Why are lemurs nearly extinct, and yet so diverse?

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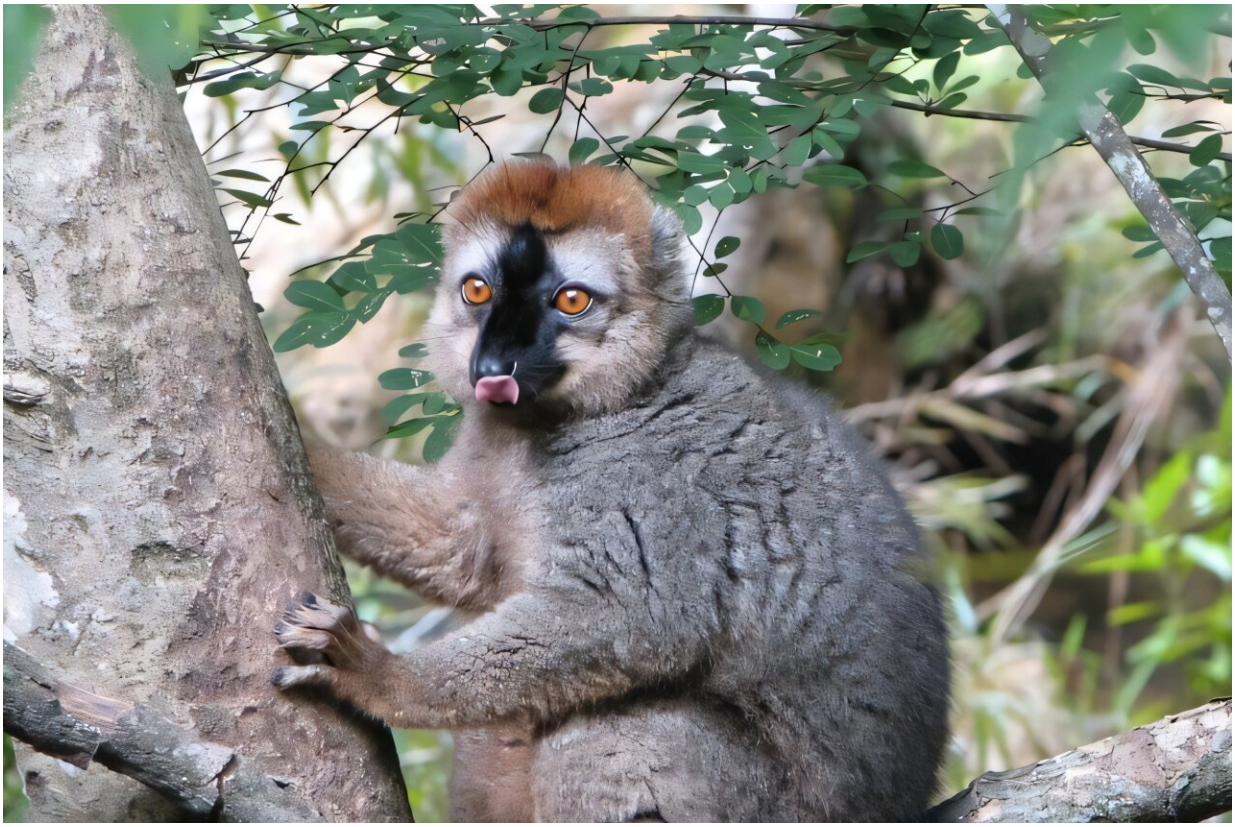

Red fronted lemur (Eulemur rufifrons). Credit: Bernard Gagnon, CC BY-SA, via Wikimedia Commons

Lemurs, small, big-eyed primates that live in the trees of Madagascar off the southeast coast of Africa, are a mystery of evolution. When the first

ones arrived there tens of millions of years ago, they found an island with wildly diverse ecosystems, from wet tropical forests in the east to arid expanses in the southwest.

Without many other mammalian competitors, those early lemurs evolved into a dizzying array of forms, everything from teacup-sized mouse lemurs to giant sloth lemurs. Many of these lemurs have incredibly high levels of genetic diversity, yet paradoxically, almost all—90%—of the more than 100 species that live on the island are threatened with extinction.

To find out why—and maybe solve the mystery—anthropologists and biologists at Université de Montréal and Pompeu Fabra University (PFU), in Spain, took a genetics approach: they sequenced the genomes of 162 lemurs from 50 species across Madagascar, by far the largest effort to sequence lemur genomes to date.

In a major advance in the understanding of how primate genomic diversity has been influenced by ecological and anthropogenic factors, their international research team revealed the extraordinary diversity of these long-neglected, endangered primates.

Led by UdeM assistant professor Joseph Orkin, principal investigator at the multiomic primate evolution lab of UdeM's anthropology and biological sciences departments, and Spanish research professor Tomas Marques Bonet, principal investigator at the PFU's Institute of Evolutionary Biology, in Barcelona, they uncovered a number of things.

In particular, they showed how ecological variation, climatic fluctuations and recent human activity have all influenced the genetic diversity of lemurs, as well as their prospects of survival over the long term.

Widespread gene flow

Published in *Nature Ecology & Evolution*, the study's analyses reveal widespread gene flow between lemur species over hundreds of thousands of years.

"As climatic shifts periodically connected once-isolated habitats, lemurs from different species and populations would interbreed, sharing genetic material that boosted their overall diversity," Orkin said.

"On top of that, the most diverse species appear to be the ones with fragmented populations in multiple ecosystems across the island. This pattern of isolation and reconnection seems to be building up and redistributing genetic variation across the island."

He added, "Many species of lemurs have super-high levels of genomic diversity, which seems counterintuitive when you consider that so many of them are critically endangered. It was really exciting to see how the ecology of Madagascar helped to shape the diversity of lemurs."

Humans played a major role

While Madagascar itself may be a laboratory for the diversity of lemurs, recent human activity has played a major role in their collapsing populations. The data show a striking correspondence between human population expansion, deforestation, and shifts in hunting practices—and the start of severe lemur population declines.

No one knows when exactly humans first arrived on Madagascar, but it's clear that their numbers started to grow around 1,000 years ago and that the landscape of the island started changing in a major way by the 1700s, said Orkin.

"When we looked at the genetic evidence for population declines, we

kept seeing these two consistent inflection points around 1,000 and 300 years ago. It was really striking to see such a clear overlap between the timing of human population expansion and the decline of lemur populations."

These findings carry significant implications for conservation strategies, he added. Habitat fragmentation and deforestation not only threaten lemurs by reducing population sizes but also by cutting off the natural corridors that historically allowed gene flow. Without these genetic exchanges, the risk of inbreeding increases, further imperiling already endangered species.

"This story isn't unique to Madagascar," said Orkin. "Human population expansion is accelerating the loss of biodiversity everywhere we look. But the moral of the story is that humans are only one part of the natural world. The more we learn about how biodiversity is shaped by natural and human forces, the better chance we have of protecting it."

More information: Joseph D. Orkin et al, Ecological and anthropogenic effects on the genomic diversity of lemurs in Madagascar, *Nature Ecology & Evolution* (2024). DOI: 10.1038/s41559-024-02596-1

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