



**UNIVERSITI PUTRA MALAYSIA**

***BACTROCERA FLY INFESTATION ON STARFRUIT, AVERRHOA  
CARAMBOLA L. IN SELANGOR, MALAYSIA AND ITS PARASITOIDS***

**SALIM ALI JUMA**

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By

**SALIM ALI JUMA**

**Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in the fulfillment of the requirements for the Degree of Master of Science**

**February 2015**

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## DEDICATION

*To my beloved parents, my late father Ali and my late mother Saada. My Lord (Rabbi), forgive them and have mercy upon them as they brought me up (when I was) small. To my lovely wife Amina, my wonderful son Adil and my daughters Khdija, Hajra and Asma for their support and patience during my study in Malaysia.*



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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**February 2015**

**Chairperson: Professor Rita Muhamad Awang, PhD**

**Faculty: Agriculture**

Tephritid fruit flies, *Bactrocera carambolae* (Drew and Hancock), and *B. papayae* (Drew and Hancock), belong to the *Bactrocera dorsalis* complex are key pests of valuable fruits in Southeast Asia. Control of these pests is often limited by difficulties in their identification that have been increasing due to recent occurrences of species with morphological characteristics of both *B. carambolae* and *B. papayae* (hereafter known as intermediates). Opiinae parasitoids (Hymenoptera: Braconidae) are the important biological control agents of fruit flies in IPM. Therefore, a study was conducted to investigate the occurrence of intermediates and its proportion from their parental stocks based on field collection of flies infested starfruits, *Averrhoa carambola* L. and methyl eugenol-baited traps in three locations. In addition, field infestation of *Bactrocera* fruit flies and the associated Opiinae parasitism was assessed using infested fruits. Moreover, population fluctuation of *Bactrocera* fruit flies was studied using methyl eugenol trapping in UPM and Semenyih. A total of 7,144 fruit flies composed of *B. carambolae* (59%), *B. papayae* (16%) and intermediates (25%) were collected from 240 infested fruits. From set traps, 12,522 male flies of *B. carambolae* (21%), *B. papayae* (16%) and intermediates (63%) were collected. Nearly, all collected fruits were infested by *Bactrocera* fruit flies and the mean number of pupae per fruit respectively from UPM, DOA and Semenyih were 49, 47 and 28. However, per weight (g) of fruit the infestation was 0.65, 0.88 and 0.45. Similarly, the mean number of adult fruit flies per fruit was 34, 39 and 16 respectively. Opiinae parasitoids of four species; *Fopius arisanus* Sonum, *Diachasmimorpha longicaudata* Ashmead, *Psytalia fletcheri* Silvesteri and *Psytalia incisi* Silvesteri were identified and the percentage of parasitism were in the order of Semenyih > UPM > DOA at values of 33%, 24% and 9% respectively. The contribution of *F. arisanus* was more than 70% of total parasitoids while of others was nearly similar. The population of *B. carambolae* was significantly higher ( $P < 0.05$ ) in UPM while *B. papayae* was significantly higher ( $P < 0.05$ ) in Semenyih. The population of intermediates was not significantly different ( $P > 0.05$ ) between the locations similar to that of total flies. Among sampling months, populations showed nearly similar fluctuation trends with peak in October, December and January in

UPM. However, in Semenyih steady population throughout the year was observed with fluctuation for some fly species. The population of fruit flies in UPM was highly correlated with rainfall season though; *B. papayae* was also correlated with temperature. In Semenyih, populations of intermediates and total flies were correlated with relative humidity. Similarly, the stepwise regression analysis result from UPM showed that rainfall contributes significantly on population variations of fruit flies, except for *B. papayae*. In Semenyih, only relative humidity contributed significantly to population variations of intermediates ( $R^2 = 0.49$ ) and total fruit flies ( $R^2 = -0.37$ ). For the population dispersion, values of various indices and regression models in all sampling months for examined species indicated aggregated distribution except for few cases in Semenyih. The results suggest the existence of intermediate species of damaging *B. dorsalis* species and their parasitoids in studied areas. The relatively difference among locations in flies infestation and Opiinae parasitism is mostly related to orchard management and host conditions. However, population of fruit flies is highly influenced by weather condition.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**INFESTASI LALAT BUAH *BACTROCERA* KE ATAS BUAH BELIMBING  
BESI *AVERRHOA CARAMBOLA* L. DI SELANGOR, SEMENANJUNG  
MALAYSIA DAN PARASITOIDS**

Oleh

**SALIM ALI JUMA**

**Februari 2015**

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**Fakulti: Pertanian**

Tephritid lalat buah, *Bactrocera carambolae* (Drew dan Hancock) dan *Bactrocera papayae* (Drew dan Hancock) yang tergolong dalam *Bactrocera dorsalis* kompleks merupakan perosak utama buah-buahan penting di Asia Tenggara. Kawalan terhadap perosak tersebut biasanya terhad oleh kesulitan terhadap pengidentifikasian perosak tersebut yang meningkat disebabkan oleh kehadiran spesies terbaru dengan ciri morfologikal kedua-dua *B. carambolae* dan *B. papayae* (selepas ini dirujuk sebagai perantara). Opiinae parasitoids (Hymenoptera: Braconidae) merupakan agen kawalan biologi penting lalat buah *Bactrocera* dalam IPM. Oleh sebab itu, satu kajian dijalankan untuk menyelidik kewujudan perantara dan perkadaran daripada stok induknya dan kemudian menilai infestasi lapangan lalat buah *Bactrocera* dan parasitisme Opiinae yang berkaitan berdasarkan pengumpulan lapangan lalat buah belimbing besi yang telah diserang, iaitu *Averrhoa carambola* L. dan dengan menggunakan perangkap methyl eugenol di Universiti Putra Malaysia (UPM), Jabatan Pertanian (DOA) Serdang dan Semenyih. Di samping itu, turun naik populasi lalat buah *Bactrocera* telah dikaji dari Disember 2012 hingga November 2013 menggunakan perangkap methyl eugenol di UPM dan di Semenyih. Sebanyak 7,144 lalat buah yang terdiri daripada *B. carambolae* (59%), *B. papayae* (16%) dan perantaranya (25%) telah dikumpul dari buah yang telah diserang. Daripada set perangkap, 12,522 lalat jantan *B. carambolae* (21%), *B. papayae* (16%) dan perantara (63%) telah dikumpul. Hampir semua buah yang dikumpul telah diserang oleh lalat buah *Bactrocera* dan min bilangan pupa dari UPM, DOA dan Semenyih ialah 49, 47 dan 28 per buah dan masing-masing 0.647, 0.876 dan 0.446 buah per g. Begitu juga, min bilangan lalat buah dewasa per buah ialah masing-masing 34, 39 dan 16. Empat spesies Opiinae parasitoids; *Fopius arisanus* Sonum, *Diachasmimorpha longicaudata* Ashmead, *Psytalia fletcheri* Silvesteri dan *Psytalia incisi* Silvesteri telah dikenal pasti dan peratus parasitisme adalah dalam susunan, iaitu Semenyih > UPM > DOA pada nilai masing-masing 33%, 24% dan 9%. Sumbangan *F. arisanus* adalah lebih daripada 70% dari keseluruhan parasitoids manakala yang lain-lain adalah hampir sama. Populasi *B. carambolae* secara

signifikan adalah lebih tinggi ( $P < 0.05$ ) di UPM, manakala *B. papayae* secara signifikan adalah lebih tinggi ( $P < 0.05$ ) di Semenyih. Populasi perantara secara signifikkannya tidak berbeza ( $P < 0.05$ ) antara lokasi iaitu sama dengan jumlah keseluruhan lalat. Antara bulan persampelan, populasi menunjukkan hampir sama trend fluktuasi dengan catatan tertinggi adalah dalam bulan Oktober, Disember dan Januari di UPM. Walau bagaimanapun, di Semenyih, populasi sekata di sepanjang tahun telah diperoleh dengan catatan fluktuasi bagi sesetengah spesis lalat. Populasi lalat buah di UPM mempunyai korelasi yang tinggi dengan musim hujan, sedangkan, *B. papayae* juga mempunyai korelasi dengan suhu. Di Semenyih, populasi perantara dan jumlah keseluruhan lalat mempunyai korelasi dengan kelembapan relatif. Di samping itu, analisis regresi berperingkat di UPM menunjukkan bahawa faktor hujan menyumbang secara signifikan ke atas variasi populasi lalat buah kecuali *B. papayae*. Di Semenyih, hanya kelembapan relatif menyumbang secara signifikan ke atas variasi populasi perantara ( $R^2 = 0.49$ ) dan jumlah keseluruhan lalat ( $R^2 = -0.37$ ). Bagi serakan populasi, nilai bagi pelbagai indeks dan model regresi dalam semua bulan persampelan bagi spesis yang spesifik menunjukkan distribusi beragregat kecuali bagi beberapa kes di Semenyih. Oleh itu, perbezaan relatif dari segi porposisi, infestasi, dan distribusi parasitoidsnya dipengaruhi oleh keadaan perumahan dan pengurusan di ladang buah-buahan. Manakala, populasi lalat buah dipengaruhi oleh keadaan cuaca.



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I certify that a Thesis Examination Committee has met on 16 February 2015 to conduct the final examination of Salim Ali Juma on his thesis entitled "*Bactrocera* Fly infestation on Starfruit, *Averrhoa carambola* L. in Selangor, Malaysia and its Parasitoids" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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## LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CRD	Completely Randomized Design
DOA	Department of Agriculture
EPP	Entry Point Project
GFO	Golden Fruit orchards
GI	Green's Index
ID	Index of Dispersion
IDS	Institute for Development Studies
IPM	Integrated Pest management
MAT	Male Annihilation Technique
MCI	Mean Crowding Index
ME	Methyl Eugenol
MOA	Ministry of Agriculture and Agro-Based Industry Malaysia
NAP	National Agricultural Policies
RH	Relative Humidity
SAS	Statistical Analysis Software
SIT	Sterile Insect Technique
S.E	Standard Error
UPM	Universiti Putra Malaysia

## CHAPTER 1

### INTRODUCTION

Fruits are important agricultural products that contribute significantly to food security as well as increase household income and national earning. Accordingly, sustainable production of adequate and high quality fruits is necessary to meet the increasing demand of both domestic and international level. Starfruit is widely cultivated in Southeast Asia as a food and commercial crop. In Malaysia, starfruit has been included in the National Agricultural Policies (NAP) 1, 2 and 3 established in 1984, 1994, and 1998-2010 respectively and in the Entry Point Project (EPP)7 (2013) as an important export fruit. It is grown throughout the country primarily for commercial purpose and holding a significant rank in export market, and making it an economically viable fruit crop. According to Arshad *et al.*, (2007), in 2004, about RM3.1 million was obtained from export portion of produced starfruit primarily, to Singapore, Hong Kong and Netherlands. This export value ranked third contributing 12.86% of the fresh fruit market after papaya (33.68%) and melon (22.67%). Malaysia is exporter of starfruit (IDS, 2003). For that reason, starfruit gains its national and universal status. It considerably contributes to the economy of Malaysia through the increase of income to farmers, workers and government. However, production and market of starfruit face problems from invasive insect pests, particularly fruit flies (Vijaysegaran, 1984).

*Bactrocera* fruit flies (Diptera: Tephritidae) represent the most damaging pests of starfruit and other valuable tropical fruits, particularly in Southeast Asia and Pacific regions (Allwood *et al.*, 1999; Vargas *et al.*, 2002). The damage occurs when gravid female fruit fly oviposits on fruit to initiate a life cycle while allowing the entrance of pathogenic organisms (Christenson and Foote, 1960). In addition, the hatched larvae feed on and destroy the flesh of fruit resulting in reduced growth, rot and immature shedding of fruits (Galán-Saúco *et al.*, 1993). Such damage to fruit; consequently, results in reduced fruit production and market opportunities. In Malaysia, fruit fly problem has been previously addressed and *Bactrocera carambolae* and *Bactrocera papayae* of *B. dorsalis* complex species with their intermediate species have been reported to seriously attack many species of commercial crops throughout Peninsular Malaysia, especially starfruit of all varieties (Allwood *et al.*, 1999; Wee and Tan, 2005). Both immature and mature fruits are infested though; mature ones are mostly affected causing almost total loss of yield in absence of preventive strategies.

Currently, several measures have been implemented to control fruit fly problem on starfruit orchards in Malaysia. The use of Opiinae parasitoids (Hymenoptera: Braconidae) as a biological control agent of fruit flies is worldwide increasing included in IPM programs to reduce the effects of pervasively used chemical pesticides (Li *et al.*, 2006; Nicácio *et al.*, 2011). This entomophagous insect deposits its egg on fruit fly egg or larvae existing inside the fruit, resulting in the death of its host in immature stage (Hajek, 2004). This process reduces population of fruit flies, hence, reducing crop loss in the field. The presence of potential parasitoids of *Bactrocera* fruit flies in Malaysia has been long addressed (Clausen *et al.*, 1965).



However, they have not been utilized in controlling fruit fly problems. The advanced monitoring of fruit fly population in terms of distribution, fluctuation and dispersion is important before application of management strategies, as it enables planning of the right time of the year and space in an orchard for better management outcomes.

There are several studies that have addressed *Bactrocera* fruit flies and their parasitoids because of their economic importance in agricultural sector. In Malaysia, field surveys on *Bactrocera* fruit flies and their parasitoids have been studied many years ago and *B. dorsalis* Hendel was identified as a major pest of starfruit and Opiinae as its important parasitoids (Vijaysegaran, 1984). The population of *B. dorsalis* was reported to fluctuate with weather and fruit factor (Tan and Serit, 1994). However, the occurrence of intermediate species of *B. dorsalis* complexes in recent years tends to complicate the identification of their sibling species, hence, limits the effectiveness of biological control efforts. To date, there is a dearth of recent studies on intermediates of *B. dorsalis* complex species and Opiinae parasitoids. Therefore, this study was intended to build up a record and update the status of *Bactrocera* fruit flies in terms of species composition, infestation, population fluctuation and dispersion and associated parasitoid parasitism in selected areas in the State of Selangor, Malaysia. It is also expected to contribute to the development of knowledge on the ecology, identification, and rearing of these insect species for the success of biological and other control programs against fruit fly problem.

Therefore, the objectives of this study are to:

1. Investigate the occurrence of Tephritid fruit flies with intermediate morphologies of *B. carambolae* and *B. papayae*.
2. Assess the field infestation of *Bactrocera* fruit flies on starfruit and their associated Opiinae parasitism
3. Study population fluctuation of *Bactrocera* fruit fly species.

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