UNIVERSITI PUTRA MALAYSIA

FORAGING BEHAVIOURS OF STINGLESS BEES Heterotrigona itama Cockerell AND Geniotrigona thoracica Smith AS POTENTIAL POLLINATORS TO STAR FRUIT Averrhoa carambola L.

WAN NUR ASIAH BINTI WAN MOHD ADNAN

FPAS 2021 19

FORAGING BEHAVIOURS OF STINGLESS BEES *Heterotrigona itama* Cockerell AND *Geniotrigona thoracica* Smith AS POTENTIAL POLLINATORS TO STAR FRUIT *Averrhoa carambola* L.

By

WAN NUR ASIAH BINTI WAN MOHD ADNAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

March 2021

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

FORAGING BEHAVIOURS OF STINGLESS BEES *Heterotrigona itama* Cockerell AND *Geniotrigona thoracica* Smith AS POTENTIAL POLLINATORS TO STAR FRUIT *Averrhoa carambola* L.

By

WAN NUR ASIAH WAN MOHD ADNAN

March 2021

Chairman : Associate Professor Puan Chong Leong, PhD
Faculty : Forestry and Environment

Star fruit, *Averrhoa carambola* is Malaysia's most exported exotic fruit and is mostly marketed overseas. The demand for this fruit increases yearly and sometimes exceeds the supply capacity. The low production of this fruit due to the pests and diseases also decreased the cultivation land. To improve the productivity of this fruit to prevent insect pest visitation and other diseases, star fruit trees have been planted in netting structure and there is a need to find a potential pollinator to enhance the fruit production. Stingless bee could be one potential pollinator to be introduced in the netting structure. Unfortunately, there is still a lack in knowledge on the foraging behaviours of *Heterotrigona itama* and *Geniotrigona thoracica* in order to confirm their potential as efficient pollinators of start fruit flowers. To fill the knowledge gap, this study was conducted at the Integrated Farm, Universiti Putra Malaysia (UPM) to i) investigate the foraging activities of two selected stingless bee species, *G. thoracica* and *H. itama* in relation to seasonal and abiotic factors, ii) determine the pollen resources taken by *G. thoracica* and *H. itama*, and construct the pollen profile as a baseline data, iii) assess the efficacy and compare their visitation rate to the flowers of star fruit. The observation of bees that flew in and out from their nest was made hourly from 0800 to 1600 hours. Pollens from their corbiculae legs were collected, examined and counted under light microscope and SEM. The flower visitation rates of these bees were calculated based on visitation frequency on star fruit flowers. Results showed that the daily foraging activities and foraging pattern of these two bee species were significantly different at various times of the day. The two bees were observed to be more actively foraging in the morning during 0900 hours to 1100 hours after which they slowed down until the end of the day. Nectar collection for *G. thoracica* (67,363 individuals) and *H. itama* (53,518 individuals) were significantly higher compared to pollen collection which were 11,075 individuals (*G. thoracica*) and 6,803 individuals (*H. itama*). Bee activities also varied at different time and seasons (wet and dry) of the year and was demonstrated by significant fluctuations in the number of foraging bees among all months of observations. The highest foraging activities were recorded in January 2015 (wet

season) for both species, i.e., 12,303 individuals (*G. thoracica*) and 12,979 individuals (*H. itama*). The lowest foraging activities were recorded in September 2014 for *G. thoracica* (7,517 individuals) and in August for *H. itama* (1,960 individuals). Variations in abiotic factors such as temperature, relative humidity and light intensity at the study area significantly affected the bees' foraging activities. Composition of plant diversity at the study site influenced the foraging activities of the two bee species. Three most preferred plant families were Oxalidaceae (1,342 individual pollens or 18% of the total pollens collected), Arecacea (1,064 individual pollens or 15%) and Fabaceae (722 individual pollens or 10%). Star fruit being a tree is the most preferred vegetation category from which the main pollen and nectar resources were obtained by the bees followed by shrubs, grass, herbs and vegetables. Pollens of star fruit were highly attractive to these two bees due to the aromatic odor produced by this tree. Performances of flower visitation rate of these bees were slightly higher for *G. thoracica* compared to *H. itama* (I_{VR} *G. thoracica* = 0.47 ± 0.02; I_{VR} *H. itama* = 0.12 ± 0.02). The number of bees and their visitation (*G. thoracica*) to the star fruit panicles proportionately increased with the increase in the number of flowers on the panicles. The visitation rates of *G. thoracica* and *H. itama* remained low and quite similar to each other due to similar resources and foraging activities, and total dependence on one resource in the net cage. In conclusion, *G. thoracica* and *H. itama* were more actively foraging in the morning and during wet season. *G. thoracica* preferred to visit bigger panicles with more flowers and their visitations also increased when the size of the panicles increased. *Geniotrigona thoracica* could be a potential pollinator of the star fruit tree compared to *H. itama* based on its slight advantage of having higher frequency of visitation to the star fruit flowers.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

PERILAKU MENCARI MAKANAN LEBAH KELULUT, *Heterotrigona itama* Cockerell DAN *Geniotrigona thoracica* Smith SEBAGAI AGEN PENDEBUNGA BERPOTENSI KEPADA BELIMBING *Averrhoa carambola* L.

Oleh

WAN NUR ASIAH BINTI WAN MOHD ADNAN

Mac 2021

Pengerusi : Profesor Madya Puan Chong Leong, PhD
Fakulti : Perhutanan dan Alam Sekitar

Lebah kelulut (Apidae, Meliponini) telah menarik minat yang mendalam di kalangan penyelidik dan petani sebagai agen pendebunga alternatif disebabkan oleh taburannya yang meluas dan kekurangan populasi lebah madu sedunia. Di Malaysia, industri lebah kelulut telah menjadi terkenal dan mendapat perhatian dari kerajaan untuk meningkatkan pendapatan sosioekonomi di kalangan petani. Walau bagaimanapun, masih terdapat kekurangan pengetahuan tentang beberapa aspek perilaku mencari makanan oleh *Heterotrigona itama* dan *Geniotrigona thoracica* untuk mengesahkan potensi mereka sebagai agen pendebunga yang cekap. Untuk mengisi jurang pengetahuan tersebut, kajian ini telah dilakukan di Ladang Bersepadu, Universiti Putra Malaysia (UPM) untuk i) menyiasat kegiatan mencari makanan dua spesies lebah kelulut, *G. thoracica* dan *H. itama* dan hubungannya dengan faktor musim dan abiotik, ii) menentukan sumber debunga yang diambil oleh *G. thoracica* dan *H. itama*, dan membina profil debunga sebagai satu data asas, iii) menilai keberkesanan dan membandingkan kadar lawatan bunga oleh *G. thoracica* dan *H. itama* pada bunga buah belimbing (*Averrhoa carambola* L.). Kajian lebah terbang masuk dan keluar dari sarang mereka di Ladang Bersepadu, UPM dicatatkan untuk setiap jam dari jam 0800 hingga 1600. Debunga dari corbiculae dikumpulkan kemudian diperhatikan dan dihitung di bawah mikroskop cahaya. Kadar lawatan bunga lebah ini dihitung berdasarkan kekerapan kunjungan pada bunga buah belimbing. Hasil kajian menunjukkan bahawa kegiatan mencari makanan harian dan corak mencari makanan kedua-dua spesies lebah ini berbeza secara signifikan pada pelbagai waktu dalam sehari. Kedua-dua lebah tersebut dilihat lebih aktif mencari makanan pada waktu pagi pada jam 0900 hingga jam 1100 dan selepas itu mereka menjadi kurang aktif sehingga penghujung hari. Pengumpulan nektar bagi *G. thoracica* (67,363 individu) dan *H. itama* (53518 individu) lebih tinggi secara signifikan berbanding pengumpulan debunga iaitu 11,075 individu (*G. thoracica*) dan 6,803 individu (*H. itama*). Kegiatan lebah juga bervariasi pada waktu dan musim yang berlainan (hujan dan kering) tahun itu dan ditunjukkan oleh turun naik jumlah lebah mencari makanan yang signifikan di antara bulan-bulan yang dikaji.

Kegiatan mencari makanan tertinggi dicatatkan pada Januari 2015 (musim hujan) untuk kedua-dua lebah, 12,303 individu (*G. thoracica*) dan 12,979 individu (*H. itama*). Kegiatan mencari makanan terendah dicatatkan pada bulan September 2014 bagi G. thoracica (7517 individu) dan pada bulan Ogos bagi *H. itama* (1960 individu). Variasi faktor abiotik seperti suhu, kelembapan relatif dan intensiti cahaya di kawasan kajian mempengaruhi kegiatan mencari makanan lebah secara signifikan. Komposisi kepelbagaian tanaman di Ladang Bersepadu, UPM sangat mempengaruhi kegiatan mencari makanan dua spesies lebah tersebut. Tiga keluarga tanaman yang paling disukai adalah Oxalidaceae (1,342 individu debunga atau 18% daripada jumlah debunga yang dikumpulkan), Arecacea (1,064 individu debunga atau 15%) dan Fabaceae (722 individu debunga atau 10%). Lebah tersebut lebih menyukai Oxalidaceae (*A. carambola*) daripada kategori tanaman berkayu sebagai sumber utama debunga dan nektar mereka diikuti oleh pokok renek, rumput, tumbuh-tumbuhan dan sayur-sayuran. Debunga *A. carambola* adalah sangat menarik bagi kedua-dua lebah ini kerana aroma yang terhasil daripada debunga dan nektar. Prestasi kadar lawatan bunga lebah-lebah ini sedikit tinggi bagi *G. thoracica* berbanding *H. itama*. (I_{VR} *G. thoracica* = 0.47 ± 0.02; I_{VR} *H. itama* = 0.12 ± 0.02). Lawatan mereka pada panikel belimbing meningkat secara berkadar dengan bertambahnya jumlah bunga pada panikel. Kadar lawatan serangga *G. thoracica* dan *H. itama* adalah rendah dan hampir sama antara satu sama lain disebabkan sumber dan kegiatan mencari makanan yang hampir sama, dan kebergantungan pada satu sumber di dalam sangkar jaring. Kesimpulannya, *G. thoracica* dan *H. itama* lebih aktif mencari makanan pada waktu pagi dan semasa musim hujan. *G. thoracica* lebih suka melawat panikel yang lebih besar dengan lebih banyak bunga. *G. thoracica* lebih berpotensi menjadi pendebunga belimbing berdasarkan kepada kekerapan melawat bunga belimbing yang lebih tinggi berbanding dengan *H. itama*.

ACKNOWLEDGEMENTS

Bismillahirrahmannirrahim,

Firstly, I give thanks to merciful Allah for giving me the strength to complete this study.

I would like to express my sincere gratitude and thanks to my supervisors, Associate Professor Puan Chong Leong, Associate Professor Nur Azura Adam and Dr Syari Jamian for continuous support of my study and research, on your patience, motivation, enthusiasm and immense knowledge. Your guidance helped me in all the time research and writing of this thesis.

My sincere thanks also go to Dr Ahmad Said Sajap, Dr Che Salmah Md Rawi and Dr Abu Hassan Ahmad for unstintingly provided valuable advices for my study.

I thank my fellow labmates: Haziq, Marina Roseli, Siti Asma Samsudin, Mohamad Syukri Tan Shi Lan, Dr Salmah, for the stimulating discussions and for all the fun during our study.

I would like to thank my husband Mr Azlan Shah bin Mohamed Aris for continuous supporting me to finish this study till the end with your invaluable help in financial and your energy during my research study. For my sons and daughter, Adam Putra, Aisyah Putri and Adnan Putra thanks for your sacrifice your childhood time to spend with me during my research study.

Last but not the least; I would like also to thanks my late father Haji Wan Mohd Adnan and my mother Hajjah Fatimah Mohamed, for giving birth to me at the first place and supporting me spiritually throughout my life. To all my sibling also: Ainun, Atikah, Athirah, Azizi, Ariff, Amir and Amin, thank you also for your invaluable help during this journey.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Puan Chong Leong, PhD
Associate Professor
Faculty of Forestry and Environment
Universiti Putra Malaysia
(Chairman)

Nur Azura binti Adam, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Syari bin Jamian, PhD
Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

_____
ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:11 November 2021

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: Wan Nur Asiah binti Wan Mohd Adnan (GS35840)

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: _____

Signature: _____
Name of Member of Supervisory Committee: _____

Signature: _____
Name of Member of Supervisory Committee: _____

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
^{0}C	Degree Celsius
%	Percentage
DOA	Division of Agriculture
DJPEN	Directorate General for National Export Development
FI	Flight In
FO	Flight Out
h	Hour
IVR	Insect Visitation Rate
LI	Light Intensity
MARDI	Malaysian Agriculture Research and Development Institute
MANOVA	Multivariate Analysis
MOA	Ministry of Agriculture
RH	Relative Humidity
SDR	Species Diversity Richness
SE	Standard Error
SPSS	Statistic Package for Social Science
UPM	Universiti Putra Malaysia

CHAPTER 1

GENERAL INTRODUCTION

1.1 Introduction

Stingless bees belong to the tribe Meliponini (Michener, 2013) which is relatively small in size. They are also called 'sweat bees' and 'dimmer bees' because they gather salt from human sweat (Vijaykumar, 2017). Stingless bees are social bees which possess sting which remains non-functional (Heard, 2016). They defend themselves by biting their enemies using mandibles, but the bite intensity is similar to the bite of an ant. They are able to produce honey similar to honey bee (Apidae). Nowadays, there are more than 600 species of stingless bee that can be found throughout the tropics. Their distribution is pan-tropical with the highest diversity found in tropical mainland like America, Africa, Madagascar, Australia and South East Asia (Heard, 2016). In Malaysia, there are 35 identified species of stingless bee (Eltz & Bru, 2003; Hannah et al., 2012; Norowi et al., 2010; Farisya et al., 2015).

The cultivation of stingless bee on a commercial scale for honey production or pollination is known as meliponiculture. Such activities have been widely practiced in Brazil, Mexico, Africa, Australia and Thailand (Cortopassi-Laurino et al., 2006; Halcroft et al., 2013c; Sawatthum, 2004). In Malaysia, there is a keen interest on stingless bees among researchers and farmers recently as alternative pollinators due to their wide distributions. The stingless bee industry has become popular and gaining attention from the government for improving income among farmers. The diverse groups of stingless bees found in Malaysia could be potential pollinators of various crops. It was reported that stingless bees pollinate several crops in Australia and improve the productivity of these crops (Heard, 2016). Greco et al. (2011) reported that the Australian stingless bee, *Austroplebeia australis* Friese and *Trigona carbonaria* have improved the production of chilli, *Capsicum annum* in greenhouse. *Trigona carbonaria* has also been showed to improve the production of blueberry in Australia (Kendall et al., 2020). Thus, stingless bees in Malaysia also have similar potential that should be explored and studied so as to allow them to serve as efficient pollinators and further improve local fruit production.

1.2 Problem Statement and Justification of the Study

Star fruit (*Averrhoa carambola*) was introduced and commercialised for the world's market over 100 years ago and is a tropical fruit that is well established in the market (Hashim et al., 2017). Star fruit is Malaysia's most exported exotic fruit and is mostly

marketed overseas (Abdullah et al., 2007; Hashim et al., 2017). The demand of star fruit in the market is still higher but the production of this fruit has become low and insufficient to be exported (Hashim et al., 2017; DOA 2018). Many reasons have contributed to the low production of star fruit in Malaysia, such as pests and diseases as well as the decrease in cultivation land for this fruit. In 2003, star fruit tree had been cultivated in netting structure to prevent the insect visitation cause diseases to star fruit tree (Zabedah et al., 2003). Introducing potential pollinator to the star fruit in the netting system is needed to enhance the production of this fruit. Stingless bees are one potential pollinator that could be used in the netting system compared to honey bees due to their small foraging range and they are not harmful to the farmers due to the lack of sting and their resistant to diseases that are associated with honey bees (Heard, 2016).

The ideal candidates of an alternative pollinator in commercial pollination can be found in the diverse group of stingless bees (Heard and Dollin, 2015). However, not all species have an economic value despite high diversity of stingless bee species in Malaysia (Kelly et al., (2014)). For example, in Australia there are only two species of stingless bee dominating the stingless bee industry which are *Tetragonula carbonaria* and *Austroplebeia australis* (Halcroft et al., 2013a). In Thailand, there are four stingless bee species with economic values, namely *Trigona pegdeni*, *Tetragonula laeviceps*, *Lepidotrigona terminata* and *Lepidotrigona ventralis doipaensis* (Sawatthum, 2004).

A recent study showed that there are five species of stingless bee that have a commercial value in Malaysia. They are *Geniotrigona thoracica*, *Heterotrigona itama*, *L. terminata*, *Tetragonula fuscobalteata* and *T. laeviceps* (Kelly et al., 2014). Among the five species of stingless bee that have been commercialized in Malaysia, only two species were chosen as an alternative pollinator to the star fruit tree based on their high abundance and popularity among the stingless beekeepers in Malaysia (Salim et al., 2012: Farisya and Thevan, 2015; Hamid et al., 2016). This research mainly focused on the foraging behaviour of two stingless bee species, i.e. *G. thoracica* which is one of the largest stingless bee species in Malaysia and *H. itama* which is the most abundant stingless bees found in orchard. Moreover, there is still a lack in knowledge on many aspects of the foraging behaviours of these bees to confirm their potential as efficient pollinators of many crops especially star fruit.

In order to use stingless bee as a potential pollinator of the target crop, their biological and ecological aspects like foraging behaviours toward potential crops need to be further investigated as the related research is still very limited as compared to those done on honey bees (Heard and Dollin, 2015). Thus, the study of some aspects foraging behaviours of *G. thoracica* and *H. itama* as potential pollinators of star fruit was conducted.

Star fruit was chosen as the target crop in this study as there is a high preference for the crop by the two bee species (Norowi et al., 2010). However, Norowi et al. (2010) did not provide any statistical data to support such statement which was made solely based on

their observations in the field. Thus, this study was conducted to confirm whether these two bee species had a higher preference for the star fruit flowers and hence become the potential pollinators of this crop in open orchards and netting system.

In order to use stingless bees to serve as a potential pollinator of the target crop, like star fruit, their foraging behaviours need to be further investigated as the related research is still very limited especially in Malaysia as compared to those done on honey bees. Thus, this study was conducted to examine the foraging behaviour of two stingless bee species. namely *Heterotrigona itama* and *Geniotrigona thoracica* as a potential pollinators of star fruit**.**

1.3 Objectives of the Study

The general objective or scope of the study was to investigate some aspects of foraging behaviours of *G. thoracica* and *H. itama* bees as a potential pollinator of the star fruit crop. The specific objectives are:

i. To investigate the foraging activities of two selected stingless bee species, *G. thoracica* and *H. itama* in relation to seasonal factors and abiotic factors;

ii. To determine the pollen resources taken by *G. thoracica* and *H. itama* and construct the pollen profile as a baseline data;

iii. To assess the performance and compare the flower visitation rate of *G. thoracica* and *H. itama* on the star fruit (*Averrhoa carambola*) flowers.

1.4 Significance of the Study

This research would contribute to the knowledge on foraging behaviour of stingless bee species in Malaysia, i.e., *G. thoracica* and *H. itama* as the potential alternative pollinators which can generate income to the bee farmers either in term of stingless bee honey production and increasing in their crop yields resulted from successful pollination services provided by these stingless bees. Mustafa et al. (2018) reported that 36% and 29% of stingless bee keepers have generate additional income of RM833 and RM1,666 monthly, respectively with stingless bee honey production. Hence, this encouraged the bee keepers to cultivate a variety of crops so as to provide continuous supply of nectar and pollen in a way to increase honey production. The result of this research will facilitate the bee farmers to develop a better management approach on these potential pollinators of their target crops. The daily and monthly patterns with respect to foraging activities of *G. thoracica* and *H. itama* will provide information to the beekeepers on the right time to apply insecticide or fungicide to their crops, if any, and to sustain the

stingless bees' colonies for pollination based on the number of individual bees hovering at the entrance of the colony. The result pertaining to seasonal changes in the bees' foraging behaviour will aid the beekeepers to pay more attention on colony sustainability. Melissopalynology or pollen analysis using pollen samples collected from corbiculae of the bees will provide information on the type of flowers favoured by stingless bees. The study on flower visitation rate of *G. thoracica* and *H. itama* on star fruit flowers will allow beekeepers to assess the suitable stingless bee species to be used as a pollinator of this crop.

REFERENCES

Abou-Shaara, H. F., Al-Ghamdi, A. A. & Mohamed, A. A. (2012). Tolerance of two honey bee races to various temperature and relative humidity gradients. *Environmental and Experimental Biology*, 10: 133–138.

Abrol, D.P. (2013). Pollination biology. In Asiatic Honey bee, *Apis cerana: In Biodiversity Conservation and Agricultural Production* (Ed), (pp 509-574). Springer publication No.34, New York.

Ackerman, J.D., (2000). Abiotic pollen and pollination: Ecological, functional, and evolutionary perspectives. *Plant Systematics and Evolution*, 222: 167–185.

Akter, A., Biella, P., & Klecka, J. (2017). Effects of small-scale clustering of flowers on pollinator foraging behaviour and flower visitation rate. *PLoS ONE*, 12.

Albano, S. & Salvado, E. & Borges, Paulo & Mexia, Antonio. (2009). Floral visitors, their frequency, activity rate and index of visitation rate in the strawberry fields of Ribatejo, Portugal: Selection of potential pollinators. Part 1. *Advances in Horticultural Science*, 23: 238-245.

Aleixo, K.P., Menezes, C., & Imperatriz Fonseca, V.L. (2017). Seasonal availability of floral resources and ambient temperature shape stingless bee foraging behavior (*Scaptotrigona aff. depilis*). *Apidologie* 48: 117–127.

Amano, K., Nemoto, T. & Heard, T.A. (2000). What are stingless bees, and why and how to use them as crop pollinators? – A review. *The Japan Agricultural Research Quarterly*, 34: 183–190.

Amarasekare, P. (2002). Interference Competition and Species Coexistence. *Proceedings: Biological Sciences* 269(1509):2541-2550.

Antonini, Y., Martins, R. P., Aguiar, L. M. & Loyola, R. D. (2012). Richness, composition and trophic niche of stingless bee assemblages in urban forest remnants. *Urban Ecosystems*, 16(3): 527-541.

Appanah, S. (1982). Pollination of androdioecious *Xerospermum intermedium* Radlk. (Sapindaceae) in a rain forest. *Biological Journal of the Linnean Society*, 18: 11–34.

Appanah, S. (1993). Mass flowering of dipterocarp forests in the aseasonal tropics. *Journal of Bioscience*, 18: 457–474.

Appanah, S., Willemstein, S.C. & Marshall, A.G. (1986). Pollen foraging by two *Trigona* colonies in a Malaysian rainforest. *Malayan Nature Journal*, 39: 177–191.

Araujo E.D., Costa M., Chaud-Netto J., & Fowle H.G. (2004). Body size and flight distance in stingless bees (Hymenoptera: Meliponini): Inference of flight range and possible ecological implications, *Brazilian Journal Biology*, 64 :563–568.

Balfour, Nicholas & Gandy, Sam & Ratnieks, Francis. (2015). Exploitative competition alters bee foraging and flower choice. *Behavioral Ecology and Sociobiology*, 69 :1731-1738.

Basari, N., Ramli, S. N., & Mohd Khairi, N. (2018). Food reward and distance influence the foraging pattern of stingless bee, *Heterotrigona itama*. *Insects*, 9(4): 138.

Bhargava, H.R., Jyothi, J.V.A., Bhushanam, M. & Surendra, N.S. (2009): Pollen Analysis of *Apis* honey, Karnataka, India. *Apiacta* 4

Biesmeijer J.C. & van Nieuwstadt M.G.L. (1997). Colony foraging patterns of stingless bees in Costa Rica, with special reference to pollen, In *The Organisation of Foraging in Stingless Bees of the Genus Melipona, dissertation Utrecht University, The Netherlands*, pp. 35–57.

Biesmeijer, J.C. & Tóth, E. (1998). Individual foraging, activity level and longevity in the stingless bee *Melipona beecheii* in Costa Rica (Hymenoptera, Apidae, Meliponinae). *Insectes Sociaux,* 45: 427– 443.

Biesmeijer, J.C. & Ermers, M. (1999). Social foraging in stingless bees: how colonies of *Melipona fasciata* choose among nectar sources. *Behavioral Ecology and Sociobiology,* 46: 129–140.

Biesmeijer J.C. & de Vries, H. (2001). Exploration and exploitation of food sources by social insect colonies: a revision of the scout-recruit concept. *Behavioral Ecology and Sociobiology,* 49: 89–99.

Biesmeijer, J., & Slaa, J. E. (2004). Information flow and organization of stingless bee foraging. *Apidologie*, 35 (2) :143-157.

Biesmeijer, J., Slaa, J. & Koedam, D. (2007). How stingless bees solve traffic problems. *Entomologische Berichten*, 67: 7-13.

Biesmeijer, J. C., Slaa, E. J., Castro, M. S., Viana, B. F., Kleinert, A. M. P. & 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*, 5: 1–8.

Biurrun, I., Burrascano, S., Dembicz, I., Guarino, R., Kapfer, J., Pielech, R., García-Mijangos, I., Wagner, V., Palpurina, S. & Dengler, J. (2019). GrassPlot v. 2.00 – frst update on the database of mult-scale plant diversity in Palaearctc grasslands. *Palaearctc Grasslands* 44: 26–47.

Bosch, Jordi & Vicens, Narcís. (2006). Relationship between body size, provisioning rate, longevity and reproductive success in females of the solitary bee *Osmia cornuta*. *Behavioral Ecology and Sociobiology,* 60. 26-33.

Brodschneider, R., Gratzer, K., Kalcher-Sommersguter, E., Heigl, H., Auer, W., Moosbeckhofer, R., & Crailsheim, K. (2019). A citizen science supported study on seasonal diversity and monoflorality of pollen collected by honey bees in Austria. *Scientific Reports* 9:16633

Brosi, B. J. (2009). The complex responses of social stingless bees (Apidae: Meliponini) to tropical deforestation. *Forest Ecology and Management,* 258: 1830–1837.

Bruijn, L.L.M. & Sommeijer, M.J. (1997). Colony foraging in different species of stingless bees (Apidae, Meliponinae) and the regulation of individual nectar foraging. *Insectes Sociaux* 44: 35–47.

Brunet, J. (2019). Pollinator Decline: Implications for Food Security & Environment. *Scientia* 371.

Cameron, P. (1901). On the Hymenoptera collected during the "Skeat Expedition" to the Malay Peninsula, 1899–1900. *Proceedings of the Zoological Society of London,* 1901: 16–44.

Cameron, P. (1902). On the Hymenoptera collected by Mr. Robert Shelford at Sarawak, and on the Hymenoptera of the Sarawak Museum. *Journal of the Straits Branch of the Royal Asiatic Society,* 37: 29–131.

Cameron, P. (1908). On some bornean species of *Trigona* (Apidae). *The Entomologist,* 41: 192–195.

Campbell, D.R. & Motten, A.F. (1985). The mechanism of competition between two forest herbs. *Ecology,* 66: 554–563.

Chen, L. J., Liu, K. W., Xiao, X. J., Tsai, W. C., Hsiao, Y. Y., Huang, J., & Liu, Z. J. (2012). The anther steps onto the stigma for self-fertilization in a slipper orchid. *PloS one,* 7(5): 374-378.

Cockerell, T.D.A. (1918). Descriptions and records of bees - LXXX. *Annals and Magazine of Natural History,* 2: 384–390.

Cockerell, T.D.A. (1929). Descriptions and records of bees - CXX. *Annals and Magazine of Natural History,* 4: 584–594.

Contreras-Oliva, A., Perez-Sato, J. A., Gómez-Merino, F. C., López-Garay, L. A., Villanueva-Gutierrez, R., Crosby-Galván, M. M. & Trejo-Téllez, L. I. (2018). Characterization of *Scaptotrigona mexicana* pot-pollen from Veracruz, Mexico. In P. Vit et al. (Eds.), *Pot-Pollen in Stingless Bee Melittology* (pp. 325-337). Berlin, Germany: Springer, Cham.

Corbet, S.A., Fussell, M., Ake, R., Fraser, A. & Gunson, C. (1993). Temperature and the pollinating activity of social bees. *Ecological Entomology,* 18: 17-30.

Cortopassi-Laurino, M. & Ramalho, M. (1988). Pollen harvest by Africanized *Apis mellifera* and *Trigona spinipes* in São Paulo. *Botanicals and ecological views,* 19: 1–24.

Cortopassi-Laurino, M., Imperatriz-Fonseca, V. L., Roubik, D. W., Dollin, A. & Heard, T. (2006). Global meliponiculture: challenges and opportunities. *Apidologie,* 37 (2): 275-292.

Couvillon, M., Walter, C., Blows, E., Czaczkes, T., Alton, K., & Ratnieks, F. (2015). Busy Bees: Variation in Insect Flower-Visiting Rates across Multiple Plant Species. *Psyche* 10:34630.

Danaraddi, C.S., Hakkalappanavar, S., Biradar, S.B., Tattimani, M., Vinod, S.K. (2011). Studies on foraging behaviour of stingless bee, *Trigona iridipennis* Smith at Dharwad, Karnataka. *International Journal for Crop Improvement*, 2 :163–169.

Dantas, M. (2016). Thermogenesis in stingless bees: An approach with emphasis on brood's thermal contribution. *Journal of Animal Behaviour and Biometeorology*, 4: 101-108.

Darwin. (1876). *The effects of cross and self-fertilization in the vegetable kingdom*. London: John Murray.

Dasgupta, P., Chakraborty, P., & Bala, N. N. (2013). *Averrhoa carambola*: an updated review. *International Journal of Pharmacy Research & Review*, 2(7): 54-63.

Delgado-Carrillo, O., Marten-Rodrıguez, S., Ashworth, L., Aguilar, R., Lopezaraiza-Mikel, M. & Quesada, M. ()2018). Temporal variation in pollination services to *Cucurbita moschata* is determined by bee gender and diversity. *Ecosphere* 9(11) :1-16.

Denno, R., McClure, M., & Ott, J. (2003). Interspecific Interactions in Phytophagous Insects: Competition Reexamined and Resurrected. *Annual Review of Entomology*, 40:297-331.

Department of Agriculture (DOA). (2012). Fruit Crop Statistics of Malaysia 2012. Putrajaya: Department of Agriculture.

Department of Agriculture (DOA). (2014). *Technical Document for Market Access on Star Fruit (Carambola)*. Putrajaya: Crop Protection & Plant Quarantine Services Division.

Department of Agriculture (DOA). (2018). *Phytosanitary Requirements for Exportation of Horticulture Produce from Malaysia*. Putrajaya: Department of Agriculture.

Deparment of Agriculture (DOA). (2019). *Booklet Statistik Tanaman (Sub-Sektor Tanaman Makanan)*: Department of Agriculture.

Dewirman, P. P., Dahelmi, Salmah, S., & Swasti, E. (2017). Daily flight activity of *Trigona laeviceps* and *T. minangkabau* in red pepper (*Capsicum annuum* L.) plantations in low and high lands of West Sumatra. *International Journal of Applied Environmental Sciences* 12(8) :1497-1507.

Di Pasquale G, Alaux C, Le Conte Y, Odoux J-F, Pioz M. & Vaissière, B.E. (2016) Variations in the Availability of Pollen Resources Affect Honey Bee Health. *PLoS ONE* 11(9).

Dicenta, F., Ortega, E., Cánovas, J. A. & Egea, J. (2001). Self-pollination versus cross-pollination of six self-compatible almond cultivars: Pollen tube growth and fruit set. In B. E. Ak (Ed.) *XI GREMPA Seminar on Pistachios and Almonds* (pp. 369-372). Zaragoza: Cahiers Options Méditerranéennes.

Ebeling, Anne & Klein, Alexandra & Schumacher, Jens & Weisser, Wolfgang & Tscharntke, Teja. (2008). How does plant richness affect pollinator richness and temporal stability of flower visits? *Oikos*, 117 :1808 - 1815.

Eeraerts, M., Vanderhaegen, R., Smagghe, G. & Meeus, I. (2020). Pollination efficiency and foraging behaviour of honey bees and non-Apis bees to sweet cherry. *Agricultural and Forest Entomology* 22: 75-82.

Elizabeth, L. & Scott, R. (2002). The mechanisms of pollination and fertilization in plants. *Annual Review of Cell and Developmental Biology*. 18. 81-105.

Eltz, T. (2002). Ecology of Stingless Bees (Apidae, Meliponini) in Lowland Dipterocarp Forests in Sabah, Malaysia, and an Evaluation of Logging Impact on Populations and Communities. PhD Thesis, Bavarian Julius Maximilians University of Würzburg.

Eltz, T., Brühl, C.A., Imiyabir, Z. & Linsenmair, K.E. (2003). Nesting and nest trees of stingless bees (Apidae: Meliponini) in lowland dipterocarp forests in Sabah, Malaysia, with implications for forest management. *Forest Ecology and Management*, 172: 301-313.

Essernberg, C. J. (2013). Explaining the effects of floral density on flower visitor species composition. *The American Naturalist* 181(3).

Faegri, K., & Van der Pijl, L. (1979). *The principles of pollination ecology*. Pergamon Press Oxford.

Fewell, J.H. & Winston, M. L. (1996). Regulation of nectar collection in relation to honey storage levels by honey bees, *Apis mellifera*. *Behavioral Ecology*, 7(3): 286-291.

Fewell, J.H. & Winston, M.L. (1992). Colony state and regulation of pollen foraging in the honey bee, *Apis mellifera* L. *Behavioral Ecology and Sociobiology*, 30: 387–393.

Fidalgo, A. O. & Kleinert, A. M. P. (2007). Foraging behavior of *Melipona rufiventris* Lepeletier (Apinae; Meliponini) in Ubatuba, SP, Brazil. *Brazilian Journal of Biology*, 67(1): 133-140.

Fidalgo, A. O. & Kleinert, A. M. P. (2010). Floral preferences and climate influence in nectar and pollen foraging by *Melipona rufiventris* Lepeletier (Hymenoptera: Meliponini) in Ubatuba, Sao Paulo State, Brazil. *Neotropical Entomology*, 39: 879-884.

Figueiredo-Mecca, G., Bego, L. & Nascimento, F.S. (2013) Foraging behaviour of *Scaptotrigona depilis* (Hymenoptera, Apidae, Meliponini) and its relationship with temporal and abiotic factors. *Sociobiology* 60, 277–282

Food and Agriculture Organization of the United Nations (FAO). (2015). Retrieved from http://www.fao.org/pollination/en/

Fülöp, A., & Menzel, R. (2000). Risk-indifferent foraging behaviour in honeybees. *Animal behaviour*, 60: 657-666.

Fumero-Caban, J. J. & Melendez-Ackerman, E. J. (2007). Relative pollination effectiveness of floral visitors of Pitcairnia angustifolia (Bromeliaceae). American Journal of Botany 94(3): 419-424

Galán-Saúco, V. & Farré-Massip, J. M. (2005). Tropical and subtropical fruits in Spain. *Acta Horticulturae*, 694: 259-264.

Garbuzov, M., & Ratnieks, F.L.W. (2014). Quantifying variation among garden plants in attractiveness to bees and other flower-visiting insects. Functional Ecology, 28(2):364-374.

Gebremedhn, H., Tadesse, A. & Belay T. (2014). Relating climatic factors to foraging behaviour of honeybees (*Apis mellifera*) during blooming period of *Guizotia abyssinica* (L.F.). *Livestock Research for Rural Development*, 26.

Ghazi, R., Zulqurnain, N.S. & Azmi, W.A. (2018) Melittopalynological studies of stingless bees from the east coast of Peninsular Malaysia. In Vit P., Pedro S., Roubik D. (Eds.) *Pot-Pollen in Stingless Bee Melittology* (pp. 77-88). Berlin, Germany: Springer, Cham.

Greco, M., Spooner-Hart, R., Beattie, A., Barchia, I. & Holford, P. (2011). Australian stingless bees improve greenhouse Capsicum production. *Journal of Apicultural Research* 50: 102-115.

Greenleaf, S. S., Williams, N. M., Winfree, R., and Kremen, C. (2007). Bee foraging ranges and their relationship to body size. *Oecologia* 153: 589–596.

Grüter, C. (2020). *Stingless bees, Their Behaviour, Ecology and Evolution*. Springer, Cham, Springer Nature Switzerland.

Gojmerac, W., L. (1983). *Bee, beekeping honey and pollination*. Avi Publishing Company, Inc., Westport, Connecticut.

Goulson, D. (1999). Foraging strategies of insects for gathering nectar and pollen, and implications for plant ecology and evolution. *Perspectives in Plant Ecology, Evolution and Systematics*, 2(2): 185–209.

Goulson, Dave & Sparrow, Kate. (2008). Evidence for competition between honeybees and bumblebees; effects on bumblebee worker size. *Journal of Insect Conservation* 13. 177-181.

Gow, M. S., & Gimenes, M. (2013). Differences of the daily flight activity rhythm in two neotropical stingless bees (Hymenoptera, Apidae). *Sociobiology* 60(2):183-189.

Halcroft, M., Haigh, A. & Spooner-Hart. R. (2013a). Ontogenic time and worker longevity in the Australian stingless bee, *Austroplebeia australis*. *Insectes Sociaux*, 60: 259-264.

Halcroft, M., Spooner-Hart. R., & Dollin, A. (2013b). Australian Stingless Bees. In P. Vit, S.R.M. Pedro & D. Roubik (Eds.), *Pot-honey: a legacy of stingless bees* (pp 35–72). New York: Springer.

Halcroft, M., Spooner-Hart. R., Haigh, A., Heard, T. & Dollin, A. (2013c). The Australian stingless bee industry: A follow-up survey, one decade on. *Journal of Apicultural Research*, 52(2): 1-7.

Hamid, S. A., Salleh, M. S., Thevan, K. & Hashim, N. A. (2016). Distribution and morphometrical variations of stingless bees (Apidae: Meliponini) in urban and forest areas of Penang Island, Malaysia. *Journal of Tropical Resources and Sustainable Science*, 4: 1–5.

Harder, L. D. (1998). Pollen-size comparisons among animal pollinated angiosperms with different pollination characteristics. *Biological Journal of the Linnean Society*, 64: 513–525.

Hart A.G., & Ratnieks F.L.W. (2002) Task-partitioned nectar transfer in stingless bees: work organisation in a phylogenetic context, *Ecology Entomology* 27, 163–168.

Hartfelder K., Makert G. R., Judice C. C., Pereira G. A., Santana W. C. (2006). Physiological and genetic mechanisms underlying caste development, reproduction and division of labor in stingless bees. *Apidologie* 37 (2) : 144-163.

Hashim, N., Janius, R., Osman, R., & Othman, J. (2017). Variability and Predictability of Malaysian Export-Grade Star fruit Properties. *Journal of Engineering Science and Technology* 12(2): 460 – 470.

Heard, T. (1999). The role of stingless bees in crop pollination. *Annual Review of Entomology*, 44:183-206.

Heard, T. (2001). Stingless bees and crop pollination. *Annual Review of Entomology* 82: 110-112.

Heard, T. (2016). *The Australian native bee book*. West End: Sugarbag Bees.

Heard, T.A. & Exley, E.M. (1994). Diversity, abundance, and distribution of insect visitors to macadamia flowers. *Environmental Entomology*, 23(1): 91–100.

Heard, T., & Dollin, A. (2000). Stingless bee keeping in Australia: Snapshot of an infant industry. *Bee World*, 8: 116-125.

Heithaus, E. R. (1979a). Flower visitation records and resource overlap of bees and wasps in Northwest Costa Rica. *Brenesia,* 16: 9–52.

Heithaus, E. R. (1979b). Flower-feeding specialization in wild bee and wasp communities in seasonal Neotropical habitats. *Oecologia,* 42: 179–194.

Hidalgo, H., Nicolas, A., & Cedon, R. (2020). Development Barriers of Stingless Bee Honey Industry in Bicol, Philippines. *International Journal on Advanced Science, Engineering and Information Technology,* 10 :1254.

Hilário, S.D., Imperatriz-Fonseca, V.L., & Leinert, A.M.P. (2000). Flight activity and colony strength in the stingless bee *Melipona bicolor bicolor* (Apidae, Meliponinae). *Revista Brasileira de Biologia*, 60: 299–306.

Hilário, S.D., Imperatriz-Fonseca, V.L., & Leinert, A.M.P. (2001). Responses to climatic factors by foragers of *Plebeia pugnax* Moure (in litt.) (Apidae, Meliponinae). *Revista Brasileira de Biologia*, 61: 191–196.

Hofstede, F. E. & Sommeijer, M. J. (2006). Effect of food availability on individual foraging specialisation in the stingless bee *Plebeia tobagoensis* (Hymenoptera, Meliponini). *Apidologie*, 37(3): 387-397.

Inoue, T., Salmah, S. & Abbas, I. (1985). Foraging behaviour of individual workers and foraging dynamics of colonies of three Sumatran stingless bees. *Researches on Population Ecology*, 27: 373–392.

Inoue, T., Yumoto, T., Hamid, A. A., Lee, H. S. & Ogino, K. (1995). Construction of a canopy observation system in a tropical rainforest of Sarawak. *Selbyana,* 16(1): 24-35.

Jaapar, M., F., Halim, M., Mispan, R. M., Jajuli, R., Saranum, M.M., Zainuddin, M. Y., Ghazi, R. & Idris, A. G. (2016). The diversity and abundance of stingless bee (Hymenoptera: Meliponini) in Peninsular Malaysia. *Advances in Environmental Biology*, 10(9) :1-7.

Jaapar, M., Jajuli, R., Radzali, M. & Idris, A.B. (2018). Foraging behavior of stingless bee *Heterotrigona itama* (Cockerell, 1918) (Hymenoptera: Apidae: Meliponini). AIP Conference Proceedings. 1940. 10.1063/1.5027952. J. Biogeogr., 42 (2014), pp. 589-601.

Jacobo, J. (2019, July 9). Nearly 40% decline in honey bee population last winter 'unsustainable,' experts say. Retrieved from https://abcnews.go.com/US/40-decline-honey-bee-population-winter-unsustainable-experts/story?id=64191609.

Jauker, B., Krauss, J., Jauker, F. & Steffan-Dewenter, I. (2013). Linking life history traits to pollinator loss in fragmented calcareous grasslands. *Landscape Ecology*, 28: 107–120.

Johnson, L. K., (1983). Foraging strategies and the structure of stingless bee communities in Costa Rica. *Social Insect Tropical*, 2:31-58.

Johnson, S. D. & Anderson, B. (2010). Coevolution between food-rewarding flowers and their pollinators. *Evolution: Education and Outreach*, 3: 32-39.

Joshi, N. C., & Joshi, P. C. (2010). Foraging Behaviour of *Apis* spp. on Apple flowers in a subtropical environment. *New York Science Journal* 3: 71-76.

Kacelnik, A., Houston, A.I., & Schmid-Hempel, P. (1986). Central-place foraging in honey bees: The effect of travel time and nectar flow on crop filling. *Behavioral Ecology and Sociobiology* 19 :19-24.

Kahono, S., Chantawannakul, P., & Engel, M. (2018). Social Bees and the Current Status of Beekeeping in Indonesia. 10.1007/978-981-10-8222-1_13.

Kaluza, B. F., Wallace, H., Heard, T. A., Klein, A. M., & Leonhardt, S. D. (2016). Urban gardens promote bee foraging over natural habitats and plantations. *Ecology and Evolution*, 6(5).1304-1316.

Kaluza, B., Wallace, H., Heard, T., Minden, V., Klein, A., & Leonhardt, S. (2018). Social bees are fitter in more biodiverse environments. *Scientific Reports*, 8.

Kajobe, R. & Echazarreta, C.M. (2005) Temporal resource partitioning and climatological influences on colony flight and foraging of stingless bees (Apidae; Meliponini) in Ugandan tropical forests. *African Journal of Ecology* 43: 267–275.

Kasper, M.L., Reeson, A.F., Mackay, D.A., & Austin, A.D. (2008). Environmental factors influencing daily foraging activity of *Vespula Germanica* (Hymenoptera, Vespidae) in Mediterranean Australia. *Insectes Soc* 55:288–295

Kearns, C. A. & Inouye, D. W. (1997). Pollinators, flowering plants, and conservation biology. *BioScience*, 47: 297-307.

Kehrberger, S., & Holzschuh, A. (2019). How does timing of flowering affect competition for pollinators, flower visitation and seed set in an early spring grassland plant? *Scientific Reports*, 9. 15593.

Kelly, N., Farisya, M. S. N., Kumara, T. K. & Marcela, P. (2014). Species diversity and external nest characteristics of stingless bees in Meliponiculture. *Pertanika Journal Tropical Agricultural Science*, 37(3): 293–298.

Kendall, L. K., Gagic, V., Evan, L. J., Cutting, B. T., Scalzo, J., Hanusch, Y., Jones, J., Rocchetti, M., Sonter, C., Keir, M. & Rader, R. (2020). Self-compatible blueberry cultivars require fewer floral visits to maximize fruit production than a partially self-incompatible cultivar. *Journal of Applied Ecology*. 1-9.

Keppner, E., & Jarau, S. (2016). Influence of climatic factors on the flight activity of the stingless bee *Partamona orizabaensis* and its competition behaviour at food sources. *Journal of Comparative Physiology A.* 202.

Kiew, R., Muid, M. 1991.*Beekeeping in Malaysia: Pollen Atlas*. *Malaysian Beekeeping.* Research and Development Team, University Pertanian; Selangor, Malaysia; 186 p

Kishan Tej, M., Srinivasan, M.R., Vijayakumar, K., Natarajan, N. & Mohan Kumar, S. (2017). Morphometry analysis of stingless bee *Tetragonula iridipennis* Smith (1854). *International Journal* of *Current* Microbiology and *Applied* Sciences, 6(10): 2963-2970.

Klein, A.-M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C. & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. *Proceedings of the Royal Society B: Biological Sciences*, 274(1608): 303-313.

Klein, S., Pasquaretta, C. & He, X.J. (2019). Honey bees increase their foraging performance and frequency of pollen trips through experience. *Scientific Reports* 9, 6778.

Kleinert-Giovannini A. (1982). The Influence of Climatic Factors on Flight Activity of *Plebeia Emerina* Friese (Hymenoptera, Apidae, Meliponinae) in Winter. *Revista Brasileira de Entomologia* 26:1–13.

Kramer, D. L. (2001). Foraging behaviour. In C. W. Fox et al. (Eds.) *Evolutionary Ecology: Concepts and Case Studies* (pp. 232-246). New York: Oxford University Press.

Kremen, C., Williams, N. M. & Thorp, R. W. (2002). Crop pollination from native bees at risk from agricultural intensification. *Proceedings of the National Academy of Sciences of the United States of America*, 99(26): 16812-16816.

Kuhn-Neto, B., & Contrera, F., Castro, M., & Nieh, J. (2009). Long distance foraging and recruitment by a stingless bee, *Melipona mandacaia*. Apidologie. 40. 472-480.

Layek, U., Kundu, A., Bisui, S. & Karmakar, P. (2021). Impact of managed stingless bee and western honey bee colonies on native pollinators and yield of watermelon: A comparative study. *Annals of Agricultural Sciences*, 66(1): 38-45.

Lee, S. S., Norsham, S, Y., Boon, K. S. & Chua, L. S. L. (2002). The role of selected animals in. pollination and dispersal of trees in the forest: implications for conservation and management. *Journal of Tropical Forest Science*, 14(2): 234-263.

León, A., Arias-Castro, C., Rodríguez-Mendiola, M., Meza-Gordillo, R., Gutiérrez-Miceli, F. & Nieh, J. (2015). Colony foraging allocation is finely tuned to food distance and sweetness even close to a bee colony. *Entomologia Experimentalis et Applicata*, 155: 47–53.

Leonhardt, S. D., Dworschak, K., & Eltz, T., & Nico, B. (2007). Foraging loads of stingless bees and utilisation of stored nectar for pollen harvesting. *Apidologie* 38(2): 125-135.

Lihoreau M, Raine, N.E., Reynolds, A.M., Stelzer, R.J., Lim, K.S., Smith, A.D. (2012) Radar Tracking and Motion-Sensitive Cameras on Flowers Reveal the

Development of Pollinator Multi-Destination Routes over Large Spatial Scales. *PLoS Biol* 10(9): e1001392.

Lindauer, M. & Kerr W.E. (1960) Communication between the workers of stingless bees, *Bee World* 41, 29–41; 65–71.

Liskens, H.F., & Jorde, W. (1997). Pollen as food and medicine—A review. *Economic Botany* 51**,** 78.

Lob, S., Norezienda, A., Shamsul Bahri A.R., Nurul Faziha, I., & Iffah Hazirah, M.N. (2017). Composition and identification of pollen collected by stingless bee (*Heterotrigona itama*) in forested and coastal area of Terengganu, Malaysia. *Malaysian Applied Biology*, 46(3): 227–232.

Lord, E.M. & Russell, S.D. (2002). The mechanisms of pollination and fertilization in plants. *Annual Review of Cell and Developmental Biology*, 18: 81–105.

Macarthur, R., & Pianka, A. E. (1966). On optimal use of a patchy environment. *The American Naturalist* 100:916

Mach, B.M., Potter, D.A. (2018). Quantifying bee assemblages and attractiveness of flowering woody landscape plants for urban pollinator conservation. *PLoS ONE* 13(12): 1-18.

Machado, T., Viana, B.F. & da Silva, C.I. (2020) How landscape composition affects pollen collection by stingless bees? *Landscape Ecology* 35, 747–759.

Macias-Macias J.O., Tapia-Gonzalez, J.M., & Contreras-Escareno, F. (2017). Foraging behaviour, environmental parameters and nests development of *Melipona colimana* Ayala (Hymenoptera: Meliponini) in temperate climate of Jalisco, México. *Brazilian Journal of Biology* 77:383-387.

Maia-Silva C., Hrncir, M., Silva C.I., & Imperatriz-Fonseca, V.L. (2015). Survival strategies of stingless bees (*Melipona subnitida*) in an unpredictable environment, the Brazilian tropical dry. *Apidologie* 46:631–643.

Manda, H., Vyas, K., Pandya, A., & Singhal, G. (2012). Complete review on *Averrhoa carambola*. *World Journal of Pharmacy and Pharmaceutical Sciences,* 1(1): 17-33.

Marques-Souza, A. C., Oliveira Moura, C., & Nelson, B. W. (1996). Pollen collected by *Trigona williana* (Hymenoptera: Apidae) in Central Amazonia. *Review Biology Tropical*, 44(2): 567-573.

Marquez-Souza, A. C., Absy, M. L., & Kerr, W.E. (2007). Pollen harvest features of the Central Amazonian bee *Scaptotrigona fuvicutus* Moure 1964 (Apidae: Meliponinae), in Brasil. *Acta Botanical Brasil* 21:11-20.

Meléndez-Ramírez, V., Parra-Tabla, V., Kevan, P. G., Ramírez-Morillo, I., Harries, H., Fernández-Barrera, M., & Zizumbo-Villareal. V. (2004). Mixed mating strategies and pollination by insects and wind in coconut palm (Cocos nucifera L. (Arecaceae)): importance in production and selection. *Agriculture and Forest Entomology*, 6(2):155-163.

Michener, C.D. (1974). *The social behaviour of the bees*. Harvard University Press, Cambridge, MA, xii+404.

Michener, C. D. (2003). The social behavior of bees. A comparative study. *Annual Review of Entomology*, 14(1): 299-342.

Michener, C. D. (2007). *The bees of the world.* The Johns Hopkins University Press, Baltimore.

Michener, C.D. (2013). The Meliponini. In P. Vit, S.R.M. Pedro & D. Roubik (Eds.), *Pot-honey: a legacy of stingless bees* (pp 3–17). New York: Springer.

Miller-Struttmann, N.E., Geib, J.C., Franklin, J.D., Kevan, P.G., Holdo, R.M., Ebert-May, D., Lynn, A.M., Kettenbach, J.A., Hedrick, E. & Galen, C. (2015). Functional mismatch in a bumble bee pollination mutualism under climate change. *Science*, 349(6255):1541-1544.

Mohammad, S.M., Mahmud-Ab-Rashid, N., & Zawawi, N. (2020). Botanical origin and nutritional values of bee bread of stingless bee (*Heterotrigona itama*) from Malaysia. *Journal of Food Quality*, 2020: 1-12.

Mohd Fahimee Jaapar, Halim, M., Mispan, M. R., Jajuli, R., Saranum, M. M., Zainuddin, M. Y., Ghazi, R. & Idris, A. G. (2016). The diversity and abundace of stingless bee (Hymenoptera: Meliponini) in Peninsular Malaysia. *Advance in Environmental Biology*, 10(9): 1–7.

Mohd Fauzi, M. J. & Tih, S. (2010). Potential of selected Malaysian tropical fruits in Europe: strategic framework to penetrate EU market. *Journal of Agribusiness Marketing*, Special Edition: 1-27.

Mohd Mansor, I., & Wan Iryani W. I., (2018). Development of stingless beekeeping projects in Malaysia. *E3S Web of Conferences* 52:1-5.

Mohd Yasin, N., Ahmad, M. S., Aziz, N. A. & Ahmad, A. K. (2008). Exploratory study in assessing the market potential and distribution network of selected tropical fruits in Europe. *Journal of Agribusiness Marketing*, 1(12): 1-16.

Momose, K., Yumoto, T., Nagamitsu, T., Makoto, K., Nagamasu, H., Sakai, S., Harrison, R., Hamid, A., & Inoue, T. (1998). Pollination Biology in a Lowland Dipterocarp Forest in Sarawak, Malaysia. I. Characteristics of the Plant-Pollinator Community in a Lowland Dipterocarp Forest. *American Journal of Botany*, 85: 1477-1501.

Morris, R.J., Lewis, O., Charles, H., & Godfray, J. (2005). Apparent competition and insect community structure: towards a spatial perspective. *Annales Zoologici Fennici, 42*: 449-462.

Mukherjee, N., Sutherland, W.J., Dicks, L., Hugé, J., Koedam, N. & Dahdouh-Guebas, F. (2014). Ecosystem service valuations of mangrove ecosystems to inform decision making and future valuation exercises. *PLoS ONE*, 9(10): 1–9.

Mustafa, M. Z., Yaacob, N. S. & Sulaiman, S. A. (2018). Reinventing the honey industry: Opportunities of the stingless bee. *Malaysian Journal of Medical Sciences*, 25(4): 1-5.

Nagamitsu, T. & Inoue, T. (2002). Foraging activity and pollen diets of subterranean stingless bee colonies in response to general flowering in Sarawak, Malaysia. *Apidologie*, 33(3): 303-314.

Nagamitsu, T. & Inoue, T. (2005). Floral resource utilization by stingless bees (Apidae, Meliponini). In D.W. Roubik, S. Sakai, A.A. Hamid Karim (Eds.) *Pollination Ecology and the Rain Forest. Ecological Studies (Analysis and Synthesis)* (pp. 73-88). New York: Springer.

Nagamitsu, T., & Inoue, T. (2006). Floral resource utilization by stingless bees (Apidae, Meliponini). *In book: Pollination Ecology and the Rain Forest* (pp.73-88). Springer.

Nagamitsu, T., Momose, K., Inoue, T. & Roubik, D.W. (1999). Preference in flower visits and partitioning in pollen diets of stingless bees in an Asian tropical rain forest. *Researches on Population Ecology*, 41: 195–202.

Nascimento, D. L., & Nascimento, F. S. (2012). Extreme effects of season on the foraging activities and colony productivity of a stingless bee (*Melipona asilvai* Moure, 1971) in Northeast Brazil. *Psyche: A Journal of Entomology*. Article ID 267361, 6 p.

Nicholls, C. I. & Altieri, A. (2013). Plant biodiversity enhances bees and other insect pollinators in agroecosystems. A review. *Agronomy Sustainable Development*, 33:257-274.

Nieh J.C. (1999) Stingless-bee communication. *America Science*, 87, 428–435.

Nieh, J. C. (2004). Recruitment communication in stingless bees (Hymenoptera, Apidae, Meliponini). *Apidologie* 35 (2):159-182.

Nik Rozana, N. M. M., Suntharalingam, C., & Othman, M. F. (2017). Competitiveness of Malaysia's fruits in the global market: Revealed comparative advantage analysis. *Malaysian Journal of Mathematical Sciences,* 11(S): 143–157.

Nogueira-Neto, P. (1970). *A criação de abelhas indígenas sem ferrão. São Paulo*, Chácaras e Quintais, 2ª ed., 365 p.

Nogueira-Neto, P. (1997). Vida e criação de abelhas indígenas sem Ferrão. São Paulo, Nogueirapis, 446 p.

Norowi, M. H., Mohd Fahimee, J., Sajap, A. S., Rosliza, J. & Suri, R. (2010). Conservation and Sustainable Utilization of Stingless Bees for Pollination Services in Agricultural Ecosystems in Malaysia. In *Proceedings of International Seminar on Enhancement of Functional Biodiversity Relevant to Sustainable Food Production*, Tsukuba, Japan, 9-11 November 2010 (pp 1–11). Tsukuba: National Institute for Agro-Environmental Sciences.

Nunes-Silva, P., Hilário, S. D., Pérsio de Souza, S. F & Imperatriz-Fonseca, V. L. (2010). Foraging activity in *Plebeia remota*, a stingless bee species, is influenced by the reproductive state of a colony. *Psyche* 1:1–17.

Nunez, J. A. (2000). Foraging efficiency and survival of African honey bees in the trophic. *Annals IX Encontro Sobre Abelhos, Ribeireo Preto*, SP: 9-16.

Núñez-Elisea, R., Schaffer, B., Zekri, M., O'Hair, S. K. & Crane, J. H. (2001). In situ soil-water characteristic curves for tropical fruit orchards in trenched calcareous soil. *HortTechnology*, 11(1): 65-69.

Nurul huda, A., Che Salmah, M. R., Abu Hassan, A., Hamdan, A., & Abdul Razak, M. N. (2015). Pollination services of mango flower pollinators. *Journal of Insect Science* 15(1)113.

Öckinger, H., & Smith, H.G. (2007). Semi-natural grasslands as population sources for pollinating insects in agricultural landscapes. *Journal Application Ecology*, 44: 50-59.

Odoux, J. F., (2012). Territorial biodiversity and consequences on physico-chemical charactersitics of pollen collected by honey bee colonies. *Apidologie*, 43: 561-575.

Ollerton, J. (2017). Pollinator diversity: distribution, ecological function and conservation. *Annual Review of Ecology, Evolution and Systematics*, 48: 353-376.

Pereboom, J. J., & Biesmeijer J. C. (2003). Thermal constraints for stingless bee foragers: the importance of body size and coloration. *Oecologia*. 2003;137(1):42-50.

Pierrot, L. M. & Schlindwein, C. (2003). Variation in daily flight activity and foraging patterns in colonies of Uruçu, *Melipona scutellaris* Latreille (Apidae, Meliponini). *Revista Brasileira de Zoologia* 20: 565-571.

Pignata M. I. B., & Diniz-Filho J. A. F. (1996). Phylogenetic autocorrelation and evolutionary constraints in worker body size of some neotropical stingless bees (Hymenoptera: Apidae). *Heredity*,76: 222–228.

Polatto, L. P., Chaud-Netto, J. & Alves-Junior, V. V. (2014). Influence of abiotic factors and floral resource availability on daily foraging activity of bees: influence of abiotic and biotic factors on bees. *Journal of Insect Behavior*, 27: 593–612.

Polce, C., Garratt, M. P., Termansen, M., Ramirez-Villegas, J., Challinor, A. J., Lappage, M. G., Boatman, N. D., Crowe, A., Endalew, A. M., Potts, S. G., Somerwill, K. E. & Biesmeijer, J. C. (2014). Climate-driven spatial mismatches between British orchards and their pollinators: increased risks of pollination deficits. *Global change biology*, 20(9): 2815-2828.

Puškadija, Z., Stefanic, E., Anto, M., Zdunić, Z., Parađiković, N., Tihomir, F., & Opačak, A. (2007). Influence of weather conditions on honey bee visits (Apis melifera carnica) during sunflower (Helianthus annuus L.) blooming period. *Poljoprivreda (Osijek)* 1:1-4

Quezada-Euan, J. J., Parra, G., Maues, M., Roubik, D., & Imperatriz-Fonseca, V. L. (2018). The economic and cultural values of stingless bees (Hymenoptera: Meliponini) among ethnic groups of tropical America. *Sociobiology*, 65 :534.

Raghunandan, K. S., & Basavarajappa, S. (2014). Floral hosts and pollen calendar of Asian giant honeybee, Apis dorsata Fabricus at southern Karnataka, India. *Journal of Ecology and the Natural Environment*, 6(9):321-330.

Rahman, M. A., Mohamad, O., & Maimun, T. (2007). Evaluation of yield and fruit quqlity traits of eight selected starfruit clones. *Journal of Tropical Agriculture and Food Science*, 35(1): 21-27.

Ramalho, M. (2004). Stingless bees and mass flowering trees in the canopy of Atlantic Forest: a tight relationship. *Acta Botanical Brasil*, 18(1):37-47.

Ramalho, M., Imperatriz-Fonseca, V.L., & 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 (3) :221-228.

Ramalho, M., Kleinert-Giovannini, A. & Imperatriz-Fonseca, V. L. (1990). Important bee plants for stingless bees (*Melipona* and Trigonini) and Africanized honeybees (*Apis mellifera*) in neotropical habitats: a review. *Apidologie*, 21(5): 469-488.

Ramalho, M., Silva, M.D., & Carvalho, C.A.L. (2007). Dinâmica de uso de fontes de pólen por *Melipona scutellaris* Latreille (Hymenoptera, Apidae): Uma Análise Comparativa com *Apis mellifera* L. (Hymenoptera, Apidae), no Domínio Tropical Atlântico. *Neotropical Entomology* 36: 38–45.

Ranger S. & O'Donnell S. (1999). Genotypic effects on forager behavior in the neotropical stingless bee *Partamona bilineata* (Hymenoptera: Meliponidae). *Naturwissenschaften* 86 (4), 187-190.

Rattanawannee, A., & Duangphakdee, O. (2019). Southeast Asian Meliponiculture for Sustainable Livelihood. 10.5772/intechopen.90344.

Reitz, S. R., & Trumble, T. (2002). Competitive Displacement Among Insects and Arachnids. *Annual Review of Entomology* 47:435-465.

Reverté, S., Retana, J., Gómez, J. M., Bosch, J. (2016). Pollinators show flower colour preferences but flowers with similar colours do not attract similar pollinators. Annals of Botany 118(2):249-257.

Riessberger, U. & Crailsheim, K. (1997). Short-term effect of different weather conditions upon the behaviour of forager and nurse honey bees (*Apis mellifera carnica* Pollmann). *Apidologie*, 28(6): 411-426.

Rollin, O., Benelli, G., Benvenuti, S. (2016). Weed-insect pollinator networks as bio-indicators of ecological sustainability in agriculture. A review. *Agronomy Sustainainble Development* **36,** 8 (2016).

Roubik, D.W. (1982) Seasonality in colony food storage, brood production and adult survivorship: studies of *Melipona* in tropical forest (Hymenoptera: Apidae). *Journal of the Kansas Entomological Society* 55: 789–800.

Roubik, D.W. (1989). *Ecology and natural history of tropical bees*. New York: Cambridge University Press.

Roubik, D.W. (2006). Stingless bee nesting biology. *Apidologie*, 37:124–143.

Roulston, T.H., & Cane, J.H. (2000). Pollen nutritional content and digestibility for animals. *Plant Systematic Evolution*, 222:187–209.

Ruedenauer, F. A., Johannes, S., Casper, V. d. K., & Leonhardt, S. D. (2019). Pollinator or pedigree: which factors determine the evolution of pollen nutrients? *Oecologia* 191.

Sakagami, S.F. (1982) Stingless bees. In: Hermann HR (Ed), *Social insects, Volume III* (pp 361–423). Academic Press, New York.

Salim, H. M. W., Dzulkiply, A. D., Harrison, R. D., Fletcher, C., Kassim, A. R. & Potts, M. D. (2012). Stingless bee (Hymenoptera: Apidae: Meliponini) diversity in Dipterocarp Forest Reserves in Peninsular Malaysia. *The Raffles Bulletin of Zoology*, 60(1): 213–219.

Samejima, H., Marzuki, M., Nagamitsu, T., & Nakasizuka, T. (2004). The effects of human disturbance on a stingless bee community in a tropical rainforest. *Biological Conservation,* 120: 577–587.

Samuelson, E., Chen-Wishart, Z. & Gill, R. (2016). Effect of acute pesticide exposure on bee spatial working memory using an analogue of the radial-arm maze. *Scientific Reports* 6, 38957.

Samsudin, S. F., Mamat, M. R. & Hazmi, I. R. (2018). Taxonomic study on selected species of stingless bee (Hymenoptera: Apidae: Meliponini) in Peninsular Malaysia. *Serangga*, 23(2): 203-258.

Saravia-Nava, A., Niemeyer, H. M., & Pinto, C. F. (2018). Pollen types used by the native stingless bee, *Tetragonisca angustula* (Latrielle), in an Amazon-Chiquitano Transitional Forest of Bolivia. *Neotropical Entomology*.

Saufi, N. F. M. & Thevan, K. (2015). Characterization of nest structure and foraging activity of stingless bee, *Geniotrigona thoracica* (Hymenopetra: Apidae: meliponini). *Jurnal Teknologi,* 7 7 (33): 69-74.

Sawatthum, A., Jitake, P., Rangyai, O., Prang prayong, P., Pimboon, P. & Suparit, K. (2017). Efficacy of stingless bee *Lepidotri gonaterminata* as insect pollinator of F1 hybrid cucumber. *International Journal of Geomate,* 13: 98-102.

Schmickl, T. & Crailsheim, K. (2007). HoPoMo: A model of honeybee intracolonial population dynamics and resource management. *Ecological Modelling*, 204(1): 219-245.

Seeley, T.D. & Tovey, C.A. (1994). Why search time to find a food-storer bee accurately indicates the relative rates of nectar collecting and nectar processing in honey bee colonies. *Animal Behaviour,* 47: 311-316.

Selvaraju, K., Vikram, P., Soon, J. M., Krishnan, K. T., & Mohammed, A. (2019). Melissopalynological, physicochemical and antioxidant properties of honey from West Coast of Malaysia. *Journal of food science and technology*, *56*(5), 2508–2521.

Shackleton, K., Balfour, N.J., Toufailia, H.A. (2019). Unique nest entrance structure of Partamona helleri stingless bees leads to remarkable 'crash-landing' behaviour. *Insectes Sociaux*. 66, 471–477.

Shui, G., & Leong, L. P. (2006). Residue from star fruit as valuable source for functional food ingredients and antioxidant nutraceuticals. *Food Chemistry,* 97(2): 277–284.

Slaa, E. J., Wassenberg, J. & Biesmeijer, J. C. (2003a). The use of field-based social information in eusocial foragers: local enhancement among nestmates and heterospecifics in stingless bees. *Ecological Entomology,* 28: 369–379.

Slaa, E. J., Tack, A. J. M. & Sommeijer, M. J. (2003b). The effect of intrinsic and extrinsic factors on flower constancy in stingless bees. *Apidologie,* 34: 457–468.

Slaa, J., Sánchez, L., Braga, K., Hofstede, F. (2006). Stingless bees in applied pollination: Practice and perspectives. *Apidologie*, 37(2):293-315

Smith, F. (1857). Catalogue of the hymenopterous insects collected at Sarawak, Borneo; Mount Ophir, Malacca; and at Singapore. *Journal of the Proceedings of the Linnean Society of London. Zoology,* 2(6): 42–88.

Smith, J. P., Heard, T. A., Beekman, M. & Gloag, R. (2016). Flight range of the Australian stingless bee *Tetragonula carbonaria* (Hymenoptera: Apidae). *Austral Entomology,* 56(1): 50-53.

Soares, K.O., Lima, M.V., Evangelista-Rodrigues, A., Silva, A.A.F., Silva, F.J.D.A., Lima, A.I.B.L.C. & da Costa, C.R.G. (2019). Factors influencing the foraging behavior of *Trigona spinipes* (Apidae, Meliponinae). *Biological Rhythm Research,* 1-11.

Sommeijer, M. J., de Rooy, G.A., Punt, W. & de Bruijn, L.L.M. (1983). A comparative study of foraging behavior and pollen resources of various stingless bees (Hym., Meliponinae) and honeybees (Hym., Apinae) in Trinidad, West-Indies. *Apidologie,* 14(3): 205-224.

Stein, K., Coulibaly, D., Stenchly, K., Goetze, D., Porembski, S., Lindner, A., Konaté, S. & Linsenmair, E. K. (2017). Bee pollination increases yield quantity and quality of cash crops in Burkina Faso, West Africa. *Scientific Reports,* 7(1): 17691.

Stewart, A. J. A. (1996). Interspecific competition reinstated as an important force structuring insect herbivore community. *Trends in Ecology and Evolution* 11:233-234.

Sulaeman, A., Fikri, A. M., Kalsum, N. & Mahani, M. (2019). Trigonapropolis and its potency for health and healing process, *In The Role of Functional Food Security in Global Health, edited by R R Watson, R B Singh & T Takahashi (Academic Press, Cambridge)* pp 425-448.

Talavera, S., Bastida, F., Ortiz, P.L., & Arista, M. (2001). Pollinator attendance and reproductive success in *Cistus Libanotis* L. (Cistaceae). *International Journal Plant Science*,162(2):343-352

Talavera, G., Espadaler, X. & Vila, R. (2014). Discovered just before extinction? The first endemic ant from the Balearic Islands (*Lasius balearicus* sp. nov.) is endangered by climate change. *Journal of Biogeography*, 42(3): 589-601.

Tan, K., & Yang, M. (2009). Worker reproduction in mixed species colonies of honey bees. *Behavioural Ecology* 20(5):1106–1110

Teixeira, L.V. & Campos, F.N.M. (2005) Stingless bees (Hymenoptera, Apidae) flight activity beginning: body size and ambient temperature influence. *Revista Brasileira de Zoologia* 7 : 195–202.

Tenczar, P., Lutz, C., Rao, V., Goldenfeld, N. & Robinson, G. (2014). Automated monitoring reveals extreme interindividual variation and plasticity in honeybee foraging activity levels. *Animal Behaviour* 95: 41–48.

Thakodee, T., Deowanish, S. & Duangmal, K. (2018). Melissopalynological analysis of stingless bee (*Tetragonula pagdeni*) honey in Eastern Thailand. *Journal of Asia-Pacific Entomology*, 21(2): 620-630.

The Star. (2019, April 8). Mardi launches star fruit clone 'Bintang Mas'. https://www.thestar.com.my/news/nation/2019/04/08/mardi-launches-star-fruit-clone-bintang-mas/

Thierry, B., Theraulaz, G., Gautier, J. Y. & Stiegler, B. (1996) Joint memory. *Behavioural Processes*, 35(1-3): 127–140.

Thomson, J. D. (1983). Component analysis of community-level interactions in pollination systems. In C.E. Jones, R.J. Little (Eds.), *Handbook of Experimental Pollination Biology* (pp. 451–460). Michigan: Scientific and Academic Editions.

Tongchitpakdee, S. (2012). Longan and carambola. In M. Siddiq (Ed.), *Tropical and Subtropical Fruits: Postharvest Physiology, Prosessing and Packaging* (pp. 233). New York: John Wiley & Sons.

Osborne, J., Martin, A., Carreck, N., Swain, J., Knight, M., Goulson, D., Hale, R. & Sanderson, R. (2008). Bumblebee flight distances in relation to the forage landscape. *The Journal of animal ecology*. 77.

Valido, A., Rodríguez-Rodríguez, M.C. & Jordano, P. (2019). Honeybees disrupt the structure and functionality of plant-pollinator networks. *Science Report* 9: 4711.

van der Sluijs, J.P., & Vaage, N.S. (2016). Pollinators and Global Food Security: The Need for Holistic Global Stewardship. *Food ethics* 1:75–91.

Varma, S., Rajesh, T. P., Manoj, K., Asha, G., Jobiraj, T. & Palatty, A. S. (2020). Nectar robbers deter legitimate pollinators by mutilating flowers. Oikos 129(6) : 868-878.

Veiga, J., Menezes, C., Venturieri, G., & Contrera, F. (2013). The bigger, the smaller: Relationship between body size and food stores in the stingless bee *Melipona flavolineata*. *Apidologie*, 44. 324-333.

Vicens, N., & Bosch, J. (2000). Pollinating efficacy of *Osmia cornuta* and *Apis mellifera* (Hymenoptera: Megachilidae, Apidae) on 'Red Delicious' apple. *Environmental Entomology,* 29(2): 235-240.

Vijayakumar, K. (2014). Nest and colony characters of *Trigona (Lepidotrigona) ventralis* var. *arcifera* Cockerell from North East India. *Asian Journal of Conservation Biology,* 3(1): 90–93.

Villanueva-Gutiérrez, R., Moguel-Ordóñez, Y. B., Echazarreta-González, C. M., & Arana-López, G. (2009). Monofloral honeys in the Yucatán Peninsula, Mexico, Grana, 48(3): 214-223.

Villanueva-Gutierrez, R., Roubik, D., & Porter-Bolland, L. (2015). Bee–Plant Interactions: Competition and Phenology of Flowers Visited by Bees. In Islebe, G., Calme, S., Schmook, B., & Leon, J (Ed.), *Biodiversity and Conservation of the Yucatán Peninsula* (pp.131-152) Springer International Publishing.

Vollet-Neto, A., Menezes, C., & Imperatriz-Fonseca, V.L. (2015). Behavioural and developmental responses of a stingless bee (*Scaptotrigona depilis*) to nest overheating. *Apidologie*, 46. 455-464.

Wahizatul, A. A., Zulqurnain, N.S. & Ghazi, R. (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: 27-35.

Wahizatul, A. A., Chuah, T. S. & Nur Suhaili, S. (2016). Pollination efficiency of the stingless bee, *Heterotrigona itama* (Hymenoptera: Apidae) on chili (*Capsicum annuum*) in greenhouse. *Journal of Tropical Plant Physiology*, 8(1): 1-11.

Wahizatul, A. A., Samsuri, N., Firdaus, M., Hatta, M., Ghazi, R. & Chuah, T. S. (2017). Effects of stingless bee (*Heterotrigona itama*) pollination on greenhouse cucumber (*Cucumis sativus*). *Malaysian Applied Biology,* 46: 51-55.

Wahizatul, A. A., Ghazi, R. & Nasharuddin, I. S. (2019). Morphological, Nest Architecture and Colony Characteristics of Stingless Bees (Hymenoptera; Apidae; Meliponini) from Tasik Kenyir, Terengganu. In M. T. Abdullah et al. (Eds.) *Greater Kenyir Landscapes* (pp. 111-122). Cham, Switzerland: Springer International Publishing.

Wagner, A., Van Nest, B., Hobbs, C. & Moore, D. (2013). Persistence, reticence and the management of multiple time memories by forager honey bees. *The Journal of experimental biology*. 216.

Wan Nur Asiah, W. M. A., Sajap, A. S., Nur Azura, A. & Norowi, M. H. (2015). Flight intensity of two species of stingless bees *Heterotrigona itama* and *Geniotrigona thoracica* and its relationships with temperature, light intensity and relative humidity. *Serangga,* 20(1): 35-42.

Warren, O. & Sargent, S. A. (2011). Carambola (*Averrhoa carambola* L.). In E. M. Yahia (Ed.), *Postharvest Biology and Technology of Tropical and Subtropical Fruits* (pp. 397-413). Oxford: Woodhead Publishing.

Wilcock, C. & Neiland, R. (2002). Pollination failure in plants: why it happens and when it matters. *Trends in Plant Science,* 7(6): 270-277.

Willmer, P. (2011). *Pollination and Floral Ecology*, Princeton University Press.

Wilms, W. & Wichers, B. (1997). Floral resource partitioning between native Melipona bees and the introduced Africanized honeybee in the Brazilian Atlantic rain forest. *Apidologie,* 28: 339–55.

Winston, M. L. (2003). *A biologia da abelha*, Porto Alegre, Magister, 276 p.

Wood, T. J., Kaplan, I., & Szendrei, Z. (2018). Wild Bee Pollen Diets Reveal Patterns of Seasonal Foraging Resources for Honey Bees. Frontiers in Ecology and Evolution, 6: 210.

Woodcock, T., Larson, B., Kevan, P., Inouye, D., & Lunau, K. (2014). Flies and Flowers II: Floral Attractants and Rewards. *Journal of Pollination Ecology*, 12: 63 - 94.

Xu, Z., & Deng, M. (2017). *Identification and Control of Common Weeds: Volume 2*. Springer Netherlands.

Young, A. M., & Severson, D. W. (1994). Comparative analysis of steam distilled floral oils of cacao cultivars (*Theobroma cacao* L., Sterculiaceae) and attraction of flying insect: Implications for *Theobroma* pollination syndrome. *Journal of Chemical Ecology* 20(10).

Zabedah, M., Yusoff, A.M, Halim, R.A., Hassan, S.A. & Fauzi, R.M. (2008). Performance of starfruit cv. B10 under netted structure. II. Effect of crop load

on exportable yield, fruit size, fruit physical and chemical properties. *Journal of Tropical Agriculture and Food Science,* 36(1): 35– 41.

Zakaria, N. A. & Abdul Rahim, A. R. (2014). An overview of fruit supply chain in Malaysia. *Jurnal Mekanikal,* 37: 36-46.

Zar, J. H. (1999). *Biostatistical Analysis*. Prentice Hall, 663 pp

Zeuss, D., Brandl, R. & Brändle, M. (2014). Global warming favours light-coloured insects in Europe. *Nature Communications,* 5: 3874.

Zubaidah, A. H., Shamsul Bahri, A. R., Sanusi, J. & Nur Azura, A. (2017). Ultrastructural comparison of three stingless bees' species of Borneo. *Malaysian Journal of Microscopy,* 13(1): 8-16.

BIODATA OF STUDENT

Wan Nur Asiah was born on 14 March 1986 in Klang, Selangor. She had early education in Sekolah Kabangsaan Seri Terentang, Pekan, Pahang and her secondary school education in Sekolah Menengah Paya Besar, Kuantan, Pahang. In 2005, she joined Universiti Sains Malaysia in Bachelor of Science (Zoology) for three years, then obtained her Master of Science (Entomology) from the same university in 2012.

LIST OF PUBLICATIONS

Journal

Wan Nur Asiah, W. M. A., Sajap, A. S., Nur Azura, A. & Norowi, M. H. (2015). Flight intensity of two species of stingless bees *Heterotrigona itama* and *Geniotrigona thoracica* and its relationships with temperature, light intensity and relative humidity. *Serangga*, 20(1): 35-42.

Wan Nur Asiah, W. M. A., Syari, J., Nur Azura, A., Mohamad Shukri, T. S., Siti Asma, S., & Chong Leong, P. (2021). Foraging activities of stingless bees, *Geniotrigona thoracica* and *Heterotrigona itama* (Apidae: Meliponini) in relation to wet and dry seasons in Selangor, Malaysia. *Serangga*, 26(4): 152-160.

Conference Proceedings

Wan Nur Asiah, W. M. A., Sajap, A. S., Nur Azura, A. & Norowi, M. H. (2015). Flight Intensity of two stingless bees' species, *Heterotrigona itama* and *Geniotrigona thoracica* and its relationships with temperature, light Intensity and relative Humidity. International Symposium on Insects (ISoI 2014). Bayview Hotel, Melaka, Malaysia.1-3 Disember 2014. Oral Presenter.

Wan Nur Asiah, W.M.A., Nur Azura A., & Sajap, A. S. (2016). Temporal foraging pattern of stingless bee, *Heterotrigona itama* (Cockerell, 1918).9th International Conference on Plant Protection in the Tropics. Hilton Hotel, Kuching, Sarawak, Malaysia. 3-5 August 2016. Oral Presenter.

Wan Nur Asiah, W. M. A., Nur Azura, A., Syari, J., & Chong Leong, P. (2018). Pollens Profile of *Geniotrogona thoracica* in Selangor, Malaysia. 3rd International Symposium on Insect (IsoI 2018). Bayview Hotel, Langkawi, Kedah, Malaysia. 19 -21 March 2018. Poster Presenter.

UNIVERSITI PUTRA MALAYSIA

STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT

ACADEMIC SESSION : First Semester 2021/2022

TITLE OF THESIS / PROJECT REPORT :

ORAGING BEHAVIOURS OF STINGLESS BEES *Heterotrigona itama* Cockerell AND *Geniotrigona thoracica* Smith AS POTENTIAL POLLINATORS TO STAR FRUIT *Averrhoa carambola* L.

NAME OF STUDENT: WAN NUR ASIAH BINTI WAN MOHD ADNAN

I acknowledge that the copyright and other intellectual property in the thesis/project report belonged to Universiti Putra Malaysia and I agree to allow this thesis/project report to be placed at the library under the following terms:

1. This thesis/project report is the property of Universiti Putra Malaysia.
2. The library of Universiti Putra Malaysia has the right to make copies for educational purposes only.
3. The library of Universiti Putra Malaysia is allowed to make copies of this thesis for academic exchange.

I declare that this thesis is classified as :

*Please tick (√)

☐	**CONFIDENTIAL**	(Contain confidential information under Official Secret Act 1972).
☐	**RESTRICTED**	(Contains restricted information as specified by the organization/institution where research was done).
☐	**OPEN ACCESS**	I agree that my thesis/project report to be published as hard copy or online open access.

This thesis is submitted for :

☐ **PATENT** Embargo from _____ (date) until _____ (date)

Approved by:

_____
(Signature of Student)
New IC No/ Passport No.:

Date :

_____
(Signature of Chairman of Supervisory Committee)
Name:

Date :

[Note : If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization/institution with period and reasons for confidentially or restricted.]