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Diversity and Population Dynamic of Arthropod Visitors in Bitter Melon (*Momordica charantia* L.) Agroecosystems

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ABSTRACT

Previous studies have emphasized the ecological benefits of shaded agroecosystems in enhancing arthropod diversity and maintaining ecosystem stability, yet limited research has focused on *Momordica charantia* under such conditions. This study aimed to assess the diversity and abundance of arthropods inhabiting bitter melon plants grown beneath shade. The research was conducted for five consecutive weeks using direct observation and trapping methods in a field setting, with specimens identified to the morphospecies level and classified by ecological role. A total of 465 individuals were recorded, consisting of pollinators, detritivores, pests, and predators. The Shannon–Wiener diversity index (H') indicated moderate diversity, and the evenness index (E) showed high community uniformity, reflecting ecological stability. Pollinators and detritivores were the most dominant functional groups, while pests and predators appeared in low abundance, suggesting natural regulatory interactions. These findings demonstrate that shaded bitter melon ecosystems can sustain high arthropod diversity and provide essential ecosystem services such as pollination and biological control, supporting sustainable agroecosystem management.

Keywords: arthropod diversity; bitter melon; population dynamic; biodiversity; sustainable agriculture

INTRODUCTION

Agricultural ecosystems are complex biological systems where the interactions between plants and insects play a fundamental role in sustaining productivity and biodiversity. Insect pollinators, in particular, are essential agents that contribute significantly to the reproductive success of many flowering plants, including horticultural crops. Globally, it is estimated that the major food crops benefit from animal-mediated pollination, with insects representing the dominant pollinating group (Klein *et al.*, 2007). However, the diversity and abundance of pollinators are influenced by several ecological and anthropogenic factors such as land-use changes, pesticide application, and habitat fragmentation, which may threaten pollination services in agroecosystems (Pontarp *et al.*, 2024). Therefore, understanding the diversity of insect pollinators within agricultural landscapes is critical to ensuring sustainable crop yields and ecosystem stability.

Bitter melon (*Momordica charantia*), a member of the Cucurbitaceae family, is a vegetable crop of high economic and nutritional importance, cultivated widely in tropical and subtropical regions. The fruit is valued for its medicinal properties and its role in traditional diets as a source of bioactive compounds, vitamins, and minerals (Bhardwaj *et al.*, 2014). Despite its potential, the productivity of bitter melon remains inconsistent due to its dependence on effective pollination. As a monoecious species bearing separate male and female flowers, *M. charantia* relies primarily on external pollinators particularly insects to transfer pollen and ensure fruit set (Layek *et al.*, 2025). Without sufficient pollinator activity, fruit yield and quality may decline significantly, emphasizing the ecological and economic importance of maintaining pollinator populations in bitter melon cultivation systems.

The diversity of insect pollinators visiting M. charantia flowers may vary according to habitat conditions, local flora composition, and environmental factors such as temperature and humidity. Previous studies have shown that members of the orders Hymenoptera, Diptera, and Lepidoptera are among the most frequent visitors of Cucurbitaceae flowers (Chaudhary *et al.*, 2024). Nevertheless, the community structure and abundance of these insects in tropical agroecosystems remain underexplored. The richness and abundance of pollinating insects not only affect pollination success but also provide insight into the ecological integrity of the agroecosystem (Giovanetti *et al.*, 2021). Therefore, assessing the diversity and abundance of pollinator insects in M. charantia cultivation areas can serve as a basis for developing pollinator-friendly management strategies that enhance both productivity and ecological balance.

Beyond their role in fruit production, pollinator diversity is essential for maintaining genetic variability within plant populations and for promoting ecosystem resilience. A diverse pollinator community ensures stable pollination under fluctuating environmental conditions and reduces the risk of yield loss caused by the decline of any single pollinator species (Ollerton, 2017). Understanding the temporal and spatial distribution of pollinator taxa thus provides crucial insights for conserving pollination services and supporting sustainable agricultural practices that integrate biodiversity conservation with production goals. Therefore, the objective of this research is to determine the diversity and abundance of insect pollinators associated with bitter melon (*Momordica charantia*) flowers in an agroecosystem environment.

MATERIAL AND METHOD

Research Method

This study was a field-based descriptive and quantitative ecological survey designed to assess the diversity and abundance of insect pollinators visiting bitter melon (*Momordica charantia*) flowers. The research was conducted at the Agribusiness Clinic, Faculty of Agriculture, Sriwijaya University, Indralaya, South Sumatra, Indonesia. Specimen identification and data analysis were performed at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University. The research subjects were insect pollinators that visited the flowers of bitter melon cultivated in the Agribusiness Clinic experimental field. Observations focused on insect taxa, abundance, and visiting behavior in relation to the flowering period of the plants.

Research Procedure

The study used purposive sampling to select observation plots consisting of eight ridges (1 × 22 m each) with a spacing of 0.5 m. From these, four ridges were selected, and ten plants per ridge were observed, totaling 40 sample plants. Observations were carried out for five weeks, twice a week (Tuesdays and Thursdays), and twice per day morning and afternoon. During each observation period, the observer walked along the ridges and monitored each sample plant for 1–2 minutes, recording all insect visitors. Insects were photographed and collected using tweezers or insect nets, preserved in vials containing 70% alcohol, and labeled with collection details. Specimens were then taken to the Entomology Laboratory for identification based on morphological characteristics using entomological keys and reference books (Kalshoven, 1981).

Instrument and Materials

The instruments used included: stationery, vials, stereo microscope, magnifying glass, digital camera, tweezers, insect nets, plastic bags, and name labels. The materials consisted of 70% alcohol for specimen preservation and several reference books for insect identification.

Analysis Technique

Data obtained were tabulated and analyzed both quantitatively and descriptively to determine the diversity, abundance, and distribution of pollinating insects.

Three ecological indices were calculated as follows:

Shannon–Wiener Diversity Index (H') (Odum, 1993):

$$H' = -\sum_{i=1}^{n} pi \ln pi$$

H' = Diversity Index

Pi = The ratio of the number of individuals of a species to the total number of species

In = The total number of individuals of all species

Ni = The total number of individuals of a species

Simpson's Dominance Index (D) (Odum, 1993):

$$D = \frac{N_{max}}{N}$$

A value of D close to 1 indicates high dominance by a few species.

Evenness Index (E) (Odum, 1993):

$$E = \frac{H'}{\ln(S)} \quad (3)$$

A value of E close to 1 indicates even distribution among species.

Additionally, relative abundance and visitation frequency were calculated to determine the ecological roles of each insect taxon. Data were processed using R Studio 2025 and PAST 4 software. The results were interpreted to describe species composition, diversity level, dominance structure, and pollination potential of insect visitors in the bitter melon agroecosystem.

RESULT AND DISCUSSION

Composition of Arthropod Visitors to Bitter Melon Plants

The composition of arthropods recorded during the study is presented in Table 1, representing six orders with twelve morphospecies. The Hymenoptera was the most dominant order, represented mainly by pollinators such as *Apis mellifera*, *Trigona* spp., and *Trigona spinipes*, with a total of 200 individuals. The Formicidae family, represented by Camponatus carnelius, accounted for 212 individuals, playing a crucial role as detritivores that contribute to nutrient cycling. Meanwhile, members of the Coleoptera, Thysanoptera, Lepidoptera, Hemiptera, and Araneae orders were found in smaller proportions, consisting mostly of pest and predator species that maintain ecological balance within the system.

During the observation period, a total of 465 individual arthropods were successfully captured in the traps. Based on the analysis (Figure 1), the Shannon–Wiener diversity index (H') of the arthropod community was 1.609, which falls into the moderate diversity category

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(1 < H' < 3). The dominance index (D) was recorded at 0.456, indicating that no single species overwhelmingly dominated the community, and that the distribution of individuals among species was relatively balanced. Meanwhile, the evenness index (E) was calculated at 0.527, suggesting a moderate level of species evenness (0.4 < E < 0.6), where some species were more abundant than others. These results align with the findings of Farooq *et al.* (2022), who reported that arthropod diversity in agroecosystems with the intermediate stability typically shows moderate diversity and evenness values. Thus, it can be inferred that the environmental heterogeneity and resource distribution within the study area contributed to maintaining a balanced yet moderately diverse arthropod community structure.

The evenness index (E) obtained was 0.527, which falls into the moderate category (0.4 < E < 0.6). This indicates that individuals within the community were distributed relatively evenly among species, though slight variations in abundance occurred. The weekly data supported this observation, showing evenness values ranging from 0.4642 (week 3) to 0.5899 (week 5), with an overall mean of 0.527. Such a distribution pattern suggests that no single species overwhelmingly dominated the community, but instead, most species coexisted with relatively balanced proportions. According to Wohlgemuth *et al.* (2016), a moderate to high level of evenness reflects a stable community structure, where interspecific interactions remain balanced. Therefore, the observed arthropod community exhibits a relatively uniform species distribution, typical of an agroecosystem with moderate structural complexity compared to monoculture systems.

The dominance index (D) obtained was 0.456, which is categorized as moderate dominance (0.3 < D < 0.5). This value indicates that a few species were slightly more abundant than others but did not completely dominate the community structure. Weekly dominance values varied narrowly, from 0.4433 (week 3) to 0.4624 (week 2), suggesting minor fluctuations in the relative abundance of dominant taxa. Such dominance may be associated with temporary environmental factors or resource availability favoring certain species. However, the overall moderate dominance supports the conclusion that no single species exerted ecological pressure on the community composition. This finding is consistent with Joern and Laws (2013), who reported that higher arthropod diversity tends to suppress species dominance, leading to more stable ecological networks. Hence, a community with moderate dominance typically maintains resilience and functional balance within its ecosystem.

Overall, the community characteristics observed in this study can be described as having moderate diversity (H' = 1.609), moderate evenness (E = 0.527), and moderate dominance (D = 0.456). This combination reflects a relatively balanced and moderately stable ecosystem, where individuals are distributed evenly across species and no taxon exerts disproportionate control over the community structure. Such ecological equilibrium is essential to maintain ecosystem functionality and resilience against disturbances. This finding is further supported by Safitri *et al.* (2025), who emphasized that communities with

Table 1. Diversity of arthropods on bitter melon plants

Order	Family	Species	Common Name	Role	Number of Individuals
Hymenoptera	Apidae	*Apis mellifera*	Honey bee	Pollinator	51
Hymenoptera	Apidae	*Trigona spp.*	Stingless bee	Pollinator	80
Hymenoptera	Apidae	*Trigona spinipes*	Stingless bee	Pollinator	69
Hymenoptera	Formicidae	*Camponatus carnelius*	Ant	Detritivore	212
Coleoptera	Chrysomelidae	*Aulacophora similis* Oliver	Leaf beetle	Pest	16
Coleoptera	Chrysomelidae	*Aulacophora lewisii*	Leaf beetle	Pest	6
Coleoptera	Coccinellidae	*Henosepilachna vigintioctopunctata*	Pumpkin beetle	Pest	2
Coleoptera	Coccinellidae	*Anatis* sp.	Predatory beetle	Predator	1
Thysanoptera	Thripidae	*Thrips tabaci*	Onion thrips	Pest	18
Lepidoptera	Noctuidae	*Spodoptera litura*	Armyworm	Pest	4
Hemiptera	Miridae	*Nesidiocoris tenuis*	Mirid bug	Pest	5
Araneae	Thomisidae	*Thomisus tenuis*	Crab spider	Predator	1
Total					465

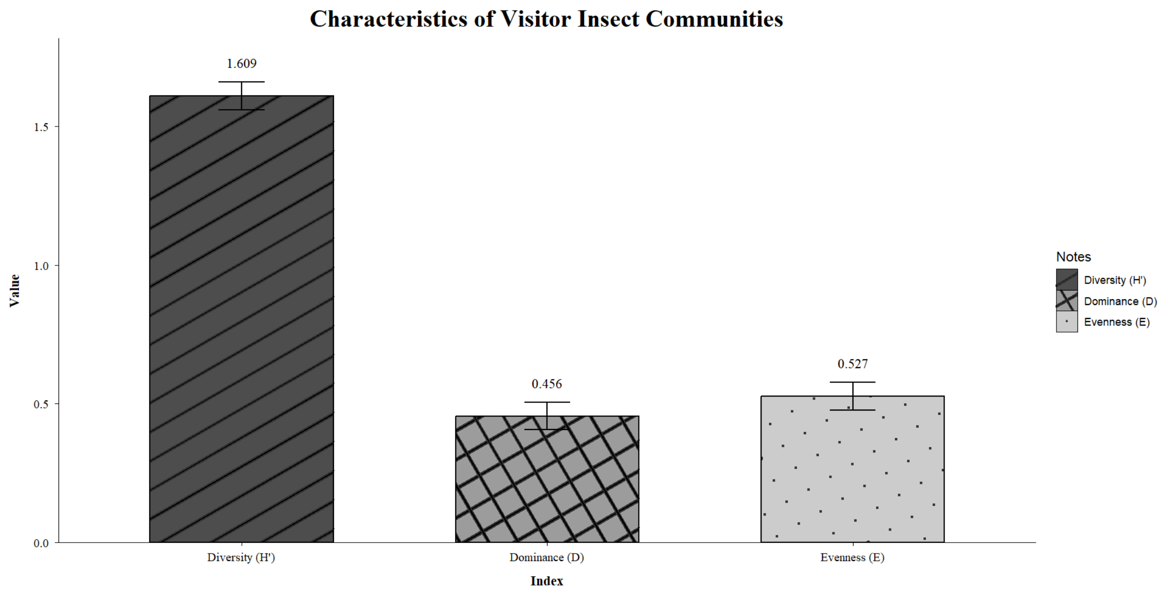

Figure 1. Community Characteristics of Arthropods on bitter melon plants: Diversity (H'), Dominance (D), and Evenness (E)

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balanced species distributions and low to moderate dominance tend to preserve ecological processes more effectively over time. Thus, the arthropod community in this study exemplifies a moderately diverse and ecologically stable system, sustaining its functional roles within the agroecosystem landscape.

Population Dynamics of Arthropod Morphospecies on Bitter Melon Plants

The population of arthropods found on chili plants under areca palm shade exhibited notable fluctuations from the first to the fifth week of observation (Figure 2). Overall, the number of individuals tended to remain relatively stable during the early weeks, with a gradual increase observed in several dominant species such as *Camponatus carnelius* (Hymenoptera: Formicidae) and *Trigona* spp. (Hymenoptera: Apidae). The highest abundance was recorded in Week 2 and Week 3, primarily due to the consistent dominance of *Camponatus carnelius*, which reached 43 individuals, followed by *Trigona* spp. with 16 individuals and *Trigona spinipes* with 14 individuals. These three species collectively represented the majority of individuals throughout the sampling period.

The overall arthropod population composition was dominated by members of the order Hymenoptera, particularly *Apis mellifera*, *Trigona* spp., and *Trigona spinipes*, which served as pollinators in the agroecosystem. Their stable presence across all observation weeks indicates a favorable foraging environment under area bitter melon plants. Similar patterns of consistent abundance across weeks have been reported by Martin-Chave *et al.* (2019), indicating that stable microclimatic conditions under shaded environments tend to support sustained arthropod activity. Predatory arthropods were present in very low numbers throughout the observation period. *Thomisus tenuis* (Araneae: Thomisidae) and *Anatis* sp. (Coleoptera: Coccinellidae) appeared only once during the five weeks of sampling, while *Henosepilachna vigintioctopunctata* was detected twice in Week 3 and Week 4. Although their frequency of occurrence was low, these predators play an important role in maintaining ecological balance by preying on herbivorous insects. Similar findings were reported by Vargas *et al.*, (2023), who emphasized that predator populations, even at low densities, contribute significantly to the biological control of pest arthropods in tropical agroecosystems.

Based on Figure 2, the overall arthropod population reached its highest total abundance during Week 2 and Week 3, mainly due to the elevated counts of *Camponatus carnelius*, *Trigona* spp., and *Trigona spinipes*. From Week 4 onwards, a slight decrease in total individuals was observed, yet the community composition remained stable. The persistence of pollinator and detritivore groups suggests that the shaded chili ecosystem provides continuous resources and microhabitat stability for diverse arthropod guilds. These results align with the observations of Olfert *et al.* (2002), who reported that temporal distribution patterns of arthropods in shaded cropping systems are strongly influenced by plant phenology and microclimatic consistency, both of which contribute to maintaining ecosystem equilibrium and biodiversity.

Distribution of the Role of Arthropods in Bitter Melon Plants

The distribution of arthropod functional roles on red chili plants under Arenga pinnata shade exhibited clear fluctuations from week 1 to week 5. During the initial weeks (M1–M2), pollinators and detritivores were dominant, each contributing

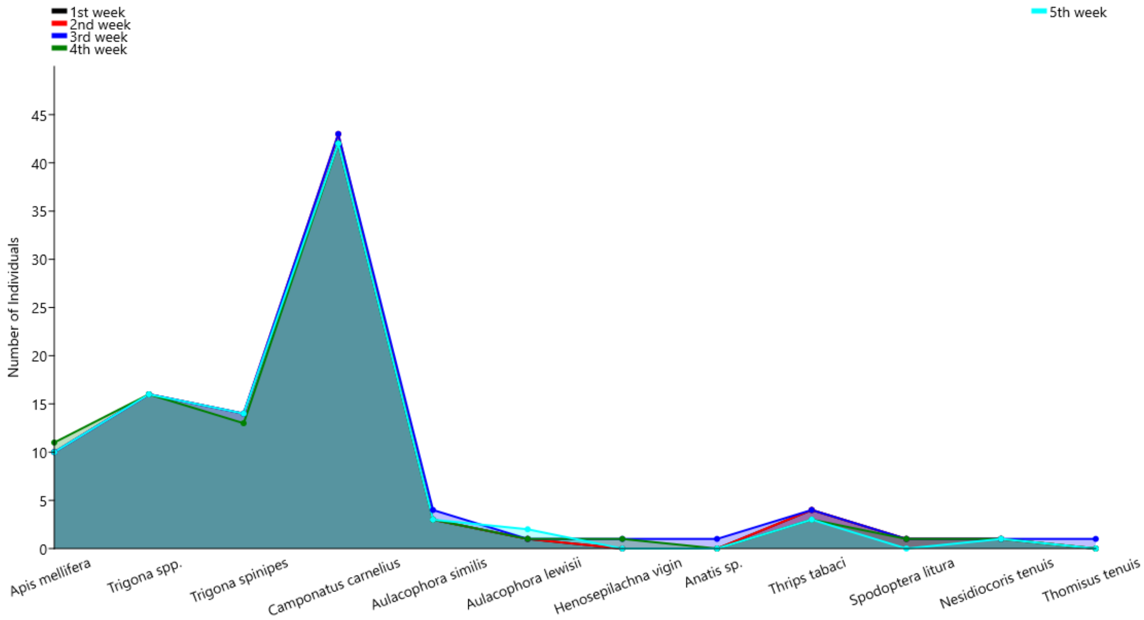

Figure 2. Population Dynamics of Arthropod Visitors on Bitter Melon Plants

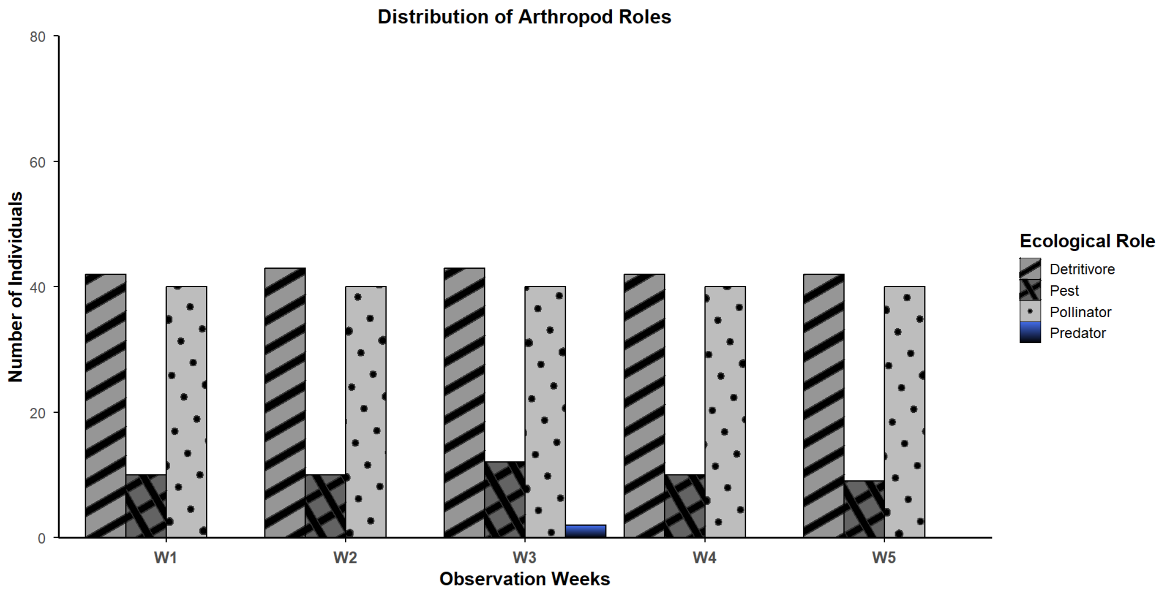

Figure 3. Distribution Pattern of the Role of Arthropod Visitors Based on Bitter Melon Plants

approximately 40–45 of the total arthropods, while pests appeared in smaller proportions of around 10%, and predators were absent (Figure 3). This pattern indicates that beneficial arthropods, particularly pollinators and decomposers, were already well established during the early growth phase of the crop. Furthermore, the early presence of beneficial arthropods can suppress herbivore populations and contribute to ecosystem stability in tropical agricultural systems.

The population of arthropods reached its peak in week 3 (M3), when detritivores attained 44% of the total abundance, slightly surpassing pollinators (41%) and far exceeding pests (12%) and predators (2%). Following this peak, the total number of arthropods declined slightly but remained dominated by detritivores and pollinators. For example, in weeks 4 and 5 (M4–M5), detritivores maintained a steady proportion of around 45%, while pollinators remained at 40%, and pests fluctuated between 9–10%. The decomposer populations typically stabilize after initial growth peaks due to the balance between available organic matter and arthropod activity.

In the final observation period, the functional composition of the arthropod community became more balanced. Although detritivores consistently dominated throughout the study (212 individuals), pollinators maintained a strong presence with 200 individuals, followed by pests (51) and a minor number of predators (2). This distribution suggests that the ecosystem under palm shade provides favorable microhabitats that support both decomposer and pollinator activities simultaneously. Such conditions contribute positively to nutrient cycling and pollination processes within the red chili agroecosystem.

Overall, the dominance of detritivores and pollinators across the observation period reflects a functionally stable arthropod community. The relatively low abundance of pest species indicates that the presence of beneficial arthropods plays a major role in maintaining ecological balance. According to Jasrotia *et al.*, (2023), the persistence of beneficial arthropods especially decomposers and natural enemies serves as an essential component in the biological control and long-term sustainability of agroecosystems.
Therefore, the consistent presence of detritivores and pollinators under shaded cultivation systems contributes significantly to both soil fertility and pest suppression, strengthening the ecological resilience of red chili cultivation.

CONCLUSION

The arthropod community found on chili plants under areca palm shade showed moderate diversity and stable population dynamics during the observation period. *Camponatus carnelius* dominated as a detritivore, while *Trigona* spp. and *Apis mellifera* were the main pollinators. The low abundance of pest species such as *Aulacophora similis*, *Aulacophora lewisii*, and *Thrips tabaci* indicated good ecological balance supported by predator presence. The consistent occurrence of pollinators and detritivores reflected habitat stability and suitable microclimatic conditions.

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