Human-driven habitat change leads to physical and behavioral change in mosquitofish

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Mosquitofish (female). Credit: Public Domain

Bahamian mosquitofish in habitats fragmented by human activity are more willing to explore their environment, more stressed by change and have smaller brain regions associated with fear response than mosquitofish from unaffected habitats. The new study from North Carolina State University shows that these fish have adapted quickly in specific ways to human-driven change, and cautions that environmental restoration projects should understand these changes so as not to damage adapted populations.

The Bahamas mosquitofish is a small, coastal fish species that frequently

inhabits tidal creeks—shallow, tidally influenced marine ecosystems. In the 1960s and 70s, road construction in The Bahamas caused many of these habitats to become "fragmented," or largely cut off from the ocean.

"Mosquitofish in these fragmented areas suddenly found themselves in a much different environment than previously, in terms of things like predation and tidal dynamics," says Brian Langerhans, associate professor of biology at NC State and corresponding author of the study. "We set out to determine how natural variation in structural habitat complexity and human-induced fragmentation influenced exploratory behavior, stress response, and brain anatomy."

Langerhans and a team of NC State researchers observed about 350 mosquitofish from seven different populations: Three fragmented and four non-fragmented. The habitats varied in complexity, from simple mud-bottomed spaces to those that included a large number of rocks and vegetation, such as mangroves.

"We were testing predictions based upon our understanding of natural selection," Langerhans says. "For instance, in a fragmented space with fewer natural predators, we hypothesized that those fish would be more exploratory, since exploratory behavior could be rewarded in terms of competing for food. We also wanted to see if there were physiological changes to the areas of the brain that are associated with those and other similar behaviors."

The team measured stress response and exploratory behavior by temporarily placing mosquitofish in a different environment and observing changes in respiration and their willingness to explore. They also compared brain size in fish from the different habitats.

They found that overall, fish from a more complex environmental

habitat were more willing to explore new environments. But for a given level of habitat complexity, fish in fragmented sites were more exploratory than those from unfragmented sites. In addition, fish from fragmented habitats had a higher stress response to change.

"These findings were in line with our expectations," Langerhans says. "Exploratory behavior can reward fish in habitats with few predators by helping them compete for food, and can give fish in complex habitats an advantage in locating safety and hard-to-find food resources. As for the stress response, fish in unfragmented tidal creeks with lots of predators and high tidal dynamics have a higher level of everyday stress than those in more static, predator-free habitats. Change will be much more stressful for fish in the latter areas, since they're less stressed to begin with."

They also noted that while there were no overall differences in brain size between fish from differing habitats, fish from fragmented environments had a smaller telencephalon—the region of the brain associated with fear response, while fish in complex environments had a larger optic tectum and cerebellum, brain regions associated with responding to visual stimuli, motor skills, and associative learning.

"Brain tissue is expensive for an organism to produce," Langerhans says. "If fish in fragmented or simple environments no longer experience major demands for behaviors such as avoiding predation or navigating complex situations, seeing changes in these brain areas isn't that surprising."

The study also highlights how quickly organisms adapt to new environments, and how those environments affect the biological makeup of their inhabitants—something that restoration project planners should keep in mind when attempting to restore habitats to their ancestral state.

"Everything that humans plan to do to these environments should have a lot of forethought put into it," Langerhans says. "If local adaptations occurred over a 50-year period in response to an altered environment and we quickly restore it to 'normal,' you could do more harm than good to some of its inhabitants."

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More information: Matthew R. Jenkins et al, Natural and anthropogenic sources of habitat variation influence exploration behaviour, stress response, and brain morphology in a coastal fish, *Journal of Animal Ecology* (2021). DOI: 10.1111/1365-2656.13557

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