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UPDATE ON THE HOST RANGE OF DIFFERENT SPECIES OF FRUIT FLIES IN INDONESIA

PEMBARUAN INFORMASI KISARAN INANG SPESIES LALAT BUAH DI INDONESIA

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ABSTRACT

Recent reviews on Dorsalis and Dacine fruit flies had implication on host-insect inventory, including in Indonesia. Update is needed because of these changes and due to the rising of fruit and vegetable trade within islands, as well as with neighboring countries. Fruits were collected over a 3-year period from 24 provinces of Indonesia, covering areas from Aceh to Papua. This work was done specifically to obtain detailed information regarding the host range of the important species of *Bactrocera* spp., *Atherigona orientalis*, and *Dacus longicornis*, as well as *Adrama determinata*. Male lure Steiner traps to attract fruit flies were used in this study as an additional method to support species variation. A total of 1125 fruit samples were collected from many locations. Thirty five plant species from 18 families were recorded as fruit fly hosts and 27 plant species were new report as specific host for certain species of fruit fly. A larger array of host plants for fruit flies in Indonesia than reported before suggests the importance of effective quarantine measures to limit the spread of harmful fruit fly and to prevent the accidental introduction of invasive alien fruit fly species from other countries.

Key words: distribution, fruit fly, fruit survey, host, infestation

INTISARI

Guna mendapatkan informasi terkini mengenai peran lalat buah (Diptera: Tephritidae dan Muscidae) dalam bidang pertanian, diperlukan inventarisasi kisaran inangnya termasuk yang ada di Indonesia melalui metode surveilansi. Pembaruan informasi mengenai inang lalat buah ini sangat penting untuk dilakukan mengingat semakin maraknya perdagangan buah dan sayur antar pulau di Indoensia dan juga dengan luar negeri. Surveilansi dilakukan dengan cara buah dikoleksi dalam kurun waktu lebih dari tiga tahun dari 24 provinsi di Indonesia, mulai dari Aceh hingga Papua. Zat pemikat lalat buah jantan dalam perangkap Steiner juga digunakan sebagai metode tambahan untuk mendapatkan variasi spesies yang lebih banyak. Sejumlah 1125 sampel buah dikoleksi dari berbagai lokasi. Penelitian ini berhasil mendapatkan informasi secara detail mengenai kisaran inang lalat buah penting dalam bidang pertanian yaitu Adrama determinata*,* Atherigona orientalis*,* Bactrocera *spp., dan* Dacus longicornis*. Tiga puluh lima jenis dari 18 famili tumbuhan tercatat sebagai inang lalat buah dan 27 jenis diantaranya merupakan laporan baru sebagai inang lalat buah. Kisaran inang yang lebih luas ditemukan pada penelitian ini dibandingkan dengan data laporan-laporan sebelumnya menunjukkan betapa pentingnya perlakuan karantina yang efektif di dalam mencegah penyebaran dan pemasukan spesies lalat buah berbahaya antar pulau di Indonesia dan dari luar negeri.*

Kata kunci: distribusi, inang, lalat buah

INTRODUCTION

Indonesia is the largest archipelago in the world which consists of over 17,000 islands. Throughout the country, fruits and vegetables are grown and unpurposely serve as fruit flies host. Although in most areas fruits and vegetables are produced for local markets, major producing islands also trade fresh fruits or fresh vegetables each other and with other countries. For the purpose of biosecurity, since Januari 27, 2006 Indonesian government restricted point of entries limited to seven sites only (Permentan No. 37, 2006), namely Jakarta's Tanjung Priok harbour and Soekarno-Hatta airport (Java), Surabaya's Tanjung Perak harbour (Java), Medan's Belawan harbour (Sumatra), Batam's Kabil harbour (Riau Archipelago), Makassar's Soekarno-Hatta harbour (South Sulawesi), and Denpasar's Ngurah Rai airport (Bali). The increasing trade exchange increases the possibility of introduction of new fruit fly species not only from other countries but also from other areas within the country.

Reviews on the taxonomic status of Dorsalis complex worldwide resulted in 53 species (Drew & Hancock, 1994) and 68 species (Lawson *et al*., 2000). Tsuruta & White (2001) added six species and Drew *et al.* (2005) added one species; making 75 species of fruit fly belong to this group. Dacine fruit flies combined with Dorsalis complex and

non-Dorsalis complex (in total over 500 species) are endemic to subtropical and tropical rain forests from the Indian subcontinent across to Oceania (Drew, 1989). The latest survey in 2009 by Indonesian Ministry of Agriculture revealed that the number of fruit fly species in Indonesia is 18 species and 45 species within Dorsalis complex and non-Dorsalis complex, respectively, including three species of *Dacus*. In this project, almost all of fruit fly species were caught using lure trap with Methyl Eugenol and Cue Lure as attractants.

Information on fruit fly host plants and its occurrence in Indonesia is very limited. To collect such information, there are several technical difficulties; among others are different cultural practices throughout the archipelago. Although some fruit production areas have good orchards management with the size of more than two hectares, many fruit trees, in Java particularly, are mostly grown in backyards without proper cultural practices. Survey on host plants of fruit flies species is needed to provide trade activities with information required by modern trade scheme. This research was conducted to gather information on host range of different species of fruit flies. To achieve the goal, rotten fruits from 34 species of fruit or vegetable species within 16 families spread over 24 provinces in Indonesia were collected, and maintained in the laboratory until the fruit fly emerged.

MATERIALS AND METHODS

Sampling Location

The fruit fly sampling sites encompassed 24 provinces in Indonesia covered wide areas from the province of Aceh in western Indonesia to Papua the eastern of Indonesia (Table 1 and Figure 1).

Host Survey

Fruit samples, mostly overripe or rotten, were collected from urban areas (yards), orchards (fields), and forest areas (forests) starting from May 2007 to November 2010. The samples, ranging from one to 231 units, were collected either from recently fallen fruits or from the trees, and they were recorded as the host. The distribution of the fruit flies and the hosts were also recorded. Each fruit sample was placed in a paper bag and labeled with name of fruit, date of collection, information of site, and name of collector. The samples were brought to the Basic Entomology Laboratory in the Department at Plant Protection, Faculty of Agriculture, Gadjah Mada University for identification of fruit fly species and their host.

Identification of the species of fruit fly was based on the adult. The fruit was put on sawdust in a transparent plastic container. The sawdust served as medium for larvae to pupate, which usually took 5–11 days. Pupae were collected from the sawdust and moved to cages until adult flies emerged. The adults were reared by feeding with sugar, yeast extract and water for seven days. Later, the adults were killed by placing them in the freezer for 24 hours for identification.

Trapping

Steiner traps were used to sample flying male fruit flies. A total of 60 Steiner traps were placed in the selected sites. In each site, which could be urban area, orchard, and forest, 20 Steiner traps were placed (10 Steiner traps with ME lure and 10 Steiner traps with CUE lure) were placed. The twenty Steiner traps were placed along each of the 100 m transects at 5 m interval. The Steiner trap was made from a transparent plastic container with a large opening (funnel) both at each end. The lower half

Table 1. The sampling sites of fruit fly by collecting from rotten fruits and traps containing Methyl Eugenol lure and Cue lure

No.	Location		Position	
	Province	District	Geographical Site	Elevation (m AMSL)
1.	Aceh	Aceh Besar	N 5°25'45.83", E 95°20'54.99"	287
2.	Riau	Pekanbaru	N 0°32'0.00", E 101°27'0.00"	13
3.	RiauArchipelagoes	Batam	N 1°5'13.89", E 103°57'15.50"	111
4.	North Sumatra	Karo	N 3°15'23.03", E 98°40'4.98"	297
5.	West Sumatra	Agam	S 0°15'16.38", E 100°10'20.97"	498
		Payakumbuh	S 00°10.674', E 100°34.394"	516
		Solok	S 0°48'10.90", E 100°38'39.85"	399
6.	South Sumatra	Palembang	S 2°57'14.36", E 104°44'57.26"	7
7.	Lampung	Bandar Lampung	S 2°57'14.36", E 104°44'57.26"	11
8.	West Kalimantan	Pontianak	S 0°2'2.12", E 109°19'35.51"	4
9.	South Kalimantan	Banjarbaru	S 3°40'39.85", E 114°51'38.10"	171

Table 1. (continued)

No.	Location		Position	
	Province	District	Geographical Site	Elevation (m AMSL)
10.	East Kalimantan	West Kutai	S 00°17’20.4”, E 115°43’31.8”	96
		Samarinda	S 0°31'13.43", E 117°13'30.82"	3
		Tarakan	N 3°21'17.86", E 117°36'23.86"	73
11.	Special Capital Territory of Jakarta	Depok	S 6°23'31.52"S, E 106°53'20.11"	8
12.	West Java	Indramayu	S 6°27'40.42", E 108°17'55.29"	12
		Karawang	S 6°18'53.69", E 107°30'52.25"	15
		Subang	S 6°34'5.05", E 107°45'35.39"	95
		West Bandung	S 6°49'38.46", E 107°41'10.97"	149
13.	Central Java	Batang	S 7°7'55.81", E 109°50'52.40"	1445
		Demak	S 6°51'32.44", E 110°35'36.89"	3
		Kendal	S 7°2'39.47", E 110°2'45.81"	411
		Pemalang	S 6°53'45.82", E 109°27'26.24"	10
		Sragen	S 7°22'43.81", E 110°57'49.78"	75
		Sukoharjo	S 7°38'9.74", E 110°53'17.46"	114
14.	Special Region of Yogyakarta	Bantul	S 7°54'5.32", E 110°17'50.44"	38
		Gunung Kidul	S 7°56'59.98", E 110°35'04.09"	199
		Kulonprogo	S 7°47'49.94", E 110°06'19.92"	357
		Sleman	S 7°45'30.72", E 110°23'21.64"	160
15.	East Java	Bangkalan	S 6°58'45.69", E 112°52'50.82"	49
		Banyuwangi	S 8°16'24.70", E 113°58'40.73"	474
		Batu	S 7°47'51.81", E 112°30'57.65"	1308
		Blitar	S 8°07'41.36", E 112°10'02.25"	150
		Kediri	S 7°46'36.61", E 112°07'42.81"	110
		Magetan	S 7°39'17.14", E 111°22'20.93"	228
		Malang	S 7°54'59.46", E 112°33'30.72"	707
		Mojokerto	S 7°39'46.08", E 112°32'12.13"	611
		Pasuruan	S 7°39'0`9.65", E 112°48'29.54"	34
		Probolinggo	S 7°45'04.80", E 113°14'45.46"	5
		Surabaya	S 7°19'59.13", E 112°47'26.19"	7
16.	Bali	Buleleng	S 8°09'49.77", E 115°14'57.77"	926
		Karangasem	S 8°28'17.39", E 115°27'15.19"	380
17.	West Nusa Tenggara	East Lombok	S 8°21'57.25", E 116°32'10.76"	1170
		Bima	S 8°27'38.64", E 118°43'38.49"	33
		Sumbawa	S 8°39'17.37", E 117°21'59.77"	431
		West Lombok	S 08°27’55.0”, E 116°05’02.2”;	338
18.	East Nusa Tenggara	Ende	S 8°50'34.87", E 121°39'13.54"	38
19.	South Sulawesi	Barru	S 04°11’31.4”, E 119°40’00.6”	33
		Gowa	S 5°14'31.66", E 119°52'14.18"	1132
		Maros	S 05°00’37.6”, E 119°41’24.4”	58
		Soppeng	S 4°20'16.34", E 120°00'14.25"	38
20.	Central Sulawesi	Banawa	S 0°47'14.98", E 119°39'52.15"	61
21.	Gorontalo	Pohuwato	N 0°41'56.03", E 121°43'10.15"	266
22.	Moluccas	Ambon	S 3°42'26.19", S 128°09'53.61"	28
		Namlea	S 3°14'01.91", S 127°05'14.72"	21
23.	West Papua	Sorong	S 0°59'53.02", E 131°18'57.30"	16
		Yapen Archipelagoes	S 01°46’18.9”, E 136°10’57.2”	708
24.	Papua	Jayawijaya	S 4°01'50.96", S 139°03'21.11"	3225
		Puncak	S 4°40'18.88", S 139°22'56.04"	2402
		Yapen Waropen	S 0°52'49.30", S 134°02'29.14"	140

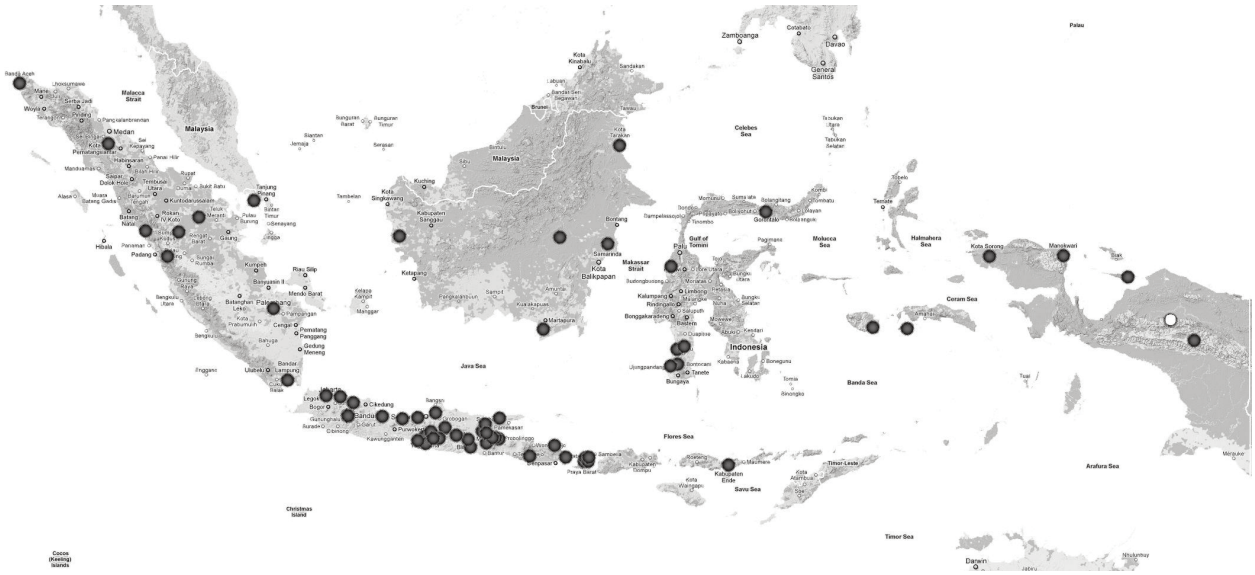

Figure 1. Distribution of sampling sites; black dot spots indicated that fruit fly was present, whereas white dot spots indicate that fruit fly was absent

of the funnels was protected with a gauze wire. The container size is 13.5 cm high, 12.5 cm top diam eter, and 10.5 cm bottom diameter. The Steiner traps were placed horizontally, in which a cotton wick impregnated with a mixture of attractant (ME lure or CUE lure) and insecticides (transflutrin 0.06%, imiprotrin 0.05% and sipermetrin 0.10%) was suspended to prevent escape and predation of the captured fruit flies. The cotton wicks were soaked in 2 to 3 mL mixture of 4 mL attractant and 1 mL insecticide. A glued wire, placed on top of the trap structure, was used to hang the trap to tree branches. The Steiner traps were activated for 3×24 hours. Captured fruit flies were collected every day and stored in small paper boxes with tissue paper inside and labeled for further identification.

Identification

The adult specimens were sorted and separated to morphospecies using a dissecting microscope at 7× power then preserved on carding (Suputa *et al*., 2007). The species of fruit flies were identified to species level, and their respective count was recorded. The identification was based on their morphological characters using the following references: *Treubia* which is a journal on zoology and hydrobiology of the Indo-Australian archipelago, *Economic Fruit Flies of The South Pacific Region* by Drew et al. (1982), *Fruit Flies of Economic Significance: Their Identification and Bionomics* by White and Elson-Harris (1992), *Tropical Fruit Flies (Diptera: Tephritidae: Dacinae) of the Australasian and Oceanian Regions* by Drew (1989), *Bulletin of Entomological Research "supplement series" the* Bactrocera dorsalis *complex of the fruit flies (Diptera: Tephritidae: Dacinae) in Asia* by Drew and Hancock (1994), identification key software of Dacinae by White and Hancock (1997), and identification key software of Dorsalis by Lawson *et al*. (2003).

RESULTS AND DISCUSSION

Number of Surveys

A total of 1125 fruit samples from 34 plant species belonging to 17 families of Anthophytes and one family of Gnetophytes were collected. As many as 44 species of fruit flies were collected, and they belong to nine subgenera of fruit flies; 40 genera of *Bactrocera*, two genera of *Dacus*, one genus of *Adrama*, and one genus of *Atherigona.* There were 19 species of fruit flies emerged from 35 species of collected plant. Thirty three species were attracted to Cue lure, seven species were attracted to ME, and four species emerged from plant with no lure record known yet (Table 2).

Host Ranges

More than single species of fruit fly, occurred as mix of *Bactrocera* spp., *Atherigona orientalis*, *Dacus longicornis*, or *Adrama determinata* occasionally emerged from one fruit. In two samples, a mixed population of inter-species *Atherigona*, *Bactrocera*, and *Dacus* was reared from one fruit. These samples were found at several provinces in Indonesia in fruits of the following: *Luffa cylindrica* (L.) Roem. and *Momordica*

Table 2. Species of fruit flies in Indonesia collected from the traps using lure and their supposed respective host plants

Species	Host plant [Indonesian Common Name] (Total Fruit Number)	Lure	Sample Collection Sites
Subgenus Asiadacus *Bactrocera apicalis* (de Meijere)	UHP	CUE	West Kutai (East Kalimantan)
Subgenus *Bactrocera dorsalis* Complex *Bactrocera affinidorsalis* Drew & Hancock	UHP	CUE	Maros (South Sulawesi)
B. bimaculata Drew & Hancock	UHP	CUE	Bima (West Nusa Tenggara)
B. carambolae Drew & Hancock		ME	Bantul, Gunung Kidul, Kulonprogo, Sleman (Special Region of Yogyakarta); Bangkalan, Banyuwangi, Batu, Blitar, Kediri, Magetan, Malang, Mojokerto, Pasuruan, Probolinggo, Surabaya (East Java); Buleleng, Karangasem (Bali); Indramayu, Karawang, Subang, West Bandung (West Java); Depok (Special Capital Territory of Jakarta); Pekanbaru (Riau); Batam (Riau Archipelagoes); West Kutai, Samarinda, Tarakan (East Kalimantan); East Lombok, Bima, Sumbawa, West Lombok (West Nusa Tenggara); Barru, Gowa, Maros, Soppeng (South Sulawesi); Batang, Demak, Kendal, Pemalang, Sragen, Sukoharjo (Central Java)
	Anacardiaceae: *Mangifera indica* L. [Mangga] (28)		Batu, Malang, Pasuruan, Probolinggo (East Java); Indramayu, Karawang (West Java); Sleman (Special Region of Yogyakarta)
	Caricaceae: *Carica papaya* L. [Pepaya] (23)		Banyuwangi, Batu, Malang (East Java); Subang (West Java)
	Myrtaceae: *Syzygium aquaticum* Burm. F. [Jambu air] (34)		Batu, Mojokerto, Surabaya (East Java); Sleman (Special Region of Yogyakarta); Demak (Central Java)
	Psidium guajava L. [Jambu biji] (65)		Batu, Blitar, Mojokerto, Surabaya (East Java); Depok (Special Capital Territory of Jakarta); Karawang (West Java); Sleman (Special Region of Yogyakarta)
	Syzygium malaccense (L.) Merr. & L.M.Perry [Jambu bol] (52)		Batu, Blitar, Mojokerto, Surabaya (East Java); Bantul, Sleman (Special Region of Yogyakarta)
	Oxalidaceae: *Averrhoa carambola* L. [Belimbing] (65)		Batu, Blitar, Mojokerto, Surabaya (East Java); Bantul, Kulonprogo, Sleman (Special Region of Yogyakarta); Depok (Special Capital Territory of Jakarta)
B. cibodasae Drew & Hancock	UHP	CUE	West Bandung (West Java); Sleman (Special Region of Yogyakarta)
B.floresiae Drew & Hancock ψ	UHP	ME	Ende (East Nusa Tenggara); East Lombok (West Nusa Tenggara)
B. fuscitibia Drew & Hancock	UHP	CUE	Malang (East Java); Maros, Soppeng (South Sulawesi)
B. makilingensis Drew & Hancock	UHP	CUE	East Lombok, West Lombok (West Nusa Tenggara)

Table 2. (continued)

Species	Host plant [Indonesian Common Name] (Total Fruit Number)	Lure	Sample Collection Sites
B. melastomatos Drew & Hancock ψ		CUE	Palembang (South Sumatra)
	Melastomaceae:		
	Melastoma malabathricum L [Karamunting] (20)		Palembang (South Sumatra)
B. merapiensis Drew & Hancock	UHP	CUE	Agam, Payakumbuh (West Sumatra); Sleman (Special Region of Yogyakarta)
B. minuscula Drew & Hancock	UHP	CUE	East Lombok, West Lombok (West Nusa Tenggara); Barru, Maros, Soppeng (South Sulawesi); Pohuwato (Gorontalo)
B. neocognata Drew & Hancock		CUE	East Lombok, West Lombok (West Nusa Tenggara); Sleman (Special Region of Yogyakarta)
	Annonaceae:		
	Stelechocarpus burahol (Blume) Hook. & Thomson [Kepel/burahol] Ж (9)		Sleman (Special Region of Yogyakarta)
B. papayae Drew & Hancock		ME	Aceh Besar (Aceh); Pekanbaru (Riau); Batam (Riau Archipelagoes); Karo (North Sumatra); Agam, Payakumbuh (West Sumatra); Palembang (South Sumatra); Bandar Lampung (Lampung), West Kutai, Samarinda, Tarakan (East Kalimantan); Banjarbaru (South Kalimantan); Depok (Special Capital Territory of Jakarta); Indramayu, Karawang, Subang, West Bandung (West Java); Batang, Demak, Kendal, Pemalang, Sragen, Sukoharjo (Central Java); Bantul, Gunung Kidul, Kulonprogo, Sleman (Special Region of Yogyakarta); Bangkalan, Banyuwangi, Batu, Blitar, Kediri, Magetan, Malang, Mojokerto, Pasuruan, Probolinggo, Surabaya (East Java); Buleleng, Karangasem (Bali); East Lombok, Bima, Sumbawa, West Lombok (West Nusa Tenggara); Ende (East Nusa Tenggara); Barru, Maros, Soppeng (South Sulawesi); Ambon, Namlea (Moluccas); Sorong, Yapen Archipelagoes (West Papua); Yapen Waropen (Papua)
	Anacardiaceae:		
	Mangifera indica L. [Mangga] (66)		Indramayu, Karawang (West Java); Pemalang (Central Java); Batu, Malang, Pasuruan, Probolinggo, Surabaya (East Java); Buleleng (Bali)
	Mangifera odorata Grift. [Kuweni] (28)		Batu, Malang (East Java); Pemalang (Central Java)
	Annonaceae:		
	Annona muricata L. [Sirsak] (7)		Blitar, Malang, Surabaya (East Java); Sleman (Special Region of Yogyakarta)
	Annona squamosa L. [Srikaya] (23)		Blitar, Malang, Surabaya (East Java); Sleman (Special Region of Yogyakarta)
	Stelechocarpus burahol (Blume) Hook. & Thomson [Kepel/burahol] Ж (9)		Sleman (Special Region of Yogyakarta)

Table 2. (continued)

Species	Host plant [Indonesian Common Name] (Total Fruit Number)	Lure	Sample Collection Sites
	Caricaceae: *Carica papaya* L. [Pepaya] (23)		Banyuwangi, Malang (East Java); Sleman (Special Region of Yogyakarta); Indramayu, Subang (West Java)
	Combretaceae: *Terminalia catappa* Linn. [Ketapang] (38)		Bantul, Sleman (Special Region of Yogyakarta)
	Lauraceae: *Persea americana* Mill [Apokat] (7)		Sleman (Special Region of Yogyakarta)
	Rutaceae: *Citrus maxima* Merr. [Jeruk pamelo] (5)		Magetan (East Java)
	Citrus nobilis Lour var. *microcarpa* [Jeruk siam madu]Ж (11)		Karo (North Sumatra)
	Sapindaceae: *Nephelium lappaceum* L. [Rambutan] (31)		Batu, Blitar (East Java); Sleman (Special Region of Yogyakarta)
	Solanaceae: *Capsicum annuum* L. [Cabai merah] ψ (266)		Banjarbaru (South Kalimantan); Kediri, Malang (East Java); Sleman (Special Region of Yogyakarta)
	Thymelaeaceae: *Phaleria macrocarp* (Scheff) Boerl. [Mahkota dewa] Ж (16)		Sleman (Special Region of Yogyakarta)
B. sembaliensis Drew & Hancock	UHP	CUE	East Lombok, Bima, Sumbawa, West Lombok (West Nusa Tenggara)
B. sulawesiae Drew & Hancock	UHP	ME	Maros (South Sulawesi)
B. sumbawaensis Drew & Hancock ψ	UHP	CUE	Sumbawa (West Nusa Tenggara)
B. verbascifoliae Drew & Hancock		CUE	West Lombok, East Lombok (West Nusa Tenggara)
	Solanaceae: *Solanum verbascifolium* L. [Teter] (12)		Banyuwangi (East Java)
Subgenus Bactrocera			
B. aemula (Drew) ψ	UHP	CUE	Ambon, Namlea (Moluccas)
B. albistrigata (de Meijere)		CUE	Aceh Besar (Aceh); Pekanbaru (Riau); Batam (Riau Archipelagoes); Karo (North Sumatra); Agam, Payakumbuh (West Sumatra); Palembang (South Sumatra); Bandar Lampung (Lampung), West Kuta, Samarinda, Tarakan (East Kalimantan); Banjarbaru (South Kalimantan); Depok (Special Capital Territory of Jakarta); Indramayu, Karawang, SubangWest Bandung (West Java); Batang, Demak, Kendal, Pemalang, Sragen, Sukoharjo (Central Java); Bantul, Gunung Kidul, Kulonprogo, Sleman (Special Region of Yogyakarta); Bangkalan, Banyuwangi, Batu, Blitar, Kediri, Magetan, Malang,

Table 2. (continued)

Species	Host plant [Indonesian Common Name] (Total Fruit Number)	Lure	Sample Collection Sites
			Mojokerto, Pasuruan, Probolinggo, Surabaya (East Java); Buleleng, Karangasem (Bali); East Lombok, Bima, Sumbawa, West Lombok (West Nusa Tenggara); Ende (East Nusa Tenggara); Barru, Maros, Soppeng (South Sulawesi); Pohuwato (Gorontalo); Ambon, Namlea (Moluccas); Sorong, Yapen Archipelagoes (West Papua); Yapen Waropen (Papua)
	Fabaceae: *Inocarpus fagifer* (Parkinson) Fosberg [Gayam] Ж (19)		Bantul, Kulonprogo, Sleman (Special Region of Yogyakarta)
	Combretaceae: *Terminalia catappa* Linn. [Ketapang] Ж (38)		Blitar (East Java); Bantul, Kulonprogo, Sleman (Special Region of Yogyakarta)
	Myrtaceae: *Syzygium malaccense* (L.) Merr. & L.M.Perry [Jambu bol] (52)		Demak, Kendal (Central Java); Bantul, Kulonprogo, Sleman (Special Region of Yogyakarta); Malang (East Java)
B. curvifera (Walker) ψ	UHP	ME	Namlea (Moluccas); Yapen Archipelagoes (West Papua)
B. impunctata (de Meijere) ψ	UHP	ME	Depok (Special Capital Territory of Jakarta)
B. lata ψ	UHP	CUE	Pekanbaru (Riau)
B. latifrons ψ	**Solanaceae:** *Capsicum annuum* L. [Cabai merah] (266)	ULR	Pekanbaru (Riau); Banjarbaru (South Kalimantan); Bantul, Sleman (Special Region of Yogyakarta); Kediri, Malang (East Java)
	Physalis minima L. [Ciplukan] Ж (36)		Malang (East Java)
B. limbifera (Bezzi)		CUE	Pontianak (West Kalimantan); Bantul, Kulonprogo, Sleman (Special Region of Yogyakarta); Pasuruan, Mojokerto (East Java); West Lombok (West Nusa Tenggara); Maros (South Sulawesi); Banawa (Central Sulawesi)
	Fabaceae: *Inocarpus fagifer* (Parkinson) Fosberg [Gayam] Ж (19)		Bantul, Kulonprogo, Sleman (Special Region of Yogyakarta); Pasuruan (East Java)
	Combretaceae: *Terminalia catappa* Linn. [Ketapang] Ж (38)		Bantul, Kulonprogo, Sleman (Special Region of Yogyakarta); Pasuruan (East Java)
B. moluccensis (Perkins)		CUE	Ambon (Moluccas); Bantul, Kulonprogo, Sleman (Special Region of Yogyakarta); Pasuruan (East Java); Maros (South Sulawesi); Yapen Waropen (Papua)
	Fabaceae: *Inocarpus fagifer* (Parkinson) Fosberg [Gayam] Ж (19)		Bantul, Sleman (Special Region of Yogyakarta)
B. nigrotibialis (Perkins)	UHP	CUE	East Lombok, West Lombok (West Nusa Tenggara)
B. paramusae (Drew)	UHP	CUE	Maros (South Sulawesi)

Table 2. (continued)

Species	Host plant [Indonesian Common Name] (Total Fruit Number)	Lure	Sample Collection Sites
B. umbrosa (Fabricius)		ME	Aceh Besar (Aceh); Pekanbaru (Riau); Batam (Riau Archipelagoes); Karo (North Sumatra); Agam, Payakumbuh (West Sumatra); Palembang (South Sumatra); Bandar Lampung (Lampung), West Kutai, Samarinda, Tarakan (East Kalimantan); Banjarbaru (South Kalimantan); Depok (Special Capital Territory of Jakarta); Indramayu, Karawang, Subang, West Bandung (West Java); Batang, Demak, Kendal, Pemalang, Sragen, Sukoharjo (Central Java); Bantul, Gunung Kidul, Kulonprogo, Sleman (Special Region of Yogyakarta); Bangkalan, Banyuwangi, Batu, Blitar, Kediri, Magetan, Malang, Mojokerto, Pasuruan, Probolinggo, Surabaya (East Java); Buleleng, Karangasem (Bali); East Lombok, Bima, Sumbawa, West Lombok (West Nusa Tenggara); Ende (East Nusa Tenggara); Barru, Maros, Soppeng (South Sulawesi);Banawa (Central Sulawesi); Ambon, Namlea (Moluccas); Sorong, Yapen Archipelagoes (West Papua); Yapen Waropen (Papua)
	Moraceae:		
	Artocarpus communis Forst. [Cempedak] (5)		Bantul, Sleman (Special Region of Yogyakarta); Malang, Mojokerto (East Java)
	Artocarpus heterophyllus Lam. [Nangka] (6)		Batam (Riau Archipelagoes); Bantul, Sleman (Special Region of Yogyakarta); Malang (East Java)
Subgenus Bulladacus			
B. mcgregori (Bezzi)	**Gnetaceae:**	ULR	
	Gnetum gnemon L. [Melinjo] (56)		Bantul, Kulonprogo, Sleman (Special Region of Yogyakarta); Blitar, Malang (East Java)
Subgenus Sinodacus			
B. hochii (Zia)	UHP	CUE	Palembang (South Sumatra); Bantul (Special Region of Yogyakarta)
Subgenus Zeugodacus			
B. calumniata (Hardy)		CUE	Aceh Besar (Aceh); Bantul, Sleman (Special Region of Yogyakarta); Buleleng (Bali); Mojokerto (East Java); West Lombok (West Nusa Tenggara)
	Caricaceae:		
	Carica papaya L. [Pepaya] Ж (23)		Indramayu, Subang (West Java)
	Cucurbitaceae:		
	Cucumis sativus L. [Mentimun] Ж (37)		Sleman (Special Region of Yogyakarta)
	Cucurbita moschata Duchesne ex Poir [Labu] Ж (1)		Malang (East Java)
	Luffa cylindrica (L.) Roem. [Belustru] Ж (34)		Blitar (East Java); Bantul, Sleman (Special Region of Yogyakarta)
	Momordica charantia L. [Parea] Ж (77)		Blitar, Kediri (East Java); Bantul, Sleman (Special Region of Yogyakarta)

Table 2. (continued)

Species	Host plant [Indonesian Common Name] (Total Fruit Number)	Lure	Sample Collection Sites
B. caudata (Fabricius)		CUE	Aceh Besar (Aceh); Pekanbaru (Riau); Batam (Riau Archipelagoes); Karo (North Sumatra); Agam, Payakumbuh (West Sumatra); Palembang (South Sumatra); Bandar Lampung (Lampung), West Kutai, Samarinda, Tarakan (East Kalimantan); Banjarbaru (South Kalimantan); Depok (Special Capital Territory of Jakarta); Indramayu, Karawang, Subang, West Bandung (West Java); Batang, Demak, Kendal, Pemalang, Sragen, Sukoharjo (Central Java); Bantul, Gunung Kidul, Kulonprogo, Sleman (Special Region of Yogyakarta); Bangkalan, Banyuwangi, Batu, Blitar, Kediri, Magetan, Malang, Mojokerto, Pasuruan, Probolinggo, Surabaya (East Java); Buleleng, Karangasem (Bali); East Lombok, Bima, Sumbawa, West Lombok (West Nusa Tenggara); Ende (East Nusa Tenggara); Barru, Maros, Soppeng (South Sulawesi); Banawa (Central Sulawesi); Ambon, Namlea (Moluccas); Sorong, Yapen Archipelagoes (West Papua); Yapen Waropen (Papua)
	Cucurbitaceae: *Cucurbita pepo* L [Sukini] Ж (2)		Bantul (Special Region of Yogyakarta)
B. cucurbitae (Coquillett)		CUE	Aceh Besar (Aceh); Pekanbaru (Riau); Batam (Riau Archipelagoes); Karo (North Sumatra); Agam, Paya kumbuh (West Sumatra); Palembang (South Sumatra); Bandar Lampung (Lampung), West Kutai, Samarinda, Tarakan (East Kalimantan); Banjarbaru (South Kalimantan); Depok (Special Capital Territory of Jakarta); Indramayu, Karawang, Subang, West Bandung (West Java); Batang, Demak, Kendal,Pemalang, Sragen, Sukoharjo (Central Java); Bantul, Gunung Kidul, Kulonprogo, Sleman (Special Region of Yogyakarta); Bangkalan, Banyuwangi, Batu, Blitar, Kediri, Magetan, Malang, Mojokerto, Pasuruan, Probolinggo, Surabaya (East Java); Buleleng, Karangasem (Bali); East Lombok, Bima, Sumbawa, Wes Lombok (West Nusa Tenggara); Ende (East Nusa Tenggara); Barru, Maros, Soppeng (South Sulawesi); Banawa (Central Sulawesi); Pohuwato (Gorontalo); Ambon, Namlea (Moluccas); Sorong, Yapen Archipelagoes (West Papua); Yapen Waropen (Papua)
	Cucurbitaceae: *Cucumis melo* L. [Melon] (33)		Bantul, Sleman (Special Region of Yogyakarta); Sragen, Sukoharjo (Central Java); Blitar, Kediri (East Java)
	Cucumis sativus L. [Mentimun] (37)		Bantul, Sleman (Special Region of Yogyakarta); Batu,Blitar, Kediri, Malang,Mojokerto (East Java); Maros (South Sulawesi)
	Cucurbita pepo L. [Sukini] (2)		Bantul (Special Region of Yogyakarta)
	Citrullus lanatus (Thunb.) [Semangka] (6)		Bantul (Special Region of Yogyakarta); Sragen (Central Java); Kediri (East Java)

Table 2. (continued)

Species	Host plant [Indonesian Common Name] (Total Fruit Number)	Lure	Sample Collection Sites
	Luffa cylindrica (L.) Roem. [Belustru] (34)		Bantul, Sleman (Special Region of Yogyakarta); Blitar, Kediri (East Java); Buleleng, Karangasem (Bali); Maros (South Sulawesi)
	Momordica charantia L. [Parea] (77)		Bantul (Special Region of Yogyakarta); Blitar, Kediri (East Java); Maros(South Sulawesi)
B. emittens (Walker)	UHP	CUE	Maros (South Sulawesi); West Lombok (West Nusa Tenggara)
B. exornata (Hering)	UHP	CUE	Soppeng (South Sulawesi)
B. heinrichi (Hering)	UHP	CUE	Kulonprogo (Special Region of Yogyakarta); Batu (East Java)
B. persignata (Hering)	UHP	CUE	Bantul (Special Region of Yogyakarta); Soppeng (South Sulawesi); Pohuwato (Gorontalo); West Lombok (West Nusa Tenggara); Ende (East Nusa Tenggara)
B. pseudocucurbitae White	UHP	CUE	East Lombok, Sumbawa (West Nusa Tenggara)
B. synnephes (Hendel)		CUE	Bantul, Sleman (Special Region of Yogyakarta); Malang (East Java); Barru, Maros (South Sulawesi); Soppeng (South Sulawesi)
	Cucurbitaceae:		
	Luffa cylindrica (L.) Roem. [Belustru] Ж (34)		Bantul, Sleman (Special Region of Yogyakarta); Barru, Maros (South Sulawesi)
	Momordica charantia L. [Parea] Ж (77)		Barru, Maros (South Sulawesi)
	Cucumis sativus L. [Mentimun] Ж (37)		Bantul, Sleman (Special Region of Yogyakarta); Barru, Maros (South Sulawesi)
B. tau (Walker)		CUE	Aceh Besar (Aceh); Bantul, Sleman (Special Region of Yogyakarta); Buleleng, Karangasem (Bali); Payakumbuh (West Sumatra)
	Passifloraceae:		
	Passiflora edulis Sims [Markisa] (9)		Aceh Besar (Aceh); Solok (West Sumatra)
Subgenus Callantra			
Dacus leongi Drew & Hancock	UHP	CUE	Bantul (Special Region of Yogyakarta)
D. longicornis Wiedermann		CUE	Kutai Timur (East Kalimantan); Bantul, Sleman (Special Region of Yogyakarta); Blitar, Kediri (East Java); Buleleng, Denpasar (Bali), Lombok (West Nusa Tenggara); Maros, Soppeng (South Sulawesi); Banawa (Central Sulawesi); Pohuwato (Gorontalo)
	Cucurbitaceae:		
	Luffa cylindrica (L.) Roem. [Belustru] Ж (34)		Bantul, Sleman (Special Region of Yogyakarta); Blitar, Kediri (East Java); Maros (South Sulawesi)
	Momordica charantia L. [Parea] Ж (77)		Bantul, Sleman (Special Region of Yogyakarta); Blitar, Kediri (East Java); Maros (South Sulawesi)
Other Flies attack on Fruits and Vegetables			
Diptera: Tephritidae: Trypetinae	**Theaceae:**		
Adrama determinata (Walker)	*Camellia sinensis* (L.) Kuntze [Teh] (3)	ULR	Batang (Central Java)

Table 2. (continued)

Species	Host plant [Indonesian Common Name] (Total Fruit Number)	Lure	Sample Collection Sites
Diptera: Muscidae	**Rutaceae:**		
Atherigona orientalis (Schin.)	*Citrus maxima* Merr. [Jeruk pamelo] Ж (5)	ULR	Magetan (East Java)
	Solanaceae:		
	Capsicum annuum L. [Cabai merah] Ж (266)		Banjarbaru (South Kalimantan); Bantul, Sleman (Special Region of Yogyakarta); Kediri, Malang (East Java)
	Solanum melongena L. [Terung] Ж (2)		Malang (East Java)
	Lycopersicon esculentum Mill., nom. cons. [Tomat] Ж (21)		Malang (East Java); Sleman (Special Region of Yogyakarta)
	Anacardiaceae:		
	Mangifera indica L. [Mangga] Ж (66)		Sleman (Special Region of Yogyakarta); Batu (East Java)
	Cucurbitaceae:		
	Luffa cylindrica (L.) Roem. [Belustru] Ж (34)		Sleman (Special Region of Yogyakarta); Kediri (East Java)
	Momordica charantia L. [Parea] Ж (77)		Kediri (East Java)

ψ: Species was collected and shipped by Staff of BPTPH, Indonesian Quarantine, Islamic State Sultan Syarif Kasim Riau University, and University of Papua
Ж: New report regarding the host of fruit fly
CUE: Cue Lure
ME: Methyl Eugenol
UHP: Unknown host plant
ULR: Unknown lure response

charantia L. To control fruit fly, farmers used a para-pheromone, such as Methyl Eugenol, for their crops. Methyl Eugenol has no effect to *Atherigona* and *Dacus*. Kido *et al*. (1996) reported that *A. orientalis* responded to Methyl Eugenol as a non-target fruit fly species but Leblanc *et al*. (2009) gave the new confirmation that *A. orientalis* does not respond to the Methyl Eugenol, but merely attracted to the decaying flies. Suputa *et al.* (2004) reported that *D. longicornis* from Indonesia responded to CUE lure only. Misinterpretation in lure trap with specific fruit fly species was indicated by farmers.

Two species of fruit flies (*A. orientalis* and *B. papaya*) emerged from *Capsicum annuum*; from *Carica papaya* emerged three species of *Bactrocera* i.e. *B. calumniata, B. carambolae,* and *B. papayae*; from *Citrus maxima* emerged two species of fruit fly i.e. *A. orientalis* and *B. papaya*; from *Cucumis sativus* have emerged three species of *Bactrocera* i.e. *B. calumniata, B. cucurbitae,* and *B. synnephes*; from *Cucurbita pepo* emerged two species of *Bactrocera* i.e. *B. caudata* and *B. cucurbitae*; from *Inocarpus fagifer* emerged three species of *Bactrocera* i.e. *B. albistrigata, B. limbifera,* and *B. moluccensis*; from *L. cylindrica* emerged five species of fruit fly within three genus i.e. *A. orientalis, B. calumniata, B. cucurbitae, B. synnephes,* and *D. longicornis*; from *Mangifera indica* emerged three species of fruit fly i.e. *A. orientalis, B. carambolae,* and *B. papayae*; from *M. charantia* emerged five species of fruit fly within three genus i.e *A. orientalis, B. calumniata, B. cucurbitae, B. synnephes,* and *D. longicornis*; from *Syzygium jambos* emerged two species of *Bactrocera* i.e. *B. albistrigata* and *B. carambolae*; and from *Terminalia catappa* emerged three species of *Bactrocera* i.e. *B. albistrigata, B. limbifera,* and *B. papayae*. In Malang, East Java, from *C. papaya* emerged three species of *Bactrocera* i.e. *B.*

albistrigata, B. carambolae, B. papayae, and from *Solanum muricatum* emerged only one species of *Bactrocera* i.e. *B. papayae* (Toto Himawan, UB Malang, personal communication).

All fruit fly species were oligophagous except *B. papayae*, *B. carambolae*, *B. albistrigata*, *B. calumniata*, and *B. limbifera* which were polyphagous. There are 28 fruit fly hosts reported as new in this study. *B. papayae* is a serious polyphagous species and the most important pest infesting commercial crops. It was also the common fruit fly found in Methyl Eugenol lure traps, followed by *B. carambolae, B. albistrigata*, and *B. calumniata* were also polyphagous and infested commercial crops. They were the common fruit fly found in CUE lure traps. *B. limbifera* was a polyphagous and responded to cue lure but this species is not an important pest. Beside *Bactrocera* spp., *A. orientalis* was also a serious pest to commercial crops. It attacked citrus, chili, mango, and bitter gourd. Some new recorded hosts were autochthonous in Indonesia, such as *P. macrocarpa* and *Stelechocarpus burahol*. The record of *B. papayae* from *P. macrocarpa* was intriguing, since *P. macrocarpa* is known as toxic to animals, including insects. Suatma et al. (2008) reported that the extract *P. macrocarpa* was embryotoxic and fetotoxic.

B. calumniata was reared from Cucurbitaceae fruit samples from Java. It appeared that *B. calumniata*, fruit fly known to have strict preference on cucurbits fruit, was able to out-compete *B. cucurbitae*, *B. synnephes*, and *D. longicornis* on cucurbits fruit in Java. The record of *B. calumniata* from *C. papaya* is also an anomalous record requiring confirmation; *C. papaya* does not belong to Cucurbitaceae.

Combining data from host rearing and lure traps, 44 species of fruit flies were reported existed in Indonesia (Table 1). However, not all the fruit fly species were recorded from the host plant. The fruit collections were mainly made from the sites easily accessible to vehicles. Additional survey to document fruit fly host associations would be useful particularly from remote areas in Indonesia archipelago, where introduced plants are less abundant.

This study suggests that the number plant species serving as hosts for fruit flies in Indonesian Islands is larger than that was reported in this work because of limitation in the number of selected habitats. The findings also show that some fruit fly species i.e. *Adrama determinata, Atherigona orientalis, B. albistrigata, B. calumniata, B. carambolae, B. cucurbitae, B. latifrons, B. papaya, B. synnephes, B. tau, B. umbrosa,* and *D. longicornis* present in Indonesia are of economic importance on certain crops. This emphasizes the need for effective quarantine measures that exclude exotic fruit fly pests and thereby protect potential markets of high value fruits and vegetable exports.

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