New study links speciation and size evolution across all ray-finned fishes

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A comprehensive new study of more than 7,000 species of fish documents for the first time correlation on a grand scale between the rapidity of the origin of the species and the rate of morphological change.

In other words, groups of fish that rapidly split into new species tend to quickly evolve diversity in physical traits, such as the size of their bodies, while others described by Charles Darwin as "living fossils" because of their prehistoric characteristics show little change over millions of years in either numbers of species or types of morphologies.

The study is important because it links speciation with morphological adaptation on a scale that has never been done. It also demonstrates that variation in a single evolutionary process may create both living fossils and adaptive radiations, which are two of the most famous and celebrated phenomena in the history of life, the authors say.

Findings of the study are being published this week in *Nature Communications*.

A multidisciplinary team of researchers created a "Tree of Life" of ray-finned fishes, which comprise a majority of vertebrate biological diversity, to compare evolutionary rates across all families of fishes. The project was funded by the National Science Foundation, the Miller Institute at University of California, Berkeley, and UCLA, and featured scientists from the University of Michigan, UCLA, University of Torino,

University of Idaho, and Oregon State University.

"We were able to document the link between speciation and morphological evolution, but the question remains as to whether the speciation process itself leads to changes in anatomy or whether something in the anatomically diverse lineages promotes speciation," said Daniel Rabosky, an assistant professor of ecology and evolutionary biology at the University of Michigan and co-lead author on the study.

Co-lead author Michael Alfaro, a UCLA scientist who specializes in the evolution of marine fishes, said one key facet in the correlation between evolutionary and morphological change is body size.

"The fastest speciating fish typically also had the fastest rate of size evolution," Alfaro said. "It didn't seem to matter whether they were freshwater or marine fish, or lived in cold or warm environments – the correlation was amazingly consistent. Changes in body size were closely linked to speciation, but whether one causes the other isn't yet clear."

The research team synthesized existing data from GenBank, FishBase and other sources to create their comprehensive phylogenetic tree of living fishes, which is one of the largest trees ever assembled for any group of animals.

Inclusion of so many species was critical to investigating body size evolution at such a grand scale.

Co-author Brian Sidlauskas, an Oregon State University ichthyologist specializing in the conservation of freshwater fish, said the study helps illustrate and explain the differences between dynamic groups of fish, characterized by African cichlids, and living fossils such as sturgeon and gars.

"Cichlids are the poster children for explosive adaptive radiation, having rapidly diversified into a vast number of species with different characteristics," said Sidlauskas, who curates the Oregon State University Ichthyology Collection in the Department of Fisheries and Wildlife. "Whitefishes are another example. They have only been in glacial lakes for a few thousand years, yet they already have branched repeatedly into two or three different morphologies, including some that feed on the bottom and others in mid-water."

Based on the new results, cichlids and whitefishes fall into the 10 percent of fastest-evolving and speciating fishes, along with rockfishes, snailfishes, pufferfishes and several other groups.

"Sturgeon and gars are just the opposite, showing remarkably few changes over millions of years and little tendency to speciate," Sidlauskas noted. "It isn't just ecological opportunity. If you put a handful of gars into the Rift Lakes of Africa, it is doubtful they would have evolved much. Yet cichlids evolved into hundreds of different species with different morphologies. Something in the wiring differs from one group of fish to another, and that's what we need to investigate next."

The authors say that although their study focused on ray-finned fishes, the same correlation potentially may be applicable to other branches of the Tree of Life, including mammals, birds, insects, plants and snails.

Provided by Oregon State University