When Their Tools Get Dull, Leaf-Cutters Switch Jobs

New research provides a glimpse of nature's way of providing for its displaced workers

EUGENE, Ore.—When their razor-sharp mandibles wear out, leaf-cutter ants change jobs, remaining productive while letting their more efficient sisters take over cutting, say researchers from two Oregon universities.

Their study—appearing online ahead of regular publication in the journal Behavioral Ecology and Sociobiology—provides a glimpse of nature's way of providing for its displaced workers.

Leaf-cutter ants slice leaves, carry pieces back to the underground nest for further processing and, like tiny mushroom farmers, grow an edible fungus on the resulting substrate. The ants doing the cutting are usually members of the generalized forager caste, one of four size-based behavioral castes of workers. The foragers are second in size to the majors, the large workers that protect the colony and do heavy clearing work on the trails constructed to connect the nest to the leaf sources. In addition to cutting, the foragers transport the cuttings, scout for new resources and also help protect the colony.

"Cutting leaves is hard work. Much of the cutting is done with a V-shaped blade between teeth on their mandibles that they use like a tailor who holds a pair of scissors in a fixed V shape to slice through cloth," Schofield said. "This blade starts out as sharp as the sharpest razor blade that humans have developed."

Over time, though, their mandibles slowly dull. It takes longer and requires more energy to get the job done. When it takes an ant about three times as much time and energy to cut out a leaf disc than it would have taken when her blades were sharp, behavior changes, the researchers reported. The cutting ants rest their blades and join the delivery staff, carrying the discs cut from the leaves into their nest.

"Imagine having only two tiny knives to use for your entire life, with no sharpening allowed," Schofield said. "You would want them to be made of the best material possible. You would use them very carefully, but cutting would still get harder and harder as they dulled until you had to rely on others to cut for you. That's what it is like to be a leaf-cutter ant."

The composition of the cutting blades is of particular interest to researchers. The findings support the idea that wear and fracture are big problems for smaller animals. The researchers estimate that, because of wear, the colony spends twice as much energy cutting leaves as it would if all ants had sharp mandibles. This cost should have resulted in an evolutionary pressure to develop materials that resist dulling, the research team noted. The cutting blades are indeed made of a zinc-rich biomaterial that the researchers suspect is wear resistant.

Schofield was lead author of a study published in 2001 that had identified a family of biomaterials present in mandibular teeth, tarsal claws, stings and other such tools of small organisms. In 2009, a team led by Schofield reported that a similar type of substance empowers the claw tips of striped shore crab and is present on the walking legs of Dungeness crabs.

"Humans are just starting to try to engineer tiny machines and tools, and we have a lot still to learn from organisms that have coped with being small for millions of years," Schofield said. “And in addition, it’s good to know how important wear is to these ants, because they are agricultural pests, and this research hints that crops that produce high levels of wear might discourage them.”

A four-member team of researchers from the UO and Oregon State University conducted the new study. With support from the National Science Foundation, the team studied a colony of the leaf-cutter ants (Atta cephalotes) from the Soberania National Park, near Gamboa, Panama. Leaf-cutter ants range from the southern United States through South America.

Co-authors with Schofield were Kristen D. Emmett and Jack C. Niedbala, UO undergraduates at the time of the project, and Michael H. Nesson of OSU's department of biochemistry and biophysics.

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