

Evolution in species may reverse predator-prey population cycles

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Populations of predators and their prey usually follow predictable cycles. When the number of prey increases – perhaps as their food supply becomes more abundant – predator populations also grow.

When the predator [population](#) becomes too large, however, the [prey](#) population often plummets, leaving too little food for the [predators](#), whose population also then crashes. This canonical view of predator-prey relationships was first identified by mathematical biologists Alfred Lotka and Vito Volterra in the 1920s and 1930s.

But all bets are off if both the predator and [prey species](#) are evolving in even small ways, according to a new study to be published this week in the journal *Proceedings of the National Academy of Sciences*. When both species are evolving, the traditional cycle may reverse, allowing predator populations to peak before those of the prey. In fact, it may appear as if the prey are eating the predators.

Researchers at the Georgia Institute of Technology have proposed a theory to explain these co-evolutionary changes. And then, using data collected by other scientists on three predator-prey pairs – mink-muskrat, gyrfalcon-rock ptarmigan and phage-*Vibrio cholerae* – they show how their theory could explain unexpected [population cycles](#).

The new theory and analysis of these co-evolution cycles could help epidemiologists predict cycles of disease and the virulence of infectious agents, and lead to a better understanding of how population cycles may

affect ecosystems. The research was supported by the National Science Foundation and the Burroughs Wellcome Fund.

"Our work shows that co-evolution can yield new and unique behavior at the population scale," explained Joshua Weitz, an associate professor in the School of Biology at Georgia Tech. "When you include evolution, the classic prey-predator dynamics have a much greater range of possible outcomes. We are not replacing the original theory, but proposing a more general model that opens the door to these new phenomena."

Evolution is often perceived as an historical event, noted Weitz, who also has a courtesy appointment in the Georgia Tech School of Physics. But organisms are evolving continuously, with certain phenotypes becoming dominant as environmental and other conditions favor them. In organisms such as birds or small mammals, those changes can be manifested in as few as ten generations. In microbial species with brief lifespans, evolutionary changes can happen within days or weeks.

Evolutionary changes can dramatically affect relationships between species, potentially making them more vulnerable or less vulnerable. For instance, if a mutation that confers viral resistance in a species of bacteria becomes dominant, that may change the predator-prey relationship by rendering the bacteria population safe from harm. More generally, co-evolutionary cycles can arise when predator offense is costly and prey defense is effective against low offense predators.

"With predator and prey co-evolution, you can see oscillations in which there are lots of prey around even when there are many predators, or lots of predators around even when there are very few prey," noted Michael Cortez, a postdoctoral fellow in the Weitz lab and first author of the paper.

"When prey is abundant and there are few predators, it may be because

there are lots of defended prey – prey that the predators can't eat," he added. "When there are lots of predators around and few prey, it's because the prey are very good food sources and the predators are doing quite well."

In their paper, Weitz and Cortez simulated models in which the evolutionary process was sped up to show how their theory of co-evolution would affect predator-prey population cycles. Speeding up the process allowed them to break the cycle up into smaller segments that could be analyzed in more detail. They then used the earlier observations of the changing abundances of the three pairs of predators and prey—leveraging data sets collected by other scientists – to show how the models would apply.

"Although the structure of the cycles in these three systems had been noted as unusual by the authors who observed them, there had been, as yet, no unified theoretical framework from which to make sense of such as radical departure from the classic signature of predator-prey interactions," Weitz said.

Scientists have long studied how the interaction between species affects overall populations in ecosystems. Weitz and Cortez believe their new model will give scientists a broader and more complete picture of the complex process.

"This study identifies how adaptation between two species and interactions between their numbers can result in something different from what you would get if you just had the interaction between the numbers," said Cortez. "This is something that will show up across many ecological systems. We can now explain broad trends that occur in vastly different systems using a theoretical approach, and the fact that we can identify the mechanism responsible for it is unique to our study."

More information: Michael H. Cortez and Joshua S. Weitz,
"Coevolution Can Reverse Predator-Prey Cycles," *Proceedings of the
National Academy of Sciences*, 2014.

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