Natural Field Infestation of Mangifera casturi and Mangifera lalijiwa by Oriental Fruit Fly, Bactrocera dorsalis (Diptera: Tephritidae)

Grant T McQuate1, Charmaine D Sylva1 and Nicanor J Liquido2

1Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center, USDA-ARS, Hilo, HI, USA.
2CPHST Plant Epidemiology and Risk Analysis Laboratory, USDA-APHIS-PPQ, Honolulu, HI, USA.

ABSTRACT: Mango, Mangifera indica (Anacardiaceae), is a crop cultivated pantropically. There are, however, many other Mangifera spp (“mango relatives”) which have much more restricted distributions and are poorly known but have potential to produce mango-like fruits in areas where mangoes do not grow well or could be tapped in mango breeding programs. Because of the restricted distribution of many of the Mangifera spp, there has also been limited data collected on susceptibility of their fruits to infestation by tephritid fruit flies which is important to know for concerns both for quality of production and for quarantine security of fruit exports. Here, we report on natural field infestation by the oriental fruit fly, Bactrocera dorsalis (Diptera: Tephritidae), of two mango relatives native to Indonesia: Mangifera casturi and Mangifera lalijiwa. Rates of infestation of fruits of these two Mangifera spp by tephritid fruit flies have not previously been reported.

KEYWORDS: Mango, Mangifera spp, Mangifera casturi, Mangifera lalijiwa, Bactrocera dorsalis, mango relative

Introduction

The mango, Mangifera indica L. (Anacardiaceae), is the best known and most widely cultivated species in the genus Mangifera. It is native to India and Burma and has been cultivated in India for more than 4000 years but has also been widely distributed so that it is now pantropically cultivated.1,2 Many people are not aware that there are many other species within the genus Mangifera that, although having much more restricted distributions, also have excellent fruits which may be of comparable or even superior quality relative to the mango.2 A total of 69 species of Mangifera have been described,2 of which edible fruit is produced by at least 26 species beyond mango.3 This genus is strictly Asian in origin and, with the exception of the pantropical cultivation of mango, occurs in tropical parts of Asia: India, Burma, Sri Lanka, Thailand, Indochina, South Tropical China, Malaysia, Indonesia, Papua New Guinea, the Philippines, the Solomon Islands, and a few species in the Pacific Islands.2 The nature and quality of fruits vary among Mangifera spp, and there is also variation in adaptability to different climates, with some species growing well in areas where mangoes cannot be grown satisfactorily, such as in an ever–humid climate, without a prolonged dry season.4

The diversity among Mangifera spp has generated interest in testing various species for suitability for fruit production in areas beyond Asia as well as consideration for use as rootstocks and for breeding with mango. The Center for Tropical Plant Conservation of the Fairchild Tropical Botanic Garden in Coral Gables, FL, USA, has a project focused on identification, collection, and propagation of “wild mangoes,” which includes Mangifera caesia Jack, Mangifera casturi Kosterm., Mangifera foetida Loure., Mangifera griffithii Hooker f., Mangifera lalijiwa Kosterm., Mangifera laurena Bl., Mangifera odorata Griff., Mangifera pajang Kosterm., Mangifera pentandra Hooker f., and Mangifera zeylanica (Bl) Hooker f. Their objective is both to contribute to the long-term conservation of these species and to use them for breeding with mango.5 Two of these wild mango species (M casturi and M lalijiwa) have been introduced to Hawaii by a local nursery as trees with potential to produce mango-like fruits in wet climates without having anthracnose problems commonly found with mango flowers and fruits.

Tephritid fruit flies are major pests of many tropical fruits, and Mangifera spp are not an exception. Twelve Mangifera spp have been listed for which infestation data by Bactrocera spp (Diptera: Tephritidae) have been recorded (Mangifera altissima Blanco, M caesia, Mangifera calonera Kurz, M foetida, M griffithii, M indica, M laurina, Mangifera longipetiolata King, Mangifera minor Bl., M odorata, M pajang, and M zeylanica).6,7 A total of 46 fruit fly species have been listed for which M indica has been documented to be a host, although some records require confirmation.8 The five fruit fly genera included are as follows: Anastrepha (8 species), Bactrocera (29), Ceratitis (7), Dirioxa (1), and Toxotrypana (1). There are also at least two species of Dacus (Dacus bivittatus and Dacus ciliatus) for which there are records that mango is a host (D bivittatus9,10 and D ciliatus11). Because of lesser commercial development and more restricted geographic ranges of other Mangifera spp, there is much less published regarding infestation of other Mangifera...
spp by tephritid fruit flies. As an example, a comprehensive publication on fruit flies of economic importance only lists infestation of one other Mangifera sp (infestation of M. foetida by Bactrocera tau [Walker]).

Here, we report on a survey to assess whether M. casturi and M. lalijiwa are naturally infested in the field by tephritid fruit flies. There has been no record to date of tephritid fruit fly infestation in fruits of these two Mangifera spp, so we took advantage of an opportune time when both species were fruiting, which may not be all that common because of irregular bearing, especially with M. casturi.

Materials and Methods

Field site

The field research was conducted from July 2 to 30, 2015 at Kabuganaan Farm located in the vicinity of Kurtistown on the Island of Hawaii, Hawaii, USA (Universal Transverse Mercator grid [USGS 2001]: Easting 0284328, Northing 2165904 m, Zone 05 Q) and was at 277-m elevation. Relative positions of the M. casturi and M. lalijiwa trees in the orchard at Kabuganaan farm and the relative position of Kurtistown on the Island of Hawaii are presented in Figure 1. A Davis Instruments Vantage Pro2 Weather Station (Hayward, CA, USA) was deployed at Kabuganaan farm for the collection of temperature, relative humidity, and rainfall data. Over the course of the study, temperature averaged 23.7°C ± 0.06°C (SEM), relative humidity averaged 86.8% ± 0.16% (SEM), and there was a total of 56-mm rain.

Fruit tree species

Two mango relatives were tested in this field trial, M. casturi and M. lalijiwa. The former species name is listed by The Plant List as an accepted name, whereas the latter species name is listed as an unresolved name. Fruits of M. casturi (referred to as “kastooree” in its native area) were of the “Kasturi” form, where the fruit skin is “smooth, glossy green with dark spots which multiply and at maturity make the fruit completely or partly black.” The pulp is dark orange and very sweet. Mangifera casturi is rather common in South Kalimantan, Indonesia, around Banjarmasin and in the Martapura District, but is also found in Central and East Kalimantan. It is not known in the wild, being only found under cultivation. Fruits of M. lalijiwa, larger than those of M. casturi, are green when immature and turn yellowish at maturity. They are locally called “Mangga ubi” (West Java), “laleejeewo” (East Java), or “tabar” (Madura Island) in their native areas. The pulp is pale yellow with a sweet acid taste. Mangifera lalijiwa is present in Java, Madura, Bali, and probably in Sumatra as well. It is cultivated and likely very rare in the wild. Relative external and internal appearances of mature fruits of these two species are presented in Figure 2A and B, respectively.

Traps

Tephritid fruit fly detection traps were deployed from July 2 to 30, 2015, using yellow bottom Multilure traps from Better World Manufacturing (Fresno, CA, USA) baited with a protein bait solution: 8% Solulys (Roquette America, Inc., Geneva, IL, USA), 4% Borax 20 Mule Team (Scottsdale, AZ, USA), and 88% water. Each trap contained 300 mL of protein bait solution. Traps were serviced weekly (July 9, 16, 23, and 30). Fresh bait was used on July 2, 9, and 23. Water was added on July 16 to make the fluid volume to 300 mL. A total of 4 protein-baited traps were deployed, 2 each in the M. casturi and M. lalijiwa trees. Traps were placed 2 to 3 m above the ground, were surrounded by foliage, and were placed near developing fruits when possible. The 2 traps per tree were placed on opposite sides of each tree, with trap position shifted each week.

Bioassay

Fruits were collected weekly from July 2 to 30, 2015. Each week, 10 random ripe intact (undamaged) fruits were harvested from the M. casturi tree and 10 random ripe undamaged fruits were also collected from the ground underneath the M. casturi tree. Concurrently, 10 random ripe intact (undamaged) fruits were harvested from the M. lalijiwa tree. Ground fruits, though, were not as readily available under the M. lalijiwa tree. Only 3 undamaged ground fruits were collected from the M. lalijiwa tree in the third week. No undamaged ground fruits were available at the collection times for the other 3 weeks. All fruits were brought back to the Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center in Hilo, HI, for processing for assessment of infestation by tephritid fruit flies. The fruits were weighed and notes were taken on external skin characteristics (blemishes). All collected fruits were held individually without sand in double-stacked 4-L Hi-Plas buckets (Highland Plastics, Inc., Mira Loma, CA, USA). The top bucket had screened top and screened bottom holes that permitted the draining of fluids from the fruit to prevent drowning of any infesting tephritid fruit fly larvae (Figure 3). A HOBO Pro v2 data logger (Onset Computer Corporation, Bourne, MA, USA) was deployed in the fruit holding room. Temperature over the course of the holding period fell within the range of 25°C to 27°C, whereas relative humidity ranged from 80% to 82%. Two weeks after fruits were first placed in the holding buckets, pupae were recovered from the holding buckets and fruits were cut open to recover all larvae remaining inside the fruit. The larvae and pupae were transferred to 9.0 cm (diameter) × 4.5 cm screened-top Hi-Plas cups (Highland Plastics, Inc.) with 20-mL sand per container for use as a pupariation medium and held for adult emergence. The total numbers of dead larvae, dead pupae, and adult flies recovered from each fruit were recorded. Species and sex of the adult flies were identified. Dead pupae

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Figure 1. Relative positions of the *Mangifera lalijiwa* (no. 1) and the *Mangifera casturi* (no. 2) trees in the orchard at Kabuganaan Farm and the relative position of Kurtistown on the Island of Hawaii. Other fruit trees present in the orchard are as follows: 3—Tahitian lime (*Citrus latifolia* (Yu. Tanaka) Tanaka); 4—pommelo (*Citrus maxima* (Burm.) Merr. cv. “Halawa”); 5—navel orange (*Citrus sinensis* (L.) Osbeck cv. “Cara Cara”); 6—tangelo (*Citrus paradisi* Macfad. × *Citrus reticulata* Blanco cv. “Minneola”); 7—orange (*Citrus sinensis* (L.) Osbeck cv. “Valencia”); 8—navel orange (*Citrus sinensis* (L.) Osbeck cv. “Fisher”); 9—tangerine (*C reticulata* Blanco cv. “Honey”); 10—lemon (*Citrus limon* (L.) Burm. f. cv. “Variegated Pink Eureka”); 11—pommelo (*C maxima* (Burm.) Merr. cv. “Chandler”); 12—starfruit (*Averrhoa carambola* L. cv. “Kari”); 13—white sapote (*Casimiroa edulis* La Llave & Lex. cv. “Suebelle”); 14—guava (*Psidium guajava* L. cv. “White Indonesian”); 15—wampi (*Clausena lansium* (Lour.) Skeels); 16—longan (*Dimocarpus longan* Lour. cv. “Biew Kiew”); 17—rambutan (*Nephelium lappaceum* L. cv. “Jitlee”); 18 abiu (*Pouteria caimito* (Ruiz & Pav.) Radlk. cv. “Gray”); 19—rambutan (*Nephelium lappaceum* L. cv. “R-9”); 20—longan (*Dimocarpus longan* Lour. cv. “Kohala”); 21—mango (seedling tree grown from seed from a *Mangifera indica* L. cv. “Carabao” fruit); 22—lychee (*Litchi chinensis* Sonn. cv. “Kaimana”); and 23—rollinia (*’Rollinia mucosa’* (Jacq.) Baill.). The size of the circle representing each tree is an indication of the relative cross-sectional area of the canopy of each tree species. Only *Clausena lansium*, *M casturi*, and *M lalijiwa* were fruiting at the time of the study. Map prepared by C.D.S. using ArcGIS.32
were identified to species based on counts of numbers of lobes in the prothoracic spiracles.  

Statistical analyses

Averages were calculated for weights of fruits collected and numbers of fruit flies recovered per kg fruit and per kg infested fruit. Percentage infestation was calculated based on total number of fruits collected. Oriental fruit fly, Bactrocera dorsalis (Hendel), catch per trap per day was calculated each week for traps in the M. casturi and M. lalijiwa trees.

Results

Trapping

Bactrocera dorsalis was caught every week in traps placed in each tree species. Trap catch averaged $0.61 \pm 0.88$ (SEM) flies/trap/d (range: 0.14-1.14) in the M. casturi tree and $1.82 \pm 4.38$ (SEM) flies/trap/d in the M. lalijiwa tree (range: 1.57-2.14). One female melon fly (Bactrocera cucurbitae [Coquillett]) was also recovered from a trap in the M. lalijiwa tree on 23 July (week 3).

External skin characteristics (blemishes) of collected fruits

For M. casturi, no skin blemishes were noted on any of the 40 tree fruits or the 40 ground fruits collected. One tree fruit with a crack was found and that was held in addition to the 10 blemish-free fruits collected each week. For M. lalijiwa, 10 blemish-free tree fruits were collected each week for the first 3 weeks, but only 6 blemish-free tree fruits were available for collection in the fourth week. In addition to these fruits, 13 tree fruits were collected over the course of the study that had cracks in the skin. Only 5 M. lalijiwa ground fruits were collected over the course of the study, 3 of which were blemish-free, whereas 2 had cracks in the skin.

Infestation

Infestation by B. dorsalis was found in ripe fruits of both Mangifera spp (Table 1). However, infestation of mature undamaged fruits on trees was only found with M. lalijiwa fruits where infestation was found in all 4 fruit collections, with a total of 6 of 36 fruits infested (16.7%). Infestation of the mature undamaged on-tree M. lalijiwa fruits averaged $12.5 \pm 8.0$ (SEM) pupae/kg fruit and $77.1 \pm 4.3$ (SEM) pupae/kg infested fruit.
Table 1. Natural field infestation by Bactrocera dorsalis of both undamaged and cracked mature Mangifera casturi and Mangifera lalijiwa fruits harvested from the tree or collected from the ground during July 2015 in the vicinity of Kurtistown, Hawaii, USA.

| FRUIT SPECIES | TOTAL NO. OF COLLECTIONS WITH BACTROCERA DORSALIS INFESTATION | TOTAL NO. OF INFESTED FRUITS | TOTAL WEIGHT OF INFESTED FRUITS, KG | TOTAL NO. OF PUPAE/KG INFESTED FRUIT | AVG. NO. OF PUPAE/KG FRUIT | TOTAL NO. OF ADULTS/KG INFESTED FRUITS | AVG. NO. OF ADULTS/KG FRUIT |
|---------------|---------------------------------------------------------------|-----------------------------|---------------------------------|-------------------------------------|---------------------------|---------------------------------------|---------------------------|
| Mangifera casturi | On tree Undamaged 4 4.08 0 0.0 0 0 0 | Cracked 1 1.13 0 0.0 0 0 0 | | | | | |
| | On tree Cracked 1 1.13 0 0.0 0 0 0 | On tree Undamaged 4 4.30 3 0.33 2 2.09 27.2 0.70 9.07 | | | | | |
| | On tree Cracked 1 1.13 0 0.0 0 0 0 | On tree Undamaged 4 10.4 6 1.69 4 12.5 77.1 1.63 10.1 | | | | | |
| | On tree Cracked 1 1.13 0 0.0 0 0 0 | On tree Undamaged 1 0.76 0 0.0 0 0.0 0.0 0.0 | | | | | |
| | On tree Cracked 1 0.61 0 0.0 0 0 0 | On tree Undamaged 1 0.61 0 0.0 0 0.0 0.0 0.0 | | | | | |
| Mangifera lalijiwa | On tree Undamaged 4 4.30 3 0.33 2 2.09 27.2 0.70 9.07 | Cracked 1 1.13 0 0.0 0 0 0 | | | | | |
| | On tree Cracked 1 1.13 0 0.0 0 0 0 | On tree Undamaged 4 10.4 6 1.69 4 12.5 77.1 1.63 10.1 | | | | | |
| | On tree Cracked 1 1.13 0 0.0 0 0 0 | On tree Undamaged 1 0.76 0 0.0 0 0.0 0.0 0.0 | | | | | |
| | On tree Cracked 1 0.61 0 0.0 0 0 0 | On tree Undamaged 1 0.61 0 0.0 0 0.0 0.0 0.0 | | | | | |

Infestation rate of mature on-tree M lalijiwa fruits increased in fruits which had cracks (107.9 ± 51.3 [SEM] pupae/kg fruit and 149.8 ± 13.8 [SEM] pupae/kg infested fruit). A picture of an infested, cracked fruit taken from the M lalijiwa tree is shown in Figure 4. It had been infested with 35 B dorsalis larvae from which 18 male and 8 female adults emerged. The infestation in this fruit is included in the M lalijiwa “on-tree” “cracked” fruit data presented in Table 1. No infestation was found in the mature M lalijiwa fruits collected from the ground, either from the 3 undamaged fruits or from the 2 cracked fruits. Although no infestation was found in mature undamaged on-tree M casturi fruits, infestation was found in 1 mature on-tree M casturi fruit with a crack (85.9 pupae/kg fruit) and in 3 of 40 (7.5%) mature undamaged fruits collected from the ground (2.09 ± 1.30 [SEM] pupae/kg fruit and 27.2 ± 0.5 [SEM] pupae/kg infested fruit). A characteristic of M casturi fruits that may have prevented successful infestation by B dorsalis is the presence of a pressurized latex. When the fruit is harvested from the tree, there is typically a spray of latex from the fruit when the fruit is detached from the stem (Figure 2C and Video 1). No infestation was found in the mature intact on-tree fruits but was found under conditions where that latex pressure was released in a cracked on-tree fruit and in intact fruits recovered from the ground.

Discussion

We provide here the first report of infestation of M casturi and M lalijiwa by B dorsalis. Because it was natural field infestation for both Mangifera spp, both species can be considered to be “suitable hosts” for B dorsalis.13,14 The rate of infestation of undamaged M lalijiwa fruits by B dorsalis (1.63 flies/kg fruit) fell within the lower part of the range of infestation rates of mango by B dorsalis reported from the vicinity of Hilo, Hawaii from 1950 to 1962 (range: 0.78-103.68 flies/kg fruit).6 Of the two Mangifera species, undamaged fruits of M lalijiwa were more readily infested by B dorsalis, with no undamaged M casturi on-tree fruits found to be infested. Infestation was, though, found in damaged fruits of both species. Although it might be expected that average infestation levels would be higher in ground fruits than in undamaged fruits on the tree, this was not found to be the case with M lalijiwa fruits sampled. It is thought, though, that the lack of infestation in the M lalijiwa ground fruits could be an artifact of low sample size (only 5 ground fruits were collected).

The overall list of suitable hosts of B dorsalis was most recently documented to be 478 plant taxa, belonging to 211 genera in 76 plant families.13 This host list includes reports of infestation by Bactrocera invadens (Drew, Tsuruta, & White), Bactrocera papaya (Drew & Hancock), and Bactrocera philippensis (Drew & Hancock), which had been considered to be separate species, but recently published research has concluded that these 3 species, actually, are all also B dorsalis.15 This brings to 11 the total number of Mangifera spp which are documented to be suitable hosts of B dorsalis (and to 14 the total number of fruit.
Mangifera spp which are documented to be suitable hosts of Bactrocera spp). Given that some of the Mangifera spp are good hosts for B. dorsalis, we expect that there are additional, yet undocumented, B. dorsalis hosts among others of the 69 Mangifera spp identified by Kostermans and Bompard. It is, however, challenging to document the host status of many of the Mangifera spp. Mangifera spp tend to occur as scattered individuals at very low densities in tropical lowland rainforests. These widely scattered trees can be quite tall such that tree crowns, where fruits are present, can be rather inaccessible, resulting in Mangifera spp being poorly represented even in herbarium collections. An additional problem is that it is common for fruiting to occur only at intervals of 3 to 8 years. As an example, M. casturi can vary considerably in regularity of bearing among different locales. A tree planted from seed in the Bogor (Indonesia) Botanical Gardens was bearing fruit after 10 years and, subsequently, regularly bore fruit twice a year. Conversely, M. casturi is reported to not flower consistently in South Florida. The M. casturi tree sampled at Kabuganaan Farm in this study has, thus far, only fruited one year (the year that this study was conducted) since it was planted out in 2002. The M. lalijica tree was also planted out in 2002 but has borne fruit a number of years since 2002, although not every year. Although M. lalijica is reported to not have anthracnose fungus problems when grown in the Waimanalo area of the Island of Oahu, Hawaii (http://www.frankiesnursery.com/), bearing seems to be enhanced in the Kurtistown area of Hawaii Island in years where it is drier during flowering (G.T.M.—unpublished data [2002 - 2017]). Given that no infestation was recorded in mature M. casturi fruits that were undamaged and still on the tree, there is a possibility that this fruit could be a conditional nonhost for B. dorsalis. Further fruit collections, though, would be required to establish this. Its irregular bearing in Florida and Hawaii, however, could be problematic for the development of commercial production of M. casturi.

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Author Contributions
CDS and GTM conceived and designed the experiments and analyzed the data. GTM wrote the first draft of the manuscript. CDS, GTM, and NJL contributed to the writing of the manuscript; agree with manuscript results and conclusions; and made critical revisions and approved final version. GTM and NJL jointly developed the structure and arguments for the paper. All authors reviewed and approved the final manuscript.

REFERENCES
1. Nakasone HY, Paull RE. Tropical Fruits. New York, NY: CAB International; 1998.
2. Kostermans AJGH, Bompard JM. The Mangoes. San Diego, CA: Academic Press; 1993.
3. Mukherjee SK, Litz RE. Introduction: botany and importance. In: Litz RE, ed. The Mango: Botany, Production and Uses, 2nd ed. Cambridge, MA: CAB International; 2009:1-18.
4. Bompard JM. Taxonomy and systematics. In: Litz RE, ed. The Mango: Botany, Production and Uses, 2nd ed. Cambridge, MA: CAB International; 2009:19-41.
5. Campbell RJ. Kastoori (Mangifera casturi) as a graft interstock for wild mangos. Proc Fl State Hortic. 2007;120:15-16.
6. Liquido NJ, McQuate GT, Suiter KA. Compendium of Fruit Fly Host Information (CoFFHI), 2nd ed. Raleigh, NC: United States Department of Agriculture,
7. Norrbom AL. The fruit fly (Diptera: Tephritidae) databases. In: Liquido NJ, McQuate GT, Suiter KA, eds. Compendium of Fruit Fly Host Information (CoFFHI), 2nd ed. Raleigh, NC: United States Department of Agriculture, Center for Plant Health Science and Technology; 2016. https://coffhi.cphst.org/. Accessed May 23, 2017.

8. White IM, Elson-Harris MM. Fruit Flies of Economic Significance: Their Identification and Bionomics. Wallingford, UK: CAB International; 1992.

9. Isabirye BE, Akol AM, Muyinza H, Masembe C, Nankinga CK. Fruit fly (Diptera: Tephritidae) host status and relative infestation of selected mango cultivars in three agro ecological zones in Uganda. Int J Fruit Sci. 2016;16:23–41.

10. N’Depo OR, Hala NF, N’da AA, et al. Fruit flies (Diptera: Tephritidae) populations dynamic in mangoes production zone of Côte-d’Ivoire. Agr Sci Res J. 2013;3:352–363.

11. Kambura CW. Diversity and Host Preference of Tephritid Fruit Fly Species Infesting Cucurbit and Major Horticultural Crops Grown in the Lower Coastal Kenya [MS thesis]. Nairobi, Kenya: University of Nairobi, Kenya; 2016.

12. ESRI. ArcGIS 10.3. Redlands, CA: ESRI; 2013.

13. Liquido NJ, McQuate GT, Birnbaum AL, et al. A review of recorded host plants of oriental fruit fly, Bactrocera (Bactrocera) dorsalis (Hendel) (Diptera: Tephritidae), Version 2.1. In: Liquido NJ, McQuate GT, Suiter KA, eds. Compendium of Fruit Fly Host Information (CoFFHI), 2nd ed. Raleigh, NC: United States Department of Agriculture, Center for Plant Health Science and Technology; 2016. https://coffhi.cphst.org/. Accessed March 17, 2017.

14. Liquido NJ, McQuate GT, Birnbaum AL, et al. Host plants of oriental fruit fly, Bactrocera dorsalis (Hendel) (Diptera: Tephritidae). In: Liquido NJ, McQuate GT, Suiter KA, eds. Compendium of Fruit Fly Host Information (CoFFHI), 2nd ed. Raleigh, NC: United States Department of Agriculture, Center for Plant Health Science and Technology; 2016. https://coffhi.cphst.org/. Accessed March 17, 2017.

15. Schutze MK, Aketarawong N, Amornsak W, et al. Synonymization of key pest species within the Bactrocera dorsalis species complex (Diptera: Tephritidae): taxonomic changes based on a review of 20 years of integrative morphological, molecular, cytogenetic, behavioural and chemoeological data. Syst Entomol. 2015;40:456–471.