



Science Blog

August 2001

From [North Carolina State University](#)

Fire ant queens and workers negotiate ♦ truce' on colony sex ratio

It may be the world's tiniest power struggle: Queens and workers in fire ant society are often at odds about the proportion of new male and female ants raised in their colonies.

The conflict offers a glimpse into a complex insect society that is neither an absolute monarchy under the control of the queen, nor a workers' paradise where the queen is a slave to the will of her offspring. Rather, workers and queens have arrived at a kind of negotiated middle ground, according to research conducted at North Carolina State University and published Friday, Aug. 17, in the journal *Science*.

The findings have implications for how scientists understand the complicated structure of social insect societies, including those of ants, wasps, bees and termites, explains Dr. Ed Vargo, NC State assistant professor of entomology and co-author of the *Science* paper.

"This will cause people to think a little more about the role that queens have in societies like this, and to focus a little more on the mechanisms the queens use to exert control," Vargo said.

For decades, entomologists have thought that the workers in ant colonies ♦ all female and all daughters of the queen ♦ control how many males are allowed to live in the colony by killing many of their brothers while still larvae. Scientists assumed the queen was simply an egg-laying machine. They were puzzled, though, that the ratio of females to males in some ant colonies was not quite as high as they would expect in a worker-dominated society.

The research by Vargo and his three European colleagues has found an explanation: The queen can, in fact, alter the sex ratio of her colony by limiting the number of female eggs she lays. "The queen and the workers are having a conflict, and in some circumstances the queens can exert more control, and in some circumstances the workers can exert more control," Vargo said.

To examine the determination of sex ratios in social insect societies, the scientists studied colonies of fire ants (*Solenopsis invicta*) in Vargo's lab. Fire ants were the social insect of choice because they have only one queen per colony, and because their colonies tend to "specialize" in producing mostly male or mostly female offspring.

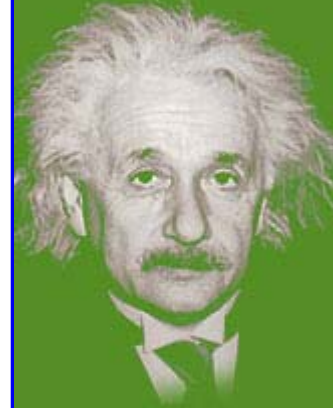
The scientists switched queens from about a dozen female-producing colonies with queens from about a dozen male-specialist colonies. Originally female-specializing colonies almost immediately began producing mostly males, while the originally male-specialist colonies produced females. Within five to six weeks, the sex ratio of the queen's new colony was nearly identical to her original colony.

"We found that the sex ratio of the queen in the original colony followed the queen to the new colony she was transferred to," Vargo said. "It completely reversed the sex ratio in that new colony, but stayed the same for the queen."

The researchers next examined the sex of the eggs produced by seven male- and 10 female-specialist colonies. They found that the queens from the female-producing colonies laid female eggs almost exclusively, and queens

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from male-producing colonies laid more than 50 percent male eggs. A queen is able to determine the sex of her offspring by allowing or not allowing stored sperm to fertilize the eggs. Fertilized eggs become females with diploid, or paired, chromosomes; unfertilized eggs become males with haploid, or single, chromosomes.

The root of the power struggle between queens and workers results from the different interests they have in raising new members of the colony. Both ♦ as a result of evolutionary pressures ♦ are interested in ensuring the survival of their genes. The queen does this by producing new queens and male drones to mate with those queens, which will create new colonies. But males, which die after mating, are of no use to the female workers.

"Because of the complex system of sex determination in ants and other social insects, it turns out that workers are more closely related to each other than they would be to their own offspring," Vargo explained. "Workers gain more by staying with their mother and working with their sisters than by going off on their own."

On average, fire ant sisters share about 75 percent of the same genes. They share only one-half of their genes with their mother, and only about 25 percent with their brothers. So, it's in the evolutionary interest of the workers to maximize the number of sisters they have and minimize the number of brothers.

The queens have their gambit, though: They can force their daughters to raise male young by overwhelming them with male eggs. The workers may selectively eliminate some males, but won't kill many of them, Vargo speculates, because that would waste too much of their colony's limited resources.

That "tug-of-war" is what happens in a single colony. Among groups of fire ant colonies, Vargo says, an entirely different struggle is taking place, as queens compete among themselves to ensure that their genes survive to create the next generation of colonies.

For example, it's in the interest of the queen to produce mostly males in an area where most of the other queens are producing breeding females, and vice versa. It's still a mystery, though, whether queens can change the number of breeding males and females they produce over time, and what genetic or ecological factors cause queens to have a



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bias toward producing either sex.

Vargo's colleagues on the fire ant research are Dr. Luc Passera at the University Paul-Sabatier in France; Dr. Serge Aron at the Free University of Brussels, Belgium; and Dr. Laurent Keller at the University of Lausanne, Switzerland.

Editor's note: A copy of the Science paper is available before 2 p.m. Aug. 16 by contacting Science at 202-326-6440. After that, the paper is available by contacting Kevin Potter in News Services at 919-515-3470 or kevin_potter@ncsu.edu, or by contacting Dr. Ed Vargo at 919-513-2743 or ed_vargo@ncsu.edu.

Digital photos of Dr. Ed Vargo examining fire ants are available by contacting NC State News Services at 919-515-3470 or newstips@ncsu.edu.

An abstract of the paper follows.

"Queen control of sex ratio in fire ants" Authors: L. Passera, University Paul-Sabatier, Toulouse, France; S. Aron, Free University of Brussels, Belgium; E.L. Vargo, North Carolina State University; and L. Keller, University of Lausanne, Switzerland.

Published: August 17, 2001, in Science

Abstract: The haplodiploid sex-determination system of ants gives rise to conflict between queens and workers over colony sex ratios, and the female-biased allocation ratios seen in many species suggest that workers often prevail in this conflict. We exchanged queens between male- and female-specialist colonies of the fire ant, *Solenopsis invicta*. These exchanges quickly reversed the sex-ratio biases of adopting colonies. In addition, the sex ratio of queen-laid eggs differed strongly between male- and female-dominated colonies. These findings suggest that queens can force workers to raise male sexuals by limiting the number of female brood, and may help to explain why sex investment ratios lie between the queen and worker equilibria in this and many other ant species.

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