Native ants use chemical weapon to turn back invading Argentine ants

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A native winter ant in the act of trying to apply a drop of the whitish toxin it can secrete from its abdomen onto an Argentine ant. The angle of the photograph distorts the relative sizes of the two species, which are roughly the same size. Credit: Trevor Sorrells

(PhysOrg.com) -- Argentine ants are taking over the world – or at least the nice temperate parts. They've spread into Mediterranean and subtropical climates across the globe in sugar shipments from Argentina, and no native ant species has been known to withstand their onslaught – until now. A group of Stanford University undergraduate students working on a class project have discovered that a native species, the plucky winter ant, has been using chemical warfare to combat the Argentine tide.

The winter ants – named for their unusual ability to function in cold weather, rather than grind to a halt like most insects – manufacture a poison in a gland in their abdomen that they dispense when under extreme duress. One tiny drop applied to an Argentine ant is enough to put an end to it. In laboratory testing, the poison had a 79 percent kill rate.

"This is the first well-documented case where a native species is successfully resisting the Argentine ant," said Deborah M. Gordon, a biology professor at Stanford who specializes in studying ants and taught the three-week summer class in which the students first saw the winter ants wielding their poison.

"I did not believe it at first," she said. "This is a group of ants that does not have a sting and you don't see them acting aggressively, but the students were able to show very clearly not just that the winter ants are using poison, but when they use it, how they use it and what the impact is."

Gordon and her students presented their findings in a paper published earlier this year in PLoS ONE, a journal published by the Public Library of Science.

Argentine ant invasion

The Argentine ants are happy anyplace that has cool, rainy winters and hot, dry summers. They have conquered the entire coastline around the Mediterranean Sea, parts of South Africa, Hawaii, Japan and Australia, as well as the full length of the California coastline.

"If you live in a Mediterranean climate, the Argentine ant is the ant in your kitchen," Gordon said. "These ants, wherever they become established, wipe out all the native ants."

The extermination of native ants sets off a ripple effect through an ecosystem. Some native ant species that eat seeds have coevolved with certain native grasses and other plants to become a crucial part of the plant's propagation by carrying the seeds to new areas. Without the native ant species to spread their seeds, the grasses can't flourish. Any significant impact on the plants would also likely affect creatures that feed on or nest in the plants.

Leah Kuritzky marks the trail of some of the winter ants she and her fellow student researchers studied on the Stanford campus. Credit: Leah Kuritzky

Argentine ants have been declared agricultural pests in California because of the damage they do to citrus crops. The invaders are partial to areas where the ground has been disturbed, such as plowed fields and construction sites. They also spread through plants sold by nurseries.

The invaders are agriculturalists after a fashion themselves, tending

"herds" of aphids and other scale insects that attach to plants and suck out the sugary sap. The ants, in turn, feed on the sugar-rich liquid that the aphids excrete, "quaintly called honeydew," Gordon said. By protecting the aphids from predators, the Argentines enable the insects to spread.

That yummy honeydew is what brings the Argentine invaders and the winter ants into conflict, as winter ants also tend aphids.

The Stanford students began observing the native ants as part of a 2008 short summer class for sophomores called Ecology of Invasions, taught by Gordon. At a variety of locations on the Stanford campus, they started out simply observing and recording ant behavior while visiting each site at the same time every day.

"We were looking at the nest openings of the winter ants and one day it was just winter ants going about their business foraging for food and making trails – just typical ant behavior," said Leah Kuritzky, a student in the class and one of the coauthors of the PLoS ONE paper.

An ant 'massacre'

"The next day we came back and the ground was littered with Argentine ants. There were dead ants all around and there was a lot of fighting around the nest entrances."

In earlier observations, the students had noticed the winter ants occasionally secreting a whitish fluid from their abdomens and, by prodding a few with a paperclip, had figured out that the ants tended to secrete when hassled.

"They would curl their abdomens around and deposit the white secretion on the paper clip used to prod them," said Trevor Sorrells, then a junior

who was a teaching assistant for the class.

Watching the combat, the students saw the winter ants use their lethal secretions against the invaders. Intrigued, the group decided to continue the research after the class ended.

Kuritzky did a chemical analysis of the secretion, using gas chromatography and mass spectrometry. She determined that part of the secretion consisted of a type of hydrocarbon, which many social insects use to carry a colony-specific odor that helps them identify friend from foe. But what substance gives the secretion is lethal punch still has to be determined.

"Whatever it is, it is clearly very toxic," Gordon said.

To assess the lethality of the secretion – and how freely the winter ants wielded it – Sorrells and the other students ran a series of "trials by combat" in palm-sized shallow glass petri dishes in the lab.

He organized some group rumbles with 20 ants per dish, varying the ratio of winter ants to Argentine ants to see if that had an effect. He also ran some one-on-one gladiatorial combat in a one-centimeter square "ring."

"It turns out the winter ants use the secretion only when they are really overwhelmed, so it is probably energetically very expensive for the winter ant to manufacture and use this stuff," Gordon said.

In the great outdoors, without petri dish arenas in which to settle their disputes, the winter ants tend to use their secretion either when vastly outnumbered or in the immediate defense of queen and colony.

Gordon has been conducting ant population studies in Stanford's Jasper

Ridge Biological Preserve for 18 years, during which she has seen territory change hands as the invaders pushed into the preserve and displaced the winter ants. But several years ago, the winter ants began gaining the upper hand.

"It looks like the Argentine ants are getting pushed back tree by tree," Gordon said. The winter ants are showing up in trees where the Argentine ants had been.

"It seems the winter ants let the Argentine ants find the aphids and then they take over. Over time, the winter ants may be starving the Argentine ants out," she said.

The recent shift in the balance of power may be in part a result of cooler weather, which favors the winter ants, and low rainfall, which inhibits the Argentine ants, Gordon suggested.

So in a natural habitat, without warm buildings in which the Argentine ants can gather around the kitchen hearth, the winter ants can hold the invaders back. But continued development, which creates the disturbed ground and toasty homes that the Argentine ants favor, may well trump the winter ants' chemical weapon in the long run. Already, Gordon said, the Argentine ants in California far outnumber the native winter ants.

Provided by Stanford University