

Hurricanes twist evolution in island lizards

April 27 2020



Photos of *Anolis scriptus*, the Turks and Caicos anole, on Pine Cay. Credit: Colin Donihue, Washington University in St. Louis

Hold that thought: A good grip can mean the difference between life and death for lizards in a hurricane—and as a result, populations hit more frequently by hurricanes have larger toepads.

A new study from Washington University in St. Louis is the first to

demonstrate evolutionary response to hurricanes on a wide geographic scale. The research is published the week of April 27 in the *Proceedings of the National Academy of Science*.

Lizard groups that more frequently experience hurricanes evolve larger toepads than those that experience relatively fewer hurricanes, according to a new analysis that spans 12 island populations of *Anolis sagrei* lizards and, separately, 188 *Anolis* species with ranges from Florida to Brazil.

Scientists have known for a long time that lizards on the Caribbean islands have larger toepads than those on the mainland. But this physical difference has never been definitively linked to an evolutionary response to hurricanes. Hurricanes happen so infrequently that researchers used to think their effects would be erased by natural selection favoring normal conditions.

"What we found is that hurricanes actually do have evolutionary effects on lizards that span both geographic and phylogenetic scales," said Colin Donihue, a postdoctoral fellow in biology in Arts & Sciences at Washington University. "We showed that hurricanes affect a single anole species in Turks & Caicos, and those effects are likely inherited to the next generation—suggesting an evolutionary change. The effects are paralleled across 12 island populations of a different anole species, and ultimately can be detected across an entire genus of very distantly related anole lizards."

The hurricane effect was much broader than anyone anticipated.

"My role on this paper was to tell Colin not to bother, he was never going to find anything," said Jonathan Losos, the William H. Danforth Distinguished Professor at Washington University and professor of biology in Arts & Sciences. Losos is director of the Living Earth Collaborative.

"I thought it was extremely unlikely that hurricanes would have a big enough and long-lasting enough effect on the populations that it would show up when you compare populations or species," Losos said. "Of course, I was absolutely wrong and Colin was absolutely right. And the patterns he found are quite exciting."

The effects are observable at the population level, at the species level and across a broad region of neotropics including the Caribbean, Central America and much of South America. The new analysis relies on 70 years of NOAA hurricane data from the north Atlantic and north Pacific oceans and hundreds of anole toepad measurements from across their entire neotropical range.

"We poked and prodded the data every which way to try to find if there were any holes in it," Losos said. "And I'm convinced that it's robust."

In 2017, Donihue had just finished a detailed survey of *Anolis* lizards in Turks & Caicos for another research effort when Hurricane Irma struck the islands directly, a Category 5 storm with winds in excess of 170 mph. Two weeks later, Hurricane Maria scored a second direct hit on the islands. Donihue's immediate before-after comparison showed that survivors of these hurricanes had different physical traits than the general population before the storms.

For the new study, Donihue and colleagues returned to Turks & Caicos one year later and took new measurements. Lizards in the next generation had toepads as large as the survivors that had been measured immediately following the hurricane.

The researchers thought that if hurricanes really do affect toepad evolution, then those lizards that live in areas hit by hurricanes more frequently should have larger toepads—all other things being equal. But it's not actually possible to go back and see how the incidence of

hurricanes has affected toepad size. Instead, as a next step, the researchers looked at many different lizard populations with different histories—substituting a comparison across space for a comparison over time.

To quantify exposure to hurricanes, collaborator Alex Kowaleski, a postdoctoral scholar at the Penn State College of Earth and Mineral Sciences, used data from NOAA on historical hurricane paths, primarily tapping the Atlantic Basin Hurricane Database (HURDAT 2) archive of the track and intensity of all North Atlantic cyclones. Even among the first set of 12 island populations that Donihue wanted to compare, there was a great amount of variability in exposure. For example, one population had been hit four times in the past 70 years, and one had not experienced a direct hit.

HURDAT 2 contains position and intensity data every 6 hours, but, for this study, Kowaleski interpolated the track and intensity data to every 15 minutes.

"This was important because it is possible for a hurricane to strike a location between two timesteps," Kowaleski said. "Interpolation allows us to better capture hurricane strikes at each location."

"Correcting for things like differences in body size, we found that island populations that had been hit by hurricanes more [frequently] had larger toepads," Donihue said. "Hurricanes seem to be having some sort of additive effect on the evolution of these lizards—that the more hurricanes you have, the larger toepads you have, on average."

"Toepads might be a key trait for helping lizards hold on tight to the vegetation during storms," he said. "But there's probably a tradeoff between the traits that make you really good at surviving a hurricane and the traits that make you really good at being a lizard day in, day out."

"Most of the selective pressure is to just be good at being a lizard: to go catch food, find a mate and avoid predators. These [hurricane](#) events are very infrequent and unpredictable, so we expect that there are other selective pressures that are acting on toepads. In other words, over time, these toepads are not going to turn into big snowshoes, or something like that. There's a balance."

The results may have implications for other types of animals—not just [lizards](#)—and also for other changes under new climate scenarios.

"Our best idea right now is that tropical cyclones will become less frequent globally; however, a higher percentage of them will become intense hurricanes," Kowaleski said. "Increases in sea-surface temperatures will cause a higher percentage of tropical cyclones that do form to become Category 4 or 5 hurricanes."

"Precipitation intensity also is expected to increase in tropical cyclones due to climate warming," Kowaleski said.

"My best guess is that this isn't just a lizard thing," Donihue said. "For any other species affected by hurricanes where survival is non-random, you would predict this same kind of pattern occurring."

"I'm really hoping that this is going to spark some new analyses of old data—or new data collection going forward—thinking about how hurricanes might be affecting things like the evolution of plants and trees, or snails ... or any of the other species affected by hurricanes in this region."

More information: Colin M. Donihue et al., "Hurricane effects on Neotropical lizards span geographic and phylogenetic scales," *PNAS* (2020). www.pnas.org/cgi/doi/10.1073/pnas.2000801117

Provided by Washington University in St. Louis

Citation: Hurricanes twist evolution in island lizards (2020, April 27) retrieved 10 April 2024 from <https://phys.org/news/2020-04-hurricanes-evolution-island-lizards.html>

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