Ants regulate growth of seemingly 'useless' organ to make huge soldiers

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The variation in the size of soldiers and minor workers is caused by the brief presence, during the larval phase of a seemingly 'useless' rudimentary organ. This discovery answers a question -- about the difference in ants in a single colony -- that it lead Charles Darwin to doubt his own theory of evolution. Credit: Alex Wild

Scientists at McGill have found the answer to a question that perplexed Charles Darwin. So much so, that it actually led him to doubt his own theory of evolution. He wondered, if natural selection works at the level of the individual, fighting for survival and reproduction, how can a single colony produce worker ants that are so dramatically different in size—from the "minor" workers with their small heads and bodies, to the large-headed soldiers with their huge mandibles—especially if, as in the genus *Pheidole*, they are sterile? The answer, according to a paper published today in *Nature*, is that the colony itself generates soldiers and regulates the balance between soldiers and "minor" workers thanks to a seemingly unimportant rudimentary "organ" which appears only briefly during the final stages of larval development. And only in some of the ants—the ones that will become soldiers.

"It was a completely unexpected finding. People had noticed that during the development of soldiers that a seemingly useless rudimentary "organ" would pop up and then disappear. But they assumed that it was just a secondary effect of the hormones and nutrition that were responsible for turning the larvae into soldiers," says Ehab Abouheif from McGill's Biology Department, the senior author on the paper.

Rajendhran Rajakumar the first author adds, "What we discovered was that these rudimentary "organs" are not a secondary effect of hormones and nutrition, but are instead responsible for generating the soldiers. It is their passing presence that regulates the head and body of soldiers to grow at rapid rates, until you get these big-headed soldiers with huge mandibles and big bodies."

Now you see it, now you don't

Abouheif has been studying wings in ants for the past twenty-three years. He was curious about the function of the wing imaginal disc which appear, transiently, in the final stages of larval development among the

soldier ants. Even though the soldier ants never actually develop wings. So he and his team, spent nine years in the lab, using various techniques (surgical and molecular) to cut away portions of the rudimentary wing discs from the larvae of soldier ants in the widespread and very diverse *Pheidole* genus. They discovered that by doing so, they affected the growth of the head and the body. Indeed, they found that they were able to scale the size of soldier ants by cutting away differing degrees of the imaginal wing discs, with a corresponding decrease in the size of the heads and bodies of the soldier ants. It was clear confirmation that the rudimentary wing discs play a crucial role in the development of soldier ants.

Ehab Abouheif, a McGill biologist has been studying ants for close to 25 years. His interested in ant evolution was prompted by reading Charles Darwin's The Origin of the Species, where he describes how perplexed he felt about the great

variety in the sizes of worker ants in a single colony -- from the large-headed "soldier" ants to the small-bodied "minor" workers. Credit: Neale McDevitt

Soldier ants keep the colony in balance

The researchers also discovered that the colony as a whole maintains the balance between soldiers and minor workers by regulating the growth of the rudimentary wing discs in larvae. Earlier research had shown that the ratio of "minor" workers to soldiers remains constant in all colonies of the *Pheidole* genus, with a proportion of "minor" workers at 90-95 % to 5-10% soldiers. The McGill team has found that the soldier ants maintain this ratio by halting the growth of the rudimentary wing disc with an inhibitory pheromone when there are too many soldiers. However, the colony is able to ramp up the number of soldier ants very quickly if it is under threat or the numbers of soldiers have dropped for some reason, because the rudimentary wing discs that play such a crucial role in regulating the number of soldier ants appear only in the final stages of larval development.

A more important role for all rudimentary organs than previously suspected?

Based on his teams' discovery in ants, Abouheif proposes that rudimentary organs may play a much larger role in an organism's development than had previously been imagined. "Until now, people have assumed that these organs simply offer evidence of evolution and common descent, overlooking any current functions for them. Now that we know the crucial role played in *Pheidole* ant colonies by the rudimentary wing disc, it means that we will have to go back and look at other rudimentary organs in the same light. Who knows what scientists will discover?"

USEFUL ANT FACTS

The males and the queen are the only ants with wings.

The wings grow, during the larval stage, from wing imaginal discs.

All *Pheidole* worker ants are female and sterile.

In colonies of the *Pheidole* genus, the worker castes are made up of both large-headed, big-bodied "major" ants, known as soldiers, and small-headed and bodied, "minor" workers.

The soldier ants are larger and have disproportionally larger heads than the "minor" workers.

The "minor" workers carry out most of the tasks in the colony, they go out and forage & they nurse the brood.

With large mandibles and heads filled with muscles, the large-headed "soldiers" act mainly in defense of the colony. They can also use their mandibles to crack seeds and help process food and will take on the roles of minor workers if a lot of them have died.

Useful ant facts. Credit: McGill University

More information: Rajendhran Rajakumar et al, Social regulation of a rudimentary organ generates complex worker-caste systems in ants, *Nature* (2018). DOI: 10.1038/s41586-018-0613-1

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