Mystery of monarch migration takes new turn

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During the fall, hundreds of millions of monarch butterflies living in eastern North America fly up to 1,500 miles to the volcanic forests of Mexico to spend the winter, while monarchs west of the Rocky Mountains fly to the California coast. The phenomenon is both spectacular and mysterious: How do the insects learn these particular routes and why do they stick to them?

A prevailing theory contends that eastern and western monarchs are genetically distinct, and that genetic mechanisms trigger their divergent migratory paths.

An analysis led by Emory University biologists, however, finds that the two groups of monarchs are genetically mixed. Their research, published in the journal Molecular Ecology, suggests that environmental factors may be the key to the butterflies' choice of winter homes, and to where they wind up in the spring.

"Our data gives the strongest signal yet that the eastern and western monarchs belong to a single genetic population," says Emory biologist Jaap de Roode, who led the research. "This distinction is important to help us better understand the behavior of the organism, and to conserve the monarch flyways."

In addition to researchers in the de Roode lab, the study involved a scientist from the Institute of Integrative Biology in Zurich, Switzerland.

Biologists have long been fascinated by the innate and learned behaviors underlying animal migrations. When monarchs are breeding, for instance, they can live up to four weeks, but when they are migrating, they can live as long as six months.

"As the day length gets shorter, their sexual organs do not fully mature and they don't put energy into reproduction. That enables them to fly long distances to warmer zones, and survive the winter," de Roode says. "It's one of the basic lessons in biology: Reproduction is very costly, and if you don't use it, you can live much longer."

Mass movements of animals have huge ecological impacts. They are also visually arresting, from the spectacle of giant herds of wildebeest trekking across the Serengeti to hundreds of thousands of sandhill cranes flocking along the banks of Nebraska's Platte River.

In the case of long-lived mammals and birds, the younger animals may learn some of the behaviors associated with migration. That's not the case with the monarchs, notes Amanda Pierce, a graduate student in Emory's Population Biology, Ecology and Evolution program, and a co-author of the study.

"We know there is no learning component for the butterflies, because each migration is separated by two to three generations," Pierce says. "To me, that makes the problem even more interesting. How can these small, delicate animals travel thousands of kilometers and arrive at the same destination as their great-great grandparents?"

The question of whether eastern and western monarchs are genetically the same has been hotly debated, and may be an essential piece to the puzzle of their divergent migration patterns.

The researchers used 11 genetic markers to compare the genetic

structures of eastern and western monarchs, as well as non-migratory monarch populations in Hawaii and New Zealand. The results showed extensive gene flow between the eastern and western monarchs, and a genetic divergence between these North American butterflies and those from Hawaii and New Zealand.

"In a sense, the genetic markers provide a DNA 'fingerprint' for the butterflies," de Roode says. "Just by looking at this fingerprint, you can easily separate the butterflies of North America from those in Hawaii and New Zealand, but you can't tell the difference between the eastern and western monarchs."

The Emory researchers have now joined a project headed by Harvard, which also involves the University of Georgia and the University of Massachusetts, to sequence the full genomes of monarch butterflies from places around the world. That data should rule out genetic differences between the eastern and western monarchs, or reveal whether any smaller genetic differences, beyond the 11 markers used in the study, may be at play between the two groups.

The idea that eastern and western monarchs are distinct populations has been bolstered by tagging-and-tracking efforts based in the United States. That data, gathered through citizen science, indicates that the butterflies stay on separate sides of the Rocky Mountains – a formidable high-altitude barrier.

De Roode, however, theorizes that when spring signals the eastern monarchs to leave the overwintering grounds in Mexico, they may simply keep radiating out, reproducing and expanding as long as they find milkweed plants, the food for their caterpillars.

"Few people have tagged the monarchs within Mexico to see where they go," he notes, "because Mexico doesn't have as much citizen science as

the U.S."

If the theory is correct, some of the monarchs leaving Mexico each spring may wind up in western North America, while others may filter into the eastern United States. This influx to the western U.S. could be crucial to survival of monarchs on that side of the continental divide.

"There are far fewer monarchs west of the Rockies," de Roode says. He notes that all of the overwintering monarchs on a typical overwintering site along the California coast consist of about the same number clustered onto a single big tree in Mexico's Monarch Butterfly Biosphere Reserve, where hundreds of millions of monarchs blanket the landscape in the winter.

The monarch butterfly migration has been called an endangered phenomenon, due to the loss of habitat along the routes. The Mexican overwintering sites, located in the Trans-Mexican Volcanic Belt region northwest of Mexico City, particularly suffer from deforestation. Drug trafficking in the region has decimated eco-tourism and hampered efforts to protect the trees.

"We hope our research can aid in the conservation of the monarch flyways," de Roode says.

Raising monarchs for release at weddings, memorials and other events is a growing industry, but U.S. Department of Agriculture regulations restrict shipping the butterflies across state lines.

De Roode stresses that this regulation should remain in force, even if further research confirms that eastern and western monarchs are genetically identical, because parasites that the butterflies carry can differ by region. "It's not a good idea to be shipping parasites around," he says.

Provided by Emory University