On organic coffee farm, complex interactions keep pests under control

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(PhysOrg.com) -- Proponents of organic farming often speak of nature's balance in ways that sound almost spiritual, prompting criticism that their views are unscientific and naďve. At the other end of the spectrum are those who see farms as battlefields where insect pests and plant diseases must be vanquished with the magic bullets of modern agriculture: pesticides, fungicides and the like.

Which view is more accurate? A 10-year study of an organic coffee farm in Mexico suggests that, far from being romanticized hooey, the "balance and harmony" view is on the mark. Ecologists John Vandermeer and Ivette Perfecto of the University of Michigan and Stacy Philpott of the University of Toledo have uncovered a web of intricate interactions that buffers the farm against extreme outbreaks of pests and diseases, making magic bullets unnecessary. Their research is described in the July/August issue of the journal *BioScience*.

The major players in the system—several ant species, a handful of coffee pests, and the predators, parasites and diseases that affect the pests—not only interact directly, but some species also exert subtle, indirect effects on others, effects that might have gone unnoticed if the system had not been studied in detail.

A key species in the complex web is the tree-nesting Azteca ant (*Azteca instabilis*). The ants aren't particular about the kind of tree they live in, but for some reason their nests are found in only about 3 percent of shade trees on the farm, and ant-inhabited trees aren't randomly distributed—they're found in clumps.

The researchers believe the clumpiness results, at least in part, from the ants' vulnerability to a parasitic fly. Ant colonies expand by sending off queens and broods to nearby trees, but when all the trees in an area have ant nests, the flies can more easily find ants to parasitize. So high-density clusters are preferentially attacked and eventually disappear, either because the ants all die or because the ants move to other trees.

The ants have a cozier relationship with the green coffee scale, a flat, featureless insect that is a serious coffee pest in some regions, but not on the farm where the study was done. Azteca protects the scale from predators and parasites in return for honeydew, a sweet, sticky liquid the scale secretes. One of those predators is the lady beetle (Azya orbigera), whose adult and larval forms both feed on scale. When an adult beetle tries to attack a scale insect, the ants chase it away. But beetle larvae, which are covered with waxy gunk that gums up the ants' mouthparts, are able to polish off plenty of scale. The ants even aid the murderous larvae, albeit inadvertently. In the course of shooing off parasitic wasps that attack scale, the ants also scare away bugs that parasitize beetle larvae.

The beetles also seem to influence the ants' distribution patterns by preying on the scale, on which the ants depend for honeydew. The researchers explored the relationship using theoretical modeling and found that if ants take over the whole plantation, the beetle goes extinct because adult beetles can't get enough to eat. If the ants disappear from the farm, the beetles go extinct because the larvae starve. But if ants are confined to clusters, due to the influences of both beetles and parasitic flies, the beetles thrive and keep the scale insects under control.

"The interesting thing is that the beetles could not exist except for the highly patterned ant population, but it could be those very same beetles causing the pattern formation in the first place," said Vandermeer, who is the Asa Gray Distinguished University Professor of Ecology and Evolutionary Biology. "The beetle creates the conditions for its own survival."

The white halo fungus, a disease of scale insects, also enters in. The disease occurs here and there throughout the farm but runs rampant only where large populations of scale are found, which is only where the ants are protecting the scale. By suppressing the scale, on which the ants depend for honeydew, the fungus indirectly affects the ants' survival. But that's not all: The fungus also attacks coffee rust, a notorious pest that virtually wiped out coffee production in Sri Lanka (previously known as Ceylon), Java and Sumatra in the mid-19th century and has since infiltrated Central and South America but has not caused serious problems in those areas. White halo fungus only works its magic against coffee rust, however, in the process of conducting major assaults on scale, and those assaults happen only where there's lots of scale—in other words, where the scale is under ants' protection.

In addition to Azteca, other ant species protect scale, and some of these ants are predators of the coffee berry borer and leaf miner, which are also coffee pests. The researchers are still working out the details of the relationships among the various ants and the other species with which they interact.

As the research team continues to discover more species that are part of the web and more complex direct and indirect interactions among all the members, it's increasingly clear that the "naďve" view of nature working in harmony closely matches the scientific facts.

"There are many farmers in the tropics who have been on their land for a long time—sometimes many generations—and have seen these things happening and intuitively understand the connections," said Vandermeer. "The stories they tell about the balance of nature sound almost romantic and religious sometimes, but if you just change the words, they start sounding like what we're describing."

Though this study is being done within the confines of a 300-hectare (740 acre) farm in southern Mexico, the researchers believe their approach and findings are more broadly applicable.

"Our view is that interaction webs of this sort will prove common in agro-ecosystems in general," said Perfecto, professor of ecology and natural resources. "Although widely appreciated in natural systems, such webs haven't been seen in agro-ecosystems because the people studying them haven't looked at them in this way. They're looking for magic-bullet solutions; they want to find the thing that causes the problem and then fix it. Our approach is to understand systems that are working well, where there are no problems. By doing that, we can define systems that are more resilient and resistant to pest outbreaks."

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