Researcher reveals how amphibians crossed continents

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Pseudophilautus poppiae, a microendemic shrub frog from Southern Sri Lanka that only occurs in a few hectares of cloud forest. Credit: Alex Pyron

There are more than 7,000 known species of amphibians that can be found in nearly every type of ecosystem on six continents. But there have been few attempts to understand exactly when and how frogs, toads, salamanders and caecilians have moved across the planet throughout time.

Armed with DNA sequence data, Alex Pyron, an assistant professor of biology at the George Washington University, sought to accurately piece together the 300-million-year storyline of their journey.

Dr. Pyron has succeeded in constructing a first-of-its-kind comprehensive diagram of the geographic distribution of amphibians, showing the movement of 3,309 species between 12 global ecoregions. The phylogeny—or diagram of evolutionary relationships—includes about half of all extant amphibian species from every taxonomic group.

"There have been smaller-scale studies, but they included only a few major lineages and were very broad," Dr. Pyron said. "What we needed was a large-scale phylogeny that included as many species as possible. That allows us to track back through time, not only how different species are related, but also how they moved from place to place."

His findings, which appear in the journal *Systematic Biology*, suggest that, contrary to popular belief, certain groups of amphibians may have swam long distances from one landmass to another within the past few million years.

Biologists have long hypothesized the distribution of extant lineages of amphibians has been driven by two major processes: vicariance and dispersal.

Vicariance occurs when a population is separated following a large-scale geophysical event. After the fragmentation of supercontinent Pangaea and the subsequent split of the Laurasian and Gondwanan landmasses, certain groups of amphibians were able to "hitch a ride" from one continent to another, Dr. Pyron explained. The researcher's biogeographic analysis supports this hypothesis, showing that continental movement can explain the majority of patterns in the distribution of extant species of amphibians.

Dr. Pyron also found that dispersal during the Cenozoic Era (66 million years ago to the present), likely across land bridges or short distances across oceans, also contributed to their distribution.

Given their ancient origin, it is unsurprising that the history of amphibians is a mixture of both vicariance and dispersal. But the third and final distribution pattern that Dr. Pyron notes in his study was an unexpected finding.

Past studies have assumed that long-distance over water dispersal was essentially impossible for amphibians due to salt intolerance. However, when Dr. Pyron began completing his analysis, he noticed a number of cases of distribution that could not be explained by old age.

For instance, one group of frogs found in Australia and New Guinea (pelodryadine hylids) that originated around 61 to 52 million years ago is deeply nested within a group of amphibians that exist only in South America. By the time pelodryadines originated, all major continental landmasses occupied their present-day positions, with South America and Australia long separated from Antarctica.

"They're 120 million years too late to have walked to Australia," Dr. Pyron said.

So how could this group of South American amphibians be related to frogs on the other side of the world?

"You wouldn't think that frogs would be able to swim all the way there, but that seems like one of the more likely explanations for how you could have such a young group nested within South America and have it somehow get to this other continent," Dr. Pyron said.

In his study, Dr. Pyron points two other instances of long-distance oceanic dispersal.

"What you have is this mixture of processes. You have vicariance, which over 300 million years has put certain groups in Africa, some in Australia and others in South America," Dr. Pyron said. "But even more recently, within the last few million years, you have these chance events of long distance dispersals across the ocean, which can influence distribution patterns."

Dr. Pyron's next research question is whether there is any specific quality, such as tolerance to salt water, which allows some groups of amphibians to be better dispersers. He has also begun to conduct a similar analysis with lizards and snakes to see if the same distribution patterns hold up. And as new species are discovered, Dr. Pyron will continue to revise his model.

These findings not only provide evidence for the unlikely hypothesis of long-distance oceanic dispersal, but they also provide a model for explaining the distribution of other species and learning about the geographic diversity of different groups. For example, an endangered frog in South America unconnected to any other major lineages would need to be a high conservation priority.

"That's something we can only learn from a biogeographic analysis," Dr. Pyron said.

More information: R. Alexander Pyron. "Biogeographic Analysis Reveals Ancient Continental. Vicariance and Recent Oceanic Dispersal in Amphibians." *Syst Biol* first published online June 19, 2014 DOI: 10.1093/sysbio/syu042

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