

## Short Communication

# Host Plants of Invasive Tephritid Fruit Fly Species of Economic Importance

Grant T. McQuate<sup>1\*</sup> and Nicanor J. Liquido<sup>2</sup><sup>1</sup>Tropical Crop & Commodity Protection Research Unit, Daniel K. Inouye U. S. Pacific Basin Agricultural Research Center, USA<sup>2</sup>Plant Epidemiology and Risk Analysis Laboratory, CPHST, USA**\*Corresponding author**

Grant T. McQuate, USDA-ARS, Daniel K. Inouye US. Pacific Basin Agricultural Research Center, 64 Nowelo Street, Hilo, Hawaii 96720, USA, Tel: 808-959-4339; Fax: 808-959-5470; Email: Grant.McQuate@ars.usda.gov

Submitted: 29 June 2017

Accepted: 28 August 2017

Published: 29 August 2017

ISSN: 2333-6668

## Copyright

© 2017 McQuate and Liquido

## OPEN ACCESS

## Keywords

- Tephritidae
- Host plant
- *Bactrocera*
- *Ceratitis*
- Provisional host list

**Abstract**

There are many tephritid fruit fly species worldwide, a number of which pose a threat of introduction and establishment in new areas where they had not previously been present. Tephritid fruit fly larvae feeding in fruits and vegetables can ruin fruits and vegetables for local consumption as well as create concern for risk of introducing fly species to new areas through produce shipments. Using recently updated provisional host lists developed for 11 tephritid fruit fly species that have previously invaded, or have potential to invade, the U.S.A., 100 plant families, and 330 plant genera, are identified which include plant species for which natural field infestation by tephritid fruit flies has been documented. Although fruit fly species vary considerably in the range of host plants that they can infest, natural field infestation for one species, the oriental fruit fly (*Bactrocera dorsalis*), has been documented in 76 plant families. Natural infestation by all 11 tephritid fruit fly species covered here has been documented in one family, Myrtaceae, while field infestation by 10 of the 11 fruit fly species have been documented in the Anacardiaceae, Rutaceae, and Sapotaceae families. Fruits in these plant families can be at risk of infestation by a wide range of invasive tephritid fruit fly species. Knowledge of the host status of different fruits and vegetables is needed in assessing the risk of fruit fly species in imported and exported fruit and vegetable commodities and for developing systems approaches and other mitigation measures to facilitate global trade.

**ABBREVIATIONS**

APHIS: Animal and Plant Health Inspection Service; ARS: Agricultural Research Service; CoFFHI: Compendium of Fruit Fly Host Information; CPHST: Center for Plant Health Science and Technology; GRIN: Germplasm Repository Information Network; PPQ: Plant Protection and Quarantine; USDA: United States Department of Agriculture

**INTRODUCTION**

Infestation of fruits and vegetables by tephritid fruit flies (Diptera: Tephritidae) is a significant agricultural problem, with tephritid fruit fly species present in all world regions, except Antarctica [1]. Overall, there are more than 4,400 tephritid fruit fly species known worldwide, with nearly 200 considered to be pests [2]. Tephritid fruit fly larvae feeding in fruits and vegetables can ruin the fruits and vegetables for local consumption as well as create concern for risk of introducing fly species to new areas through produce shipments. To prevent domestic and transnational spread of economically significant fruit flies, regulatory restrictions are developed in regards to the movement of commodities across national and international borders.

Knowledge of the host status of different fruits and vegetables is needed in assessing the risk of these fruit fly species in imported and exported fruit and vegetable commodities and for developing systems approaches and other mitigation measures to facilitate global trade. In order to provide comprehensive, up-to-date, information on quarantine-significant fruit fly species for fruit fly host suitability assessments as needed by the United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA-APHIS-PPQ) during emergency quarantine action programs, an online project, the USDA Compendium of Fruit Fly Host Information (CoFFHI) was initiated (<https://coffhi.cphst.org>) [3]. Selection of fruit fly species for which host plants would be summarized in CoFFHI was based on immediate needs of USDA-APHIS-PPQ staff in developing risk assessment and mitigation of fruit flies in various commodities. At present, CoFFHI (Edition 2.0) provides up-to-date provisional host lists, as well as additional host plant summarization data, for 11 tropical/subtropical tephritid fruit fly species of economic importance, eight of which have been detected in California between 1954-2012 [4]. We provide herein an overview of the development of tephritid fruit fly provisional host lists together with an overview of host plant

species reported for the 11 tropical/subtropical tephritid fruit fly species of economic importance currently listed in CoFFHI, Edition 2, to provide background on the overall range of plant species potentially subject to infestation by tephritid fruit flies with potential to invade the U. S. A. or other countries.

## MATERIALS AND METHODS

Provided herein are, first, methods involved in developing provisional host lists for USDA for tephritid fruit fly species of economic importance. Background is provided on the initial selection of fruit fly species for which host plants are summarized, the acquisition of data on host plants, updating/verification of host plant scientific names, and classification of plant species as “suitable” or “undetermined” hosts (see below). This is followed by description of methods used to develop the host plant summaries presented in this paper.

### Selection of tephritid fruit fly species for which comprehensive host plant listings are developed

Based on need by USDA-APHIS-PPQ for updated host plant information, the following tropical/subtropical fruit fly species were selected, with the number of detections in California between 1954 and 2012 [4] (an indication of experienced invasiveness) provided in parentheses after the species name: the Mexican fruit fly, *Anastrepha ludens* Loew (465); the West Indian fruit fly, *Anastrepha obliqua* (Macquart) (7); the carambola fruit fly, *Bactrocera carambolae* Drew & Hancock; the guava fruit fly, *Bactrocera correcta* (Bezzi) (126), the melon fly, *Bactrocera cucurbitae* (Coquillett) (28), the oriental fruit fly, *Bactrocera dorsalis* (Hendel) (1,558); *Bactrocera latifrons* (Hendel) (1); *Bactrocera pedestris* (Bezzi); the *Bactrocera tau* complex; the peach fruit fly, *Bactrocera zonata* Saunders (57); and the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (1,417).

### Acquisition of host plant data

Literature, worldwide, was identified and acquired that provided data on the status of fruits and vegetables as hosts of the selected tephritid fruit fly species. Such references were acquired from publications indexed in searchable databases, e.g., Agricola, CAB Abstracts, Entomology Abstracts, Zoological Record, and Scopus, accessible through Digi Top, USDA’s digital desktop library. Host listings of various state, national and international regulatory agencies were also obtained. Additionally, pertinent data were obtained from searches of the USDA-APHIS pest interception databases and comparable databases from other countries, when available.

### Standardization of host plant taxonomy

The taxonomy of the recorded host plants was updated/verified according to current botanical classification using the USDA-ARS Germplasm Repository Information Network (GRIN, <http://www.ars-grin.gov/>). In cases where a plant species was not included in GRIN, currently accepted taxonomic classification was obtained through the Plant List (<http://www.theplantlist.org/>), Tropicos (<http://www.tropicos.org/>), BONAP’s Taxonomic Data Center (<http://bonap.net/tdc>), or the Global Biodiversity Information Facility (<http://www.gbif.org/>).

## Classification of host plant data

Host plant taxa where data provided confirmed infestation records under natural field conditions were classified as “suitable hosts.” These plant taxa satisfy the definition and attributes of a natural, suitable host plant consistent with the terms used by the International Plant Protection Convention (IPPC) [5], the North American Plant Protection Organization (NAPPO) Regional Standard for Phytosanitary Management (RSPM) No. 30 (“Guidelines for the Determination and Designation of Host Status of a Fruit or Vegetable for Fruit Flies [Diptera: Tephritidae]”) [6], and the USDA “Guidelines for Plant Pest Risk Assessment of Imported Fruit and Vegetable Commodities” [7]. Host plant species where data came from laboratory infestation studies, from interception data or was from merely listing a fruit or vegetable as a host without providing any supporting data (“listing only”) were classified as “undetermined hosts.”

## HOST PLANT SUMMARIZATION FOR THIS PAPER

Based on up-to-date provisional host lists of the 11 tropical/subtropical tephritid fruit fly species published online in CoFFHI, Edition 2.0, total numbers of plant families, plant genera, and plant taxa encompassed by “Suitable Host” listings and “Undetermined Host” listings were determined for each fruit fly species. “Plant taxa” was used rather than “plant species” because host lists include some variety listings as well as some “Genus sp.” or “Genus spp.” listings. Suitable hosts listed for all 11 fruit fly species were combined and sorted to identify the total number of plant taxa and plant families which have been identified as suitable hosts of this group of tephritid fruit fly species of invasive concern.

## RESULTS AND DISCUSSION

Table 1 presents numbers of “suitable” and “undetermined” host plants for 11 tropical/subtropical tephritid fruit fly species with invasive potential, as summarized in CoFFHI, Edition 2.0. Also presented are the number of plant families and plant genera represented in the host plant list for each fruit fly species. Considered in aggregate, there are a total of 852 plant taxa that are documented to be infested in the field by the 11 tephritid fruit fly species of economic importance presented in this paper. These 852 plant taxa represent a total of 100 plant families and 330 plant genera. Numbers of suitable host plant taxa in each of these families is presented in (Table 2). The ten families with the greatest numbers of suitable hosts are Cucurbitaceae (77), Solanaceae (58), Rutaceae (57), Myrtaceae (48), Moraceae (44), Sapotaceae (44), Rosaceae (41), Anacardiaceae (34), Annonaceae (26), and Ebenaceae (25). The three tephritid fruit fly species with the most suitable hosts are oriental fruit fly (478 hosts representing 76 plant families), Mediterranean fruit fly (361 hosts representing 63 plant families), and melon fly (136 hosts representing 30 plant families). Out of the total number of host plant taxa covered by the 11 tephritid fruit fly species, 56% of the plant taxa are hosts of oriental fruit fly, 42% are hosts of Mediterranean fruit fly and 16% are hosts of melon fly. The plant families in which suitable hosts have been recorded for each of the tephritid fruit fly species reported here are listed in (Table 3). Natural infestation by all 11 tephritid fruit fly species covered here has been documented in one family, Myrtaceae, while field

**Table 1:** Numbers of suitable and undetermined host plant taxa documented for 11 potentially invasive tropical/subtropical tephritid fruit fly species of economic importance.

Fruit Fly Species		Suitable Hosts <sup>a</sup>			Undetermined Hosts <sup>b</sup>			Total Plant Taxa
Scientific Name	Common Name	Plant Families	Plant Genera	Plant Taxa	Plant Families	Plant Genera	Plant Taxa	
<i>Anastrepha ludens</i>	Mexican Fruit Fly	17	24	45	18	32	51	96
<i>Anastrepha obliqua</i>	West Indian Fruit Fly	21	37	77	25	41	73	150
<i>Bactrocera carambolae</i>	Carambola Fruit Fly	38	58	101	16	29	40	141
<i>Bactrocera correcta</i>	Guava Fruit Fly	34	50	73				73
<i>Bactrocera cucurbitae</i>	Melon Fly	30	62	136	39	80	137	273
<i>Bactrocera dorsalis</i>	Oriental Fruit Fly	78	211	478	51	96	149	627
<i>Bactrocera latifrons</i>		13	25	59	13	17	23	82
<i>Bactrocera pedestris</i>		12	19	26	3	3	3	29
<i>Bactrocera tau</i> complex		23	44	77	15	21	31	108
<i>Bactrocera zonata</i>	Peach Fruit Fly	23	38	55	25	41	81	136
<i>Ceratitis capitata</i>	Mediterranean Fruit Fly	63	159	361	48	106	177	538

<sup>a</sup> "Suitable hosts" are plant species for which there are confirmed infestation records under natural field conditions.

<sup>b</sup> The "undetermined host status" category is conferred to plant species devoid of record of infestation by a tephritid fruit fly species under natural field conditions, and their association with a tephritid fruit fly species is based on laboratory infestation data, interceptions at ports of entry, or mere listings as hosts without any accompanying verifiable data.

**Table 2:** Number of suitable host plant taxa, per plant family, for 11 tropical/subtropical potentially invasive tephritid fruit fly species of economic importance.

Number of Suitable Hosts <sup>a</sup>	Plant Families
77	Cucurbitaceae
58	Solanaceae
57	Rutaceae
48	Myrtaceae
44	Moraceae, Sapotaceae
41	Rosaceae
34	Anacardiaceae
26	Annonaceae
25	Ebenaceae
22	Fabaceae
21	Apocynaceae
20	Clusiaceae, Rubiaceae
15	Passifloraceae, Sapindaceae
14	Phyllanthaceae
12	Arecaceae, Loganiaceae, Malvaceae
11	Capparaceae, Rhamnaceae
9	Lauraceae, Musaceae, Oleaceae
7	Celastraceae, Meliaceae
6	Boraginaceae, Cactaceae, Combretaceae, Juglandaceae, Salicaceae
5	Brassicaceae, Burseraceae, Euphorbiaceae, Putranjivaceae, Santalaceae, Vitaceae
4	Calophyllaceae, Lamiaceae, Malpighiaceae, Melastomataceae
3	Asteraceae, Chrysobalanaceae, Cornaceae, Ericaceae, Lecythidaceae, Opiliaceae, Pandanaceae, Polygalaceae
2	Achariaceae, Actinidaceae, Adoxaceae, Asparagaceae, Bignoniaceae, Cannabaceae, Caricaceae, Convulvulaceae, Elaeocarpaceae, Gentianaceae, Gnetaceae, Goodeniaceae, Irvingiaceae, Lythraceae, Myristicaceae, Olacaceae, Oxalidaceae, Rhizophoraceae, Simaroubaceae, Thymelaeaceae, Ximeniaceae, Zingiberaceae
1	Agavaceae, Berberidaceae, Bromeliaceae, Corynocarpaceae, Dilleniaceae, Dipterocarpaceae, Fagaceae, Flagellariaceae, Hanguanaceae, Icacinaceae, Menispermaceae, Muntingiaceae, Myricaceae, Poaceae, Podocarpaceae, Primulaceae, Salvadoraceae, Schoepfiaceae, Simmondsiaceae, Staphyleaceae, Symplocaceae, Tropaeolaceae, Ulmaceae, Urticaceae, Verbenaceae

<sup>a</sup> Suitable hosts are plant species for which there are confirmed infestation records under natural field conditions.

**Table 3:** Plant families in which natural infestation is documented for each of 11 potentially invasive tropical/subtropical tephritid fruit fly species.

Fruit Fly Species	Plant Families in which Natural Infestation is Documented
<i>Anastrepha ludens</i>	6,7,20,23,27,34,38,49,52,63,69,79,80,81,85,86,90
<i>Anastrepha obliqua</i>	6,8,12,15,24,25,27,34,37,38,53,54,55,58,63,67,79,80,81,86,95
<i>Bactrocera carambolae</i>	6,7,8,10,18,20,22,23,25,26,27,29,34,37,41,42,46,49,52,53,56,58,62,63,64,66,67,70,73,77,78,80,81,85,86,90,92,94
<i>Bactrocera correcta</i>	6,7,8,10,19,22,23,26,27,31,33,35,46,50,51,53,56,58,59,60,62,63,64,67,70,77,79,80,81,82,85,86,87,98
<i>Bactrocera cucurbitae</i>	4,6,7,16,19,22,23,26,27,31,38,47,49,51,54,58,60,63,67,68,69,70,77,79,80,81,85,86,90,98
<i>Bactrocera dorsalis</i>	3,5,6,7,8,10,11,14,15,17,18,19,20,21,22,23,24,25,26,27,28,29,31,32,34,35,36,37,38,39,41,44,45,46,47,48,49,50,51,52,53,54,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,73,74,75,76,77,78,79,80,81,82,84,85,86,87,88,90,91,93,98,99,100
<i>Bactrocera latifrons</i>	27,31,48,52,63,65,69,70,77,80,81,85,90
<i>Bactrocera pedestris</i>	6,7,31,56,58,63,67,79,81,85,86,90
<i>Bactrocera tau</i> complex	1,6,10,23,24,31,38,41,51,55,58,59,63,65,67,69,70,71,79,80,86,90,98
<i>Bactrocera zonata</i>	6,7,10,23,27,31,34,35,38,49,50,52,53,54,58,63,65,76,77,79,81,86,90
<i>Ceratitis capitata</i>	2,6,7,8,9,10,11,13,14,15,19,20,21,22,23,24,25,26,27,30,31,34,36,38,40,43,47,49,51,52,53,54,55,56,58,59,60,63,65,66,67,69,70,72,74,76,77,79,80,81,82,83,84,85,86,88,89,90,93,96,97,98,99

Plant families: 1-Achariaceae; 2-Actinidaceae; 3-Adoxaceae; 4-Agavaceae; 5-Amaryllidaceae; 6-Anacardiaceae; 7-Annonaceae; 8-Apocynaceae; 9-Araceae; 10-Arecaceae; 11-Asparagaceae; 12-Asteraceae; 13-Berberidaceae; 14-Bignoniaceae; 15-Boraginaceae; 16-Brassicaceae; 17-Bromeliaceae; 18-Burseraceae; 19-Cactaceae; 20-Calophyllaceae; 21-Cannabaceae; 22-Capparaceae; 23-Caricaceae; 24-Celastraceae; 25-Chrysobalanaceae; 26-Clusiaceae; 27-Combretaceae; 28-Convulvaceae; 29-Cornaceae; 30-Corynocarpaceae; 31-Cucurbitaceae; 32-Dilleniaceae; 33-Dipterocarpaceae; 34-Ebenaceae; 35-Elaeocarpaceae; 36-Ericaceae; 37-Euphorbiaceae; 38-Fabaceae; 39-Fagaceae; 40-Flagellariaceae; 41-Gentianaceae; 42-Gnetaceae; 43-Goodeniaceae; 44-Hanguanaceae; 45-Icacinaceae; 46-Irvingiaceae; 47-Juglandaceae; 48-Lamiaceae; 49-Lauraceae; 50-Lecythidaceae; 51-Loganiaceae; 52-Lythraceae; 53-Malpighiaceae; 54-Malvaceae; 55-Melastomataceae; 56-Meliaceae; 57-Menispermaceae; 58-Moraceae; 59-Muntingiaceae; 60-Musaceae; 61-Myricaceae; 62-Myristicaceae; 63-Myrtaceae; 64-Olacaceae; 65-Oleaceae; 66-Opiliaceae; 67-Oxalidaceae; 68-Pandanaceae; 69-Passifloraceae; 70-Phyllanthaceae; 71-Poaceae; 72-Podocarpaceae; 73-Polygalaceae; 74-Polygonaceae; 75-Primulaceae; 76-Putranjivaceae; 77-Rhamnaceae; 78-Rhizophoraceae; 79-Rosaceae; 80-Rubiaceae; 81-Rutaceae; 82-Salicaceae; 83-Salvadoraceae; 84-Santalaceae; 85-Sapindaceae; 86-Sapotaceae; 87-Schoepfiaceae; 88-Simaroubaceae; 89-Simmondsiaceae; 90-Solanaceae; 91-Staphyleaceae; 92-Symplocaceae; 93-Thymelaeaceae; 94-Tropaeolaceae; 95-Ulmaceae; 96-Urticaceae; 97-Verbenaceae; 98-Vitaceae; 99-Ximeniaceae; 100-Zingiberaceae

infestation by 10 of the 11 fruit fly species have been documented in the Anacardiaceae, Rutaceae, and Sapotaceae families.

## CONCLUSION

There are many tephritid fruit fly species worldwide, a number of which pose a threat of introduction and establishment in new areas where they had not previously been present. Tephritid fruit fly larvae feeding in fruits and vegetables can ruin fruits and vegetables for local consumption as well as create concern for risk of introducing fly species to new areas through produce shipments. Using recently updated provisional host lists developed for 11 tephritid fruit fly species that have previously invaded, or have potential to invade, the U.S.A., 100 plant families, and 330 plant genera, are identified which include plant species for which natural field infestation has been documented. Although fruit fly species vary considerably in the range of hosts that they can infest, natural field infestation for one species, the oriental fruit fly (*Bactrocera dorsalis*), has been documented in as many as 76 plant families. Natural infestation by all 11 tephritid fruit fly species covered here has been documented in one family, Myrtaceae, while field infestation by 10 of the 11 fruit fly species have been documented in the Anacardiaceae, Rutaceae, and Sapotaceae families. Fruits in these plant families can be at risk of infestation by a wide range of invasive tephritid fruit fly species. Knowledge of the host status of different fruits and vegetables is needed in assessing the risk of fruit fly species in imported and exported fruit and vegetable commodities and for developing systems approaches and other mitigation measures to facilitate global trade.

## ACKNOWLEDGEMENTS

We thank the technical assistance of present and previous NCSU-CIPM, USDA-APHIS-CPHST and USDA-ARS Research Assistants and University of Hawaii (UH)-Hilo students for help in summarizing tephritid fruit fly host data: Megan A. Hanlin, Amanda L. Birnbaum, Kelly A. A. Nakamichi, Jess R. Inskeep, Alexander J. Ching, Amber Tateno, Kelly Ann L. K. Lee, Ashley Mc Guigan, Kyle Kumashiro, Noah J. Hegerfeldt, April M. Greenwell, Kristine G. Ayson, and John E. Montoya (CIPM); Sarah A. Marnell and Rick S. Kurashima (CPHST); Charmaine D. Sylva (ARS); and Sierra V. Salazar, Monique R. Walls, and Leslie L. Wynne (UH-Hilo). We also thank Karl A. Suiter and Sandra Sferrazza (NCSU-CIPM) for help in developing the CoFFHI website where access to up-to-date fruit fly host information is made available. To all of them, *Mahalo!* 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. USDA is an equal opportunity provider and employer.

## REFERENCES

- White IM, Elson-Harris MM. Fruit flies of economic significance: Their identification and bionomics. C.A.B. International, Wallingford. 1992.
- Carroll LE, White IM, Freidberg A, Norrbom AL, Dallwitz MJ, Thompson FC. Pest fruit flies of the world. Version: 8 December 2006. <http://delta-intkey.com>.
- Liquido NJ, McQuate GT, Suiter KA. USDA Compendium of fruit fly host information (CoFFHI), Edition 2.0. United States Department of

- Agriculture, Center for Plant Health Science and Technology, Raleigh, N.C. 2016. <https://coffhi.cphst.org/>.
4. Papadopoulos NT, Plant RE, Carey JR. From trickle to flood: The large-scale, cryptic invasion of California by tropical fruit flies. *Proc R. Soc. B* 2013; 280: 1-10.
  5. International Plant Protection Convention (IPPC). International Standards for Phytosanitary Measures (ISPM) 37. Determination of host status of fruit to fruit flies (Tephritidae). FAO, Rome. 2016. [https://www.ippc.int/static/media/files/publication/en/2016/05/ISPM\\_37\\_2016\\_En\\_HostStatus\\_2016-04-26.pdf](https://www.ippc.int/static/media/files/publication/en/2016/05/ISPM_37_2016_En_HostStatus_2016-04-26.pdf)
  6. North American Plant Protection Organization (NAPPO). Regional Standard for Phytosanitary Management (RSPM) No. 30. Guidelines for the Determination and Designation of Host Status of a Fruit or Vegetable for Fruit Flies (Diptera: Tephritidae). Secretariat of the North American Plant Protection Organization, Ottawa, Canada. 2008. <https://www.nappo.org/files/4714/3895/5199/RSPM30-20-10-08-e.pdf>
  7. United States Department of Agriculture (USDA). Animal and Plant Health Inspection Service (APHIS). Plant Protection and Quarantine (PPQ). Guidelines for Plant Pest Risk Assessment of Imported Fruit and Vegetable Commodities. USDA-APHIS-PPQ, Raleigh, NC. USA. 2012. [https://www.aphis.usda.gov/import\\_export/plants/plant\\_imports/process/downloads/PRAGuidelines-ImportedFruitVegCommodities.pdf](https://www.aphis.usda.gov/import_export/plants/plant_imports/process/downloads/PRAGuidelines-ImportedFruitVegCommodities.pdf)

**Cite this article**

McQuate GT, Liquido NJ (2017) Host Plants of Invasive Tephritid Fruit Fly Species of Economic Importance. *Int J Plant Biol Res* 5(4): 1072.