Lessons From an Insect's Life Cycle: Extreme Sibling Rivalry

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To understand the rules that govern life, biologists often seek out the weird extremes. And when it comes to family life, it is hard to find a weirder example than that of a common wasp known as Copidosoma floridanum.

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Graphic

Homicidal Larvae

"You couldn't dream up a more surreal life cycle than these guys have," said Mike Strand, a professor at the University of Georgia.

Copidosoma floridanum, native throughout the United States, is a parasite. The female wasps lay one or two eggs inside the egg of the cabbage looper moth. As the host egg develops into a caterpillar, the wasp egg grows into a microscopic cluster of grapes.

Each grapelike mass of cells develops into a wasp embryo. A single egg can give rise to more than 3,000 genetically identical siblings, each about a fifth of an inch long.

"The caterpillar is about two to three inches long, so you can stuff a lot of wasps in there," Dr. Strand said.

Most of the larvae are maggotlike creatures that drink the caterpillar's blood. But up to a quarter of the wasps take on an entirely different form. They develop slender, snakelike bodies and rasping jaws. Instead of slurping blood, these hundreds of soldiers attack other wasp larvae. "They just latch on and suck away," Dr. Strand said.

The blood-suckers that are not killed by the soldiers eventually begin to devour the organs of their host, become pupae, and then develop into adults that fly away. The soldiers, on the other hand, cannot escape. "It's lights out for the soldiers when their siblings eat the caterpillar," Dr. Strand said.

Biologists have known about Copidosoma floridanum's strange soldiers for more than a century, but they are enjoying a new surge of interest as a model that scientists can study to learn about the evolution of families. The forces driving this evolution can be particularly intense for the wasps, because thousands of them are struggling for food inside a single host. Biologists are trying to understand how the soldiers fit into that struggle. "The big debate about these soldiers is what they're doing in their host," said Andrew Gardner, an evolutionary biologist at the University of Edinburgh.

Some of the evidence scientists have gathered suggests that soldiers exist to wipe out the competition. A cabbage looper often plays host to larvae from several wasp mothers. It may even carry larvae from other species of wasps. Soldiers kill off unrelated wasps, and thus allow their siblings to enjoy a bigger meal.

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The soldiers themselves cannot reproduce (they do not even have sex cells). Yet natural selection might favor genes for these dead-end creatures. By killing off competitors, they increase the odds that their genetically identical siblings will survive and have offspring.

Dr. Strand and his colleagues have found that soldiers can tell the difference between their siblings and unrelated wasps — a crucial skill for killing off rivals. In another experiment, they injected unrelated Copidosoma wasp eggs into a cabbage looper that was already host to developed larvae. The intruders were almost always annihilated by the resident soldiers.

On the other hand, Dr. Strand and co-workers have also documented that soldiers will even kill members of their own family.

When Copidosoma mothers lay two eggs in a host, one egg produces thousands of males, and the other produces thousands of females. The female soldiers will kill off many of their brothers.

Dr. Gardner and his colleagues recently built a mathematical model of Copidosoma floridanum's soldiers and blood-feeders to understand how this kind of fratricide might have evolved. While the soldiers are genetically identical to the sisters, they share only some of their genes with the males, which come from a separate egg. That means that the soldiers get a bigger evolutionary benefit from the success of their sisters than from that of their brothers. A few males are more than enough to fertilize thousands of female wasps. Any more males inside a host are just competition for the sisters.

"There's a war between the two sexes," Dr. Gardner said. "The female soldiers are eating the males so that the females can take more of the resources."

Dr. Gardner's model predicts that if a sex-ratio conflict is driving the evolution of soldiers, female eggs should develop into more soldiers than male eggs do. And that does appear to be the case. In fact, male soldiers do not even attack other wasps.

Dr. Gardner and Dr. Strand are now joining forces to study the wasps. They agree that the full story of the soldiers may actually combine their two explanations. "It's got to be both," Dr. Strand said.

It turns out that soldiers come in two different forms. Soldiers that develop early tend to attack their own family. Late-developing soldiers are more likely to attack other species of wasps. Dr. Strand and Dr. Gardner plan to combine their experimental data and mathematical models to see if the soldiers benefit their siblings in two ways, rather than one.

Scientists have estimated that several hundred other wasp species also produce soldiers, but they do not know how they are related. Their evolutionary tree may reveal whether soldiers began as brother-killers, or as a way to wipe out wasps beyond the family.

"Did they start out one way, or did they start out the other way?" Dr. Strand asked. "We don't have good answers yet."

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