

*New Records and Accounts***First Records of Parasitoids Attacking the Asian Citrus Psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Liviidae), in Hawaii****Janis N. Matsunaga**

Hawaii Department of Agriculture, Plant Pest Control Branch, 1428 S. King St. Honolulu, HI 96814, Janis.N.Matsunaga@hawaii.gov

Abstract. *Tamarixia* sp. prob. *radiata* (Hymenoptera: Eulophidae) and *Diaphorencyrtus aligharensis* (Hymenoptera: Encyrtidae), two natural enemies released against the Asian citrus psyllid (*Diaphorina citri*) in various areas around the world, were discovered attacking this pest on the island of Oahu, Hawaii, in 2012.

Key words: Hawaii, new state record, *Tamarixia radiata*, *Diaphorencyrtus aligharensis*, *Diaphorina citri*

The Asian citrus psyllid, *Diaphorina citri*, is a sap-sucking citrus pest first found in Hawaii attacking a navel orange tree in the Waiakea area of Hawaii Island in May, 2006. Immediately following its discovery on the Big Island, surveys detected *D. citri* on Maui, Lanai, and Oahu, and the insect subsequently spread to Kauai and Molokai islands.

Diaphorina citri not only causes physical feeding damage to host plants including leaf curl and shoot breakage, it is also a vector of *Candidatus Liberibacter asiaticus* Jagoueix, Bové and Garnier, a bacterium which causes one of the most destructive citrus diseases in the world, Huanglongbing (HLB) or citrus greening disease (Manjunath et al. 2008). In *Citrus* species and other closely related plants in the Rutaceae family, HLB infection causes twig dieback, poor flowering, seed abortion, bitter fruit which drop prematurely, and ultimately tree death within a few years (Grafton-Cardwell et al. 2006).

Populations of *D. citri* have been monitored and tested for the presence of HLB

since its arrival in Hawaii. While citrus greening disease was not detected in Hawaii to date, the control of *D. citri* remains a matter of concern, as citrus greening is established in the mainland U.S., including Florida (Macfarland and Hoy 2001) and Southern California (Hoddle and Pandey 2014). According to the USDA National Agricultural Statistics Service's 2012 Census of Agriculture, 616 farms with approximately 928 acres of citrus crops are grown in the State of Hawaii, making this insect vector a substantial threat to local farmers and agriculture.

In 2012, during routine sampling of *D. citri* for HLB, two separate parasitoid species were reared from nymphs, collected on Oahu. Michael W. Gates, Research Entomologist with the Systematic Entomology Laboratory (SEL), Agricultural Research Service, U.S. Department of Agriculture, identified these two species as *Diaphorencyrtus aligarhensis* and *Tamarixia* sp. prob. *radiata*, both wasps not previously recorded from Hawaii.

Tamarixia radiata and *Diaphorencyrtus*

tus aligarhensis are known parasitoids of *D. citri*, released through classical biological control efforts in the continental US and other citrus producing regions of the world (Étienne et al. 2001, Macfarland and Hoy 2001, Rohrig et al. 2012). *Tamarixia radiata* was imported into Florida from Taiwan and Vietnam, and released in 1999 (Hoy and Nguyen 2001). It established throughout citrus growing regions, though at relatively low rates of parasitism (Qureshi et al. 2009). In 2011, three years following the discovery of *D. citri*, California began releases of *T. radiata* on citrus plants in residential and urban gardens (Hoddle 2012). According to Kistner (2014), *T. radiata* has established stable populations in California, with preliminary studies suggesting that *T. radiata* may be playing a positive role in the suppression of *D. citri* densities. *Diaphorencyrtus aligarhensis* was imported from Taiwan, and released in Florida beginning in 2000. Additional releases were attempted with stock colonies from China, however, *D. aligarhensis* was not able to establish (Qureshi et al. 2009).

In Hawaii, Pawaa collections of *D. aligarhensis* (2012) yielded very low numbers of individuals emerging from *D. citri* pupae. The rate of parasitism from 2012 and October 2014 material of *T. sp. prob. radiata* attacking *D. citri* was on average less than 10%. In an additional collection from Kunia in December, 2014, parasitism rose to over 90%. These populations of *D. aligarhensis* and *T. sp. prob. radiata* have not been monitored closely since initial collections in 2012, with the exception of the October and December 2014 material. Establishment of these parasitoids on other islands has not been reported.

Similar to their host, these two parasitoids appear to have established in Hawaii by accident, and were not the result of purposeful introduction. It is not unusual for *T. radiata* to be discovered in non-

release locations, as it has also dispersed to Texas, Brazil, and Puerto Rico (Michaud 2004, Gómez Torres et al. 2006, Pluke et al. 2008). While this fortuitous introduction is a potentially helpful tool in controlling the Asian citrus psyllid, and potentially HLB, the arrival of these host specific parasitoids suggest that a high risk pathway for *Ca. L. asiaticus* and its insect vector remains open [In lab tests, Hoddle and Pandey (2014) found that *T. radiata* will also parasitize *Bactericera cockerelli* Sulc (Hemiptera: Trioziidae) at low levels (<5%); *B. cockerelli* is not known to occur in Hawaii, but is a routinely intercepted pest on imported Solanaceous produce at Hawaii ports of entry.]

***Diaphorencyrtus aligarhensis* (Shafee, Alam, and Agarwal)
(Hymenoptera: Encyrtidae)**

Material examined: OAHU: Pawaa, 28.vi.2012; ex. *Diaphorina citri* on *Murraya paniculata*; coll. W. Nagamine; Deposited at SEL. Honolulu, Pawaa, 13.vii.2012; ex. *Diaphorina citri* on *Murraya paniculata*; coll. C. Young and M. Lee (specimens deposited at SEL).

***Tamarixia sp. prob. radiata* (Waterson)
(Hymenoptera: Eulophidae)**

According to Gates, "These specimens match the two shriveled specimens in the [SEL] collection that were identified by Burks as *T. radiata*. It also matches Waterson's original description. The group needs to be revised and a reliable key to species produced." The adults provided were not identifiable to species.

Material examined: OAHU: Pawaa, 13.vii.2012; *Diaphorina citri* on *Murraya paniculata*; coll. C. Young and M. Lee. Kunia, 21.viii.2012; ex. *Diaphorina citri* on *Citrus limon* terminal shoots; coll. J. (Matsunaga) Garcia (specimens deposited at SEL and Hawaii Department of Agriculture). Kunia, 17.x.2014; ex. *Diaphorina*

citri on *Citrus limon* terminal shoots; coll. J. Matsunaga.

Acknowledgments

I thank Walter Nagamine, Monica (Lee) Tauyan, and Cheryl Young for their extensive collections and persistence, and Michael W. Gates for his identification of specimens.

Literature Cited

- Étienne, J., S. Quilici, D. Marival, and A. Franck.** 2001. Biological control of *Diaphorina citri* (Hemiptera: Psyllidae) in Guadeloupe by imported *Tamarixia radiata* (Hymenoptera: Eulophidae). *Fruits* 56: 307-315.
- Hoy, M.A., and R. Nguyen.** 2001. Classical biological control of Asian citrus psylla. *Citrus Industry* 81: 48–50.
- Grafton-Cardwell, E., K.E. Godfrey, M.E. Rogers, C.C. Childers, and P.A. Stansly.** 2006. Asian citrus psyllid. Oakland: Univ. Calif. Agri. Nat. Res. Publ. 8205. <http://www.anrcatalog.ucdavis.edu/pdf/8205.pdf> [accessed 23 October 2014].
- Hoddle, M.S.** 2012. Has the Asian citrus psyllid parasitoid, *Tamarixia radiata*, established in California? University of California Riverside, Center for Invasive Species Research Blog. [blog] 19 July. <http://cistr.ucr.edu/blog/asian-citrus-psyllid-2/> has-the-asian-citrus-psyllid-parasitoid-tamarixia-radiata-established-in-california/ [accessed 25 November 2014].
- Hoddle, M.S., and R. Pandey.** 2014. Host range testing of *Tamarixia radiata* (Hymenoptera: Eulophidae) sourced from the Punjab of Pakistan for classical biological control of *Diaphorina citri* (Hemiptera: Liviidae: Euphyllurinae: Diaphorinini) in California. *J. Econ. Entomol.* 107(1): 125–136.
- Kistner, E.J.** 2014. *Tamarixia radiata* and natural enemy impacts on the invasive Asian citrus psyllid in southern California. University of California Riverside, Center for Invasive Species Research Blog. [blog] 31 October. <http://cistr.ucr.edu/blog/uc-riverside/tamarixia-radiata-natural-enemy-impacts-invasive-asian-citrus-psyllid-southern-california/> [accessed 25 November 2014].
- Manjunath, K.L., S.E. Halbert, C. Ramadugu, S. Webb, and R. F. Lee.** 2008. Detection of ‘*Candidatus Liberibacter asiaticus*’ in *Diaphorina citri* and its importance in the management of citrus huanglongbing in Florida. *Phytopathology* 98(4): 387–396.
- Mcfarland, C.D., and M.A. Hoy.** 2001. Survival of *Diaphorina citri* (Homoptera: Psyllidae), and its two parasitoids, *Tamarixia radiata* (Hymenoptera: Eulopidae) and *Diaphorencyrtus aligarhensis* (Hymenoptera: Encyrtidae), under different relative humidities and temperature regimes. *Fla. Entomol.* 84(2): 227–233.
- Michaud, J.P.** 2004. Natural mortality of Asian citrus psyllid (Homoptera: Psyllidae) in central Florida. *Biol Control* 29: 260–269.
- Pluke, R.W.H., J.A. Qureshi, and P.A. Stansly.** 2008. Citrus flushing patterns, *Diaphorina citri* (Hemiptera: Psyllidae) populations and parasitism by *Tamarixia radiata* (Hymenoptera: Eulophidae) in Puerto Rico. *Fla. Entomol.* 91(1): 36–42.
- Qureshi, J. A., M.E. Rogers, D.G. Hall, and P.A. Stansly.** 2009. Incidence of invasive *Diaphorina citri* (Hemiptera: Psyllidae) and its introduced parasitoid *Tamarixia radiata* (Hymenoptera: Eulophidae) in Florida citrus. *J. Econ. Entomol.* 102: 247–256.
- Rohrig, E.A., D.G. Hall, J.A. Qureshi, and P.A. Stansly.** 2012. Field release in Florida of *Diaphorencyrtus aligarhensis* (Hymenoptera: Encyrtidae), an endoparasitoid of *Diaphorina citri* (Homoptera: Psyllidae), from mainland China. *Fla. Entomol.* 95: 479–481.
- Torres, M.L.G., D.E. Nava, S. Gravena, V.A. Costa, and J. R.P. Parra.** 2006. Registro de *Tamarixia radiata* (Waterston) (Hymenoptera: Eulophidae) em *Diaphorina citri* Kuwayama (Hemiptera: Psyllidae) em São Paulo, Brasil. *Rev. Agricultura.* 81: 112–117.
- United States Department of Agriculture, National Agricultural Statistics Service.** 2014. 2012 Census of Agriculture – Hawaii State and County Data, Volume 1, Geographic Area Series, Part 11. Washington, DC: USDA, NASS.