'Friendly fungi' killing psyllids in Florida citrus

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The Asian citrus psyllid, *Diaphorina citri*, transmits citrus greening disease, which poses a serious threat to the citrus industry in Florida. Between September 2005 and February 2006, dead adult psyllids were collected from citrus groves in central Florida that were killed by two different fungal pathogens. This was an exciting finding because we need all the allies we can get to help reduce psyllid populations.

In other citrus-growing regions of the world, as in Asia and in the Caribbean basin, several fungal pathogens have been described as natural enemies of psyllids. These pathogens are most effective in killing psyllids during periods of high relative humidity, which favor fungal growth and development.

We conducted laboratory studies to identify these two fungal pathogens and to study their basic biology at the Entomology and Nematology Department of the University of Florida's Institute of Food and Agricultural Sciences in Gainesville.

IDENTIFICATION

We used a combination of morphological and molecular (DNA sequence) data to identify the two pathogens. The dead psyllid on the graphic below was killed by a newly described isolate of *Hirsutella citriformis*. The psyllids are held tightly to the citrus foliage by the "arm-like" structures produced by the fungus which emerge from the psyllid's head, thorax or abdomen. The tiny spores (conidia) found along the "arms" of this fungus initiate new infections in the psyllids. Different isolates of *Hirsutella* attack other psyllids and related insect pests in Florida and elsewhere.

The first of two illustrations showing the two "friendly fungi" that kill psyllids in Florida: Adult psyllid killed by Hirsutella citriformis. The arrows point to the "arms" of the fungus, which are covered with microscopic spores (conidia) that can infect other psyllids.

The dead psyllid on the second graphic was killed by a newly described strain of *Paecilomyces fumosoroseus*. This fungus produces infective spores (conidia) almost over the entire surface of the dead psyllid. This strain of *P. fumosoroseus* has a broad host range; under laboratory conditions we showed that it kills other citrus pests including the citrus leafminer, the brown citrus aphid, the two-spotted spider mite and the citrus red mite. The strain also can kill some beneficial insects, including the parasitoid wasp that attacks psyllid nymphs, *Tamarixia radiata*, whic was imported from Asia and released in Florida as part of a classical biological program.

BIOLOGY OF THE BENEFICIAL FUNGI

Each pathogen was cultured on artificial media (in vitro) and maintained directly on other psyllids (in vivo) by a "touch test," where healthy Asian citrus psyllids from a laboratory colony were exposed to the field-collected psyllid cadavers. We were able to transmit the infection to healthy psyllids using both fungi produced in vitro and in vivo. Only dead adult psyllids were collected in the field, but both pathogens could kill D. citri adults and nymphs under laboratory conditions. On artificial media, *H. citriformis* was very slow-growing, whereas *P. fumosoroseus* grew rapidly.

Psyllids exposed to *H. citriformis* survived an average of seven to nine days, but psyllids infected with *P. fumosoroseus* only lived three days. *Hirsutella citriformis* penetrates the external surfaces of psyllids and grows in the hemolymph (blood) until the insect dies, but *P. fumosoroseus* appears to use toxins to rapidly kill psyllids and apparently does not grow inside of the insect host. Psyllids infected with these pathogens have dramatic changes in their behavior — they have a reduced tendency to fly, and they twitch, shake and flick their wings prior to death.

The second illustration shows an adult psyllid killed by Paecilomyces fumosoroseus. Almost the entire surface of the dead psyllid is covered with the fungus, which produces numerous spores (conidia) that can infect other psyllids.

FIELD STUDIES

The dead adult psyllids killed by *H. citriformis* were found attached to the underside of citrus foliage in Polk, Hendry and Marion counties, and those killed by *P. fumosoroseus* were collected in Polk County. Hundreds of psyllids were collected that were killed by *H. citriformis*, but only a few psyllids killed by *P. fumosoroseus* were found. This difference in abundance is probably due to the fact that psyllids killed by *H. citriformis* are tightly attached to the citrus foliage, but those psyllids killed by *P. fumosoroseus* are only loosely attached and may be removed from the tree by wind and rain.

Two pilot field trials, conducted during March and August 2006, using this strain of *P. fumosoroseus* as a microbial insecticide, resulted in reduced populations of psyllid nymphs. However, economic and technical issues, coupled with the frequent use of copper applications (which could kill these "friendly fungi") to control citrus canker and other plant pathogens, likely will prevent the commercial development of these beneficial fungi for use in Florida's citrus pest management programs.

We do not yet understand the significance of these two fungi as mortality factors of the Asian citrus psyllid in Florida's citrus groves. Research is needed to determine how the pathogens are transmitted, when the beneficial fungi are most abundant, and how widespread these psyllid diseases are distributed in Florida. Quantitative sur-

veys also are needed to evaluate how the weather influences the number of psyllids killed by these pathogens throughout the year. So far, we have identified two new natural enemies in Florida that kill Asian citrus psyllids and gained knowledge about the basic biology of each pathogen in our laboratory studies. Future research may tell us how we can enhance the effectiveness of these beneficial fungi to reduce populations of the Asian citrus psyllid.

Isolates of both of the fungal pathogens have been deposited in the USDA-ARS Collection of Entomopathogenic Fungal Cultures (ARSEF) (H. citriformis: ARSEF 8315; *P. fumosoroseus*: 8316) for permanent preservation and so they can be accessed by others for future research.

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