Thrips show altered feeding behavior

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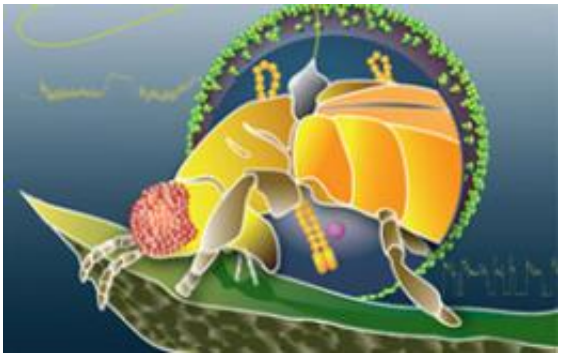

Thrips feeding. Illustration: Okemura Design

(PhysOrg.com) -- Thrips — tiny insects that pierce and suck fluids from tomatoes, grapes, strawberries and hundreds of other plant species — show altered feeding behavior when they're infected with tomato spotted wilt virus (TSWV), newly published research by University of California scientists reveals.

Male Western flower thrips (Frankliniella occidentalis) infected with TSWV fed up to three times more than uninfected males, according to the research, published this week in the Proceedings of the National Academy of Sciences (PNAS) by UC Davis plant pathology doctoral candidate Candice Stafford and entomologists Gregory Walker of UC Riverside and Diane Ullman of UC Davis.

"Until now, behavioral changes in plant virus vectors have been observed only as a response to plant-host infection, and there have been no

examples of vector infection with a plant virus altering feeding behavior," the scientists wrote.

"Since plants do not move around to come in contact with one another, virus transmission from one host plant to another was a major hurdle for plant-infecting viruses to overcome," said Walker, UC Riverside professor of entomology. "To overcome this problem, most plant viruses have exploited the mobility of herbivorous insects, especially piercing-sucking insects, as a vehicle for transport from one plant to another."

Walker said the study "demonstrates for the first time that a plant-infecting virus not only uses an insect for transport from an infected host to a new host, but also manipulates the behavior of the insect on the new host in order to maximize the probability that it will be successfully inoculated."

Earlier research showed that males transmit TSWV more efficiently than females and that animal-infecting members of the virus family, Bunyaviridae — in which TSWV is classified — alter the feeding of their vectors.

Compelled by this knowledge, the UC scientists asked whether TSWV, a plant-infecting bunyavirus, may modify the feeding behavior of its vector, the Western flower thrips. When they examined infected and uninfected male and female thrips, infected males made almost three times more probes into the plants than uninfected males, including three times more non-ingestion probes (probes in which they salivate, but leave cells largely undamaged).

"These probes are especially important because TSWV infection requires a functional cell, so this probing behavior is predictive of virus transmission," said Ullman, UC Davis professor of entomology and associate dean for undergraduate academic programs in the College of

Agricultural and Environmental Sciences.

"I have always been intrigued by how parasites alter the behaviors of their vectors, and thought it was odd that such behavioral alterations have not been reported for vectors of plant infecting viruses," said Stafford, whose major professor is Ullman. "Although several plant viruses infect their insect vectors, we have shown that vector infection by a plant virus alters feeding behavior, which has major implications for virus transmission."

An increase in the number of times an insect probes into a plant increases the probability of virus transmission, the scientists noted. "Uninfected male thrips make very few probes and therefore their feeding behaviors are not conducive to virus transmission," said Stafford. "However, when male thrips are infected with TSWV they make up to three times more probes than uninfected males and are more efficient vectors than female thrips. We hypothesize that this increase in feeding may also result in increased nutrition to counterbalance negative impacts virus infection has on fitness."

Said Ullman: "We were also fascinated by the possibility that modification of vector-feeding behavior could be a conserved trait among plant and animal-infecting members of the Bunyaviridae that evolved as a mechanism to enhance virus transmission. The outcome of our research deeply underscores the evolutionary importance of vector behavioral modification to parasites infecting hosts in both plant and animal kingdoms."

Thrips probe or insert their tubular stylets into cells to suck out the contents. It is during this process that Western flower thrips transmit TSWV. Without feeding, there is no passage of the virus.

TSWV damages a wide range of plant hosts, including ornamentals, field

crops, and fruits and vegetables. The virus wilts and stunts the plants, adversely affecting the quality and the yield. Tomato spotted wilt virus symptoms are diverse, depending on the host, but one of the most striking and common of these symptoms is the development of concentric rings of chlorosis.

TSWV is transmitted in a persistent manner by just 10 thrips species, including the western flower thrips; the onion thrips, Thrips tabaci; and the chili thrips, Scirtothrips dorsalis. It is found worldwide primarily due to the global movement of virus-infected plant material and infected thrips. Early and accurate detection of infected plants combined with thrips control strategies can reduce virus spread.

Thrips, which belong to the order Thysanoptera, are up to a millimeter long or less. Worldwide, there are more than 5,000 known species of thrips. The pest species annually cause billions of dollars in damage to U.S. agricultural crops. Thrips also can be beneficial by feeding on mite and insect eggs.

More information: Infection with a plant virus modifies vector feeding behavior, *PNAS* Published online before print May 23, 2011, doi: 10.1073/pnas.1100773108

Abstract
Vector infection by some animal-infecting parasites results in altered feeding that enhances transmission. Modification of vector behavior is of broad adaptive significance, as parasite fitness relies on passage to a new host, and vector feeding is nearly always essential for transmission. Although several plant viruses infect their insect vectors, we have shown that vector infection by a plant virus alters feeding behavior. Here we show that infection with Tomato spotted wilt virus (TSWV), type member of the only plant-infecting genus in the Bunyaviridae, alters the feeding behavior of its thrips vector, Frankliniella occidentalis

(Pergande). Male thrips infected with TSWV fed more than uninfected males, with the frequency of all feeding behaviors increasing by up to threefold, thus increasing the probability of virus inoculation. Importantly, infected males made almost three times more noningestion probes (probes in which they salivate, but leave cells largely undamaged) compared with uninfected males. A functional cell is requisite for TSWV infection and cell-to-cell movement; thus, this behavior is most likely to establish virus infection. Some animal-infecting members of the Bunyaviridae (La Crosse virus and Rift Valley fever virus) also cause increased biting rates in infected vectors. Concomitantly, these data support the hypothesis that capacity to modify vector feeding behavior is a conserved trait among plant- and animal-infecting members of the Bunyaviridae that evolved as a mechanism to enhance virus transmission. Our results underscore the evolutionary importance of vector behavioral modification to diverse parasites with host ranges spanning both plant and animal kingdoms.

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