Journal of Fundamental and Applied Sciences

ISSN 1112-9867

Available online at http://www.jfas.info

Research Article

Special Issue

INFESTATION OF FRUIT FLY, *BACTROCERA* (DIPTERA: TEPHRITIDAE) ON MANGO (*MANGIFERA INDICA* L.) IN PENINSULAR MALAYSIA

M. Salmah[1,2,*], N.A. Adam[2], R. Muhamad[2], W. H. Lau[2] and H. Ahmad[3]

[1]School of Agriculture Science and Biotechnology, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, 22200 Besut, Terengganu, Malaysia

[2]Department of Plant Protection, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

[3]School of Biological Science, Universiti Sains Malaysia, 11800 Penang, Malaysia

Published online: 08 August 2017

ABSTRACT

A survey was carried out in mango orchards in Peninsular Malaysia with aimed to determine the infestation levels of fruit fly *Bactrocera* (Diptera: Tephritidae) on mango (*Mangifera indica* L.) through damaged fruit collection. Two fruit fly species emerged from the collected fruits: *Bactrocera dorsalis* (Hendel) and *Bactrocera carambolae* (Drew & Hancock). *Bactrocera dorsalis* was recorded the most abundant species (91%) compared to *B. carambolae* (9%). The highest fruit infestation was observed in Bumbong Lima (93.49±2.25 pupae/kg), followed by Bukit Changgang (36.08±8.35 pupae/kg) and Pulau Gadong (26.78 ±4.86 pupae/kg) whilst Jitra showed the lowest fruit infestation (10.79±3.34 pupae/kg).

Keywords: *Bactrocera*; infestation; mango.

Author Correspondence, e-mail: salmahmohamed@unisza.edu.my

doi: http://dx.doi.org/10.4314/jfas.v9i2s.49

1. INTRODUCTION

Many species of the fruit flies of economic importance in tropics and subtropics region are in the genus *Bactrocera* [9]. This includes certain members in *B. dorsalis* complex that are the most widely distributed and problematic pest of horticulture crops in Southeast Asia mainly in Malaysia, Indonesia and Thailand. A Carambola fruit fly, *Bactrocera carambolae* (Drew & Hancock) and an Oriental fruit fly, *Bactrocera dorsalis* (Hendel) are considered the most virulent and serious fruit fly species on various commercial fruits such as mango (*Mangifera indica* L.) [5]. Both species are endemic in Malaysia [27] and previously has been identified as Dacus Malaysian A and Dacus Malaysian B [7] or *B. dorsalis A* and *B. dorsalis B* [32]. Later on, they were referred as Carambola fruit fly, *B. carambolae* and Asian Papaya fruit fly, *B. papayae* (Drew & Hancock) respectively [8]. However, due to synonymization of morphological, molecular, cytogenetic, behavioural and chemo ecological data of *B. dorsalis* and its related siblings i.e *B. papayae*, invasive fruit fly, *B. invadens* (Drew, Tsuruta & White) and Philippine fruit fly, *B. philippinensis* (Drew & Hancock), they were considered as the same biological species as *B. dorsalis* but exception on *B. carambolae* as distinct species [26]. *Bactrocera* females lay eggs by inserting them beneath the skin of mature and ripening mango in clusters but a small number can also oviposit into unripe fruit [25]. Female of *B. dorsalis* usually lays eggs ranging from 10-50 eggs per cluster [22]. In 1 to 2 days, the eggs hatched and the larvae (the whitish maggots) feed on the fruit flesh and contaminating it with frass and providing entry for fungi and bacteria. As a result, the fruits become soft, watery and rot and this caused fruit to damage and drop on the ground prior to harvest. Without proper control, direct damage can lead to yield loss between 90-100% depending on the fruit fly population, season, host variety and location [16]. For instance, in [31] reported that losses due to fruit flies ranged from 17% to 73% for mango in West Africa, whilst [19] reported that 30-80% of mango losses in Nguruman, Kenya. Their occurrence has resulted in strict fruit quarantine and export prohibitions for countries known to contain those flies.

Based on the serious damage caused by fruit flies, it is very crucial to determine the infestation level in field as it is one aspect of fundamental importance in the management of fruit flies. Therefore, this study was aimed to identify species of fruit flies infesting mango

and to determine the infestation levels of fruit flies on mango in different locations of Peninsular Malaysia.

2. MATERIALS AND METHODS

2.1. Sampling Sites

The sampling was conducted in four mango orchards; Jitra, Kedah (6°19'24.64"N 100°25'04.10"E), Bumbong Lima, Kepala Batas, Penang (5°33'23.57"N 100°26'45.80"E), Bukit Changgang, Banting, Selangor (2°50'51.85"N 101°37'34.03"E) and Pulau Gadong, Melaka (2°13'29.3"N 102°12'23.2"E), respectively. Jitra and Bumbong Lima are located in the northern region of Peninsular Malaysia whilst Bukit Changgang and Pulau Gadong are located in the central and southern region of Peninsular Malaysia respectively. These locations were selected because they represent the major cultivated mango crops grown in Peninsular Malaysia. Jitra orchard is a private commercial orchard and had a total area of 100 ha of tropical fruit crops such as limes, guavas, sapodillas, papayas, jackfruits and star fruits. About 5 ha is covered with 1200 of mango trees. Bumbong Lima mango orchard is surrounded by paddy fields and cultivated with 276 Chokanan mango trees in one hectare area. Bukit Changgang and Pulau Gadong mango orchards are bordered with oil palm plantations and vegetable farms. In one hectare of Bukit Changgang and Pulau Gadong orchard, 200 and 252 of Chokanan mango trees were planted, respectively.

2.2. Management Control Practices of Fruit Fly

The fruit fly management control practices were different in all locations. For example, Jitra mango orchard is a totally organic orchard where no synthetic chemical fertilizers and pesticides were applied in the orchard. Only mechanical weeding was done at the end of the fruiting season. Similarly, in Bumbong Lima orchard, no agronomic treatments were also applied except the mechanical weeding and herbicides treatment was sprayed every month. Bukit Changgang and Pulau Gadong mango orchard were regularly treated with synthetic pesticides and fertilizers. No fruit bagging was applied in all orchards.

2.3. Host Fruit

Those four orchards were planted with six to seven-year old mango cv. Chokanan (MA224). Chokanan is a local sweet variety mango and the most highly demanded variety by the local. It is also widely planted in Malaysia [6].

2.4. Time of Sampling

The sampling of damaged fruits was done between April and June in 2014, which at this period the fruits were abundantly available for sampling and development of fruit flies. In Malaysia, the peak mango fruiting season for Chokanan variety is between April to June for every year [6].

2.5. Damaged Fruit Collection

Damaged mango fruit samples were collected once every month during the mango fruiting seasons. For each location, 20 mango trees in one hectare plot were randomly selected and 2 fruits per tree were collected (i.e. 40 fruits/location/visit) to obtain adequate number of fruit flies for identification. The fruits were considered damaged when fruit flies oviposition punctures or signs of larval infestation were visible.

Fruit samples were transported to the laboratory where they were individually weighed and counted, categorized by sampling date and sample site. The fruits were placed in groups of 6-10 depending on fruit and plastic container size with screened tight fitting net lid to avoid from *Drosophila* flies from entering the containers. About 2 cm height of moistened and sterilized fine vermiculite was layered at the bottom of the containers as pupation media. Vermiculite was sterilized at 120^{o}C at 2 hours and then cooled at room temperature before being used. Fine vermiculite was used for easy pupal sieving and sorting.

The containers were then transported to the insectary for incubation under ambient conditions of 28 ± 2^{o}C, 60-70% RH, 12:12 h L:D, which are suitable conditions to prevent pupal water loss and minimize development of mould [10]. The incubation ranges for about 14 to 21 days in order to allow all *Bactrocera* larvae in fruits to drop into vermiculite and pupate. Any left larvae inside the fruits were collected manually by dissecting the fruits and using fine forceps to collect larvae and placed into containers. After the incubation period, the vermiculite was

sieved and the recovered fly puparia were calculated and transferred in groups of 100 pupae into small plastic cups layered with moistened tissue paper.

The plastic cups containing fly pupae were transferred to a small adult rearing cage (20x20x20 cm) until the emergence of adult flies. Inside the cage, the newly emerged adult flies were fed with water (soaked in cotton wool), sugar cubes (in Petri dish) which were placed on the cage floor. They were left in the cage for 3-4 days until the adult reached the full development of morphological characteristics. Emerged adults were recorded and fully grown adults were placed in specimen screw cap vials containing 70% ethanol for preservation and later identification.

2.6. Fruit Fly Identification

The fruit flies were examined morphologically under Meiji Techno RZ stereo microscope (Meiji Techno, Japan). The emerged adult fruit flies species were identified based on DORSALIS LUCID v3.3 software [17, 8].

2.7. Data Collection

Data on total fruit weight, total of pupae recovered, total flies emerged and number of different species of fruit flies obtained were recorded and labeled accordingly to each plot sampled. Infestation rate was recorded as the total number of pupae recovered per total of weight (kg) fruits collected from each sampling plot.

2.8. Data Analysis

Data on total fruit weight, total of pupae recovered, total flies emerged, number of different species of fruit flies obtained and infestation rate were subjected to One-way Analysis of Variance (ANOVA). Means were separated with Tukey's Range (HSD) Test at 0.05 level of significance. All data analyses were performed using MINITAB®17 software [21].

3. RESULTS AND DISCUSSION

3.1 Species of Fruit Fly and Their Abundance

Table 1 shows the total of mango fruits sampled, total fruit weight, total pupae recovered and adult flies emerged at different mango orchards. A total of 480 mango fruits (120.48 kg) were collected from four mango orchards. There was no significant difference ($F = 7.97$; $df = 3$; $P >$

0.05) of total fruit weight samples was recorded among locations. In total, about 5229 fly pupae were recovered with the average of 10.9 pupae per fruit. The percentage number of pupae recovered from Pulau Gadong, Bukit Changgang, Bumbong Lima and Jitra were 16.41%, 20.12%, 57.93% and 5.55%, respectively. About 97.88% of fruit fly pupae were successfully emerged as fruit fly adults, whereas the rest pupae were failed to emerge as fruit fly adults. Significantly, more pupae recovered and adult flies emerged from Bumbong Lima fruit samples ($P < 0.05$) compared to fruit samples from Pulau Gadong and Jitra. However, no significant difference ($P > 0.05$) of pupae recovered and adult flies emerged were observed between fruit samples from Bumbong Lima and Bukit Changgang. The lowest pupae and adult flies emerged recorded were from Jitra fruit samples at 290±13.54 pupae and 284±12.99 adults respectively.

Table 1. Total of mango fruits sampled, total fruit weight, total pupae recovered and adult flies emerged at different mango orchards

Location	Fruit Sampled	Total Fruit Weight (kg)	Total Pupae Recovered	Adult Flies Emerged
Pulau Gadong	120	32.04±6.52a	858±16.82a	835±14.24a
Bukit Changgang	120	29.16±0.26 a	1052±32.68ab	1012±31.97ab
Bumbong Lima	120	32.40±0.31a	3029±122.61b	2987±116.15b
Jitra	120	26.88±0.25a	290±13.54a	284±12.99a

Means with the same letters in different rows are not significantly different ($P > 0.05$) by Tukey's (HSD) test.

Two species of fruit fly were identified from damaged mango fruit samples collection: *Bactrocera dorsalis* (Hendel) and *Bactrocera carambolae* (Drew & Hancock). Among them, *Bactrocera dorsalis* was the most abundant species and accounted for 91.1% of total emerged adults compared to *B. carambolae* which only recorded 8.9% of total adults. Table 2 displays the mean number of different species of fruit flies recovered from damaged fruits collection at different locations. Overall, there was a significant difference ($F = 172.74$; $df = 3$; $P < 0.05$) observed among the numbers of *B. dorsalis* in all locations but no significant difference ($P > 0.05$) was observed among *B. dorsalis* numbers between Pulau Gadong and Bukit Changgang.

The numbers of *B. dorsalis* was significantly ($P < 0.05$) the highest in Bumbong Lima whilst Jitra recorded the lowest number of *B. dorsalis*. In contrast, no significant difference ($F = 1.98$; $df = 3$; $P > 0.05$) was observed among the number of *B. carambolae* in all locations although the number of *B. carambolae* was recorded higher in Bumbong Lima compared to other locations.

Table 2. Mean number of different species of fruit flies recovered from damaged fruits collection at different locations

Location	Fruit Fly Species	
	B. dorsalis	***B. carambolae***
Pulau Gadong	247.7±37.1a	30.7±8.1a
Bukit Changgang	310.3 ±11.2a	27.0±8.3a
Bumbong Lima	916.0 ±39.4b	79.7±38.8a
Jitra	80.3 ±5.2c	14.3±4.3a

Means with the same letters in different rows are not significantly different ($P > 0.05$) by Tukey's (HSD) test.

This findings showed that among the two species of fruit flies identified, *B. dorsalis* was recorded as dominant species that emerged from the incubated damaged fruits. This shows that *B. dorsalis* is a major fruit fly pest of mango in Peninsular Malaysia. *Bactrocera dorsalis* was classified as highly polyphagous species and are prevalent in peninsular Thailand and Malaysia and polyphagous status has been confirmed by the total number of hosts from which they were reared [4, 8]. The aggressiveness of *B. dorsalis* infested mango indicated that this species is predominance on Chokanan mango fruit. The dominancy of *B. dorsalis* over other *Bactrocera* species were also recorded in mango orchard in China [18], coffee orchard in Central Aceh [33] and wax apple orchard in North Sumatera [15]. Similarly, in [2] found that only *B. invadens* species emerged from mangoes collected from field showing that the species was predominance species while [11] recorded that 88% of fruit flies adults emerged from reared mangoes were dominance by *B. invadens*. In contrast, in [14] reported that *B. carambolae* is a predominance species infesting on starfruit compared to *B. dorsalis* in Selangor. According to [11], predominance by certain species in the same host attacked most

likely due to the food source competition by larvae in the same fruit and the aggressive behaviour of adult fly that do not allow different species of females to oviposit eggs in the same fruits.

3.2. Infestation Rate of Fruit Flies

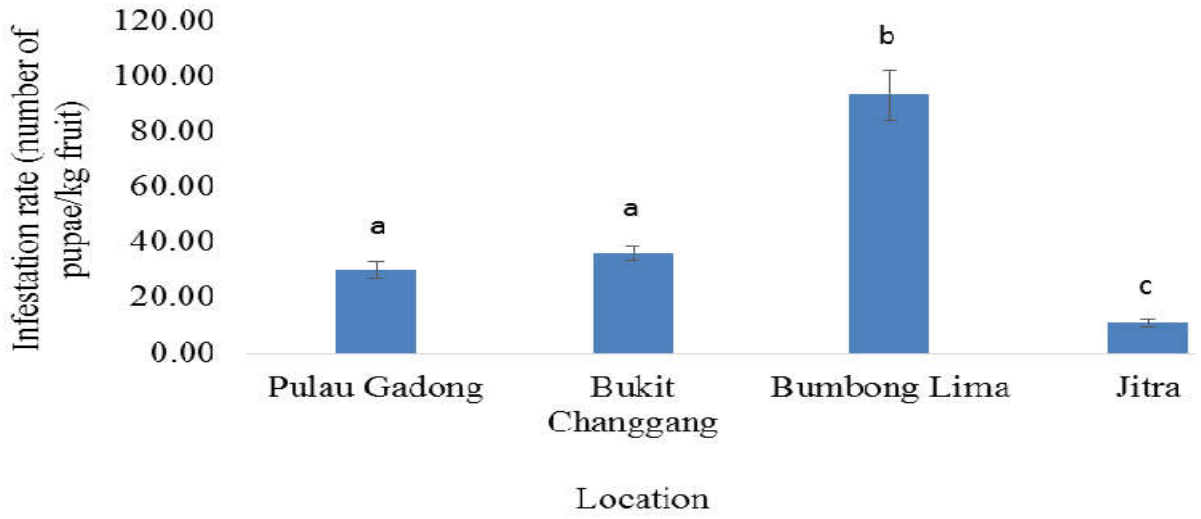

Fig.1. Infestation rate of fruit flies in four mango orchards**.** Means with the same letters in different bars are not significantly different (P > 0.05) by Tukey's (HSD) test

Fig. 1 shows the infestation rate of fruit flies obtained from four different mango orchards. There was a significant difference (F = 38.58; df = 3; P < 0.05) of infestation rates among mango orchards. Fruit infestation of Bumbong Lima was significantly different (P < 0.05) with Pulau Gadong, Bukit Changgang and Jitra. Whereas, a significant difference (P < 005) was recorded between Jitra and other orchards. However, no significant difference (P > 0.05) of fruit infestation was observed between Pulau Gadong and Bukit Changgang. Hence, the highest fruit infestation rates were recorded in Bumbong Lima (93.09±9.00 pupae/kg), followed by Bukit Changgang (35.95±2.37 pupae/kg) and Pulau Gadong (30.09±3.16 pupae/kg) whilst Jitra showed the lowest infestation rate (10.74±1.25 pupae/kg).

The highest fruit infestation recorded in Bumbong Lima most probably because of the fallen damaged fruits were not removed and destroyed. The fallen fruits exposed on the ground attract females of fruit flies to oviposit eggs and increase the flies' population in the orchard. In addition, it was observed that no other control methods such as fruit bagging, pheromone traps and protein bait had been applied. Since the orchard is not a commercial orchard, therefore the yield and control management of fruit flies was not in the high priority. In

Integrated Pest Management (IPM) program practices, good field sanitation can reduce and control the population of fruit flies effectively [3, 16]. Field sanitation by removing and destroying of fallen and damaged fruits prevents further fruit flies infestation. For example, in [23] reported that about 40-60% reduction of fruit flies population recorded in North-Western Himalayan, India when they installed 25 lure attractant traps in one hectare plot along with bait application and orchard sanitation. Studied by [24] indicated that foliar applications of GF-120 NF Naturalyte Fruit Fly Bait in combination with good sanitation can effectively reduce infestation by *B. dorsalis* in papaya orchards in Hawaii.

Results showed that the infestation rate of *Bactrocera* was recorded the lowest in Jitra compared with other mango orchards. Through serious observation, there was a huge number of weaver ants (*Oecophylla* sp.) present in the study plot. Previous studies suggest that *Oecopylla* ant is an effective predator and significantly can reduced the fruit fly infestation on mango in the field [29]. It was confirmed that the number of eggs laid by fruit flies *B. dorsalis* and *Ceractitis cosyra* on mango were reduced up to 75% and 50% respectively when the weaver ants presence [20]. According to [1], fruit flies spent less time on ant-colonized mango trees compared on ant-free mango trees because they emit chemical signals (i.e pheromones) that can repel female of fruit flies from approaching the mango fruits and also the pheromones significantly affected the oviposition behavior of fruit flies.

Meanwhile, similar infestation rates in Pulau Gadong and Bukit Changgang was recorded due to both orchards were regularly sprayed with synthetic chemical pesticides to control fruit flies. The repeated spraying of pesticides to the field can kill the adult flies which reducing significantly the attack and infestation of fruits [13]. Most farmers practice this method due to its great outcomes. However, pesticides may contaminates the fruit to negatively affect the consumers' health as well as kills non-target insects including the natural enemies particularly parasitoids and predators. In [12, 30] agreed that cultivated mango crop that use synthetic pesticides regularly and human interference may contribute unfavourable conditions that negatively impact the parasitoids population. The use of synthetic pesticides may negatively affect beneficial organisms, such as parasitoids, predators and pollinators in field [28]. Therefore, it is very important to use biopesticides together with other environmental-friendly

control methods to supress fruit flies population and at the same time the population of natural enemies can be conserve and sustain in field.

4. CONCLUSION

In conclusion, this study showed that *B. dorsalis* is the predominance species on mango specifically on Chokanan variety. The infestation rate was found to be diverse in mango orchards due to the different of fruit fly control practices. Without proper fruit flies integrated control, the level of fruit fly infestation was recorded high such as in Bumbong Lima mango orchard. Whilst, organic mango cultivation such as in Jitra showed better controlled of fruit fly populations due to the presence of high populations of weaver ant as a natural predator against fruit flies. Nonetheless, the level of fruit flies infestation was recorded low in Bukit Changgang and Pulau Gadong most probably due to gradually used of synthetic pesticides in both mango orchards.

5. ACKNOWLEDGEMENTS

The authors would like to thank the Ministry of Education of Malaysia (MOE) for the financial grant (FRGS: 07-01-12-1123FR) during this study. Thanks are also extended to the mango orchards' owner for their permission, assistance and cooperation in fruit sample collection.

6. REFERENCES

[1] Adandonon A, Vayssières J F, Sinzogan A, Van Mele P. Density of pheromone sources of the weaver ant Oecophylla longinoda affects oviposition behaviour and damage by mango fruit flies (Diptera: Tephritidae). International Journal of Pest Management, 2009, 55(4):285-292

[2] Ambele F C, Billah M K, Afreh-Nuamah K, Obeng-Ofori D. Susceptibility of four mango varieties to the Africa Invader fly, Bactrocera invadens Drew, Tsuruta and White (Diptera: Tephritidae) in Ghana. Journal of Applied Biosciences, 2012, 49:3425-3434

[3] Badri I., Osman M. S., Salleh M. M. Serangga perosak buahan-buahan tropika Malaysia.

Kuala Lumpur: Institut Penyelidikan dan Kemajuan Pertanian Malaysia (MARDI), 2008

[4] Clarke A R, Allwood A, Chinajariyawong A, Drew R A, Hengsawad C, Jirasurat M, Krong C K, Kritsaneepaiboon S, Vijaysegaran S. Seasonal abundance and host use patterns of seven Bactrocera Macquart species (Diptera: Tephritidae) in Thailand and Peninsular Malaysia. Raffles Bulletin of Zoology, 2001, 49(2):207-220

[5] Clarke A R, Armstrong K F, Carmichael A E, Milne J R, Raghu S, Roderick G K, Yeates D K. Invasive phytophagous pests arising through a recent tropical evolutionary radiation: The Bactrocera dorsalis complex of fruit flies. Annual Review of Entomology, 2005, 50:293-319

[6] Department of Agriculture (DOA). Pakej teknologi mangga. Putrajaya: Ministry of Agriculture and Agro-Based Industry Malaysia, 2009

[7] Drew R A I. Taxonomic studies on oriental fruit fly. In 1st International Symposium on Fruit Flies in the Tropics, 1991, pp. 63-66

[8] Drew R A, Hancock D L. The Bactrocera dorsalis complex of fruit flies (Diptera: Tephritidae: Dacinae) in Asia. Bulletin of Entomological Research Supplement Series, 1994, 2:1-68

[9] Drew R A I, Rodgers D J, Vijaysegaran S, Moore C J. Mating activity of *Bactrocera cacuminata* (Hering) (Diptera: Tephritidae) on its larval host plants *Solanum muaritianum* Scopoli in southeast Queensland. Bulletin of Entomological Research, 2008, 98(1):77-81

[10] Ekesi S, Mohamed S A. Mass rearing and quality control parameters for tephritid fruit flies of economic importance in Africa. In I. Akyar (Ed.), Wide spectra of quality control. Rijeka: InTech Publishing, 2011, pp. 387-410

[11] Ekesi S, Billah M K, Nderitu P W, Lux S A, Rwomushana I. Evidence for competitive displacement of Ceratitis cosyra by the invasive fruit fly Bactrocera invadens (Diptera: Tephritidae) on mango and mechanisms contributing to the displacement. Journal of Economic Entomology, 2009, 102(3):981-991

[12] Hernández-Ortiz V, Delfín-González H, Escalante-Tio A, Manrique-Saide P. Hymenopteran parasitoids of Anastrepha fruit flies (Diptera: Tephritidae) reared from different hosts in Yucatan, Mexico. Florida entomologist, 2006, 89(4):508-515

[13] Juma S A. *Bactrocera* fly infestation on starfruit, *Averrhoa carambola* L. in Selangor,

Malaysia and its parasitoids. Master thesis, Selangor: Universiti Putra Malaysia, 2015

[14] Juma S, Rita M, Nur Azura A, Alvin K W H, Manjeri G. Occurrence of tephritid fruit flies with intermediate morphologies of Bactrocera carambolae and B. papayae (Diptera: Tephritidae) in Selangor, Peninsular Malaysia. Australian Journal of Basic and Applied Sciences, 2014, 8(17):609-616

[15] Kartika A P, Tati S S. Fruit fly infestation on wax apple (*Syzygium samarangense*) at North Sumatera, Indonesia. In 1st Symposium of Tephritid Workers of Asia, Australia and Oceania, 2016, pp. 93

[16] Kumar P, Abu B, Alma L, Ketelaar J W, Vijaysegaran S. Field exercise guides on fruit flies integrated pest management-For farmer's field schools and training of trainers: Area-wide integrated pest management of fruit flies in south and Southeast Asia. Bangkok: Asian Fruit Fly IPM Project, 2011

[17] Lawson A. E., McGuire D. J., Yeates D. K., Drew R. A. I., Clarke A. R. Dorsalis: An interactive identification tool for fruit flies of the Bactrocera dorsalis complex. Brisbane: Griffith University, 2003

[18] Li Z. On the way: A review on the prevention and control of fruit flies of economic importance in China. In 1st Symposium of Tephritid Workers of Asia, Australia and Oceania, 2016, pp. 31

[19] Lux S A, Overholt W A, Kimani S. Economic role and distribution of fruit flies: ICIPE annual scientific report (1995-1998). Nairobi, ICIPE Press, 1998

[20] Migani V, Ekesi S, Merkel K, Hoffmeister T. At lunch with a killer: The effect of weaver ants on host-parasitoid interactions on mango. Plos One, 2017, 12(2):1-19

[21] MINITAB®17. Statistical software. Sydney: Minitab Pty Ltd., 2017

[22] Mohd N M A Z, Nur A A, Muhamad R. Growth and development of *Bactrocera papayae* (Drew & Hancock) feeding on guava fruits. Australian Journal of Basic and Applied Sciences, 2011, 5(8):111-117

[23] Prabhakar C S, Sood P, Mehta P K. Fruit fly (Diptera: Tephritidae) diversity in cucurbit fields and surrounding forest areas of Himachal Pradesh, a North-Western Himalayan state of India. Archives of Phytopathology and Plant Protection, 2012, 45(10):1210-1217

[24] Piñero J C, Mau R F L, Vargas R I. Managing oriental fruit fly (Diptera: Tephritidae), with spinosad-based protein bait sprays and sanitation in papaya orchards in Hawaii. Journal of Economic Entomology, 2009, 102(3):1123-1132

[25] Rattanapun W. Mango varietal preference and the effect of physiological changes during mango ripening on host utilisation by *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae). PhD thesis, Bangkok: Kasetsart University, 2009

[26] Schutze M K, Aketarawong N, Amornsak W, Armstrong K F, Augustinos A A, Barr N, Bo W, Bourtzis K, Boykin L M, Caceres C, Cameron S L. 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 chemoecological data. Systematic Entomology, 2015, 40(2):456-471

[27] Tan Y L. Identification of *Bactrocera* genus (Diptera: Tephritidae) via molecular marker. Master thesis, Selangor: Malaysia University of Science and Technology, 2004

[28] Tello V, Díaz L, Sánchez M. Side effects of the natural pesticide Spinosad (GF-120 Formulation) on Eretmocerus paulistus (Hymenoptera: Aphelinidae), a parasitoid of the whitefly Aleurothrixus floccosus (Hemiptera: Aleyrodidae), under laboratory conditions. Ciencia e Investigación Agrarian, 2013, 40(2):407-417

[29] Van Mele P, Vayssières J F, Van Tellingen E, Vrolijks J. Effects of an African weaver ant, Oecophylla longinoda, in controlling mango fruit flies (Diptera: Tephritidae) in Benin. Journal of Economic Entomology, 2007, 100(3):695-701

[30] Vayssières J F, Adandonon A, N'Diaye O, Sinzogan A, Kooymann C, Badji K, Rey J Y, Wharton R A. Native parasitoids associated with fruit flies (Diptera: Tephritidae) in cultivated and wild fruit crops in Casamance, Senegal. African Entomology, 2012, 20(2):308-315

[31] Vayssières J F, Korie S, Ayegnon D. Correlation of fruit fly (Diptera Tephritidae) infestation of major mango cultivars in Borgou (Benin) with abiotic and biotic factors and assessment of damage. Crop Protection, 2009, 28(6):477-488

[32] White I. M., Elson-Harris M. Fruit flies of economic significance: Their identification and bionomics. Oxford: Centre for Agriculture and Biosciences International, 1992

[33] Zulida S, Tati S S. Fruit fly diversity and its parasitoid in coffee orchard at

Takengon-Central Aceh, Indonesia. In 1st Symposium of Tephritid Workers of Asia, Australia and Oceania, 2016, pp. 87

How to cite this article:
Salmah M, Adam NA, Muhamad R, Lau WH, Ahmad H. Infestation of fruit fly, *Bactrocera* (Diptera: Tephritidae) on mango (*Mangifera indica* L.) in Peninsular Malaysia. J. Fundam. Appl. Sci., 2017, 9(2S), *799-812*.