Monarch butterflies help explain why parasites harm hosts

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Monarch detail. Credit: University of Georgia

It's a paradox that has confounded evolutionary biologists since Charles Darwin published On the Origin of Species in 1859: Since parasites depend on their hosts for survival, why do they harm them?

A new University of Georgia and Emory University study of monarch butterflies and the microscopic parasites that hitch a ride on them finds that the parasites strike a middle ground between the benefits gained by reproducing rapidly and the costs to their hosts. The study, published in the early online edition of the journal *Proceedings of the National Academy of Sciences*, provides the first empirical evidence in a natural system of what's called the "trade-off hypothesis."

“Parasites have to harm their host to replicate and be transmitted,” said lead author Jacobus de Roode, a former post-doctoral researcher at UGA and now an assistant professor at Emory University. “But what this study found is that if they harm their host too much, they’ll suffer too. On the other hand, this study also shows that it does not benefit the parasite to be maximally benign, because those parasites don’t replicate enough to be effectively transmitted.”

In a painstaking, three-year study conducted in the laboratory of Sonia Altizer, assistant professor in the UGA Odum School of Ecology, researchers infected monarch caterpillars with varying levels of spores from a protozoan parasite commonly found in wild populations. After the adult butterflies emerged, females were mated and placed in outdoor mesh cages. The butterflies spread the parasites when they deposit spores onto eggs or leaves of the milkweed plants that caterpillars feed on.

These spores are then consumed by caterpillars as they feed. Each butterfly had one stalk of milkweed in its cage, and every day for up to 30 days the researchers gave the butterflies a new stalk while taking the previous stalk back to the lab for analysis. The spores on the eggs and on the milkweed were counted, which is no easy task considering that each spore is 1/100th the size of the powdery scales on butterfly wings. A single egg can have more than 1,000 spores on it.

The researchers crunched the numbers and found clear support of a hypothesis that is popular among scientists but, until now, had not been well studied in a naturally occurring parasite and its host. They found that female monarchs that were too heavily infected often died before they mated or, if they survived, did not mate. Females who had an intermediate parasite load were long lived and laid a large number of eggs, while females with light parasite loads also were long lived and had many offspring, but relatively few offspring were infected.

“The findings of this study are significant because they provide an explanation for why so many parasites cause disease and death to their hosts,” de Roode said.

The results demonstrated that the trade-off hypothesis holds for monarchs in a controlled setting, but the researchers also wanted to know how natural selection influences virulence in the wild. They isolated parasite strains from monarch butterflies in eastern and western North America that have different migratory behaviors. Eastern monarchs famously migrate from breeding grounds as far north as Canada to their wintering sites in central Mexico and then back again, traveling up to 5,000 km round-trip. Western monarchs migrate roughly a third of this distance to winter along the California coast.

“We thought that if the parasites are going to be more benign in any population, it’s going to be in the eastern monarchs,” Altizer said, “because those butterflies fly the farthest distances, and parasites that kill their hosts during this long journey won’t produce any offspring.”

The team exposed western and eastern monarchs to parasite strains from their own and the opposite population. Monarchs from both populations were equally susceptible to infection, but parasites from the western population caused the butterflies to die sooner, confirming the team’s predictions that eastern parasites are more benign.

Aside from shedding light on the vexing evolutionary question of why parasites harm their hosts, the study has implications for the health of humans and butterflies.

In some cases, scientists have predicted how public health interventions can influence the evolution of disease virulence based on the trade-off hypothesis. Predictions require careful knowledge of host and parasite biology, but one idea is that interventions that block parasite

transmission opportunities could cause natural selection to favor strains with lower virulence. The team's findings suggest that when transmission opportunities are more limited, such as in the eastern monarch populations, natural selection will favor parasites that can persist longer on infected hosts and cause less damage.

The study also calls into question the wisdom of captive breeding of monarchs for intentional release at events such as weddings. Captive rearing conditions can promote parasite transmission and favor more virulent parasite strains that have the potential to harm wild populations that come into contact with them.

Altizer points out that migratory monarchs are already facing challenges from climate change – which reduces their migratory range – and habitat destruction in their winter breeding grounds.

"There's a very real probability that the eastern migratory population will be lost sometime in the next 50 to 100 years," Altizer said. "Smaller, non migratory populations will likely persist, but we're expecting that many more butterflies will be infected and that the parasites could become more virulent."

Source: University of Georgia