Monarch butterflies bred in captivity may lose the ability to migrate, study finds

June 24 2019

A tethered monarch butterfly flying in the flight simulator. Credit: Aye Tenger-Trolander

Monarch butterflies purchased from a commercial breeder did not fly in a southward direction, even in offspring raised outdoors, in a new study conducted by scientists at the University of Chicago. Wild-caught monarchs bred indoors under simulated outdoor conditions also did not orient south, suggesting that captive breeding disrupts the monarch's famous annual migratory behavior.

The National Wildlife Federation estimates that the North American monarch population has declined 90% over the last two decades. As the number of butterflies that reaches their winter habitats in California and Mexico dwindles, monarch enthusiasts have turned to a variety of conservation efforts, including captive breeding and release of the butterflies throughout the summer and autumn. However, the new study, published this week in the *Proceedings of the National Academy of Sciences*, shows that these well-intentioned practices may not have the desired effect.

"We hope this will be an avenue into understanding how monarchs are losing migration," said Marcus Kronforst, Ph.D., associate professor of ecology and evolution at UChicago and the study's senior author. "These monarchs have been brought into captivity and prevented from migrating for many generations, and they have genetically lost migration. It's a microcosm for what's happening naturally."

A 'flight simulator' for butterflies

Ayse Tenger-Trolander, a Ph.D. student in Kronforst's lab and lead author of the new study, ordered several adult monarch butterflies from a commercial supplier and placed them in an outdoor garden on the rooftop of a building on the UChicago campus. The butterflies were enclosed in mesh cages but otherwise exposed to natural light, temperature and moisture.

Monarchs breed during the summer and autumn, the autumn generation being the one that migrates. Tenger-Trolander collected eggs from the commercially purchased adults after they mated and raised them to adult butterflies. That summer generation then became the parents of the autumn generation.

Tenger-Trolander then tested this autumn generation in a "flight simulator" to see the predominant direction they fly. The simulator is an open-ended, metal cylinder, like a pipe standing on one end. The butterfly is connected to a rod near the top opening of the cylinder by a metal pin, or tether, attached to its abdomen. This makes the butterflies fly in place inside the cylinder, but they are free to rotate 360 degrees. The rotating dial records the direction of the butterfly every two milliseconds and saves the data to a computer.

Butterflies that exhibit migratory behavior should fly predominantly toward the south inside this flight simulator. The locally-captured monarchs raised in the same gardens did just that. However, Tenger-Trolander saw that the generation of butterflies bred from the commercial monarchs didn't fly in a dominant direction.

Tenger-Trolander also performed a second set of experiments starting with only wild-caught monarchs and rearing the offspring completely inside. She tried to mimic outdoor conditions by adjusting temperature and the hours of daylight, but as a group, these butterflies did not show signs of migratory flight either. Some individuals did fly pointing south, but as a group they did not collectively fly predominantly in a southward direction. In fact, taking a chrysalis that had been developing outdoors and bringing it inside just as it was about to emerge also "broke" the migratory behavior in the group as a whole.

"I thought there was no way that would matter, but it did," said Tenger-Trolander. "We know there are many hobbyists and enthusiast breeders

who are trying to do their best husbandry and avoid buying from commercial breeders. But there could be an issue with the way they're raising them indoors too."

A tethered monarch butterfly flying in the flight simulator. Credit: Aye Tenger-Trolander

Differences buried in the genome

Several populations of monarchs have dispersed throughout the world to Central and South America, the Caribbean, southern Europe, northern Africa and across the Pacific Ocean to Australia, but none of these new populations migrate like those in North America. Kronforst and Tenger-

Trolander also studied the genetic makeup of the commercially-bred butterflies to see how they differ from typical North American monarchs. Is the reason the commercial monarchs don't migrate because they originated from a newer, non-migrating population?

The genetic analysis showed that the commercially-bred butterflies did originate from North America, but they are genetically different enough to count as distinct population, separate from North American or any of the other groups that made it to another continent. Kronforst said he believes the loss of migration lies in these genetic discrepancies.

"We can't point to a single genetic change that did it because there are lots of them," he said. "But we think somewhere buried in the genome are changes that have broken it."

The U.S. Fish and Wildlife Service is considering whether to list the North American monarch as a threatened species under the U.S. Endangered Species Act. Any conservation efforts are welcome, the researchers say, and hobbyists raising caterpillars in their gardens or elementary school science classes releasing butterflies into the wild are great ways to engage the public. But the new study shows that however well-intentioned, monarch enthusiasts should remember that the migratory behavior of these beloved butterflies is incredibly fragile.

"It looks like buying monarchs to raise and release doesn't contribute to the migratory population, and raising them indoors probably isn't helpful either," Kronforst said. "If you want to grow milkweed in your garden and raise monarchs you find around your house, just don't take them inside. If you keep them outdoors, they should be totally fine."

More information: Ayşe Tenger-Trolander el al., "Contemporary loss of migration in monarch butterflies," *PNAS* (2019). www.pnas.org/cgi/doi/10.1073/pnas.1904690116

Provided by University of Chicago

Citation: Monarch butterflies bred in captivity may lose the ability to migrate, study finds (2019, June 24) retrieved 26 April 2024 from https://phys.org/news/2019-06-monarch-butterflies-bred-captivity-ability.html

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