Biological control of Asian citrus psyllid in California

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What is biological control?

Biological control is the intentional use by humans of natural enemies, predators, parasitoids, and pathogens to reduce pest populations to less damaging levels. Classical biological control is the importation and release of a natural enemy species into an area where it is lacking. An example of classical biological control is the importation, release, and establishment in California of *Tamarixia radiata*, a parasitoid that attacks Asian citrus psyllid (ACP) nymphs, an invasive pest infesting citrus. The parasitoid was collected from Punjab Pakistan, which is part of the native range of ACP.

Punjab Pakistan was selected for foreign exploration because it has a very good (about 70%) climate match with major citrus production areas in California. Following release from quarantine in December 2011, *Tamarixia* established readily in California's urban areas, it spread naturally into ACP-infested areas up to eight miles from the nearest release sites, and it has provided significant control of ACP.

Studies across numerous sites over several years indicate that ACP densities have declined in urban citrus by at least 70% and *Tamarixia* is one of the dominant natural enemies contributing to this mortality. Predatory hover fly larvae are important native natural enemies of immature ACP.

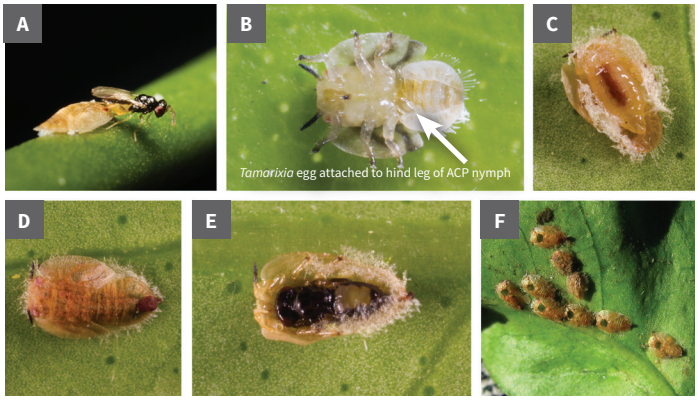

Fig. 1. *(A) Tamarixia wasp laying eggs under ACP nymph. (B) Tamarixia egg attached to underside of ACP nymph. (C) Tamarixia larva inside body cavity of hollowed out ACP nymph. (D) Mummified, beige ACP nymph with silk strands radiating from margins. (E) Tamarixia pupa inside body cavity of ACP nymph. (F) ACP nymphs showing Tamarixia emergence holes.* ***Note:*** *Photos (B), (C), and (D) show Tamarixia after nymph has been "flipped" onto its back. Photo credits, (A), (B), (C), (D), and (E), Mike Lewis, Center for Invasive Species Research, UC Riverside. (F) Jim Davis, American Insectaries.*

How does *Tamarixia* kill ACP?

(Fig. 1) Female *Tamarixia* lay eggs underneath the ACP nymph (***A & B***), the egg hatches, and the parasitoid larva consumes the inside of its host (***C***). The parasitoid larva pupates inside the shell of the ACP nymph (***D & E***), and after pupation is complete, the adult parasitoid chews a circular exit hole in the head region of the nymph and emerges (***F***). *Tamarixia* can also kill ACP nymphs by eating them, this is referred to as host feeding. To host feed, a female parasitoid uses her ovipositor to mutilate the nymph. This causes insect "blood" to leak from the host. The female parasitoid feeds on this liquid which provides protein for egg maturation. The trauma of being stabbed and fed on is sufficient to kill the ACP nymph.

Who is working on the Project?

The Joint Agency Biocontrol Taskforce for ACP biocontrol in California is comprised of team members representing UC Riverside (Mark Hoddle, Beth Grafton-Cardwell, Matt Daugherty, and Richard Stouthamer), CDFA (David Morgan, Victoria Hornbarker, and Mike Pitcairn), Citrus Research Board Scientists (Ruth Henderson, Raju Pandey, and Rick Dunn), Cal Poly Pomona (Anna Soper and Valerie Mellano), citrus growers (Jim Gorden and John Gless), pest control advisors (Joe Barcinas, Jim Davis, and Brett Chandler), and USDA-CPHST (Greg Simmons).

What are the challenges and opportunities?

Field studies in Southern California show that Argentine ants protect ACP nymphs from natural enemies in order to harvest the sugary honeydew excreted by ACP nymphs. Ants kill *Tamarixia* that attempt to parasitize ACP nymphs. Thus, Argentine ant control is needed to maximize natural enemy impacts on ACP infestations. When ants are controlled, natural enemies (both *Tamarixia* and predators) exert substantial control of ACP. Novel approaches to ant control are being investigated and new monitoring and control technologies are being developed for potential use in citrus orchards ***(Fig. 2).***

Fig. 2. *An Argentine ant worker has captured a female Tamarixia that was attempting to parasitize ACP nymphs in this colony. Photo Credit, Mike Lewis, Center for Invasive Species Research, UC Riverside.*

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An additional challenge is that ACP natural enemies often lack food in citrus orchards, especially nectar and pollen, and the absence of these resources reduces their life span and how many pests they can kill. Flowering plants, like alyssum (*Lobularia maritima*) and buckwheat (*Fagopyrum esculentum*), attract adult hover flies. Experiments have demonstrated that the presence of flowering plants significantly increases mortality of ACP nymphs by hover fly larvae ***(Fig. 3)***. More work is needed to determine the feasibility of growing flowering plants to attract hover flies in citrus orchards.

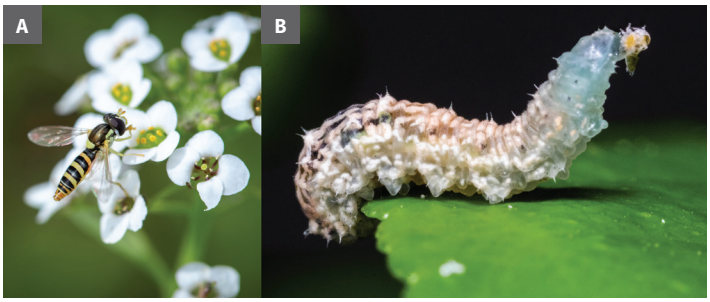

Fig. 3. *(A) Adult hover fly feeding on alyssum flowers in a citrus orchard in Riverside. (B) Syrphid fly larva feeding on an ACP nymph. Photo credits, Mike Lewis, Center for Invasive Species Research, UC Riverside.*

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