Identification and Diversity of Insects Associated with Tim-Tim Coffee (*Coffea arabica x Coffea canephora*) in Rusip Antara, Central Aceh, Indonesia

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Abstract: Coffee plantations support diverse insect communities that play key roles in pest regulation, pollination, and ecosystem stability. This study analyzed insect family composition, abundance, and community structure in the Tim-Tim (Typica) coffee plantation ecosystem in Rusip Antara Subdistrict, Central Aceh Regency, using different trapping methods. Sampling was conducted from May to September 2025 in one representative plantation block with three observation plots, each containing 25 coffee plants. Three types of traps were employed: light traps, yellow plate traps, and malaise traps. Insect community structure was analyzed using the Shannon–Wiener diversity index (H′), evenness index (E), and similarity index. A total of 2,659 individuals from 65 families were recorded, dominated by Hymenoptera, Diptera, Coleoptera, and Hemiptera. Light traps captured the highest number of individuals and exhibited the highest diversity (H′ = 2.34), reflecting the activity of nocturnal insects attracted to light. Yellow plate traps showed moderate diversity (H′ = 1.77) but the highest evenness (E = 0.80), indicating balanced diurnal insect communities. Malaise traps recorded lower diversity (H′ = 1.33) and evenness (E = 0.57), primarily capturing high-flying insects such as Diptera and Hymenoptera. Similarity analysis revealed moderate to low overlap among trap types, demonstrating that different traps capture complementary components of the community. These findings highlight the high insect diversity and ecological stability of the Tim-Tim coffee plantation and emphasize the importance of multiple trapping methods for understanding community structure and supporting natural biological control in sustainable coffee agroecosystems.

Keywords: Biodiversity; Exploration; Gayo coffee; Identification; Insects

Introduction

Coffee is one of the most important agricultural commodities contributing significantly to rural economies, particularly in highland regions where it serves as a primary source of livelihood, International Coffee Organization (ICO, 2022). In Indonesia, Gayo coffee from Central Aceh is widely recognized in national and international markets for its distinctive flavor, strong aroma, and balanced acidity (Rahardjo, 2012). Among the cultivated varieties, Tim-Tim (Typica) coffee is highly valued for producing premium-quality beans and constitutes a major component of the regional coffee production system (Wintgens, 2004).

The Rusip Antara Subdistrict, located at an altitude of 1,200–1,500 m asl, provides favorable agroecological conditions for Tim-Tim coffee cultivation, characterized by cool temperatures and fertile volcanic soils (Wintgens, 2004). Despite its strategic importance, coffee production in this highland and ecosystem faces persistent challenges from insect pests that reduce yield quantity and bean quality (Johnson et al., 2020).

At the farm level, pest management practices remain predominantly conventional and are frequently implemented without prior taxonomic identification of

insect species. Such generalized approaches often lead to reactive and non-specific control measures, resulting in the indiscriminate use of chemical pesticides. This practice may disrupt ecological balance by affecting non-target organisms, including predatory and parasitoid insects functioning as natural enemies (Bianchi et al., 2006). The decline of these beneficial insects can reduce biological control services and increase the risk of secondary pest outbreaks (Tscharntke et al., 2011).

Accurate identification and assessment of insect biodiversity associated with coffee plants are therefore essential. Each insect species possesses distinct ecological roles—ranging from herbivores and pollinators to predators and decomposers (Perfecto et al., 2015). A comprehensive understanding of insect community structure supports the development of ecologically based pest management strategies such as Integrated Pest Management (IPM) (Gonthier et al., 2013).

Practices of conventional pest management without prior taxonomic identification can reduce the effectiveness of pest control and harm ecological balance. In coffee systems, planting patterns and management approaches influence pest attack intensity and the presence of natural enemies (Kuswardani et al., 2023). Effective pest management strategies, including identification and targeted control, are therefore essential for sustainable agroecosystems.

The novelty of this research lies in providing the first comprehensive documentation of insect biodiversity specifically associated with Tim-Tim (Typica) coffee in the highland and agroecosystem of Rusip Antara, Central Aceh. By generating baseline biodiversity data, this study contributes new scientific information on species composition, ecological roles, and potential natural enemy presence within Tim-Tim coffee plantations.

Method

The study was conducted from May to September 2025 in a coffee plantation located in Pilar Village, Rusip Antara Subdistrict, Central Aceh Regency. The research employed a field survey method focusing on insect biodiversity associated with coffee plants.

Insect sampling was conducted using purposive sampling by selecting one representative coffee plantation block. Within this block, three observation plots were established, each consisting of 25 coffee plants. Insects were collected using three types of traps: yellow pan traps, light traps, and malaise traps.

All collected specimens were subjected to preliminary sorting at the Laboratory of the Faculty of Mathematics and Natural Sciences, Almuslim

University. Final sorting and taxonomic identification were carried out at the Agricultural Entomology Laboratory, Faculty of Agriculture, Universitas Gadjah Mada. Specimens were identified to the family level based on standard entomological identification keys.

The materials used in this study included adult insects collected from coffee plantations, 70% alcohol, detergent, distilled water, raffia rope, label paper, and plastic bags. The equipment used included yellow pan traps, light traps, malaise traps, boots, machetes, small shovels, 5 L jerrycans, small buckets, film bottles, fine brushes, basins, microscopes, forceps, magnifying glasses, and stationery.

The Shannon–Wiener diversity index was calculated using Formula 1.

$$H': -\sum p_i \ln (p_i) \tag{1}$$

Where:
H' = Diversity index
p_i = Proportion of the i-th family relative to the total number of species

The Shannon–Wiener evenness index was calculated to evaluate the distribution uniformity of individuals among species, using Formula 2 (Magurran, 2004).

$$E = \frac{H'}{Ln(S)} \tag{2}$$

Where:
E = Evenness index
H' = Diversity index
S = Total number of species

Community similarity of parasitoid Hymenoptera among different coffee plantation management types was analyzed using the Sørensen Similarity Index (Magurran, 2004), calculated with the Formula 3.

$$C = \frac{2w}{a+b} \tag{3}$$

Where:
C = Similarity index
w = Number of species shared between sites a and b
a = Number of species found in site a
b = Number of species found in site b

Results and Discussion

*Family Composition and Abundance of **Insect** Individuals*
The total number of insects collected from the Tim-Tim coffee plantation ecosystem using various traps,

namely light traps, yellow plate traps, and malaise traps, in Rusip Antara Subdistrict, Central Aceh Regency, was 2,659 individuals, representing 65 families.

Table 1. Composition and Number of Insect Individuals Collected in the Tim-Tim Coffee Plantation Using Different Trap Types

Family	Yellow Plate Trap	Light Trap	Malaise Trap
Ichneumonidae	27	45	9
Formicidae	15	18	5
Eurytomidae	20	22	9
Betthylidae	16	34	7
Apidae	19	34	7
Braconidae	16	19	1
Chrysididae	15	19	2
Diapriidae	11	18	2
Dryinidae	19	22	2
Eurytomidae	17	23	1
Evaniidae	22	31	1
Sphecidae	12	19	1
Tiphiidae	10	20	2
Vespidae	9	14	5
Tabanidae	13	16	7
Pipunculide	9	11	7
Tachinidae	8	16	9
Asilidae	5	8	2
Tipulidae	6	11	1
Tephritidae	5	9	1
Calliphoridae	8	9	3
Dolichopodidae	12	17	3
Micropezidae	16	22	7
Muscidae	12	17	5
Mycetophilidae	3	7	1
Neriidae	8	9	2
Sarcophagidae	5	8	4
Scenopinidae	9	11	2
Stratiomyidae	5	9	1
Cercopidae	12	17	2
Cicadellidae	11	19	3
Coreidae	15	22	1
Cydnidae	19	31	7
Lygaeidae	12	22	3
Pentatomidae	16	19	3
Reduviidae	21	34	1
Gryllidae	22	26	2
Phlaeothripidae	12	17	2
Araneidae	12	23	4
Cheiracanthiidae	16	19	1
Lycosidae	21	31	3
Oxyopidae	22	32	5
Pholcidae	15	19	8
Salticidae	17	22	9
Anisolabididae	16	19	2
Chelisochidae	19	22	2
Brabidae	21	34	2
Gryllidae	23	37	2
Anthicidae	22	37	5
Aphodiidae	17	22	5
Apionidae	12	35	5

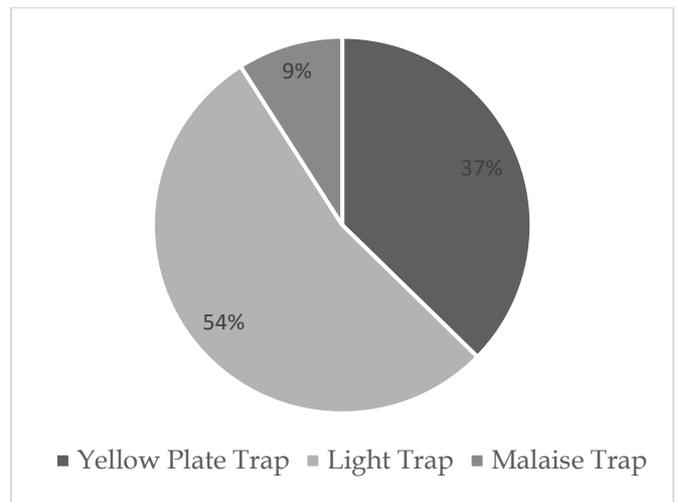| Family	Yellow Plate Trap	Light Trap	Malaise Trap
Cantharidae	14	19	2
Carabidae	16	22	6
Chrysomelidae	17	33	2
Cicindelidae	22	32	6
Coccinellidae	19	12	3
Elateridae	20	23	5
Hydrophilidae	34	38	5
Languriidae	16	22	5
Ptilodactylidae	19	33	3
Salpingidae	12	18	4
Scarabaeidae	27	33	1
Scaritidae	22	26	2
Staphylinidae	12	19	7
Tenebrionidae	18	19	3

Figure 1. Composition and Abundance of Insect Individuals in the Tim-Tim Coffee Plantation Using Different Trap Types

The results showed that the insect community found in the study area was highly diverse, consisting of several major orders, including Hymenoptera, Diptera, Hemiptera, Coleoptera, and Arachnida, as well as minor orders such as Orthoptera, Thysanoptera, Dermaptera, and Blattodea. A total of 65 families were recorded during the study.

Based on the total number of individuals captured, the light trap yielded the highest number of individuals compared to the yellow plate trap and the malaise trap. This suggests that many insects in the Tim-Tim coffee plantation are nocturnal and exhibit phototactic behavior, being attracted to light sources. In integrated pest management studies, the use of automated monitoring systems has been recommended to improve detection and response against to pest populations (Widanti et al., 2024). Moreover, environmentally friendly pest control alternatives, such as biolarvicides derived from plant extracts, have been investigated to reduce the negative impacts of chemical pesticides on non-target organisms (Supriatno et al., 2024). These

strategies align with broader agroecological principles that integrate biodiversity conservation and agricultural productivity.

Hymenoptera dominated the captures across all trap types, particularly families such as Ichneumonidae, Formicidae, Braconidae, and Eurytomidae. Most families within this order consist of parasitoids and predators that play important roles in regulating pest populations in coffee plantations. The high abundance of Hymenoptera indicates that the Tim-Tim coffee agroforestry system still supports ecological balance and provides suitable habitats for natural enemies (Borror et al., 1996). In addition, the presence of Apidae as pollinators further emphasizes the ecological importance of coffee plantations in sustaining beneficial insect communities (Primack et al., 1998).

Diptera were also frequently encountered, particularly families such as Muscidae, Tachinidae, and Micropezidae. Members of this order function as decomposers, parasitoids, and in some cases pollinators, contributing to nutrient cycling and biological control. Variation in Diptera abundance suggests that microclimatic factors, including humidity, shade intensity, and availability of organic matter, influence insect distribution and abundance (Nugroho et al., 2021). That environmental factors strongly influence community structure within ecosystems.

Coleoptera and Hemiptera also showed relatively high abundance. Coleopteran families such as Scarabaeidae, Carabidae, and Chrysomelidae function as decomposers, herbivores, and predators, while several Hemipteran families, including Cicadellidae and Cydnidae, have the potential to act as sap-feeding pests. The relatively high abundance of Coleoptera indicates the availability of litter and organic materials in the plantation, which serve as important food resources (Ludwig & Reynolds, 1988). Meanwhile, the presence of potential pest groups from Hemiptera highlights the importance of maintaining natural enemy populations to preserve ecosystem stability (Magurran, 2004).

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Furthermore, the spatial distribution of insects in the Tim-Tim coffee plantation suggests that structural complexity, such as shade trees and undergrowth vegetation, provides refuges for beneficial insects while limiting pest outbreaks. Studies have shown that agroforestry systems with high structural diversity can enhance predator–prey interactions, leading to improved natural pest control (Perfecto et al., 2015). This highlights the value of maintaining diversified coffee landscapes as a sustainable pest management strategy.

Seasonal variations also influenced insect activity and abundance. Observations indicated that Hymenopteran parasitoids were more abundant during the wet season, likely due to higher prey availability and increased floral resources. Such seasonal patterns have been documented in other tropical coffee systems, emphasizing the need to consider temporal dynamics when designing conservation and pest management programs (Philpott et al., 2008).

Additionally, the interplay between microclimate and insect functional groups underscores the importance of canopy cover management. Shaded coffee plantations maintain stable temperatures and humidity levels, which are conducive to the survival of both nocturnal and diurnal insects, enhancing ecosystem resilience (Clough et al., 2011). This supports previous findings that habitat complexity and shade management are critical for sustaining biological control services.

Promoting habitat heterogeneity around coffee plantations, such as buffer strips with flowering plants, can attract additional natural enemies and pollinators, increasing ecosystem service provision. Incorporating such practices within Tim-Tim coffee agroecosystems can improve sustainability while reducing reliance on chemical pesticides (Tscharntke et al., 2011).

Insect Diversity Index

The Insect diversity index for each trap type is presented in Table 2.

Table 2. Insect Diversity Index in the Tim-Tim Coffee Plantation Ecosystem Based on Different Trap Types

Trap Types	Species Diversity (H')
Light Trap	2.34
Yellow Plate Trap	1.77
Malaise Trap	1.33

Comparison of the diversity index (H') among the three trap types showed that the light trap exhibited the highest diversity value compared to the yellow plate trap and the malaise trap. This is attributed to the ability of light traps to attract nocturnal insects, such as those from the orders Coleoptera and Diptera, which are naturally attracted to light. The high number of families captured by light traps, including Hydrophilidae, Scarabaeidae, and Muscidae, reflects high taxonomic variation and relatively even distribution of individuals among species (Sucipto et al., 2025). The high diversity recorded in light traps indicates that environmental conditions in the Tim-Tim coffee plantation support the presence of various insect groups with intense nocturnal activity.

Light traps contributed the most to insect diversity values because they were able to attract a wide range of nocturnal insects from several orders, such as Coleoptera, Hemiptera, and Diptera. In contrast, yellow plate traps were more effective in capturing diurnal insects, particularly pollinators and parasitoids such as Apidae and Braconidae. This finding demonstrates that variation in trapping methods strongly influences the calculation of diversity indices. The use of multiple trap types provides a more comprehensive understanding of insect community structure in coffee plantations (Kuswardani et al., 2023).

Yellow plate traps exhibited moderate diversity values, capturing many diurnal insects attracted to bright yellow colors, such as Apidae and Braconidae from the order Hymenoptera. These traps effectively detect pollinator and parasitoid insects that contribute significantly to maintaining ecosystem balance. Although the number of individuals captured was lower than that of light traps, the functional diversity of insects recorded in yellow plate traps was relatively high, encompassing groups such as pollinators, predators, and natural enemies of pests (Primack et al., 1998). This highlights the trap's ability to provide a representative overview of insect communities associated with the coffee canopy and flowering structures. Moreover, integrated management strategies, including the application of biolarvicides and the use of organic soil amendments, support non-target insect diversity and overall ecosystem functioning (Santoso et al., 2024; Supriatno et al., 2024).

Malaise traps showed the lowest diversity values among the three trap types. This is due to the functional limitation of this trap, which is primarily effective in capturing small-sized or low-flying insects, such as Diptera and Thysanoptera (Nugroho et al., 2021).

The relatively low number of individuals captured resulted in lower Shannon index (H') values, while dominance by certain families, such as Tachinidae and Pipunculidae, reduced evenness (E). Nevertheless, malaise traps remain important because they are capable of detecting small parasitoid insects that are often not captured by other trapping methods (Ludwig & Reynolds, 1988).

Diversity values reflect the complexity of biological interactions within the coffee plantation ecosystem. The orders Hymenoptera and Diptera comprised the highest number of families, including Ichneumonidae, Braconidae, Formicidae, and Muscidae, which function as parasitoids, predators, and decomposers, respectively. This diversity serves as an important indicator that pest populations in coffee plantations can be naturally regulated by their natural enemies. According to Magurran (2004), high Shannon–Wiener index values indicate insect communities composed of many species with relatively even individual distributions, thereby preventing strong dominance by a single family.

Overall, the high insect diversity index values observed in the Tim-Tim coffee plantation indicate that this agroecosystem possesses good ecological stability and strong potential for natural biological control. Complex and diverse insect communities help maintain pest population balance, enhance pollination processes, and support agricultural sustainability. Therefore, conservation efforts aimed at maintaining insect diversity—such as reducing synthetic pesticide use and preserving natural vegetation surrounding coffee plantations—are essential for sustaining ecosystem health (Altieri & Nicholls, 2017).

The observed differences in diversity among trap types also reflect niche differentiation within the coffee plantation ecosystem. Nocturnal species captured by light traps are often overlooked in traditional surveys, yet they perform critical ecological roles, such as

decomposing organic matter and preying on pest larvae. Incorporating nocturnal sampling methods therefore provides a more accurate representation of ecosystem functioning and overall insect diversity (Kremen et al., 2002).

Functional diversity, rather than species richness alone, is a key factor for ecosystem stability. In this study, light traps not only captured more species but also a broader array of functional groups, including predators, parasitoids, and detritivores. This underscores the importance of using multiple trap types to assess ecosystem services such as pest regulation and nutrient cycling in coffee agroecosystems (Tscharntke et al., 2005).

Spatial heterogeneity within the Tim-Tim coffee plantation also contributed to insect diversity. Areas with complex canopy structures and understory vegetation were associated with higher Shannon index values, highlighting the role of habitat complexity in supporting multiple insect guilds. Maintaining structural diversity in coffee plantations can therefore enhance ecological resilience and natural biological control (Perfecto et al., 2010).

The findings indicate that conservation-oriented management practices, including reduced pesticide use and preservation of native vegetation, are essential to sustain the high insect diversity observed. Protecting both diurnal and nocturnal insects enhances pollination, pest suppression, and overall agroecosystem stability, aligning with principles of sustainable coffee production (Philpott et al., 2009).

Insect Evenness Index

The insect evenness index for each trap type is presented in Table 3.

Table 3. Insect Evenness Index in the Tim-Tim Coffee Plantation Ecosystem Using Different Trap Types

Trap Types	Species Evenness (E)
Yellow Plate Trap	0.80
Light Trap	0.72
Malaise Trap	0.57

Comparison of the evenness index (E) among the three trap types showed that the yellow plate trap exhibited the highest evenness value, followed by the light trap and the malaise trap. The evenness index was calculated based on family-level data. Higher evenness values indicate a more balanced distribution of individuals among insect families.

The relatively high evenness recorded in the yellow plate trap suggests that individuals were distributed more proportionally across several families, with no single family overwhelmingly dominant. Habitat conditions and host availability can influence

community balance, as shown by host type effects on pest life cycles (Nik & Rusae, 2024). Families such as Apidae, Braconidae, and Formicidae were represented by comparable numbers of individuals, possibly reflecting adequate food resources and habitat quality (Kuswardani et al., 2023).

Light traps showed moderate evenness values due to the dominance of certain nocturnal families, such as Hydrophilidae and Scarabaeidae, which are strongly attracted to light sources. Although overall abundance and diversity were high in light traps, the concentration of individuals within a few dominant families reduced the evenness value. This uneven distribution suggests that specific nocturnal insect groups were more responsive to light stimuli than others. Environmental factors such as nighttime humidity, temperature, and light intensity may influence the activity patterns of these groups (Ludwig & Reynolds, 1988). Likewise, the influence of plant extract treatments on insect mortality highlights the need to understand differential responses among insect taxa, which can affect evenness measurements (Mustapa et al., 2023).

Malaise traps exhibited the lowest evenness values among the three trap types. These traps primarily capture small and low-flying insects, particularly certain Diptera and Thysanoptera. The relatively limited number of families captured, combined with the dominance of a few taxa, resulted in lower evenness values (Nugroho et al., 2021). Trap placement and vegetation structure may also influence capture selectivity.

Higher evenness values in the yellow plate trap reflect a more proportionally distributed diurnal insect community, whereas lower evenness values in the light and malaise traps indicate greater dominance by particular families. According to Magurran (2004), evenness provides insight into how individuals are distributed among taxa and complements diversity indices in describing community structure.

Environmental heterogeneity within the coffee plantation contributes significantly to evenness by providing diverse microhabitats for various insect species. For instance, shaded areas, understory vegetation, and leaf litter create niches that support both dominant and rare taxa, promoting a more uniform distribution across families (Klein et al., 2002).

Behavioral differences among species also influence evenness. Diurnal species, particularly pollinators and parasitoids, exhibit more consistent activity patterns across different areas of the plantation, resulting in balanced representation in yellow plate traps (Winfree et al., 2007). Such behaviors enhance the stability of ecosystem functions, including pollination and pest regulation.

Evenness indices can also be affected by temporal variation. Seasonal fluctuations in temperature, rainfall, and flowering phenology of coffee plants can alter insect activity, leading to shifts in the relative abundance of families. Continuous monitoring across multiple seasons provides a more reliable assessment of community evenness and ecological stability (Blüthgen et al., 2008).

Management practices, such as intercropping, organic fertilization, and reduced pesticide application,

contribute to higher evenness values by minimizing dominance of pest species and promoting coexistence of multiple functional groups. Such practices ensure that both common and rare insects maintain ecological roles, thereby enhancing the resilience of coffee agroecosystems (Perfecto et al., 2004).

Insect Similarity Index

The insect similarity index for each trap type is shown in Table 4.

Table 4. Insect Similarity Index in the Tim-Tim Coffee Plantation Ecosystem Using Different Trap Types

Trap Type	Total Insect (Species)	Shared Insect Species (Species)	Similarity Index Value
Light Trap	260	21	0,87
Yellow Plate Trap	60		
Malaise Trap	15		

Figure 2. Research Activity Documentation

The results showed that the three trap types had complementary functions in detecting insect diversity. Comparison of the similarity indices among the traps indicated that the level of similarity in insect composition between trap types ranged from moderate to low. The highest similarity values were generally observed between yellow plate traps and light traps. This was due to overlapping activity patterns of several insect families that are active both during the day and at night, such as Formicidae, Braconidae, and Chrysomelidae. According to Magurran (2004), high similarity values indicate that communities within a location share similar taxonomic and ecological structures in terms of family composition and relative abundance. Yellow plate traps and light traps captured similar insect groups because they were placed in comparable microhabitats and influenced by similar environmental factors that drive insect activity.

The lowest similarity values were observed between malaise traps and the other two trap types. Malaise traps primarily captured low-flying insects from the orders Diptera and Thysanoptera, whereas light traps and yellow plate traps were more effective in capturing insects that fly at higher levels or are attracted to light and color. This finding is consistent with Hamidah et al. (2025), who reported that differences in trapping mechanisms and insect activity periods can result in low similarity values among trap types. Consequently, different traps tend to represent different components of the insect community within the coffee plantation ecosystem.

Relatively low similarity values indicate that each trap type has specificity in capturing insect groups. The insect roles in agricultural landscapes vary widely depending on trap type and ecological role (Asby et al., 2025; Fajeriadi et al., 2025). Furthermore, studies in rice agroecosystems have highlighted that insect functional

groups such as predators and pollinators respond differently to environmental structures, supporting the idea of complementary sampling (Asby et al., 2025).

Functional diversity contributes to low similarity values by promoting ecological complementarity among species. For example, different insect families perform unique roles such as herbivory, predation, decomposition, and pollination, and the selective capture by specific trap types highlights these functional differences (Cardinale et al., 2012). Such complementarity is critical in agroecosystems where multiple ecosystem services are necessary for crop productivity.

Microhabitat heterogeneity also influences similarity indices between traps. Variations in canopy cover, understory vegetation, and microclimatic conditions can create distinct ecological niches, leading to differential species activity and distribution. Yellow plate and light traps overlap more in similarity because they share similar microhabitat exposure, while malaise traps, often placed in lower vegetation strata, sample a distinct set of species (Barton et al., 2015).

Temporal patterns of insect activity affect similarity values. Nocturnal and diurnal species exhibit differing responses to environmental cues such as light, temperature, and humidity, which influence their probability of capture in specific traps. Integrating data across multiple temporal periods ensures a more accurate representation of community similarity and highlights the dynamic nature of insect assemblages (Kremen et al., 2002).

Management practices within the coffee agroecosystem, including intercropping, ground cover maintenance, and pesticide reduction, can also affect similarity among trap types. These practices enhance habitat complexity, support diverse insect assemblages, and reduce dominance by a few pest species, resulting in complementary captures across different trap methods (Perfecto et al., 2004).

Conclusion

Based on the results of this study, it can be concluded that the Tim-Tim coffee plantation ecosystem in Rusip Antara District, Central Aceh Regency, supports a diverse and structurally complex insect community. A total of 2,659 individuals belonging to 65 families were recorded, representing several major insect orders such as Hymenoptera, Diptera, Coleoptera, and Hemiptera. The high richness and abundance indicate that the agroecosystem provides suitable habitats, adequate food resources, and favorable microclimatic conditions to sustain various ecological functional groups. The combined use of light traps, yellow plate traps, and Malaise traps proved complementary in revealing community structure; light traps recorded the highest number of individuals and the highest diversity index (H'), reflecting greater taxonomic richness particularly of nocturnal Coleoptera and Diptera, whereas yellow plate traps exhibited the highest evenness (E), indicating a more proportional distribution of diurnal families such as Apidae, Braconidae, and Formicidae. Malaise traps primarily captured small and low-flying taxa, including Diptera and Thysanoptera. The higher H' value in light traps, despite lower evenness compared to yellow plate traps, suggests that diversity was driven mainly by richness rather than uniform distribution. Overall, these findings highlight the ecological stability and functional complexity of the Tim-Tim coffee agroecosystem, supported by the presence of natural enemies (e.g., Ichneumonidae and Braconidae) and pollinators (Apidae) that contribute to natural pest regulation and ecosystem services. Future research is recommended to conduct species-level identification, seasonal comparisons, and longer-term monitoring to better understand temporal dynamics and strengthen biodiversity-based pest management strategies in coffee agroecosystems.

Author Contributions
Formal analysis, writing—review and editing, G.S.B.; Conceptualization, methodology, investigation, writing—original draft preparation, G.S.B. and T.J.H.; validation, review and editing, F.F., E.T. and M.F.M; supervision, review and editing, G.S.B. and F.F. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest
The authors declare no conflict of interest.

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