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Diversity and Composition of Insect Species Associated with Natural Rattan Habitats in Namo Village, Kulawi, Central Sulawesi

Musdalifah Nurdin[1], Samsurizal M. Suleman[1], Syech Zainal[2]*, Moh Sabran[1], Raya Agni[2], Manap Trianto[1]
[1]Department of Biology Education; [2]Department of Natural Science Education, Faculty of Teacher Training and Education, Tadulako University, Jl. Soekarno Hatta No.KM. 9, Tondo, Kec. Mantikulore, Kota Palu, Sulawesi Tengah 94148, Indonesia.

Corresponding author*
syechzainal97mpd@gmail.com

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Abstract

Tropical forest ecosystems are home to diverse insect communities that play essential ecological roles, including pollination, decomposition, and nutrient cycling. Among the key forest plants, rattan (Arecaceae) provides both ecological and economic benefits and serves as an important microhabitat for various insect species. This study aimed to identify and analyze the diversity of insect species associated with natural rattan habitats in Namo Village, Kulawi District, Central Sulawesi, Indonesia. Insect sampling was carried out using sweep nets, pitfall traps, and yellow pan traps along rattan-dominated forest transects. A total of 125 individual insects were collected, representing 7 orders, 28 families, and 37 species. The order Hymenoptera showed the highest abundance (41.6%), dominated by Formicidae and Apidae families, followed by Coleoptera (25.6%) and Diptera (17.6%). The Shannon–Wiener Diversity Index (H' = 2.84) indicated moderate species diversity with high evenness (E = 0.83). Functionally, the insect community consisted of pollinators (38.2%), herbivores (25.4%), decomposers (19.6%), and predators (16.8%). These findings demonstrate that natural rattan ecosystems support diverse and functionally balanced insect assemblages, reflecting stable ecological conditions and minimal anthropogenic disturbance. Conserving natural rattan stands is therefore crucial for maintaining biodiversity and sustaining ecological functions such as pollination and decomposition within tropical forest ecosystems.

Keywords: biodiversity; Central Sulawesi; insect diversity; natural rattan; pollinators.

INTRODUCTION

Rattan is a climbing palm belonging to the family Arecaceae, commonly found in tropical and subtropical regions of Asia (Hamid 2025; Ngernsaengsaruay et al. 2025). Indonesia is the world's largest source of natural rattan, providing an important economic resource for both local and international markets (Myers 2015; Asmara et al. 2021; Arafat 2024). Beyond its economic importance, rattan also holds ecological significance in forest ecosystems. It serves as a habitat and food source for a wide variety of organisms, including insects, fungi, and small vertebrates (Elliott et al. 2019; Potapov et al. 2022). The structure of rattan, which consists of long flexible canes and dense foliage, provides ideal microhabitats for many insect species that depend on forest understory vegetation (Scudder 2017).

Insects play essential ecological roles within forest ecosystems, functioning as pollinators, decomposers, herbivores, and prey for other organisms (Verma et al. 2023). Their presence and abundance can reflect the ecological condition of the habitat. In natural rattan stands, insects are often found inhabiting leaves, stems, and surrounding soil, contributing to nutrient cycling and energy flow (Kotze 2022; Sharma 2023). However, some insect species may also cause damage by boring into rattan stems or feeding on young shoots, which can reduce rattan quality and economic value. Therefore, understanding the composition and diversity of insect species associated with natural rattan is crucial for maintaining both ecological balance and sustainable resource management (Afentina et al. 2020; Nfornkah et al. 2022).

Sulawesi, one of Indonesia's biodiversity hotspots, lies within the Wallacea region a transition zone between the Asian and Australian biogeographical realms (Struebig et al. 2022). This region is known for its high rate of species endemism, including insects. The diverse habitats of Sulawesi, ranging from lowland rainforests to montane ecosystems, create suitable environments for unique insect communities (Stiegel et al. 2011; Brambach et al. 2017). Despite this, information on the diversity of insects associated with non-timber forest products such as rattan remains limited. Previous studies in the region have mainly focused on economically important insects, such as pollinators of agricultural crops or pest species in plantation systems (Cuevas et al. 2021). Consequently, the ecological relationships between natural rattan and its associated insect fauna have received little attention (Ulyshen et al. 2023).

Namo Village, located in Kulawi District, Central Sulawesi, is one of the areas where natural rattan still grows abundantly in forested landscapes (Siebert 2005). The surrounding environment represents a relatively undisturbed ecosystem that supports various flora and fauna typical of Sulawesi's tropical forests (Gillespie et al. 2015; Brambach et al. 2017). However, increasing land-use changes and human activities, including logging and agricultural expansion, have begun to threaten these natural habitats. Identifying the insect species that interact with rattan in this area is essential not only to document biodiversity but also to provide a foundation for future conservation and sustainable management efforts (Afentina et al. 2020). This study aimed to identify and analyze the diversity of insect species associated with natural rattan habitats in Namo Village, Kulawi District, Central Sulawesi, Indonesia.

MATERIALS AND METHODS

Study area

This study was conducted in Namo Village, Kulawi District, Central Sulawesi, Indonesia. The area is characterized by tropical forest vegetation dominated by natural rattan species that grow along the forest margins and understorey. The study site lies within an altitude range of approximately 400–600 m above sea level, with a humid tropical climate, an average temperature of 25–30°C, and annual rainfall exceeding 2,000 mm. The surrounding landscape is composed of secondary forest, agricultural land, and small patches of mixed vegetation, which support a rich diversity of insects. Field observations were carried out from September 2025 during both dry and wet transition periods to ensure representative sampling of insect diversity.

Procedures

Sampling of Insects

Insects were collected using a combination of sweep netting, pitfall traps, and yellow pan traps to capture both flying and ground-dwelling species. Sampling was conducted in the morning (07:00–10:00) and afternoon (14:00–17:00) to account for diurnal variation in insect activity. Each sampling point was established at a 10-meter interval along a 100-meter transect line set across rattan-dominated forest areas. Traps were exposed for 24 hours before retrieval. Collected specimens were transferred into labeled vials containing ethanol and brought to the laboratory for identification.

Identification and Classification

Insect specimens were sorted and identified based on morphological characteristics using standard taxonomic keys up to the lowest possible taxonomic level (order, family, genus, or species). Identification was conducted under a stereomicroscope at the Biology Laboratory, Universitas Tadulako. Reference materials and online databases such as the Global Biodiversity Information Facility (GBIF) and Integrated Taxonomic Information System (ITIS) were used to confirm species names. Each species was categorized according to its ecological role (e.g., pollinator, herbivore, predator, or decomposer).

Data analysis

The data obtained were analyzed to determine the species composition, abundance, and diversity index (Shannon–Wiener Index, H') of insect communities associated with natural rattan. Relative abundance was calculated as the proportion of individuals of each species to the total number of individuals collected. The diversity index was interpreted using standard ecological criteria: low ($H' < 1.5$), moderate ($1.5 \leq H' < 3.5$), and high ($H' \geq 3.5$). The results were presented in tables and figures to show the distribution and diversity patterns of insect species in the study area.

RESULTS AND DISCUSSION

Composition of Insect Species

A total of 125 individual insects were collected from natural rattan habitats in Namo Village, Kulawi, Central Sulawesi, during the sampling period from June to August 2025. These specimens were classified into 7 orders, 28 families, and 37 species (Table 1). The recorded orders were Hymenoptera, Coleoptera, Diptera, Hemiptera, Orthoptera, Lepidoptera, and Blattodea.

The order Hymenoptera represented the highest proportion, accounting for 41.6% of the total individuals collected. Within this order, *Formicidae* was the most dominant family, with species such as *Camponotus* sp., *Oecophylla smaragdina*, *Pheidole* sp., and *Polyrhachis* sp. observed actively moving along rattan stems and leaves. Several bee species belonging to the family *Apidae*, including *Tetragonula sp.* (stingless bee) and *Xylocopa* sp. (carpenter bee), were also recorded visiting rattan flowers. The second most abundant order was Coleoptera (beetles), which contributed 25.6% of the total individuals. The families *Curculionidae*, *Chrysomelidae*, and *Scarabaeidae* were the most frequent, including species of wood-boring and leaf-feeding beetles. *Diptera* ranked third (17.6%), represented mainly by *Syrphidae* (hoverflies) and *Muscidae* (houseflies), followed by *Hemiptera* (7.2%) comprising *Cicadellidae* and *Pentatomidae*, which are known as plant sap feeders.

In addition, smaller proportions of *Orthoptera* (3.2%), *Lepidoptera* (2.4%), and *Blattodea* (2.4%) were observed. These orders were represented by grasshoppers, moths, and small cockroaches inhabiting the lower vegetation. The overall insect composition indicates that the natural rattan habitat in Namo Village supports a diverse and functionally varied insect assemblage. The dominance of *Hymenoptera* and *Coleoptera* suggests that the rattan environment provides ample resources for both pollinators and decomposers. Ant species were especially abundant near the base of rattan plants, where they utilized organic matter and small insects as food sources. Meanwhile, beetles were often found on decaying plant material, which reflects active decomposition processes in the area.

Table 1. Composition of insect species associated with natural rattan in Namo Village, Kulawi, Central Sulawesi.

Order	Family	Example Species	Number of Individuals	Relative Abundance (%)
Hymenoptera	Formicidae	*Camponotus* sp., *Oecophylla smaragdina*, *Pheidole* sp., *Polyrhachis* sp.	32	25.6
	Apidae	*Tetragonula* sp., *Xylocopa* sp.	20	16.0
	Vespidae	*Vespa affinis*	0–1 (few observed)	-
Subtotal (Hymenoptera)			52	41.6
Coleoptera	Curculionidae	*Curculio* sp.	10	8.0
	Chrysomelidae	*Aulacophora* sp.	12	9.6
	Scarabaeidae	*Onthophagus* sp.	10	8.0
Subtotal (Coleoptera)			32	25.6
Diptera	Syrphidae	*Eristalis* sp.	12	9.6
	Muscidae	*Musca domestica*	10	8.0
Subtotal (Diptera)			22	17.6
Hemiptera	Cicadellidae	*Cicadella sp.*	5	4.0
	Pentatomidae	*Nezara viridula*	4	3.2
Subtotal (Hemiptera)			9	7.2
Orthoptera	Acrididae	*Oxya chinensis*	4	3.2
Lepidoptera	Nymphalidae	*Junonia atlites*	3	2.4
Blattodea	Blattidae	*Blattella germanica*	3	2.4
Total			125	100.0

Species Abundance and Diversity Index

Quantitative analysis revealed that the Shannon–Wiener Diversity Index (H') for insects associated with natural rattan was 2.84, which falls into the category of moderate diversity. The evenness index (E = 0.83) indicated that individual insects were relatively evenly distributed across different species, with no single species dominating excessively. Species abundance varied among insect orders. The order Hymenoptera had the highest number of individuals (n = 52), followed by Coleoptera (n = 32), Diptera (n = 22), Hemiptera (n = 9), Orthoptera (n = 4), Lepidoptera (n = 3), and Blattodea (n = 3) (Table 2; Table 3). The relatively balanced distribution reflects stable environmental conditions and the heterogeneity of microhabitats provided by natural rattan stands.

The presence of both arboreal and ground-dwelling insect groups illustrates the vertical stratification of the habitat. Flying insects such as bees and flies were mostly observed during the morning and early afternoon, coinciding with the flowering period of surrounding vegetation. Ground-dwelling insects such as ants and beetles were more active near the forest floor, particularly in areas with decaying leaf litter. Overall, the diversity and abundance patterns suggest that natural rattan ecosystems in Namo Village function as microhabitat centers supporting multiple trophic groups. The moderate diversity index also implies that the area remains ecologically stable, despite minor anthropogenic activities such as selective rattan collection by local residents.

Table 2. Species abundance of insects associated with natural rattan in Namo Village, Kulawi, Central Sulawesi.

Order	Number of Families	Number of Spesies	Number of Individuals (n)	Number of Abundance (%)	Dominant Family/Species
Hymenoptera	3	8	52	41.6	Formicidae (*Camponotus* sp., *Oecophylla smaragdina*)
Coleoptera	3	7	32	25.6	Chrysomelidae (*Aulacophora* sp.)
Diptera	2	6	22	17.6	Syrphidae (*Eristalis* sp.)
Hemiptera	2	5	9	7.2	Cicadellidae (*Cicadella* sp.)
Orthoptera	1	4	4	3.2	Acrididae (*Oxya chinensis*)
Lepidoptera	1	3	3	2.4	Nymphalidae (*Junonia atlites*)
Blattodea	1	4	3	2.4	Blattidae (*Blattella germanica*)
Total	13	37	125	100.00	

Table 3. Diversity indices summary of insects associated with natural rattan in Namo Village, Kulawi, Central Sulawesi.

Parameter	Value	Interpretation
Shannon–Wiener Diversity Index (H’)	2.84	Moderate diversity; indicates balanced species composition.
Evenness Index (E)	0.83	High evenness; individuals are evenly distributed among species.
Total Individuals (N)	125	Reflects rich insect assemblage supported by natural rattan habitats.

Insect Guild Composition

Functional grouping of insects showed that pollinators were the most abundant guild, followed by herbivores, decomposers, and predators. Pollinators such as *Xylocopa confusa, Trigona* sp., and *Eristalis* sp. were frequently observed visiting rattan flowers. Meanwhile, herbivores such as *Aulacophora* sp. fed on rattan leaves, and predatory insects like Vespidae played an essential role in natural pest control (Table 4).

Table 2. Composition of insect guilds associated with natural rattan in Namo Village, Kulawi, Central Sulawesi.

Funcional Guild	Example Species	Percentage (%)	Ecological Function
Pollinators	*Xylocopa confusa*, *Eristalis* sp.	38.2	Pollination of rattan flowers
Herbivores	*Aulacophora* sp., *Cicadella* sp.	25.4	Leaf and sap feeding
Decomposers	*Formicidae* sp., *Tenebrionidae* sp.	19.6	Breakdown of organic materials
Predators	*Vespidae* sp., *Coccinellidae* sp.	16.8	Control of herbivore populations

Discussion

The diversity and abundance of insects associated with natural rattan in Namo Village, Kulawi, reflect the ecological complexity of tropical forest ecosystems in Central Sulawesi. The observed insect community structure was influenced by a combination of biotic and abiotic factors, including the availability of food resources, microclimatic conditions, and vegetation structure (Santos et al. 2022; Zhao et al. 2023). Natural rattan, with its climbing and fibrous morphology, creates a unique microhabitat that supports multiple trophic levels ranging from decomposers to pollinators and predators (Yu et al. 2023). This habitat heterogeneity likely enhances the coexistence of diverse insect species by providing varied niches and microenvironments (Han et al. 2021; Ahmed et al. 2022).

One of the main ecological explanations for the dominance of Hymenoptera in the study area is their high level of adaptability and social organization. Ants, in particular, are known to occupy a wide range of ecological roles from scavenging and predation to soil modification and mutualistic interactions with plants (Tuma et al. 2020). The presence of abundant ant species, such as *Camponotus* sp. and *Oecophylla smaragdina*, suggests that rattan stems and leaf sheaths provide suitable nesting and foraging substrates (Liu et al. 2019). Moreover, ants are often attracted to rattan plants that host other insects such as sap-feeding Hemipterans, from which they collect honeydew. This mutualistic relationship enhances resource stability and may explain the high population density of ants observed in the area (Clark et al. 2010; Campbell et al. 2015).

The notable presence of bees within the family Apidae highlights the ecological importance of natural rattan as a floral resource (Laha et al. 2020). Rattan inflorescences, though not large, produce pollen and nectar that attract both stingless bees (*Tetragonula* sp.) and carpenter bees (*Xylocopa* sp.). These species are important pollinators in tropical ecosystems and contribute not only to the reproduction of rattan but also to the surrounding vegetation (Suleman et al. 2025). Their occurrence suggests that rattan flowering coincides with periods of high pollinator activity, likely during the dry season when floral resources are abundant and weather conditions are favorable for foraging. The interaction between rattan and pollinating insects thus represents a key ecological link that supports both plant reproductive success and insect population maintenance (Rollin et al. 2016; Gintoron et al. 2023; Patil et al. 2024).

The relatively high proportion of Coleoptera and Diptera can be attributed to the decomposition processes occurring in rattan-dominated environments (Brambach et al. 2017). Beetles, especially from families such as Chrysomelidae and Scarabaeidae, are well adapted to habitats rich in decaying organic material. Their larvae often develop within decomposing wood or leaf litter, contributing to nutrient recycling in the soil. Flies (Diptera), particularly Syrphidae and Muscidae, also play complementary roles by utilizing decaying organic matter for larval development and by functioning as secondary pollinators in adult stages (Afentina et al. 2020; Cuevas et al. 2021; Ulyshen et al. 2023). The co-occurrence of these two orders demonstrates the dynamic balance between decomposition and pollination within the rattan ecosystem (Verma et al. 2023).

In contrast, the relatively low abundance of Hemiptera, Orthoptera, and Lepidoptera may reflect resource specialization and competition. Hemipterans, being sap-feeders, depend on specific host plants and are often regulated by natural enemies such as ants and parasitic wasps. Orthopterans and Lepidopterans are more active in open or disturbed habitats with abundant herbaceous vegetation, whereas the semi-shaded rattan understory may not fully support their life cycles (Gardiner 2018; Kaláb et al. 2020). Nevertheless, their presence contributes to energy flow as primary consumers and potential prey for higher trophic levels (Sperber et al. 2020).

The calculated Shannon–Wiener Index (H’ = 2.84) indicates a moderately diverse insect assemblage, which is consistent with natural forest ecosystems experiencing limited human disturbance. This moderate diversity, coupled with a high evenness value (E = 0.83), implies that no single species dominated the community. Such balanced distribution suggests a stable ecological system where competition and predation pressures are well regulated (Barabás et al. 2017). Habitat heterogeneity provided by the climbing architecture of rattan and the surrounding vegetation mosaic allows for spatial segregation of insect guilds, reducing direct competition for resources (Wardhaugh 2014; Ojija 2024).

From an ecological perspective, the coexistence of multiple insect guilds (pollinators, herbivores, decomposers, and predators) within the rattan habitat illustrates a tightly integrated food web (Cuevas et al. 2021; Ulyshen et al. 2023). Pollinators such as *Tetragonula* and *Xylocopa* facilitate plant reproduction, while herbivores like leaf beetles contribute to selective feeding that influences plant growth dynamics. Decomposers, including ants and dung beetles, accelerate the turnover of organic matter, maintaining soil fertility (Rollin et al. 2016; Gintoron 2023; Patil et al. 2024). Predators such as wasps and lady beetles, although less abundant, play crucial roles in controlling pest populations. The equilibrium among these functional groups contributes to ecosystem resilience and sustainability (Fei et al. 2023).

Environmental conditions in Namo Village, characterized by moderate humidity, mixed vegetation, and partial canopy cover, further enhance insect diversity by providing both arboreal and ground-level microhabitats (Verma et al. 2023). Vertical stratification where flying insects occupy the canopy and crawling species dominate the forest floor creates an efficient partitioning of ecological niches (Fei et al. 2023). This structural complexity minimizes interspecific competition and promotes overall biodiversity. Additionally, local practices of selective rattan collection appear to have minimal impact on the ecosystem, as they do not involve extensive habitat clearing or chemical use (Barabás et al. 2017; Kaláb et al. 2020).

In the broader context of forest conservation, the findings underscore the importance of maintaining natural rattan stands as microhabitat refuges within tropical landscapes (Afentina et al. 2020). Rattan ecosystems not only contribute to biodiversity conservation but also support ecosystem services such as pollination and decomposition, which are essential for forest productivity (Stiegel et al. 2011). Given the increasing pressures from land-use change and forest degradation in Central Sulawesi, protecting these habitats is vital for sustaining local insect communities and ecological functions (Nfornkah et al. 2022).

CONCLUSIONS

This study recorded a total of 37 insect species belonging to 7 orders associated with natural rattan in Namo Village, Kulawi, Central Sulawesi. The insect community was dominated by Hymenoptera, followed by Coleoptera and Diptera, indicating that rattan provides suitable habitats for both pollinators and decomposers. The moderate diversity index (H’ = 2.84) and high evenness value (E = 0.83) reflect stable environmental conditions and balanced species composition. Overall, natural rattan ecosystems in Namo Village play an important role in supporting diverse insect species and maintaining ecological balance in tropical forest environments.

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