. As a result, the post-reproductive period is not influenced by natural selection. This result could be of interest to those who study menopause in humans and who have argued that post-reproductive humans can increase their own fitness by contributing to the fitness of their grandchildren and that the prolonged post-reproductive lifespan of humans is, therefore, the product of natural selection.

“But such arguments are difficult to prove by working on a single population or species. Nevertheless, our results show how it would be possible to evaluate whether or not menopause in humans has been shaped by natural selection. Appropriate comparisons, such as those between humans and apes, would help.”

Reznick was assisted in the study by Michael Bryant of the California Institute of the Arts and Donna Holmes of the University of Idaho. The Population Biology Division of the National Research Foundation provided support.

Source: University of California, Riverside