How interspecies competition led to a 'bizarre' pattern in our own evolutionary tree

April 17 2024

A cast of the skull of Homo Floresiensis, one of the hominin species analyzed in the latest study. Credit: The Duckworth Laboratory, University of Cambridge

Competition between species played a major role in the rise and fall of hominins—and produced a "bizarre" evolutionary pattern for the Homo

lineage—according to a new University of Cambridge study that revises the start and end dates for many of our early ancestors.

Conventionally, climate is held responsible for the emergence and extinction of hominin species. In most vertebrates, however, interspecies competition is known to play an important role.

Now, research shows for the first time that competition was fundamental to "speciation"—the rate at which new species emerge—across five million years of hominin evolution.

The study, published in *Nature Ecology & Evolution,* also suggests that the species formation pattern of our own lineage was unlike almost anything else.

"We have been ignoring the way competition between species has shaped our own evolutionary tree," said lead author Dr. Laura van Holstein, a University of Cambridge biological anthropologist from Clare College. "The effect of climate on hominin species is only part of the story."

In other vertebrates, species form to fill ecological "niches" says van Holstein. Take Darwin's finches: some evolved large beaks for nut-cracking, while others evolved small beaks for feeding on certain insects. When each resource niche gets filled, competition kicks in, so no new finches emerge and extinctions take over.

Van Holstein used Bayesian modeling and phylogenetic analyses to show that, like other vertebrates, most hominin species formed when competition for resources or space were low.

"The pattern we see across many early hominins is similar to all other mammals. Speciation rates increase and then flatline, at which point

extinction rates start to increase. This suggests that interspecies competition was a major evolutionary factor."

However, when van Holstein analyzed our own group, Homo, the findings were "bizarre."

A cast of the skull of Homo Heidelbergensis, one of the hominin species analyzed in the latest study. Credit: The Duckworth Laboratory, University of Cambridge

For the Homo lineage that led to modern humans, evolutionary patterns suggest that competition between species actually resulted in the appearance of even more new species—a complete reversal of the trend

seen in almost all other vertebrates.

"The more species of Homo there were, the higher the rate of speciation. So when those niches got filled, something drove even more species to emerge. This is almost unparalleled in evolutionary science."

The closest comparison she could find was in beetle species that live on islands, where contained ecosystems can produce unusual evolutionary trends.

"The patterns of evolution we see across species of Homo that led directly to modern humans is closer to those of island-dwelling beetles than other primates, or even any other mammal."

Recent decades have seen the discovery of several new hominin species, from Australopithecus sediba to Homo floresiensis. Van Holstein created a new database of "occurrences" in the hominin fossil record: each time an example of a species was found and dated, around 385 in total.

Fossils can be an unreliable measure of species' lifetimes. "The earliest fossil we find will not be the earliest members of a species," said van Holstein.

"How well an organism fossilizes depends on geology, and on climatic conditions: whether it is hot or dry or damp. With research efforts concentrated in certain parts of the world, and we might well have missed younger or older fossils of a species as a result."

Van Holstein used data modeling to address this problem, and factor in likely numbers of each species at the beginning and end of their existence, as well as environmental factors on fossilization, to generate new start and end dates for most known hominin species (17 in total).

She found that some species thought to have evolved through "anagenesis"—when one slowly turns into another, but lineage doesn't split—may have actually "budded": when a new species branches off from an existing one. (For example, the hominin species Australopithecus afarensis was believed to have speciated via anagenesis from Australopithecus anamensis. However, the new data modeling suggests they overlapped by around half a million years.)

A cast of the skull of Homo Erectus, one of the hominin species analyzed in the latest study. Credit: The Duckworth Laboratory, University of Cambridge

This meant that several more hominin species than previously assumed were co-existing, and so possibly competing.

While early species of hominins, such as Paranthropus, probably evolved physiologically to expand their niche—adapting teeth to exploit new types of food, for example—the driver of the very different pattern in our own genus Homo may well have been technology.

"Adoption of stone tools or fire, or intensive hunting techniques, are extremely flexible behaviors. A species that can harness them can quickly carve out new niches, and doesn't have to survive vast tracts of time while evolving new body plans," said van Holstein.

She argues that an ability to use technology to generalize, and rapidly go beyond ecological niches that force other species to compete for habitat and resources, may be behind the exponential increase in the number of Homo species detected by the latest study.

But it also led to Homo sapiens—the ultimate generalizers. And competition with an extremely flexible generalist in almost every ecological niche may be what contributed to the extinction of all other Homo species.

"These results show that, although it has been conventionally ignored, competition played an important role in human evolution overall. Perhaps most interestingly, in our own genus it played a role unlike that across any other vertebrate lineage known so far," added van Holstein.

More information: Diversity-dependent speciation and extinction in hominins, *Nature Ecology & Evolution* (2024). DOI: 10.1038/s41559-024-02390-z

Provided by University of Cambridge