The Joy of sets: For ants and trees, multiple partners are a boon

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In the complex world of ant-plant partnerships, serial monogamy can help trees maximize their evolutionary fitness, a new University of Florida study shows.

Trees that sequentially partner with multi-species sets of ants produce more offspring than trees that maintain a lifelong association with any single ant — even when those sets include ant species that appear to harm the tree, said Todd Palmer, a UF biology professor.

The study has broad implications because many of the world's ecosystems rely on cooperative partnerships between species, Palmer said.

"When you snorkel on a coral reef, you're hovering over an animal — the coral — that relies heavily on the algae it cooperates with for photosynthesis, just as when you eat an apple, you're reaping the benefits of a tree that was pollinated by an insect," he said.

According to Palmer, many prior studies of cooperation in nature, or mutualism, have focused on the "cheater problem": How can cooperation persist when both sides have an incentive to reap benefits without contributing to the common good? Ecological studies tend to be short-term, with species labeled as "cooperators" or "freeloaders," depending on cost-benefit ratios calculated over just a few years.

Palmer and his team took a different approach, looking at a common

African tree and its relationships with four specialized ant partners over the tree's lifetime.

The surprising finding was that the tree in Kenya did best when occupied by all four ant species over its lifetime, even though one ant species joined forces with beetles in ways that increased tree death rates; another sterilized the tree; and a third was so scared of the other three competing ant species that it didn't do much of anything, said Palmer, whose paper is published this week online in Proceedings of the National Academy of Sciences.

"Looking at the costs and benefits to the tree, not just at a single moment, but in terms of number of offspring produced over a lifetime, the best possible outcome is obtained not by having what we thought was the "good mutualist," but rather by having all four ant species at different life stages — even the so-called parasite, cheater, freeloader scumbag ants," he said.

In the past, only one of the four ant species was recognized as a cooperator, because it successfully defended the tree from elephants and other herbivores in exchange for using the tree's resources, Palmer said. The other three ants were thought to exhibit varying degrees of cheating behavior, he said.

The key to the new findings is the timing. When a species lives a long time, its needs may change drastically as it grows from young to old, and sequential associations with several partners may help it meet those needs at different times, he said.

"A human analogy might be that what we look for in romantic partnerships when we're younger — perhaps a daring and exciting person who likes to be bold and take risks — is not necessarily the thing that we are looking for in a romantic partner when we get older, when

stability, the ability to hold down a job and provide for children becomes more important," he said. "The best possible partner is really a function of where you are in your life and what your needs are at that particular moment."

In the same way, a mutualistic species may require a partner that helps it survive during its vulnerable younger years, even if that partner prevents it from reproducing, Palmer said. Later in life, when large size makes individuals less vulnerable, the ideal partner may be one that enhances reproduction even as it reduces the chances of longer-term survival, he said.

Over eight years, Palmer and colleagues monitored annual survival, growth, reproduction and ant occupancy of 1,750 Acacia drepanolobium trees and constructed demographic models that related the trees' lifetime fitness to occupation by different combinations of the four ant partners. The ostensible freeloaders turned out to be more than they seemed, he said.

The ant that conspires with a wood-boring beetle that can kill trees? It turns out that before it kills them, it causes them to produce an inordinate number of seeds, Palmer said. Likewise, the ant that castrates the tree is actually an aggressive defender, so while the tree doesn't reproduce for many years, it is likely to survive to produce fruit more down the road after the castrator is evicted by another ant species.

And the ant that appeared to be a do-nothing actually does just enough, Palmer said. "It defends trees a little bit, but unlike the other ant species, it is very faithful and hardly ever abandons the tree," he said. "And having any ant at all is very much better than having no ant, because if you have no ants, you get hammered by everything from caterpillars to elephants."

Provided by University of Florida