

Study finds human-driven mass extinction is eliminating entire branches of the tree of life

September 18 2023



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The passenger pigeon. The Tasmanian tiger. The Baiji, or Yangtze river

dolphin. These rank among the best-known recent victims of what many scientists have declared the sixth mass extinction, as human actions are wiping out vertebrate animal species hundreds of times faster than they would otherwise disappear.

Yet, an analysis from Stanford University and the National Autonomous University of Mexico, published in the *Proceedings of the National Academy of Sciences*, shows the crisis may run even deeper. Each of the three [species](#) above was also the last member of its [genus](#), the higher category into which taxonomists sort species. And they aren't alone.

Up to now, public and scientific interest has focused on extinctions of species. But in their new study, Gerardo Ceballos, senior researcher at the Institute of Ecology at the National Autonomous University of Mexico, and Paul Ehrlich, Bing Professor of Population Studies, Emeritus, in the Stanford School of Humanities and Sciences, have found that entire genera (the plural of "genus") are vanishing as well, in what they call a "mutilation of the tree of life."

"In the long term, we're putting a big dent in the evolution of life on the planet," Ceballos said. "But also, in this century, what we're doing to the tree of life will cause a lot of suffering for humanity."

"What we're losing are our only known living companions in the entire universe," said Ehrlich, who is also a senior fellow, emeritus, by courtesy, at the Stanford Woods Institute for the Environment.

A 'biological annihilation'

Information on species' conservation statuses from the [International Union for the Conservation of Nature](#), [Birdlife International](#), and other databases has improved in recent years, which allowed Ceballos and Ehrlich to assess [extinction](#) at the genus level. Drawing from those

sources, the duo examined 5,400 genera of land-dwelling [vertebrate animals](#), encompassing 34,600 species.

A total of 73 genera of land-dwelling vertebrates, Ceballos and Ehrlich found, have gone extinct since 1500 AD. Birds suffered the heaviest losses with 44 genus extinctions, followed in order by mammals, amphibians, and reptiles.

Based on the historic genus extinction rate among mammals—estimated for the authors by Anthony Barnosky, professor emeritus of integrative biology at UC Berkeley—the current rate of vertebrate genus extinction exceeds that of the last million years by 35 times.

This means that, without [human influence](#), Earth would likely have lost only two genera during that time. In five centuries, human actions have triggered a surge of genus extinctions that would otherwise have taken 18,000 years to accumulate—what the paper calls a "biological annihilation."

"As scientists, we have to be careful not to be alarmist," Ceballos acknowledged—but the gravity of the findings in this case, he explained, called for more powerful language than usual. "We would be unethical not to explain the magnitude of the problem, since we and other scientists are alarmed."

Next-level loss, next-level consequences

On many levels, genus extinctions hit harder than species extinctions.

When a species dies out, Ceballos explained, other species in its genus can often fill at least part of its role in the ecosystem. And because those species carry much of their extinct cousin's genetic material, they also retain much of its evolutionary potential.

Pictured in terms of the tree of life, if a single "twig" (a species) falls off, nearby twigs can branch out relatively quickly, filling the gap much as the original twig would have. In this case, the diversity of species on the planet remains more or less stable.

But when entire "branches" (genera) fall off, it leaves a huge hole in the canopy—a loss of biodiversity that can take tens of millions of years to "regrow" through the evolutionary process of speciation. Humanity cannot wait that long for its life-support systems to recover, Ceballos said, given how much the stability of our civilization hinges on the services Earth's biodiversity provides.

Take the increasing prevalence of Lyme disease: white-footed mice, the primary carriers of the disease, used to compete with passenger pigeons for foods, like acorns. With the pigeons gone and predators like wolves and cougars on the decline, mouse populations have boomed—and with them, human cases of Lyme disease.

This example involves the disappearance of just one genus. A mass extinction of genera could mean a proportional explosion of disasters for humanity.

It also means a loss of knowledge. Ceballos and Ehrlich point to the gastric brooding frog, also the final member of an extinct genus. Females would swallow their own fertilized eggs and raise tadpoles in their stomachs, while "turning off" their stomach acid. These frogs might have provided a model for studying human diseases like acid reflux, which can raise the risk of esophageal cancer—but now they're gone.

Loss of genera could also exacerbate the worsening climate crisis. "Climate disruption is accelerating extinction, and extinction is interacting with the climate, because the nature of the plants, animals,

and microbes on the planet is one of the big determinants of what kind of climate we have," Ehrlich pointed out.

A crucial, and still absent, response

To prevent further extinctions and resulting societal crises, Ceballos and Ehrlich are calling for immediate political, economic, and social action on unprecedented scales.

Increased conservation efforts should prioritize the tropics, they noted, since tropical regions have the highest concentration of both genus extinctions and genera with only one remaining species. The pair also called for increased public awareness of the extinction crisis, especially given how deeply it intersects with the more-publicized climate crisis.

"The size and growth of the human population, the increasing scale of its consumption, and the fact that the consumption is very inequitable are all major parts of the problem," the authors said.

"The idea that you can continue those things 'and' save biodiversity is insane," Ehrlich added. "It's like sitting on a limb and sawing it off at the same time."

More information: Ceballos, Gerardo, Mutilation of the tree of life via mass extinction of animal genera, *Proceedings of the National Academy of Sciences* (2023). [DOI: 10.1073/pnas.2306987120](https://doi.org/10.1073/pnas.2306987120).
doi.org/10.1073/pnas.2306987120

Provided by Stanford University

Citation: Study finds human-driven mass extinction is eliminating entire branches of the tree of life (2023, September 18) retrieved 2 December 2025 from

<https://phys.org/news/2023-09-human-driven-mass-extinction-entire-tree.html>

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