

Diversity of Pollinating Insects in Antigonon leptopus at PTPN IV Kebun Melati Perbaungan and Its Development as a Monograph Book for Biology Learning

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Abstract

Pollinator insects have a crucial ecological role in supporting the reproduction of flowering plants and maintaining ecosystem balance, especially in oil palm plantation agroecosystem areas. This study aims to analyze the diversity of pollinating insects in Bridal Tear flowers (*Antigonon leptopus*) at PTPN IV Kebun Melati Perbaungan and develop the results of the research into a monograph book for biology learning. The research was carried out for three months (January-March 2026) at three observation stations using an exploratory survey method using a sweeping net. The results of the study found 179 individuals of pollinating insects classified into 7 species, 7 genera, 5 families, and 2 orders (Hymenoptera and Lepidoptera). Species identified include *Apis cerana*, *Xylocopa latipes*, *Vespa affinis*, *Suastus gremius*, *Neptis hylas*, *Graphium sarpedon*, and *Cepora nerissa*. Analysis of the ecological index showed moderate diversity values ($H'=1.884$), high uniformity ($E=0.968$), and low dominance ($D=0.159$), indicating a relatively stable community structure. The highest abundance is found in the morning and evening. This study concludes that *Antigonon leptopus* plays an important role as a source of food for pollinating insects and the results of the research have the potential to be developed as a monograph book to support biology learning.

Keywords: Diversity; Pollinating Insects; *Antigonon Leptopus*; Monograph Book; Oil Palm Plantations.

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INTRODUCTION

Insects constitute one of the most diverse and ecologically important groups of organisms and play fundamental roles in maintaining ecosystem functioning and agricultural sustainability. They contribute to a wide range of ecological processes, including pollination, decomposition, herbivory, predation, parasitism, and nutrient cycling. Pollinating insects, in particular, are essential for the reproduction of many flowering plants and contribute substantially to agricultural productivity. In tropical agricultural landscapes such as Indonesia, the availability and diversity of insect pollinators are therefore important components of ecosystem services and sustainable agricultural production (Utari et al., 2024). The decline of insect diversity has consequently become an ecological concern because changes in pollinator abundance and composition may affect plant reproduction and the stability of agricultural ecosystems.

The ecological importance of insect pollinators is particularly relevant in oil palm plantation landscapes. Oil palm (*Elaeis guineensis*) is one of Indonesia's major agricultural commodities, and its productivity is influenced by insect-mediated pollination. The introduction of the weevil *Elaeidobius kamerunicus* as an important oil palm pollinator has contributed substantially to fruit formation and oil palm productivity (Sari & Emmi, 2023). However, pollination and other ecological processes in plantation landscapes should not be considered solely in relation to the main crop. The availability of flowering plants and other forms of supporting vegetation may provide alternative food resources and habitats for diverse insect communities. Therefore, maintaining vegetation diversity within plantation ecosystems can contribute to the conservation of beneficial insects and the sustainability of agroecosystem functions.

Pollinating insects comprise several taxonomic groups, including Hymenoptera, Lepidoptera, Diptera, and Coleoptera. Bees are among the most important pollinators because of their frequent flower visitation and their ability to transfer pollen between flowers. Nevertheless, butterflies, flies, beetles, and other flower-visiting insects may also contribute to pollination depending on their ecological characteristics and interactions with particular plant species (Masawet, 2019). Studies of flower-visiting insects in Indonesian agricultural landscapes have reported substantial contributions from Hymenoptera and Lepidoptera, demonstrating that flowering plants can provide important resources for maintaining insect communities. Consequently, documenting the taxonomic composition, abundance, and community structure of insects associated with flowering plants is important for understanding local biodiversity and the ecological functions supported by agricultural vegetation.

The diversity and abundance of flower-visiting insects are influenced by several characteristics of flowering plants, including flower color, morphology, floral accessibility, nectar availability, pollen availability, and flowering period (Willmer, 2011). In agricultural landscapes characterized by intensive management, flowering plants that occur in plantation understories, along roadsides, and around drainage channels may provide alternative resources for insects. Such vegetation can function as habitat or resource patches that support pollinators and natural enemies when resources in the surrounding landscape are limited (Potts et al., 2016). Thus, the identification of flowering plant species that are frequently visited by insects can provide important information for understanding the ecological value of understory vegetation in plantation ecosystems.

One flowering plant with potential ecological importance in agricultural landscapes is *Antigonon leptopus* (Bridal Tear), a climbing plant belonging to the family Polygonaceae. The species is widely adapted to tropical environments and can grow in disturbed areas. Its conspicuous pink flowers and accessible floral resources make it attractive to various insect visitors, including bees, butterflies, wasps, flies, and other arthropods. The morphological characteristics and floral biology of *A. leptopus* allow a variety of insects to access its nectar and pollen, suggesting that the plant can serve as a resource for flower-visiting insect communities (Raju et al., 2001; Raju et al., 2024).

The floral biology of *A. leptopus* further supports its potential importance as a resource for insects. The flowers provide nectar and pollen that can be utilized by different insect visitors, while

the relatively open floral structure allows access by insects with different morphological characteristics. Previous observations have documented visits by bees, wasps, flies, butterflies, and thrips, with bees playing an important role in pollination (Raju et al., 2001). The generalist nature of its flower visitors indicates that *A. leptopus* may support a relatively diverse assemblage of insects. However, the presence of insect visitors does not necessarily indicate that all visitors function as pollinators. Therefore, field-based identification and classification of insect visitors according to their ecological roles are necessary to accurately describe the insect community associated with *A. leptopus*.

Within oil palm plantations, flowering vegetation may also provide resources for predatory and parasitoid insects that contribute to natural pest regulation. Refugia vegetation can provide nectar, pollen, shelter, and suitable microhabitats for beneficial arthropods (Prabawati et al., 2017). In oil palm agroecosystems, predators and parasitoids are important components of biological control because they can suppress populations of herbivorous pests, including leaf-eating caterpillars. Previous research has indicated that flowering vegetation can support predatory insects such as species of *Sycanus*, which are recognized as natural enemies of oil palm pests (Fardani et al., 2020). Thus, studying the insect community associated with *A. leptopus* should not be limited to pollinators alone but should also consider other functional groups that occur around the plant.

The ecological significance of *A. leptopus* in oil palm plantations is particularly relevant because plantation management practices may influence the availability of understory vegetation and insect resources. Weed control through manual removal, pruning, and herbicide application can alter vegetation structure and consequently affect the availability of food and shelter for insects. Other understory plants, including *Ageratum conyzoides*, *Borreria alata*, *Mimosa pudica*, and *Turnera subulata*, may also contribute to the availability of nectar, pollen, and habitat for insects (Zakaria et al., 2024). In this context, *A. leptopus* represents one component of the vegetation mosaic within the plantation landscape whose association with insect communities requires further empirical documentation.

This study was conducted at PTPN IV Kebun Melati, located in Melati I and Melati II Villages, Perbaungan District, Serdang Bedagai Regency, North Sumatra. The plantation landscape is characterized by the proximity of oil palm cultivation areas to residential areas and smallholder agricultural land. Such landscape conditions may facilitate interactions and movement of insects among different habitat types. The presence of *A. leptopus* along plantation roads and drainage channels provides an appropriate field setting for examining insect visitation and community composition. However, the diversity and community structure of insects associated with *A. leptopus* at this plantation have not been adequately documented.

The limited availability of locally based biodiversity data represents an additional challenge in university-level biology education. Courses in entomology require students to develop competencies in insect identification, classification, ecological roles, and relationships between insects and their habitats. Nevertheless, learning materials often emphasize general taxonomic and ecological concepts without sufficiently connecting them to biodiversity occurring in students' immediate environments. Research-based learning materials can address this limitation by presenting authentic data, species characteristics, ecological interactions, and environmental conditions obtained from field studies (Aisyah et al., 2020). Local biodiversity data therefore have educational value because they enable students to connect theoretical concepts with observable ecological phenomena.

One form of research-based teaching material that can be developed from biodiversity research is a monograph. A monograph is a scientific book that focuses systematically on a particular topic or subject area and is supported by scientific evidence, methodological procedures, data, discussion, and references (Rahmi, 2021). A monograph developed from field research can present taxonomic identification, morphological characteristics, photographs, ecological roles, habitat characteristics, and community structure in an integrated form. Such material can function as a contextual reference for students while also documenting local

biodiversity that may otherwise remain poorly recorded. Previous studies have demonstrated the potential of research-based and local-potential teaching materials to support learning and provide contextual scientific resources (Pahriah et al., 2022; Hayati et al., 2025).

Despite the ecological and educational importance of flowering plants in agricultural landscapes, there remains a limited body of documented information concerning the insect community associated specifically with *Antigonon leptopus* in oil palm plantations in Perbaungan. Existing studies have discussed the ecological role of flowering vegetation, refugia plants, and natural enemies in agricultural systems, but localized information concerning the taxonomic composition, abundance, diversity, evenness, dominance, and temporal visitation pattern of insects associated with *A. leptopus* at PTPN IV Kebun Melati remains limited. This gap is important because insect communities can vary according to habitat characteristics, vegetation composition, flowering conditions, and observation time. Consequently, field-based research is required to provide empirical information specific to the local plantation ecosystem.

Based on this research gap, the present study aims to analyze the insect community associated with *Antigonon leptopus* at PTPN IV Kebun Melati, Perbaungan. Specifically, the study seeks to identify the taxonomic composition of insect visitors, determine their abundance and ecological roles, analyze community diversity, evenness, and dominance, and describe temporal variation in insect visitation during different observation periods. The study also aims to organize the research findings into a monograph that can be used as contextual teaching material for biology learning, particularly in entomology and insect ecology. By integrating biodiversity research with the development of research-based teaching materials, this study is expected to contribute both empirical information on local insect communities and an educational resource that connects ecological concepts with real conditions in oil palm plantation ecosystems.

RESEARCH METHODS

Research Design and Study Area

This study employed a quantitative descriptive approach using a field survey to examine the insect community associated with *Antigonon leptopus* (Bridal Tear) in the oil palm plantation landscape of PTPN IV Kebun Melati, Perbaungan District, Serdang Bedagai Regency, North Sumatra, Indonesia. The research was conducted from January to March 2026. The study site was selected purposively based on the presence of naturally growing and flowering *A. leptopus* populations that were sufficiently abundant to support repeated observations.

Three observation stations were established to represent differences in habitat characteristics and levels of anthropogenic influence. Station I was located at the edge of a rice field adjacent to an open area (3°31'57.8266"N, 98°57'46.2823"E), characterized by relatively high exposure to sunlight. Station II was located along the main plantation road (3°32'11.0627"N, 98°57'44.2991"E), representing a habitat exposed to relatively high human activity and vehicular disturbance. Station III was located within the oil palm plantation and adjacent to residential areas (3°31'55.2713"N, 98°57'42.1279"E), characterized by greater canopy shade and relatively higher humidity.

The three stations were deliberately selected to represent contrasting environmental conditions, namely open habitat, anthropogenically disturbed habitat, and relatively shaded plantation habitat. Differences in habitat structure and environmental conditions were considered relevant to variation in insect abundance and visitation activity (Krebs, 1989).

Sampling Procedure

Sampling was conducted during three observation periods each day: morning (09.00–10.00 WIB), midday (13.00–14.00 WIB), and late afternoon (17.00–18.00 WIB). These observation periods were selected to represent different environmental conditions during the diurnal activity cycle of flower-visiting insects. Insect activity may vary with temperature, humidity, solar radiation, and floral resource availability, with many pollinating insects showing different foraging patterns throughout the day (Heinrich, 1979).



At each observation station, flowering *A. leptopus* plants were selected as observation units. The same observation area was monitored during each sampling period to facilitate comparison among stations and observation times. Sampling was conducted repeatedly during the research period to account for temporal variation in insect visitation and environmental conditions.

Insect observations were conducted using two complementary techniques. First, active insects were collected using a sweeping net by making standardized sweeps around flowering *A. leptopus*. Second, direct visual observations were conducted to record insects visiting the flowers and making contact with the reproductive structures of the flowers. During visual observations, the observer recorded the number and identity of visiting insects, their visitation time, and their interaction with the flowers.

An insect was considered a **flower visitor** when it was observed landing on or interacting with the flower. An insect was classified as a **potential pollinator** when it was observed making physical contact with the reproductive structures of the flower, particularly the anthers and/or stigma. This operational distinction was applied to avoid assuming that every insect visiting *A. leptopus* necessarily performs a pollination function.

Collected specimens were placed in labeled collection containers and transported to the laboratory for identification. Specimen labels included the observation station, date, observation period, and specimen code. Morphological identification was conducted using a stereomicroscope and relevant taxonomic identification literature (Gullan & Cranston, 2014). Where identification to species level could not be established reliably from available morphological characteristics, specimens were identified to the lowest taxonomic level supported by the evidence.

Environmental Measurements

Environmental parameters were recorded during every observation period at each station. Air temperature and relative humidity were measured using a thermohygrometer. Measurements were taken at approximately the same location and period as insect observations to enable comparison between insect visitation activity and environmental conditions.

In addition to abiotic measurements, observations were made of the flowering condition of *A. leptopus*. The number of flowers in bloom within the observation area was recorded during each sampling period. This information was used as an indicator of floral resource availability and was considered when interpreting differences in insect visitation among observation periods.

Photographic and video documentation was also collected to support field observations, specimen identification, and documentation of insect–flower interactions. The visual records were used as supplementary evidence and as potential material for the development of the research-based monograph.

Data Analysis

The collected data were analyzed quantitatively to describe the taxonomic composition, abundance, diversity, evenness, and dominance of insects associated with *A. leptopus*. Descriptive statistics were used to summarize the number of individuals and species recorded at each observation station and during each observation period.

The Shannon–Wiener diversity index (H') was used to determine the diversity of the insect community:

$$H' = -\sum p_i \ln p_i$$

where p_i represents the proportion of individuals belonging to species i in the total community. The diversity values were interpreted using the criteria adopted from Odum (1993), with $H' < 1$ classified as low diversity, $1 \leq H' \leq 3$ as moderate diversity, and $H' > 3$ as high diversity.

The Pielou evenness index (E) was used to determine the distribution of individuals among species:

$$E = H' / \ln S$$

where H' is the Shannon–Wiener diversity index and S is the total number of species recorded. Values approaching 1 indicate a more even distribution of individuals among species,

whereas values approaching 0 indicate an uneven distribution. The interpretation followed the criteria reported by Yuniarti (2013), with $E < 0.4$ classified as low, $0.4-0.6$ as moderate, and $E \geq 0.6$ as high.

The Simpson dominance index (D) was calculated to determine the extent to which the community was dominated by particular species:

$$D = \sum (p_i^2)$$

where p_i represents the proportion of individuals belonging to species i . Values approaching 0 indicate low dominance, whereas values approaching 1 indicate greater dominance by one or several species (Simpson, 1949).

Relative abundance was calculated to determine the contribution of each species to the total number of individuals recorded:

$$KR = (n_i/N) \times 100\%$$

where n_i is the number of individuals of species i and N is the total number of individuals recorded.

The composition of insects was subsequently grouped according to their observed or documented ecological roles, including potential pollinators, predators, herbivores, omnivores, and decomposers. Functional classification was based on taxonomic information and relevant ecological literature. Because field visitation alone cannot establish the effectiveness of an insect as a pollinator, the term **potential pollinator** was used unless direct evidence of pollen transfer or reproductive consequences was available.

Differences in insect visitation among the three observation periods were analyzed descriptively by comparing the number of individuals and species recorded during morning, midday, and late-afternoon observations. Environmental measurements and flowering intensity were also compared descriptively with visitation patterns to provide ecological context for observed temporal variation.

Finally, the taxonomic data, morphological descriptions, photographic documentation, ecological roles, community structure, and environmental observations were organized as the scientific content for a research-based monograph. The monograph was intended to provide contextual learning material for university-level biology courses, particularly topics related to entomology, insect identification, community ecology, plant-insect interactions, and biodiversity.

RESULTS AND DISCUSSION

Composition and Taxonomy of Pollinating Insects in *Antigonon leptopus* Flowers

The diversity of insects visiting Bridal Tear flowers (*Antigonon leptopus*) was investigated at three observation stations representing different habitat characteristics within the PTPN IV Kebun Melati Perbaungan area. Station I represented an open habitat adjacent to rice fields, Station II represented a roadside habitat exposed to relatively high anthropogenic activity, and Station III represented a more shaded habitat within an oil palm plantation adjacent to residential areas. Observations were conducted during three diurnal periods, namely 09:00–10:00 WIB, 13:00–14:00 WIB, and 17:00–18:00 WIB, from January to March 2026.

A total of 179 insect individuals were recorded visiting *A. leptopus* flowers. Based on laboratory identification using a stereoscopic microscope and taxonomic identification keys, the specimens were classified into seven species, seven genera, five families, and two orders, namely Hymenoptera and Lepidoptera. The identified insects consisted of *Apis cerana*, *Xylocopa latipes*, *Vespa affinis*, *Suastus gremius*, *Neptis hylas*, *Graphium sarpedon*, and *Cepora nerissa*.

The taxonomic composition indicates that *A. leptopus* flowers were visited primarily by bees, wasps, and butterflies. Hymenoptera comprised three species from two families, namely Apidae and Vespidae, whereas Lepidoptera comprised four species from four families, namely Hesperidae, Nymphalidae, Papilionidae, and Pieridae. The relatively broad taxonomic representation indicates that *A. leptopus* provides floral resources accessible to insects with different morphological and behavioral characteristics.

Table 1. Taxonomic Composition of Pollinating Insects Found in *Antigonon leptopus* Flowers

Classes	Order	Family	Genus	Species	Number of Individuals
Insect	Hymenoptera	Apidae	<i>São Paulo</i>	<i>Apis cerana</i>	31
Insect	Hymenoptera	Apidae	<i>Xylocopa</i>	<i>Xylocopa latipes</i>	37
Insect	Hymenoptera	Stuart O'Neill	<i>Vespa</i>	<i>Vespa affinis</i>	14
Insect	Lepidoptera	Hesperiidae	<i>Suastus</i>	<i>Suastus gremius</i>	17
Insect	Lepidoptera	Nymphalidae	<i>Neptis</i>	<i>Neptis hylas</i>	26
Insect	Lepidoptera	Papilionidae	<i>Graphium</i>	<i>Graphium sarpedon</i>	22
Insect	Lepidoptera	Pieridae	<i>Cepora</i>	<i>Cepora nerissa</i>	32
Total					179

The composition presented in Table 1 shows that *Xylocopa latipes* was the most frequently recorded species, with 37 individuals (20.7%), followed by *Cepora nerissa* with 32 individuals (17.9%) and *Apis cerana* with 31 individuals (17.3%). Meanwhile, *Vespa affinis* had the lowest number of individuals, with 14 individuals (7.8%). At the order level, Lepidoptera accounted for 97 individuals (54.2%), while Hymenoptera accounted for 82 individuals (45.8%). Therefore, although bees represented an important component of the insect community, the overall abundance was slightly higher for Lepidoptera than for Hymenoptera.

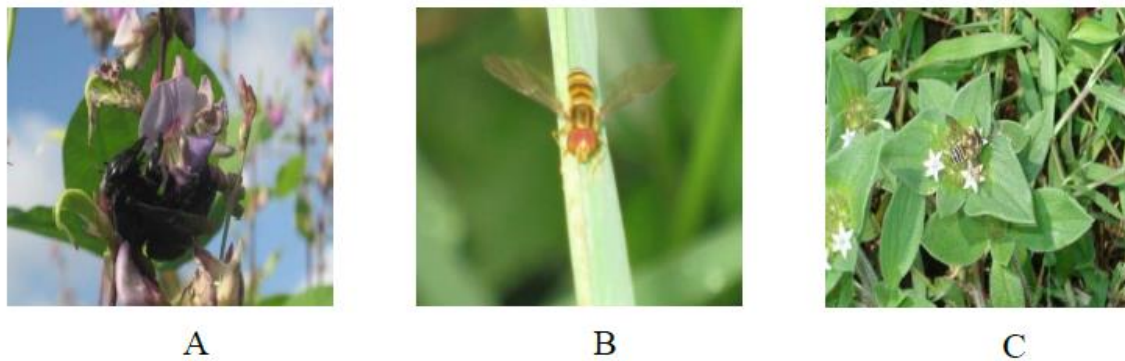


Figure 4.1 Several types of pollinating insects found on the flowers of *Antigonon leptopus*: (a) *Apis cerana*, (b) *Xylocopa latipes*, (c) *Vespa affinis*, (d) *Cepora nerissa*, (e) *Suastus gremius*, (f) *Neptis hylas*, (g) *Graphium sarpedon*. (Source: Research Paper, 2026)

Patterns of Insect Visits and Floral Resources

The relatively high number of insect visitors recorded on *A. leptopus* flowers can be associated with the floral characteristics of this species. *Antigonon leptopus* produces conspicuous pink flowers and accessible floral resources, particularly nectar and pollen. Such characteristics can facilitate visits by insects with different feeding strategies. Raju et al. (2001) reported that the flowers of *A. leptopus* are visited by a broad range of insects, including bees, wasps, flies, butterflies, and thrips. The present findings are consistent with the generalist floral visitation pattern of *A. leptopus*, although only Hymenoptera and Lepidoptera were recorded during the present observation period.

The relatively high abundance of *Xylocopa latipes* and *Apis cerana* indicates that bees constitute an important group of visitors to *A. leptopus*. The two species contributed 68 individuals, representing 38.0% of all recorded insects. Bees are generally attracted to flowers that provide accessible nectar and pollen because these resources are important for adult nutrition and, particularly in social bees, colony provisioning. Michener (2007) explains that bees exhibit diverse foraging behaviors associated with the collection of nectar and pollen, and their body morphology can facilitate contact with floral structures during foraging.

However, the presence of an insect on a flower should not automatically be interpreted as evidence that the species functions as an effective pollinator. A flower visitor can contribute to

pollination only when its behavior results in contact with reproductive structures and subsequent transfer of pollen. Therefore, the insects recorded in this study are more appropriately described as flower-visiting insects, while their role as pollinators should be interpreted based on the direct observations of contact with the reproductive organs of *A. leptopus*. This distinction is important because visitation frequency alone does not necessarily represent pollination effectiveness.

The high representation of Lepidoptera is another important finding. Four butterfly species were recorded, with *Cepora nerissa* being the most abundant lepidopteran species, followed by *Neptis hylas*, *Graphium sarpedon*, and *Suastus gremius*. Together, these four species accounted for 97 individuals, or 54.2% of the total insects recorded. The relatively high representation of butterflies may be associated with the conspicuous floral color of *A. leptopus* and the availability of nectar. Willmer (2011) noted that floral visual characteristics, including color and floral display, can influence the attraction of insect visitors, particularly groups with well-developed visual systems.

The occurrence of butterflies from four different families also suggests that the floral resources of *A. leptopus* are not restricted to a single butterfly taxon. The accessible floral structure and nectar availability may allow different butterfly species with varying body sizes and proboscis characteristics to exploit the flowers. Nevertheless, differences in abundance among butterfly species may also reflect factors beyond floral attractiveness, including species-specific foraging behavior, surrounding vegetation, microclimatic conditions, and the availability of alternative nectar sources.

Relative Abundance of Insect Visitors

The abundance pattern demonstrates that insect visitation to *A. leptopus* was not evenly distributed among species. *Xylocopa latipes* had the highest abundance, with 37 individuals, whereas *Vespa affinis* had the lowest abundance, with 14 individuals. The difference in abundance may indicate differences in foraging preferences, population size around the observation stations, flight activity, and the ability of each species to exploit the floral resources available at the study site.

The relatively high abundance of *X. latipes* may be associated with its strong foraging activity and ability to exploit flowers of different structural characteristics. As a large-bodied bee, *Xylocopa* species are capable of visiting relatively robust flowers and can travel between floral patches in search of resources. The presence of *X. latipes* in relatively high numbers therefore indicates that *A. leptopus* may function as an important floral resource within the surrounding agricultural landscape.

Meanwhile, *Cepora nerissa* was the second most abundant species, with 32 individuals. The relatively high abundance of this butterfly may indicate that the flowering period of *A. leptopus* overlaps with the foraging activity of adult butterflies in the study area. Adult butterflies generally depend strongly on nectar resources, whereas their larvae depend on particular host plants. Consequently, the presence of adult butterflies on *A. leptopus* flowers reflects the availability of nectar but does not necessarily indicate that *A. leptopus* functions as a larval host plant for these species.

The relatively low abundance of *Vespa affinis* may be explained by differences in feeding behavior compared with bees and butterflies. Wasps can utilize floral nectar, but their foraging activities may also be associated with animal prey and other food resources. Therefore, the frequency with which they visit flowers may be lower than that of insects that rely more strongly on nectar and pollen. This difference emphasizes that insect abundance on a particular plant is influenced not only by floral characteristics but also by the ecological requirements of each taxon.

Absence of Diptera and Coleoptera

No members of Diptera or Coleoptera were recorded visiting *A. leptopus* during the observation period. The absence of these groups should not be interpreted as evidence that they are unable to visit *A. leptopus*. Rather, it may reflect the particular environmental conditions, observation period, sampling effort, or temporal activity patterns of the insects present in the study area.

Flower-visiting insect communities are influenced by multiple factors, including floral morphology, nectar and pollen availability, surrounding vegetation, temperature, humidity, and the temporal pattern of insect activity (Gullan & Cranston, 2014). The three observation periods used in this study covered the morning, midday, and late afternoon, but they may not have captured all periods of activity for every insect group. In addition, insects belonging to Diptera and Coleoptera may have specific microhabitat requirements or feeding behaviors that reduce their frequency of visitation to *A. leptopus* under the conditions observed.

The absence of Diptera and Coleoptera also demonstrates the importance of interpreting insect diversity at the landscape scale. PTPN IV Kebun Melati consists of a mosaic of oil palm plantations, rice fields, roadsides, residential areas, and patches of lower vegetation. Such habitat heterogeneity can provide different resources for insect communities. Consequently, the composition observed on *A. leptopus* represents the subset of insects that utilized the flowers during the sampling period rather than the complete insect diversity of the plantation ecosystem.

Ecological Significance of *Antigonon leptopus* in the Plantation Landscape

The findings demonstrate that *A. leptopus* provides floral resources utilized by a relatively diverse assemblage of bees, wasps, and butterflies. The presence of 179 individuals belonging to seven species indicates that flowering vegetation around oil palm plantations can contribute to maintaining insect activity within an agricultural landscape. This finding is particularly relevant because intensively managed oil palm plantations may have relatively simplified vegetation structures compared with natural ecosystems.

The ecological function of *A. leptopus* should therefore be considered in relation to the availability of flowering resources within the surrounding landscape. Flowering plants can provide nectar and pollen during periods when resources from the main crop or other vegetation are limited. Such resources may support beneficial insects, including pollinators and natural enemies, and consequently contribute to ecological processes within agricultural systems.

Nevertheless, the role of *A. leptopus* as a refugia plant should be interpreted carefully. The present study directly documents the diversity and abundance of insects visiting its flowers, but it does not by itself establish the long-term population-supporting effect of the plant or its direct contribution to pest suppression. Evidence for such functions would require additional observations, such as comparisons between areas with and without *A. leptopus*, measurements of insect reproductive success, or assessment of predator and parasitoid populations associated with the plant.

Overall, the results indicate that *A. leptopus* is an ecologically relevant flowering plant in the PTPN IV Kebun Melati landscape because its flowers are utilized by several insect taxa. The dominance of individual species such as *X. latipes* and *C. nerissa*, together with the presence of seven insect species from two orders, demonstrates that the plant can function as an important local floral resource. These findings provide an empirical basis for further investigation of flowering refugia and insect biodiversity in oil palm agroecosystems and can subsequently be incorporated into locally based entomology learning materials.

Implications for Entomology Learning Materials

The documented diversity of insects visiting *A. leptopus* has educational value because it provides an authentic example of insect-plant interactions in an agricultural environment. The identification of seven species from seven genera and five families can be used to introduce students to insect taxonomy, morphological identification, ecological interactions, and community structure. Photographic documentation of the identified insects can further support the development of contextual learning materials.

The results are particularly relevant for a research-based monograph because they connect theoretical concepts in entomology with empirical observations from a local ecosystem. Students can use the documented species as examples for understanding taxonomic hierarchy, insect diversity, floral resource utilization, and the ecological role of flowering plants in agricultural landscapes. Thus, the research findings not only contribute to documenting local insect diversity

but also provide scientifically grounded material for contextualizing entomology and ecology learning in higher education.

Distribution and Pattern of Pollinator Abundance by Station and Observation Time

The abundance of insects visiting *Antigonon leptopus* flowers varied among the three observation stations and across the three observation periods. A total of 179 individuals were recorded during the study. Station I recorded the highest number of individuals, with 76 individuals (42.5% of the total observations), followed by Station III with 63 individuals (35.2%) and Station II with 40 individuals (22.3%). The difference in the number of individuals among stations indicates that local habitat characteristics may influence the availability of floral resources and the activity of flower-visiting insects.

Table 2. Abundance of Pollinating Insects at Each Station and Observation Time

Station	Observation Time	Number of Individuals	Relative Abundance (%)
Station I	Morning (09:00–10:00 WIB)	33	43.42
	Midday (13:00–14:00 WIB)	17	22.37
	Late afternoon (17:00–18:00 WIB)	26	34.21
	Total	76	100.00
Station II	Morning (09:00–10:00 WIB)	17	42.50
	Midday (13:00–14:00 WIB)	9	22.50
	Late afternoon (17:00–18:00 WIB)	14	35.00
	Total	40	100.00
Station III	Morning (09:00–10:00 WIB)	22	34.92
	Midday (13:00–14:00 WIB)	15	23.81
	Late afternoon (17:00–18:00 WIB)	26	41.27
	Total	63	100.00

Source: Research data, 2026.

The highest abundance at Station I may be associated with the relatively open habitat and the availability of vegetation surrounding the *A. leptopus* population. Station I is located near rice fields and an open area, allowing relatively high exposure to sunlight and potentially providing access to a broader range of flowering plants. The presence of flowering vegetation surrounding the focal plant can increase the availability of nectar and pollen and may consequently influence the number of insects visiting a particular flowering plant.

The availability and spatial distribution of floral resources are important factors affecting insect visitation. Pollinators respond not only to the presence of a particular plant species but also to the quantity, continuity, and diversity of floral resources available within the surrounding landscape (Potts et al., 2016). Therefore, the relatively high number of insects at Station I may reflect the combined influence of *A. leptopus* flowers and other flowering vegetation occurring within the surrounding agricultural landscape.

Station III recorded 63 individuals, representing the second-highest abundance. This station was located within an oil palm plantation adjacent to residential areas and was characterized by greater canopy cover and relatively more sheltered environmental conditions. Although the vegetation structure at this station was less open than at Station I, the shaded conditions may provide a suitable microhabitat for some insects, particularly during periods when solar radiation and temperature become higher. The relatively high abundance at Station III therefore indicates that flower-visiting insects may utilize both open and partially shaded habitats, depending on their ecological and behavioral requirements.

In contrast, Station II recorded the lowest abundance, with 40 individuals. The station was located alongside the main road and was exposed to relatively high human and vehicle activity. Such environmental characteristics may reduce the suitability of the habitat for some insects through changes in vegetation structure, disturbance frequency, and microclimatic conditions. However, the present study did not directly measure noise, vibration, or air pollution. Therefore, these factors should be regarded as possible explanations rather than demonstrated causes of the lower abundance at Station II.

The relationship between habitat disturbance and insect abundance has been widely discussed in landscape ecology. Habitat fragmentation and disturbance can alter the availability of floral resources, nesting sites, shelter, and other ecological requirements for insects (Tschardt et al., 2005). In the present study, the lower number of flower-visiting insects at Station II may therefore be related to the characteristics of the roadside environment and its surrounding vegetation. Nevertheless, further studies involving quantitative measurements of anthropogenic disturbance would be necessary to establish a causal relationship.

Temporal Pattern of Insect Visitation

The distribution of insect individuals across observation times showed a similar general pattern at all three stations. The morning period (09:00–10:00 WIB) consistently recorded the highest number of individuals at Station I and Station II, whereas Station III recorded its highest number during the late-afternoon period (17:00–18:00 WIB). At all stations, the lowest abundance was recorded during the midday observation period (13:00–14:00 WIB).

At Station I, 33 individuals were recorded in the morning, decreasing to 17 individuals at midday and increasing again to 26 individuals in the late afternoon. A similar pattern occurred at Station II, with 17 individuals in the morning, nine individuals at midday, and 14 individuals in the late afternoon. Station III showed a somewhat different pattern, with 22 individuals in the morning, 15 individuals at midday, and 26 individuals in the late afternoon. These findings indicate that flower-visiting activity was generally lower during the midday period but increased again toward the late afternoon.

The temporal pattern can be associated with daily fluctuations in environmental conditions. Insects are ectothermic organisms whose activity is influenced by temperature, solar radiation, humidity, wind, and resource availability. Moderate environmental conditions during the morning and late afternoon may allow insects to maintain active foraging while reducing the physiological costs associated with excessive heat. Heinrich (1979) emphasized that insect activity and thermoregulation are closely related to environmental temperature and the ability of insects to maintain an appropriate body temperature.

However, the interpretation of this temporal pattern should be directly connected to the abiotic measurements collected during the study. If the measured temperature and humidity data are available, they should be presented alongside the abundance data to determine whether changes in insect abundance correspond to changes in these environmental parameters. For example, the reported temperature range of 27–29°C in the morning and 31–34°C at midday can only be incorporated into the final analysis if these values represent the actual measurements obtained at the respective stations and observation periods.

The decrease in abundance during the midday period may indicate reduced foraging activity under relatively warmer conditions. Nevertheless, temperature should not be considered the only determinant. Nectar production, floral opening, wind conditions, light intensity, and the presence of alternative floral resources may also influence insect visitation. Consequently, the observed temporal pattern is best interpreted as the combined response of insects to environmental and biological conditions.

Species-Specific Variation in Abundance

The abundance of individual insect species also varied within the observed community. Based on the overall taxonomic data, *Xylocopa latipes* was the most abundant species, with 37 individuals, followed by *Cepora nerissa* with 32 individuals and *Apis cerana* with 31 individuals. In

contrast, *Vespa affinis* had the lowest abundance, with 14 individuals. These differences indicate that the utilization of *A. leptopus* flowers was not equally distributed among insect species.

The relatively high abundance of *Xylocopa latipes* may be associated with its foraging behavior and ability to exploit floral resources from plants with accessible flowers. The species may benefit from the nectar and pollen available on *A. leptopus*, while its relatively large body size allows it to interact effectively with the floral structures. The presence of *Apis cerana* in relatively high numbers similarly indicates that *A. leptopus* provides floral resources that are utilized by social bees.

Cepora nerissa also occurred in relatively high abundance, with 32 individuals. Its frequent visitation may be related to the availability of nectar and the conspicuous floral display of *A. leptopus*. Butterfly visitation is influenced by visual floral cues, nectar availability, and the surrounding habitat structure (Willmer, 2011). However, frequent flower visitation does not necessarily demonstrate that the species is an effective pollinator. Confirmation of pollination effectiveness requires evidence of contact with reproductive structures and, ideally, subsequent pollen transfer.

The lowest abundance was recorded for *Vespa affinis*, with 14 individuals. The relatively low frequency of visitation may be associated with the species' broader feeding ecology. Adult social wasps can utilize nectar as an energy source but also obtain animal prey for protein requirements. Consequently, their dependence on floral resources may differ from that of bees that actively collect nectar and pollen during foraging.

The abundance of *Suastus gremius* was also relatively low compared with the dominant species. Its lower visitation frequency should not be attributed solely to host-plant specialization without supporting evidence from the present study. The abundance of butterflies on flowers is influenced by multiple factors, including nectar availability, adult foraging behavior, habitat structure, population density, and the availability of larval host plants in the surrounding area. Therefore, the present results indicate a difference in flower visitation frequency but do not establish the specific ecological cause of the lower abundance.

Relationship Between Habitat and Temporal Patterns

The combined station and temporal data demonstrate that insect visitation was influenced by both spatial and temporal conditions. Station I had the highest overall number of individuals, whereas Station II had the lowest. At the temporal level, midday consistently showed the lowest abundance at all three stations. This pattern suggests that the availability of suitable habitat and the daily environmental cycle jointly shape insect visitation to *A. leptopus* flowers.

The highest abundance at Station I may reflect the availability of floral resources and relatively open habitat, whereas the comparatively high abundance at Station III suggests that some insects can utilize flowering plants under more sheltered conditions. Station II, despite its accessibility and open exposure, recorded fewer individuals, indicating that openness alone does not guarantee higher insect visitation. Habitat quality is determined by a combination of floral resources, vegetation structure, microclimate, and disturbance.

The results are consistent with the broader understanding that pollinator communities respond to landscape-level resource availability and habitat quality (Potts et al., 2016). Agricultural landscapes that retain flowering vegetation can provide supplementary resources for flower-visiting insects and potentially contribute to maintaining insect diversity. In the context of oil palm plantations, the presence of flowering plants such as *A. leptopus* may therefore contribute to the ecological heterogeneity of the plantation landscape.

Nevertheless, the current study is observational and does not experimentally test the causal effects of habitat characteristics or environmental variables. Therefore, the results should be interpreted as describing patterns of insect visitation rather than demonstrating direct causal relationships between particular environmental factors and insect abundance. Future research could strengthen these findings by incorporating repeated sampling, quantitative vegetation assessments, temperature and humidity measurements, floral density, and statistical tests of differences among stations and observation periods.

Overall, the findings demonstrate that the abundance of insects visiting *A. leptopus* varied spatially and temporally within the PTPN IV Kebun Melati landscape. Station I supported the highest total abundance, while Station II recorded the lowest abundance. In terms of daily activity, insect visitation generally declined during the midday period and increased again in the late afternoon. These patterns reinforce the ecological importance of considering habitat characteristics and daily environmental variation when evaluating flower-visiting insect communities in oil palm plantation landscapes.

Community Structure: An Index of Diversity, Uniformity, and Dominance

A total of 179 individuals of flower-visiting insects were recorded on *Antigonon leptopus* flowers during the study period. The individuals represented seven species, seven genera, five families, and two orders, namely Hymenoptera and Lepidoptera. The number of individuals varied among the three observation stations. Station I recorded the highest number of individuals (76 individuals; 42.5%), followed by Station III (63 individuals; 35.2%) and Station II (40 individuals; 22.3%). These differences indicate variation in the abundance of flower-visiting insects among the observation sites and may be associated with differences in local habitat conditions and the availability of floral resources.

Table 3. Diversity, Evenness, and Dominance Indices of Pollinating Insects at Each Observation Station

Station	Diversity Index (H')	Category	Evenness Index (E)	Category	Dominance Index (D)	Category
Station I	1.886	Moderate	0.969	High	0.158	Low
Station II	1.866	Moderate	0.959	High	0.167	Low
Station III	1.899	Moderate	0.975	High	0.152	Low
Average	1.884	Moderate	0.968	High	0.159	Low

The Shannon-Wiener diversity index (H') ranged from 1.866 to 1.899 among the three observation stations, with an overall mean of 1.884. Based on the classification used in this study, the diversity at all stations was categorized as moderate. Station III recorded the highest diversity value (H' = 1.899), followed by Station I (H' = 1.886) and Station II (H' = 1.866). The relatively narrow range of H' values suggests that the pollinating insect community associated with *A. leptopus* was relatively similar in terms of diversity across the three habitat conditions.

The slightly higher diversity at Station III, despite its lower total abundance than Station I, indicates that species diversity is influenced not only by the total number of individuals but also by the distribution of individuals among species. Diversity indices integrate both species richness and relative abundance. Therefore, a station with fewer individuals can have a higher diversity value when individuals are distributed more evenly among the recorded species. This pattern is consistent with the evenness values obtained in this study.

The Pielou evenness index (E) ranged from 0.959 to 0.975, with an average value of 0.968, and was classified as high at all stations. The highest evenness was recorded at Station III (E = 0.975), whereas the lowest was found at Station II (E = 0.959). Values approaching 1 indicate that the individuals recorded were relatively evenly distributed among the observed species. The high evenness values therefore indicate that no single species accounted for a disproportionately large proportion of the individuals recorded at any station. This result complements the diversity index and suggests a relatively balanced distribution of the flower-visiting insect community.

The Simpson dominance index (D) ranged from 0.152 to 0.167, with an average of 0.159, and was classified as low. Station II had the highest dominance value (D = 0.167), while Station III had the lowest value (D = 0.152). The relatively low dominance values indicate that the community was not strongly dominated by a single recorded species. The combination of high evenness and low dominance provides additional evidence that the observed individuals were distributed relatively evenly among the seven species.

The diversity pattern observed in this study may be related to the ecological characteristics of *A. leptopus* as a flowering plant that can be visited by different insect groups. Previous research has reported that *A. leptopus* has accessible flowers and provides nectar and pollen resources for a range of insect visitors (Raju et al., 2001). Flower characteristics, including accessibility of floral rewards, color, morphology, and nectar availability, can influence the composition of flower-visiting insect communities (Willmer, 2011). However, the present study only recorded insects visiting *A. leptopus* and did not experimentally measure nectar quantity, pollen availability, or floral traits. Therefore, the relationship between floral characteristics and the observed community structure should be interpreted as an ecological explanation rather than a direct causal relationship.

Differences among stations may also reflect variation in surrounding habitat characteristics. Station I was located near an open rice-field environment, Station II was situated along a main road with relatively high human activity, and Station III was located within an oil palm plantation area adjacent to residential land. Habitat heterogeneity can influence the availability of food resources, shelter, and movement corridors for insects. Agricultural landscapes containing a variety of flowering plants can provide complementary resources for pollinating insects and contribute to maintaining their populations (Potts et al., 2016). Nevertheless, because this study did not statistically test the relationship between habitat variables and insect abundance, the differences among stations should not be interpreted as evidence of a direct causal effect of habitat type.

The results also demonstrate an important relationship between abundance and community structure. Station I had the highest number of individuals, but it did not have the highest diversity index. Conversely, Station III had fewer individuals but the highest H' and E values and the lowest dominance value. This finding emphasizes that abundance alone is insufficient to describe the ecological condition of a community. The proportional distribution of individuals among species is equally important when assessing community structure. Thus, the ecological characteristics of Station III may have provided conditions that allowed the recorded species to occur with a relatively balanced distribution.

Overall, the combination of moderate diversity, high evenness, and low dominance indicates that the flower-visiting insect community associated with *A. leptopus* at PTPN IV Kebun Melati Perbaungan had a relatively balanced structure during the observation period. However, the interpretation of community stability should be made cautiously. Diversity, evenness, and dominance indices describe the structure of the observed community, but they do not by themselves demonstrate long-term ecological stability. Assessment of ecological stability would require repeated observations over a longer period and, preferably, additional environmental and population-level measurements.

From an applied perspective, the presence of seven flower-visiting insect species associated with *A. leptopus* indicates that flowering vegetation within agricultural landscapes can provide resources for insects. Maintaining flowering plants and habitat heterogeneity around oil palm plantations may therefore contribute to the conservation of local insect diversity. Nevertheless, management recommendations concerning *A. leptopus* should consider its ecological characteristics, including its potential status as a rapidly growing or invasive plant in particular environments. Its use as a refugia plant should consequently be evaluated according to local ecological and plantation-management conditions.

Implications for Biology Learning and Monograph Development

The empirical findings of this study also provide relevant material for the development of contextual learning resources in biology, particularly for courses related to entomology, insect ecology, biodiversity, and environmental management. The identification of seven insect species, differences in abundance among stations, and the calculation of diversity, evenness, and dominance indices provide authentic examples that can be used to connect theoretical concepts with field-based ecological observations.

The research findings can be organized into a monograph containing taxonomic descriptions, photographic documentation, habitat characteristics, observation data, ecological indices, and interpretations of insect–plant interactions. Such a monograph can provide students with locally relevant scientific information and examples of ecological analysis. Rather than functioning only as a supplementary textbook, the monograph can be used as a contextual learning resource that encourages students to interpret biodiversity data and understand ecological relationships based on empirical observations.

The development of a research-based monograph is particularly relevant because learning resources derived from local biodiversity can help students connect abstract ecological concepts with biological phenomena occurring in their surrounding environment. In this context, the results of the present study provide a scientific basis for developing teaching materials on insect diversity and ecological interactions associated with flowering plants in agricultural landscapes.

CONCLUSION

This study identified 179 individuals of flower-visiting insects associated with *Antigonon leptopus* flowers at PTPN IV Kebun Melati Perbaungan. The insects comprised seven species, seven genera, five families, and two orders, namely Hymenoptera and Lepidoptera. The recorded species were *Apis cerana*, *Xylocopa latipes*, *Vespa affinis*, *Suastus gremius*, *Neptis hylas*, *Graphium sarpedon*, and *Cepora nerissa*.

The highest number of individuals was recorded at Station I (76 individuals), followed by Station III (63 individuals) and Station II (40 individuals). The observation data also showed variation in insect abundance among the three observation periods, with higher numbers generally recorded in the morning and late afternoon than during the midday observation period. This pattern indicates temporal variation in flower-visiting activity under the environmental conditions observed during the study.

The community analysis produced an average Shannon-Wiener diversity index of $H' = 1.884$, categorized as moderate, an average Pielou evenness index of $E = 0.968$, categorized as high, and an average Simpson dominance index of $D = 0.159$, categorized as low. These values indicate that the recorded insect community had moderate diversity and a relatively even distribution of individuals without strong dominance by a single species during the observation period.

The findings indicate that *A. leptopus* flowers were visited by several groups of insects and may function as a floral resource within the agricultural landscape of PTPN IV Kebun Melati. However, the present study does not establish a direct causal relationship between *A. leptopus* and the abundance or diversity of pollinating insects. Further research involving floral-resource measurements, additional environmental variables, longer observation periods, and comparative sampling of other flowering plants is recommended to clarify these ecological relationships.

In addition to its ecological contribution, the empirical data obtained from this study provide a basis for developing a research-based monograph as a contextual learning resource for biology education. The monograph can integrate species identification, field observations, ecological indices, photographic documentation, and interpretation of insect–plant interactions to support learning in entomology and ecology. Thus, the study contributes both empirical information on flower-visiting insect diversity and locally relevant material for the development of biology learning resources.

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