No single explanation for biodiversity in Madagascar

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Over 90 percent of the more than 700 species of reptiles and amphibians that live in Madagascar -- like the jeweled chameleon (*Furcifer campani*) shown here -- occur nowhere else on Earth. A study of how Madagascar's unique biodiversity responded to environmental fluctuations in the past suggests that the climate change and deforestation that the island is experiencing today will have varying effects on different species. Credit: Jason L. Brown, City College of New York.

No single "one-size-fits-all" model can explain how biodiversity hotspots come to be, finds a study of more than 700 species of reptiles and amphibians on the African island of Madagascar.

By analyzing the geographic distribution of Madagascar's lizards, snakes, frogs and tortoises, an international team of researchers has found that each group responded differently to environmental fluctuations on the island over time.

The results are important because they suggest that climate change and land use in Madagascar will have varying effects on different species, said Jason Brown of the City College of New York.

"It means that there won't be a uniform decline of species—some species will do better, and others will do worse," said Brown, a co-author on the study appearing online in the journal *Nature Communications*.

The study is part of a larger body of research aimed at identifying the climate, geology and other features of the environment that help bring new species of plants and animals into being in an area, and then sustain once they're there.

Located 300 miles off the southeast coast of Africa, the island of Madagascar is a treasure trove of unusual animals, about 90 percent of which are found nowhere else on Earth. Cut off from the African and Indian mainlands for more than 80 million years, the animals of Madagascar have evolved into a unique menagerie of creatures, including more than 700 species of reptiles and amphibians—snakes, geckos, iguanas, chameleons, skinks, frogs, turtles and tortoises.

Visitors to the island may come across neon green geckos that can grow up to a foot in length, and tiny tree frogs that secrete toxic chemicals from their skin and come in combinations of black and iridescent blue, orange, yellow and green. They'll also find about half of the world's chameleons—lizards famous for their bulging eyes, sticky high-speed tongues and ability to change color.

Researchers have long sought to understand how Madagascar—a country that makes up less than 0.5 percent of the Earth's land surface area—gave rise to so many unusual species.

Previous studies have linked the distribution of species to various factors, such as steep slopes that fuel diversity by creating a range of habitats in a small area. But few studies have integrated all of these variables into a single model to examine the relative influence of multiple factors at once, Brown said.

He and Duke University biologist Anne Yoder and colleagues developed a model that combines the modern distributions of 325 species of amphibians and 420 species of reptiles that live in Madagascar today with historical and present-day estimates of topography, rainfall and other variables across the island.

From steep tropical rainforests to flat, desert-like regions, the researchers analyzed three measures of biodiversity: the number of species, the proportion of unique species and the similarity of species composition from one site to another.

"Not surprisingly, we found that different groups of species have diversified for different reasons," Yoder said.

For example, changes in elevation—due to the mountains, rivers and other features that shape the land—best predicted which parts of the island had high proportions of unique tree frog species. But the biggest influence on why some areas had higher proportions of unique leaf chameleons was climate stability through time.

"What governs the distribution of, say, a particular group of frogs isn't the same as what governs the distribution of a particular group of snakes," Brown said. "A one-size-fits-all model doesn't exist."

Understanding how species distributions responded to environmental fluctuations in the past may help scientists predict which groups are most vulnerable to global warming and deforestation in the future, or which factors pose the biggest threat.

Other studies have found that some of Madagascar's reptiles and amphibians are already moving up to higher elevations due to climate change, and roughly 40 percent of the country's reptile species are threatened with extinction due to logging and farming in their forest habitats.

The difficulty of using this model to predict species' responses is that the environmental fluctuations the researchers examined occurred over tens of thousands of years, whereas the changes in climate and land use that Madagascar is currently experiencing are taking place over a matter of decades, said Brown, who was a postdoctoral research associate at Duke at the time of the research.

Making accurate predictions about the threat of future extinction requires determining the timescales at which current environmental changes pose a threat.

"One of the lessons learned is that when trying to assess the impacts of future climate change on species distribution and survival, we have to deal in specifics rather than generalities, since each group of animals experiences its environment in a way that is unique to its life history and other biological characteristics," Yoder said.

More information: "A necessarily complex model to explain the biogeography of the amphibians and reptiles of Madagascar," Brown, Jl, et al. *Nature Communications*, October 2014. DOI: 10.1038/ncomms6046

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