Imported parasitoids for biological control of Asian citrus psyllid

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Asian citrus psyllid (ACP) is the primary vector of pathogens responsible for causing huanglongbing (HLB), or citrus greening disease. HLB is the most devastating disease of citrus, and is present in most citrus growing regions except the Mediterranean and Australia. ACP and the Asian form of HLB caused by *Candidatus* Liberibacter asiaticus were first discovered in Florida in 1998 and 2005, respectively. This pest-disease complex is established throughout Florida and is causing serious economic losses to a citrus industry valued at $9 billion in annual revenues.

Classical biological control is often a key tactic used against invasive insect pests for long-term and sustainable management. Generally, the natural enemies that co-evolved with the target pest in its native habitat are considered most effective and therefore the best choice for biological control of invasive pest species. Successful examples abound, beginning in the United States with control of cottony cushion scale more than 100 years ago in California. Historically, most major insect pests in Florida citrus have been the subject of successful classical biological control.

Tamarixia radiata (Figure 1) and *Diaphorencyrtus aligarhensis* (Figure 2), the two well-known parasitoids of ACP nymphs, were first imported into Florida from Taiwan and southern Vietnam and released in numerous locations from 1999 to 2001. A statewide evaluation in 2006–2007 showed widespread dispersal and establishment of *T. radiata*, but *D. aligarhensis* was not detected. Repeated efforts to establish an all-female colony of *D. aligarhensis* have not been successful, but we are continuing efforts to establish this species including release of both males and females. Parasitism rates of ACP by *T. radiata* were generally low in 2006–07, averaging below 20 percent, but high at some locations, averaging 39 percent to 56 percent during late season, suggesting a need for better strains and for augmentation in spring when citrus trees flush strongly and ACP numbers increase rapidly.

Photo by Jeff Lotz

Figure 1. Female *Tamarixia radiata* laying egg on ACP nymph.

After the advent of HLB in Florida, new strains of *T. radiata* collected from Pakistan, southern China and northern Vietnam plus the already established population in Florida were used to initiate a mass production and release program at the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (DPI) in Gainesville and at the University of Florida (UF) Southwest Florida Research and Education Center (SWFREC) in Immokalee. More than 3.5 million parasitoids have been released so far, mostly in commercial citrus. Parasitism rates approaching 60 percent to 80 percent at release sites have been observed in spring and summer, showing that augmentation can potentially increase parasitism in the field.

Also encouraging is that *T. radiata* provided good control of ACP in northwestern India (Punjab), which is now within present-day Pakistan. *T. radiata* also provided good control of ACP following release in Réunion, Taiwan and Guadaloupe. The parasitic wasp also has been detected in Brazil, Puerto Rico, Texas and elsewhere where no known releases were made. Parasitism averaged more than 80 percent at one study location in Puerto Rico, resulting in significant reduction of the ACP population. Hence, present efforts at mass production and release of parasitoids for ACP control in Florida are focused on *T. radiata*.

Photo by Eric Rohrig

Figure 2. Female *Diaphorencyrtus aligarhensis.*

Figure 3. *Tamarixia radiata* female emerged by chewing a circular exit hole in the integument of the dorsal thorax of mummified nymph.

POTENTIAL IMPACT OF *TAMARIXIA RADIATA*

The female *T. radiata* lays her egg under a third to fifth instar ACP nymph while *D. aligarhensis* injects her egg inside the second to fourth instar. Once hatched, the *T. radiata* larva rapidly consumes the body contents of the nymph, and then fastens the tan shell or mummy to the leaf with silk threads before pupating inside. ACP mummies caused by *D. aligarhensis* are dark brown and attached to the leaf by a dried secretion from the larva. Adult *T. radiata* emerge by chewing a circular exit hole in the integument of the dorsal thorax (Figure 3) whereas *D. aligarhensis* emerges through the dorsal abdomen. Female wasps may also feed on ACP blood after piercing the nymph with

Figure 4. DPI new facility for production of *Tamarixia radiata* in Dundee.

the ovipositor. Each *T. radiata* female is capable of destroying up to 500 nymphs through a combination of host feeding and parasitization. See http://entnemdept.ifas.ufl.edu/creatures/ and http://www.biocontrol.entomology.cornell.edu/parasitoids/Tamarixia.html

Mass production and widespread release of *T. radiata* has potential to improve parasitism rates in Florida, and parasitoid augmentation is needed for many reasons. Parasitism rates have been generally falling in commercial groves due to aggressive control of ACP and the negative impact of insecticides on parasitoid populations. Due to natural attrition and insecticide applications during the dormant (winter) season, mass release of *T. radiata* in spring and summer is necessary to re-establish populations wherever citrus or ornamental orange jasmine (*Murraya paniculata*), another preferred host of ACP, are present.

Additionally, conventional groves which refrain from spraying during tree blooms and flush cycles to allow for the safe foraging of honeybees and other beneficial insects require more frequent release of *T. radiata*. Fruit destined for export to the fresh fruit market in Europe must meet Global Good Agricultural Practice requirements that specifically require the use of integrated pest management, including biological control agents. Additionally, resistance of ACP to commonly used pesticides has increased the need for supplementary biological control measures. Certified organic producers cannot use broad-spectrum insecticides that conventional growers use, and also need additional tactics to manage ACP, including release of parasitic wasps.

The demand for *T. radiata* in Florida is extremely high for all these reasons. Large numbers of wasps are required to service the state's current 530,000 acres (approximately 68,000,000 trees) of commercial citrus in addition to more than 100,000 acres of abandoned groves and the abundance of dooryard citrus and orange jasmine hedges.

PRODUCTION OF *TAMARIXIA RADIATA*

Over the past few years, DPI in Gainesville and SWFREC in Immokalee have been producing approximately 1.1 to 1.5 million *T. radiata* per year. DPI recently established a new rearing facility to produce the parasite in Dundee (figures 4 and 5); combined, these facilities now produce approximately 200,000 *T. radiata* per month. Continuing expansion in Dundee should enable total wasp production to increase to 300,000 per month within the next six months and 400,000 per month within one year (4.8 million+/year). This level of production will enable *Tamarixia* releases in a broad range of select habitats.

RELEASE OF *TAMARIXIA RADIATA* IN MANAGED AND UNMANAGED HABITATS

Tamarixia releases will be conducted by DPI staff, grower cooperators and other interested parties to target specific locations where the wasps might be expected to have maximum impact. For example, DPI and the U.S. Department of Agriculture (USDA) currently scout 6,000 blocks of citrus for ACP throughout Florida on a three-week cycle. The resulting data are used to identify ACP "hot spots" that serve as reservoirs for ACP to reproduce and disperse into surrounding groves. Therefore, efforts to boost biological control in commercial citrus groves will focus on "hot spots." Scouts are releasing *Tamarixia* at these sites, and data from ACP monitoring will be analyzed to determine the impact on pest populations. Hot spots may receive consistent, occasional or one-time releases depending on impact and the citrus management practices. Additional collaborative research to evaluate the impact of *T. radiata* releases on ACP in commercial citrus is being conducted by scientists from UF, DPI and USDA.

Abandoned groves, dooryard citrus

Photo by Robin Stuart

Figure 5. Cages for rearing *Tamarixia radiata*.

and orange jasmine (*Murraya* sp.) plantings are common throughout South Florida, often in close proximity to commercial citrus groves, and thus can serve as sources of psyllids and disease inoculum. Orange jasmine is typically irrigated and trimmed; both practices induce new flush required by psyllids for reproduction. DPI and UF personnel will release wasps at these sites when identified, and the general public can assist by bringing such sites to their attention. The resulting impact on ACP populations will be assessed.

In addition to providing wasps for release in Florida, our rearing facilities are providing production technology and colony-starter wasps when requested to surrounding states (Georgia, Alabama, Louisiana and Mississippi), the Caribbean and other cooperators, including Texas and California. Overall, establishing and augmenting natural enemies — particularly species specific parasitoids — can reduce ACP populations in Florida and surrounding areas, and ultimately the spread of HLB.

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