# Ants, not evil spirits, create devil's gardens in the Amazon rainforest, study finds

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For the first time, scientists have identified an ant species that produces its own natural herbicide to poison unwanted plants. Stanford University biologist Deborah M. Gordon and her co-workers describe the findings in the Sept. 22 issue of the journal *Nature*.

The discovery was made during a four-year field study led by Stanford graduate student Megan E. Frederickson in the Amazon jungle of western Peru. The research focused on devil's gardens, mysterious tracts of vegetation that randomly appear in the Amazonian rainforest.

"Devil's gardens are large stands of trees in the Amazonian rainforest that consist almost entirely of a single species, Duroia hirsuta, and, according to local legend, are cultivated by an evil forest spirit," write Frederickson and her colleagues in Nature. "Here we show that the ant, Myrmelachista schumanni, which nests in D. hirsuta stems, creates devil's gardens by poisoning all plants except its hosts with formic acid. By killing other plants, M. schumanni provides its colonies with abundant nest sites--a long-lasting benefit, as colonies can live for 800 years."

## Devilish ants

Most tropical rainforests are densely populated with a remarkable diversity of trees, vines, shrubs and wildflowers. But devil's gardens usually consist of a single plant, D. hirsuta, which happens to be the preferred habitat of the devil's garden ant, M. schumanni.

In addition to the evil-spirit legend, two scientific proposals have been offered to explain why devil's gardens occur. One hypothesis is that D. hirsuta trees release toxic secretions that kill competing plants--a process botanists call allelopathy. Others argue that devil's garden ants are responsible for controlling vegetation, either by extensive pruning or poisoning. "The idea is that by killing other plants, the insects create a space for young D. hirsuta saplings to grow, thereby allowing the ant colony to expand as it occupies new nesting sites in the saplings," Frederickson explains.

To test this hypothesis, she and her colleagues conducted a series of experiments at the Madre Selva Biological Station in the Amazonian rainforest of Loreto, Peru. The research team located 10 devil's gardens for the study, ranging in size from one to 328 D.hirsuta plants.

Two saplings of a common Amazonian tree called Cedrela odorata, or Spanish cedar, were planted inside each garden near the base of a D. hirsuta tree actively patrolled by worker ants. A sticky insect barrier was applied to one cedar sapling to exclude ants, while the other sapling was left untreated. The researchers planted two additional saplings--one treated, one untreated--about 150 feet outside of each garden but within the primary rainforest.

The results were immediate. Worker ants promptly attacked the untreated saplings, injecting a poison called formic acid into the leaves, which began to die within 24 hours. "Most of the leaves on these saplings were lost within five days, and the proportion lost was significantly higher than on ant-excluded saplings," the authors write. On the other hand, cedars treated with Tanglefoot fared well, whether inside or outside devil's gardens.

"These results show that devil's gardens are produced by M. schumanni workers rather than by D. hirsuta allelopathy," the authors conclude.

## Domatia

To find out if worker ants only attack non-host plants, the scientists decided to mimic D. hirsuta's hollow stems, called domatia, which are the ants' primary nesting sites. Artificial domatia were constructed out of foil-wrapped test tubes partially filled with cotton. Two cedar saplings, with and without artificial tubes, were planted in devil's gardens near two D. hirsuta saplings, one with and one without domatia. After 24 hours, there was significant leaf death on all of the cedar plants, but none on any D. hirsuta saplings. "We conclude that M. schumanni attacks only non-host plants, such as C. odorata, and that it does not rely on the presence of domatia to discriminate between its host and other plant species," the Stanford team notes.

Chemical analysis revealed that the only compound produced by the ants' poison glands is formic acid, a toxin that is common in many ant species and, in fact, got its name from formica, which is Latin for ant. "Treatment of leaves with formic acid induced leaf necrosis on all the plants we tested," the authors write. "To our knowledge this is the first record of an ant using formic acid as a herbicide--although it is known to have bactericidal and fungicidal properties."

The ants employ a very effective system of lethal injection, notes Gordon, associate professor of biological sciences at Stanford. "The system harnesses two fundamental tools: formic acid, which many ant species use for other purposes, and the basic circulatory system of all vascular plants," she says.

A census of the rainforest from 2002 to 2004 revealed that devil's gardens grew by 0.7 percent per year. "Using this growth rate, we estimate that the largest devil's garden in our plot, with 351 plants, is 807 years old," the authors conclude. They estimate that a typical garden is tended by a single ant colony with as many as 3 million workers and 15,000 queens, adding that the presence of multiple queens "undoubtedly contributes to colony longevity."

## Niche construction

"The cultivation of devil's gardens by ants is an excellent example of niche construction," Frederickson says. "By killing plants of other species, the ant promotes the growth and establishment of D. hirsuta, thereby gaining more nest sites."

The plants also benefit by increasing their biomass and eliminating the competition, says co-author Michael J. Greene, a former Sanford postdoctoral fellow, now assistant professor of biology at the University of Colorado-Denver. "This work is a truly remarkable example of how effectively ants can manipulate their environment in order to promote their own survival," he adds.

A devil's garden begins when a M. schumanni queen colonizes a single D. hirsuta tree, the authors write: "Over time, D. hirsuta saplings grow within the vegetation-free area created by the ants, and the ant colony expands to occupy them. The devilry of M. schumanni today provides homes for ants in the future."

Frederickson is conducting new field studies to determine which chemical cues the ants use to discriminate between host plants and other species. She also has begun searching for devil's gardens in other parts of the western Amazon to see how widespread the herbicide phenomenon is. "Megan's work reveals a system that is amazing because the ants exert so much control over their environment, creating single-species stands in one of the most diverse places on Earth," Gordon says.

Source: Stanford University