Milkweed defensive strategy drives away friends of enemies

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In a mutually beneficial arrangement, ants consume aphid excrement, known as honeydew, while protecting the pests from other insects. Milkweed drives away ants by releasing a toxin that poisons the honeydew. Credit: Ellen Woods '10/Provide

Over millions of years under attack from insects, milkweed plants have developed considerable defenses. These include incredible toxicity – sufficient to kill a horse or sheep – which emanates from a milkweed's leaves in a sticky liquid.

Yet one of the plant's main pests, the aphid, has evolved its own defenses to thwart the milkweed toxin. Increased toxicity would then seem to offer no direct advantage to the plant's survival, but a new study by Anurag Agrawal, professor of ecology and evolutionary biology in the College of Agriculture and Life Sciences, shows how milkweed toxins affect the web of creatures that surround the predatory aphids, especially ants, which frequently serve as aphid protectors.

Ants are attracted to aphids because they feast on the aphid's honeydew – the cheerful moniker scientists have given to aphid poop. Wanting to protect their food source, ants will battle against other predators, such as ladybugs, that want to eat the aphids themselves.

When milkweed toxicity goes up, it doesn't poison the aphids, but it results in poisonous doses in their poop. The ants move away, and the ladybugs move in.

"Many ecologists thought there would be a direct relationship – if there's more toxin, there would be fewer aphids. But that's not how this

interaction proceeds," Agrawal said. "The part that was surprising and changes the way we think about these interactions, is that the plant can still defend itself against the aphids, but not by poisoning them directly. The plant is able to poison the protector of the aphids."

Three-sided defenses are quite common in nature – for example, many plants defend themselves by sending out smelly volatile organic compounds when they're being attacked by a pest. It's the ecological version of a stratagem dictating that the enemy of an enemy is a friend.

In the case of milkweeds and aphids, however, the defense involves four players, and requires driving away the aphid's friend, rather than pulling in an enemy.

The interactions between milkweeds and aphids are one example of co-evolution, a biological principle in which predators and prey evolve in concert with one another, and a major focus of Agrawal's lab.

"Co-evolution, this reciprocal adaptation back and forth, can generate extremes in nature," Agrawal said. "If you have a predator and a prey, the prey should evolve in ways to escape the predator, and the predator should evolve in ways to catch the prey. If that happens over time, we can observe an increase of the tactics or strategies that both use. Over time, they are essentially engaged in an arms race."

That back-and-forth process may also be responsible for the creation of new species. The much-devoured milkweed, for instance, began with one common ancestor, and now boasts 140 species.

The study "Plant chemical defense indirectly mediates aphid performance via interactions with tending ants" was published this month in the journal *Ecology* with co-author Tobias Züst of the Institute of Plant Sciences at the University of Bern.

More information: Tobias Züst et al. Plant chemical defense indirectly mediates aphid performance via interactions with tending ants, *Ecology* (2017). DOI: 10.1002/ecy.1707