JOURNAL OF SUSTAINABLE NATURAL RESOURCES
e-ISSN: 2716-7143

J-SuNR

Vol. 6 No. 1 (2025) 8-15
https://publisher.uthm.edu.my/ojs/index.php/j-sunr

Insect Pollinator Diversity and Significance of Pollen Resources in Urban Landscape

Suhaila Ab Hamid[1]*, Nadia Aqilah Azwari[1], Nurul Ain Elias[1], Ahmad Mustaqim Rahim[1]

[1] *School of Biological Sciences, Universiti Sains Malaysia, 11800 Minden, Penang, MALAYSIA*

*Corresponding Author: ahsuhaila@usm.my
DOI: https://doi.org/10.30880/jsunr.2025.06.01.002

Article Info

Received: 7 January 2025
Accepted: 15 June 2025
Available online: 30 June 2025

Keywords

Bioindicator, city, flora, insect, landscape, urban environment

Abstract

Insects are the most common pollinators of flowering plants. Urban landscape often lacks of flora diversity, potentially limiting the pollinators' population; thus, flowering plants would face a great decline, and this may reduce the habitat diversity of nature. Therefore, this study was conducted to determine insect pollinators in selected parks in the urban area of Penang Island and its floral source. Insect trapping using light traps and sweep nets was carried out and a total of 65 families from 10 orders were collected from three parks: Youth Park, Botanic Garden and Moon Gate in Penang. Out of that, 13 families were determined as pollinators. Insects from the order Lepidoptera, Coleoptera, Hymenoptera and Hemiptera were the principal representative orders in all study areas. Diurnal insects reported three pollen types; predominant (eight pollen species), secondary (nine pollen species) and important minor (one pollen species) while nocturnal insects recorded the Apidae family with four pollen types; predominant (13 pollen species) secondary (five pollen species), important minor (six pollen species) and minor (two pollen species). The presence of insect pollinators in urban areas suggests that such environments can play a significant role in supporting insect biodiversity that will survive in the urban landscape with nature-based.

1. Introduction

Insect pollinators play an important role in improving crop productivity and helping to achieve optimum pollination during flowering time. Interaction at individual, population and community levels of pollinators may be affected by the changes in landscape structure and land use [1]. Understanding the outcomes of interactions between pollinators and plants contributes to a deeper knowledge of ecosystem functioning [2]. Ecosystem services provided by insect pollinators, such as pollination have been taken for granted and little attention is paid to the need to conserve and enhance pollinator diversity [3]. Pollinators not only outcross pollen among individuals but also increase the total amount of pollen deposited on flower stigmas, where these are known to increase the quantity and quality of crops [1]. Insect pollinator visitation to flowering plants helps in plant reproduction, which influences the structure of the plant community.

In the coming decades, the International Union for Conservation of Nature (IUCN) predicts thousands of flowering plant species will be lost which can be considered as global loss for the world due to climate change, pollution and habitat destruction. The pollinators that are highly dependent on the 20,000 flowering plant species would face a great decline, and this may reduce the habitat diversity of nature. According to Steffan et al. [1], adverse changes for pollinator populations are habitat fragmentation and degradation. Natural habitat has been fragmented into small, isolated patches, making the pollinator species food source becoming scarce due to food source reduction [1]. In urban areas, especially in big cities, insect pollinators must compete for limited plant species and struggle to survive in air pollution. Pollutants from air pollution could destroy the scent trails that lead to the flower [4] as insects depend on the chemicals that are being produced by flowers. Locating their food source has become complicated for the pollinators. Previously, insects could travel over 800 m now can only reach 200 m from plants. Not only that, chemical pollutants may also affect reproduction, decline nectar production and eliminate the larvae that act as hosts for plants such as moths and butterflies.

An insect that carries pollen on its body can indeed be considered a pollinator. Pollination occurs when pollen is transferred from the male part (anther) of a flower to the female part (stigma), enabling fertilization and seed production. This transfer can happen intentionally, as in the case of bees collecting pollen for food, or unintentionally, when insects inadvertently carry pollen while feeding on nectar. Insects such as bees, butterflies, moths, flies, beetles, and wasps contribute to pollination by transporting pollen between flowers. Some, like bees, actively collect pollen, while others, like flies, may carry pollen on their bodies as they move from flower to flower. Therefore, any insect that carries pollen on its body and facilitates its transfer between flowers plays a role in pollination. Even if the insect does not intentionally collect pollen, its movements can result in pollination. Studies show that bees that feed on contaminated pollen affect their behaviour, physiology and produce fewer generations [5]. Various factors would affect the efficacy of pollinators such as the abundance of pollen collected on their body and the degree of flower constancy [6]. The movement of pollinators between flowers is considered as another factor that contributes to pollination. This is because the higher visitation rate of pollinators on flowers results in a greater rate of pollination [6]. Any variation in visitation rate among pollinator species may be affected by pollination syndrome that involves the characteristics of the flower. To enhance pollinator populations in urban landscape settings, a database on the diversity of insect species that act as pollinators needs to be conducted so that future town management programs in enhancing pollinator fauna can reach their objective. Therefore, this study was conducted to determine the diversity of insect pollinators and their associated floral resources in the urban area of Penang Island. Understanding these interactions is essential not only for academic knowledge but also for informing urban planning and conservation strategies aimed at supporting biodiversity in rapidly developing environments.

2. Materials and Methods

2.1 Insect Trapping

The study was conducted at three urban areas on Penang Island: Youth Park (5.42548, 100.30068), Moon Gate (5.43567, 100.29278) and Botanical Garden (5.43773, 100.2907), from September 2018 to January 2019. Youth Park is an urban park in the city of Georgetown, Penang. Moongate is the trailhead entrance to Penang Hill hiking route and Botanical Garden is the semi-natural garden located at the base of Penang Hill. Light traps were deployed at all sampling sites for collecting nocturnal insects. Two types of light traps were used: white cloth with light and fluorescence-UV trap. Two poles approximately 1.5 meters and four meters of white cloth were used to set the light trap. The white cloth was secured to the poles using rope. A 12 watts white light bulb was used, and all insects that landed on the white cloth were collected using glass vials. For the fluorescence-UV light trap, a fluorescence-UV lamp was placed above the bucket. Then, pure concentration of ethyl acetate was applied to a sponge placed inside the bucket to immobilize insects that attracted to the light. All light traps were operated from 7.00 pm to 12.00 am. Meanwhile, a sweep net was used to collect diurnal insects. At each study area, three randomly placed quadrats measuring 2.5 m × 2.5 m were established. Five sweep net strokes were performed per quadrat by which the sampling was conducted between 8.00 am to 10.00 am. This step was repeated three times at each quadrat and the captured insects were immediately placed into plastic bags. The combination of methods allowed sampling of a broad spectrum of insect niches and behaviours.

2.2 Preparation of Pollen Slide

Pollen slide preparation was carried out following the method described by [7]. The amount of 20 g of gelatine was dissolved to 50 ml of distilled water in a beaker and the water was heated until the gelatine dissolved. Basic fuchsin crystals were added gradually until the solution reached the desired colour which is a medium reddish-pink to magenta hue. The stained gelatine solution was poured into a sterile Petri dish. A portion of the solidified fuchsin jelly was placed on a microscope slide and covered with a coverslip. The slide was gently heated over a flame until the jelly melted and spread evenly. To extract pollen, the insect body was gently rubbed against the surface of the melted fuchsin jelly to allow any adhering pollen grains to transfer into the medium. A new coverslip was then carefully placed over the jelly containing the pollen, and the slide was reheated briefly to ensure the jelly was evenly spread and the pollen was properly embedded for microscopic examination.

2.3 Insect and Pollen Identifications

Insect identification was done by referring to Triplehorn and Johnson [8] and comparison with insect collections deposited at the Entomology Lab in USM. Pollen identification was carried out using the Pollen Atlas [9] and pollen abundance was calculated as follows [10]:

$$\text{Pollen Abundance} = \frac{\text{Total number of pollen grains of species}}{\text{Total number of all observed pollen grains}} \times 100 \qquad [11]$$

Based on the pollen abundance, the pollen types were classified as follows; predominant (>45%), secondary (16-45%), important minor (3-15%), minor (<3%) [12].

2.4 Ecological Indices

The ecological indices were calculated to assess the insect community including species richness (Margalef's index), diversity (Shannon-Wiener index, H'), and equitability (Pielou's evenness index, J).

3. Results and Discussion

Youth Park recorded the highest number of insects, with a relative abundance of 42.4%, while the Botanical Garden had the lowest at 21.0% (Table 1). A total of 10 insect orders comprising 54 families were recorded at Youth Park. At Moon Gate, 37 families from 9 orders were recorded, while the Botanical Garden yielded 41 families from the same number of orders. The Shannon-Weaver diversity index was highest at Youth Park (3.21) and lowest at Moon Gate (2.93). Equitability was highest at the Botanical Garden (1.98), followed by Moon Gate (1.87) and Youth Park (1.85). Insects from order Lepidoptera, Coleoptera, Hymenoptera and Hemiptera were the principal representative orders in all study areas (Table 2). The insect families found in all study areas included Ectobiidae, Scarabaeidae, Staphylinidae, Tenebrionidae, Cercopidae, Cicadellidae, Braconidae, Diapriidae, Formicidae, Vespidae, Arctiidae, Crambidae, Erebidae, Geometridae, Oecophoridae, Pyralidae and Tortricidae. In Youth Park, the most dominant families were Erebidae (18.9%), Geometridae (9.9%) and Crambidae (8.9%) and Noctuidae (6.0%). At Moon Gate, the dominant families were Erebidae (18.6%), Geometridae (13.3%), Crambidae (12.2%) and Noctuidae (9.1%). In the Botanical Garden, Erebidae (13.3%), Scarabaeidae (9.3%), Ectobiidae (8.0%) and Crambidae (6.7%) were the most dominant. In terms of family richness, Diptera was the most diverse order (18 families), followed by Coleoptera (16 families) and Lepidoptera (12 families). Among the recorded insects, 13 families were determined as pollinators. Youth Park and Botanical Garden had the greatest number of pollinators with 7 families while Moon Gate only recorded 5 families.

Table 1 *Insects abundance and diversity in Youth Park, Moon Gate and Botanical Garden*

Location	Relative Abundance (%)	Order	Family	Shannon-Wiener (H')	Equitability
Youth Park	42.4	10	54	3.21	1.85
Moon Gate	36.8	9	37	2.93	1.87
Botanical Garden	21.0	9	41	3.19	1.98

Table 2 *Centesimal frequency (Fc, %) of insect orders and family from the three locations. +: indicate pollinator -: indicate non-pollinator*

Orders	Family	Pollinator	Youth Park	Moon Gate	Botanical Garden
Blattodea	Blatellidae	-	0.33	0	0
	Ectobiidae	+	1.98	0.31	8
Coleoptera	Carabidae	-	0.66	0.38	0
	Cerambycidae	-	0.33	0	0
	Chrysomelidae	-	1.33	0	0.67
	Cleridae	-	0.33	0	0
	Coccinellidae	-	0.33	0	0
	Curculionidae	-	0.33	0	0
	Endomychidae	-	0.33	0	0
	Erotylidae	-	0	0.38	0.67
	Euglenidae	-	0	0	0.67
	Lampyridae	-	0.33	0	0
	Lucanidae	-	0.00	0.38	0
	Nitidulidae	-	0.33	0.38	0
	Ptinidae	-	0.00	0.38	0.67
	Scarabaeidae	+	4.31	3.42	9.33
	Staphylinidae	-	2.98	1.14	0.67
	Tenebrionidae	-	0.99	0.38	0.67
Dermaptera	Forficulidae	-	2.32	2.32	0
Diptera	Calliphoridae	-	0.33	0.33	0
	Cecidomyiidae	+	0.33	0.33	0
	Choloropidae	-	0	0	0.67
	Muscidae	-	0	0	0.67
	Mycetophilidae	-	0.66	0.66	0.67
	Tipulidae	-	0.99	0.99	0
	Alydidae	-	0	0	2
	Cercopidae	+	0.62	0.66	2
	Cicadellidae	-	3.00	2.98	5.33
	Coreidae	-	0	0	0.67
	Delphacidae	-	0.33	0.33	0
	Gerridae	-	0.33	0.33	0
	Hecalinae	-	0.33	0.33	0
	Miridae	-	0.66	0.66	0
	Nabidae	-	0.33	0.33	0
	Reduviidae	+	1.99	1.99	0.67
	Rhopalidae	-	0	0	0.67
Hymenoptera	Apidae	+	0	0	0.67
	Braconidae	-	2.65	2.65	0.67
	Diapriidae	-	0.66	0.66	0.67
	Eucharitidae	-	0	0	0.67
	Evaniidae	-	0	0	0.67
	Formicidae	-	0.66	0.66	2
	Sphecidae	-	0	0	0.67
	Tiphiidae	+	1.99	1.99	4.00
	Vespidae	-	3.97	3.97	0.67
Lepidoptera	Arctiidae	-	0.33	0.33	2.00
	Crambidae	+	8.94	8.94	6.67
	Depressariidae	-	0.66	0.66	0
	Erebidae	+	18.87	18.87	13.33
	Geometridae	-	9.93	9.93	2.67
	Nymphalidae	+	0.33	0.33	2.67
	Noctuidae	-	5.96	5.96	6.00
	Oecophoridae	-	1.99	1.99	3.33
	Psychidae	-	0.33	0.33	0
	Pyralidae	-	1.66	1.66	6.00

	Tortricidae	+	4.64	4.66	3.33
Mantodea	Metallyticidae	-	0	0	0.67
	Hymenopodidae	-	0.33	0.33	0
	Mantidae	-	0.33	0.33	0
Neuroptera	Chrysopidae	-	0.33	0.331	0
Orthoptera	Acrididae	+	1.99	1.99	0.67
	Gryllidae	-	0.66	0.66	0
	Tettigonidae	-	2.65	2.65	5.33

3.1 Pollen Analysis

Diurnal insects were associated with three categories of pollen types: predominant (8 species), secondary (9 species) and important minor type (1 species) (Table 3). Pollen type was characterized as unifloral if it contained a predominant pollen type (Figure 1). Conversely, it was considered multifloral if no predominant pollen type was observed [12]. Pollinators that carry the greatest number of pollen species were from moth, family Erebidae (five pollen species) and the pollen species were *Allophylus* sp., *Mallotus polyadenos*, *Eugenia malaccensis* and *Bertya cunninghamii* and *Goniophlebium persicifolium*. According to Table 4, a total of four predominant pollen types (13 pollen species), secondary (5 pollen species), important minor (6 pollen species) and minor (2 pollen species) have been recorded from the Apidae family (bees) in all selected areas. The pollen species that can be found in all sampling areas was *Goniophlebium persicifolium*.

Table 3 *List of diurnal insect pollinators, pollen abundance and pollen type in all sampling areas*

Pollinators	Pollen	Pollen abundance (%)	Pollen type
Scarabaeidae	*Tagetes* sp.	45	Secondary
	Eugenia malaccensis	45	Secondary
	Goniophlebium persicifolium	10	Important minor
Erebidae	*Allophylus* sp.	25	Secondary
	Mallotus polyadenos	25	Secondary
	Eugenia malaccensis	25	Secondary
	Bertya cunninghamii	25	Secondary
	Goniophlebium persicifolium	25	Secondary
Forficulidae	*Thunbergia laurifolia*	100	Predominant
Ectobiidae	*Goniophlebium persicifolium*	100	Predominant
Cercopidae	*Samaneae saman*	100	Predominant
Acrididae	*Goniophlebium persicifolium*	100	Predominant
Nymphalidae	*Goniophlebium persicifolium*	33	Secondary
	Campomanesia sp.	33	Secondary
	Aristolochia sp.	33	Secondary
	Terminalia sp.	100	Predominant
Reduviidae	*Muntingia calabura*	50	Predominant
Tortricidae	*Eugenia malaccensis*	50	Predominant
Apidae	*Goniophlebium persicifolium*	100	Predominant

> 45: Predominant, 16-45: Secondary, 3-15: Important minor, < 3: Minor [12].

Table 4 *Nocturnal insect pollinator from family Apidae (Hymenoptera), pollen abundance and pollen type in all sampling areas*

Pollinator	Pollen	Pollen Abundance (%)	Pollen type
Apidae	*Allamanda cathartica*	100	Predominant
	Allophylus sp.	100	Predominant
	Tabernaemontana divaricata	100	Predominant
	Spathiphyllum sp.	90	Predominant
	Trema tomentosa	100	Predominant
	Hymenocallis littoralis	100	Predominant
	Persicaria sp.	100	Predominant
	Amaranthus spinosus	3	Important minor
	Glycine max	23	Secondary
	Schefflera sp.	41	Secondary
	Lagerstroma indica	50	Predominant
	Goniophlebium persicifolium	50	Predominant
	Croton tiglium	66	Predominant
	Calliandra haematocephala	100	Predominant
	Mallotus nesophilus	33	Secondary
	Impatiens sp.	17	Secondary
	Symplocos sp.	2	Minor
	Mallotus phillippensis	11	Important minor
	Sphenodesme sp.	10	Important minor
	Raphanus sativus	82	Predominant
	Myxoporum smilacifolium	9	Important minor
	Asphodelus sp.	6	Important minor
	Thunbergia laurifolia	100	Predominant
	Elaeocarpus stipularis	29	Secondary
	Mussaenda sp.	1	Minor

> 45: Predominant, 16-45: Secondary, 3-15: Important minor, < 3: Minor [12].

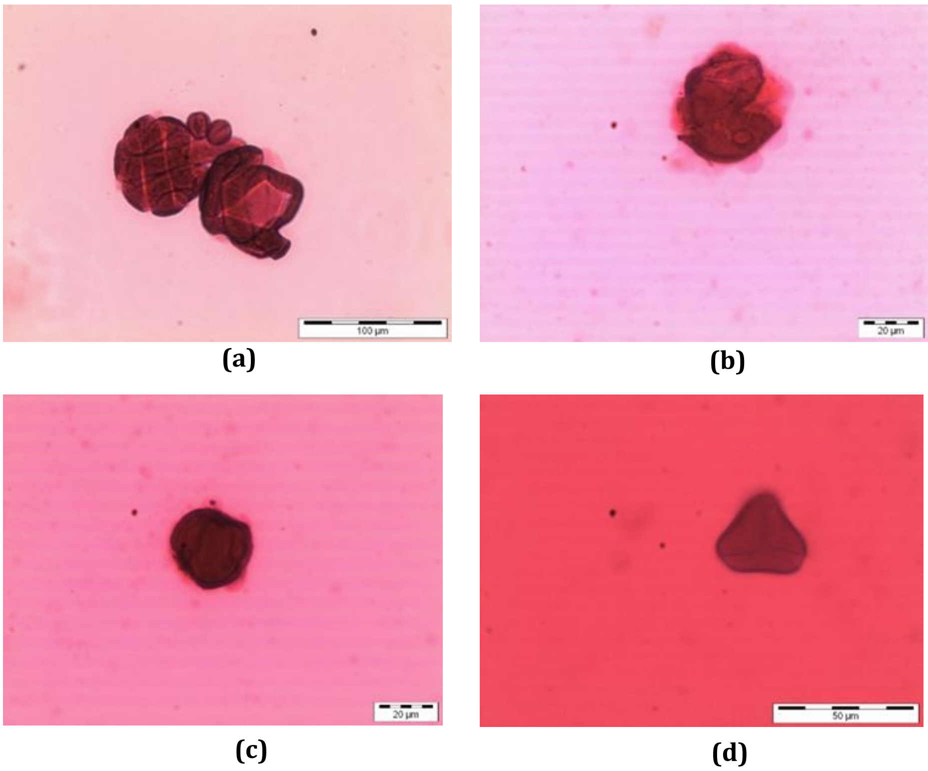

Fig 1 *(a) Thunbergia laurifolia (clockvines.); (b) Allamanda cathartica (Alamanda); (c) Tabernaemontana divaricata (pinwheel flower); (d) Eugenia malaccensis (malay apple)*

The recorded insect orders in the selected urban parks indicated a moderate level of diversity, with 9 to 10 orders identified. The overall number of insects across all three study areas yielded moderate diversity index (H') values. The general range for diversity index values falls between 1.5 and 3.5, with higher values indicating greater species richness and evenness within the community. Despite the moderate H values, species evenness also exhibited moderate levels. The insect diversity index recorded in this study was lower compared to other areas in Malaysia, such as in Bukit Soga Recreational Park, where a higher Shannon-Wiener index value (H'= 4.78) was reported by Rahman et al. [13]. The predominant insect orders identified were Lepidoptera, Coleoptera, Hymenoptera and Hemiptera. Those recorded orders which are commonly found in urban environments. Diptera exhibited the highest family richness (18 families) followed by Coleoptera (16 families) and Lepidoptera (12 families). Of the 65 families recorded, only 12 families were identified as pollinators and most of them come from the order Lepidoptera which are moths and butterflies. Although Lepidoptera are generally less efficient pollinators in cultivated crops [14] but in parks and gardens, it seems that they are dominating. The family of Nymphalidae, Crambidae, Erebidae and Totricidae from the order Lepidoptera plays a good role in the maintenance of wild plant diversity. Lepidopterans feed on floral nectar of various flowers to attain their nutrients and water and while foraging the flowers, pollination may take place. Moth families that are involved in phalaenophily or moth syndrome are usually from the family Noctuidae, Geometridae, Tortricidae and Pyralidae [15]. Butterflies are very active during the day (diurnal) while moths are more active during the evening and night (nocturnal). The abundance of insect pollinators observed in the study areas is likely influenced by the floral resources' availability. Habitat in Youth Park appears to provide favourable conditions that support insect pollinator's diversity. According to Scriven et al. [16] a great diversity of flower species is pivotal for pollinator diversity. Youth Park also may have favourable conditions for insect pollinators such as source of food, humidity and temperature. According to Daniels et al. [17], additional planning and maintaining urban green infrastructure can enhance pollinator habitat suitability.

Most pollen types were recorded from the family Apidae of order Hymenoptera which consists of honeybees, bumble bees, stingless bees and orchid bees. Pollen analysis showed that bees (Apidae) were among the most productive pollinators in this study by carrying 26 plant pollens from the selected study areas. Bees are recognized as excellent bioindicators of environmental quality as their intensive foraging behavior allows them to sense the presence of food within three kilometers from their hives [18]. Furthermore, the ability of an insect to carry a wide variety and number of pollen types also reflects its effectiveness as pollinator based on the foraging behaviour, pollinating ability, and ecology [19]. Bees in this study were observed visiting *Allamanda cathartica, Allophylus* sp., *Tabernaemontana divaricate* and *Goniophlebium persicifolium*. Fern pollen or its scientific name, *Goniophlebium persicifolium* was also found on Scarabaeidae (beetle), Erebidae and Nymphalidae (moth and butterfly) and Acrididae (grasshopper).

4. Conclusion

This is the first study to determine the insect pollinators in the urban landscape of Penang Island. The flies (order Diptera) were the richest insect order and lepidopterans/butterflies were the most diverse insect pollinators (11 families) in the study areas. Bee from the family Apidae is the best pollinator as it is recorded to carry the most pollen from urban parks during nighttime. Ten families of insects were recorded as diurnal pollinators in these areas. This showed that urban parks play a major role in supporting insect species. Nevertheless, bees from the family Apidae (order Hymenoptera) can be the bioindicator for this urban area as they collected the greatest number of pollen types in this study and were found to be foraging actively during nighttime. Differences in foraging behaviour and morphology of insect pollinators might be the reason for various pollen species found on them.

Acknowledgement

We would like to acknowledge the School of Biological Sciences, Universiti Sains Malaysia for providing the necessary field equipment and facilities needed to carry out this research. Appreciation also goes to Majlis Perbandaran Pulau Pinang, Penang Hill Corporation and Jabatan Taman Botani Pulau Pinang for permission to conduct this study.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contribution

The authors confirm their contribution to the paper as follows: ***study conception and design:*** *Suhaila A.H..;* ***data collection:*** *Nadia Aqilah, A., Nurul Ain, E.;* ***analysis and interpretation of results:*** *Nadia Aqilah, A., Suhaila A.H.,* ***draft manuscript preparation:*** *Suhaila A.H., Ahmad Mustaqim, R. All authors reviewed the results and approved the final version of the manuscript.*

References

[1] Steffan, I., Cunningham, S.A., Kremen, C., Bogdanski, A., Gemmill-Herren, B., Greenleaf, S., & Alexandra, M. (2008). Review and Landscape effects on crop pollination services: are there general patterns? *Ecology Letter, 11(1)*, 499–515.

[2] Saunders, M.E. (2018). Insect pollinators collect pollen from wind-pollinated plants: implications for pollination ecology and sustainable agriculture. *Insect Conservation Diversity, 11(1)*, 13–31.

[3] Jadhav, J.A., Sreedevi, K., & Prasad, P.R. (2015). Insect pollinator diversity and abundance in sunflower ecosystem. *Current Biotica, 5(3),* 344–350.

[4] Kluser, S., Neumann, P., Chauzat, M.P., & Pettis, J. (2010). *Global Honeybee Colony Disorders and Other Threats to Insect Pollinators.* United Nations Environment Programme (UNEP).

[5] Tokach, R., Smart, A. & Wu-Smart, J. (2023) Re-using food resources from failed honey bee (*Apis mellifera* L.) colonies and their impact on colony queen rearing capacity. *Sci Rep 13*, 18127. https://doi.org/10.1038/s41598-023-44037-2

[6] Couvillon, M.J., Walter, C.M., Blows, E.M., Czaczkes, T.J., Alton, K.L., & Ratnieks, F.L.W. (2015). Busy Bees: Variation in Insect Flower-Visiting Rates across Multiple Plant Species. *Psyche: A Journal of Entomology* 2015, 1–7.

[7] Beattie, A., Turnbull, C., Hough, T., Jobson, S., Knox, R. (1985). The Vulnerability of Pollen and Fungal Spores to Ant Secretions: Evidence and Some Evolutionary Implications. *American Journal of Botany*, *72(4),* 606-614.

[8] Triplehorn, C.A, & Johnson, N.F. (2005). *Borror and DeLong's Introduction to the Study of Insects*. Cengage Learning.

[9] Ruth, K., & Muid, M. (1991). *Beekeeping in Malaysia: Pollen Atlas*. Malaysian Beekeeping Research and Development Team, Serdang, Selangor, Malaysia.

[10] Kumara, T., & Pasulupeti, V.R. (2017). *Stingless Bee (Geniotrigona thoracica): Its Biology & Honey Properties*. Kota Bharu, Kelantan. Penerbit Bawal Trading Sdn.Bhd.

[11] Almeida, T.E., Salino, A., Dubuisson, J.Y., & Hennequin, S. (2017). *Adetogramma* (Polypodiaceae), a new monotypic fern genus segregated from Polypodium. *PhytoKeys, 78(1),* 109–131.

[12] Song, X.Y., Yao, Y.F, & Yang, W.D. (2012). Pollen Analysis of Natural Honeys from the Central Region of Shanxi, North China. *PLoS One, 7(11),* e49545.

[13] Rahman, A.A.A, Mohamed, M., & Linatoc, A.C. (2018). Butterfly (Lepidoptera: Rhophalocera) diversity in Bukit Soga, the green lung of Batu Pahat, Malaysia. *AIP Conference Proceedings* 2002.

[14] Hooks, C. R., & Espindola, A. (2020). *Moths, Butterflies and Pollinators*. Retrieved from Maryland Agronomy News: https://blog.umd.edu/agronomynews/2020/06/05/moths-butterflies-and-pollination/

[15] Dudareva, N., & Pichersky, E. (2006). *Biology of Floral Scent*. Boca Raton. CRC Press.

[16] Scriven, L.A., Sweet, M.J, & Port, G.R. (2013). Flower diversity is more important than habitat type for increasing flower-visiting insect diversity. *International Journal of Ecology*, 2013, 1-12

[17] Daniels, B., Jedamski, J., Ottermanns, R., & Ross-Nickoll, M. (2020). A "plan bee" for cities: Pollinator diversity and plant-pollinator interactions in urban green spaces. *PLoS One, 15(7),* e0235492.

[18] Celli, G., & Maccagnani, B. (2003). Honeybees as bioindicators of environmental pollution. *Bulletin of Insects*, *56,* 137-139.

[19] Huda, N.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.