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Research Article

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Influence of vegetation structure on the diversity and distribution of nocturnal insects in oil palm plantations of Central Kalimantan

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ABSTRACT

Environmental changes caused by oil palm plantation activities can affect the diversity of nocturnal insects that play important roles in the ecosystem as pollinators, decomposers, predators, and food sources for other insects as well as bioindicators. This study aimed to determine the levels of diversity, evenness, and dominance of nocturnal insects at two stations with different oil palm planting ages in Seruyan Regency. This study used a descriptive quantitative approach with an exploratory survey method. Nocturnal insects were collected from replanting and non-replanting oil palm areas using light traps equipped with UV lamps. The insects were identified to the species level, and data were analyzed using the Shannon–Wiener diversity index (H'), Pielou's evenness index (E), and Simpson's dominance index (C) with the PAST software. The results showed that from a total of 454 individuals, 15 species of nocturnal insects were successfully identified, originating from 6 orders, namely, Coleoptera (Laccophilus gentilis, Protaetia acuminata, Pangaeus bilineatus, Adoretus versutus, Denticollis linearis, Eumorphus bulbosus, Sirthenea flavipes, Cicindela gallica), Hymenoptera (Vespa affinis, Tetraponera rufonigra), Hemiptera (Pangaeus bilineatus), Odonata (Agriocnemis pygmaea), Lepidoptera (Hypochrosis subrufa, Chytolita morbidalis), and Orthoptera (Gryllus assimilis). The most dominant species was Pangaeus bilineatus with 143 individuals, while the species with the lowest number of individuals was Cicindela gallica with 3 individuals. The Shannon–Wiener diversity index (H') value of 1.558 (Station I) and 2.129 (Station II) indicates moderate diversity, the Pielou evenness index (E) value of 0.59 (Station I) and 0.65 (Station II) indicates a fairly even distribution, and the Simpson dominance index (C) value of 0.72 (Station I) and 0.85 (Station II) indicates no extreme species dominance. The study revealed moderate nocturnal insect diversity with balanced species distribution, indicating a stable oil palm ecosystem and supporting their role as bioindicators of ecological health.

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INTRODUCTION

Biodiversity is a fundamental foundation for maintaining ecosystem stability and sustainability, encompassing genetic, species, and ecosystem variation (Putra et al., 2021; Yuslinawari et al., 2021). One of its key components is species diversity, which reflects the number and distribution of species within a specific habitat. Insects represent the most dominant animal group, accounting for over 72% of all known animal species worldwide (Gunarno, 2021). Their presence supports essential ecosystem processes, including pollination, pest regulation, organic matter decomposition, and overall biological productivity (Hadi et al., 2019; Jumrodah et al., 2023). Among them, nocturnal insects those active primarily at night play critical ecological roles as nocturnal pollinators, natural predators, and bioecological indicators due to their high sensitivity to environmental changes (Suliansyah et al., 2022).

Recent studies have highlighted that changes in land use, particularly agricultural expansion such as oil palm plantations, significantly influence insect community composition and nocturnal activity patterns (Jaroenkietkajorn et al., 2021; Pardo et al., 2021; Fatiqin et al., 2023). Advanced ecological assessments have also shown that nocturnal insect diversity can serve as a reliable indicator of habitat quality and ecosystem resilience in disturbed landscapes (Razy et al., 2020; Jannah et al., 2023). However, studies integrating nocturnal insect diversity assessment within oil palm plantation ecosystems in Indonesia, particularly across different replanting stages, remain limited. Therefore, this research aims to fill this knowledge gap by providing updated insights into the diversity and ecological significance of nocturnal insects as bioindicators within oil palm plantation environments.

The Seruyan Regency in Central Kalimantan is one of the regions dominated by extensive oil palm plantations, covering approximately 332,397.81 hectares with an annual production exceeding 950 thousand tons (Hidayat & Hariyadi, 2019). In Suka Maju Village, replanting activities have been carried out since 2020 on 328 hectares of the total 1,060 hectares of oil palm land. Changes in vegetation structure and microclimatic conditions resulting from replanting are expected to alter the dynamics of insect communities, particularly nocturnal groups that are highly sensitive to environmental fluctuations. Previous studies in other tropical regions have reported that replanting and vegetation modification significantly affect insect abundance, diversity, and functional composition (Foster et al., 2011; Azhar et al., 2014; Ganser et al., 2017). However, such studies are still scarce in Central Kalimantan, and most existing research has focused primarily on soil macrofauna or diurnal insects rather than nocturnal assemblages (Chowdhury et al., 2025; Pashkevich et al., 2021). Moreover, no previous research has specifically compared nocturnal insect diversity between replanting and non-replanting oil palm areas in this region using a quantitative ecological approach supported by biodiversity indices (Shannon–Wiener, Pielou, Simpson) and standardized UV light-trap sampling methods. Therefore, this study is unique in its integration of site-specific ecological sampling, statistical diversity analysis, and educational application, aiming not only to fill the knowledge gap regarding nocturnal insect responses to oil palm replanting practices but also to translate ecological data into a contextual learning resource for biology education at the senior high school level. This dual contribution scientific and educational strengthens the relevance and novelty of this study compared to previous works conducted in similar ecosystems.

This study aims to determine the composition, diversity, and dominance of nocturnal insects in replanting and non-replanting oil palm areas in Suka Maju Village, Seruyan Regency, Central Kalimantan. It also seeks to evaluate the potential of nocturnal insects as bioindicators of ecological health in oil palm plantation ecosystems. In addition, the results of this research are used to develop an educational booklet that integrates local biodiversity data into the teaching of the Kingdom Animalia topic for Grade X high school students. Through these objectives, the study contributes to filling the knowledge gap on the impact of oil palm replanting on nocturnal insect communities while strengthening the link between ecological research, environmental education, and sustainable biodiversity management.

RESEARCH METHODS

This research is a descriptive quantitative study that uses an exploratory survey approach. The aim of this study was to describe the diversity, evenness, and dominance of nocturnal insects in oil palm plantations on the basis of the age of the oil palm trees. The research was conducted through field observations via a plot observation method and light traps. Two observation stations were selected on the basis of differences in oil palm planting age, namely, replanted areas (<2 years old) and non-replanted areas (>2 years old). Each station consisted of one 30 × 30-meter plot with five observation points spaced 50 meters apart (Figure 1).

The population in this study included all nocturnal insects found in the oil palm plantation of Suka Maju village, Seruyan Tengah District, Seruyan Regency (Figure 2). The samples used were individual nocturnal insects captured at the two research stations during the observation period, which took place every 3 hours from 6:00 PM to 4:00 AM for two consecutive days. Sampling was conducted randomly at each observation point via light traps.

The main instruments used in this study were light traps (18-watt LED lamps) hung on 1.5-meter wooden poles, with basins filled with detergent solution placed underneath to trap the insects. Additional instruments included identification aids such as determination keys and entomological literature for species-level identification of the insect samples. Data were collected by capturing nocturnal insects via light traps placed at each observation point within the plot. All the captured samples were collected, preserved, and subsequently identified in the laboratory. The data collected included the number of individuals per species at each station.

The data analysis technique in this study was conducted quantitatively to evaluate the community structure of nocturnal insects. Quantitative analysis was performed to determine the levels of diversity, evenness, and dominance of nocturnal insect species in the oil palm plantation of Koperasi Sawit Jaya, Suka Maju Village, Seruyan Tengah District, Seruyan Regency. The data obtained from the identification of individual counts per species were analyzed via three ecological indices: the Shannon–Wiener diversity index (H'), Pielou's evenness index (E), and Simpson's dominance index (C).

$$\text{Diversity index } (H') = -\sum pi \; ln \; pi \qquad (1)$$

$$pi = \frac{ni}{N} \qquad (2)$$

$$\text{Evenness } (E) = \frac{H'}{ln \; S} \qquad (3)$$

$$\text{Dominance } (C) = \Sigma \left(\frac{ni}{N}\right) \times 100 \; \% \qquad (4)$$

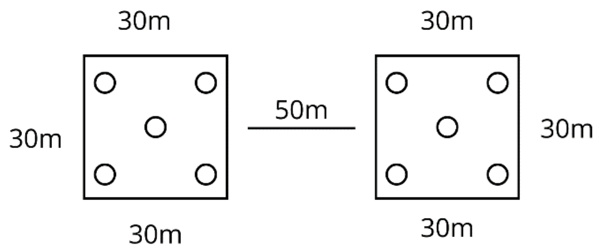

Figure 1. Plot of nocturnal insect species established in the Oil Palm Plantation of Koperasi Sawit Jaya, Suka Maju Village, Wara Subdistrict, Seruyan Tengah District, Seruyan Regency

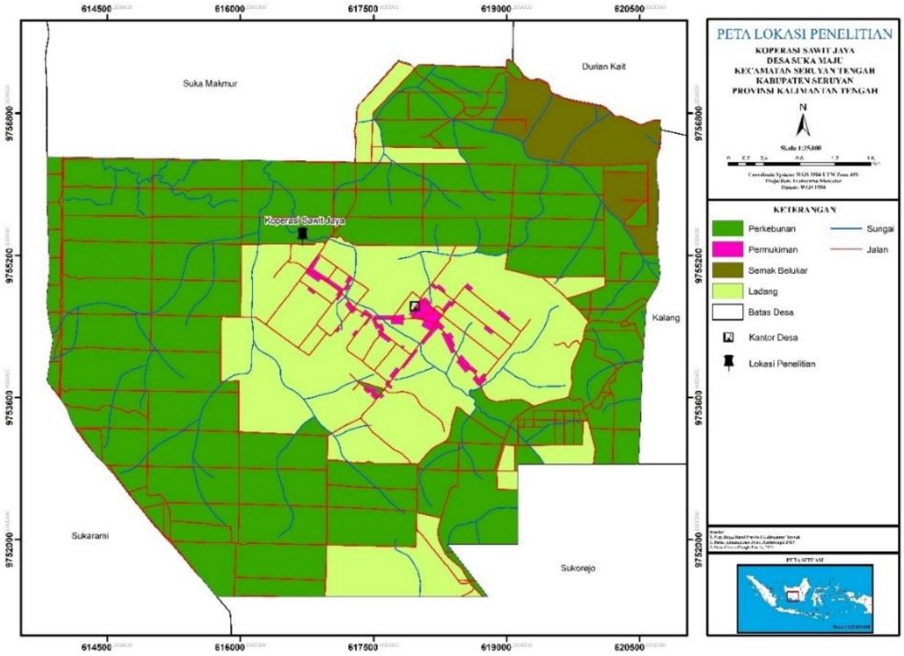

Figure 2. Study Site for Nocturnal Insect Species Diversity in the Oil Palm Plantation of Koperasi Sawit Jaya, Suka Maju Village, Seruyan Tengah District, Seruyan Regency

FINDING AND DISCUSSION

The results revealed that the diversity of nocturnal insects in the oil palm plantations at the Seruyan Regency varied across the observation stations and observation days. Among the 454 individuals captured (Station I and Station II), the species with the greatest number of individuals was *Pangaeus bilineatus*, with 143 individuals, followed by *Protaetia acuminata*, with 102 individuals. Conversely, the species with the lowest number of individuals were Cicindela gallica, with 3 individuals, and Sirthenea flavipes, with 4 individuals (Figure 3).

The present study revealed that nocturnal insect diversity in the oil palm plantation of the Seruyan Regency included 15 species from 6 orders and 14 families, with a total of 454 individuals captured across two observation stations. The species with the highest abundance was *Pangaeus bilineatus*, with 143 individuals, which were relatively evenly distributed across both stations. This was followed by *Protaetia acuminata*, with 102 individuals, and *Agriocnemis pygmaea*, with 87 individuals (Figure 6). Moreover, the species with the lowest abundance included *Cicindela gallica* (3 individuals), *Sirthenea flavipes* (4 individuals), and *Adoretus versutus* (6 individuals). The order Coleoptera represented the highest species richness, encompassing six families, indicating that beetles were taxonomically dominant in this ecosystem. Other recorded orders, such as Hymenoptera, Hemiptera, Lepidoptera, Odonata, and Orthoptera, presented relatively low diversity and abundance. Differences in individual counts between observation stations suggest variability in insect distribution, which is likely influenced by environmental factors such as food availability, habitat conditions, and other abiotic factors such as humidity and temperature. A Shannon–Wiener diversity index (H') of 1.558 (Station I) and 2.129 (Station II) indicates a moderate level of diversity, whereas an evenness index (E) of 0.59 (Station I) and 0.65 (Station II), suggests a fairly even distribution of individuals among species, and a Simpson dominance index (C) of 0.72 (Station I) and 0.85 (Station II) indicates a low level of species dominance (Figure 4).

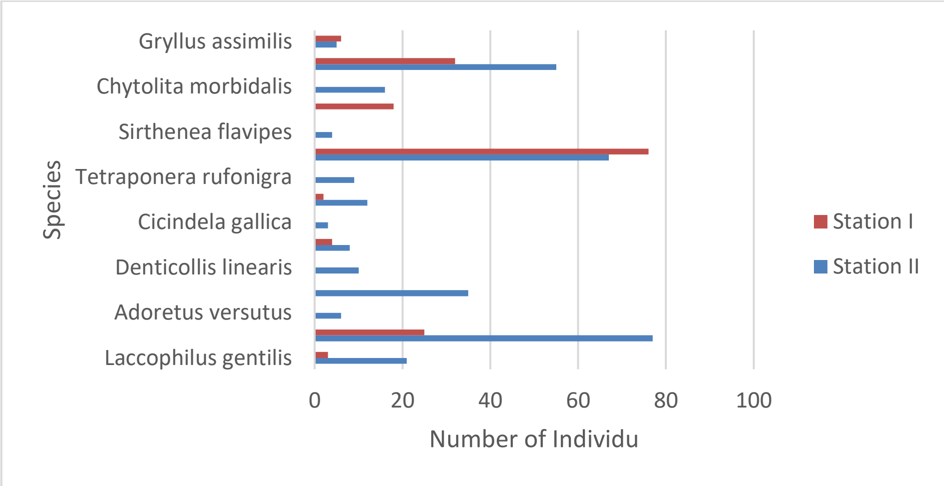

Figure 3. Results on Nocturnal Insect Species in Oil Palm Plantations of Seruyan Regency

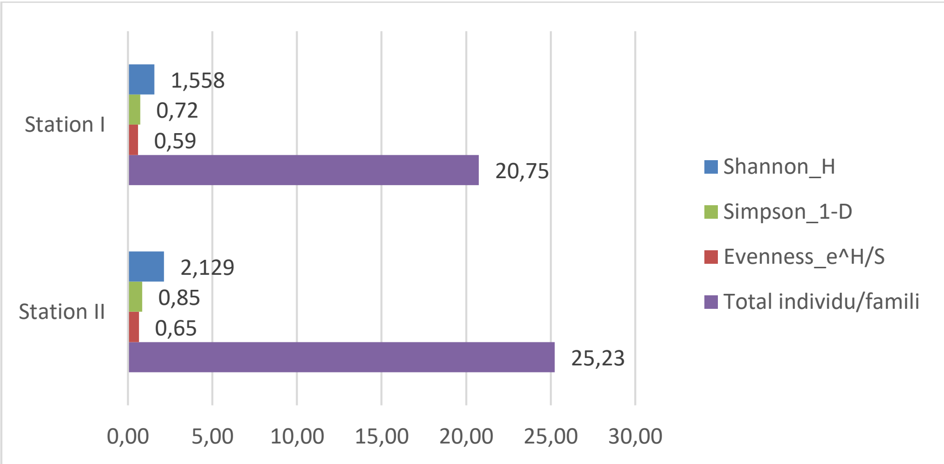

Figure 4. Analyses comparison of species in Oil Palm Plantations of Seruyan Regency

The diversity, evenness, and dominance of nocturnal insects in the oil palm plantations of Seruyan Regency are influenced by both biotic and abiotic environmental factors. The relationship between abiotic conditions and nocturnal insect community structure was analyzed at two observation stations. Station I, located in an oil palm plantation less than two years old, had an average temperature of 23–24°C, humidity of 89–92%, and light intensity ranging from 2.9 to 4.3 Cd. In contrast, Station II, situated in a plantation older than two years, showed similar temperature and humidity levels but slightly lower light intensity, ranging from 2.9 to 3.7 Cd. Overall, the biological and physical environmental conditions at both sites were suitable for nocturnal insect activity. However, differences in plantation age and light intensity are presumed to influence vegetation structure and habitat complexity, which in turn affect the variation in insect species diversity and dominance at each station. Boxplot comparison of insect abundance per species between station I and station II can be seen in Figure 5.

Figure 5 illustrates a comparison of insect abundance per species between Station I and Station II. The data are presented as a boxplot to show the distribution, variation, and presence of potential outliers in the number of individuals per species at each station. Station II, which represents oil palm plantations older than two years, generally exhibits higher and more variable insect abundance than Station I, which consists of plantations younger than two years. This suggests that more developed and complex vegetation structures in older plantations contribute to greater abundance and diversity of nocturnal insect populations.

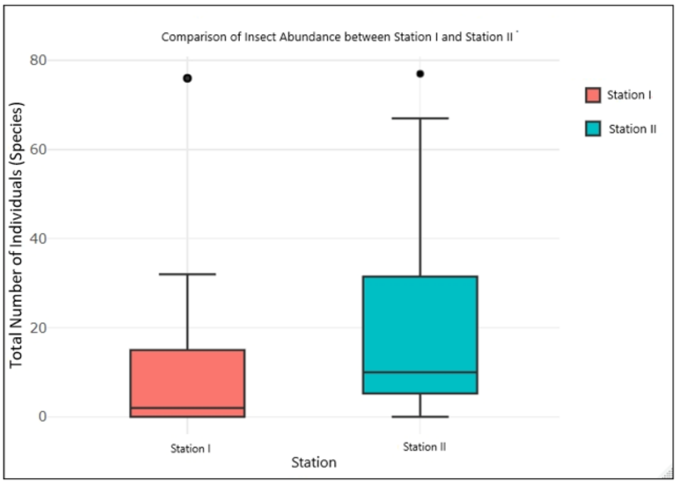

Figure 5. Boxplot Comparison of Insect Abundance Per Species Between Station I and Station II

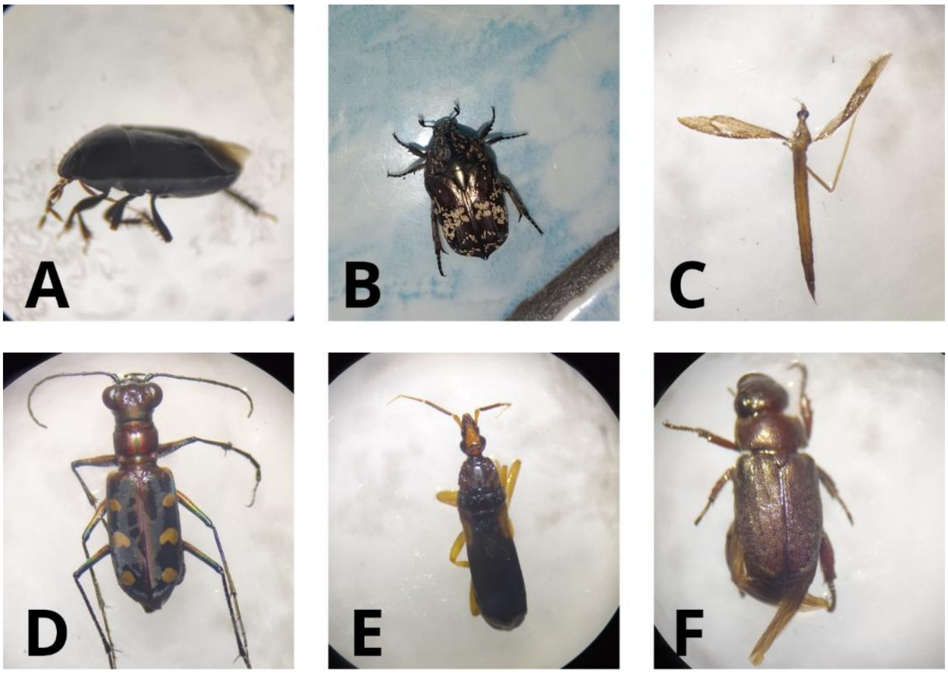

Figure 6. Nocturnal insect species found in the oil palm plantation. (A) *Pangaeus bilineatus,* (B) *Protaetia acuminata,* (C) *Agriocnemis pygmaea,* (D) *Cicindela gallica,* (E) *Sirthenea flavipes,* (F) *Adoretus versutus*

These findings indicate that the diversity index of nocturnal insects in the oil palm plantations at the Seruyan Regency has a value of H' 1.558 (Station I) and 2.129 (Station II), which suggests a moderate level of diversity. This aligns with the three criteria of species diversity index values: H' < 1 indicates low diversity, H' = 1–3 indicates moderate diversity, and H' > 3 indicates high diversity (Suliansyah et al., 2022). This moderate diversity reflects the variation in insect species found at the two observation stations, which had different environmental conditions on the basis of the age of the oil palm plantings. This finding is consistent with research by Wibowo et al. (2019), who reported that nocturnal insect diversity is moderate and influenced by pesticide use, regular pruning, and soil management practices that create stable but less varied microhabitats. Monoculture systems and land fragmentation reduce resource variety and habitat connectivity, whereas the microclimate in older plantations only supports certain insect species.

Station I, located on oil palm land less than one year old, had an average temperature of 23°C–24°C, humidity ranging from 89% to 92%, and light intensity between 2.9 Cd and 4.3 Cd. The vegetation at this station was dominated by shrubs such as *Imperata cylindrica, Chromolaena odorata*, and *Paspalum conjugatum*, which may serve as food sources and shelter for insects. Understory vegetation, such as *Chromolaena odorata*, supports both phytophagous and entomophagous insect diversity. This vegetation supports several insect species, such as *Pangaeus bilineatus* (76 individuals) and *Agriocnemis pygmaea* (35 individuals), which had the highest counts at this location. Vegetation composition influences insect diversity, as more diverse plant communities provide more varied food sources and reproductive sites (Andani & Nasirudin, 2021).

Station II had similar temperature and humidity conditions to Station I but slightly lower light intensity (2.9–3.7 Cd). The vegetation in this area was more diverse, with additional species such as Boehmeria nivea and Stenochlaena palustris supporting insects from the orders Coleoptera and Hemiptera. Species such as *Protaetia acuminata* (77 individuals) and *Pangaeus bilineatus* (67 individuals) were found in relatively high numbers, indicating that this habitat better supports insects that prefer more enclosed environments. This is supported by Putri et al (2025), who reported that insect composition and abundance are influenced by ground cover vegetation and proximity to natural habitats. Ground cover, such as living vegetation, plant residues, and organic matter, plays an important role in maintaining soil health, preventing erosion, and creating microhabitats for insects. Moreover, a study by (Hidayat & Hariyadi, 2019), revealed that areas with denser canopies and lower light intensities support different insect communities than do more open areas.

The evenness index for the nocturnal insects in this study was E = 0.59 (Station I) and 0.65 (Station II), which is considered high. This finding indicates that the distribution of individuals among species was relatively even, with no excessive dominance by a single species. The evenness index (E) reflects community stability and ranges from 0 to 1. A value near zero indicates an uneven distribution dominated by a few species, whereas a value closer to one indicates that individuals are more evenly distributed (Irni, 2021). The high evenness suggests that the oil palm plantation habitat can still support various nocturnal insect species. Environmental factors such as food availability, vegetation structure, temperature, humidity, and the level of disturbance from plantation activities play roles in maintaining the insect population balance. Additionally, diverse vegetation structures, including shrubs and ferns such as *Stenochlaena palustris*, provide shelter and food sources for insects. Although it is often considered an invasive weed in oil palm plantations, *Stenochlaena palustris* has ecological potential as shelter and food for certain insect species and can influence the structure of understory plant communities and insect diversity depending on microhabitats (Satriawan & Fuady, 2019).

The dominance index (C) of the nocturnal insects in this study was 0.72 (Station I) and 0.85 (Station II), which is considered low. According to the Simpson dominance index, values less than 0.4 indicate no dominant species and thus low dominance. In contrast, values above 0.6 suggest the presence of a dominant species and high dominance (Muhammad et al., 2023). This result revealed that no single species significantly dominated the nocturnal insect community, which is consistent with the high evenness value. This low dominance may be due to several environmental factors, such as microhabitat diversity supporting various insect species, relatively balanced competition levels, and the widespread availability of resources such as food and shelter throughout the plantation ecosystem. This phenomenon is likely influenced by environmental factors such as temperature, humidity, and light intensity, which affect insect diversity and dominance (Nurhasnita et al., 2020).

The study revealed that species from various orders, such as Sirthenea flavipes (4 individuals) from Hemiptera and *Cicindela gallica* (3 individuals) from Coleoptera, were still present, albeit in lower numbers than other species. This suggests that although individual counts varied among species, no single species was found to be overwhelmingly dominant. The stable environmental conditions at the research location also contributed to this low level of dominance. These findings align with those of Jumrodah et al (2023), who reported that low values of the insect dominance index reflect ecosystem complexity and stability. The presence of understory vegetation, such as *Imperata cylindrica, Chromolaena odorata*, and *Paspalum conjugatum*, also provides shelter and food sources for various insect species (Santoso et al., 2023). This ecological pattern observed in Seruyan Regency demonstrates that balanced vegetation composition and microclimatic stability play crucial roles in maintaining community equilibrium within nocturnal insect populations.

Comparable trends have also been reported in other tropical plantation ecosystems, which similarly exhibit moderate insect diversity and relatively balanced community structures. For instance Gunarno (2021) and Azhar et al (2014), observed that oil palm plantations in Sumatra and Malaysia showed moderate insect diversity due to limited habitat heterogeneity and frequent agricultural disturbances. Sagar & Devy (2022), found that canopy density and light intensity strongly influence nocturnal insect abundance, supporting the present findings where microclimatic factors such as humidity and light intensity shaped species composition at both stations. However, unlike studies by Chowdhury et al (2025) and Foster et al (2011), which documented a decline in insect diversity in older plantations due to reduced vegetation complexity, the current research revealed that even in mature non-replanting areas, species evenness remained high and dominance was low, indicating stable ecological conditions.

CONCLUSION

This study achieved its objectives by revealing the composition, diversity, evenness, and dominance of nocturnal insects in oil palm plantations of Seruyan Regency, Central Kalimantan. A total of 15 species from six insect orders were identified, with Pangaeus bilineatus recorded as the most abundant species and Cicindela gallica as the least abundant. The Shannon–Wiener diversity index (H' = 1.558 at Station I and 2.129 at Station II) indicated moderate diversity, while the evenness index (E = 0.59 and 0.65) reflected a balanced distribution of individuals, and the dominance index (C = 0.72 and 0.85) showed no extreme species dominance. These results demonstrate that the nocturnal insect community in oil palm plantations remains stable and diverse, highlighting its ecological importance as a bioindicator of environmental health. Furthermore, the outcomes of this study were developed into an educational booklet that integrates local biodiversity data into the Kingdom Animalia topic for Grade X biology classes, providing a contextual learning resource that promotes biodiversity awareness and supports sustainable environmental management in agricultural ecosystems.

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