SCIENTIFIC NOTE

Solanum torvum (Solanaceae), a New Host of *Ceratitis capitata* (Diptera: Tephritidae) in Hawaii

Grant T. McQuate
USDA-ARS, U.S. Pacific Basin Agricultural Research Center
P. O. Box 4459, Hilo, HI 96720

Abstract. In Hawaii, Mediterranean fruit fly, *Ceratitis capitata,* populations at low elevations have been displaced to higher elevation hosts by oriental fruit fly, *Bactrocera dorsalis*. That displacement, however, is not complete, as *C. capitata* coexists with *B. dorsalis* at a number of low elevation sites. Turkeyberry, *Solanum torvum* Sw, is a lower elevation noxious weed that has been spreading in Hawaii. Tephritid fruit fly infestation of this plant is predominantly by *Bactrocera latifrons*. However, turkeyberry fruits in Hawaii can also be infested by oriental fruit fly and, reported here for the first time, by Mediterranean fruit fly. If *S. torvum* continues to spread in Hawaii, it will continue to be a potential low elevation wild host for *C. capitata* as well as for *B. dorsalis* and *B. latifrons*.

Key words: *Ceratitis capitata, Solanum torvum,* turkeyberry, *Bactrocera dorsalis, Bactrocera latifrons*

Turkeyberry, *Solanum torvum* Sw, is a solanaceous host of *Bactrocera latifrons* (Hendel) in Hawaii (Liquido et al. 1994, Bokonon-Ganta et al. 2007, McQuate et al. 2007). Because *B. latifrons* can readily be recovered from the often extensive patches of *S. torvum* on Maui, these patches have been used as sources of wild flies to better study the biology, ecology and potential for suppression of *B. latifrons* (e.g., McQuate and Peck 2001; McQuate et al. 2004, 2007; Bokonon-Ganta et al. 2007,). Although *B. latifrons* is the primary tephritid fruit fly species infesting *S. torvum* in Hawaii, oriental fruit fly, *B. dorsalis* (Hendel), has also been recovered at some sites (Bokonon-Ganta et al. 2007). Here it is reported, for the first time, that Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), can also infest *S. torvum* in the field. We present this data in order to further document the host range of the Mediterranean fruit fly. This has importance both in terms of knowledge of the potential host base of local populations as well as knowledge of the potential of interstate transportation of turkeyberry fruits to lead to accidental introduction of Mediterranean fruit fly (Liquido et al. 1997).

Turkeyberry, also referred to as devil's fig, is a solanaceous plant native to the Antilles (the West Indies) that has become a pantropical weed. It is a spreading or sprawling shrub which grows up to about 3 m in height, has prickles scattered on stems, leaf surfaces and main veins and bears berries (1.0–1.5 cm in diameter) in clusters of a few to more than 10 (Wagner et al. 1990). As the berries reach full size brownish spots form on the background green color of the fruits (a stage I call "mature green") and later turn yellow (which I refer to as "ripe"). It is primarily these stages, rather than younger stages, that are infestable by tephritid fruit flies. In Hawaii, this plant species is typically found in pastureland and in disturbed areas where its seeds have been spread and tends to bear fruits more heavily

toward the 2nd half of the year (McQuate et al. 2007 and GTM unpublished data). It is included on the list of plant species designated as noxious weeds for eradication or control purposes by the Hawaii Department of Agriculture (HDOA 1992). *Solanum torvum* was earlier described as having naturalized in Kaneohe and Palolo Valley on Oahu, and along Iao Stream on Maui (Wagner et al. 1990). The range of *S. torvum* has, however, spread beyond these areas to include (1) sites extending westward along the windward coast of Oahu from Waimanalo to Kahuluu and at least as far as Laie (GTM unpublished data); (2) additional areas on Maui, including patches in Hana and Haiku and in the Huluhulunui Gulch, adjacent to Kaupakalua Road, north of Kokomo; and (3) the windward coast of the island of Hawaii from Papaikou to Pepeekeo (Oppenheimer et al. 1999; Starr and Starr 2003; Starr et al. 2003a, b; Bokonon-Ganta et al. 2007; GTM unpublished data). Overall, *S. torvum* seems to be spreading on Maui via seed-contaminated equipment and soil (Starr et al. 2003b) which are likely factors in the spread of this weed on other islands as well.

Collections of mature green (full size, green with brown spots) and ripe (yellow) turkeyberry fruits were made at two low elevation sites (below 200 m) on Maui. The most extensive collections were made from 10 March 2003 to 7 Dec. 2005 in a cattle pasture in Haiku, while additional collections were made from 4 Nov. 2003 to 14 July 2004 in Iao Valley. Only few collections were made at the latter site because fruit abundance was limited. Following collection, fruits were placed in screened containers which prevented any further exposure to adult tephritid fruit flies and transported to the insect ecology laboratory at the U. S. Pacific Basin Agricultural Research Center at the Waiakea Agricultural Experiment Station on the island of Hawaii. Fruit were then counted, weighed and held for fruit fly emergence in screened containers with sand on the bottom to serve as a pupation medium for any pupariating tephritid fruit fly larvae that emerged from the fruits. Recovered adult flies were identified to species.

Although, *B. latifrons* was the predominant species recovered, both oriental fruit fly and Mediterranean fruit fly were also recovered from both sites, though both oriental fruit fly and Mediterranean fruit fly were recovered infrequently (Table 1). Of the last two species, oriental fruit fly was, overall, recovered more frequently. Both oriental fruit fly and Mediterranean fruit fly were recovered from both ripe and mature green turkeyberry fruits.

Mediterranean fruit fly has a host list of over 300 species. That list includes 29 species of solanaceous plants, making it the 3rd most common host plant family (behind rosaceae [1st] and rutaceae [2nd]). Among the 29 solanaceous host plant species, 13 are other *Solanum* spp. Field infestation data, however, have been reported for only seven of those other *Solanum* spp. Of those seven, reported infestation levels ranged from very low (e.g., 1 larva from 10,476 *S. nigrum* L. fruits) to very high (e.g., 1638 larvae from 1681 *S. pseudocapsicum* fruits) (Liquido et al. 1997). *Solanum pseudocapsicum* was reported (Liquido et al. 1990) to have the highest infestation rate of any fruits on the island of Hawaii (664 Medfly/kg infested fruit). Our results with *S. torvum* fall amidst the *Solanum* species with low infestation levels.

In Hawaii, Mediterranean fruit fly populations became scarce at lower elevations, but remained abundant in many upland areas, following the accidental introduction of oriental fruit fly in 1945 (Bess 1953, Haramoto and Bess 1970). That displacement, however, was not complete (Nishida et al. 1985), with Mediterranean fruit fly dominating in low elevation coffee sites (Vargas et al. 1995) and coexisting with oriental fruit fly at a number of other sites (Nishida et al. 1985). Iao Valley was identified as one low elevation site supporting a medium density of Mediterranean fruit fly (Nishida et al. 1985). The presence of coffee plants may be a factor in maintaining the presence of Mediterranean fruit fly in Iao Valley.

At both the Haiku and Iao Valley collection sites, *B. latifrons* is the predominant tephritid fruit fly species infesting turkeyberry, but both oriental fruit fly and Mediterranean fruit

fly can coexist with *B. latifrons* at both sites. If *S. torvum* continues to spread on Maui and other Hawaiian islands, it will continue to be a potential low elevation wild host for Mediterranean fruit fly as well as for oriental fruit fly and *B. latifrons*.

Acknowledgments

I thank C. D. Sylva, H. M. Ketter and A. H. Bokonon-Ganta for help in collection and processing of fruit samples and S. Cabral and R. Horcajo for permission to collect turkeyberry fruits. I am also grateful to P. A. Follett, N. J. Liquido, J. C. Piñero, and two anonymous reviewers for helpful reviews of earlier drafts of this manuscript.

Literature Cited

Bess, H.A. 1953. Status of *Ceratitis capitata* in Hawaii following the introduction of *Dacus dorsalis* and its parasites. Proc. Hawaiian Entomol. Soc. 15: 221–234.

Bokonon-Ganta, A.H., G.T. McQuate, and **R.H. Messing.** 2007. Natural establishment of a parasitoid complex on *Bactrocera latifrons* (Diptera: Tephritidae) in Hawaii. Biol. Control 42: 365–373.

Haramoto, F.H. and **H.A. Bess.** 1970. Recent studies on the abundance of the oriental and Mediterranean fruit flies and the status of their parasites. Proc. Hawaiian Entomol. Soc. 20: 551–566.

HDOA (Hawaii Department of Agriculture). 1992. List of plant species designated as noxious weeds for eradication or control purposes (June 18, 1992). Hawaii administrative rules. Title 4 Department of Agriculture. Subtitle 6 Division of Plant Industry. Chapter 68 Noxious weed rules. Hawaii Department of Agriculture, Honolulu, HI http://www.hawaiiag.org/hdoa/adminrules/AR-68.pdf (Accessed: 26 Nov., 2007).

Liquido, N.J., P.G. Barr, and **R.T. Cunningham.** 1997. Medhost: an encyclopedic bibliography of the host plants of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (electronic database/program). ARS-144. United States Department of Agriculture, Agricultural Research Service, Washington D.C..

Liquido, N.J., R.T. Cunningham, and **S. Nakagawa.** 1990. Host plants of Mediterranean fruit fly (Diptera: Tephritidae) on the island of Hawaii (1949–1985 Survey). J. Econ. Entomol. 83: 1863–1878.

Liquido, N.J., E.J. Harris, and **L.A. Dekker.** 1994. Ecology of *Bactrocera latifrons* (Diptera: Tephritidae) populations: host plants, natural enemies, distribution, and abundance. Ann. Entomol. Soc. Am. 87: 71–84.

McQuate, G.T. and S.L. Peck. 2001. Enhancement of attraction of alpha-ionol to male *Bactrocera latifrons* (Diptera: Tephritidae) by addition of a synergist, cade oil. J. Econ. Entomol. 94: 39–46.

McQuate, G.T., A.H. Bokonon-Ganta, and **S.L. Peck.** 2007. Population biology and prospects for suppression of the solanaceous fruit fly, *Bactrocera latifrons* (Diptera: Tephritidae). Proc. Hawaiian Entomol. Soc. 39: 111–115.

McQuate, G.T., Y. –S. Keum, C.D. Sylva, Q.X. Li, and **E.B. Jang.** 2004. Active ingredients in cade oil which synergize the attractiveness of alpha-ionol to male *Bactrocera latifrons* (Diptera: Tephritidae). J. Econ. Entomol. 97: 862–870.

Nishida, T., E.J. Harris, R.I. Vargas, and **T.T.Y. Wong.** 1985. Distributional loci and host fruit utilization patterns of the Mediterranean fruit fly, *Ceratitis capitata* (Diptera: Tephritidae), in Hawaii. Environ. Entomol. 14: 602–606.

Oppenheimer, H.L., J.S. Meidell, and **R.T. Bartlett.** 1999. New plant records for Maui and Molokai, pp. 7–11 *in*: Evenhuis, N. L. and L. G. Eldredge (eds.). Records of the Hawaii Biological Survey for 1998. Part 2: Notes. Bishop Museum Occasional Papers 59. http://hbs.bishopmuseum.org/pdf/op59.pdf (Accessed: 26 Nov., 2007).

Starr, F. and **K. Starr.** 2003. Plants of Hawaii maps. Known distribution on Maui of *Solanum torvum*. http://www.hear.org/starr/hiplants/maps/html/solanum_torvum-maui.htm (Accessed: 26 Nov., 2007).

Starr, F., K. Starr, and **L.L. Loope.** 2003a. New plant records from the Hawaiian archipelago, pp. 23–34, *in*: Evenhuis, N. L. and L. G. Eldredge (eds.). Records of the Hawaii Biological Survey for 2001-2002. Part 2: Notes. Bishop Museum Occasional Papers 74. http://hbs.bishopmuseum.org/pdf/op74.pdf (Accessed: 26 Nov., 2007).

Starr, F., K. Starr, and **L.L. Loope.** 2003b. *Solanum torvum*. Plants of Hawaii Reports. United States Geological Survey – Biological Resources Division, Haleakala Field Station, Maui, Hawaii. April, 2003. http://www.hear.org/starr/hiplants/reports/pdf/solanum_torvum.pdf (Accessed 26 Nov., 2007).

Vargas, R.I., W.A. Walsh, and **T. Nishida.** 1995. Colonization of newly planted coffee fields: Dominance of Mediterranean fruit fly over oriental fruit fly (Diptera: Tephritidae). J. Econ. Entomol. 88: 620–627.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1990. Manual of the flowering plants of Hawaii. Bishop Museum Special Publication 83. University of Hawaii Press and Bishop Museum Press. Honolulu, HI.

This article reports the results of research only. Mention of a proprietary product does not constitute an endorsement or a recommendation by the USDA for its use.

Table 1. Infestation of mature green (MG) and ripe (R) turkeyberry, *Solanum torvum*, by *Bactrocera latifrons, B. dorsalis*, and *Ceratitis capitata* on the island of Maui, Hawaii. Mean numbers of fruit flies recovered per 1.0 kg of fruit is based on only those collections where the indicated species was recovered.

Collection site	Ripeness	Total no. collections	Total no. fruits	Total weight fruits (kg)	Collections with *B. l.* infestation		*B. latifrons* per 1.0 kg fruit		Collections with *B. d.* infestation		*B. dorsalis* per 1.0 kg fruit		Collections with *C. c.* infestation		*C. capitata* per 1.0 kg infestation	
					No.	%	Mean	SEM	No.	%	Mean	SEM	No.	%	Mean	SEM
Haiku	MG	30	16080	29.62	29	96.7	168.5	47.6	6	20.0	3.8	1.3	0	0.0	0.0	0.0
	R	35	62129	101.12	34	97.1	316.8	145.1	12	34.3	4.2	1.3	2	5.7	250.4*	249.6
Iao Valley	MG	3	611	1.08	3	100.0	172.4	146.1	1	33.3	10.4	0.0	1	33.3	5.2	0.0
	R	2	159	0.25	2	100.0	190.3	130.8	0	0.0	0.0	0.0	0	0.0	0.0	0.0

*This number is uncharacteristically high because one of the two collections in which *C. capitata* was recovered came at a low point in fruit availability (Feb., 2004) where only two ripe fruits were collected. Most other collections included many more fruits.