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Lost African Lake Spawned Fish Diversity "Beyond Belief"

James Owen
for [National Geographic News](#)
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The cichlids, a family of tropical freshwater fish, have evolved an astonishing array of forms in Africa. Their diversity is perhaps most impressive in the Great Lakes of East Africa, where a handful of colonizing fish species have multiplied over thousands of years into many hundreds of species found nowhere else in the world.

Scientists say they have now uncovered a second evolutionary hot spot for these fish. The experts have traced the origins of cichlids in rivers across southern Africa to a single lake that no longer exists.

Writing in the latest issue of the science journal *Nature*, researchers say their discovery shows how evolutionary processes, even when operating in one location and for a limited period, can have a huge and lasting impact on a continent's wildlife.

The study team found that cichlids found today in rivers such as the Congo, Zambezi, Okavango, and Limpopo originated from a massive lake that dried up some 2,000 years ago. Known as Lake Makgadikgadi, it once covered an area larger than Switzerland and was centered north of the Kalahari Desert in present-day Botswana.

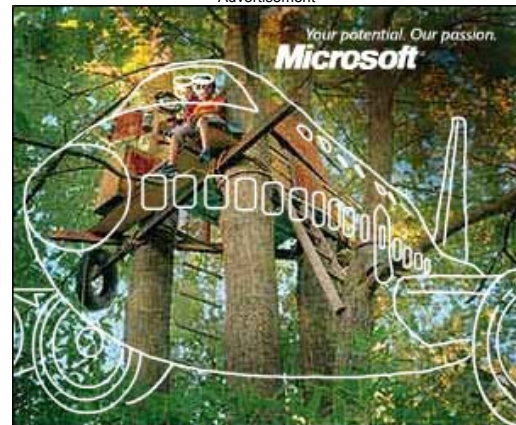
Researchers used genetic analysis to reveal the extent of the evolutionary dispersal of cichlid species from Lake Makgadikgadi. The scientists' finding is "truly impressive," said Thomas D. Kocher, a professor of zoology and genetics at the University of New Hampshire who was not involved in the study.

"The high rates of speciation [evolution of new species] observed in these African cichlids are almost beyond belief, but the evidence is clear," he added.

Kocher said Lake Makgadikgadi's remnant cichlids, which now swim the Congo, Zambezi, Okavango, and Limpopo Rivers, are almost as varied in appearance as species from the East African Great Lakes of Victoria and Malawi.

These river populations include "ambush predators with long heads and jaws, and snail crushers with deep heads and massive teeth." All that's missing, Kocher added, are a few specialized cichlids, such as plankton-sippers and algae-scrapers. He speculates that conditions preferred by these species aren't available in rivers.

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Scientists say the wide variety of cichlid fish living in rivers across southern Africa can be traced to a single lake that disappeared more than 2,000 years ago.

Photographs by Roger Bills/SAIAB

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The study was led by Domino Joyce of Hull University in England and the University of Berne in Switzerland. Her team plotted the geographical origins of southern African river cichlids through their mitochondrial DNA, which is inherited through the mother.

The researchers examined a set of closely linked genes called a haplotype, which tend to be inherited together. The haplotype revealed that the fish share a common ancestor, quite separate from that which first colonized East Africa's existing Great Lakes.

River Riddle

The findings appear to solve the riddle of why southern Africa's rivers contain such a range of cichlids when the rest of the continent supports far fewer species.

Radiocarbon dating suggests that extinct Lake Makgadikgadi formed at least 52,000 years ago: Shifting faults in the region severed the Zambezi River and diverted flows of three large rivers to an inland drainage basin, creating the lake.

Lake Makgadikgadi dried up following further land upheavals, which caused the lake to empty into the middle Zambezi River. As this happened, many newly evolved cichlid species escaped with the lake water as it flowed into the river, the theory goes.

It's possible that the lake, though short-lived on an evolutionary timescale, could have spawned as many as 100 to 400 new species of cichlids, according to Ole Seehausen, an evolutionary ecologist at the University of Bern, Switzerland, and a member of the study team. Seehausen said 25 of these species have survived in the rivers of the region.

So what triggered this explosion in cichlid diversity?

Seehausen said the vast lake would have provided a wide range of new ecological niches for the arriving river cichlids to exploit.

The evolutionary ecologist noted that Lake Victoria—another relatively young lake at around a hundred thousand years old—provides a living snapshot of the kinds of cichlids Lake Makgadikgadi might have harbored:

- *Pixichromis orthostoma* is "an ambush hunter with an extremely long head and mouth relative to its body and strongly recurved, sharply-pointed teeth to hold on to its fish prey."
- *Neochromis omnicaeruleus* lives near shores and uses jaws armed with broad bands of closely spaced teeth to work algae on rocks "like a steel brush."
- *Ptyochromis xenognathus* specializes in feeding on snails, "pulling the soft body from the shell with a quick twist."

Like East Africa's other Great Lakes, Lake Victoria was also colonized by other types of river fish, such as barbs and catfish. Yet these fish did not evolve the stunning range of forms and behavior seen in cichlids.

"It is probably important," Seehausen said, "that some cichlids have certain life history traits that allow them to live in deep-water and open-water habitats of lakes, which many other riverine fish are not good at."

Adjustable Mouths

Also important, according to Kocher, the University of

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New Hampshire zoologist and geneticist, is a physical characteristic that appears to make cichlids particularly prone to rapid diversification: Cichlids have adjustable mouths that can be quickly altered to take advantage of new feeding opportunities.

Cichlids have a second set of jaws in the back of their throats, which they use to process food before it enters their guts. Because the throat jaws do most of the work, "the oral jaws are therefore relatively free to evolve specializations for acquiring food," Kocher explained.

He said another key innovation in the type of cichlids that first colonized the Great Lakes and Lake Makgadikgadi is that females carry their eggs in their mouths for several weeks before releasing the young to fend for themselves. By contrast, most other cichlids share parental care.

This unequal parental investment leaves males free to spend more of their energies playing the field, matingwise. "As a consequence," Kocher added, "[males] have evolved an astonishing variety of nuptial colorations and behaviors to attract mates."

These differences in color are sufficient to prevent interbreeding among existing species. This may have fueled the unchecked formation of new species.

Lake Makgadikgadi may be no more. But it has left an indelible and colorful mark on the rivers of southern Africa.

The study team said the lake appears to provide an extraordinary example of how "a localized evolutionary process can have a profound and lasting effect on the ecological and genetic diversity of a continental fauna."

The discovery should provide valuable new insights into the march of evolution, which, in the case of cichlids, seems to favor the fast-forward button.

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