Farming and chemical warfare: A day in the life of an ant?

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One of the most important developments in human civilisation was the practice of sustainable agriculture. But we were not the first - ants have been doing it for over 50 million years. Just as farming helped humans become a dominant species, it has also helped leaf-cutter ants become dominant herbivores, and one of the most successful social insects in nature. According to an article in the November issue of *Microbiology Today*, leaf-cutter ants have developed a system to try and keep their gardens pest-free; an impressive feat which has evaded even human agriculturalists.

Leaf-cutter ants put their freshly-cut leaves in gardens where they grow a special fungus that they eat. New material is continuously incorporated into the gardens to grow the fungus and old material is removed by the ants and placed in special refuse dumps away from the colony. The ants have also adopted the practice of weeding. When a microbial pest is detected by worker ants, there is an immediate flurry of activity as ants begin to comb through the garden. When they find the pathogenic 'weeds', the ants pull them out and discard them into their refuse dumps.

"Since the ant gardens are maintained in soil chambers, they are routinely exposed to a number of potential pathogens that could infect and overtake a garden. In fact, many of the ant colonies do become overgrown by fungal pathogens, often killing the colony," said Professor Cameron Currie from the University of Wisconsin-Madison, USA. "Scientists have shown that a specialized microfungal pathogen attacks the gardens of the fungus-growing ants. These fungi directly attack and

kill the crop fungus, and can overrun the garden in a similar fashion to the way weeds and pests can ruin human gardens."

A curious observation was that some worker ants had a white wax-like substance across their bodies. When they looked at it under a microscope scientists discovered that this covering was not a wax, but a bacterium! These bacteria are part of the group actinobacteria, which produce over 80% of the antibiotics used by humans. The bacteria produce antifungal compounds that stop the microfungal pathogen from attacking the garden. This discovery was the first clearly demonstrated example of an animal, other than humans, that uses bacteria to produce antibiotics to deal with pathogens.

"Research in our laboratory has revealed a number of interesting properties between the bacteria and the pathogenic fungus. The bacteria appear to be specially suited to inhibiting the pathogenic fungi that infect the ants' fungus garden," said Professor Currie.

The interaction between the ants and their fungus crop, and the ants and the bacteria is known as a mutualistic relationship. In general a mutualism is established when both members of the interaction benefit from the relationship. In the ant–fungus mutualism, the ants get food from the fungus. This mutualism is so tight that if the fungus is lost, the entire colony may die. In return, the fungus receives a continuous supply of growing material, protection from the environment, and protection from disease-causing pests.

So what do the bacteria get out of producing pesticides for the ants? "For starters, they get food. Many species of fungus-growing ants have evolved special crypts on their bodies where the bacteria live and grow. Scientists believe that the ants feed the bacteria through glands connected to these crypts," said Dr Garret Suen, a post-doctoral fellow in Professor Currie's lab. "Also, the bacteria get a protected environment in

which to grow, away from the intense competition they would face if they lived in other environments such as the soil."

"Interestingly, the tight association between ant, bacteria and pathogen will sometimes result in the pathogen winning. This interplay has been described as a chemical 'arms race' between the bacteria and fungus, with one side beating the other as new compounds are evolved," said Professor Currie. "At the moment, we are beginning to understand the chemical warfare at the genetic level, and it is likely that these types of interactions are more prevalent in nature than previously thought."

So how exactly does an ant go about forming partnerships with a fungus and a bacterium? No one really knows. With new advances in molecular and genetic technologies, such as whole-genome sequencing, Professor Currie and Dr Suen hope to discover how these associations were established, and to understand how these interactions resulted in the remarkable fungus-growing ability of the ants.

Source: Society for General Microbiology