Infected 'zombie ants' face no discrimination from nest mates

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A dead ant manipulated by a species of so-called "zombie ant fungus" clings to a twig in a South Carolina forest. Credit: Hughs Lab/Penn State

Carpenter ants infected with a specialized parasitic fungus are not subjected to aggression or isolation from their nest mates, and they

continue to share in the colony's food resources until they leave the nest for the last time to die, according to a study led by Penn State researchers.

The findings suggest that, although the fungus is deadly to infected individuals, it is only a chronic condition for the colony—one that does not induce the kind of strong defensive measures thought to be common in social insect societies, the researchers said.

Studies have shown that fungal pathogens from the genus Ophiocordyceps—known as "zombie ant fungus"—control the behavior of carpenter ant workers, compelling them to climb vegetation and bite the veins or margins on the underside of leaves. The infected ants die, remaining attached to the vegetation postmortem. There, the fungus grows and releases spores onto the forest floor below, where they can infect other foraging ants.

"Previous work suggested that insect societies protect the colony through social immunity," said lead author Emilia Solá Gracia, postdoctoral scholar in biology, Penn State. "It was thought that during social interaction, ant workers detect infections in their peers and display aggression toward them or remove them from the nest.

"This fungus, which co-evolved with its host, takes 14 to 21 days to develop in infected individuals before compelling them to leave the nest and perform their last act. The question is, during this development, does the pathogen change how infected ants interact with others or alter the chemical cues they emit, which allows nest mates to detect the infection? Such detection would be optimal for the colony since infected workers die near foraging trails where the fungus releases spores that infect other members of the colony."

To test the hypothesis that infected individuals are recognized by healthy

colony members, the research team looked at whether infected ant workers are attacked by nest mates, whether they spend more or less time in trophallaxis—socially exchanging food—and whether they are spatially separated from other colony members inside the nest.

The researchers collected ants from forested areas in South Carolina and established three colonies in a Penn State laboratory, each colony consisting of three groups of worker ants. One of the three groups was untreated—healthy, the second was injected with a growth medium containing the parasitic fungus and a third received the growth medium alone. The ants were marked with unique dot patterns on their head, thorax and gaster so individuals could be followed over time.

They affixed a modified GoPro camera fitted with both an infrared lens and a macro lens on top of the colonies to capture recorded video virtually 24 hours daily.

While observing 1,240 hours of video footage, the researchers, who reported their findings in the online journal *PLOS ONE*, saw no attacks toward individuals injected with the fungus and found no significant difference in food sharing between infected and uninfected individuals.

The team did find that infected individuals spent considerably more time inside near the nest entrance and spent more time outside the nest than healthy workers.

"It could be that spending more time outside the nest is an early signal of fungal manipulation, which ultimately requires its host to leave the nest for fungal reproduction to occur," Solá Gracia said. "But the most significant finding is that this co-evolved parasite doesn't seem to directly affect social dynamics within the colony."

Taken together, these results suggest healthy individuals do not detect

the parasite inside their nest mates, according to senior author David Hughes, associate professor of entomology and biology.

"The colony's inability to detect infected individuals allows the fungus to develop within the colony, while receiving food and protection from natural enemies that could damage or kill its ant host before the parasite has completed its development," he said. "Based on our observations and the biology of the fungus, we suggest that the pathogen is a chronic parasite of the colony that is able to survive without triggering strong behavioral defenses in the society—in short, the parasite is able to fly under the radar of the colony's defenses."

More information: Emilia Solá Gracia et al, Within the fortress: A specialized parasite is not discriminated against in a social insect society, *PLOS ONE* (2018). DOI: 10.1371/journal.pone.0193536

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