



**UNIVERSITI PUTRA MALAYSIA**

***THE FORAGING BEHAVIOUR OF STINGLESS BEE *Geniotrigona thoracica* ON STAR FRUIT***

**NUR ASILAH BINTI MOHMED ZAINI**

**FP 2017 57**

**THE FORAGING BEHAVIOUR OF STINGLESS BEE *Geniotrigona***

***thoracica* ON STAR FRUIT**



**NUR ASILAH BINTI MOHMED ZAINI**

**DEPARTMENT OF PLANT PROTECTION**

**FACULTY OF AGRICULTURE**

**UNIVERSITI PUTRA MALAYSIA**

**SELANGOR DARUL EHSAN**

**2016/2017**

**THE FORAGING BEHAVIOUR OF STINGLESS BEE *Geniotrigona*  
*thoracica* ON STAR FRUIT**

**BY**

**NUR ASILAH BINTI MOHMED ZAINI**

A project report submitted to the Faculty of Agriculture in fulfilment of the requirement of PRT 4999 ( Final Year Project) for the award of the degree of Bachelor of Horticulture Science.

**Faculty of Agriculture**

**Universiti Putra Malaysia**

**2016/2017**

## ENDORSEMENT

This project report entitled The Foraging Behaviour Stingless Bee *Geniotrigona Thoracica* on Star Fruit is prepared by Nur Asilah Binti Mohmed Zaini is submitted to the Faculty of Agriculture in fulfilment of the requirement of PRT 4999 ( Final Year Project) for the award of the degree of Bachelor of Horticulture Science.

Student's name:

Student's signature:

Nur Asilah Binti Mohmed Zaini

.....

Certified by:

.....

( ASSOC. PROF. DR. NUR AZURA ADAM )

Department of plant protection

Faculty of Plant Protection,

Faculty of Agriculture,

Universiti Putra Malaysia.

Date:.....



## ACKNOWLEDGEMENT

I am grateful to my supervisor, Assoc. Prof. Dr. Nur Azura Adam, whose expertise, understanding, kindly guidance and support made it possible for me to work on a topic that was of great interest to me and finding time for me in her busy schedule. It was a pleasure working with her.

I am thankful to Miss Asiah Ahmad for always generous helping me in carry out of this final year project, sharing experience and knowledge that related with this project and also provide me some previous thesis and finding time for me in her busy schedule.

In additionally, I am sincerely would like to thank my all friends , Siti Najwa, Emir Naqib, Norazila, Nurul Izati, Marliana and Madihah for their support and helping me to run this project smoothly. I will cherish the friendship and memories.

Mostly importantly, I would like to thank my beloved parents and siblings. Their support, encouragement, patience and unconditionally love throughout my life and for following me to further my study and carry out this project smoothly.

## TABLE OF CONTENTS

CONTENT	PAGE
ENDORSEMENT	i
ACKNOWLEDGEMENT	ii
CONTENT	iii
LIST OF TABLE	v
LIST OF FIGURES	vi
ABSTRACT	vii
ABSTRAK	ix
CHAPTER 1 INTRODUCTION	
1.1 Background	1
1.2 Justification	3
1.3 Objective	3
CHAPETR 2 LITERATURE REVIEW	
2.1 Star Fruit, <i>Averrhoa carambola</i> L	4
2.1.1 History	4
2.1.2 Morphology	4
2.2 Pollinator	5
2.3 Stingless bee, <i>Geniotrigona thoracica</i>	7
2.3.1 Taxonomy	7
2.3.2 Morphology	8
2.4 Social life of stingless bee	9
2.5 Defense behaviour of stingless bee	11
2.6 Forging behaviour of stingless bee	12

2.7 Efficiency of stingless bee as pollinator	14
2.7.1 Star Fruit, <i>Averrhoa carambola</i>	15
2.7.2 Rambutan, <i>Nephelium lappaceum</i>	15
2.7.3 Coffee, <i>Coffea sp.</i>	16
2.7.4 Mango, <i>Mangifera indica</i>	16
2.8 Economic Potential of Stingless Bee	17
CHAPTER 3 MATERIALS AND METHOD	
3.1 Location	18
3.2 Preparation material	18
3.2.1 Preparation star fruit	18
3.2.2 Preparation <i>G. thoracica</i> stingless bee	18
3.3 The frequency of foragers going out and coming back to the hive	18
3.4 The average number of flower visited and time taken per flower	19
3.5 Data Analysis	19
CHAPTER 4 RESULTS	20
CHAPTER 5 DISCUSSION	22
CHAPTER 6 CONCLUSION	26
REFERENCES	27
APPENDICES	33

## LIST OF TABLE

NO.		PAGE
1	Number of stingless bee that flew out and into hive	20





## LIST OF FIGURES

NO.		PAGE
1	Examples of Star fruit flowers	5
2	Morphology of stingless bee	8
3	The workers of <i>G. thoracica</i> stingless bee	11
4	The <i>G. thoracica</i> stingless bee do pollination on flower of star fruit	13
5	Example product of honey stingless bee	17
6	The number of flower that visited in 3 minute and average period visited for each flower	21

## ABSTRACT

Department of Agriculture Malaysia has recorded the export of star fruit had dropped 73 % from 10395.1 metric tons in 2010, to only 2776.5 metric tons in 2012. An inadequate pollination rate is one of the factors that contribute to low yield. One of the effective ways of increasing the pollination rate is by having insect pollinators such as stingless bees in the star fruit farm. The study on the efficiency of stingless bee as star fruit pollinator is still lacking in Malaysia. Therefore the objectives of this study were: 1) to determine the frequency of foragers going out and coming back to the hive; 2) to investigate the average number flower visited and time taken per flower visit. The colonies of *G. thoraccica* stingless bee were obtained from Integrated Farm, Faculty of Agriculture UPM. The study consisted of two experiments: 1) observation of foraging time and 2) observation on pollination service. Three colonies of *G. thoracica* were selected for observation of foraging activity of stingless bee. Foraging bees were enumerated by using a manual tally counter to determine the number of individuals that flew in and out of their hive within a ten minute period each hour for each colony from 0800 hours to 1300 hours. Then ten *G. thoracica* foragers were selected randomly and marked using insect colouring on their thorax. The period of each flower visited by each marked forager was individually recorded by using stopwatch. The number of flowers visited by *G. thoracica* was also recorded in three minutes. Data for number of *G. thoracica* stingless bee flew out and into hive were analyzed using One-Way ANOVA at  $P=0.05$ . The foraging activity for each hour showed no significant difference ( $P > 0.05$ ). However, the peak time foraging activity of *G. thoracica* was in between 0900 hrs until 1000 hrs. The highest number of flowers visited in three minutes was 31 flowers while the lowest number of flowers visited in was seven flowers. Meanwhile the longest average

visited period for each flower is 12.88 seconds and the shortest average visited period for each flower is 2.72 seconds.



## ABSTRAK

Jabatan Pertanian Malaysia mencatatkan eksport buah belimbing telah menurun sebanyak 73% daripada 10.395,1 tan metrik pada tahun 2010, hingga hanya 2776,5 tan metrik pada 2012. Kadar pendebungaan yang tidak mencukupi adalah salah satu faktor menyumbang kepada hasil yang rendah. Salah satu cara yang berkesan untuk meningkatkan kadar pendebungaan adalah dengan mempunyai serangga pendebunga seperti lebah kelulut di ladang belimbing. Walaubagaimanapun kajian ke atas kecekapan lebah kelulut sebagai pendebunga belimbing masih kurang di Malaysia. Oleh itu objektif kajian ini ialah: 1) untuk menentukan kekerapan kelulut terbang keluar dan masuk kembali ke sarang; 2) untuk menyiasat purata bilangan bunga yang dilawat dan masa yang diambil oleh lebah kelulut melawat pada setiap bunga. Koloni *G.thoraccica* lebah kelulut diperolehi daripada Ladang Bersepadu, Fakulti Pertanian UPM. Kajian ini terdiri daripada dua eksperimen: 1) pemerhatian masa mencari makan dan 2) pemerhatian pada perkhidmatan pendebungaan. Tiga koloni *G. thoracica* telah dipilih untuk pemerhatian aktiviti mencari makanan oleh lebah kelulut. Manual tally conuter digunakan untuk mengira bilangan lebah kelulut keluar masuk dari sarang untuk mencari makana dalam masa sepuluh minit pada setiap jam dari jam 0800 hingga jam 1300. Kemudian sepuluh *G. thoracica* lebah kelulut telah dipilih secara rawak dan ditanda menggunakan pewarna serangga pada thorax mereka. Tempoh pada setiap bunga dikunjungi oleh lebah kelulut yang telah ditandai telah direkod menggunakan jam randik. Bilangan bunga dikunjungi oleh *G. thoracica* juga direkodkan dalam masa tiga minit. Analisis data untuk bilangan lebah kelulut *G. thoracica* terbang keluar dan ke dalam sarang menggunakan “One Way ANOVA “ telah digunakan dengan  $P < 0.05$ . Keputusan menunjukkan masa kemuncak aktiviti mencari sumber makanan oleh lebah kelulut *G. thoracica* adalah diantara jam 0900 hingga jam 1000. Analisis data digunakan untuk aktiviti mencari makan untuk setiap jam menunjukkan tidak ada perbezaan yang signifikan,  $p > 0.05$ .

Bilangan bunga yang paling banyak dilawati dalam 3 minit adalah 31 bunga manakala bilangan bunga yang paling sedikit dikunjungi dalam 3 minit adalah 7 bunga. Sementara itu purata paling lama melawat tempoh bagi setiap bunga adalah 12.88 saat dan purata yang singkat melawat tempoh bagi setiap bunga adalah 2.72 saat.



# CHAPTER 1

## INTRODUCTION

### 1.1 Background

The star fruit or scientific name *Averrhoa carambola* L. belongs to the family of Oxalidaceae. It is originally from Southeast Asia and has been cultivated for hundred years. Actually these fruit trees are found in the wild, popular use as dooryard trees and for local consumption (Chin & Young, 1981). The star fruit trees can grow vigorously in acidic soils and tropical climatic conditions. The characteristic of star fruit is showy, oblong and has a uniform and symmetric shape with five longitudinal ribs. The name of star fruit is representing when cutting across of fruit; it will form a star shaped section.

The star fruit an evergreen tropical fruit tree has attained a commercial fruit states in Malaysia and has been cultivated since 1937. In 1983, star fruit tree was planted as a commercial orchard. Since then, many superior clones have been registered and propagated (Abd Rahman *et al.*,2007). The planted area of star fruit tree was obviously increasing from 80 ha in years 1980 to 1934 ha in years 1993. The high requirement of labour was needed because of high demand of star fruit for exported. This cause of some grower was forced to abandon the farm. The star fruit have a good demand especially for export to European and Middle East markets.

Lately there are positive responses by producers to enhance the production areas and increasing the improvement productivity of existing clones thus increasing planting throughout Malaysia. For example, Johor state was selected as area new opening area for extended planting of star fruit (Anon, 2002). Star fruit from Malaysia is the exported fruit that

popular around the world since 1989 (Maria & Gabrielle, 2005). Special about this fruit is, even it's not popular among Malaysians but it's popular to other country.

Since 1965, production of star fruit was controlled and monitored by a government body called Federal Agricultural Marketing Authority (FAMA) to maintain the quality of star fruit for export( Sahbani *et al.*,2008). The high demand of star fruits from Malaysia in Europe countries are because of its good quality based on its taste and physical appearance. Furthermore, the taste of star fruit from our country is better compared to other exported countries (Jonathan, 1993). However, physical appearance of star fruit that attractiveness is much important as its taste. Because of that, FAMA was create a quality label that called Malaysia's Best to maintain the quality of star fruit for exported (Tom, 2009)

Based on Fruit Crop Statistic Malaysia by The Department of Agriculture Putrajaya Malaysia has recorded the production of star fruit on years 2011 starts to increase until years 2013. The production increased from 10,495 to 13,841mt per hectare. However, in years 2014 the production of star fruit decreased with 10,072.2mt per hectare. At the same time, the exported star fruit also decreased and difficult to fulfil demand of star fruit.

The star fruit's flowers are produced throughout the year. It can produce a fruit any time with favourable condition. The flower of star fruit is perfect flower meaning it is contains female and male part in one flower. However, natural fruit set of star fruit is low in 2.79 to 2.98%. It is because of the flower is heterodistylous. Its mean styles of flower have different length. It causes flower difficult to pollinate among themselves without pollinators. Most crop plants especially star fruit needed pollinator for fruit and seed set. (Zabedah *et al.*, 2003)

The pollination is the important process in fruit crop for successful of fruit set (Slaa *et al.*, 2006). Some of the crop needs pollinator for pollination especially for star fruit crop. Thirty percent of human foods depend on bee pollinated crops (Kearns & Inouye, 1997). The

bee species with wide variety was popular as efficient and effective pollinators for many crops. (Kremen *et al.*,2002). The honey bee is common pollinator that use for pollination. However, there are some reasons that honey bee that no longer efficient and also have probability as a vector of plant disease.

## **1.2 Justification**

Star fruit's flower is complete flower but is also heterodistylous. It is difficult to self-pollinate and need pollinator for development of fruit. At the same time, honey bee's ability as pollinators was limited or threated because of some factors such as economic pressure, climatic limitations, and low efficiency on some crops, parasites and diseases. Stingless bee (Meliponi) was found as other good candidate as a pollinator . The purpose of this study is to determine the effectiveness stingless bee *Geniotrigona thoraccica* as pollinator on star fruit.

## **1.3 Objective**

Therefore the objectives of this study were:-

- 1) to determine the frequency of forgers going out and coming back to the hive
- 2) to investigate the average number flower visited and time taken per flower visit



## REFERENCES

- Abd Rahman M., Mohamad O. and Maimun T. 2007. Evaluation of yield and fruit quality traits of eight selected star fruit clones. *Journal Tropical Agriculture and Food Science*. 35(1) : 21-27
- Almeida-Muradian L.B., Stramm K.M. and Estevinho L.M.. 2013. Efficiency of the FT-IR ATR spectrometry for the prediction of the physicochemical characteristics of *Melipona subnitida* honey and study of the temperature's effect on those properties. *International Journal Food Science Technology*. 49:188–195
- Alqarni A.S .2006. Tolerance of summer temperature in imported and indigenous honeybee *Apis mellifera* L. Races in central Saudi Arabia. *Saudi Journal of Biological Sciences* 13:123–127.
- Anderson, D., Sedgley M., Short J. and Allwood, A. 1982. Insect pollination of mango in Northern Australia. *Australian Journal of Agricultural Research*. 33(3): 541
- Anon. 2002. Jumlah keluasan tanaman belimbing mengikut tahun. Kuala Lumpur: Jabatan Pertanian
- Biesmeijer J.C., Slaa E.J., Siqueira de Castro M., Viana B.F., Kleinert A., and Imperatriz Fonseca V.L. 2005. Connectance of Brazilian social bee – food plant networks is influenced by habitat, but not by latitude, altitude or network size, *Biota Neotropica Journal*. 5:1–9.
- Bosch, M. & Waser, N. M. .2001. Experimental manipulation of plant density and its effect on pollination and reproduction of two confamilial montane herbs. *Oecologia*, 126:76-83.
- Bradbear, N. 2009. *Bees and their role in forest livelihoods: A guide to the services provided by bees and the sustainable harvesting, processing and marketing of their products*. Rome: Food and Agriculture Organization of the United Nations.

- Brody, A. K. & Mitchell, R. J. 1997. Effects of experimental manipulation of inflorescence size on pollination and pre-dispersal seed predation in the hummingbird-pollination plant ipomopsis aggregate. *Oecologia*, 11:86-93
- Carreck N., Williams I. 1998. The economic value of bees in the UK, *Bee World* 79: 115-123
- Chin, H. F., Young H. S..1981. *Malaysian Fruits in Colour*. Tropical Press Sdn. Bhd.
- Dasgupta P, Chakraborty P, Bala N.N, 2013, *Averrhoa carambola*: An updated review, *International Journal of Pharma Research & Review* . 2(7):54-63
- Free, J.B. 1955. The division of labor within bumble bee colonies , *Insectes Sociaux* 2:195-212
- Free, J. B. 1993. *Insect pollination of crops*. London: Academic Press.
- Gary N. E. 1967. Diurnal variations in the intensity of flight activity from honeybee colonies. *Journal of Apicultural Research* 6.2:65-68.
- Heard, T. A. 1999. The role of stingless bees in crop pollination. *Annual Review of Entomology*, 44(1):183-206.
- Hilário, S.D., Imperatriz-Fonseca V.L., and Kleinert, A. M. P. 2000. Flight activity and colony strength in the stingless bee melipona bicolor (Apidae, Meliponinae). *Revista Brasileira de Biologia*. 60(2):299–306.
- Jaapar, M. F.,Jajuli, R., and Mispan M.R..2016. *Lebah kelulut malaysia: biologi dan penternakan*. Serdang, Selangor: Penerbit MARDI.
- Jarau, S., Dambacher, J., Twele, R., Aguilar, I., Francke, W., and Ayasse, M. 2010. The trail pheromone of a stingless bee, *Trigona corvina* (Hymenoptera, Apidae, Meliponini), varies between populations, *Chemical Senses*, 35(7):593-601

- Jonathan H. C. 1993. Commercialization of carambola, atemoya, and other tropical fruits in South Florida. Proc. of the 2nd National Symp. On Exploration, Research & Commercialization. New York: *New crops*. Wiley. 448-460. pp
- Joshi N.C, and Joshi P.C .2010. Foraging behaviour of *Apis* Spp. on apple flowers in a subtropical environment. *New York Science Journal* 3, 71–76.
- Kearns C.A. and Inouye D.W. 1997. *Techniques for pollination biologists*, University Press of Colorado, Colorado
- Keasar T, Shmida A and Motro U, “*Innate movement rules in foraging bees: flight distances are affected by recent rewards and are correlated with choice of flower type,*” *Behavioral Ecology and Sociobiology*, 39:381-388.
- Klein, A., Steffan-Dewenter, I. and Tschardtke, T. 2003. Fruit set of highland coffee increases with the diversity of pollinating bees. *Proceedings of the Royal Society B: Biological Sciences*, 270(1518): 955-961
- Kremen, C., Williams, N. M., and Thorp, R. W. 2002. Crop pollination from native bees at risk from agricultural intensification. *Proceedings of the National Academy of Sciences*. 99(26):16812-16816.
- Kwapong P., Aidoo K., Combey R. and Karikari A. 2010. *Stingless Bees: Importance, Management and Utilisation: A Training Manual for Stingless Bee Keeping*. Unimax Macmillan
- Maria J. D. and Gabrielle C . 2005. *Star Attraction*. Cover Stories in Sun2Surf.
- Michael. H. and Camila, M. 2013 . The Fast Versus *The Furious: On Competition, Morphological foraging traits, and foraging strategies in stingless bees*. *stingless Bees Process Honey and Pollen in Cerumen Pots*. 1–13.
- Michener, C. D. 1974. *The social behavior of the bees; a comparative study*. Cambridge, MA: Belknap Press of Harvard University Press

- Michener C.D. 2007. *The bees of the world*. Baltimore: Johns Hopkins University Press
- Michener, C. D. 2013. *The meliponini. pot-honey*, New York: Springer. 3-17.
- Nunez, J.1970. The relationship between sugar flow and foraging and recruiting behaviour of honey bees (*Apis Mellifera L.*). *Animal Behaviour* 18:527-38.
- Pernal S.F and Currie R.W . 2010. The influence of pollen quality on foraging behavior in honeybees (*Apis mellifera L.*). *Behavioral Ecology and Sociobiology* 51:53–68.
- Phoon A, Suhaimi A, and Marshall A. 1984. The pollination of some Malaysian fruit trees. *Simpson. Biology. Kebangsaan, 1st, Kebangsaan*,. Selangor Malaysia: Bangi. pp. 87-111
- Ramalho, M. L. V. and Giannini, T. C. 1998. Within-Colony size variation of foragers and pollen load capacity in the stingless bee *melipona quadrifasciata anthidioides lepeletier* (Apidae, Hymenoptera ). *Apidologie*. 29: 221–228.
- Reichle, C. S. Jarau, I. Aguilar, A. and Ayasse, M. 2010. Recruits of the stingless bee *Scaptotrigona pectoralis* learn food odours from the hive atmosphere. *Naturwissenschaften*, 97: 519-524.
- Reyes-Carrillo J.L., Eischen F.A, Cano-Rios P, Rodriguez Martinez R and Camberos U. N. 2007. Pollen collection and honey bee forage distribution in Cantaloupe. *Acta Zoologica Mexicana* 23:29–36.
- Roubik D.W., Moreno J.E, Vergara C. and Wittmann D .1986. Sporadic food competition with the African honey bee: projected impact on neotropical social bees. *Journal Tropical Ecology* 2:97-111
- Roubik, D. W. 1998. Coffee pollination in Central American Highlands: African bees and the reproduction of an autogamous shrub. *Ecology Letters*

- Sahbani S. Abd. Ghariff R. Sebastian C. and Mohd. Hafiz M. 2008. Market price watch and FAMA's role in Malaysian agricultural marketing. Asia and Pacific Commission on Agricultural Statistics (APCAS). Twenty-second Session. 9-13 June 2008. Kuching, Sarawak, Malaysia.
- Sakagami S.F, Inoue T, and Salmah S. 1990. Stingless bees of Central Sumatra. In Sakagami S.F, Ohgushi R, Roubik D.W, (eds). *Natural history of social wasps and bees in equatorial Sumatra*. Hokkaido University Press; Sapporo, Japan. 125–137. pp
- Sánchez, D. and Vandame, R . 2013. Stingless bee food location communication: from the flowers to the honey pots. *Pot-Honey*, New York: Springer. pp. 187-199
- Saufi, N. F and Kumara T. 2015. Characterization of hive structure and foraging activity of stingless bee, *Geniotrigona Thoracica* (Hymenoptera: Apidae; Meliponini)." *Jurnal Teknologi* 77:33
- Schneider S.S., De Grande-Hoffman G. and Smith D.R. 2004. The African honeybee: factors contributing to a successful biological invasion, *Annual Review Entomology*. 49:351–376.
- Schwarz H. F. 1939. *The Indo-Malayan species of Trigona*. New York: American Museum of Natural History. 76(3): 83-141.
- Silva D.P, Moisan-De-Serres J, Souza D.C, Hilgert-Moreira S.B, Fernandes M.Z, Kevan P.G and Freitas B.M. 2013. Efficiency in pollen foraging by honey bees: time, motion, and pollen depletion on flowers of *Sysirinchium palmifolium* (Asparagales: Iridaceae). *Journal of Pollination Ecology* 11: 27–32.
- Slaa E.J., Tack A.J.M. and Sommeijer M.J. 2003. The effect of intrinsic and extrinsic factors on flower constancy in stingless bees, *Apidologie* 34: 457–468.
- Slaa, E. J., Chaves, L. A., Malagodi-Braga, K. S. and Hofstede, F. E. 2006. Stingless bees in applied pollination: Practice and perspectives. *Apidologie*, 37(2): 293-315.

- Sommeijer M.J. and Ruijter A. de. 2000. Insect pollination in greenhouses, *Proc. specialists' meeting held in Soesterberg, The Netherlands*.
- Steffan-Dewenter I. Potts S.G. and Packer L. 2005. Pollinator diversity and crop pollination services are at risk, *Trends Ecology Evolution*. 20: 651–652.
- Steven, J. C., Rooney, T. P., Boyle, O. D. and Waller, D. M. 2003. Density dependent pollinator visitation and self-incompatibility in upper great lakes populations of *Trillium grandiflorum*. *Journal of the Torrey Botanical Society*, 130: 23-29.
- Tom Bicknell .2009 June . .Room for Malaysian exports?.*Asiafruit Magazine*. 52.
- Vicens, N. and Bosch, J. 2000. Weather dependent pollinator activity in an apple orchard, with special reference to *Osmia cornuta* and *Apis mellifera* (Hymenoptera: Megachilidae and Apidae). *Environmental Entomology*, 29: 413-420.
- Wahizatul, A. A., Roziyah, G. and Nur Syuhadah, Z. 2015. Melissopalynology and foraging activity of stingless bees, *Lepidotrigona Terminata* (Hymenoptera: Apidae) from an apiary in Besut, Terengganu, *Journal of Sustainability Science and Management*, 10(1): 27-35.
- Watanabe M. 1994. Pollination worries rise as honey bees decline, *Science* (265):1170.
- Wille, A. 1983. Biology of the stingless bees. *Annual Review of Entomology*, 28(1):41-64
- Zabedah M., Fauziah M. and Nik Masdek N.H. 2003. Improvement of yield and quality of starfruit clone B10 cultivated under netted structure. *Journal Tropical Agriculture and Food Science*. 31(2):139-145