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ABUNDANCE AND DIVERSITY OF INSECT VISITORS TO GROUND COVER PLANTS IN ORGANIC ORCHARD WITH BEE HIVES (*APIS MELLIFERA*) IN BATU, INDONESIA

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Abstract

This study aims to determine the differences in abundance, richness, diversity, evenness, and dominance of insects on ground cover plants and to visually analyse their visiting patterns in organic orchard with bee hives and without bee hives (*Apis mellifera*) in Batu City, Indonesia. Total visiting insects was 733 individuals from 21 plant species. The most visited plants was *Synedrella nodiflora* visited by pests, predators pollinators, and detrivors, this shows a picture of close interaction between the two in forming a food web. The abundance and diversity of pollinating insects in orchard with bee hives (62.50) was higher than the abundance and diversity of insects in orchard without bee hives (52.11). Diversity of predatory insects (0.25) in orchard with bee hives was lower than that without bee hives (1.68). The abundance, species richness, and evenness of pests in orchard with bee hives were lower than those without bee hives. The results of independent sample t-test analysis showed that there was no difference in insect composition between the two orchard. Organic orchard with bee hives can reduce the abundance, species richness, and evenness of pests, because bees and other pollinators also act as predators. In both orchard, *Episyrpus baltaetus* actively visited plant flowers at 08.00 to 14.00 which has the potential as a predators and pollinators.

Keywords: *Apis mellifera*, ground cover plants, bee hives, organic, pollinator

INTRODUCTION

The application of intensive agricultural systems using synthetic fertilisers and pesticides has been carried out by most farmer in Indonesia and other countries for a long time. This application has side effects including target pests becoming resistant to pesticides, decline of non-target animals, the emergence of secondary pests, pesticide residues on plants, environmental pollution of soil and water, air, and impacts on health (Vishwavidyalaya *et al.*, 2018). In addition, intensive agricultural systems can increase soil erosion and reduce its quality.

Pest control can be done effectively either synthetically or by maximising the role of natural enemies in controlling pest populations. One of the efforts to maximise the performance of natural enemies is by managing a preferred habitat. Habitat management is a form of ecological based biological control conservation that aims to provide resources such as food for adult natural enemies, prey or alternative hosts, and shelter from adverse

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conditions for predatory insects, parasitoids, and pollinators. Habitat manipulation results in habitat diversification and allows natural enemies to access resources, especially on organic orchard. Effective biological conservation controls on organic orchard can increase the relative abundance of predators (Lososová *et al*., 2011; Yun Ji *et al*., 2021; Hussain *et al*., 2022; Ali *et al*., 2023). Refugia can support changes in arthropod composition that help suppress herbivore populations, while also increasing the diversity of predators and parasitoids that impact prey consumption levels (Leksono *et al*., 2018; Leksono *et al.*, 2019; Nirwana *et al.*, 2024).

Ecologically, ground cover plants have the most important benefits from their physical properties, which help reduce pollutant leaching, retain dust grains brought in from elsewhere and reduce rainwater runoff on the soil surface. Ground cover plants are also photoautotrophic and have the highest rate and efficiency of photosynthesis among plant groups, thus acting as the main producers in the ecosystem. Ground cover plants also play a role in inhibiting or preventing rapid erosion, providing good soil cover with fine roots that form organic matter and help water infiltration into the soil (Judt *et al.*, 2023).

The problem is that many farmer think that ground cover plants are a source of pests and plant diseases. In addition, it can interfere with the main crop so it must be completely and routinely cleaned. In fact, flowering plants around the orchard can provide food for honey bees and other pollinators, especially when horticultural crops are not flowering.

The importance of honey bees as pollinating agents for crops has been widely studied, but bees and other pollinators are very sensitive to environmental changes, so their presence needs to be considered from time to time (Mallinger *et al.*, 2017).

Although many studies have assessed the impact of bee hives on wild insects in agricultural environments, the results differ between locations and crop types. So the aim of this research is to analyze the abundance, species richness, diversity, evenness and dominance of insects between the two orchards and conduct a comparative test between the two orchards on the abundance of insect visitors. In addition, it can be known which types of ground cover plants are visited by pollinator.

MATERIALS AND METHODS

Study Area

This study was conducted in an organic red guava (*Psidium guajava* L.) orchard located in two separate locations approximately 500 metres apart. The distance was selected based on the foraging range of bees, which can vary by body sizes but typically extends up to about 250 metres. The organic orchard was chosen because it is free pesticide and has been cultivated for approximately 15 years. The study took place from December 2022 to May 2023. One of the research sites is an organic farm with bee hives (*Apis mellifera*) (7°54’43.81”S, 112°32’03.49”E), while the other site is an organic orchard without bee hives (*Apis mellifera*) (7°54’46.05”S, 112°31’50.97”E), both located in Tlekung Village, Batu, East Java, Indonesia. The climate in this area has an average maximum temperature of 36.0 °C, a minimum of 12.7 °C, relative humidity of 65.8%, and annual rainfall of 237.6 cm. Each farm covers an average area of 1 500 m² with surrounding flowering ground cover (Fig. 1).

Sampling Design and Methodology

Explorations were conducted in guava orchard that utilized organic practices with and without bee hives (*Apis mellifera*) for comparison. Eight bee hives were deliberately placed on the wall of a hut in the center of the orchard, which covered an area of 1 500 m². The hives, made from Silk tree (*Chinese albizia*) measured 45 × 25 × 25 cm. These bee boxes had long been inhabited by *Apis mellifera* (Fig. 2).

Identification of flowering plants around the orchard was conduted. Seven species were found in both gardens, including: *Synedrella nodiflora*, *Ageratum conyzoides*, *Lantana camara*, *Cyperus hermaphroditus*, *Spermacoce remota*, *Desmodium tortuosum* and *Cyperus rotundus*. Seven species were only found in the orchard with bee hives, including: *Eryngium foetidum*, *Salvia occidentalis*, *Bidens pilosa*, *Oxalis barrelieri*, *Galinsoga parviflora*, *Solanum nigrescens* and *Sida acuta*, and six plants species were found in the orchard without bee hives, including: *Mimosa pudica*, *Digitaria sanguinalis*, *Crassocephalum crepidiodes*, *Tridax procumbens*, *Stachytarpheta indica* and *Persea americana*.

Insect observations were made directly on flowering ground cover plants using 1 m × 1 m observations points for 15 minutes on each plant. These observations were made once a week for 6 months, resulting in 12 replicates on each orchard. Visual observations were devided into three periods: Period I at 08.00 to 11.00, period II at 11.00 to 14.00, and period III at 14.00 to 17.00.

Data Analysis

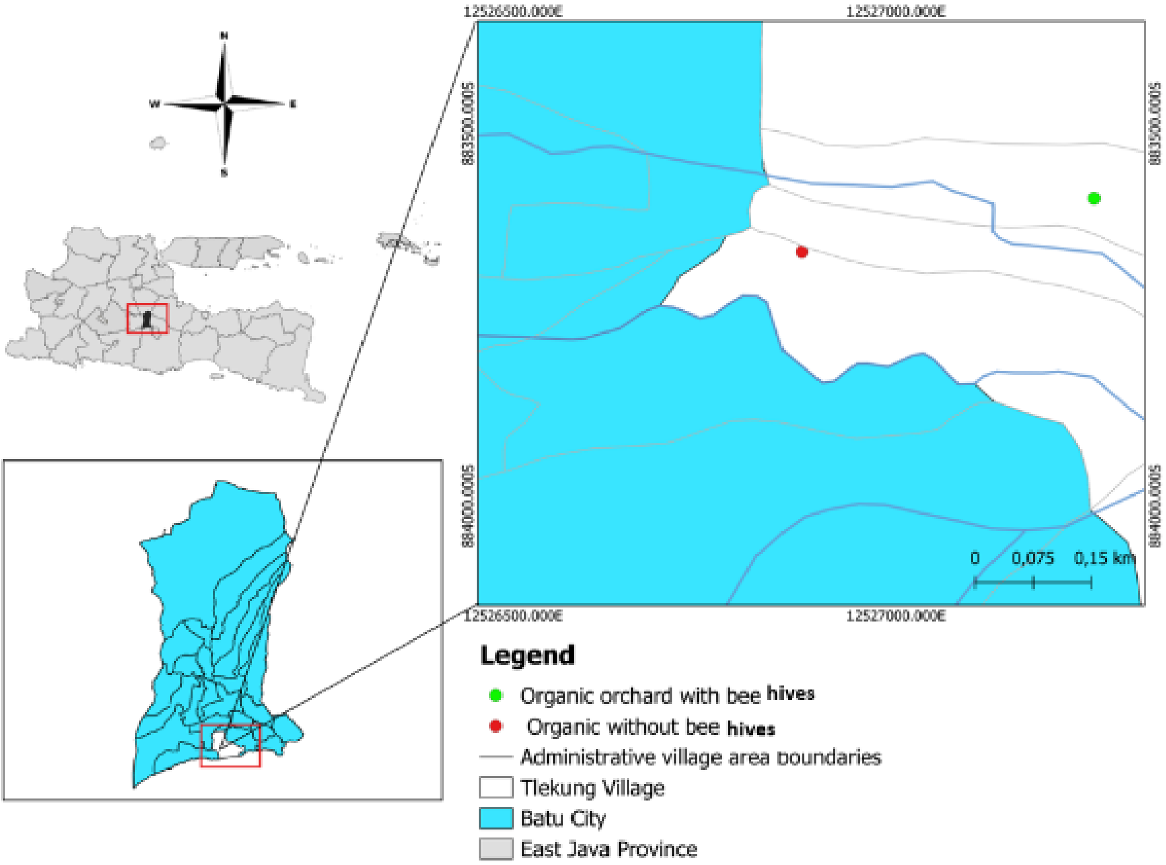
This study assessed wild bee diversity using five indices: Abundance Index (*DI*), Species Richness Index (*R*), Shannon-Wiener (*H'*), Evenness Index (*E*), and Simpson's Dominance Index were calculated using the software PAST 3 as:

$$\text{Abundance Index } (DI) = \frac{K_i}{\Sigma k} \times 100\%,$$

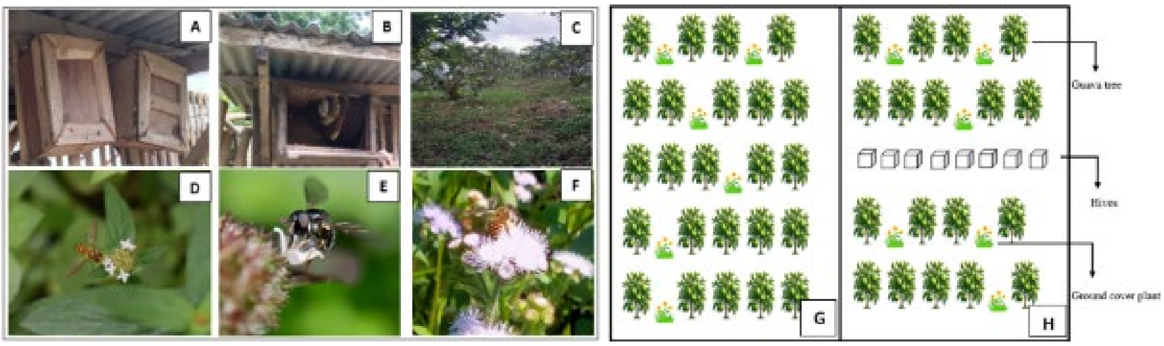
with criteria of low (< 15%), moderate (15–20%), and high (> 20%) (Ludwig *et al.,* 1988).

$$\text{Species Richness Index } (R) = \frac{S\text{-}1}{Ln(N_0)},$$

with criteria of low (< 3), moderat (3–5), and high (> 5) (Isaac *et al*., 2019).



1: *Study area map showing the location of the research site in East Java, Indonesia. Organic orchard with bee hives (Apis mellifera) (7°54’43.81”S, 112°32’03.49”E), Organic orchard without bee hives (Apis mellifera) (7°54’46.05”S, 112°31’50.97”E)*



2: *A) Boxes in orchard, B) Hives in orchard, C) Guava orchard without hives, D) Episyrphus balteatus, E) Paragus haemorrhous, F) Apis mellifera, G) plot of orchard without hives, H) Plot of orchard with hives*

Diversity Index Shannon-Wiener (H') = $\sum(n_i/N) \times (n_i/N)$,

with criteria of low ($H' < 1$), moderat ($1 < H' < 3$), and high ($H' > 3$) (Odum, 1996).

Evennes Index (E) = = $\frac{H'}{ln(S)}$,

with criteria of small, depressed communities ($0 < E < 0.4$), medium, stable communities ($0.4 < E < 0.6$), and stable evenness ($0.6 < E < 1.0$) (Odum, 1996).

Dominance Index (D) = $\sum(pi)^2 = \sum(n_i/N)^2$

with criteria of low ($0 < D < 0,5$), moderate ($0,5 < D < 0,75$), and high ($0,75 < D < 1$) (Odum, 1996)

Furthermore, to determine the difference in the mean composition of insect visitors between the two orchards, an independent samples t-test was conducted using SPSS version 23 (IBM Corp., Armork, NY, USA). To assess the similarity of composition in each period between the two orchards, the Bray-Curtis similarity index was used, followed by Principal Component Analysis (PCA).

RESULTS AND DISCUSSION

Abundance of Insect Visitors on Ground Cover Plants

A total of 733 individuals of insect visitors was observed at the study sites. In the organic orchard with hives, 14 plant species were found, while the organic orchard without hives had 13 species. The total number of insect visitors in the orchard with hives was 472 individuals, comprising 20 species, 12 families and 4 orders. The most frequently visited plant was hives, accounting for abundance of 43.9%. in contrast, the orchard without hives had 261 individuals visitors, representing 23 species, 18 families, and 7 orders. The most visited plant in this orchard was *Lantana camara*, with an abundance of 29.1%, followed by *Ageratum conzyoides* with an abundance of 22.6% (Tab. I).

The number of insect visitors in the organic orchard with hives was higher (472) compared to the orchard without hives (261). The relative abundance between the two orchard (64.4 and 35.60) was high (> 20%). The Richness Index of insect visitors in the orchard with hives (3.09) and the orchard without hives (3.414) had moderate values (> 5). The diversity index between the two orchard (1.8 and 2) was moderate ($1 < H' < 3$). The evenness index between the two orchard (0.30 and 0.33) was low ($0 < E < 0.4$). And the dominance index between the two orchard (0.249 and 0.194) was low ($0 < C < 0.5$). The highest abundance of visitor insects in the orchard with hives come from the order Asterales, family Asteraceae, specifically *Synedrella nodiflora* (43.9), likely due to the higher density of this plant species compared to other ground cover plants. In the orchard without hives, the highest abundance was observed in *Lantana camara* (29.1) from the family Verbenacae.

I: *Ground cover plant and visitor insect abundance*

Species (Family)	Total			Abundance	
	With hives	Without hives	Σ	With hives	Without hives
Synedrella nodiflora L. (Asteraceae)	207	36	243	43.9	13.8
Ageratum conyzoides L. (Asteraceae)	62	59	121	13.1	22.6
Lantana camara L. (Verbenaceae)	6	76	82	1.3	29.1
Eryngium foetidum L. (Apiaceae)	81	-	81	1.2	-
Mimosa pudica L. (Fabaceae)	-	49	49	-	18.8
Cyperus hermaphroditus Jacq. (Cyperaceae)	26	6	32	5.5	2.3
Salvia occidentalis Sw. (Lamiaceae)	31	-	31	6.6	-
Spermacoce remota Lam. (Rubiaceae)	15	10	25	3.2	3.8
Bidens pilosa L. (Asteraceae)	13	-	13	2.8	-
Desmodium tortuosum Sw. (Fabaceae)	7	4	11	1.5	1.5
Cyperus rotundus L. (Cyperaceae)	3	7	10	0.6	2.7
Oxalis barrelieri L. (Oxalidaceae)	10	-	10	2.1	-
Galinsoga parviflora Cav. (Asteraceae)	8	-	8	1.7	-
Digitaria sanguinalis L. (Poaceae)	-	6	6	-	2.3
Crassocephalum crepidiodes Benth. (Asteraceae)	-	5	5	-	1.9
Solanum nigrescens Mart. and Gal. (Solanaceae)	2	-	2	0.4	-
Tridax procumbens L. (Asteraceae)	-	1	1	-	0.4
Stachytarpheta indica L. (Verbenaceae)	-	1	1	-	0.4
Persea americana Mill. (Lauraceae)	-	1	1	-	0.4
Sida acuta Burm. (Malvaceae)	1	-	1	0.2	-
No.individuals	472	261	733		
Simpson_ID	64.4	35.60			
Species Richness	3.09	3.41			
Shannon_H	1.8	2.0			
Evenness_e^H/S	0.3	0.34			
Dominance_D	0.24	0.19			

Movement Between Flowers

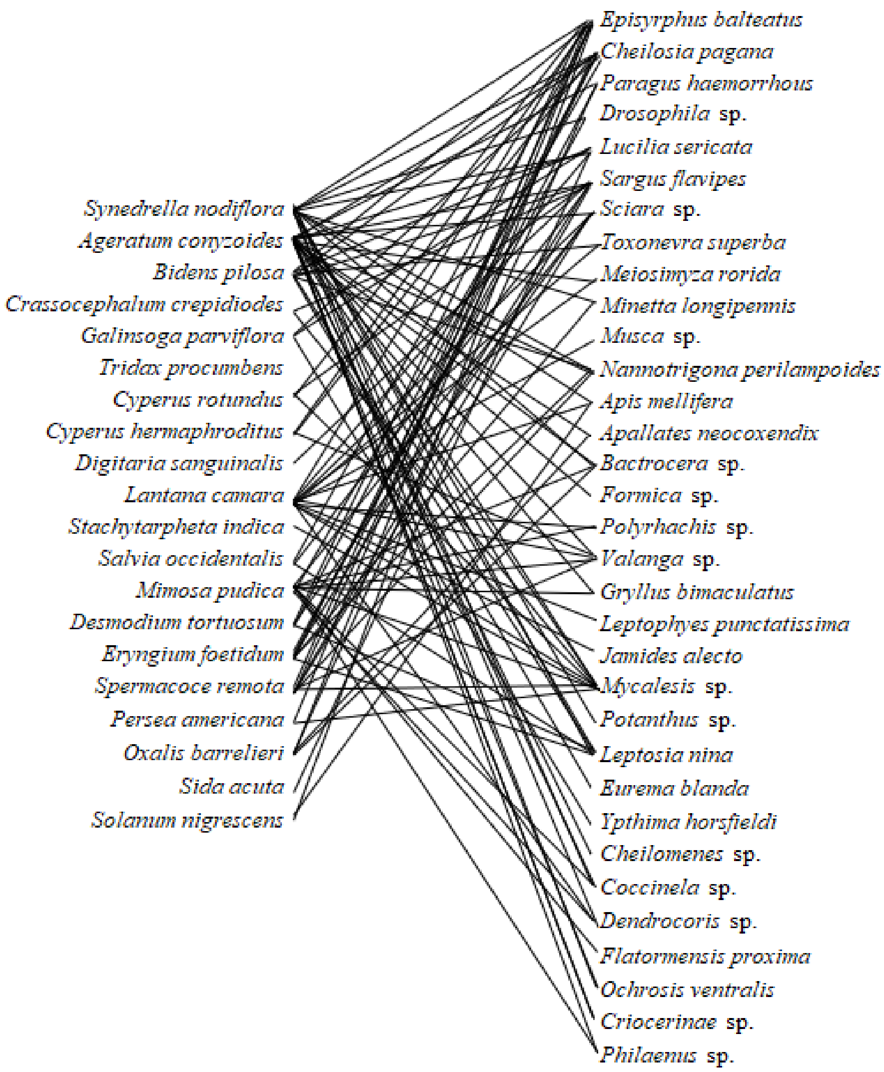
The movement of insect visitors among flowers was recorded during the observation period, tracking their movement from one plant to another. Among the 20 ground cover plant species in organic orchard, both with and without hives, the insects of *Episyrphus balteatus*, *Sargus flavipes*, *Nannonatrigona perilampoides*, *Mycalesis* sp., and *Cheilosia pagana* exhibited the most movement between flowers during the study. The most frequently visited ground cover plants were *Synedrella nodiflora*, *Ageratum conyzoides*, *Lantana camara*, *Eryngium foetidum*, and *Mimosa pudica*.

The movement of these visitor insects between flowers highlights a close interaction that forms a complex food web. For example *Synedrella nodiflora* was visitied by *Bactrocera* sp., a pest, which in turn attracted *Sargus flavipes* as a predator, *Episyrphus balteatus*, which functions both as a predator and pollinator, and *Lucilia sericata*, which acts as a detrivore (Fig. 3).

Abundance, Species Richness, Diversity, Evenness and Dominance of Insect

In the organic orchard with hives, five orders were observed visiting ground cover plants; Diptera, Lepidoptera, Hemiptera, Hymenoptera, and Coleoptera. In contrast, the organic orchard without hives had six orders: Hymenoptera, Diptera, Hemiptera, Orthoptera, Lepidoptera, and Homoptera (Tab II).

The abundance and dominance of visitor insects were higher in the orchard with hives (64.39%; 0.18) compared to the orchard without hives (35.61%; 0.11). In the orchards with hives, species richness (5.20), diversity (5.20), evenness (2.07) were lower than in the orchard without hives (5.93; 2.56; 0.46). The highest abundance of wild pollinating insects was recorded for *Episyrphus balteatus* with 148 individuals in the organic orchard with hives and 39 individuals in the orchard without hives.



3: *Association between insect attraction to ground cover plants in organic orchard*

II: *Abundance, species richness, diversity, evenness and dominance of visitor insects*

Species (family)	Total individual		Σ	%	Role
	With hives	Without hives			
Episyrphus balteatus (Syrphidae)	148	39	187	25.51	Pollinator
Sargus flavipes (Stratiomyidae)	101	29	130	17.74	Predator
Nannotrigona perilampoides (Apidae)	60	1	61	8.32	Pollinator
Mycalesis sp (Nymphalidae)	-	56	56	7.64	Pollinator
Cheilosia pagana (Syrphidae)	40	11	51	6.96	Pollinator
Lucilia sericata (Calliphoridae)	44	7	51	6.96	Detrivor
Paragus haemorrhous (Syrphidae)	7	17	24	3.27	Pollinator
Sciara sp. (Sciaridae)	-	22	22	3.00	Detrivor
Apallates neocoxendix (Chloropidae)	4	17	21	2.86	Predator
Leptosia nina (Hesperiidae)	18	-	18	2.46	Pollinator
Bactrocera (Tephritidae)	9	8	17	2.32	Pest
Apis mellifera (Apidae)	11	5	16	2.18	Pollinator
Valanga (Acrididae)	-	16	16	2.18	Predator
Drosophila (Drosophilidae)	11	1	12	1.64	Pest
Coccinela (Coccinellidae)	-	9	9	1.23	Predator
Meiosimyza rorida (Lauxaniidae)	5	-	5	0.68	Parasitoid
Jamides alecto (Lycaenidae)	-	5	5	0.68	Pollinator
Dendrocoris (Pentatomidae)	-	5	5	0.68	Pest
Ochrosis ventralis (Chrysomelidae)	4	-	4	0.55	Pest
Gryllus bimaculatus (Gryllidae)	-	3	3	0.41	Predator
Toxonevra sp. (Pallopteridae)	-	2	2	0.27	Pollinator
Minetta longipennis (Lauxaniidae)	2	-	2	0.27	Predator
Polyrhachis (Formicidae)	-	2	2	0.27	Predator
Eurema blanda (Hesperiidae)	2	-	2	0.27	Pollinator
Cheilomenes (Coccinellidae)	-	2	2	0.27	Predator
Criocerinae (Chrysomelidae)	2	-	2	0.27	Polinator
Philaenus (Cercopidae)	-	2	2	0.27	Pest
Musca sp. (Muscidae)	1	-	1	0.14	Detrivor
Formica sp. (Formicidae)	-	1	1	0.14	Predator
Leptophyes punctatissima (Tettigoniidae)	-	1	1	0.14	Predator
Potanthus sp. (Hesperiidae)	1	-	1	0.14	Pollinator
Ypthima horsfieldi (Hesperiidae)	1	-	1	0.14	Pollinator
Flatormensis proxima (Flatidae)	1	-	1	0.14	Detrivor
No.individuals	472	261	733		
Simpson_I-D	64.39	35.61			
Species Richness	5.20	5.93			
Shannon_H	2.07	2.56			
Evenness_e^H/S	0.34	0.46			
Dominance_D	0.18	0.11			

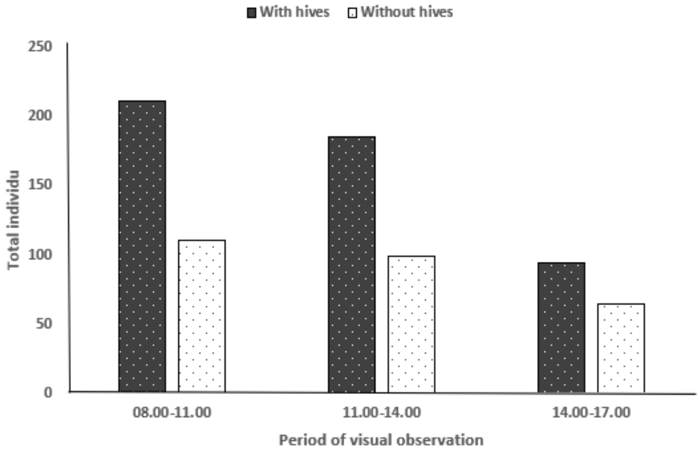
Distribution of Foraging Insects

Insect foraging activity varies with the flower opening period, temperature and light intensity. Pollinators exhibited different foraging patterns at various times of the day. The peak of foraging activity occurred between 08.00 to 11.00 (Fig. 4), when air temperature and light intensity were optimal for insect activity. Foraging activity began to decline from 14.00 to 17.00.

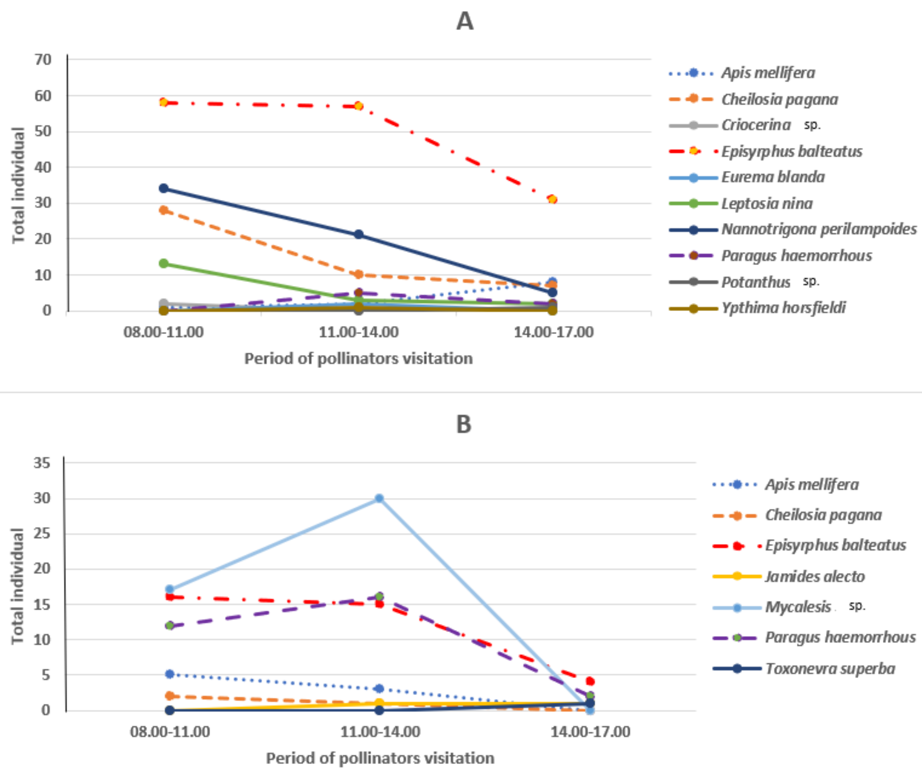
In both the organic orchard with hives and organic orchard hives, the wild pollinating insects *Episyrphus balteatus* was actively visiting flowers from 08.00 to 14.00 (Fig. 5). Additionally, *Cheilosia pagana*, *Nannotrigona perilampoides*, and *Leptosia nina* were also active during this period, with their visits decreasing thereafter. In the orchard without hives, beside *Episyrphus balteatus*, the species *Mycalesis* sp. and *Paragus haemorrhous* were actively visiting flowering plants from 08.00 to 14.00, with their activity declining in the following hours.

Abundance, Species Richness, Diversity, Evenness, and Domination of Pollinator

The abundance, species richness, diversity, evenness and dominance of pollinators differed between the orchard with and without hives were different (Tab. III).



4: *Insect visitation period in organic orchard with and without hives*



5: *Pollinator visitation period in organic orchard A) With hives, B) Without hives*

III: *Average abundance, species richness, diversity, Evenness, and domination of insect in organic orchard*

Index	With hives				Without hives			
	Pests	Predator	Pollinator	Detrivor	Pests	Predator	Pollinator	Detrivor
Abundance	5.08	22.67	62.50	9.75	6.13	30.65	52.11	11.11
Species Richness	1.26	1.71	2.29	0.78	1.44	1.83	2.65	0.89
Diversity	1.02	0.25	1.50	0.21	0.78	1.68	1.53	0.55
Evenness	0.32	0.05	0.26	0.05	0.38	0.38	0.31	0.16
Dominance	0.38	0.89	0.32	0.92	0.37	0.23	0.28	0.63

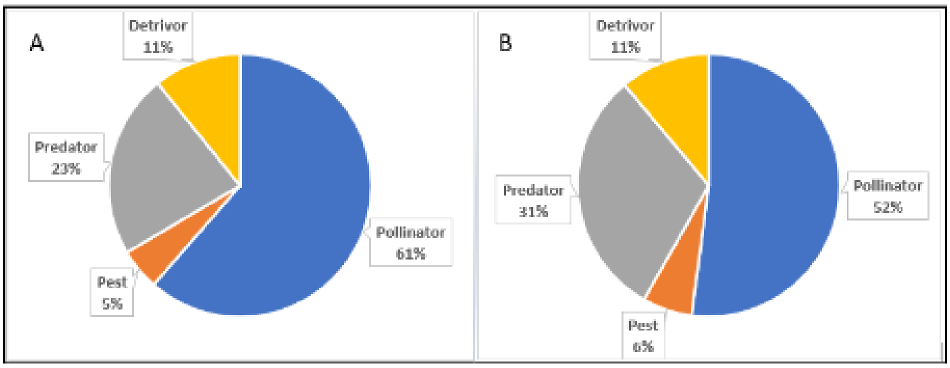
The abundance of pollinator insects in orchard with hives (62.50) was higher than the abundance of pollinator insects in orchard without hives (52.11), the abundance of pollinators in both orchard was categorised as high (> 20%). In orchard with hives, pollinators (62.50) dominated over pests (5.08) and predators (22.67). Species richness of pollinator insects in the orchard without hives was higher (2.65) compared to other insects. However, the species richness between the two orchard was categorised as low (< 3). Diversity of predatory insects in the orchard without hives (1.68) was higher than other insect species. In the orchard with hives, the diversity of pests (1.02) and pollinators (1.68) was categorised as medium ($1 < H' < 3$), in the orchard with hives, predators (1.68) and pollinators (1.53) were also categorised as medium. On orchard without hives, the evenness of pests (0.38) and detrivors (0.38) has a higher value than other types of insects. However, insect evenness in the two orchard was categorised as small ($0 < E < 0.4$). The dominance of predatory insects (0.89) was higher than other insect species in both orchard. The dominance of pollinator insects was also higher (0.32) compared to the dominance of pollinator insects on the orchard without hives (0.28). Detrivors on orchard without hives (0.92) and Predators on orchard with hives (0.89) are categorised as high ($0.75 < C < 1$). While the dominance of pests in both orchard (0.38; 0.37), and pollinators (0.32; 0.28) have low dominance ($0 < C < 0.5$).

Composition of Pollinator in Organic Orchard with and Without Hives

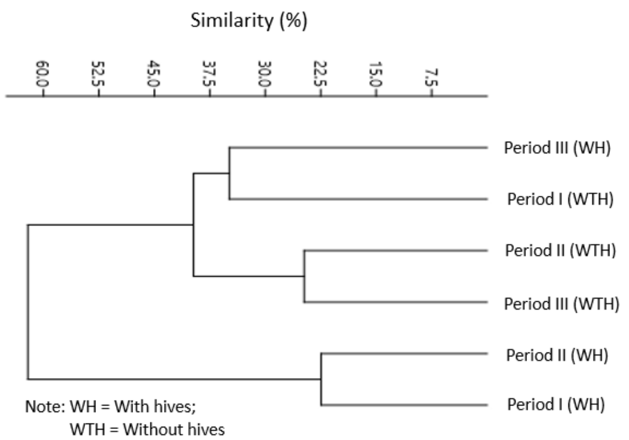
The composition of pollinating insects in ground cover plants around organic orchard with hives is 61% consisting of the Syrphidae, Hesperiidae, Apidae, and Chrysomelidae families. While non-pollinators are 39% with a composition of 22% are predators consisting of the family Lauxaniidae, and Stratiomyidae, 10% are detrivors consisting of the family Calliphoridae and Flatidae, 5% are pests consisting of the family Tephritidae, Drosophilidae, and Chrysomelidae, 2% are parasitoids consisting of the family Lauxaniidae, and Chloropidae.

The composition of pollinator in ground cover plants around organic orchard without hives was 52% consisting of the families Apidae, Syrphidae, Pallopteridae, Lycaenidae, Hesperiidae, and Nymphalidae. While non pollinators were 48% with a composition of 24% being predators consisting of the families Formicidae, Stratiomyidae, Acrididae, Gryllidae, Tettigoniidae, and Coccinellidae, 11% were detrivors consisting of the families Calliphoridae and Sciaridae, 7% were parasitoids consisting of the family Chloropidae, and 6% were pests consisting of the families Tephritidae, Drosophilidae, Pentatomidae, and Cercopidae.

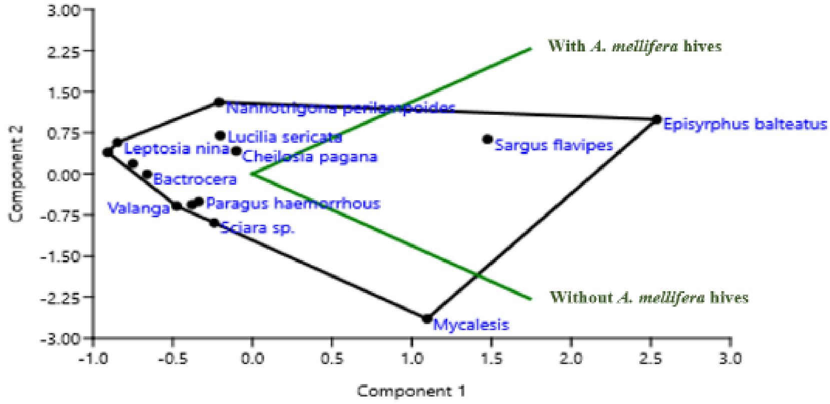
The independent sample t-test analysis indicated no difference between the composition of insect visitors between organic orchard with hives and organic orchard without hives (Sig. 0.166 > 0.05; *p value* 1.409 < t-table 5% value 1.683), suggesting no difference in average abundance between the two orchards.



6: *Composition of insects in organic orchard A) with hives B) without hives*



7: *Bray-Curtis similarity index of insect at three periods in organic orchard with and without hives*



8: *Insect abundance in two orchards using PCA*

Statistic tests for pest composition also show no difference (Sig. 0.178 > 0.05; *p-value* 1.565 < t-table 5% value 2.015). Similarly, predators composition showed no difference (Sig. 0.165 > 0.05; *p-value* 1.499 < t-table 5% value 1.812), and the detrivors composition was also similar (Sig. 0.968 > 0.05; *p-value* 1.43 < t-table value 5% 2.353). finally, there was no significant difference in pollinator composition (Sig. 0.569 > 0.05; *p-value* 0.580 < t-table value 5% 1.739).

Analysis using the *Bray Curtis Index* reverals that the orchard with hives has similarities in insect composition between period I (08.00 to 11.00) and period II (11.00 to 14.00). In contrast, the orchard without hives has similarities between period II (11.00 to 14.00) and period III (14.00 to 17.00). Additionally, the orchard with hives in period III (14.00 to 17.00) shows similarities with the orchard without hives in period I (08.00 to 11.00) (Fig. 7).

Based on the correlation analysis, the *Eigenvalue* (1.26409 + 0.735911) > 1 and the % Variance (63.204 + 36.796) > 75%, indicating that the correlation requirements are met. Consequently, further tests were conducted using *Principal Component Analysis* (PCA). The PCA result showed that the distribution of insect abundance differed between the two orchards in terms of species such as *Ephiyrphus balteatus*, *Nannotrigona perilampoides*, *Leptosia nina*, *Valanga*, *Sciara* sp., and *Mycelesis* sp., while other insect species showed similarities. The insect species characters have similarities between the two orchards are *Episyrphus baltaetus*, and *Sargus flavipes* (Fig. 8).

DISCUSSION

Several studies have reported the insect relationships between insect and flowering wild plants as a resource for pollinators and predators, but findings vary according to their habitat (Abidin, *et al.*, 2020; Leksono, *et al.*, 2018). Therefore, this study focused on insect visitors to ground cover plants in organic orchard with and without beekeeping. The results showed that the number of insect visitors was higher in the orchard with bee hives (*Apis mellifera*) compared to orchard without hives. However, species richness was higher in the orchard without hives. This suggests a difference in the composition of insect visitors between the two orchards due to several factors:

1. The competition and dominance of honey bees (*Apis mellifera*), which are very efficient at

foraging for nectar and pollen. The presence of bee hives in a orchard can lead to dominance in resource collection. *Apis mellifera* tends to dominate floral resources, leading to an increase in the number of individual insect visitors, but this dominance can also lead to a reduction in the presence of other insect species that cannot compete with honey bees, thus reducing species richness.

2. Effects of displacement of other species. The presence of large numbers of honey bees can lead to the expulsion of other smaller or less competitive pollinator species, as a result orchard without bee hives (*Apis mellifera*) have fewer individual visitors, but they are diverse, because there is no dominant species that expels other species.
3. Habitat and resource preferences. Honey bees (*Apis mellifera*) have certain preferences for the types of flowers and plants they visit. In orchard with hives, flowers favoured by *Apis mellifera* are more frequently visited, while non-preferred flowers are less exploited, thus providing opportunities for other insect species to visit. In orchard without hives, this absence of dominant preferences allows more insect species to utilise different resources, there by increasing species richness.
4. Specific effects on food webs and ecosystems. The presence of *Apis mellifera* hives can alter the overall ecosystem structure, and affect food webs and interactions between species. This can affect the presence and foraging and nesting behaviour of other insects, which in turn can affect overall species composition (Leguzamon *et al.*, 2021; Varma *et al.*, 2023).

The Shannon-H diversity index showed moderate values in both orchard, reflecting a moderate level of species diversity. The higher Shannon-H value in the orchard without hives suggests a more diverse distribution of visiting insect species. This finding implies that while no single species is overwhelmingly dominant, there is also no perfectly even distribution. The Evennes index was low in both orchards, indicating that although various species visited the plants, their distribution was uneven. The data reveral a few species that are significantly more dominant in numbers compared to others, particularly *Episyrphus balteatus*, *Sargus flavipes* and *Nannotrigona perilampoides*. These species are successful in dominating resources and effectively competing with other insect visitors (Mallinger *et al.*, 2017). Interestingly, the abundance of those species was higher in the orchard with hives than in the one without, suggesting that they likely coexist well with honey bees.

Overall, the presence of honey bees in the orchard appears to influence the distribution and movement of insect visitors among flowers. Honey bees alters the competition patterns among visiting insect species, which in turn affects their plant selection. In addition to being recognized as key pollinators in many agricultural ecoosystems, the presence of honey bees may also impact the distribution of other insect that serve as pollinators, potentially leading other species to avoid flower frequented by honey bees.

The plant *Synedrella nodiflora* attracts many insect due to its bright yellow pollen grains, round shape, and flowering time starts at 07.00 to 09.00. During this periode, it emits a distinctive odor that attracts various insect families, including Apidae, Anthophoridae, Halictdae, Sarcophagidae, Pieridae, Vespidae, and Syrpidae (Usharani *et al.*, 2018), in contrast, the orchard without hives features *Lantana camara* from the Verbenacae family. This species has diverse flower colours such as purple, white and yellow, pink and orange which emits a distinctive scent that attracts several types of insects (Suryati *et al.*, 2021).

In the organic orchard with hives, the most common insect observed is Order Diptera. This order is particularly beneficial in agriculture as its members serve both as natural enemies of pest insects and important pollinator for plants. Pollinators from the orders Diptera, Hymenoptera and Lepidoptera have specialized mouthparts for sucking nectar and other plant fluids, which enables them to thrive in environments with extreme nectar and availability and enhances their overall health (Susanti *et al.*, 2018).

The highest abundance of wild pollinating insects, *Episyrphus balteatus* was observed in both the organic orchard with hives and in orchard without hives. This species thrives around organic orchard due to its ability to inhabit various environments, including city parks, home orchard and forests. Additionally, the abundance of flowering ground cover plants in these orchards provides a rich source of pollen and nectar. *Episyrphus balteatus* prefer smaller, yellow coloured flowers, with a high nectar concentration. Although not as efficient as honey bees, this insect species is a significant and abundant pollinator. Furthermore, *Epysirphus baltaetus* is terrestrial and preys on aphids, making it a key natural enemies of cereal aphids (Jami *et al.*, 2014; Das *et al.*, 2018). Studies show that *Episyrphus balteatus* can consume up to 400 aphids before pupating (Rana *et al.*, 2014).

Insect foraging activity varies with the flower opening period, temperature and light intensity. The peak foraging activity was observed between 08.00 to 11.00, when air temperature and light intensity were optimal for insect activity. Activity than declined from 14.00 to 17.00 due to decreasing temperature, light intensity and increasing humidity, all of which are crucial factors affecting insects foraging and survival.

CONCLUSION

The total number of insect visitors was higher in the organic orchard with hives compared to the orchard without hives. The abundance of pollinating insects in orchard with hives was higher than pollinators in orchard without hives. Additionally, the abundance of pollinators exceeded that of pests, predators and detrivores. The diversity and species richness indices were moderate in both orchards, but the orchard without hives had slightly higher values for both indices. *Synedrella nodiflora* dominated in the orchard with hive, while *Lantana camara* was the dominant species in the orchard without hives. Analysis showed no significant difference in the overall composition of insect visitors between the two orchards, but there was a difference in the dominant insect species. The peak of insect activity occurred from 08.00 to 11.00, especially in the orchard with hives. Overall, although there were differences in the number and type of pollinators in the two orchard, the general insect composition was similar, suggesting that the presence of *Apis mellifera* may influence and suppress some pests, but does not drastically alter the insect dynamics in organic orchard.

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