

Moved by religion: Mexican cavefish develop resistance to toxin

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A centuries-old religious ceremony of an indigenous people in southern Mexico has led to small evolutionary changes in a local species of fish, according to researchers from Texas A&M University.

Since before the arrival of Christopher Columbus to the New World, the Zoque people of southern [Mexico](#) would venture each year during the Easter season deep into the sulfuric cave Cueva del Azufre to implore their deities for a bountiful rain season. As part of the annual ritual, they release into the cave's waters a distinctive, leaf-bound paste made of lime and the ground-up root of the barbasco plant, a natural fish toxin. Believing the cave's fish to be gifts from their gods, they scoop up their poisoned prey to feed upon until their crops are ready to harvest.

However, a team of researchers led by Dr. Michael Tobler, an evolutionary ecologist at Oklahoma State University, and Dr. Gil Rosenthal, a biology professor at Texas A&M, has discovered that some of these fish have managed not only to develop a resistance to the plant's powerful toxin, but also to pass on their tolerant genes to their offspring, enabling them to survive in the face of otherwise certain death for their non-evolved brethren.

Their findings recently were published in the online journal *Biology Letters*.

Tobler has been studying the small, cave-dwelling fish species known as the Atlantic molly or *Poecilia mexicana* and its uncanny ability to

survive in the toxic sulfur environment of Cueva del Azufre since 2004. He earned his Ph.D. from the University of Zurich in 2008 and spent the next two years as a postdoctoral research associate at Texas A&M, studying under Rosenthal and Dr. Kirk Winemiller, a professor in wildlife and fisheries science, as part of a two-year, \$79,000 Swiss National Science Foundation Postdoctoral Fellowship.

After learning about the Zoque people's sacred ritual and witnessing the event firsthand in 2007, Tobler and Rosenthal decided to investigate the effects of this peculiar ceremony on the mollies and their habitat. Ironically, it was the last ceremony ever held, as the Zoques ended the practice that year due to political pressure from the government, which sought to preserve the cave as a hotbed for tourism and potential revenue.

"We wanted to do a lab experiment where we exposed fish from different parts of the creek to barbasco," Tobler says. "Some of these fish had been more exposed than others."

In March 2010, the team collected molly specimens from two different areas of the cave annually exposed to the barbasco toxin as well as from two different areas upstream, further away from the Zoque's ritual. With both groups of fish in a single tank, they then introduced the barbasco root to determine how both groups would react.

They found that the mollies annually exposed to the barbasco indeed were more resistant than the fish further upstream — to the extent that they were able to swim in the noxious water nearly 50 percent longer. Tobler and Rosenthal's group concluded that human beings had, over time, not only affected molly population dynamics, but also inadvertently kick-started the evolutionary process of natural selection as well. Mollies able to tolerate the poisonous conditions survived and passed those traits to their offspring, resigning those that perished to

their fate of serving as a ceremonial feast for the Zoque.

"The cool thing is that this ceremony has gone on a long time and that the fish responded to it evolutionarily," Tobler says. "Lots of species couldn't live with these changes. It highlights how nature is affected by human activity."

Rosenthal contends that the idea of imposing evolutionary divergence on a species at an extremely localized spatial scale is not a new concept. In fact, he says, it's been happening since the beginning of mankind and that the idea of the "noble savage" is passé.

"We tend to have this wonderful Pocahontas idea that before Europeans came in, everything was pristine and in harmony with nature and that all of the changes in our environment have been post-industrialization," he explains. "No. People have been changing the environment forever."

Moreover, Rosenthal says, once a species has become genetically adapted to human presence, it is not very easy to suddenly reverse.

Their ritual since banned, the Zoques still perform a mock ceremony each Easter season. Tobler, however, would like to see the Zoque's original ceremony resume, but in a way that is sustainable to nature as well as other cave inhabitants. The key, he and Rosenthal believe, is to find a balance between human activity and their environment. In the case of the Zoques, it may mean a few limitations on barbascos usage for their ritual, such as releasing the toxin only 50-to-60 meters into the cave rather than 100 meters.

Pending further resolution, Tobler will continue his research with the mollies at Oklahoma State, where they are housed in a special tank built to safely imitate their sulfuric living conditions in Cueva del Azufre.

"We need to understand what the impact really is on these [fish](#) rather than eliminate the ceremony completely," Tobler says. "We want to hopefully find a balance between the cultural practices of these people and the ecosystem."

More information: An indigenous religious ritual selects for resistance to a toxicant in a livebearing fish, [doi:10.1098/rsbl.2010.0663](https://doi.org/10.1098/rsbl.2010.0663)

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