

Evolution & Behavior

How did ant-plant interactions evolve?

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ABSTRACT

Ants and plants rely on each other for food, defense and shelter. But how did these complex interactions evolve in the first



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What are those ants doing? No, over there. Ants are all kind of the same, right? Nope. Ants are diverse—[there are actually more kinds of ants than birds](#). Some live underground, and some use plants as places to hunt for food or to build a nest. Ants eat insects, plants, and oftentimes both. Many plants even rely on ants to defend them from plant-eating animals, or to move their seeds around. In return, they feed the ants or make structures for the ants to nest in. We're interested in how ants and plants became so deeply intertwined.

We know that plants are important for ants. For instance, the evolution of tropical forests dominated by flowering plants was important for the [evolution of many of the major ant groups](#). But we wanted to look in more detail at when ants began to utilize plants in different ways—for food, foraging, and

nesting. We expected to find that they evolved around the time plants began making nesting structures or specialized foods.

We also wanted to know whether using plants benefited ants over evolutionary timescales. When looking across the ant tree of life, we see some groups are more diverse than others. Differences may be due to their age, or rates at which species are formed and maintained. Since these interactions can be mutually beneficial to ants and plants at short timescales, we thought they might provide advantages over evolutionary time, and explain the uneven distribution of species across the ant tree of life. Previous work suggested plants relying on ants for [defense](#) or [seed dispersal](#) generate new species more rapidly, explaining at least in part why some

groups are more diverse than others. With this in mind, we expected to find a similar trend in ants.

Ideally, we would use fossils to answer these questions. There are LOTS of plant fossils, but these special structures are very rare in plant fossils. Similarly, there are LOTS of ant fossils ([there are as many fossil ant species as there are dinosaurs!](#)), but their interactions with plants don't tend to be preserved. So we took an alternate approach.

We used DNA sequence data to infer family trees depicting the evolutionary relationships of ants and plants. We then used fossils—which tell us the ages of ants and plants—to transform these trees and place them in time. We next consulted databases to determine whether tips in our family tree (which represent an ant or plant we see today) possessed specific characteristics (traits). We looked at whether ants used plants as food sources, and foraged on or nested in plants, and whether plant groups made specialized food or nesting structures for ants. We then used a statistical method to estimate the likelihood that individual ancestors in the family trees possessed these traits, given our family trees and these trait data. Finally, we recorded the age of ancestors that were inferred to have a high likelihood of possessing these traits.

So...what did we find?

We found that ants started using plants long before they made specialized food and nesting structures

for ants. This suggests that there was a long period in which ants relied on less specialized food sources, such as sap or plant-derived sugars exuded from aphids and their relatives. Similarly, ants nesting in plants likely constructed their own nests or relied on gaps or holes created by other insects. Our analyses also revealed a sequence by which ants evolved from plant independence to full-dependence on plants. This was achieved when a predatory, ground-foraging and -nesting lineage began foraging arboreally. They subsequently incorporated plant foods into their diet, and finally nested arboreally. Thus, we see an evolutionary pathway by which ants evolved to become increasingly dependent on plants.

We then used our ant family tree to estimate how rapidly species formed. These statistical approaches basically estimate the branching frequency of our ant family tree over time. Rates varied across the ant tree but were not correlated with plant use. This surprised us, as it conflicted with our expectations. But it highlights the complex evolutionary history of ants and suggests that differences in rates of species formation are due to multiple traits and events that vary across ants and through time. This means we have a lot more work to do to understand why some ant groups are more diverse than others. So the next time you see an ant running around, remember it is part of a diverse group of animals with a complex history!