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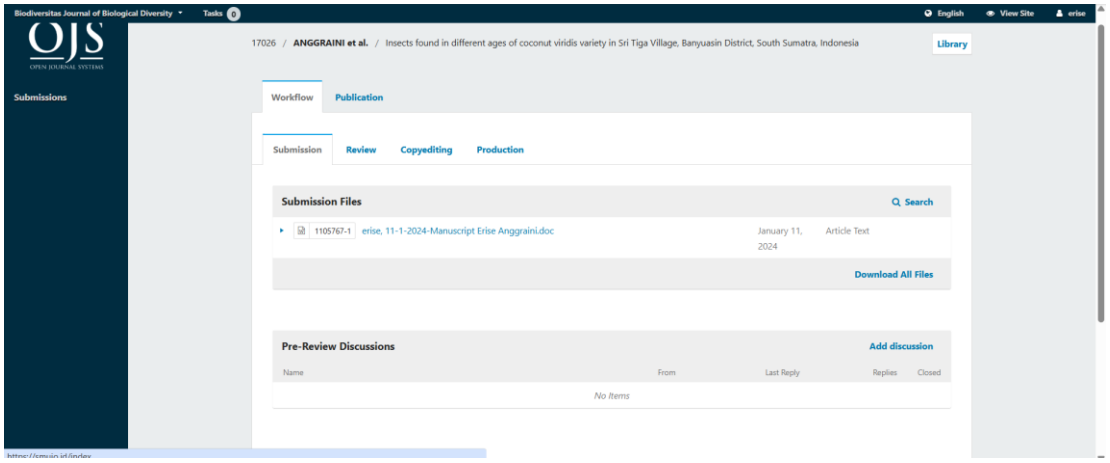
# 1. Submission

## *Submission (11 Januari 2024)*



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**Title:**

# INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY AND SURROUNDING WILD PLANTS IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA

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This research inventories insects in smallholder coconut plantations at different planting ages. Insect inventory is important because it is the basis for controlling pest insect populations. Updates on pest inventory can be a basic reference for monitoring to anticipate at any time an explosion in the insect pest population.

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Erise Anggraini

# INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA, INDONESIA

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**Abstract.** Coconut (*Cocos nucifera*) is a valuable export commodity and has good prospects in the international market. Coconut cultivation is inseparable from the presence of insect species. The presence of insects in plants is interrelated because plants are places for insects to live and eat. However, not everyone knows the relationship between plants and insects. An inventory of insect biodiversity in an ecosystem needs to be conducted. This information shows the community structure of insects associated with coconut plants and plants that grow around coconut plants. Therefore, this field practice aims to find out the insects associated with coconut plants. Field practice was carried out with a survey in a coconut plantation owned by the people in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency, South Sumatera, Indonesia. The observation was conducted from July to September. Data collection was done by determining 3 coconut plantations with different ages of coconut trees. Data collection was carried out using the purposive sampling method by direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was conducted by collecting insects directly during direct observation and in traps. Specimens that have been collected were identified using a macroscope in the Laboratory of Entomology, Department of Plant Pests and Disease, Faculty of Agriculture, Sriwijaya University. The results of this field practice found 12 species namely *Aleurocanthus* sp., *Aphis cerana*, *Aspidiotus destructor*, *Aulacophora* sp., *Cenephora hirsuta*, *Conocephalus* sp., *Cotesia congregata*, *Dianemobius fascipes*, *Eumorphus westwoodi*, *Macrotermes* sp., *Metisa plana*, *Nipaecoccus nipae*, *Oecophylla* sp., *Oryctes rhinoceros*, *Polistes carnifex*, *Polyrhachis dives*, *Pteroma pendula*, *Tettigidea lateralis*.

**Key words:** *Cocos nucifera*, viridis variety, coconut, insects

**Running title:** Insects Found in Coconut Viridis Variety and Surrounding Wild Plants

## INTRODUCTION (10 pt)

Indonesia has various agricultural sectors such as plantations, horticulture, food crops and forestry plants. The plantation sector in Indonesia makes a significant contribution to the country's economy (Purnomo et al., 2020). In Indonesia, coconut plantations have been widely developed and have become the main income for coconut farmers. Coconut plays a role in the economy, social and state income from non-oil and gas commodities (Ximenes et al., 2021). Coconut production is mostly used for consumption and industry (Hoe, 2019). Products resulting from the development of coconut plants that have been widely managed include coconut oil, coconut sugar, dried grated coconut, coconut milk, shells, coconut juice and coconut fiber (Henrietta et al., 2022). Coconut (*Cocos nucifera*) is a tropical plantation commodity that is widespread in Indonesia, the Philippines, India, and several Asia Pacific countries (Hoe, 2019). Coconut is a high-value export commodity and has good prospects in the international market. Indonesia is the first considerable coconut-producing country worldwide, followed by the Philippines and India (Zainol et al., 2023). The area of coconut plantations in Banyuasin Regency, Indonesia, in 2022 was 42,599,00 Ha (Badan Pusat Statistik, 2023). The productivity of coconut plants in Banyuasin Regency, Indonesia 2022 reached 46,760,00 tons (Badan Pusat Statistik, 2023).

In coconut cultivation, it is important to understand the life cycle of the plant from seeding to harvest. This stage requires consistent care and monitoring. In coconut cultivation, the process involves selecting quality seeds, proper soil cultivation, and proper care (Thomas et al., 2018). Coconuts thrive in sufficient sunlight, appropriate rainfall, and nutrient-

rich soil with effective drainage (Tiemann et al., 2018). The optimal range for coconut plant growth is between pH 5-8 (Fauzana et al., 2021). A deep understanding of these factors can result in sustainable coconut plantations. Furthermore, regular pruning, fertilizing, and managing pests and diseases are things that need attention (Aulia et al., 2020). A deep understanding of these factors can lead to profitable and sustainable coconut production. On the other hand, In many coconut producing areas, especially in smallholder coconut plantations, fertilizer use and insect management are often not carried out intensively (Zainol et al., 2023). Furthermore, the process of cultivating coconut cannot be separated from the presence of insect species. The existence of insects on plants is interrelated because plants are a place for insects to live and eat (Stam et al., 2014). Insects are also needed by plants during plant pollination (Moreira & Reitas, 2020). In addition, insects can cause damage to cultivated plants (Manosathiyadevan et al., 2017).

In coconut plantations, the age of coconut trees varies in each area. This results in differences in plant growth and development from one tree to another, affecting not only nutritional requirements but also harvest patterns and overall productivity (Arumugam, 2022). Management appropriate to the coconut plant's age is essential to maximize its health and yield. Coconut trees at varying stages of growth may attract different insect pests, which may prefer specific developmental stages of the trees due to physiological differences. It's essential to identify and manage these pests appropriately, considering the age of the coconut trees for effective pest control. Moreover, insects play various roles in ecosystems and significantly impact human society and the environment, such as pollinators, decomposers, and pests (Chandra et al., 2023). Recent information about insects on coconut trees, especially regarding the different ages of the trees, has yet to be recorded. Therefore, an inventory of insect biodiversity in different plant ages of coconut plantation ecosystem needs to be carried out. The diversity of insect species can be used as an indicator of changes occurring in the ecosystem (Chowdhury et al., 2023). It is important to identify the presence of different species in different ages of coconut trees. Understanding the insect species can guide integrated pest management strategies.

## MATERIALS AND METHODS (10 PT)

### Study area (10 pt)

Field practice was carried out in people's coconut plantations in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency (Figure 1). Field practice is also carried out at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University. Field practice is carried out from July to September 2023.

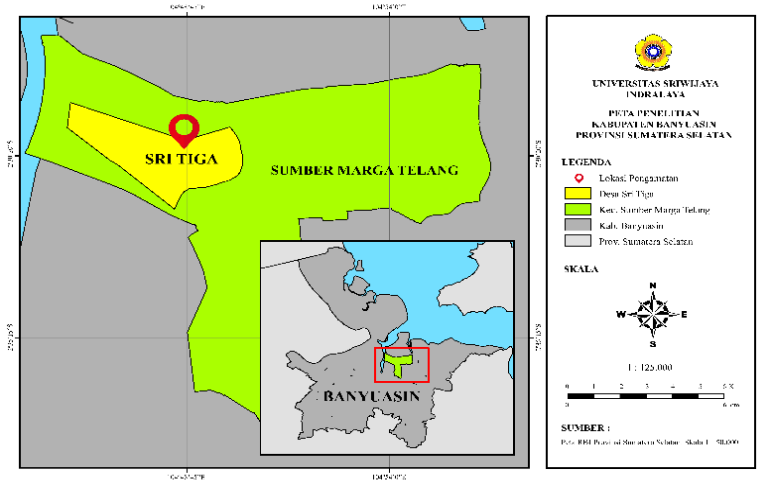


**Figure 1.** Sampling location

**Procedures**

Preparation

Initial preparations are carried out by conducting a survey to find out the research location and preparing the tools and materials that will be used. Apart from that, a survey was conducted to find out information from the community regarding the use of coconut in Sri Tiga Village, Banyuasin Regency.

Data collection

Data collection was initially carried out by determining 3 coconut plantations as objects of observation, then these gardens were observed. Data collection was carried out using the purpose sampling method by making direct observations and using traps such as insect nets (Figure 3.1 a), light traps (Figure 3.1 b) and pheromonas traps (Figure 3.1 c). Sampling is carried out by collecting insects directly, either during direct observation or in traps.

Documentation

Documentation is carried out to strengthen and support the data obtained on the observation area. Documentation was carried out in the form of photographs of insects found on coconut plants and on wild plants around the coconut plants.

Insect Identification

Identification of insects found is done by examining insects that are common and have been studied previously. The things studied were similarities in terms of color, shape, size and morphological characteristics of the insects found.

Observation Parameters

The observation parameters in this field practice are the insects caught in each trap. All insects found are then identified. Insect identification is carried out based on morphological characteristics in the form of head, abdomen, antennae, wings and others. Each insect found then determines its role in the ecosystem.

**Data analysis**

The data obtained from the observations are presented in table form. The data was then analyzed descriptively.

**Species Diversity Index (H')**

The species diversity index is used to describe the diversity of insect species found in the research area. The diversity index is expressed using the Shannon-Wiener species diversity formula:

$$H' = -\sum \text{Pi In pi}$$

Information:

H': Shannon-Wiener Diversity Index

Pi: ni/N (Comparison between the number of a species and all species)

Description of criteria:

H' < 1 : Low diversity

1 < H' < 3 : Medium diversity

H' > 3 : High diversity

**Species Evenness Index (E)**

The species evenness index is used to describe the degree of evenness of insect species found in the research area. The evenness index is expressed using the formula:

$$E = \frac{H'}{In\ S}$$

Information:

E : Evenness index (value between 0-1)

H' : Shannon-Wiener diversity index

S : Number of types

Description of criteria:

E < 0.4 : Small population uniformity

0.4 < E < 0.6 : Moderate population uniformity

E > 0.6 : High population uniformity

**Species Dominance Index (C)**

The species dominance index is used to describe the level of dominance of insect species found in the research area. The dominance index is expressed using the formula:

$$D = \sum Pi^2$$

Information:
D: Simpson Dominance Index
Pi: ni/N (Comparison between the number of a species and all species)
Description of criteria:
0 < D < 0.5 : Low dominance
0.5 < D < 0.75 : Moderate dominance
0.75< D < 1.0 : High dominance

## RESULTS AND DISCUSSION

**Abundance of insects found in coconut trees**

The insect species found in three coconut fields with varying plant ages, namely 8 years, 5 years and 2 years, were very diverse. There are 12 species from 4 orders. The four orders found most frequently include the orders Coleoptera, Hemiptera, Hymenoptera and Lepidoptera. The highest number of species found in 8 year old coconut fields was Nipaecoccus nipae which comes from the Hemiptera Order, namely 256.33 individuals. This result also found the same thing in coconut fields that were 5 years old, namely dominated by Nipaecoccus nipae as many as 265.67 individuals. Meanwhile, on 2 year old coconut fields, the insect species that were frequently encountered were Aspidiotus destructor from the Hemiptera Order, namely 96,000. Based on the results of comparing the number of species found in coconut fields of different ages, it was found that there were also different numbers of species (Table 1). In the 2 year old land, no Aphis cerana and Polistes carnifex species were found.

**Table 1.** Abundance of Insects on Coconuts

| Ordo/Spesies | Abundance of insects on coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Oryctes rhinoceros* | 28.00 | 29.00 | 22.67 | $3.20 \times 10^{-1}$ | $1.54^{ns}$ | - |
| **Hemiptera** | | | | | | |
| *Aspidiotus destructor* | 173.33a | 116.33b | 96.00b | $3.62 \times 10^{-3}$ | $31.24^{*}$ | 1.55 |
| *Nipaecoccus nipae* | 256.33a | 265.67a | 18.00b | $5.16 \times 10^{-5}$ | $276.40^{*}$ | 2.07 |
| *Planococcus sp.* | 50.67a | 44.33a | 27.67b | $58.7 \times 10^{-4}$ | $80.55^{*}$ | 0.54 |
| **Hymenoptera** | | | | | | |
| *Aphis cerana* | 5.67a | 4.33b | 0.00c | $3.13 \times 10^{-5}$ | $355.22^{*}$ | 0.25 |
| *Cotesia congregata* | 30.00a | 25.33b | 18.00c | $6.14 \times 10^{-4}$ | $78.70^{*}$ | 0.35 |
| *Dolichoderus thoracicus* | 113.33a | 103.67a | 81.33b | $45.1 \times 10^{-3}$ | $27.78^{*}$ | 0.81 |
| *Oecophylla* sp. | 98.00a | 87.33a | 60.33b | $1.15 \times 10^{-3}$ | $56.91^{*}$ | 0.75 |
| *Polistes carnifex* | 4.00a | 2.33b | 0.00c | $4.52 \times 10^{-4}$ | $92.12^{*}$ | 0.38 |
| **Lepidoptera** | | | | | | |
| *Metisa plana* | 16.33a | 13.67ab | 10.00b | $2.64 \times 10^{-2}$ | $10.31^{*}$ | 0.68 |
| *Pteroma pendula* | 20.67a | 16.67ab | 13.00b | $6.15 \times 10^{-3}$ | $23.50^{*}$ | 0.48 |
| *Pteroma plagiophleps* | 24.00a | 19.00ab | 14.00b | $6.78 \times 10^{-3}$ | $22.28^{*}$ | 0.61 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

**Abundance of insects found in wild plants around coconut trees**

Insect species found in wild plants around coconuts were also observed. There are 6 species of insects from 3 orders. The orders found include Coleoptera, Isoptera and Orthoptera. In wild plants around 8 year old and 5 year old coconuts, the most Captotermes sp insects were found. originating from the Order Isoptera, namely 18.00 individuals and 13.67 individuals respectively. Meanwhile, it was very different when the coconuts were 2 years old and no similar species were found at all. In the plants around coconuts that are 2 years old, the most common insects are Conocephalus sp. which came from the Order Orthopetra, namely 10,00 individuals (Table 2).

**Table 2.** Average abundance of insects in wild plants around coconut trees

| Ordo/Spesies | Abundance of Insects in wild plants around Coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Aulacophora* sp. | 14.67a | 8.00b | 7.00b | $9.09 \times 10^{-3}$ | 18.98* | 0.71 |
| *Eumorphus westwoodi* | 12.33a | 8.33b | 3.00c | $3.21 \times 10^{-4}$ | 109.67* | 0.42 |
| **Isoptera** | | | | | | |
| *Captotermes* sp. | 18.00a | 13.67b | 0.00c | $3.52 \times 10^{-5}$ | 335.07* | 0.53 |
| **Orthoptera** | | | | | | |
| *Conocephalus* sp. | 17.00a | 12.00b | 10.00c | $38.9 \times 10^{-4}$ | 99.47* | 0.24 |
| *Dianemobius fascipes* | 16.67a | 13.00b | 9.00c | $6.50 \times 10^{-5}$ | 246.00* | 0.17 |
| *Tettigidea lateralis* | 10.67a | 8.33ab | 6.67b | $8.19 \times 10^{-3}$ | 20.10* | 0.39 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

**Characteristics of insect communities found in coconut trees**

The characteristics of the insect community on coconuts aged 8 years, 5 years and 2 years that were analyzed included the diversity index, evenness index and dominance index. The results showed that the community characteristics of each coconut plant aged 8 years, 5 years and 2 years increased with each observation. The diversity, evenness and dominance index of 8-year-old coconut plants was higher than that of 5- and 2-year-old coconut plants (Table 3). This shows that the age of the coconut affects the number of insects found in the field. The higher the diversity index value, the more diverse the species that exist in the community. This index reflects the biological richness of the community. If the evenness index shows a high value, the individuals in the community have a more even distribution among species, while a low value indicates an uneven distribution. Meanwhile, the dominance index measures the extent to which one or several species have significant dominance or ownership in the community.

**Table 3.** Characteristics of insect communities found in coconut trees

| Coconut plants (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Coconut plants (8 years old) | Number of Individuals | 847.00 | 853.00 | 761.00 |
| | Diversity Index (H') | 1.90 | 1.95 | 2.04 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.31 |
| | Dominance Index (D) | 0.34 | 0.32 | 0.28 |
| Coconut plants (5 years old) | Number of Individuals | 754.00 | 734.00 | 695.00 |
| | Diversity Index (H') | 1.86 | 1.90 | 1.97 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.30 |
| | Dominance Index (D) | 0.16 | 0.16 | 0.17 |
| Coconut plants (2 years old) | Number of Individuals | 622.00 | 617.00 | 544.00 |
| | Diversity Index (H') | 1.75 | 1.76 | 1.80 |
| | Eveness Index (E) | 0.27 | 0.27 | 0.29 |
| | Dominance Index (D) | 0.16 | 0.15 | 0.18 |

**The characteristics of insects on wild plants around coconut trees**

Based on the results, it was found that the highest index was found in coconut fields that were 8 years old. Meanwhile, at the age of 2 years, the analysis results were lower (Table 4). This also proves that the age of the coconut greatly influences the number of species found in wild plants around the coconut. The diversity, evenness and dominance indices in coconut plants aged 8 years, 5 years and 2 years experienced increases and decreases in population numbers. The diversity index in wild plants around 8-year-old coconut plants is higher compared to 5- and 2-year-old coconut plants. Meanwhile, the evenness and dominance index of wild plants around 2-year-old coconut plants was higher than that of 8- and 5-year-old coconut plants.

**Table 4.** Characteristics of insect communities in wild plants around coconut trees

| Wild plants around the coconut trees (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Wild plants around the coconut plants (8 years old) | Number of Individuals | 99.00 | 92.00 | 77.00 |
| | Diversity Index (H') | 1.78 | 1.77 | 1.77 |
| | Eveness Index (E) | 0.39 | 0.39 | 0.41 |
| | Dominance Index (D) | 0.19 | 0.22 | 0.21 |
| Wild plants around the coconut plants (5 years old) | Number of Individuals | 72.00 | 65.00 | 53.00 |
| | Diversity Index (H') | 1.77 | 1.75 | 1.76 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.44 |
| | Dominance Index (D) | 0.21 | 0.23 | 0.23 |

| | | | | |
|---|---|---|---|---|
| Wild plants around the coconut plants (2 years old) | Number of Individuals | 42.00 | 37.00 | 28.00 |
| | Diversity Index (H') | 1.54 | 1.53 | 1.54 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.46 |
| | Dominance Index (D) | 0.26 | 0.30 | 0.32 |

**Relative abundance of insects found in coconut trees**

The relative abundance of insects on coconuts aged 8 years, 5 years and 2 years varied greatly. At plant ages of 8 years and 5 years, the abundance of insects in the Order Hemiptera was found, namely 59.00% and 58.00% respectively. while the lowest order is the Order Coleoptera which is only 3.00% and 4.00% respectively. In contrast to the age of 2 years, the most insect species found were from the Order Hymenoptera, namely 48.00% and the lowest species were in the Orders Lepidopeta and Hymenoptera, which was only 7.00% (Figure 2).

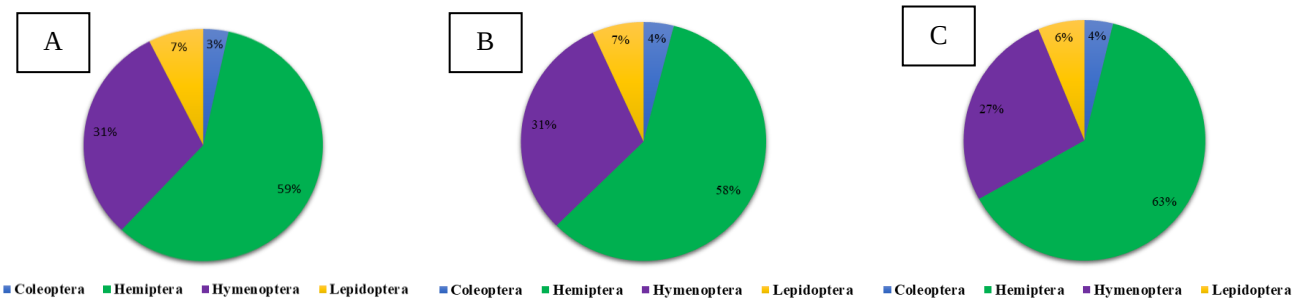


**Figure 2.** Abundance of insects found in coconut trees at: A) 8 years old, B) 5 years old, C) 2 years old.

**Relative abundance of insects found in wild plants around coconut trees**

The relative abundance of insects in wild plants around coconut plants was only found in 3 orders, namely the orders Coleoptera, Isoptera and Orthoptera. In plants aged 8 years, 5 years, and 2 years, the most Orthoptera orders were found, namely 50.00%, 53.00% and 72.00% respectively. Meanwhile, in the area around 2-year-old coconuts, only two orders were found, namely Coleoptera and Orthoptera (Figure 3).

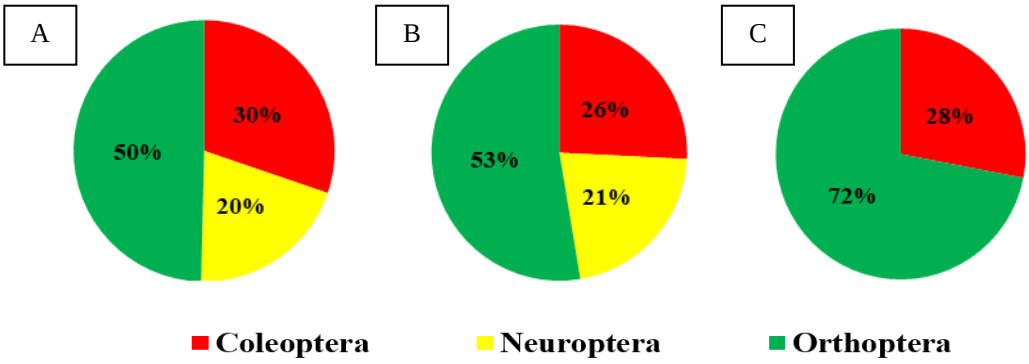


**Figure 3.** Abundance of insects on wild plants around coconut trees at different age of coconut: A) 8 years old, B) 5 years old, C) 2 years old.

The results of observations found 18 species of insects associated with coconut plants and surrounding wild plants. The 18 insect species act as phytophagous, pollinators and natural enemies. The dominant insects belong to the orders Hemiptera and Hymenoptera. The insects are *Aspidiotus destructor* (Figure 4a), *Nipaecoccus nipae* (Figure 4b), *Aleurocanthus* sp. (Figure 4c), *Polyrhachis dives* (Figure 4d), *Oecophylla* sp. (Figure 4e).

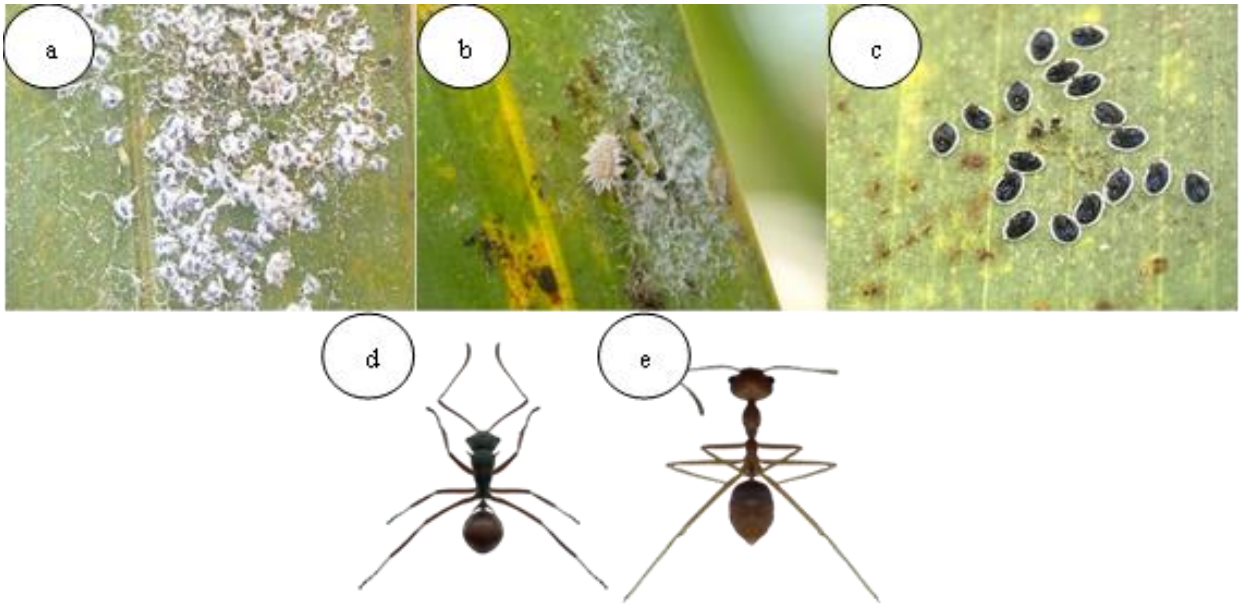


**Figure 3.** The dominant insects are found on coconut plants and surrounding plants. *Aspidiotus destructor* (a), *Nipaecoccus nipae* (b), *Aleurocanthus* sp. (c), *Polyrhachis dives* (d) dan *Oecophylla* sp. (e)

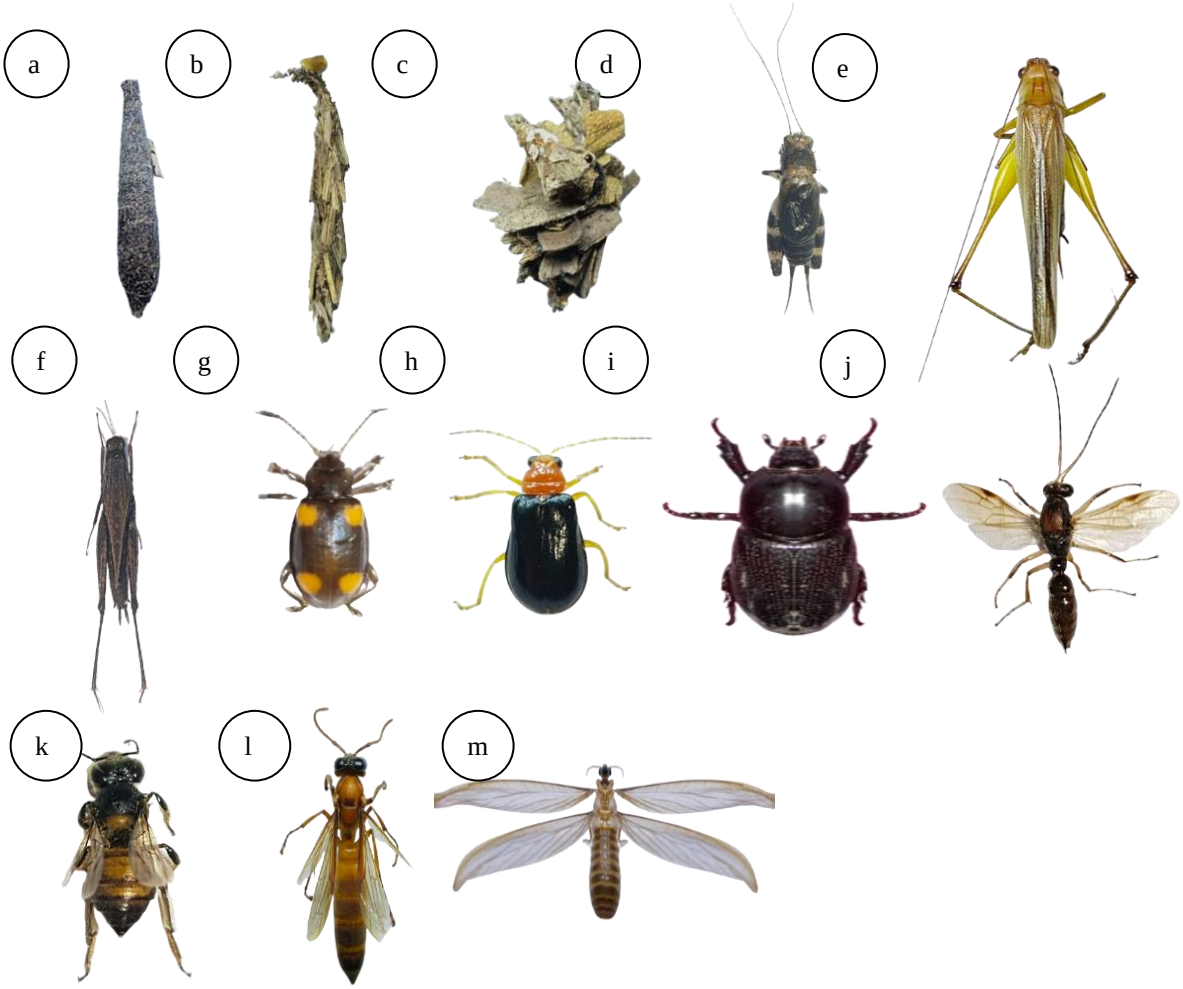


**Figure 4.** The non-dominant insects are found on coconut plants and surrounding plants. *Pteroma pendula* (a), *Cenephora hirsuta* (b), *Metisa plana* (c), *Dianemobius fascipes* (d), *Conocephalus* sp. (e), *Tettigidea lateralis* (f), *Eumorphus westwoodi* (g), *Aulacophora* sp. (h), *Oryctes rhinoceros* (i), *Cotesia congregata* (j), *Aphis cerana* (k) *Polistes carnifex* (l) and *Mactrotermes* sp. (m).

## Discussion

The results of observations in the field showed that the number of insects caught using traps in coconut plantations was identified as 7 orders, 18 species with a total of 2330.67 individuals. However, this research observation is divided into two parts, namely on coconut plants and on wild plants around coconuts which have various ages. Observations on coconuts of various ages showed findings of 4 orders and 12 species of insects. The highest number of species found in 8 year old coconut fields was Nipaecoccus nipae which comes from the order Hemiptera, namely 256.33 individuals. supported by research by Ganganalli et al. (2023), that the species of aphids that are most often found on coconuts. Meanwhile, in the wild plants around coconut, there are 3 orders and 6 species. The 6 insect species belong to the orders Coleoptera, Isoptera and Orthoptera. In wild plants around coconuts aged 8 years and 5 years, *Captotermes* sp is dominated. which comes from the order Isoptera and when coconuts are 2 years old, the most common insects are Conocephalus sp. which comes from the order Orthopetra. The seven orders found, including the orders Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Coleoptera, Isoptera and Orthoptera, have various roles in the ecosystem. This study supported the research of Hasibuan et al. (2019), that in coconut plants species were found that have roles as pests, predators, parasitoids and also pollinators. Direct observation was carried out by recording the condition or behavior of the object being observed (Firdiansyah., 2015). There were species *A. destructor*, *N. nipae, Aleurocanthus* sp., *P. pendula, C. hirsuta,* and *M. Plana* recorded by using the direct observation method. On the other hand, the traps were used to collected the fly or active insects such as insect nets, light traps and pheromones traps (Haneda et al., 2017). According to Iswara et al. (2022), traps are designed based on insect behaviour and attraction to certain lights, shapes and colours. The species obtained using the insect nets and the light trap were *E. westwoodi. Aulacophora* sp., *A. cerana, P. carnifex, Conocephalus* sp., and *T. lateralis.* Meanwhile, *O. rhinoceros* was found in the pheromone trap. Pheromones traps are traps used to attract male insects (Anggini et al., 2022). Pheromones trap was effectively to monitor and control the adults of *O. rhinoceros* (Paudel et al., 2023).

*Aspidiotus destructor* Signoret (Hemiptera: Diaspididae) is an coconut scale (Salahuddin et al., 2015). The coconut scale was found in the highest numbers at every age of coconut. The insect scale had also been confirmed to cause significant economic losses to the coconut industry in the Philippines (Serrana et al., 2019). Moreover, coconut bud borer beetles (*O. rhinoceros* L) were found at all ages of coconut. *O. rhinoceros* is one of the main pests that causes damage to germplasm in coconut (Paudel et al., 2022). In Indonesia, *O. rhinoceros* is a threat to both coconut and oil palm plants (Rahayuwati et al., 2020). These beetles are known to attack palm trees by boring into the crown and eating developing fronds (leaves that have not yet opened), which can cause death or stunted growth in young palm trees if the infestation is severe (Chalapathi Rao et al., 2018; Paudel et al., 2021, 2023). For mature oil palm trees, this damage can result in reduced productivity. This was also confirmed by Parnidi et al. (2022), that the average damage caused by this pest investment ranges from 0 to 16.7%. This study showed that there were different insects at each age of coconut. The plant age can influence the number of species and the number of individuals (Santi *et al.* 2023). As plants grow and mature, they provide different habitats and resources that can support a variety of insects species (Schowalter, 2016). Older plants tend to have more developed and complex ecosystems with greater insects species diversity (Schowalter, 2017). Additionally, mature plants are often larger and have more resources, so they can support more individuals in their ecosystem (Lindenmayer & Laurance, 2016). However, the specific impact of plant age on insect species and the number of insect individuals may vary depending on plant species, environmental conditions, and other factors (Myers & Sarfraz, 2017).

The insect diversity index on coconut plants and surrounding wild plants in Sri Tiga Village from week 1 to week 3 shows a diversity value of $1 < H' < 3$, this is in the medium category. This criterion shows the diversity of pests and natural enemies which increases in number as the population increases towards balance. According to Hasibuan et al. (2019), there are 3 criteria for insect species diversity, namely low species diversity if $H < 1$ (unstable environmental conditions), desang species diversity if H 1-3 (medium environmental conditions), and high species diversity if $H > 3$ (stable environmental conditions). The results of the dominance index calculation obtained on coconut plants and surrounding wild plants from week 1 to week 3 showed a dominance value of $0 < D < 0.5$. This means that the dominance of these insects is relatively low. The Evenness Index (E) value is 0.29-0.31 in the depressed category. According to Hasibuan et al. (2019), there are 3 criteria for the community environment based on its evenness value, namely if $E < 0.50$ then the community is in a depressed condition. If $0.50 < E' 0.75$ then society is in a stable condition, while $0.75 < E' 1.00$ means society is in an unstable condition. The evenness index value (E') can describe the stability of a community. The smaller the value of E' or closer to zero, the more uneven the distribution of organisms in a community that is dominated by a certain type and conversely, the greater the value of E' or close to one, the organisms in that community will be evenly distributed (Ambarwati et al., 2023). Apart from being influenced by plant age, insect diversity can be influenced by climate and weather factors (Subedi et al., 2023). From July to September 2023, Sri Tiga Village faced the dry season. The dry season is characterized by decreased rainfall and increased temperatures, disrupting the life cycle of insects. According to Paliama *et al*., (2022), increasing global temperatures can affect the life cycle of insects. In addition, dry seasons can cause drought and reduce water availability for insects (Benoit et al., 2023). This condition may affect the ability of insect to tolerate climatic factors in an ecosystem.

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## REFERENCES

Ambarwati, M., Dewi, K., Aurina, D. M., Faturrahman, A. D., Fatikha, L. A. Y., Rachmalia, F., Ainaya, F. A., Kinanthi, A., Rohman, C. M., Pradhana, F., Fadzilah, A., Pramudita, D. A., Ramadhan, M. F., Mahajoeno, E., Nugroho, G. D. W. I., Sujarta, P., Yap, C. K., Adha, K., Rahim, B. I. N. A., & Setyawan, A. D. W. I. (2023). Ecological index and economic potential of mollusks ( Gastropods and Bivalves ) in Ayah Mangrove Forest , Kebumen District , Indonesia. *Biodiversitas Journal of Biological Diversity*, *24*(2), 1231–1241. https://doi.org/10.13057/biodiv/d240265

Anggini, P. S., Wahyudi, L., & Mantiri, F. R. (2022). Efektivitas Feromon terhadap Interest Kumbang Tanduk (Oryctes rhinoceros) pada Tanaman Kelapa (Cocos nucifera L.). *Jurnal Bios Logos*, *12*(1), 71. https://doi.org/10.35799/jbl.v12i1.40116

Arumugam, T. (2022). Improving Coconut Using Modern Breeding Technologies : *Plants*, *11*(24). https://doi.org/https://doi.org/10.3390/plants11243414

Aulia, A. N., Chasanah, N., Prasetyo, A. S., & Nalawati, A. N. (2020). Competitiveness and Export Similairity of Indonesia ' s Coconut Oil. *Jurnal Agribest*, *04*(02), 123–132.

Badan Pusat Statistik. (2023). *Luas Areal dan Produksi Perkebunan Kelapa Rakyat Menurut Kecamatan*. https://banyuasinkab.bps.go.id/indicator/54/151/1/luas-areal-dan-produksi-perkebunan-kelapa-rakyat-menurut-kecamatan.html

Benoit, J. B., Mccluney, K. E., & Degennaro, M. J. (2023). Dehydration dynamics in terrestrial arthropods: from water sensing to trophic interactions. *Annu Rev Entomol*, 129–149. https://doi.org/10.1146/annurev-ento-120120-091609.Dehydration

Chalapathi Rao, N. B. V, Snehalatharani, A., Nischala, A., & Ramanandam, G. Maheswarappa, H. P. (2018). Management of rhinoceros beetle (Oryctes rhinoceros L.) by biological suppression with Oryctes baculovirus in Andhra Pradesh. *Journal of Plantation Crops*, *46*(2). https://doi.org/10.25081/jpc.2018.v46.i2.3725

Chandra, R., Abdul, M., Sharma, N., Bharathi, K., & Singh, S. (2023). The Role of Insects in Ecosystems , an in-depth Review of Entomological. *International Journal of Environment and Climate Change*, *13*(10), 4340–4348. https://doi.org/10.9734/IJECC/2023/v13i103110

Chowdhury, S., Dubey, V. K., Choudhury, S., Kumar, N., Semwal, A., & Kumar, V. (2023). Insects as bioindicator : A hidden gem for environmental monitoring. *Front. Environ. Sci.*, *March*, 1–16. https://doi.org/10.3389/fenvs.2023.1146052

Ganganalli, S. M., Bhaskar, H., Joshi, S., & C. V., V. (2023). Diversity of Aphid Fauna (Hemiptera: Aphididae) of Kerala. *Indian Journal of Entomology*, 1–8. https://doi.org/10.55446/ije.2023.742

Haneda, N. F., Wibowo, C., & Hasbi, M. (2017). Peranan Arthropoda di Ekosistem Ekoton dan Kelapa Sawit. *Jurnal Silvikultur Tropika*, *8*(2), 116–122. https://doi.org/10.29244/j-siltrop.8.2.116-122

Hasibuan, E. W., Siregar, A. Z., Pinem, M. I., Student, P., Utara, U. S., & Utara, S. (2019). Diversity of Insect in Coconut Plant in Kelurahan Besar , Medan Labuhan District , North of Sumatra. *International Journal of Trend in Research and Development*, *6*(5), 7–13.

Henrietta, H. M., Kalaiyarasi, K., & Raj, A. S. (2022). Coconut Tree ( Cocos nucifera ) Products : A Review of Global Cultivation and its Coconut Tree ( Cocos nucifera ) Products : A Review of Global Cultivation and its Benefits. *Journal of Sustainability and Environmental Management (JOSEM)*, *1*(May). https://doi.org/10.3126/josem.v1i2.45377

Hoe, T. K. (2019). *The Current Scenario and Development of the Coconut Industry*. *February*.

Iswara, D., Afifah, L., Abadi, S., Prabowo, D., Irfan, B., & Widiawan, A. B. (2022). Kelimpahan Serangga pada Berbagai Perangkap dengan Beberapa Teknik Pengendalian Berbeda pada Pertanaman Jagung Pioneer 36. *Jurnal Agroplasma*, *9*(2), 213–224.

Lindenmayer, D. B., & Laurance, W. F. (2016). The ecology , distribution , conservation and management of large old trees. *Biological Reviews*. https://doi.org/10.1111/brv.12290

Manosathiyadevan, M., Bhuvaneshwari, V., & Latha, R. (2017). Impact of Insects and Pests in loss of Crop Production: A Review. In A. Dhanarajan (Ed.), *Sustainable Agriculture towards Food Security* (pp. 57–67). Springer Singapore. https://doi.org/10.1007/978-981-10-6647-4_4

Mochamad Syahroni Firdiansyah. (2015). Manajemen Pengelolaan Wahana Rekreasi Olahraga Di Wisata Water Blaster Semarang Tahun 2013. *Journal of Physical Education*, *4*(2), 1582–1589.

Moreira, M. M., & Reitas, L. F. (2020). Review of the Pollination System by Small Diverse Insects. *Neotrop Entomol*, 472–481. https://doi.org/https://doi.org/10.1007/s13744-020-00779-6

Myers, J. H., & Sarfraz, R. M. (2017). Impacts of Insect Herbivores on Plant Populations. *Annu. Rev. Entomol.* https://doi.org/10.1146/annurev-ento-010715-023826

Paliama, H. G., Latumahina, F. S., & Wattimena, C. M. A. (2022). Keanekaragaman Serangga dalam Kawasan Hutan Mangrove di Desa Ihamahu. *Jurnal Tengkawang*, *12*(1), 94–104.

Parnidi Parnidi, Sunarto, D. A., & Marjani, M. (2022). Shoot Borers Beetle Pest of Coconut (Oryctes rhinoceros L.) Investment at Agave spp. *Bioeduscience*, *6*(1), 89–95. https://doi.org/10.22236/j.bes/616282

Paudel, S., Jackson, T. A., Mansfield, S., Ero, M., Moore, A., & Marshall, S. D. G. (2023). Use of pheromones for monitoring and control strategies of coconut rhinoceros beetle ( Oryctes rhinoceros ): A review. *Crop Protection*, *174*(September), 106400. https://doi.org/10.1016/j.cropro.2023.106400

Paudel, S., Mansfield, S., Villamizar, L. F., Jackson, T. A., & Marshall, S. D. G. (2021). Can biological control overcome the threat from newly invasive coconut rhinoceros beetle populations (Coleoptera: Scarabaeidae)? A review. *Annals of the Entomological Society of America*, *114*(2), 247–256.

Paudel, S., Marshall, S. D. G., Richards, N. K., Hazelman, G., Tanielu, P., & Jackson, T. A. (2022). Coconut Rhinoceros Beetle in Samoa : Review of a Century-Old Invasion and Prospects for Control in a Changing Future. *Insects*, 1–15. https://doi.org/https://doi.org/10.3390/insects13050487

Purnomo, H., Okarda, B., Dermawan, A., Pebrial, Q., Pacheco, P., Nurfatriani, F., & Suhendang, E. (2020). Forest Policy and Economics Reconciling oil palm economic development and environmental conservation in Indonesia : A value chain dynamic approach. *Forest Policy and Economics*, *111*(January), 102089. https://doi.org/10.1016/j.forpol.2020.102089

Rahayuwati, S., Kusumah, Y. M., Prawirosukarto, S., Dadang, & Santoso, T. (2020). The status of oryctes rhinoceros nudivirus (OrNV) infection in oryctes rhinoceros (Coleoptera: Scarabaeidae) in Indonesia. *Journal of Oil Palm Research*, *32*(4), 582–589.

Salahuddin, B., Khan, I., & Daud, M. K. (2015). Incidence and management of coconut scale , Aspidiotus destructor signoret ( Hemiptera : Diaspididae ), and its parasitoids on mango ( Mangifera sp .). *Crop Protection*, *74*, 103–109. https://doi.org/10.1016/j.cropro.2015.03.019

Santi, I., Tarmadja, S., Priambada, K. J., & Elfatma, O. (2023). Keanekaragaman Serangga Perkebunan Kelapa Sawit Di Provinsi Kalimantan Tengah. *Jurnal Ilmiah Hijau Cendekia*, *8*(1), 45. https://doi.org/10.32503/hijau.v8i1.2917

Schowalter, T. (2017). Arthropod Diversity and Functional Importance in Old-Growth Forests of North America. *Forests*. https://doi.org/10.3390/f8040097

Schowalter, T. D. (2016). *Insect ecology: an ecosystem approach*. Academic press.

Serrana, J. M., Ishitani, N., Carvajal, T. M., Almarinez, B. J. M., Barrion, A. T., Amalin, D. M., & Watanabe, K. (2019). Unraveling the genetic structure of the coconut scale insect pest (Aspidiotus rigidus reyne) outbreak populations in the Philippines. *Insects*, *10*(11). https://doi.org/10.3390/insects10110374

Stam, J. M., Kroes, A., Li, Y., Gols, R., Loon, J. J. A. Van, Poelman, E. H., & Dicke, M. (2014). Plant Interactions with Multiple Insect Herbivores : From Community to Genes. *Annu. Rev. Plant Biol.*, *65*, 689–713. https://doi.org/10.1146/annurev-arplant-050213-035937

Subedi, B., Poudel, A., & Aryal, S. (2023). The impact of climate change on insect pest biology and ecology : Implications for pest management strategies , crop production , and food security. *Journal of Agriculture and Food Research*, *14*(July), 100733. https://doi.org/10.1016/j.jafr.2023.100733

Thomas, G.V., Krishnakumar, V., Dhanapal, R., & Srinivasa Reddy, D. V. (2018). Preharvest approaches to control insect infestation in fruit. In *Preharvest Modulation of Postharvest Fruit and Vegetable Quality* (pp. 301–357). Elsevier. https://doi.org/https://doi.org/10.1007/978-981-13-2754-4_7

Tiemann, T. T., Donough, C. R., Lim, Y. L., Härdter, R., Norton, R., Tao, H. H., Jaramillo, R., Satyanarayana, T., Zingore, S., & Oberthür, T. (2018). Chapter Four - Feeding the Palm: A Review of Oil Palm Nutrition. In D. L. B. T.-A. in A. Sparks (Ed.), *Advances in Agronomy* (Vol. 152, pp. 149–243). Academic Press. https://doi.org/https://doi.org/10.1016/bs.agron.2018.07.001

Ximenes, R., Nurmalina, R., & Rifin, A. (2021). Demand Analysis of Indonesia ' s Coconut Crude Oil in Germany Demand Analysis of Indonesia ' s Coconut Crude Oil in Germany. *Review of Economics and Finance*, *19*(October), 281–285. https://doi.org/10.55365/1923.x2021.19.39

Zainol, F. A., Arumugam, N., Norhayate, W., Daud, W., Aisyah, N., & Suhaimi, M. (2023). Coconut Value Chain Analysis : A Systematic Review. *Agriculture*, *13*(7). https://doi.org/https://doi.org/10.3390/agriculture13071379

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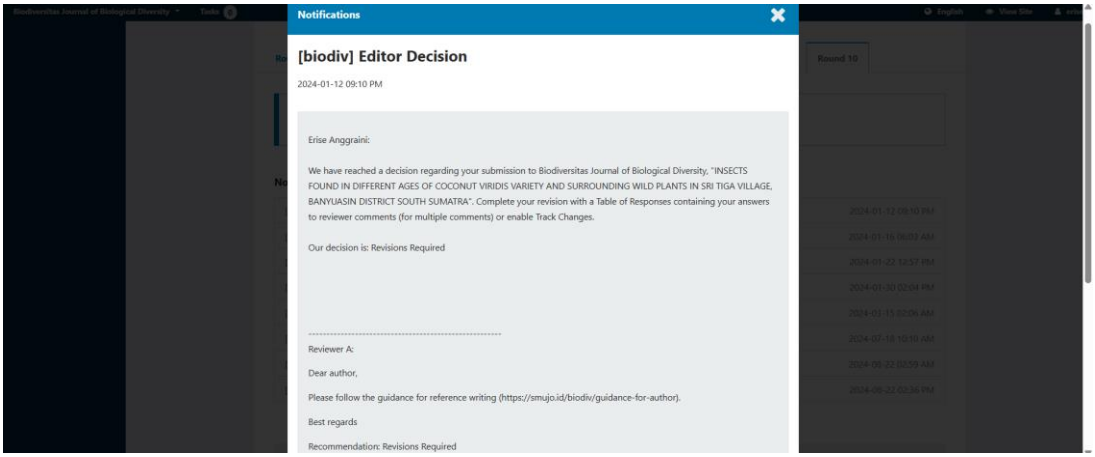


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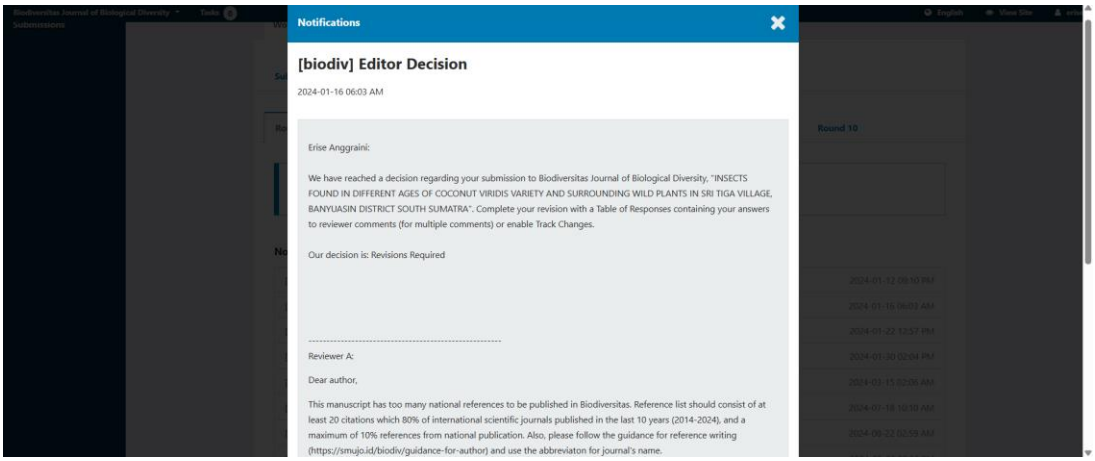


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# INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA, INDONESIA

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**Abstract.** Coconut (*Cocos nucifera*) is a valuable export commodity and has good prospects in the international market. Coconut cultivation is inseparable from the presence of insect species. The presence of insects in plants is interrelated because plants are places for insects to live and eat. However, not everyone knows the relationship between plants and insects. An inventory of insect biodiversity in an ecosystem needs to be conducted. This information shows the community structure of insects associated with coconut plants and plants that grow around coconut plants. Therefore, this field practice aims to find out the insects associated with coconut plants. Field practice was carried out with a survey in a coconut plantation owned by the people in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency, South Sumatera, Indonesia. The observation was conducted from July to September. Data collection was done by determining 3 coconut plantations with different ages of coconut trees. Data collection was carried out using the purposive sampling method by direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was conducted by collecting insects directly during direct observation and in traps. Specimens that have been collected were identified using a macroscope in the Laboratory of Entomology, Department of Plant Pests and Disease, Faculty of Agriculture, Sriwijaya University. The results of this field practice found 12 species namely *Aleurocanthus* sp., *Aphis cerana*, *Aspidiotus destructor*, *Aulacophora* sp., *Cenephora hirsuta*, *Conocephalus* sp., *Cotesia congregata*, *Dianemobius fascipes*, *Eumorphus westwoodi*, *Macrotermes* sp., *Metisa plana*, *Nipaecoccus nipae*, *Oecophylla* sp., *Oryctes rhinoceros*, *Polistes carnifex*, *Polyrhachis dives*, *Pteroma pendula*, *Tettigidea lateralis*.

**Key words:** *Cocos nucifera*, viridis variety, coconut, insects

**Running title:** Insects Found in Coconut Viridis Variety and Surrounding Wild Plants

## INTRODUCTION

Indonesia has various agricultural sectors such as plantations, horticulture, food crops and forestry plants. The plantation sector in Indonesia makes a significant contribution to the country's economy (Purnomo et al. 2020). In Indonesia, coconut plantations have been widely developed and have become the main income for coconut farmers. Coconut plays a role in the economy, social and state income from non-oil and gas commodities (Ximenes et al. 2021). Coconut production is mostly used for consumption and industry (Hoe 2019). Products resulting from the development of coconut plants that have been widely managed include coconut oil, coconut sugar, dried grated coconut, coconut milk, shells, coconut juice and coconut fiber (Henrietta et al. 2022). Coconut (*Cocos nucifera*) is a tropical plantation commodity that is widespread in Indonesia, the Philippines, India, and several Asia Pacific countries (Hoe 2019). Coconut is a high-value export commodity and has good prospects in the international market. Indonesia is the first considerable coconut-producing country worldwide, followed by the Philippines and India (Zainol et al. 2023). The area of coconut plantations in Banyuasin Regency, Indonesia, in 2022 was 42,599,00 Ha (Badan Pusat Statistik, 2023). The productivity of coconut plants in Banyuasin Regency, Indonesia 2022 reached 46,760,00 tons (Badan Pusat Statistik, 2023).

In coconut cultivation, it is important to understand the life cycle of the plant from seeding to harvest. This stage requires consistent care and monitoring. In coconut cultivation, the process involves selecting quality seeds, proper soil cultivation, and proper care (Thomas et al. 2018). Coconuts thrive in sufficient sunlight, appropriate rainfall, and nutrient-rich soil with effective drainage (Tiemann et al. 2018). The optimal range for coconut plant growth is between pH 5-8 (Fauzana et al. 2021). A deep understanding of these factors can result in sustainable coconut plantations. Furthermore,

regular pruning, fertilizing, and managing pests and diseases are things that need attention (Aulia et al. 2020). A deep understanding of these factors can lead to profitable and sustainable coconut production. On the other hand, In many coconut producing areas, especially in smallholder coconut plantations, fertilizer use and insect management are often not carried out intensively (Zainol et al. 2023). Furthermore, the process of cultivating coconut cannot be separated from the presence of insect species. The existence of insects on plants is interrelated because plants are a place for insects to live and eat (Stam et al. 2014). Insects are also needed by plants during plant pollination (Moreira & Reitas 2020). In addition, insects can cause damage to cultivated plants (Manosathiyadevan et al. 2017).

In coconut plantations, the age of coconut trees varies in each area. This results in differences in plant growth and development from one tree to another, affecting not only nutritional requirements but also harvest patterns and overall productivity (Arumugam 2022). Management appropriate to the coconut plant's age is essential to maximize its health and yield. Coconut trees at varying stages of growth may attract different insect pests, which may prefer specific developmental stages of the trees due to physiological differences. It's essential to identify and manage these pests appropriately, considering the age of the coconut trees for effective pest control. Moreover, insects play various roles in ecosystems and significantly impact human society and the environment, such as pollinators, decomposers, and pests (Chandra et al. 2023). Recent information about insects on coconut trees, especially regarding the different ages of the trees, has yet to be recorded. Therefore, an inventory of insect biodiversity in different plant ages of coconut plantation ecosystem needs to be carried out. The diversity of insect species can be used to indicate changes occurring in the ecosystem (Chowdhury et al. 2023). Identifying the presence of different species of coconut trees of different ages is important. Understanding the insect species can guide integrated pest management strategies.

## MATERIALS AND METHODS

### Study area

Field practice was carried out in people's coconut plantations in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency (Figure 1). Field practice is also conducted at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University. Field practice is carried out from July to September 2023.

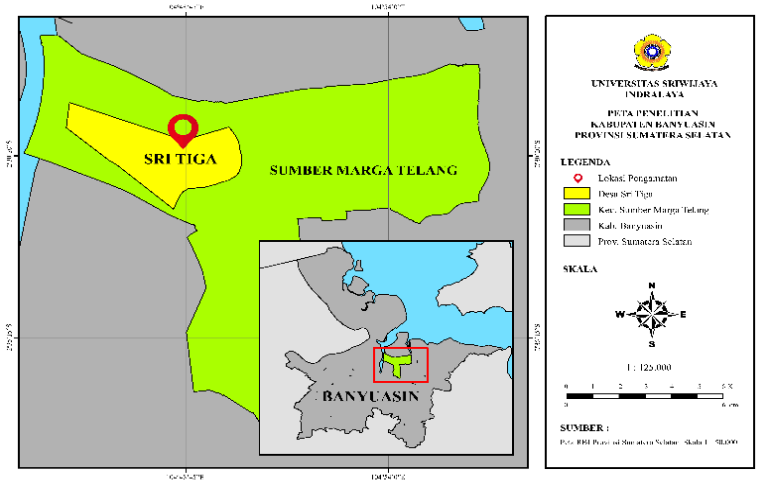


**Figure 1.** Sampling location

**Procedures**

Initial preparations are carried out by conducting a survey to find out the research location and preparing the tools and materials used. Apart from that, a survey was conducted to find out information from the community regarding the use of coconut in Sri Tiga Village, Banyuasin Regency. Data collection was initially carried out by determining three coconut plantations as objects of observation, and then these gardens were observed. Data was collected using the purpose sampling method by making direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was done by collecting insects directly, either during direct observation or in traps. Documentation was carried out in the form of photographs of insects found on coconut plants and wild plants around the coconut plants. Identification of insects found was done by examining insects that are common and have been studied previously. The things studied were similar in terms of color, shape, size, and morphological characteristics of the insects found. The observation parameters in this field practice were the insects caught in each trap. All insects found are then identified. Insect identification was carried out based on morphological characteristics such as head, abdomen, antennae, wings, and others. Each insect found then determines its role in the ecosystem.

**Data analysis**

The data obtained from the observations are presented in the table. The data was then analyzed using R Statistic software. The species diversity index was used to describe the diversity of insect species found in the research area. The diversity index was expressed using the Shannon-Wiener species diversity formula:

$$H' = -\sum \text{Pi In pi}$$

Information:
H': Shannon-Wiener Diversity Index
Pi: ni/N (Comparison between the number of a species and all species)

Description of criteria:
H' < 1 : Low diversity
1 < H' < 3 : Medium diversity
H' > 3 : High diversity

The species evenness index was used to describe the degree of evenness of insect species found in the research area. The evenness index was expressed using the formula:

$$E = \frac{H'}{In\ S}$$

Information:
E : Evenness index (value between 0-1)
H' : Shannon-Wiener diversity index
S : Number of types
Description of criteria:
E < 0.4 : Small population uniformity
0.4 < E < 0.6 : Moderate population uniformity
E > 0.6 : High population uniformity

The species dominance index was used to describe the level of dominance of insect species found in the research area. The dominance index is expressed using the formula:

$$D = \sum Pi^2$$

Information:
D: Simpson Dominance Index
Pi: ni/N (Comparison between the number of a species and all species)
Description of criteria:
0 < D < 0.5 : Low dominance
0.5 < D < 0.75 : Moderate dominance
0.75< D < 1.0 : High dominance

## RESULTS AND DISCUSSION

### Abundance of insects found in coconut trees

The insect species found in three coconut fields with varying plant ages, namely 8 years, 5 years and 2 years, were very diverse. There are 12 species from 4 orders. The four orders found most frequently include the orders Coleoptera, Hemiptera, Hymenoptera and Lepidoptera. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* which comes from the Hemiptera Order, namely 256.33 individuals. This result also found the same thing in coconut fields that were 5 years old, namely dominated by *Nipaecoccus nipae*, with as many as 265.67 individuals. Meanwhile, on 2 year old coconut fields, the insect species that were frequently encountered were Aspidiotus destructor from the Hemiptera Order, namely 96,000. Based on the results of comparing the number of species found in coconut fields of different ages, it was found that there were also different numbers of species (Table 1). In the 2 year old plantation, *Aphis cerana* and *Polistes carnifex* species were not found.

**Table 1.** Abundance of Insects on Coconuts

| Ordo/Spesies | Abundance of insects on coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Oryctes rhinoceros* | 28.00 | 29.00 | 22.67 | $3.20 \times 10^{-1}$ | $1.54^{ns}$ | - |
| **Hemiptera** | | | | | | |
| *Aspidiotus destructor* | 173.33a | 116.33b | 96.00b | $3.62 \times 10^{-3}$ | $31.24^{*}$ | 1.55 |
| *Nipaecoccus nipae* | 256.33a | 265.67a | 18.00b | $5.16 \times 10^{-5}$ | $276.40^{*}$ | 2.07 |
| *Planococcus sp.* | 50.67a | 44.33a | 27.67b | $58.7 \times 10^{-4}$ | $80.55^{*}$ | 0.54 |
| **Hymenoptera** | | | | | | |
| *Aphis cerana* | 5.67a | 4.33b | 0.00c | $3.13 \times 10^{-5}$ | $355.22^{*}$ | 0.25 |
| *Cotesia congregata* | 30.00a | 25.33b | 18.00c | $6.14 \times 10^{-4}$ | $78.70^{*}$ | 0.35 |
| *Dolichoderus thoracicus* | 113.33a | 103.67a | 81.33b | $45.1 \times 10^{-3}$ | $27.78^{*}$ | 0.81 |
| *Oecophylla* sp. | 98.00a | 87.33a | 60.33b | $1.15 \times 10^{-3}$ | $56.91^{*}$ | 0.75 |
| *Polistes carnifex* | 4.00a | 2.33b | 0.00c | $4.52 \times 10^{-4}$ | $92.12^{*}$ | 0.38 |
| **Lepidoptera** | | | | | | |
| *Metisa plana* | 16.33a | 13.67ab | 10.00b | $2.64 \times 10^{-2}$ | $10.31^{*}$ | 0.68 |
| *Pteroma pendula* | 20.67a | 16.67ab | 13.00b | $6.15 \times 10^{-3}$ | $23.50^{*}$ | 0.48 |
| *Pteroma plagiophleps* | 24.00a | 19.00ab | 14.00b | $6.78 \times 10^{-3}$ | $22.28^{*}$ | 0.61 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

### Abundance of insects found in wild plants around coconut trees

Insect species found in wild plants around coconuts were also observed. There are 6 species of insects from 3 orders. The orders found include Coleoptera, Isoptera and Orthoptera. In wild plants around 8 year old and 5 year old coconuts, the most Captotermes sp insects were found. originating from the Order Isoptera, namely 18.00 individuals and 13.67 individuals respectively. Meanwhile, it was very different when the coconuts were 2 years old and no similar species were found at all. In the plants around coconuts that are 2 years old, the most common insects are Conocephalus sp. which came from the Order Orthopetra, namely 10,00 individuals (Table 2).

**Table 2.** Average abundance of insects in wild plants around coconut trees

| Ordo/Spesies | Abundance of Insects in wild plants around Coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Aulacophora* sp. | 14.67a | 8.00b | 7.00b | $9.09 \times 10^{-3}$ | $18.98^{*}$ | 0.71 |
| *Eumorphus westwoodi* | 12.33a | 8.33b | 3.00c | $3.21 \times 10^{-4}$ | $109.67^{*}$ | 0.42 |
| **Isoptera** | | | | | | |
| *Captotermes* sp. | 18.00a | 13.67b | 0.00c | $3.52 \times 10^{-5}$ | $335.07^{*}$ | 0.53 |
| **Orthoptera** | | | | | | |
| *Conocephalus* sp. | 17.00a | 12.00b | 10.00c | $38.9 \times 10^{-4}$ | $99.47^{*}$ | 0.24 |
| *Dianemobius fascipes* | 16.67a | 13.00b | 9.00c | $6.50 \times 10^{-5}$ | $246.00^{*}$ | 0.17 |
| *Tettigidea lateralis* | 10.67a | 8.33ab | 6.67b | $8.19 \times 10^{-3}$ | $20.10^{*}$ | 0.39 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

### Characteristics of insect communities found in coconut trees

The characteristics of the insect community on coconuts aged 8 years, 5 years and 2 years that were analyzed included the diversity index, evenness index and dominance index. The results showed that the community characteristics of each coconut plant aged 8 years, 5 years and 2 years increased with each observation. The diversity, evenness and dominance index of 8-year-old coconut plants was higher than that of 5- and 2-year-old coconut plants (Table 3). This shows that the age of the coconut affects the number of insects found in the field. The higher the diversity index value, the more diverse the species that exist in the community. This index reflects the biological richness of the community. If the evenness index shows a high value, the individuals in the community have a more even distribution among species, while a low value indicates an uneven distribution. Meanwhile, the dominance index measures the extent to which one or several species have significant dominance or ownership in the community.

**Table 3.** Characteristics of insect communities found in coconut trees

| Coconut plants (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Coconut plants (8 years old) | Number of Individuals | 847.00 | 853.00 | 761.00 |
| | Diversity Index (H') | 1.90 | 1.95 | 2.04 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.31 |
| | Dominance Index (D) | 0.34 | 0.32 | 0.28 |
| Coconut plants (5 years old) | Number of Individuals | 754.00 | 734.00 | 695.00 |
| | Diversity Index (H') | 1.86 | 1.90 | 1.97 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.30 |
| | Dominance Index (D) | 0.16 | 0.16 | 0.17 |
| Coconut plants (2 years old) | Number of Individuals | 622.00 | 617.00 | 544.00 |
| | Diversity Index (H') | 1.75 | 1.76 | 1.80 |
| | Eveness Index (E) | 0.27 | 0.27 | 0.29 |
| | Dominance Index (D) | 0.16 | 0.15 | 0.18 |

**The characteristics of insects on wild plants around coconut trees**

Based on the results, it was found that the highest index was found in coconut fields that were 8 years old. Meanwhile, at the age of 2 years, the analysis results were lower (Table 4). This also proves that the age of the coconut greatly influences the number of species found in wild plants around the coconut. The diversity, evenness and dominance indices in coconut plants aged 8 years, 5 years and 2 years experienced increases and decreases in population numbers. The diversity index in wild plants around 8-year-old coconut plants is higher compared to 5- and 2-year-old coconut plants. Meanwhile, the evenness and dominance index of wild plants around 2-year-old coconut plants was higher than that of 8- and 5-year-old coconut plants.

**Table 4.** Characteristics of insect communities in wild plants around coconut trees

| Wild plants around the coconut trees (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Wild plants around the coconut plants (8 years old) | Number of Individuals | 99.00 | 92.00 | 77.00 |
| | Diversity Index (H') | 1.78 | 1.77 | 1.77 |
| | Eveness Index (E) | 0.39 | 0.39 | 0.41 |
| | Dominance Index (D) | 0.19 | 0.22 | 0.21 |
| Wild plants around the coconut plants (5 years old) | Number of Individuals | 72.00 | 65.00 | 53.00 |
| | Diversity Index (H') | 1.77 | 1.75 | 1.76 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.44 |
| | Dominance Index (D) | 0.21 | 0.23 | 0.23 |
| Wild plants around the coconut plants (2 years old) | Number of Individuals | 42.00 | 37.00 | 28.00 |
| | Diversity Index (H') | 1.54 | 1.53 | 1.54 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.46 |
| | Dominance Index (D) | 0.26 | 0.30 | 0.32 |

**Relative abundance of insects found in coconut trees**

The relative abundance of insects on coconuts aged 8 years, 5 years and 2 years varied greatly. At plant ages of 8 years and 5 years, the abundance of insects in the Order Hemiptera was found, namely 59.00% and 58.00% respectively. while the lowest order is the Order Coleoptera which is only 3.00% and 4.00% respectively. In contrast to the age of 2 years, the most insect species found were from the Order Hymenoptera, namely 48.00% and the lowest species were in the Orders Lepidopeta and Hymenoptera, which was only 7.00% (Figure 2).

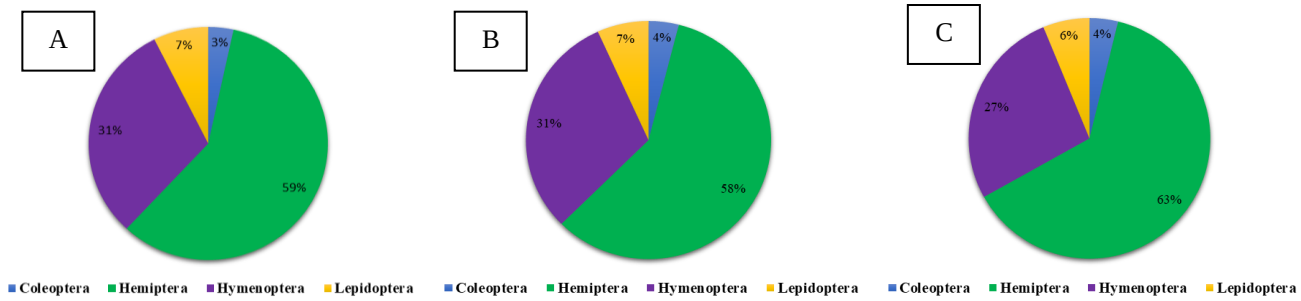


**Figure 2.** Abundance of insects found in coconut trees at: A) 8 years old, B) 5 years old, C) 2 years old.

**Relative abundance of insects found in wild plants around coconut trees**

The relative abundance of insects in wild plants around coconut plants was only found in 3 orders, namely the orders Coleoptera, Isoptera and Orthoptera. In plants aged 8 years, 5 years, and 2 years, the most Orthoptera orders were found, namely 50.00%, 53.00% and 72.00% respectively. Meanwhile, in the area around 2-year-old coconuts, only two orders were found, namely Coleoptera and Orthoptera (Figure 3).

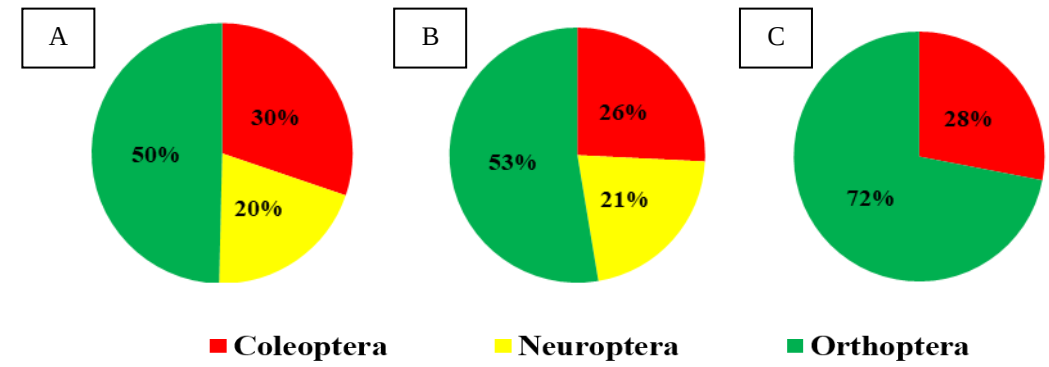


**Figure 3.** Abundance of insects on wild plants around coconut trees at different age of coconut: A) 8 years old, B) 5 years old, C) 2 years old.

The results of observations found 18 species of insects associated with coconut plants and surrounding wild plants. The 18 insect species act as phytophagous, pollinators and natural enemies. The dominant insects belong to the orders Hemiptera and Hymenoptera. The insects are *Aspidiotus destructor* (Figure 4a), *Nipaecoccus nipae* (Figure 4b), *Aleurocanthus* sp. (Figure 4c), *Polyrhachis dives* (Figure 4d), *Oecophylla* sp. (Figure 4e).

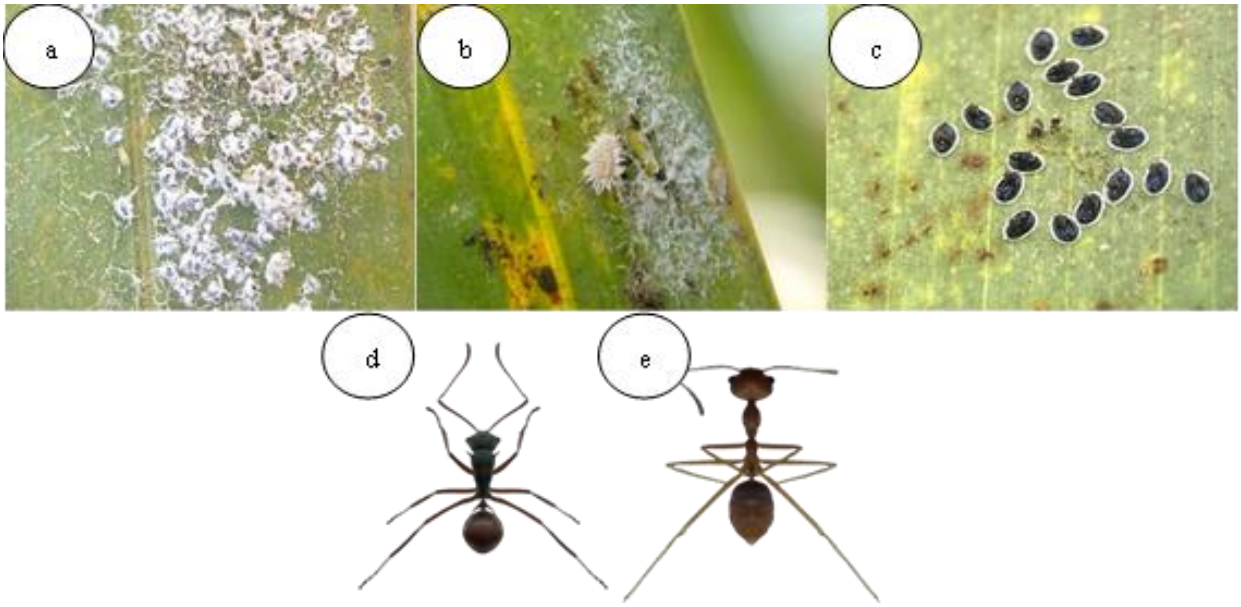


**Figure 3.** The dominant insects are found on coconut plants and surrounding plants. *Aspidiotus destructor* (a), *Nipaecoccus nipae* (b), *Aleurocanthus* sp. (c), *Polyrhachis dives* (d) dan *Oecophylla* sp. (e)

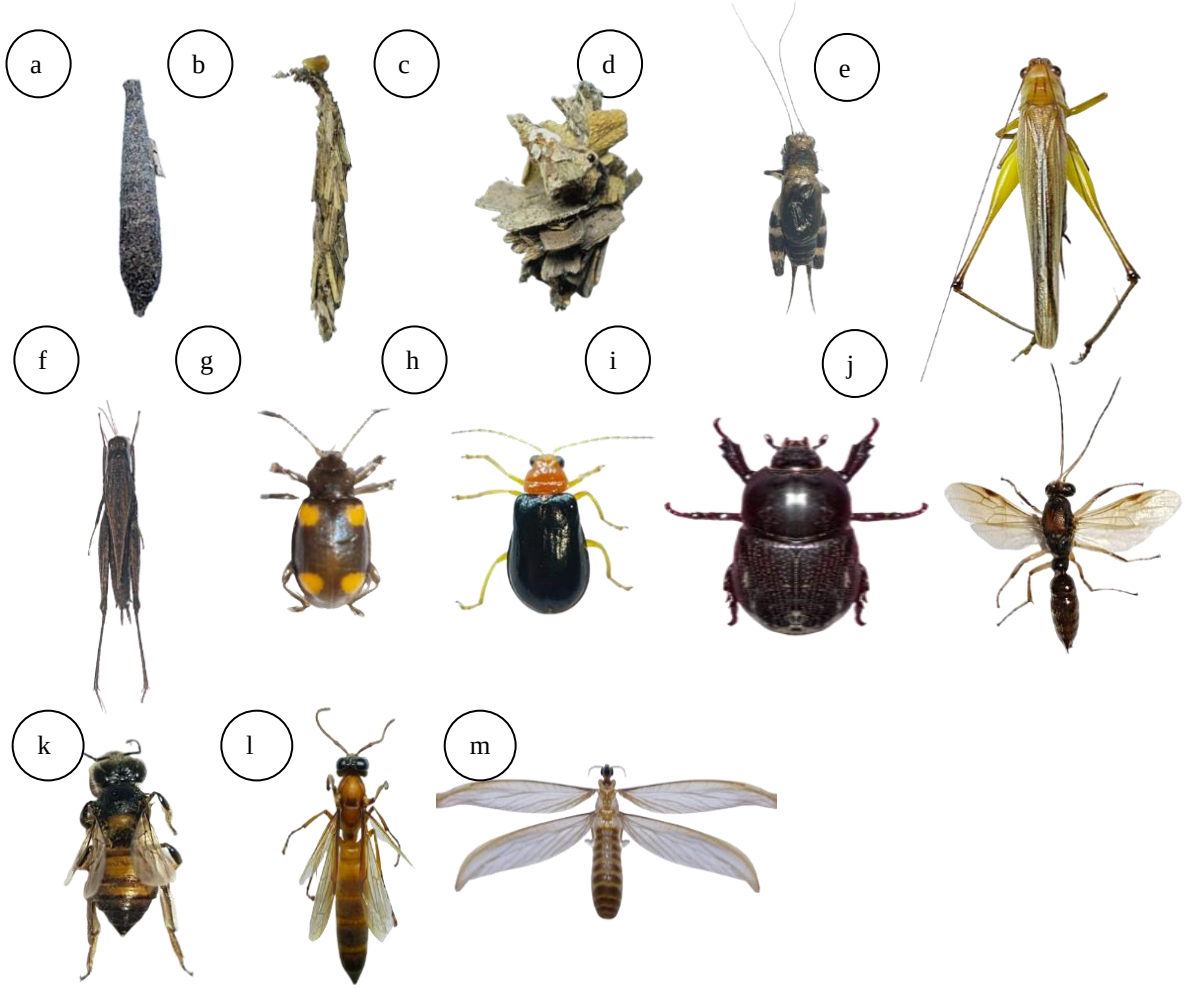


**Figure 4.** The non-dominant insects are found on coconut plants and surrounding plants. *Pteroma pendula* (a), *Cenephora hirsuta* (b), *Metisa plana* (c), *Dianemobius fascipes* (d), *Conocephalus* sp. (e), *Tettigidea lateralis* (f), *Eumorphus westwoodi* (g), *Aulacophora* sp. (h), *Oryctes rhinoceros* (i), *Cotesia congregata* (j), *Aphis cerana* (k) *Polistes carnifex* (l) and *Mactrotermes* sp. (m).

## Discussion

The results of observations in the field showed that the number of insects caught using traps in coconut plantations was identified as 7 orders, 18 species with a total of 2330.67 individuals. However, this research observation was divided into two parts, namely on coconut plants and on wild plants around coconuts which have various ages. Observations on coconuts of various ages showed findings of 4 orders and 12 species of insects. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* which comes from the order Hemiptera, namely 256.33 individuals. supported by research by Ganganalli et al. (2023), that the species of aphids that are most often found on coconuts. Meanwhile, in the wild plants around coconut, there are 3 orders and 6 species. The 6 insect species belong to the orders Coleoptera, Isoptera and Orthoptera. *Captotermes* sp dominated coconuts aged 8 years. Meanwhile, coconuts aged 2 years old, the most common insects were *Conocephalus* sp. which comes from the order Orthopetra. The seven orders found, including the orders Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Coleoptera, Isoptera and Orthoptera, have various roles in the ecosystem. This coconut plants species were found that have roles as pests, predators, parasitoids and also pollinators (Kavitha et al., 2023). Direct observation was carried out by recording the condition or behavior of the object being observed (Vislobokov, 2017). There were species *A. destructor*, *N. nipae*, *Aleurocanthus* sp., *P. pendula, C. hirsuta*, and *M. Plana* recorded by using the direct observation method. On the other hand, the traps were used to collected the fly or active insects such as insect nets, light traps and pheromones traps (Haneda et al. 2017). According to Iswara et al. (2022), traps are designed based on insect behaviour and attraction to certain lights, shapes and colours. The species obtained using the insect nets and the light trap were *E. westwoodi*. *Aulacophora* sp., *A. cerana, P. carnifex, Conocephalus* sp., and *T. lateralis.* Meanwhile, *O. rhinoceros* was found in the pheromone trap. Pheromones traps are traps used to attract male insects (Maruthadurai and Ramesh, 2020). Pheromones trap was effectively to monitor and control the adults of *O. rhinoceros* (Paudel et al. 2023).

*Aspidiotus destructor* Signoret (Hemiptera: Diaspididae) is an coconut scale (Serrana et al., 2023). The coconut scale was found in the highest numbers at every age of coconut. The insect scale had also been confirmed to cause significant economic losses to the coconut industry in the Philippines (Serrana et al. 2019). Moreover, coconut bud borer beetles (*O. rhinoceros* L) were found at all ages of coconut. *O. rhinoceros* is one of the main pests that causes damage to germplasm in coconut (Paudel et al. 2022). In Indonesia, *O. rhinoceros* is a threat to both coconut and oil palm plants (Rahayuwati et al. 2020). These beetles are known to attack palm trees by boring into the crown and eating developing fronds (leaves that have not yet opened), which can cause death or stunted growth in young palm trees if the infestation is severe (Chalapathi Rao et al. 2018; Paudel et al. 2021, 2023). For mature oil palm trees, this damage can result in reduced productivity. This was also confirmed by Parnidi et al. (2022), that the average damage caused by this pest investment ranges from 0 to 16.7%. This study showed that there were different insects at each age of coconut. The plant age can influence the number of species and the number of individuals (Myers and Sarfraz, 2017; Santi et al. 2023). As plants grow and mature, they provide different habitats and resources that can support a variety of insects species (Schowalter 2016). Older plants tend to have more developed and complex ecosystems with greater insects species diversity (Schowalter 2017). Additionally, mature plants are often larger and have more resources, so they can support more individuals in their ecosystem (Lindenmayer and Laurance 2016). However, the specific impact of plant age on insect species and the number of insect individuals may vary depending on plant species, environmental conditions, and other factors (Myers and Sarfraz 2017).

The insect diversity index on coconut plants and surrounding wild plants in Sri Tiga Village from week 1 to week 3 shows a diversity value of $1 < H' < 3$, this is in the medium category. This criterion shows the diversity of pests and natural enemies which increases in number as the population increases towards balance. According to Hasibuan et al. (2019), there are 3 criteria for insect species diversity, namely low species diversity if $H < 1$ (unstable environmental conditions), desang species diversity if H 1-3 (medium environmental conditions), and high species diversity if $H > 3$ (stable environmental conditions). The results of the dominance index calculation obtained on coconut plants and surrounding wild plants from week 1 to week 3 showed a dominance value of $0 < D < 0.5$. This means that the dominance of these insects is relatively low. The Evenness Index (E) value is 0.29-0.31 in the depressed category. According to Hasibuan et al. (2019), there are 3 criteria for the community environment based on its evenness value, namely if $E < 0.50$ then the community is in a depressed condition. If $0.50 < E' 0.75$ then society is in a stable condition, while $0.75 < E' 1.00$ means society is in an unstable condition. The evenness index value (E') can describe the stability of a community. The smaller the value of E' or closer to zero, the more uneven the distribution of organisms in a community that is dominated by a certain type and conversely, the greater the value of E' or close to one, the organisms in that community will be evenly distributed (Ambarwati et al. 2023). Apart from being influenced by plant age, insect diversity can be influenced by climate and weather factors (Subedi et al. 2023). From July to September 2023, Sri Tiga Village faced the dry season. The dry season is characterized by decreased rainfall and increased temperatures, disrupting the life cycle of insects. According to Paliama et al. (2022), increasing global temperatures can affect the life cycle of insects. In addition, dry seasons can cause drought and reduce water availability for insects (Benoit et al. 2023). This condition may affect the ability of insect to tolerate climatic factors in an ecosystem.

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## REFERENCES

Ambarwati, M., Dewi, K., Aurina, D. M., Faturrahman, A. D., Fatikha, L. A. Y., Rachmalia, F., Ainaya, F. A., Kinanthi, A., Rohman, C. M., Pradhana, F., Fadzilah, A., Pramudita, D. A., Ramadhan, M. F., Mahajoeno, E., Nugroho, G. D. W. I., Sujarta, P., Yap, C. K., Adha, K., Rahim, B. I. N. A., & Setyawan, A. D. W. I. (2023). Ecological index and economic potential of mollusks ( Gastropods and Bivalves ) in Ayah Mangrove Forest , Kebumen District , Indonesia. *Biodiversitas Journal of Biological Diversity*, *24*(2), 1231–1241. https://doi.org/10.13057/biodiv/d240265

Arumugam, T. (2022). Improving Coconut Using Modern Breeding Technologies : *Plants*, *11*(24). https://doi.org/https://doi.org/10.3390/plants11243414

Aulia, A. N., Chasanah, N., Prasetyo, A. S., & Nalawati, A. N. (2020). Competitiveness and Export Similairity of Indonesia ' s Coconut Oil. *Jurnal Agribest*, *04*(02), 123–132.

Badan Pusat Statistik. (2023). *Luas Areal dan Produksi Perkebunan Kelapa Rakyat Menurut Kecamatan*. https://banyuasinkab.bps.go.id/indicator/54/151/1/luas-areal-dan-produksi-perkebunan-kelapa-rakyat-menurut-kecamatan.html

Benoit, J. B., Mccluney, K. E., & Degennaro, M. J. (2023). Dehydration dynamics in terrestrial arthropods: from water sensing to trophic interactions. *Annu Rev Entomol*, 129–149. https://doi.org/10.1146/annurev-ento-120120-091609.Dehydration

Chalapathi Rao, N. B. V, Snehalatharani, A., Nischala, A., & Ramanandam, G. Maheswarappa, H. P. (2018). Management of rhinoceros beetle (Oryctes rhinoceros L.) by biological suppression with Oryctes baculovirus in Andhra Pradesh. *Journal of Plantation Crops*, *46*(2). https://doi.org/10.25081/jpc.2018.v46.i2.3725

Chandra, R., Abdul, M., Sharma, N., Bharathi, K., & Singh, S. (2023). The Role of Insects in Ecosystems , an in-depth Review of Entomological. *International Journal of Environment and Climate Change*, *13*(10), 4340–4348. https://doi.org/10.9734/IJECC/2023/v13i103110

Chowdhury, S., Dubey, V. K., Choudhury, S., Kumar, N., Semwal, A., & Kumar, V. (2023). Insects as bioindicator : A hidden gem for environmental monitoring. *Front. Environ. Sci.*, *March*, 1–16. https://doi.org/10.3389/fenvs.2023.1146052

Ganganalli, S. M., Bhaskar, H., Joshi, S., & C. V., V. (2023). Diversity of Aphid Fauna (Hemiptera: Aphididae) of Kerala. *Indian Journal of Entomology*, 1–8. https://doi.org/10.55446/ije.2023.742

Haneda, N. F., Wibowo, C., & Hasbi, M. (2017). Peranan Arthropoda di Ekosistem Ekoton dan Kelapa Sawit. *Jurnal Silvikultur Tropika*, *8*(2), 116–122. https://doi.org/10.29244/j-siltrop.8.2.116-122

Hasibuan, E. W., Siregar, A. Z., Pinem, M. I., Student, P., Utara, U. S., & Utara, S. (2019). Diversity of Insect in Coconut Plant in Kelurahan Besar , Medan Labuhan District , North of Sumatra. *International Journal of Trend in Research and Development*, *6*(5), 7–13.

Henrietta, H. M., Kalaiyarasi, K., & Raj, A. S. (2022). Coconut Tree ( Cocos nucifera ) Products : A Review of Global Cultivation and its Coconut Tree ( Cocos nucifera ) Products : A Review of Global Cultivation and its Benefits. *Journal of Sustainability and Environmental Management (JOSEM)*, *1*(May). https://doi.org/10.3126/josem.v1i2.45377

Hoe, T. K. (2019). *The Current Scenario and Development of the Coconut Industry*. *February*.

Iswara, D., Afifah, L., Abadi, S., Prabowo, D., Irfan, B., & Widiawan, A. B. (2022). Kelimpahan Serangga pada Berbagai Perangkap dengan Beberapa Teknik Pengendalian Berbeda pada Pertanaman Jagung Pioneer 36. *Jurnal Agroplasma*, *9*(2), 213–224.

Kavitha, K., Preetha, G., Selvarani, A., Hassan, N. S., & Swarnapriya, R. (2023). Occurrence and distribution of major pests and diseases of coconut during roving survey in Kanyakumari district of Tamil Nadu. *Journal of Krishi Vigyan*, *11*(suppl), 156–160. https://doi.org/10.5958/2349-4433.2023.00104.6

Lindenmayer, D. B., & Laurance, W. F. (2016). The ecology , distribution , conservation and management of large old trees. *Biological Reviews*. https://doi.org/10.1111/brv.12290

Manosathiyadevan, M., Bhuvaneshwari, V., & Latha, R. (2017). Impact of Insects and Pests in loss of Crop Production: A Review. In A. Dhanarajan (Ed.), *Sustainable Agriculture towards Food Security* (pp. 57–67). Springer Singapore. https://doi.org/10.1007/978-981-10-6647-4_4

Maruthadurai, R., & Ramesh, R. (2020). Mass trapping of red palm weevil and rhinoceros beetle in coconut with aggregation pheromone. *Indian Journal of Entomology*, *82*(3), 439–441. https://doi.org/10.5958/0974-8172.2020.00114.5

Moreira, M. M., & Reitas, L. F. (2020). Review of the Pollination System by Small Diverse Insects. *Neotrop Entomol*, 472–481. https://doi.org/https://doi.org/10.1007/s13744-020-00779-6

Myers, J. H., & Sarfraz, R. M. (2017). Impacts of Insect Herbivores on Plant Populations. *Annu. Rev. Entomol.* https://doi.org/10.1146/annurev-ento-010715-023826

Paliama, H. G., Latumahina, F. S., & Wattimena, C. M. A. (2022). Keanekaragaman Serangga dalam Kawasan Hutan Mangrove di Desa Ihamahu. *Jurnal Tengkawang*, *12*(1), 94–104.

Parnidi Parnidi, Sunarto, D. A., & Marjani, M. (2022). Shoot Borers Beetle Pest of Coconut (Oryctes rhinoceros L.) Investment at Agave spp. *Bioeduscience*, *6*(1), 89–95. https://doi.org/10.22236/j.bes/616282

Paudel, S., Jackson, T. A., Mansfield, S., Ero, M., Moore, A., & Marshall, S. D. G. (2023). Use of pheromones for monitoring and control strategies of coconut rhinoceros beetle ( Oryctes rhinoceros ): A review. *Crop Protection*, *174*(September), 106400. https://doi.org/10.1016/j.cropro.2023.106400

Paudel, S., Mansfield, S., Villamizar, L. F., Jackson, T. A., & Marshall, S. D. G. (2021). Can biological control overcome the threat from newly invasive coconut rhinoceros beetle populations (Coleoptera: Scarabaeidae)? A review. *Annals of the Entomological Society of America*, *114*(2), 247–256.

Paudel, S., Marshall, S. D. G., Richards, N. K., Hazelman, G., Tanielu, P., & Jackson, T. A. (2022). Coconut Rhinoceros Beetle in Samoa : Review of a Century-Old Invasion and Prospects for Control in a Changing Future. *Insects*, 1–15. https://doi.org/https://doi.org/10.3390/insects13050487

Purnomo, H., Okarda, B., Dermawan, A., Pebrial, Q., Pacheco, P., Nurfatriani, F., & Suhendang, E. (2020). Forest Policy and Economics Reconciling oil palm economic development and environmental conservation in Indonesia : A value chain dynamic approach. *Forest Policy and Economics*, *111*(January), 102089. https://doi.org/10.1016/j.forpol.2020.102089

Rahayuwati, S., Kusumah, Y. M., Prawirosukarto, S., Dadang, & Santoso, T. (2020). The status of oryctes rhinoceros nudivirus (OrNV) infection in oryctes rhinoceros (Coleoptera: Scarabaeidae) in Indonesia. *Journal of Oil Palm Research*, *32*(4), 582–589.

Santi, I., Tarmadja, S., Priambada, K. J., & Elfatma, O. (2023). Keanekaragaman Serangga Perkebunan Kelapa Sawit Di Provinsi Kalimantan Tengah. *Jurnal Ilmiah Hijau Cendekia*, *8*(1), 45. https://doi.org/10.32503/hijau.v8i1.2917

Schowalter, T. (2017). Arthropod Diversity and Functional Importance in Old-Growth Forests of North America. *Forests*. https://doi.org/10.3390/f8040097

Schowalter, T. D. (2016). *Insect ecology: an ecosystem approach*. Academic press.

Serrana, J. M., Almarinez, B. J. M., Barrion, A. T., & Amalin, D. M. (2023). Ultrastructural characterization of the scale cover of cryptic Aspidiotus spp. (Hemiptera: Diaspididae) and the ovipositor of their parasitoids. *Microscopy and Microanalysis*, *29*(2), 825–831. https://doi.org/10.1093/micmic/ozac041

Serrana, J. M., Ishitani, N., Carvajal, T. M., Almarinez, B. J. M., Barrion, A. T., Amalin, D. M., & Watanabe, K. (2019). Unraveling the genetic structure of the coconut scale insect pest (Aspidiotus rigidus reyne) outbreak populations in the Philippines. *Insects*, *10*(11). https://doi.org/10.3390/insects10110374

Stam, J. M., Kroes, A., Li, Y., Gols, R., Loon, J. J. A. Van, Poelman, E. H., & Dicke, M. (2014). Plant Interactions with Multiple Insect Herbivores : From Community to Genes. *Annu. Rev. Plant Biol.*, *65*, 689–713. https://doi.org/10.1146/annurev-arplant-050213-035937

Subedi, B., Poudel, A., & Aryal, S. (2023). The impact of climate change on insect pest biology and ecology : Implications for pest management strategies , crop production , and food security. *Journal of Agriculture and Food Research*, *14*(July), 100733. https://doi.org/10.1016/j.jafr.2023.100733

Thomas, G.V., Krishnakumar, V., Dhanapal, R., & Srinivasa Reddy, D. V. (2018). Preharvest approaches to control insect infestation in fruit. In *Preharvest Modulation of Postharvest Fruit and Vegetable Quality* (pp. 301–357). Elsevier. https://doi.org/https://doi.org/10.1007/978-981-13-2754-4_7

Tiemann, T. T., Donough, C. R., Lim, Y. L., Härdter, R., Norton, R., Tao, H. H., Jaramillo, R., Satyanarayana, T., Zingore, S., & Oberthür, T. (2018). Chapter Four - Feeding the Palm: A Review of Oil Palm Nutrition. In D. L. B. T.-A. in A. Sparks (Ed.), *Advances in Agronomy* (Vol. 152, pp. 149–243). Academic Press. https://doi.org/https://doi.org/10.1016/bs.agron.2018.07.001

Vislobokov, N. A. (2017). Flowering biology of Aspidistra (A sparagaceae): new data on pollination by dipteran insects. *Plant Species Biology*, *32*(4), 412–422. https://doi.org/https://doi.org/10.1111/1442-1984.12175

Ximenes, R., Nurmalina, R., & Rifin, A. (2021). Demand Analysis of Indonesia ' s Coconut Crude Oil in Germany Demand Analysis of Indonesia ' s Coconut Crude Oil in Germany. *Review of Economics and Finance*, *19*(October), 281–285. https://doi.org/10.55365/1923.x2021.19.39

Zainol, F. A., Arumugam, N., Norhayate, W., Daud, W., Aisyah, N., & Suhaimi, M. (2023). Coconut Value Chain Analysis : A Systematic Review. *Agriculture*, *13*(7). https://doi.org/https://doi.org/10.3390/agriculture13071379

January 2024

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Thank you so much for the very kind attention and the great help provided by the editorial team of BIODIVERSITAS Journal of Biological Diversity.

**"Letter on responses to reviewers' comments and suggestions"**

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|---|---|---|---|
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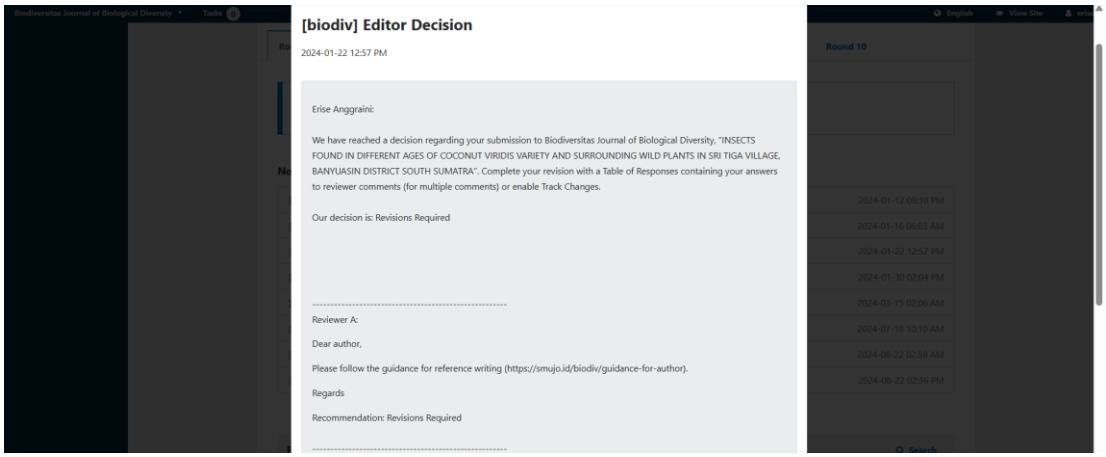

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2024-01-22 12:57 PM

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We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY AND SURROUNDING WILD PLANTS IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA". Complete your revision with a Table of Responses containing your answers to reviewer comments (for multiple comments) or enable Track Changes.

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Regards

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# INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA, INDONESIA

**Author(s) name:**

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This research inventories insects in smallholder coconut plantations at different planting ages. Insect inventory is important because it is the basis for controlling pest insect populations. Updates on pest inventory can be a basic reference for monitoring to anticipate at any time an explosion in the insect pest population.

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Erise Anggraini

# INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA, INDONESIA

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Manuscript received: DD MM 2016 (Date of abstract/manuscript submission). Revision accepted: .....

**Abstract.** Coconut (*Cocos nucifera*) is a valuable export commodity and has good prospects in the international market. Coconut cultivation is inseparable from the presence of insect species. The presence of insects in plants is interrelated because plants are places for insects to live and eat. However, not everyone knows the relationship between plants and insects. An inventory of insect biodiversity in an ecosystem needs to be conducted. This information shows the community structure of insects associated with coconut plants and plants that grow around coconut plants. Therefore, this field practice aims to find out the insects associated with coconut plants. Field practice was carried out with a survey in a coconut plantation owned by the people in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency, South Sumatera, Indonesia. The observation was conducted from July to September. Data collection was done by determining 3 coconut plantations with different ages of coconut trees. Data collection was carried out using the purposive sampling method by direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was conducted by collecting insects directly during direct observation and in traps. Specimens that have been collected were identified using a macroscope in the Laboratory of Entomology, Department of Plant Pests and Disease, Faculty of Agriculture, Sriwijaya University. The results of this field practice found 12 species namely *Aleurocanthus* sp., *Aphis cerana*, *Aspidiotus destructor*, *Aulacophora* sp., *Cenephora hirsuta*, *Conocephalus* sp., *Cotesia congregata*, *Dianemobius fascipes*, *Eumorphus westwoodi*, *Macrotermes* sp., *Metisa plana*, *Nipaecoccus nipae*, *Oecophylla* sp., *Oryctes rhinoceros*, *Polistes carnifex*, *Polyrhachis dives*, *Pteroma pendula*, *Tettigidea lateralis*.

**Key words:** *Cocos nucifera*, viridis variety, coconut, insects

**Running title:** Insects Found in Coconut Viridis Variety and Surrounding Wild Plants

## INTRODUCTION

Indonesia has various agricultural sectors such as plantations, horticulture, food crops and forestry plants. The plantation sector in Indonesia makes a significant contribution to the country's economy (Purnomo et al. 2020). In Indonesia, coconut plantations have been widely developed and have become the main income for coconut farmers. Coconut plays a role in the economy, social and state income from non-oil and gas commodities (Ximenes et al. 2021). Coconut production is mostly used for consumption and industry (Hoe 2019). Products resulting from the development of coconut plants that have been widely managed include coconut oil, coconut sugar, dried grated coconut, coconut milk, shells, coconut juice and coconut fiber (Henrietta et al. 2022). Coconut (*Cocos nucifera*) is a tropical plantation commodity that is widespread in Indonesia, the Philippines, India, and several Asia Pacific countries (Hoe 2019). Coconut is a high-value export commodity and has good prospects in the international market. Indonesia is the first considerable coconut-producing country worldwide, followed by the Philippines and India (Zainol et al. 2023). The area of coconut plantations in Banyuasin Regency, Indonesia, in 2022 was 42,599,00 Ha (Badan Pusat Statistik, 2023). The productivity of coconut plants in Banyuasin Regency, Indonesia 2022 reached 46,760,00 tons (Badan Pusat Statistik, 2023).

In coconut cultivation, it is important to understand the life cycle of the plant from seeding to harvest. This stage requires consistent care and monitoring. In coconut cultivation, the process involves selecting quality seeds, proper soil cultivation, and proper care (Thomas et al. 2018). Coconuts thrive in sufficient sunlight, appropriate rainfall, and nutrient-rich soil with effective drainage (Tiemann et al. 2018). The optimal range for coconut plant growth is between pH 5-8 (Fauzana et al. 2021). A deep understanding of these factors can result in sustainable coconut plantations. Furthermore,

regular pruning, fertilizing, and managing pests and diseases are things that need attention (Aulia et al. 2020). A deep understanding of these factors can lead to profitable and sustainable coconut production. On the other hand, In many coconut producing areas, especially in smallholder coconut plantations, fertilizer use and insect management are often not carried out intensively (Zainol et al. 2023). Furthermore, the process of cultivating coconut cannot be separated from the presence of insect species. The existence of insects on plants is interrelated because plants are a place for insects to live and eat (Stam et al. 2014). Insects are also needed by plants during plant pollination (Moreira & Reitas 2020). In addition, insects can cause damage to cultivated plants (Manosathiyadevan et al. 2017).

In coconut plantations, the age of coconut trees varies in each area. This results in differences in plant growth and development from one tree to another, affecting not only nutritional requirements but also harvest patterns and overall productivity (Arumugam 2022). Management appropriate to the coconut plant's age is essential to maximize its health and yield. Coconut trees at varying stages of growth may attract different insect pests, which may prefer specific developmental stages of the trees due to physiological differences. It's essential to identify and manage these pests appropriately, considering the age of the coconut trees for effective pest control. Moreover, insects play various roles in ecosystems and significantly impact human society and the environment, such as pollinators, decomposers, and pests (Chandra et al. 2023). Recent information about insects on coconut trees, especially regarding the different ages of the trees, has yet to be recorded. Therefore, an inventory of insect biodiversity in different plant ages of coconut plantation ecosystem needs to be carried out. The diversity of insect species can be used to indicate changes occurring in the ecosystem (Chowdhury et al. 2023). Identifying the presence of different species of coconut trees of different ages is important. Understanding the insect species can guide integrated pest management strategies.

## MATERIALS AND METHODS

### Study area

Field practice was carried out in people's coconut plantations in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency (Figure 1). Field practice is also conducted at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University. Field practice is carried out from July to September 2023.

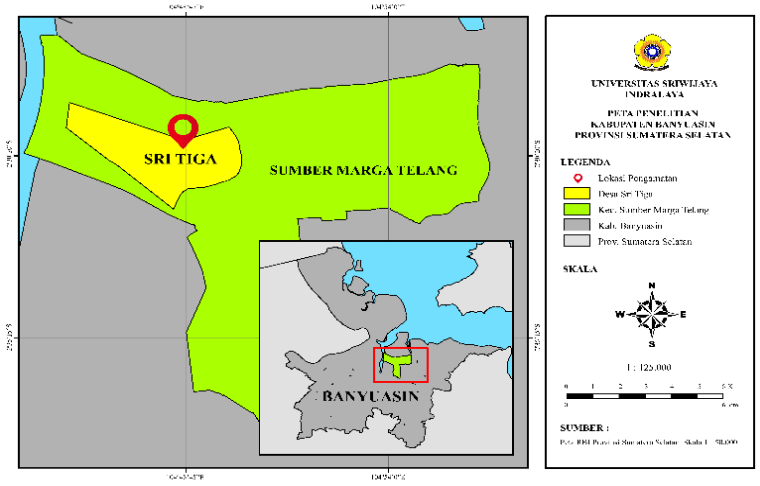


**Figure 1.** Sampling location

**Procedures**

Initial preparations are carried out by conducting a survey to find out the research location and preparing the tools and materials used. Apart from that, a survey was conducted to find out information from the community regarding the use of coconut in Sri Tiga Village, Banyuasin Regency. Data collection was initially carried out by determining three coconut plantations as objects of observation, and then these gardens were observed. Data was collected using the purpose sampling method by making direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was done by collecting insects directly, either during direct observation or in traps. Documentation was carried out in the form of photographs of insects found on coconut plants and wild plants around the coconut plants. Identification of insects found was done by examining insects that are common and have been studied previously. The things studied were similar in terms of color, shape, size, and morphological characteristics of the insects found. The observation parameters in this field practice were the insects caught in each trap. All insects found are then identified. Insect identification was carried out based on morphological characteristics such as head, abdomen, antennae, wings, and others. Each insect found then determines its role in the ecosystem.

**Data analysis**

The data obtained from the observations are presented in the table. The data was then analyzed using R Statistic software. The species diversity index was used to describe the diversity of insect species found in the research area. The diversity index was expressed using the Shannon-Wiener species diversity formula:

$$H' = -\sum \text{Pi In pi}$$

Information:
H': Shannon-Wiener Diversity Index
Pi: ni/N (Comparison between the number of a species and all species)

Description of criteria:
H' < 1 : Low diversity
1 < H' < 3 : Medium diversity
H' > 3 : High diversity

The species evenness index was used to describe the degree of evenness of insect species found in the research area. The evenness index was expressed using the formula:

$$E = \frac{H'}{In\ S}$$

Information:
E : Evenness index (value between 0-1)
H' : Shannon-Wiener diversity index
S : Number of types
Description of criteria:
E < 0.4 : Small population uniformity
0.4 < E < 0.6 : Moderate population uniformity
E > 0.6 : High population uniformity

The species dominance index was used to describe the level of dominance of insect species found in the research area. The dominance index is expressed using the formula:

$$D = \sum Pi^2$$

Information:
D: Simpson Dominance Index
Pi: ni/N (Comparison between the number of a species and all species)
Description of criteria:
0 < D < 0.5 : Low dominance
0.5 < D < 0.75 : Moderate dominance
0.75< D < 1.0 : High dominance

## RESULTS AND DISCUSSION

### Abundance of insects found in coconut trees

The insect species found in three coconut fields with varying plant ages, namely 8 years, 5 years and 2 years, were very diverse. There are 12 species from 4 orders. The four orders found most frequently include the orders Coleoptera, Hemiptera, Hymenoptera and Lepidoptera. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* which comes from the Hemiptera Order, namely 256.33 individuals. This result also found the same thing in coconut fields that were 5 years old, namely dominated by *Nipaecoccus nipae*, with as many as 265.67 individuals. Meanwhile, on 2 year old coconut fields, the insect species that were frequently encountered were Aspidiotus destructor from the Hemiptera Order, namely 96,000. Based on the results of comparing the number of species found in coconut fields of different ages, it was found that there were also different numbers of species (Table 1). In the 2 year old plantation, *Aphis cerana* and *Polistes carnifex* species were not found.

**Table 1.** Abundance of Insects on Coconuts

| Ordo/Spesies | Abundance of insects on coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Oryctes rhinoceros* | 28.00 | 29.00 | 22.67 | $3.20 \times 10^{-1}$ | $1.54^{ns}$ | - |
| **Hemiptera** | | | | | | |
| *Aspidiotus destructor* | 173.33a | 116.33b | 96.00b | $3.62 \times 10^{-3}$ | $31.24^{*}$ | 1.55 |
| *Nipaecoccus nipae* | 256.33a | 265.67a | 18.00b | $5.16 \times 10^{-5}$ | $276.40^{*}$ | 2.07 |
| *Planococcus sp.* | 50.67a | 44.33a | 27.67b | $58.7 \times 10^{-4}$ | $80.55^{*}$ | 0.54 |
| **Hymenoptera** | | | | | | |
| *Aphis cerana* | 5.67a | 4.33b | 0.00c | $3.13 \times 10^{-5}$ | $355.22^{*}$ | 0.25 |
| *Cotesia congregata* | 30.00a | 25.33b | 18.00c | $6.14 \times 10^{-4}$ | $78.70^{*}$ | 0.35 |
| *Dolichoderus thoracicus* | 113.33a | 103.67a | 81.33b | $45.1 \times 10^{-3}$ | $27.78^{*}$ | 0.81 |
| *Oecophylla* sp. | 98.00a | 87.33a | 60.33b | $1.15 \times 10^{-3}$ | $56.91^{*}$ | 0.75 |
| *Polistes carnifex* | 4.00a | 2.33b | 0.00c | $4.52 \times 10^{-4}$ | $92.12^{*}$ | 0.38 |
| **Lepidoptera** | | | | | | |
| *Metisa plana* | 16.33a | 13.67ab | 10.00b | $2.64 \times 10^{-2}$ | $10.31^{*}$ | 0.68 |
| *Pteroma pendula* | 20.67a | 16.67ab | 13.00b | $6.15 \times 10^{-3}$ | $23.50^{*}$ | 0.48 |
| *Pteroma plagiophleps* | 24.00a | 19.00ab | 14.00b | $6.78 \times 10^{-3}$ | $22.28^{*}$ | 0.61 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

### Abundance of insects found in wild plants around coconut trees

Insect species found in wild plants around coconuts were also observed. There are 6 species of insects from 3 orders. The orders found include Coleoptera, Isoptera and Orthoptera. In wild plants around 8 year old and 5 year old coconuts, the most Captotermes sp insects were found. originating from the Order Isoptera, namely 18.00 individuals and 13.67 individuals respectively. Meanwhile, it was very different when the coconuts were 2 years old and no similar species were found at all. In the plants around coconuts that are 2 years old, the most common insects are Conocephalus sp. which came from the Order Orthopetra, namely 10,00 individuals (Table 2).

**Table 2.** Average abundance of insects in wild plants around coconut trees

| Ordo/Spesies | Abundance of Insects in wild plants around Coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Aulacophora* sp. | 14.67a | 8.00b | 7.00b | $9.09 \times 10^{-3}$ | $18.98^{*}$ | 0.71 |
| *Eumorphus westwoodi* | 12.33a | 8.33b | 3.00c | $3.21 \times 10^{-4}$ | $109.67^{*}$ | 0.42 |
| **Isoptera** | | | | | | |
| *Captotermes* sp. | 18.00a | 13.67b | 0.00c | $3.52 \times 10^{-5}$ | $335.07^{*}$ | 0.53 |
| **Orthoptera** | | | | | | |
| *Conocephalus* sp. | 17.00a | 12.00b | 10.00c | $38.9 \times 10^{-4}$ | $99.47^{*}$ | 0.24 |
| *Dianemobius fascipes* | 16.67a | 13.00b | 9.00c | $6.50 \times 10^{-5}$ | $246.00^{*}$ | 0.17 |
| *Tettigidea lateralis* | 10.67a | 8.33ab | 6.67b | $8.19 \times 10^{-3}$ | $20.10^{*}$ | 0.39 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

### Characteristics of insect communities found in coconut trees

The characteristics of the insect community on coconuts aged 8 years, 5 years and 2 years that were analyzed included the diversity index, evenness index and dominance index. The results showed that the community characteristics of each coconut plant aged 8 years, 5 years and 2 years increased with each observation. The diversity, evenness and dominance index of 8-year-old coconut plants was higher than that of 5- and 2-year-old coconut plants (Table 3). This shows that the age of the coconut affects the number of insects found in the field. The higher the diversity index value, the more diverse the species that exist in the community. This index reflects the biological richness of the community. If the evenness index shows a high value, the individuals in the community have a more even distribution among species, while a low value indicates an uneven distribution. Meanwhile, the dominance index measures the extent to which one or several species have significant dominance or ownership in the community.

**Table 3.** Characteristics of insect communities found in coconut trees

| Coconut plants (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Coconut plants (8 years old) | Number of Individuals | 847.00 | 853.00 | 761.00 |
| | Diversity Index (H') | 1.90 | 1.95 | 2.04 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.31 |
| | Dominance Index (D) | 0.34 | 0.32 | 0.28 |
| Coconut plants (5 years old) | Number of Individuals | 754.00 | 734.00 | 695.00 |
| | Diversity Index (H') | 1.86 | 1.90 | 1.97 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.30 |
| | Dominance Index (D) | 0.16 | 0.16 | 0.17 |
| Coconut plants (2 years old) | Number of Individuals | 622.00 | 617.00 | 544.00 |
| | Diversity Index (H') | 1.75 | 1.76 | 1.80 |
| | Eveness Index (E) | 0.27 | 0.27 | 0.29 |
| | Dominance Index (D) | 0.16 | 0.15 | 0.18 |

**The characteristics of insects on wild plants around coconut trees**

Based on the results, it was found that the highest index was found in coconut fields that were 8 years old. Meanwhile, at the age of 2 years, the analysis results were lower (Table 4). This also proves that the age of the coconut greatly influences the number of species found in wild plants around the coconut. The diversity, evenness and dominance indices in coconut plants aged 8 years, 5 years and 2 years experienced increases and decreases in population numbers. The diversity index in wild plants around 8-year-old coconut plants is higher compared to 5- and 2-year-old coconut plants. Meanwhile, the evenness and dominance index of wild plants around 2-year-old coconut plants was higher than that of 8- and 5-year-old coconut plants.

**Table 4.** Characteristics of insect communities in wild plants around coconut trees

| Wild plants around the coconut trees (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Wild plants around the coconut plants (8 years old) | Number of Individuals | 99.00 | 92.00 | 77.00 |
| | Diversity Index (H') | 1.78 | 1.77 | 1.77 |
| | Eveness Index (E) | 0.39 | 0.39 | 0.41 |
| | Dominance Index (D) | 0.19 | 0.22 | 0.21 |
| Wild plants around the coconut plants (5 years old) | Number of Individuals | 72.00 | 65.00 | 53.00 |
| | Diversity Index (H') | 1.77 | 1.75 | 1.76 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.44 |
| | Dominance Index (D) | 0.21 | 0.23 | 0.23 |
| Wild plants around the coconut plants (2 years old) | Number of Individuals | 42.00 | 37.00 | 28.00 |
| | Diversity Index (H') | 1.54 | 1.53 | 1.54 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.46 |
| | Dominance Index (D) | 0.26 | 0.30 | 0.32 |

**Relative abundance of insects found in coconut trees**

The relative abundance of insects on coconuts aged 8 years, 5 years and 2 years varied greatly. At plant ages of 8 years and 5 years, the abundance of insects in the Order Hemiptera was found, namely 59.00% and 58.00% respectively. while the lowest order is the Order Coleoptera which is only 3.00% and 4.00% respectively. In contrast to the age of 2 years, the most insect species found were from the Order Hymenoptera, namely 48.00% and the lowest species were in the Orders Lepidopeta and Hymenoptera, which was only 7.00% (Figure 2).

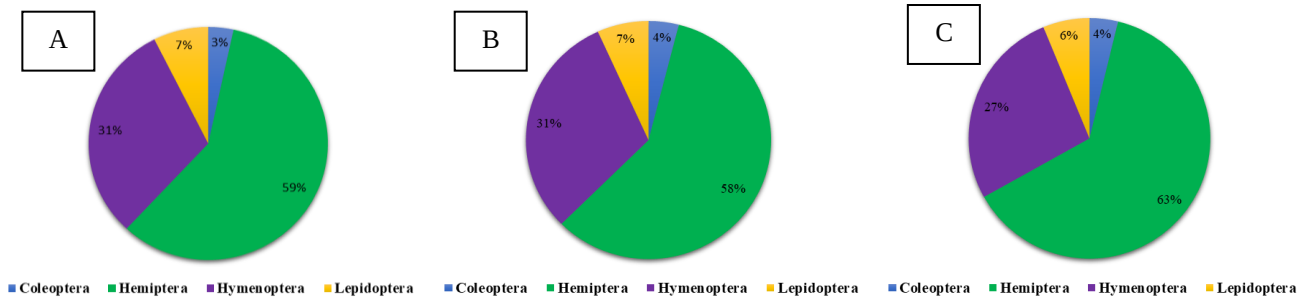


**Figure 2.** Abundance of insects found in coconut trees at: A) 8 years old, B) 5 years old, C) 2 years old.

**Relative abundance of insects found in wild plants around coconut trees**

The relative abundance of insects in wild plants around coconut plants was only found in 3 orders, namely the orders Coleoptera, Isoptera and Orthoptera. In plants aged 8 years, 5 years, and 2 years, the most Orthoptera orders were found, namely 50.00%, 53.00% and 72.00% respectively. Meanwhile, in the area around 2-year-old coconuts, only two orders were found, namely Coleoptera and Orthoptera (Figure 3).

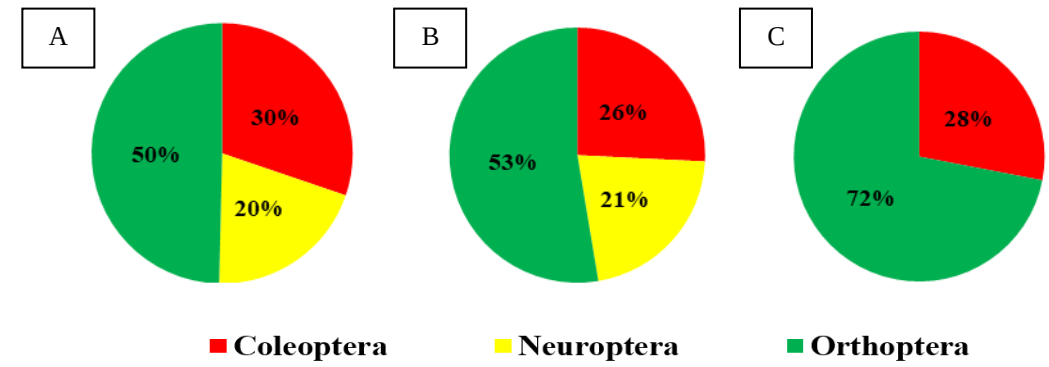


**Figure 3.** Abundance of insects on wild plants around coconut trees at different age of coconut: A) 8 years old, B) 5 years old, C) 2 years old.

The results of observations found 18 species of insects associated with coconut plants and surrounding wild plants. The 18 insect species act as phytophagous, pollinators and natural enemies. The dominant insects belong to the orders Hemiptera and Hymenoptera. The insects are *Aspidiotus destructor* (Figure 4a), *Nipaecoccus nipae* (Figure 4b), *Aleurocanthus* sp. (Figure 4c), *Polyrhachis dives* (Figure 4d), *Oecophylla* sp. (Figure 4e).

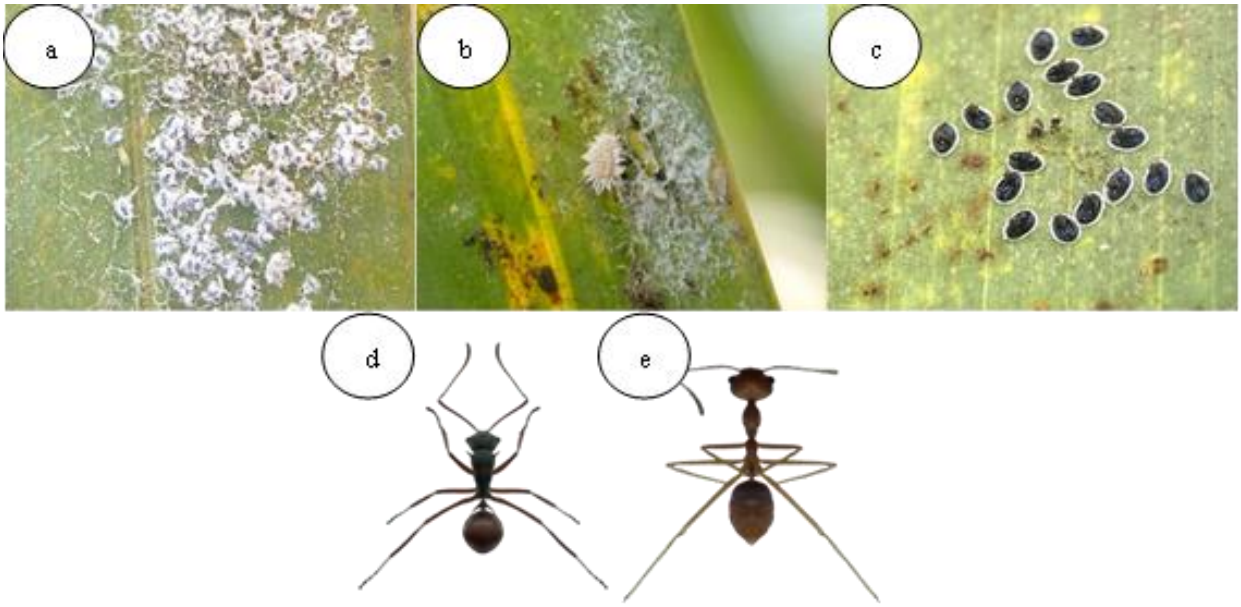


**Figure 3.** The dominant insects are found on coconut plants and surrounding plants. *Aspidiotus destructor* (a), *Nipaecoccus nipae* (b), *Aleurocanthus* sp. (c), *Polyrhachis dives* (d) dan *Oecophylla* sp. (e)

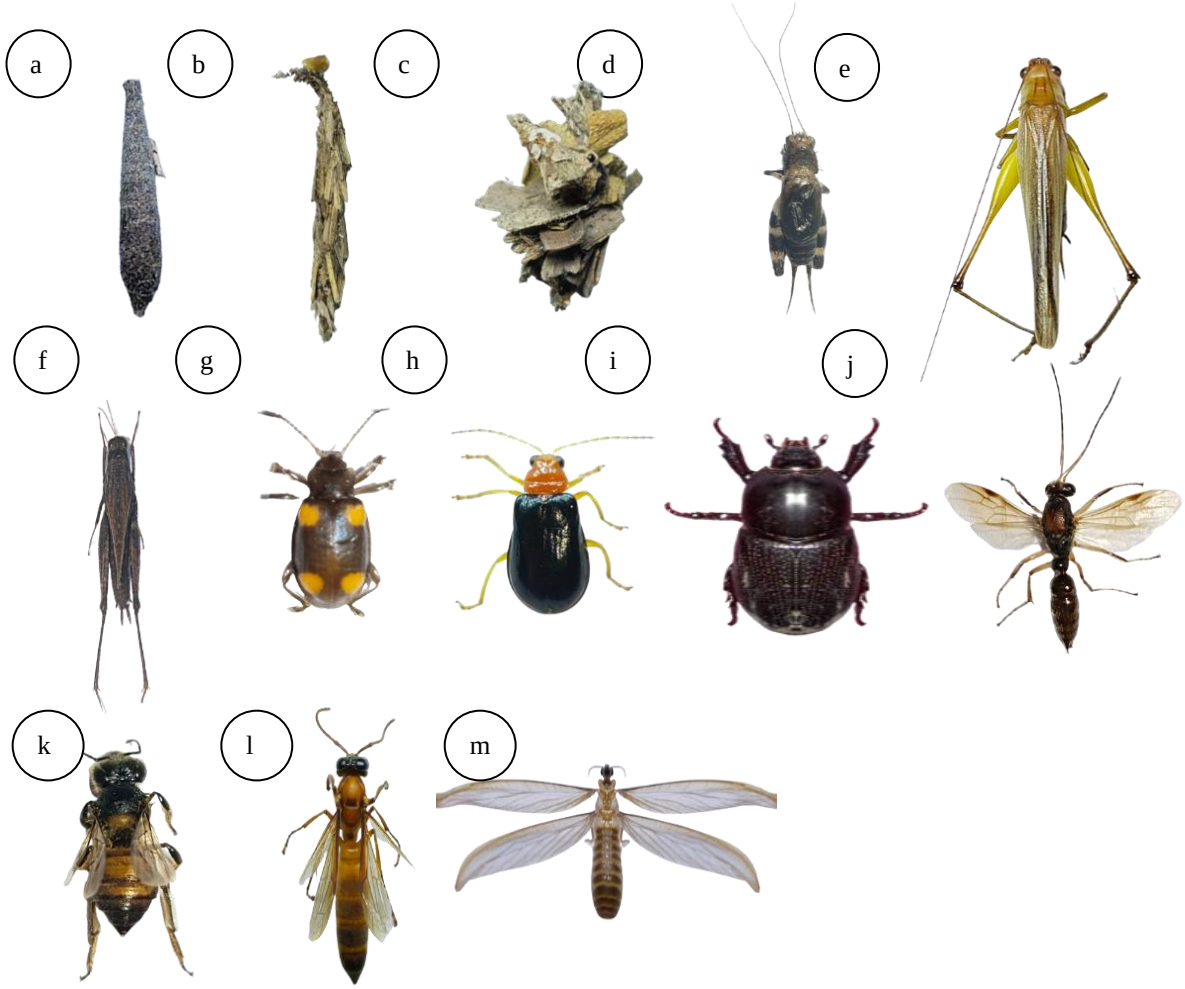


**Figure 4.** The non-dominant insects are found on coconut plants and surrounding plants. *Pteroma pendula* (a), *Cenephora hirsuta* (b), *Metisa plana* (c), *Dianemobius fascipes* (d), *Conocephalus* sp. (e), *Tettigidea lateralis* (f), *Eumorphus westwoodi* (g), *Aulacophora* sp. (h), *Oryctes rhinoceros* (i), *Cotesia congregata* (j), *Aphis cerana* (k) *Polistes carnifex* (l) and *Mactrotermes* sp. (m).

## Discussion

The results of observations in the field showed that the number of insects caught using traps in coconut plantations was identified as 7 orders, 18 species with a total of 2330.67 individuals. However, this research observation was divided into two parts, namely on coconut plants and on wild plants around coconuts which have various ages. Observations on coconuts of various ages showed findings of 4 orders and 12 species of insects. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* which comes from the order Hemiptera, namely 256.33 individuals. supported by research by Ganganalli et al. (2023), that the species of aphids that are most often found on coconuts. Meanwhile, in the wild plants around coconut, there are 3 orders and 6 species. The 6 insect species belong to the orders Coleoptera, Isoptera and Orthoptera. *Captotermes* sp dominated coconuts aged 8 years. Meanwhile, coconuts aged 2 years old, the most common insects were *Conocephalus* sp. which comes from the order Orthopetra. The seven orders found, including the orders Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Coleoptera, Isoptera and Orthoptera, have various roles in the ecosystem. This coconut plants species were found that have roles as pests, predators, parasitoids and also pollinators (Kavitha et al., 2023). Direct observation was carried out by recording the condition or behavior of the object being observed (Vislobokov, 2017). There were species *A. destructor*, *N. nipae*, *Aleurocanthus* sp., *P. pendula, C. hirsuta*, and *M. Plana* recorded by using the direct observation method. On the other hand, the traps were used to collected the fly or active insects such as insect nets, light traps and pheromones traps (Haneda et al. 2017). According to Iswara et al. (2022), traps are designed based on insect behaviour and attraction to certain lights, shapes and colours. The species obtained using the insect nets and the light trap were *E. westwoodi*. *Aulacophora* sp., *A. cerana, P. carnifex, Conocephalus* sp., and *T. lateralis.* Meanwhile, *O. rhinoceros* was found in the pheromone trap. Pheromones traps are traps used to attract male insects (Maruthadurai and Ramesh, 2020). Pheromones trap was effectively to monitor and control the adults of *O. rhinoceros* (Paudel et al. 2023).

*Aspidiotus destructor* Signoret (Hemiptera: Diaspididae) is an coconut scale (Serrana et al. 2023). The coconut scale was found in the highest numbers at every age of coconut. The insect scale had also been confirmed to cause significant economic losses to the coconut industry in the Philippines (Serrana et al. 2019). Moreover, coconut bud borer beetles (*O. rhinoceros* L) were found at all ages of coconut. *O. rhinoceros* is one of the main pests that causes damage to germplasm in coconut (Paudel et al. 2022). In Indonesia, *O. rhinoceros* is a threat to both coconut and oil palm plants (Rahayuwati et al. 2020). These beetles are known to attack palm trees by boring into the crown and eating developing fronds (leaves that have not yet opened), which can cause death or stunted growth in young palm trees if the infestation is severe (Chalapathi Rao et al. 2018; Paudel et al. 2021, 2023). For mature oil palm trees, this damage can result in reduced productivity. This was also confirmed by Parnidi et al. (2022), that the average damage caused by this pest investment ranges from 0 to 16.7%. This study showed that there were different insects at each age of coconut. The plant age can influence the number of species and the number of individuals (Myers and Sarfraz, 2017; Santi et al. 2023). As plants grow and mature, they provide different habitats and resources that can support a variety of insects species (Schowalter 2016). Older plants tend to have more developed and complex ecosystems with greater insects species diversity (Schowalter 2017). Additionally, mature plants are often larger and have more resources, so they can support more individuals in their ecosystem (Lindenmayer and Laurance 2016). However, the specific impact of plant age on insect species and the number of insect individuals may vary depending on plant species, environmental conditions, and other factors (Myers and Sarfraz 2017).

The insect diversity index on coconut plants and surrounding wild plants in Sri Tiga Village from week 1 to week 3 shows a diversity value of $1 < H' < 3$, this is in the medium category. This criterion shows the diversity of pests and natural enemies which increases in number as the population increases towards balance. According to Hasibuan et al. (2019), there are 3 criteria for insect species diversity, namely low species diversity if $H < 1$ (unstable environmental conditions), desang species diversity if H 1-3 (medium environmental conditions), and high species diversity if $H > 3$ (stable environmental conditions). The results of the dominance index calculation obtained on coconut plants and surrounding wild plants from week 1 to week 3 showed a dominance value of $0 < D < 0.5$. This means that the dominance of these insects is relatively low. The Evenness Index (E) value is 0.29-0.31 in the depressed category. According to Hasibuan et al. (2019), there are 3 criteria for the community environment based on its evenness value, namely if $E < 0.50$ then the community is in a depressed condition. If 0.50 < E' 0.75 then society is in a stable condition, while 0.75 < E' 1.00 means society is in an unstable condition. The evenness index value (E') can describe the stability of a community. The smaller the value of E' or closer to zero, the more uneven the distribution of organisms in a community that is dominated by a certain type and conversely, the greater the value of E' or close to one, the organisms in that community will be evenly distributed (Ambarwati et al. 2023). Apart from being influenced by plant age, insect diversity can be influenced by climate and weather factors (Subedi et al. 2023). From July to September 2023, Sri Tiga Village faced the dry season. The dry season is characterized by decreased rainfall and increased temperatures, disrupting the life cycle of insects. According to Paliama et al. (2022), increasing global temperatures can affect the life cycle of insects. In addition, dry seasons can cause drought and reduce water availability for insects (Benoit et al. 2023). This condition may affect the ability of insect to tolerate climatic factors in an ecosystem.

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## REFERENCES

Ambarwati M, Dewi K, Aurina DM, Faturrahman AD, Fatikha LAY, Rachmalia F, Ainaya FA, Kinanthi A, Rohman, CM, Pradhana F, Fadzilah A, Pramudita DA, Ramadhan MF, Mahajoeno E, Nugroho GDWI, Sujarta P, Yap CK, Adha K, Rahim BINA, Setyawan ADWI. 2023. Ecological index and economic potential of mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia. *Biodiversitas Journal of Biological Diversity*, *24*(2), 1231–1241. https://doi.org/10.13057/biodiv/d240265

Arumugam T. (2022). Improving Coconut Using Modern Breeding Technologies : *Plants*, *11*(24). https://doi.org/https://doi.org/10.3390/plants11243414

Aulia AN, Chasanah N, Prasetyo AS, Nalawati AN. 2020. Competitiveness and Export Similairity of Indonesia ' s Coconut Oil. *Jurnal Agribest*, *04*(02), 123–132.

Badan Pusat Statistik. 2023. *Luas Areal dan Produksi Perkebunan Kelapa Rakyat Menurut Kecamatan*. https://banyuasinkab.bps.go.id/indicator/54/151/1/luas-areal-dan-produksi-perkebunan-kelapa-rakyat-menurut-kecamatan.html

Benoit JB, Mccluney KE, Degennaro MJ. (2023). Dehydration dynamics in terrestrial arthropods: from water sensing to trophic interactions. *Annu Rev Entomol*, 129–149. https://doi.org/10.1146/annurev-ento-120120-091609.Dehydration

Chalapathi Rao NBV, Snehalatharani A, Nischala A, Ramanandam G, Maheswarappa HP. 2018. Management of rhinoceros beetle (*Oryctes rhinoceros* L.) by biological suppression with Oryctes baculovirus in Andhra Pradesh. *Journal of Plantation Crops*, *46*(2). https://doi.org/10.25081/jpc.2018.v46.i2.3725

Chandra R., Abdul M, Sharma N, Bharathi K, Singh S. 2023. The Role of Insects in Ecosystems , an in-depth Review of Entomological. *International Journal of Environment and Climate Change*, *13*(10), 4340–4348. https://doi.org/10.9734/IJECC/2023/v13i103110

Chowdhury S, Dubey VK, Choudhury S, Kumar N, Semwal A, Kumar V. 2023. Insects as bioindicator : A hidden gem for environmental monitoring. *Front. Environ. Sci.*, *March*, 1–16. https://doi.org/10.3389/fenvs.2023.1146052

Ganganalli SM, Bhaskar H, Joshi, S, Vidya CV. 2023. Diversity of Aphid Fauna (Hemiptera: Aphididae) of Kerala. *Indian Journal of Entomology*, 1–8. https://doi.org/10.55446/ije.2023.742

Haneda NF, Wibowo C, Hasbi M. 2017. Peranan Arthropoda di Ekosistem Ekoton dan Kelapa Sawit. *Jurnal Silvikultur Tropika*, *8*(2), 116–122. https://doi.org/10.29244/j-siltrop.8.2.116-122

Hasibuan EW, Siregar AZ, Pinem MI. 2019. Diversity of Insect in Coconut Plant in Kelurahan Besar, Medan Labuhan District, North of Sumatra. *International Journal of Trend in Research and Development*, *6*(5), 7–13.

Henrietta HM, Kalaiyarasi K, Raj AS. 2022. Coconut Tree (*Cocos nucifera*) Products : A Review of Global Cultivation and its Coconut Tree (C*ocos nucifera*) Products : A Review of Global Cultivation and its Benefits. *Journal of Sustainability and Environmental Management (JOSEM)*, *1*(May). https://doi.org/10.3126/josem.v1i2.45377

Hoe TK. 2019. *The Current Scenario and Development of the Coconut Industry*. *February*.

Iswara D, Afifah L, Abadi S, Prabowo D, Irfan B, Widiawan AB. 2022. Kelimpahan Serangga pada Berbagai Perangkap dengan Beberapa Teknik Pengendalian Berbeda pada Pertanaman Jagung Pioneer 36. *Jurnal Agroplasma*, *9*(2), 213–224.

Lindenmayer DB, Laurance WF. 2016. The ecology , distribution , conservation and management of large old trees. *Biological Reviews*. https://doi.org/10.1111/brv.12290

Manosathiyadevan M, Bhuvaneshwari V, Latha R. 2017. Impact of Insects and Pests in loss of Crop Production: A Review. In A. Dhanarajan (Ed.), *Sustainable Agriculture towards Food Security* (pp. 57–67). Springer Singapore. https://doi.org/10.1007/978-981-10-6647-4_4

Maruthadurai R, Ramesh, R. 2020. Mass trapping of red palm weevil and rhinoceros beetle in coconut with aggregation pheromone. *Indian Journal of Entomology*, *82*(3), 439–441. https://doi.org/10.5958/0974-8172.2020.00114.5

Moreira MM, Reitas LF. 2020. Review of the Pollination System by Small Diverse Insects. *Neotrop Entomol*, 472–481. https://doi.org/https://doi.org/10.1007/s13744-020-00779-6

Myers JH, Sarfraz RM. 2017. Impacts of Insect Herbivores on Plant Populations. *Annu. Rev. Entomol.* https://doi.org/10.1146/annurev-ento-010715-023826

Paliama HG, Latumahina FS, Wattimena CMA. 2022. Keanekaragaman Serangga dalam Kawasan Hutan Mangrove di Desa Ihamahu. *Jurnal Tengkawang*, *12*(1), 94–104.

Parnidi P, Sunarto DA, Marjani M. 2022. Shoot Borers Beetle Pest of Coconut (Oryctes rhinoceros L.) Investment at Agave spp. *Bioeduscience*, *6*(1), 89–95. https://doi.org/10.22236/j.bes/616282

Paudel S, Jackson TA, Mansfield S, Ero M, Moore A, Marshall SDG. 2023. Use of pheromones for monitoring and control strategies of coconut rhinoceros beetle (*Oryctes rhinoceros*): A review. *Crop Protection*, *174*(September), 106400. https://doi.org/10.1016/j.cropro.2023.106400

Paudel S, Mansfield S, Villamizar LF, Jackson TA, Marshall SDG. 2021. Can biological control overcome the threat from newly invasive coconut rhinoceros beetle populations (Coleoptera: Scarabaeidae)? A review. *Annals of the Entomological Society of America*, *114*(2), 247–256.

Paudel S, Marshall SDG, Richards NK, Hazelman G, Tanielu P, Jackson TA. 2022. Coconut Rhinoceros Beetle in Samoa : Review of a Century-Old Invasion and Prospects for Control in a Changing Future. *Insects*, 1–15. https://doi.org/https://doi.org/10.3390/insects13050487

Purnomo H, Okarda B, Dermawan A, Pebrial Q, Pacheco P, Nurfatriani F, Suhendang E. 2020. Forest Policy and Economics Reconciling oil palm economic development and environmental conservation in Indonesia : A value chain dynamic approach. *Forest Policy and Economics*, *111*(January), 102089. https://doi.org/10.1016/j.forpol.2020.102089

Rahayuwati S, Kusumah YM, Prawirosukarto S, Dadang, Santoso T. 2020. The status of *oryctes rhinoceros nudivirus* (OrNV) infection in *oryctes rhinoceros* (Coleoptera: Scarabaeidae) in Indonesia. *Journal of Oil Palm Research*, *32*(4), 582–589.

Santi I, Tarmadja S, Priambada KJ, Elfatma O. 2023. Keanekaragaman Serangga Perkebunan Kelapa Sawit Di Provinsi Kalimantan Tengah. *Jurnal Ilmiah Hijau Cendekia*, *8*(1), 45. https://doi.org/10.32503/hijau.v8i1.2917

Schowalter TD. 2017. Arthropod Diversity and Functional Importance in Old-Growth Forests of North America. *Forests*. https://doi.org/10.3390/f8040097

Schowalter TD. 2016. *Insect ecology: an ecosystem approach*. Academic press.

Serrana JM, Almarinez BJM, Barrion AT, Amalin DM. 2023. Ultrastructural characterization of the scale cover of cryptic Aspidiotus spp. (Hemiptera: Diaspididae) and the ovipositor of their parasitoids. *Microscopy and Microanalysis*, *29*(2), 825–831. https://doi.org/10.1093/micmic/ozac041

Serrana JM, Ishitani N, Carvajal TM, Almarinez BJM, Barrion AT, Amalin DM, Watanabe K. 2019. Unraveling the genetic structure of the coconut scale insect pest (*Aspidiotus rigidus* Reyne) outbreak populations in the Philippines. *Insects*, *10*(11). https://doi.org/10.3390/insects10110374

Stam JM, Kroes A, Li Y, Gols R, Loon JJAV, Poelman EH, Dicke M. 2014. Plant Interactions with Multiple Insect Herbivores : From Community to Genes. *Annu. Rev. Plant Biol.*, *65*, 689–713. https://doi.org/10.1146/annurev-arplant-050213-035937

Subedi B, Poudel A, Aryal S. 2023. The impact of climate change on insect pest biology and ecology : Implications for pest management strategies, crop production , and food security. *Journal of Agriculture and Food Research*, *14*(July), 100733. https://doi.org/10.1016/j.jafr.2023.100733

Thomas GV, Krishnakumar V, Dhanapal R, Srinivasa Reddy DV. 2018. Preharvest approaches to control insect infestation in fruit. In *Preharvest Modulation of Postharvest Fruit and Vegetable Quality* (pp. 301–357). Elsevier. https://doi.org/https://doi.org/10.1007/978-981-13-2754-4_7

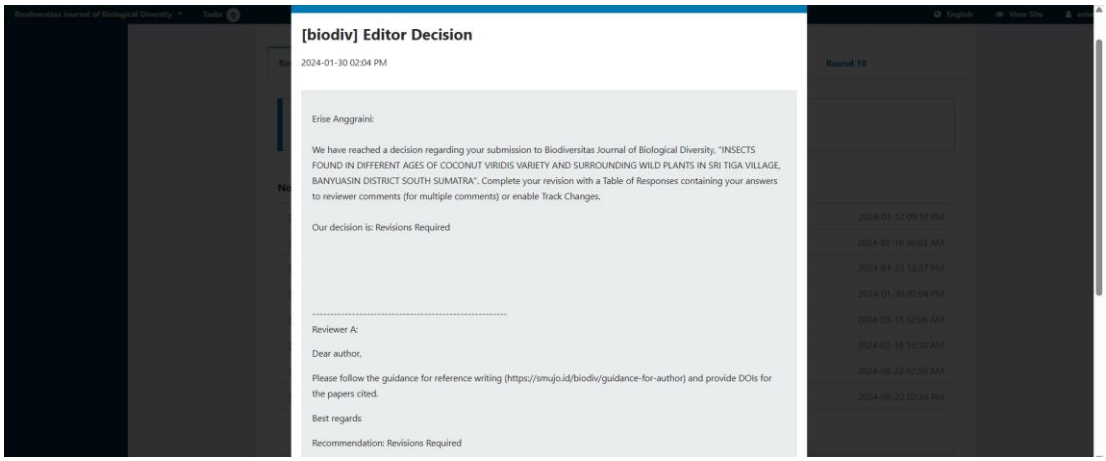
Tiemann TT, Donough CR, Lim YL, Härdter R, Norton R, Tao HH, Jaramillo R, Satyanarayana T, Zingore S, Oberthür T. 2018. Chapter Four - Feeding the Palm: A Review of Oil Palm Nutrition. In D. L. B. T.-A. in A. Sparks (Ed.), *Advances in Agronomy* (Vol. 152, pp. 149–243). Academic Press. https://doi.org/https://doi.org/10.1016/bs.agron.2018.07.001

Vislobokov NA. 2017. Flowering biology of Aspidistra (A sparagaceae): new data on pollination by dipteran insects. *Plant Species Biology*, *32*(4), 412–422. https://doi.org/https://doi.org/10.1111/1442-1984.12175

Ximenes R, Nurmalina R, Rifin A. 2021. Demand Analysis of Indonesia's Coconut Crude Oil in Germany Demand Analysis of Indonesia ' s Coconut Crude Oil in Germany. *Review of Economics and Finance*, *19*(October), 281–285. https://doi.org/10.55365/1923.x2021.19.39

Zainol FA, Arumugam N, Norhayate W, Daud W, Aisyah N, Suhaimi M. 2023. Coconut Value Chain Analysis : A Systematic Review. *Agriculture*, *13*(7). https://doi.org/https://doi.org/10.3390/agriculture13071379

## *Peer review round 4 (30 Januari 2024)*



[biodiv] Editor Decision

2024-01-30 02:04 PM

Erise Anggraini:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY AND SURROUNDING WILD PLANTS IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA". Complete your revision with a Table of Responses containing your answers to reviewer comments (for multiple comments) or enable Track Changes.

Our decision is: Revisions Required

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Reviewer A:

Dear author,

Please follow the guidance for reference writing (https://smujo.id/biodiv/guidance-for-author) and provide DOIs for the papers cited.

Best regards

Recommendation: Revisions Required

## COVERING LETTER

Dear **Editor-in-Chief,**

I herewith enclosed a research article,

- [x] The submission has not been previously published, nor is it before another journal for consideration (or an explanation has been provided in Comments to the Editor).
- [x] The submission file is in OpenOffice, Microsoft Word (DOC, not DOCX), or RTF document file format.
- [x] The text is single-spaced; uses a 10-point font; employs italics, rather than underlining (except with URL addresses); and all illustrations, figures, and tables are placed within the text at the appropriate points, rather than at the end.
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**Title:**

# INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA, INDONESIA

**Author(s) name:**

**ERISE ANGGRAINI[1,2,♥], TESSIA MASNITA SINAGA[1], HARMAN HAMIDSON[1], CHANDRA IRSAN[1], MARLIN SEFRILA[3], ASTUTI KURNIANINGSIH[3], MIRZA ANTONI[4]**

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**Novelty:**

(state your claimed novelty of the findings versus current knowledge)

This research inventories insects in smallholder coconut plantations at different planting ages. Insect inventory is important because it is the basis for controlling pest insect populations. Updates on pest inventory can be a basic reference for monitoring to anticipate at any time an explosion in the insect pest population.

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Erise Anggraini

# INSECTS FOUND IN DIFFERENT AGES OF COCONUT VIRIDIS VARIETY IN SRI TIGA VILLAGE, BANYUASIN DISTRICT SOUTH SUMATRA, INDONESIA

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**Abstract.** Coconut (*Cocos nucifera*) is a valuable export commodity and has good prospects in the international market. Coconut cultivation is inseparable from the presence of insect species. The presence of insects in plants is interrelated because plants are places for insects to live and eat. However, not everyone knows the relationship between plants and insects. An inventory of insect biodiversity in an ecosystem needs to be conducted. This information shows the community structure of insects associated with coconut plants and plants that grow around coconut plants. Therefore, this field practice aims to find out the insects associated with coconut plants. Field practice was carried out with a survey in a coconut plantation owned by the people in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency, South Sumatera, Indonesia. The observation was conducted from July to September. Data collection was done by determining 3 coconut plantations with different ages of coconut trees. Data collection was carried out using the purposive sampling method by direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was conducted by collecting insects directly during direct observation and in traps. Specimens that have been collected were identified using a macroscope in the Laboratory of Entomology, Department of Plant Pests and Disease, Faculty of Agriculture, Sriwijaya University. The results of this field practice found 12 species namely *Aleurocanthus* sp., *Aphis cerana*, *Aspidiotus destructor*, *Aulacophora* sp., *Cenephora hirsuta*, *Conocephalus* sp., *Cotesia congregata*, *Dianemobius fascipes*, *Eumorphus westwoodi*, *Macrotermes* sp., *Metisa plana*, *Nipaecoccus nipae*, *Oecophylla* sp., *Oryctes rhinoceros*, *Polistes carnifex*, *Polyrhachis dives*, *Pteroma pendula*, *Tettigidea lateralis*.

**Key words:** *Cocos nucifera*, viridis variety, coconut, insects

**Running title:** Insects Found in Coconut Viridis Variety and Surrounding Wild Plants

## INTRODUCTION

Indonesia has various agricultural sectors such as plantations, horticulture, food crops and forestry plants. The plantation sector in Indonesia makes a significant contribution to the country's economy (Purnomo et al. 2020). In Indonesia, coconut plantations have been widely developed and have become the main income for coconut farmers. Coconut plays a role in the economy, social and state income from non-oil and gas commodities (Ximenes et al. 2021). Coconut production is mostly used for consumption and industry (Hoe 2019). Products resulting from the development of coconut plants that have been widely managed include coconut oil, coconut sugar, dried grated coconut, coconut milk, shells, coconut juice and coconut fiber (Henrietta et al. 2022). Coconut (*Cocos nucifera*) is a tropical plantation commodity that is widespread in Indonesia, the Philippines, India, and several Asia Pacific countries (Hoe 2019). Coconut is a high-value export commodity and has good prospects in the international market. Indonesia is the first considerable coconut-producing country worldwide, followed by the Philippines and India (Zainol et al. 2023). The area of coconut plantations in Banyuasin Regency, Indonesia, in 2022 was 42,599,00 Ha (Badan Pusat Statistik, 2023). The productivity of coconut plants in Banyuasin Regency, Indonesia 2022 reached 46,760,00 tons (Badan Pusat Statistik, 2023).

In coconut cultivation, it is important to understand the life cycle of the plant from seeding to harvest. This stage requires consistent care and monitoring. In coconut cultivation, the process involves selecting quality seeds, proper soil cultivation, and proper care (Thomas et al. 2018). Coconuts thrive in sufficient sunlight, appropriate rainfall, and nutrient-rich soil with effective drainage (Tiemann et al. 2018). The optimal range for coconut plant growth is between pH 5-8 (Fauzana et al. 2021). A deep understanding of these factors can result in sustainable coconut plantations. Furthermore,

regular pruning, fertilizing, and managing pests and diseases are things that need attention (Aulia et al. 2020). A deep understanding of these factors can lead to profitable and sustainable coconut production. On the other hand, In many coconut producing areas, especially in smallholder coconut plantations, fertilizer use and insect management are often not carried out intensively (Zainol et al. 2023). Furthermore, the process of cultivating coconut cannot be separated from the presence of insect species. The existence of insects on plants is interrelated because plants are a place for insects to live and eat (Stam et al. 2014). Insects are also needed by plants during plant pollination (Moreira and Reitas 2020). In addition, insects can cause damage to cultivated plants (Manosathiyadevan et al. 2017).

In coconut plantations, the age of coconut trees varies in each area. This results in differences in plant growth and development from one tree to another, affecting not only nutritional requirements but also harvest patterns and overall productivity (Arumugam 2022). Management appropriate to the coconut plant's age is essential to maximize its health and yield. Coconut trees at varying stages of growth may attract different insect pests, which may prefer specific developmental stages of the trees due to physiological differences. It's essential to identify and manage these pests appropriately, considering the age of the coconut trees for effective pest control. Moreover, insects play various roles in ecosystems and significantly impact human society and the environment, such as pollinators, decomposers, and pests (Chandra et al. 2023). Recent information about insects on coconut trees, especially regarding the different ages of the trees, has yet to be recorded. Therefore, an inventory of insect biodiversity in different plant ages of coconut plantation ecosystem needs to be carried out. The diversity of insect species can be used to indicate changes occurring in the ecosystem (Chowdhury et al. 2023). Identifying the presence of different species of coconut trees of different ages is important. Understanding the insect species can guide integrated pest management strategies.

## MATERIALS AND METHODS

### Study area

Field practice was carried out in people's coconut plantations in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency (Figure 1). Field practice is also conducted at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University. Field practice is carried out from July to September 2023.

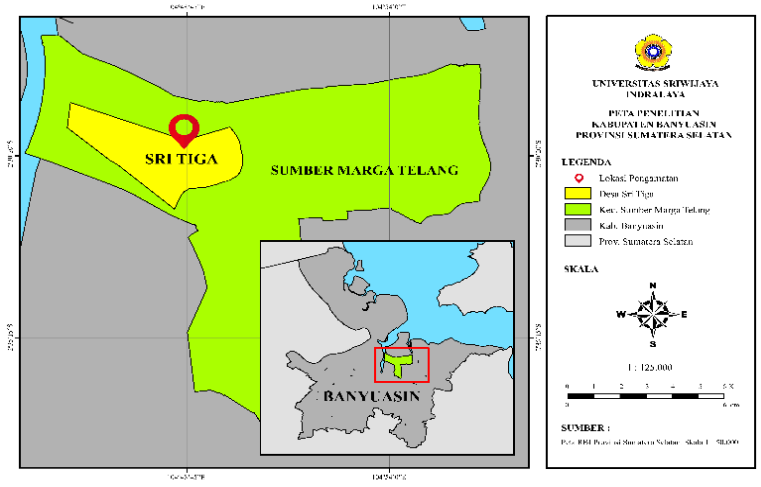



**Figure 1.** Sampling location

**Procedures**

Initial preparations are carried out by conducting a survey to find out the research location and preparing the tools and materials used. Apart from that, a survey was conducted to find out information from the community regarding the use of coconut in Sri Tiga Village, Banyuasin Regency. Data collection was initially carried out by determining three coconut plantations as objects of observation, and then these gardens were observed. Data was collected using the purpose sampling method by making direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was done by collecting insects directly, either during direct observation or in traps. Documentation was carried out in the form of photographs of insects found on coconut plants and wild plants around the coconut plants. Identification of insects found was done by examining insects that are common and have been studied previously. The things studied were similar in terms of color, shape, size, and morphological characteristics of the insects found. The observation parameters in this field practice were the insects caught in each trap. All insects found are then identified. Insect identification was carried out based on morphological characteristics such as head, abdomen, antennae, wings, and others. Each insect found then determines its role in the ecosystem.

**Data analysis**

The data obtained from the observations are presented in the table. The data was then analyzed using R Statistic software. The species diversity index was used to describe the diversity of insect species found in the research area. The diversity index was expressed using the Shannon-Wiener species diversity formula:

$$H' = -\sum \text{Pi In pi}$$

Information:
H': Shannon-Wiener Diversity Index
Pi: ni/N (Comparison between the number of a species and all species)

Description of criteria:
H' < 1 : Low diversity
1 < H' < 3 : Medium diversity
H' > 3 : High diversity

The species evenness index was used to describe the degree of evenness of insect species found in the research area. The evenness index was expressed using the formula:

$$E = \frac{H'}{In\ S}$$

Information:
E : Evenness index (value between 0-1)
H' : Shannon-Wiener diversity index
S : Number of types
Description of criteria:
E < 0.4 : Small population uniformity
0.4 < E < 0.6 : Moderate population uniformity
E > 0.6 : High population uniformity

The species dominance index was used to describe the level of dominance of insect species found in the research area. The dominance index is expressed using the formula:

$$D = \sum Pi^2$$

Information:
D: Simpson Dominance Index
Pi: ni/N (Comparison between the number of a species and all species)
Description of criteria:
0 < D < 0.5 : Low dominance
0.5 < D < 0.75 : Moderate dominance
0.75< D < 1.0 : High dominance

## RESULTS AND DISCUSSION

### Abundance of insects found in coconut trees

The insect species found in three coconut fields with varying plant ages, namely 8 years, 5 years and 2 years, were very diverse. There are 12 species from 4 orders. The four orders found most frequently include the orders Coleoptera, Hemiptera, Hymenoptera and Lepidoptera. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* which comes from the Hemiptera Order, namely 256.33 individuals. This result also found the same thing in coconut fields that were 5 years old, namely dominated by *Nipaecoccus nipae*, with as many as 265.67 individuals. Meanwhile, on 2 year old coconut fields, the insect species that were frequently encountered were Aspidiotus destructor from the Hemiptera Order, namely 96,000. Based on the results of comparing the number of species found in coconut fields of different ages, it was found that there were also different numbers of species (Table 1). In the 2 year old plantation, *Aphis cerana* and *Polistes carnifex* species were not found.

**Table 1.** Abundance of Insects on Coconuts

| Ordo/Spesies | Abundance of insects on coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Oryctes rhinoceros* | 28.00 | 29.00 | 22.67 | $3.20 \times 10^{-1}$ | $1.54^{ns}$ | - |
| **Hemiptera** | | | | | | |
| *Aspidiotus destructor* | 173.33a | 116.33b | 96.00b | $3.62 \times 10^{-3}$ | $31.24^{*}$ | 1.55 |
| *Nipaecoccus nipae* | 256.33a | 265.67a | 18.00b | $5.16 \times 10^{-5}$ | $276.40^{*}$ | 2.07 |
| *Planococcus sp.* | 50.67a | 44.33a | 27.67b | $58.7 \times 10^{-4}$ | $80.55^{*}$ | 0.54 |
| **Hymenoptera** | | | | | | |
| *Aphis cerana* | 5.67a | 4.33b | 0.00c | $3.13 \times 10^{-5}$ | $355.22^{*}$ | 0.25 |
| *Cotesia congregata* | 30.00a | 25.33b | 18.00c | $6.14 \times 10^{-4}$ | $78.70^{*}$ | 0.35 |
| *Dolichoderus thoracicus* | 113.33a | 103.67a | 81.33b | $45.1 \times 10^{-3}$ | $27.78^{*}$ | 0.81 |
| *Oecophylla* sp. | 98.00a | 87.33a | 60.33b | $1.15 \times 10^{-3}$ | $56.91^{*}$ | 0.75 |
| *Polistes carnifex* | 4.00a | 2.33b | 0.00c | $4.52 \times 10^{-4}$ | $92.12^{*}$ | 0.38 |
| **Lepidoptera** | | | | | | |
| *Metisa plana* | 16.33a | 13.67ab | 10.00b | $2.64 \times 10^{-2}$ | $10.31^{*}$ | 0.68 |
| *Pteroma pendula* | 20.67a | 16.67ab | 13.00b | $6.15 \times 10^{-3}$ | $23.50^{*}$ | 0.48 |
| *Pteroma plagiophleps* | 24.00a | 19.00ab | 14.00b | $6.78 \times 10^{-3}$ | $22.28^{*}$ | 0.61 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

### Abundance of insects found in wild plants around coconut trees

Insect species found in wild plants around coconuts were also observed. There are 6 species of insects from 3 orders. The orders found include Coleoptera, Isoptera and Orthoptera. In wild plants around 8 year old and 5 year old coconuts, the most Captotermes sp insects were found. originating from the Order Isoptera, namely 18.00 individuals and 13.67 individuals respectively. Meanwhile, it was very different when the coconuts were 2 years old and no similar species were found at all. In the plants around coconuts that are 2 years old, the most common insects are Conocephalus sp. which came from the Order Orthopetra, namely 10,00 individuals (Table 2).

**Table 2.** Average abundance of insects in wild plants around coconut trees

| Ordo/Spesies | Abundance of Insects in wild plants around Coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Aulacophora* sp. | 14.67a | 8.00b | 7.00b | $9.09 \times 10^{-3}$ | $18.98^{*}$ | 0.71 |
| *Eumorphus westwoodi* | 12.33a | 8.33b | 3.00c | $3.21 \times 10^{-4}$ | $109.67^{*}$ | 0.42 |
| **Isoptera** | | | | | | |
| *Captotermes* sp. | 18.00a | 13.67b | 0.00c | $3.52 \times 10^{-5}$ | $335.07^{*}$ | 0.53 |
| **Orthoptera** | | | | | | |
| *Conocephalus* sp. | 17.00a | 12.00b | 10.00c | $38.9 \times 10^{-4}$ | $99.47^{*}$ | 0.24 |
| *Dianemobius fascipes* | 16.67a | 13.00b | 9.00c | $6.50 \times 10^{-5}$ | $246.00^{*}$ | 0.17 |
| *Tettigidea lateralis* | 10.67a | 8.33ab | 6.67b | $8.19 \times 10^{-3}$ | $20.10^{*}$ | 0.39 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

### Characteristics of insect communities found in coconut trees

The characteristics of the insect community on coconuts aged 8 years, 5 years and 2 years that were analyzed included the diversity index, evenness index and dominance index. The results showed that the community characteristics of each coconut plant aged 8 years, 5 years and 2 years increased with each observation. The diversity, evenness and dominance index of 8-year-old coconut plants was higher than that of 5- and 2-year-old coconut plants (Table 3). This shows that the age of the coconut affects the number of insects found in the field. The higher the diversity index value, the more diverse the species that exist in the community. This index reflects the biological richness of the community. If the evenness index shows a high value, the individuals in the community have a more even distribution among species, while a low value indicates an uneven distribution. Meanwhile, the dominance index measures the extent to which one or several species have significant dominance or ownership in the community.

**Table 3.** Characteristics of insect communities found in coconut trees

| Coconut plants (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Coconut plants (8 years old) | Number of Individuals | 847.00 | 853.00 | 761.00 |
| | Diversity Index (H') | 1.90 | 1.95 | 2.04 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.31 |
| | Dominance Index (D) | 0.34 | 0.32 | 0.28 |
| Coconut plants (5 years old) | Number of Individuals | 754.00 | 734.00 | 695.00 |
| | Diversity Index (H') | 1.86 | 1.90 | 1.97 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.30 |
| | Dominance Index (D) | 0.16 | 0.16 | 0.17 |
| Coconut plants (2 years old) | Number of Individuals | 622.00 | 617.00 | 544.00 |
| | Diversity Index (H') | 1.75 | 1.76 | 1.80 |
| | Eveness Index (E) | 0.27 | 0.27 | 0.29 |
| | Dominance Index (D) | 0.16 | 0.15 | 0.18 |

**The characteristics of insects on wild plants around coconut trees**

Based on the results, it was found that the highest index was found in coconut fields that were 8 years old. Meanwhile, at the age of 2 years, the analysis results were lower (Table 4). This also proves that the age of the coconut greatly influences the number of species found in wild plants around the coconut. The diversity, evenness and dominance indices in coconut plants aged 8 years, 5 years and 2 years experienced increases and decreases in population numbers. The diversity index in wild plants around 8-year-old coconut plants is higher compared to 5- and 2-year-old coconut plants. Meanwhile, the evenness and dominance index of wild plants around 2-year-old coconut plants was higher than that of 8- and 5-year-old coconut plants.

**Table 4.** Characteristics of insect communities in wild plants around coconut trees

| Wild plants around the coconut trees (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Wild plants around the coconut plants (8 years old) | Number of Individuals | 99.00 | 92.00 | 77.00 |
| | Diversity Index (H') | 1.78 | 1.77 | 1.77 |
| | Eveness Index (E) | 0.39 | 0.39 | 0.41 |
| | Dominance Index (D) | 0.19 | 0.22 | 0.21 |
| Wild plants around the coconut plants (5 years old) | Number of Individuals | 72.00 | 65.00 | 53.00 |
| | Diversity Index (H') | 1.77 | 1.75 | 1.76 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.44 |
| | Dominance Index (D) | 0.21 | 0.23 | 0.23 |
| Wild plants around the coconut plants (2 years old) | Number of Individuals | 42.00 | 37.00 | 28.00 |
| | Diversity Index (H') | 1.54 | 1.53 | 1.54 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.46 |
| | Dominance Index (D) | 0.26 | 0.30 | 0.32 |

**Relative abundance of insects found in coconut trees**

The relative abundance of insects on coconuts aged 8 years, 5 years and 2 years varied greatly. At plant ages of 8 years and 5 years, the abundance of insects in the Order Hemiptera was found, namely 59.00% and 58.00% respectively. while the lowest order is the Order Coleoptera which is only 3.00% and 4.00% respectively. In contrast to the age of 2 years, the most insect species found were from the Order Hymenoptera, namely 48.00% and the lowest species were in the Orders Lepidopeta and Hymenoptera, which was only 7.00% (Figure 2).

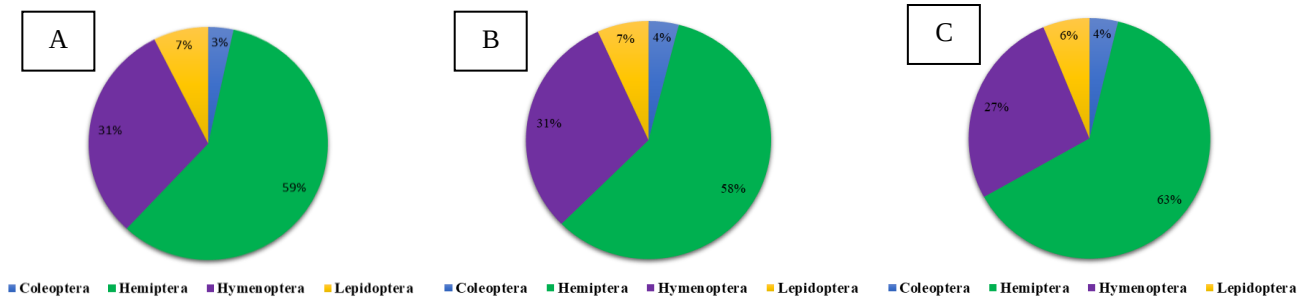



**Figure 2.** Abundance of insects found in coconut trees at: A) 8 years old, B) 5 years old, C) 2 years old.

**Relative abundance of insects found in wild plants around coconut trees**

The relative abundance of insects in wild plants around coconut plants was only found in 3 orders, namely the orders Coleoptera, Isoptera and Orthoptera. In plants aged 8 years, 5 years, and 2 years, the most Orthoptera orders were found, namely 50.00%, 53.00% and 72.00% respectively. Meanwhile, in the area around 2-year-old coconuts, only two orders were found, namely Coleoptera and Orthoptera (Figure 3).

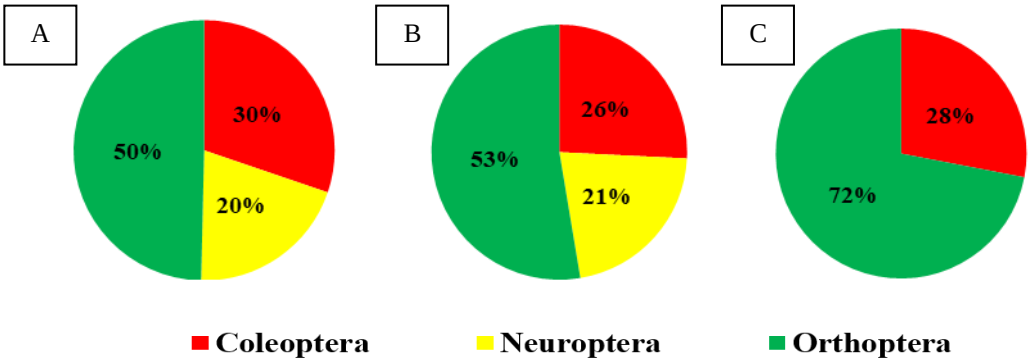



**Figure 3.** Abundance of insects on wild plants around coconut trees at different age of coconut: A) 8 years old, B) 5 years old, C) 2 years old.

The results of observations found 18 species of insects associated with coconut plants and surrounding wild plants. The 18 insect species act as phytophagous, pollinators and natural enemies. The dominant insects belong to the orders Hemiptera and Hymenoptera. The insects are *Aspidiotus destructor* (Figure 4a), *Nipaecoccus nipae* (Figure 4b), *Aleurocanthus* sp. (Figure 4c), *Polyrhachis dives* (Figure 4d), *Oecophylla* sp. (Figure 4e).

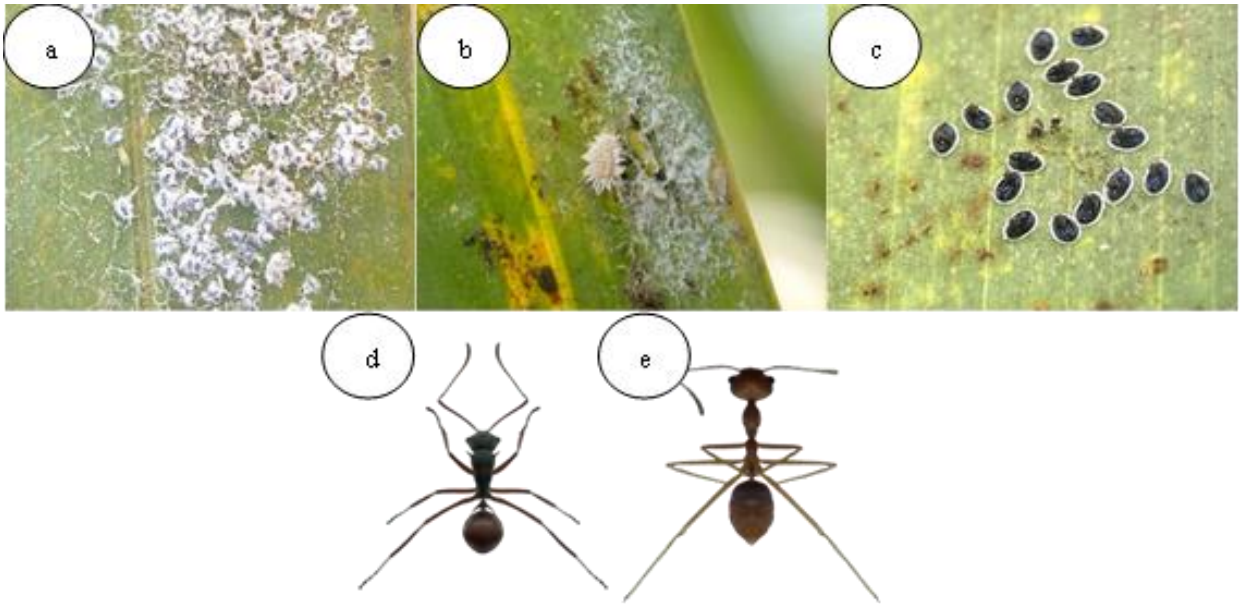



**Figure 3.** The dominant insects are found on coconut plants and surrounding plants. *Aspidiotus destructor* (a), *Nipaecoccus nipae* (b), *Aleurocanthus* sp. (c), *Polyrhachis dives* (d) dan *Oecophylla* sp. (e)

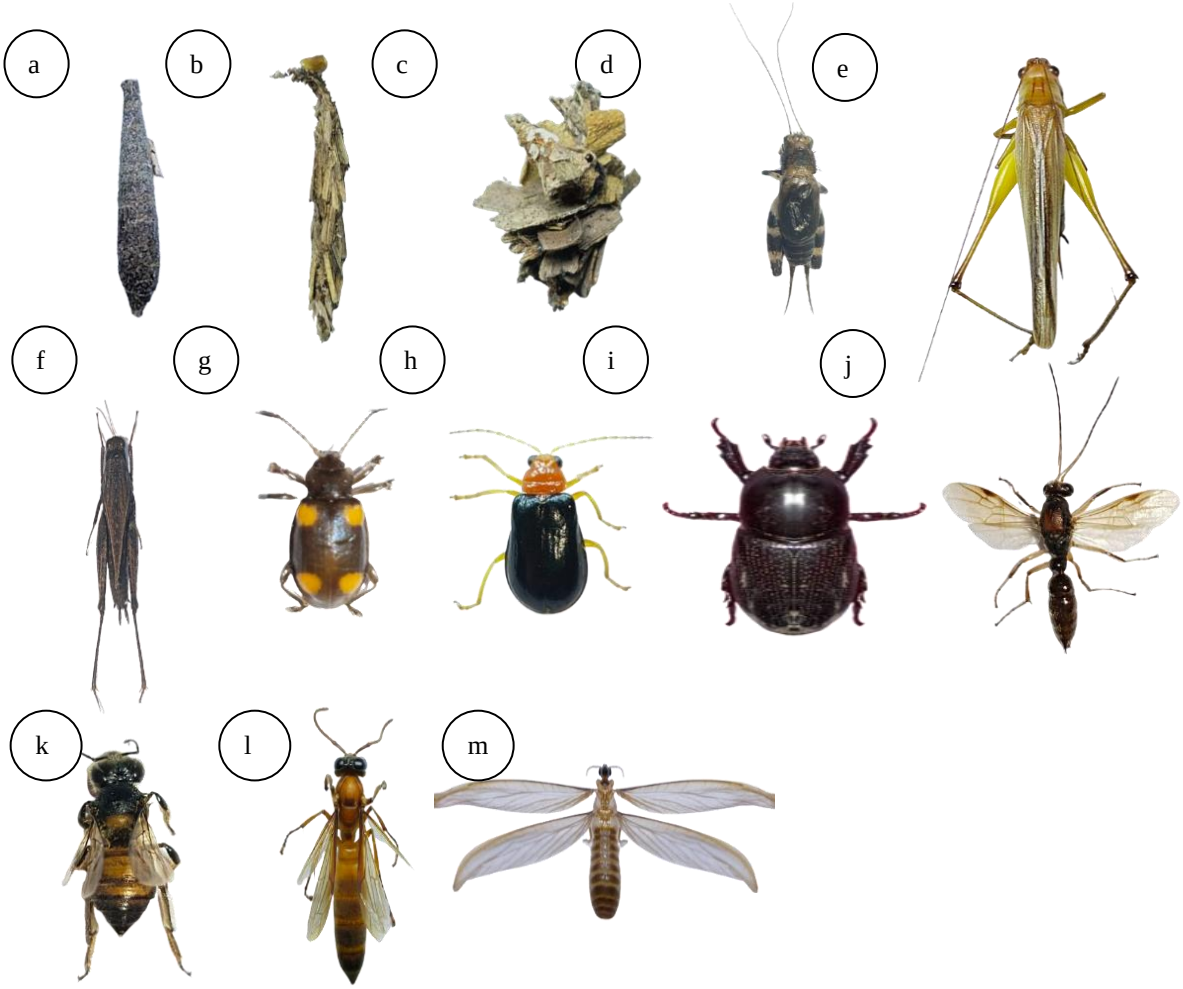



**Figure 4.** The non-dominant insects are found on coconut plants and surrounding plants. *Pteroma pendula* (a), *Cenephora hirsuta* (b), *Metisa plana* (c), *Dianemobius fascipes* (d), *Conocephalus* sp. (e), *Tettigidea lateralis* (f), *Eumorphus westwoodi* (g), *Aulacophora* sp. (h), *Oryctes rhinoceros* (i), *Cotesia congregata* (j), *Aphis cerana* (k) *Polistes carnifex* (l) and *Mactrotermes* sp. (m).

## Discussion

The results of observations in the field showed that the number of insects caught using traps in coconut plantations was identified as 7 orders, 18 species with a total of 2330.67 individuals. However, this research observation was divided into two parts, namely on coconut plants and on wild plants around coconuts which have various ages. Observations on coconuts of various ages showed findings of 4 orders and 12 species of insects. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* which comes from the order Hemiptera, namely 256.33 individuals. supported by research by Ganganalli et al. (2023), that the species of aphids that are most often found on coconuts. Meanwhile, in the wild plants around coconut, there are 3 orders and 6 species. The 6 insect species belong to the orders Coleoptera, Isoptera and Orthoptera. *Captotermes* sp dominated coconuts aged 8 years. Meanwhile, coconuts aged 2 years old, the most common insects were *Conocephalus* sp. which comes from the order Orthopetra. The seven orders found, including the orders Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Coleoptera, Isoptera and Orthoptera, have various roles in the ecosystem. This coconut plants species were found that have roles as pests, predators, parasitoids and also pollinators (Kavitha et al. 2023). Direct observation was carried out by recording the condition or behavior of the object being observed (Vislobokov 2017). There were species *A. destructor, N. nipae, Aleurocanthus* sp., *P. pendula, C. hirsuta*, and *M. Plana* recorded by using the direct observation method. On the other hand, the traps were used to collected the fly or active insects such as insect nets, light traps and pheromones traps (Haneda et al. 2017). According to Iswara et al. (2022), traps are designed based on insect behaviour and attraction to certain lights, shapes and colours. The species obtained using the insect nets and the light trap were *E. westwoodi. Aulacophora* sp., *A. cerana, P. carnifex, Conocephalus* sp., and *T. lateralis.* Meanwhile, *O. rhinoceros* was found in the pheromone trap. Pheromones traps are traps used to attract male insects (Maruthadurai and Ramesh, 2020). Pheromones trap was effectively to monitor and control the adults of *O. rhinoceros* (Paudel et al. 2023).

*Aspidiotus destructor* Signoret (Hemiptera: Diaspididae) is an coconut scale (Serrana et al. 2023). The coconut scale was found in the highest numbers at every age of coconut. The insect scale had also been confirmed to cause significant economic losses to the coconut industry in the Philippines (Serrana et al. 2019). Moreover, coconut bud borer beetles (*O. rhinoceros* L) were found at all ages of coconut. *O. rhinoceros* is one of the main pests that causes damage to germplasm in coconut (Paudel et al. 2022). In Indonesia, *O. rhinoceros* is a threat to both coconut and oil palm plants (Rahayuwati et al. 2020). These beetles are known to attack palm trees by boring into the crown and eating developing fronds (leaves that have not yet opened), which can cause death or stunted growth in young palm trees if the infestation is severe (Chalapathi Rao et al. 2018; Paudel et al. 2021, 2023). For mature oil palm trees, this damage can result in reduced productivity. This was also confirmed by Parnidi et al. (2022), that the average damage caused by this pest investment ranges from 0 to 16.7%. This study showed that there were different insects at each age of coconut. The plant age can influence the number of species and the number of individuals (Myers and Sarfraz, 2017; Santi et al. 2023). As plants grow and mature, they provide different habitats and resources that can support a variety of insects species (Schowalter 2016). Older plants tend to have more developed and complex ecosystems with greater insects species diversity (Schowalter 2017). Additionally, mature plants are often larger and have more resources, so they can support more individuals in their ecosystem (Lindenmayer and Laurance 2016). However, the specific impact of plant age on insect species and the number of insect individuals may vary depending on plant species, environmental conditions, and other factors (Myers and Sarfraz 2017).

The insect diversity index on coconut plants and surrounding wild plants in Sri Tiga Village from week 1 to week 3 shows a diversity value of $1 < H' < 3$, this is in the medium category. This criterion shows the diversity of pests and natural enemies which increases in number as the population increases towards balance. According to Hasibuan et al. (2019), there are 3 criteria for insect species diversity, namely low species diversity if $H < 1$ (unstable environmental conditions), desang species diversity if H 1-3 (medium environmental conditions), and high species diversity if $H > 3$ (stable environmental conditions). The results of the dominance index calculation obtained on coconut plants and surrounding wild plants from week 1 to week 3 showed a dominance value of $0 < D < 0.5$. This means that the dominance of these insects is relatively low. The Evenness Index (E) value is 0.29-0.31 in the depressed category. According to Hasibuan et al. (2019), there are 3 criteria for the community environment based on its evenness value, namely if $E < 0.50$ then the community is in a depressed condition. If 0.50 < E' 0.75 then society is in a stable condition, while 0.75 < E' 1.00 means society is in an unstable condition. The evenness index value (E') can describe the stability of a community. The smaller the value of E' or closer to zero, the more uneven the distribution of organisms in a community that is dominated by a certain type and conversely, the greater the value of E' or close to one, the organisms in that community will be evenly distributed (Ambarwati et al. 2023). Apart from being influenced by plant age, insect diversity can be influenced by climate and weather factors (Subedi et al. 2023). From July to September 2023, Sri Tiga Village faced the dry season. The dry season is characterized by decreased rainfall and increased temperatures, disrupting the life cycle of insects. According to Paliama et al. (2022), increasing global temperatures can affect the life cycle of insects. In addition, dry seasons can cause drought and reduce water availability for insects (Benoit et al. 2023). This condition may affect the ability of insect to tolerate climatic factors in an ecosystem.

## ACKNOWLEDGEMENTS

The authors thank to farmers of smallholding coconut plantation in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia to allow the authors observed the insect in coconut trees. This research was part of a research project, and the chairman of the research project was Erise Anggraini, with contract number 0094.073/UN9/SB3.LP2M.PT/2023.

## REFERENCES

Ambarwati M, Dewi K, Aurina DM, Faturrahman AD, Fatikha LAY, Rachmalia F, Ainaya FA, Kinanthi A, Rohman, CM, Pradhana F, Fadzilah A, Pramudita DA, Ramadhan MF, Mahajoeno E, Nugroho GDWI, Sujarta P, Yap CK, Adha K, Rahim BINA, Setyawan ADWI. 2023. Ecological index and economic potential of mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia. Biodiversitas 24: 1231–1241. DOI: 10.13057/biodiv/d240265

Arumugam T. (2022). Improving coconut using modern breeding technologies. Plants 11: 1-22. DOI: 10.3390/plants11243414

Aulia AN, Chasanah N, Prasetyo AS, Nalawati AN. 2020. Competitiveness and export similairity of Indonesia's coconut oil. J Agribest 04: 123–132. DOI: 10.32528/agribest.v4i2.3546

Badan Pusat Statistik. 2023. *Luas Areal dan Produksi Perkebunan Kelapa Rakyat Menurut Kecamatan*. https://banyuasinkab.bps.go.id/indicator/54/151/1/luas-areal-dan-produksi-perkebunan-kelapa-rakyat-menurut-kecamatan.html

Benoit JB, Mccluney KE, Degennaro MJ. (2023). Dehydration dynamics in terrestrial arthropods: from water sensing to trophic interactions. Annu Rev Entomol 68: 129–149. DOI: 10.1146/annurev-ento-120120-091609

Chalapathi Rao NBV, Snehalatharani A, Nischala A, Ramanandam G, Maheswarappa HP. 2018. Management of rhinoceros beetle (*Oryctes rhinoceros* L.) by biological suppression with *Oryctes baculovirus* in Andhra Pradesh. J Plant Crops 46: 124-127. DOI: 10.25081/jpc.2018.v46.i2.3725

Chandra R., Abdul M, Sharma N, Bharathi K, Singh S. 2023. The role of insects in ecosystems, an in-depth review of entomological. International J Environ and Climate Change 13:4340–4348. DOI: 10.9734/IJECC/2023/v13i103110

Chowdhury S, Dubey VK, Choudhury S, Kumar N, Semwal A, Kumar V. 2023. Insects as bioindicator : A hidden gem for environmental monitoring. Front. Environ. Sci 11: 1–16. DOI: 10.3389/fenvs.2023.1146052

Ganganalli SM, Bhaskar H, Joshi, S, Vidya CV. 2023. Diversity of Aphid Fauna (Hemiptera: Aphididae) of Kerala. Indian J Entomol 1–8. DOI: 10.55446/ije.2023.742

Haneda NF, Wibowo C, Hasbi M. 2017. Peranan arthropoda di ekosistem ekoton dan kelapa sawit. J Silvikultur Tropika 8: 116–122. DOI: 10.29244/j-siltrop.8.2.116-122

Hasibuan EW, Siregar AZ, Pinem MI. 2019. Diversity of insect in coconut plant in Kelurahan Besar, Medan Labuhan District, North of Sumatra. Inter J Trend in Research and Develop 6: 7–13.

Henrietta HM, Kalaiyarasi K, Raj AS. 2022. Coconut tree (*Cocos nucifera*) products : a review of global cultivation and its coconut tree (C*ocos nucifera*) products : a review of global cultivation and its benefits. J Sus and Environ Manage. DOI: 10.3126/josem.v1i2.45377

Hoe TK. 2019. *The Current Scenario and Development of the Coconut Industry*. *February*

Iswara D, Afifah L, Abadi S, Prabowo D, Irfan B, Widiawan AB. 2022. Kelimpahan serangga pada berbagai perangkap dengan beberapa teknik pengendalian berbeda pada pertanaman jagung pioneer 36. J Agroplasma 9: 213–224

Lindenmayer DB, Laurance WF. 2016. The ecology, distribution, conservation and management of large old trees. Biological Reviews 93: 1434-1458. DOI: 10.1111/brv.12290

Manosathiyadevan M, Bhuvaneshwari V, Latha R. 2017. Impact of insects and pests in loss of crop production: a review. in a Dhanarajan (Ed.). Springer Singapore 57-67. DOI: 10.1007/978-981-10-6647-4_4

Maruthadurai R, Ramesh, R. 2020. Mass trapping of red palm weevil and rhinoceros beetle in coconut with aggregation pheromone. Indian J Entomol 82: 439–441. DOI: 10.5958/0974-8172.2020.00114.5

Moreira MM, Reitas LF. 2020. Review of the pollination system by small diverse insects. Neotrop Entomol, 472–481. DOI: 10.1007/s13744-020-00779-6

Myers JH, Sarfraz RM. 2017. Impacts of insect herbivores on plant populations. Annu. Rev. Entomol. DOI: 10.1146/annurev-ento-010715-023826

Paliama HG, Latumahina FS, Wattimena CMA. 2022. Keanekaragaman serangga dalam kawasan hutan mangrove di Desa Ihamahu. *Jurnal Tengkawang* 12: 94–104. DOI: 10.26418/jt.v12i1.53861

Parnidi P, Sunarto DA, Marjani M. 2022. Shoot borers beetle pest of coconut (*Oryctes rhinoceros* L.) investment at *Agave* spp. Bioeduscience 6: 89–95. DOI: 10.22236/j.bes/616282

Paudel S, Jackson TA, Mansfield S, Ero M, Moore A, Marshall SDG. 2023. Use of pheromones for monitoring and control strategies of coconut rhinoceros beetle (*Oryctes rhinoceros*): A review. Crop Protection . DOI: 10.1016/j.cropro.2023.106400

Paudel S, Mansfield S, Villamizar LF, Jackson TA, Marshall SDG. 2021. Can biological control overcome the threat from newly invasive coconut rhinoceros beetle populations (Coleoptera: Scarabaeidae)? A review. Annals Entomol Society of America 114: 247–256. DOI: doi.org/10.1093/aesa/saaa057

Paudel S, Marshall SDG, Richards NK, Hazelman G, Tanielu P, Jackson TA. 2022. Coconut rhinoceros beetle in Samoa: review of a century-old invasion and prospects for control in a changing future. Insects 1–15. DOI: 10.3390/insects13050487

Purnomo H, Okarda B, Dermawan A, Pebrial Q, Pacheco P, Nurfatriani F, Suhendang E. 2020. Forest policy and economics reconciling oil palm economic development and environmental conservation in Indonesia: a value chain dynamic approach. Forest Policy and Economics, 111: 1-12. DOI: 10.1016/j.forpol.2020.102089

Rahayuwati S, Kusumah YM, Prawirosukarto S, Dadang, Santoso T. 2020. The status of *Oryctes rhinoceros nudivirus* (OrNV) infection in *oryctes rhinoceros* (Coleoptera: Scarabaeidae) in Indonesia. Journal of Oil Palm Research 32: 582–589 [Indonesian]

Santi I, Tarmadja S, Priambada KJ, Elfatma O. 2023. Keanekaragaman serangga perkebunan kelapa sawit di Provinsi Kalimantan Tengah. Jurnal Ilmiah Hijau Cendekia 8:45. DOI: 10.32503/hijau.v8i1.2917

Schowalter TD. 2017. Arthropod diversity and functional importance in old-growth forests of North America. Forests. DOI: 10.3390/f8040097

Schowalter TD. 2016. Insect Ecology: An Ecosystem Approach. Academic press.

Serrana JM, Almarinez BJM, Barrion AT, Amalin DM. 2023. Ultrastructural characterization of the scale cover of cryptic *Aspidiotus* spp. (Hemiptera: Diaspididae) and the ovipositor of their parasitoids. Microscopy and Microanalysis 29: 825–831. DOI: 10.1093/micmic/ozac041

Serrana JM, Ishitani N, Carvajal TM, Almarinez BJM, Barrion AT, Amalin DM, Watanabe K. 2019. Unraveling the genetic structure of the coconut scale insect pest (*Aspidiotus rigidus* Reyne) outbreak populations in the Philippines. Insects. DOI: 10.3390/insects10110374

Stam JM, Kroes A, Li Y, Gols R, Loon JJAV, Poelman EH, Dicke M. 2014. Plant interactions with multiple insect herbivores : from community to genes. Annu. Rev. Plant Biol 65: 689–713. DOI: 10.1146/annurev-arplant-050213-035937

Subedi B, Poudel A, Aryal S. 2023. The impact of climate change on insect pest biology and ecology : Implications for pest management strategies, crop

production , and food security. J Agriculture and Food Research. DOI: 10.1016/j.jafr.2023.100733
Thomas GV, Krishnakumar V, Dhanapal R, Srinivasa Reddy DV. 2018. Preharvest approaches to control insect infestation in fruit. Elsevier. DOI: 10.1007/978-981-13-2754-4_7
Tiemann TT, Donough CR, Lim YL, Härdter R, Norton R, Tao HH, Jaramillo R, Satyanarayana T, Zingore S, Oberthür T. 2018. Chapter four-feeding the palm: a review of oil palm nutrition. Advances in Agronomy 152: 149–243). DOI: 10.1016/bs.agron.2018.07.001
Vislobokov NA. 2017. Flowering biology of Aspidistra (a sparagaceae): new data on pollination by dipteran insects. Plant Species Biology 32: 412–422. DOI: 10.1111/1442-1984.12175
Ximenes R, Nurmalina R, Rifin A. 2021. Demand analysis of Indonesia's coconut crude oil in Germany. Review of Economics and Finance 19: 281–285. DOI: 10.55365/1923.x2021.19.39
Zainol FA, Arumugam N, Norhayate W, Daud W, Aisyah N, Suhaimi M. 2023. Coconut value chain analysis : a systematic review. Agriculture. DOI: 10.3390/agriculture13071379

February 2024

Dear Editors,
BIODIVERSITAS Journal of Biological Diversity

As requested, this is our response to reviewers' comments and suggestions.

Thank you so much for a very kind attention and great helps provided by editorial team of BIODIVERSITAS Journal of Biological Diversity.

**"Letter on responses to reviewers' comments and suggestions"**

| No. | Location in manuscript | Reviewers' suggestion | Our response |
|---|---|---|---|
| 1 | Reference | Please follow the guidance the reference | We already revised the reference based on the guidance |

Best regards,

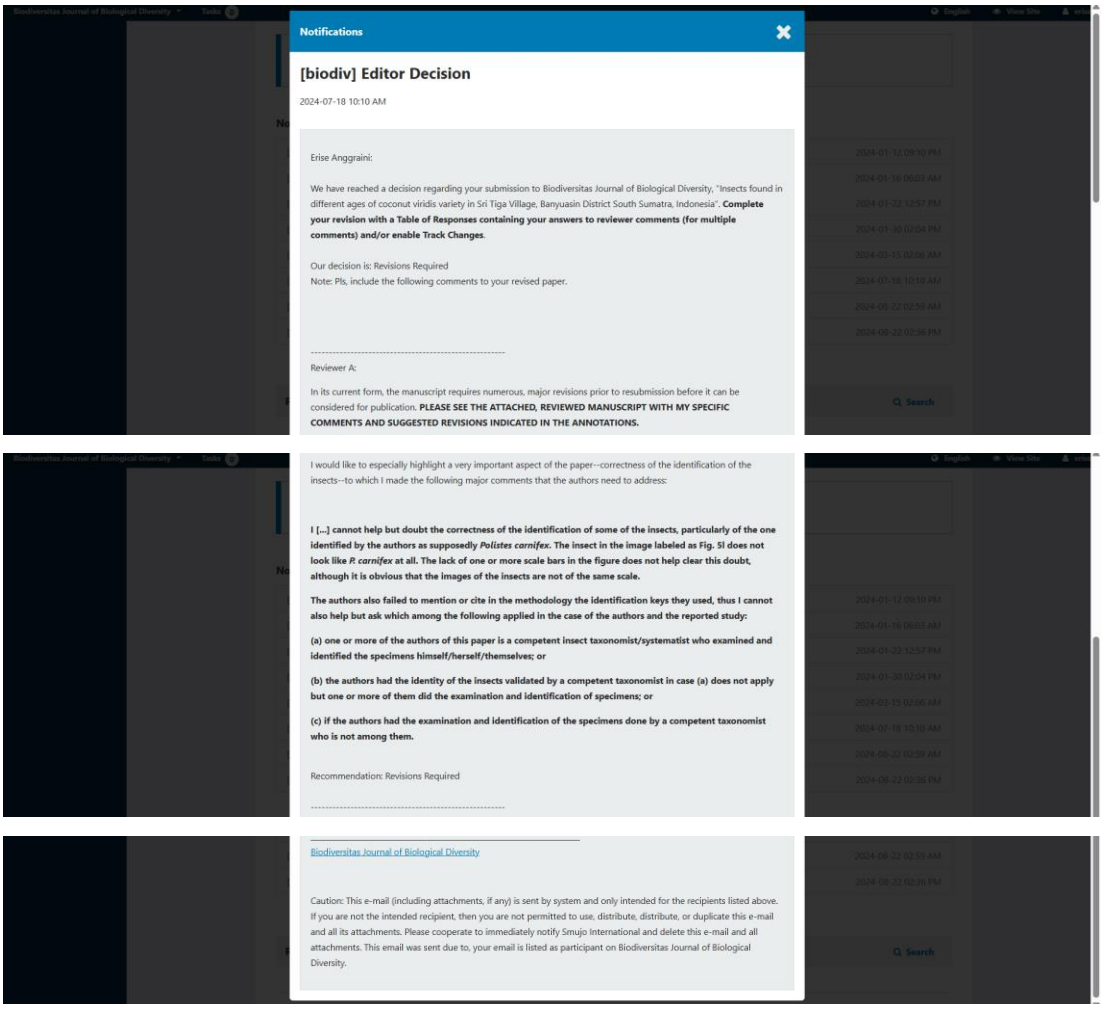
Corresponding author,

Erise

## *Peer review round 5 (15 Maret 2024)*


## *Peer review round 6*

## *Peer review round 7 (18 Juli 2024)*



Notifications

[biodiv] Editor Decision

2024-07-18 10:10 AM

Erise Anggraini:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Insects found in different ages of coconut viridis variety in Sri Tiga Village, Banyuasin District South Sumatra, Indonesia". **Complete your revision with a Table of Responses containing your answers to reviewer comments (for multiple comments) and/or enable Track Changes**.

Our decision is: Revisions Required
Note: Pls, include the following comments to your revised paper.

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Reviewer A:

In its current form, the manuscript requires numerous, major revisions prior to resubmission before it can be considered for publication. **PLEASE SEE THE ATTACHED, REVIEWED MANUSCRIPT WITH MY SPECIFIC COMMENTS AND SUGGESTED REVISIONS INDICATED IN THE ANNOTATIONS.**

I would like to especially highlight a very important aspect of the paper--correctness of the identification of the insects--to which I made the following major comments that the authors need to address:

**I [...] cannot help but doubt the correctness of the identification of some of the insects, particularly of the one identified by the authors as supposedly *Polistes carnifex*. The insect in the image labeled as Fig. S1 does not look like *P. carnifex* at all. The lack of one or more scale bars in the figure does not help clear this doubt, although it is obvious that the images of the insects are not of the same scale.**

**The authors also failed to mention or cite in the methodology the identification keys they used, thus I cannot also help but ask which among the following applied in the case of the authors and the reported study:**

**(a) one or more of the authors of this paper is a competent insect taxonomist/systematist who examined and identified the specimens himself/herself/themselves; or**

**(b) the authors had the identity of the insects validated by a competent taxonomist in case (a) does not apply but one or more of them did the examination and identification of specimens; or**

**(c) if the authors had the examination and identification of the specimens done by a competent taxonomist who is not among them.**

Recommendation: Revisions Required

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Biodiversitas Journal of Biological Diversity

Reviewer:

Reviewer 1

Comments for the Authors:

The manuscript titled "Insects found in different ages of coconut viridis variety in Sri Tiga Village, Banyuasin District, South Sumatra, Indonesia" is appropriate for the journal. The research conducted by the authors is highly relevant in the exploration of insect biodiversity across different stages of coconut plant growth. The results hold great promise and warrant further comprehensive evaluations. .

As listed below, some aspects should be clarified or revised:

| Location in manuscript | Reviewers' suggestion |
|---|---|
| 17-19 | Please rewrite the sentence to be more academic |
| 23 | Year? |
| 24 | Specify the ages |
| 27-30 | Please add closing statement after the result |
| 71-73 | Please describe the climate condition and type of ecosystem of the study area. The information is crucial |
| 82-83 | Describe the information about plantation chosen. What is the specification of the plantation |
| 84 | Explain in more detail |
| 86 | Need to be careful about this wild plants? Do you mean weeds? And please describe why is it important to observe them. Please state it in the introduction section |
| 87 | By whom? Any publication? Please cite the reference |
| 143 | This 'wild plants' is very ambiguous |
| 161-166 | Describe the Table 3 |
| 207 | It would be great if you make one more table containing the species and the role of each of them. This information is necessary for pest control. |
| 242-249 | Please add more explanation about the role another 4 dominant species *Nipaecoccus nipae* (b), *Aleurocanthus* sp. (c), *Polyrhachis dives* (d) dan *Oecophylla* sp. (e). |

| | |
|---|---|
| 304-305 | Then further study is required to validate the data and for comparison in different season and climate condition. |

**Reviewer:**
**Sultan Ahmmed, Ph.D**
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# Insects found in different ages of coconut viridis variety in Sri Tiga Village, Banyuasin District South Sumatra, Indonesia

**Abstract.** Coconut (*Cocos nucifera*) is a valuable export commodity and has good prospects in the international market. Coconut cultivation is inseparable from the presence of insect species. The presence of insects in plants is interrelated because plants are places for insects to live and eat. However, not everyone knows the relationship between plants and insects. An inventory of insect biodiversity in an ecosystem needs to be conducted. This information shows the community structure of insects associated with coconut plants and plants that grow around coconut plants. -Therefore, this field practice aims to find out the insects associated with coconut plants. Field practice was carried out with a survey in a coconut plantation owned by the people in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency, South Sumatera, Indonesia. –The observation was conducted from July to September. Data collection was done by determining 3 coconut plantations with different ages of coconut trees. Data collection was carried out using the purposive sampling method by direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was conducted by collecting insects directly during direct observation and in traps. Specimens that have been collected were identified using a macroscope in the Laboratory of Entomology, Department of Plant Pests and Disease, Faculty of Agriculture, Sriwijaya University. The results of this field practice found 12 species namely *Aleurocanthus* sp., *Aphis cerana*, *Aspidiotus destructor*, *Aulacophora* sp., *Cenephora hirsuta*, *Conocephalus* sp., *Cotesia congregata*, *Dianemobius fascipes*, *Eumorphus westwoodi*, *Macrotermes* sp., *Metisa plana*, *Nipaecoccus nipae*, *Oecophylla* sp., *Oryctes rhinoceros*, *Polistes carnifex*, *Polyrhachis dives*, *Pteroma pendula*, *Tettigidea lateralis*.

**Key words:** *Cocos nucifera*, viridis variety, coconut, insects

**Running title:** Insects Found in Coconut Viridis Variety and Surrounding Wild Plants

## INTRODUCTION

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Indonesia has various agricultural sectors such as plantations, horticulture, food crops and forestry plants. The plantation sector in Indonesia makes a significant contribution to the country's economy (Purnomo et al. 2020). In Indonesia, coconut plantations have been widely developed and have become the main income for coconut farmers. Coconut plays a role in the economy, social and state income from non-oil and gas commodities (Ximenes et al. 2021). Coconut production is mostly used for consumption and industry (Hoe 2019). Products resulting from the development of coconut plants that have been widely managed include coconut oil, coconut sugar, dried grated coconut, coconut milk, shells, coconut juice and coconut fiber (Henrietta et al. 2022). Coconut (*Cocos nucifera*) is a tropical plantation commodity that is widespread in Indonesia, the Philippines, India, and several Asia Pacific countries (Hoe 2019). Coconut is a high-value export commodity and has good prospects in the international market. Indonesia is the first considerable coconut-producing country worldwide, followed by the Philippines and India (Zainol et al. 2023). The area of coconut plantations in Banyuasin Regency, Indonesia, in 2022 was 42,599,00 Ha (Badan Pusat Statistik, 2023). The productivity of coconut plants in Banyuasin Regency, Indonesia 2022 reached 46,760,00 tons (Badan Pusat Statistik, 2023).

In coconut cultivation, it is important to understand the life cycle of the plant from seeding to harvest. This stage requires consistent care and monitoring. In coconut cultivation, the process involves selecting quality seeds, proper soil cultivation, and proper care (Thomas et al. 2018). Coconuts thrive in sufficient sunlight, appropriate rainfall, and nutrient-rich soil with effective drainage (Tiemann et al. 2018). The optimal range for coconut plant growth is between pH 5-8 (Fauzana et al. 2021). A deep understanding of these factors can result in sustainable coconut plantations. Furthermore, regular pruning, fertilizing, and managing pests and diseases are things that need attention (Aulia et al. 2020). A deep understanding of these factors can lead to profitable and sustainable coconut production. On the other hand, In many coconut producing areas, especially in smallholder coconut plantations, fertilizer use and insect management are often not carried out intensively (Zainol et al. 2023). Furthermore, the process of cultivating coconut cannot be separated from the presence of insect species. The existence of insects on plants is interrelated because plants are a place for insects to live and eat (Stam et al. 2014). Insects are also needed by plants during plant pollination (Moreira and Reitas 2020). In addition, insects can cause damage to cultivated plants (Manosathiyadevan et al. 2017).

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In coconut plantations, the age of coconut trees varies in each area. This results in differences in plant growth and development from one tree to another, affecting not only nutritional requirements but also harvest patterns and overall productivity (Arumugam 2022). Management appropriate to the coconut plant's age is essential to maximize its health and yield. Coconut trees at varying stages of growth may attract different insect pests, which may prefer specific developmental stages of the trees due to physiological differences. It's essential to identify and manage these pests appropriately, considering the age of the coconut trees for effective pest control. Moreover, insects play various roles in ecosystems and significantly impact human society and the environment, such as pollinators, decomposers, and pests (Chandra et al. 2023). Recent information about insects on coconut trees, especially regarding the different ages of the trees, has yet to be recorded. Therefore, an inventory of insect biodiversity in different plant ages of coconut plantation ecosystem needs to be carried out. The diversity of insect species can be used to indicate changes occurring in the ecosystem (Chowdhury et al. 2023). Identifying the presence of different species of coconut trees of different ages is important. Understanding the insect species can guide integrated pest management strategies.

## MATERIALS AND METHODS

### Study area

Field practice was carried out in people's coconut plantations in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency (Figure 1). Field practice is also conducted at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University. Field practice is carried out from July to September 2023.

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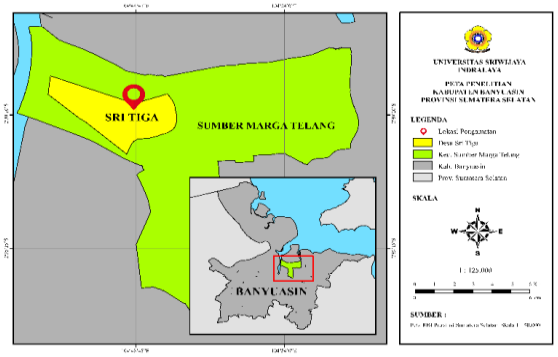


**Figure 1.** Sampling location

**Procedures**

Initial preparations are carried out by conducting a survey to find out the research location and preparing the tools and materials used. Apart from that, a survey was conducted to find out information from the community regarding the use of coconut in Sri Tiga Village, Banyuasin Regency. Data collection was initially carried out by determining three coconut plantations as objects of observation, and then these gardens were observed. Data was collected using the purpose sampling method by making direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was done by collecting insects directly, either during direct observation or in traps. Documentation was carried out in the form of photographs of insects found on coconut plants and wild plants around the coconut plants. Identification of insects found was done by examining insects that are common and have been studied previously. The things studied were similar in terms of color, shape, size, and morphological characteristics of the insects found. The observation parameters in this field practice were the insects caught in each trap. All insects found are then identified. Insect identification was carried out based on morphological characteristics such as head, abdomen, antennae, wings, and others. Each insect found in the study~~then~~ determines its role in the ecosystem.

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**Data analysis**

The data obtained from the observations are presented in the table. The data was then analyzed using R Statistic software.

The species diversity index was used to describe the diversity of insect species found in the research area. The diversity index was expressed using the Shannon-Wiener species diversity formula:

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$$H' = -\sum Pi \ In \ pi$$

Information:
H': Shannon-Wiener Diversity Index
Pi: ni/N (Comparison between the number of a species and all species)
Description of criteria:
H' < 1 : Low diversity
1 < H' < 3 : Medium diversity
H' > 3 : High diversity

The species evenness index was used to describe the degree of evenness of insect species found in the research area. The evenness index was expressed using the formula:

$$E = \frac{H'}{In \ S}$$

Information:
E : Evenness index (value between 0-1)
H' : Shannon-Wiener diversity index
S : Number of types
Description of criteria:
E < 0.4 : Small population uniformity

0.4 < E < 0.6 : Moderate population uniformity
E > 0.6 : High population uniformity

The species dominance index was used to describe the level of dominance of insect species found in the research area. The dominance index is expressed using the formula:

$$D = \sum Pi^2$$

Information:
D: Simpson Dominance Index
Pi: ni/N (Comparison between the number of a species and all species)
Description of criteria:
0 < D < 0.5 : Low dominance
0.5 < D < 0.75 : Moderate dominance
0.75< D < 1.0 : High dominance

## RESULTS AND DISCUSSION

### Abundance of insects found in coconut trees

The insect species found in three coconut fields with varying plant ages, namely 8 years, 5 years and 2 years, were very diverse. There ~~are~~ were 12 species from 4 orders. The four orders found most frequently ~~include~~ belongs to the orders Coleoptera, Hemiptera, Hymenoptera and Lepidoptera. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* of 256.33 individuals which comes from the Hemiptera Order~~, namely 256.33 individuals~~. This result also found the same thing in coconut fields ~~that were~~of 5 years old, ~~namely~~ dominated by *Nipaecoccus nipae*, with as many as 265.67 individuals. Meanwhile, on 2 year old coconut fields, the insect species that were frequently encountered were *Aspidiotus destructor* of 96,000 individuals from the Hemiptera Order, ~~namely 96,000~~. Based on the results of comparing the number of species found in coconut fields of different ages, it was found that there were also different numbers of species (Table 1). In the 2 year old plantation, *Aphis cerana* and *Polistes carnifex* species were not found.

**Table 1.** Abundance of Insects on Coconuts

| Ordo/Spesies | Abundance of insects on coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Oryctes rhinoceros* | 28.00 | 29.00 | 22.67 | $3.20 \times 10^{-1}$ | $1.54^{ns}$ | - |
| **Hemiptera** | | | | | | |
| *Aspidiotus destructor* | 173.33a | 116.33b | 96.00b | $3.62 \times 10^{-3}$ | $31.24^{*}$ | 1.55 |
| *Nipaecoccus nipae* | 256.33a | 265.67a | 18.00b | $5.16 \times 10^{-5}$ | $276.40^{*}$ | 2.07 |
| *Planococcus sp.* | 50.67a | 44.33a | 27.67b | $58.7 \times 10^{-4}$ | $80.55^{*}$ | 0.54 |
| **Hymenoptera** | | | | | | |
| *Aphis cerana* | 5.67a | 4.33b | 0.00c | $3.13 \times 10^{-5}$ | $355.22^{*}$ | 0.25 |
| *Cotesia congregata* | 30.00a | 25.33b | 18.00c | $6.14 \times 10^{-4}$ | $78.70^{*}$ | 0.35 |
| *Dolichoderus thoracicus* | 113.33a | 103.67a | 81.33b | $45.1 \times 10^{-3}$ | $27.78^{*}$ | 0.81 |
| *Oecophylla* sp. | 98.00a | 87.33a | 60.33b | $1.15 \times 10^{-3}$ | $56.91^{*}$ | 0.75 |
| *Polistes carnifex* | 4.00a | 2.33b | 0.00c | $4.52 \times 10^{-4}$ | $92.12^{*}$ | 0.38 |
| **Lepidoptera** | | | | | | |
| *Metisa plana* | 16.33a | 13.67ab | 10.00b | $2.64 \times 10^{-2}$ | $10.31^{*}$ | 0.68 |
| *Pteroma pendula* | 20.67a | 16.67ab | 13.00b | $6.15 \times 10^{-3}$ | $23.50^{*}$ | 0.48 |
| *Pteroma plagiophleps* | 24.00a | 19.00ab | 14.00b | $6.78 \times 10^{-3}$ | $22.28^{*}$ | 0.61 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

### Abundance of insects found in wild plants around coconut trees

Insect species found in wild plants around coconuts trees were also observed. There are 6 species of insects from 3 orders. The orders found include Coleoptera, Isoptera and Orthoptera. In wild plants around 8 year old and 5 year old coconuts, the most *Captotermes* sp. insects were found~~.~~ originating from the Order Isoptera, namely 18.00 individuals and 13.67 individuals, respectively. Meanwhile, it was ~~very~~ far different when observation made in the coconuts plant of ~~were~~

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2 years old and no similar species were found at all. In case ~~the plants around~~ of coconuts trees of ~~that are~~ 2 years old, the most common insects are *Conocephalus* sp. which came from the Order Orthopetra, namely 10,00 individuals (Table 2).

**Table 2.** Average abundance of insects in wild plants around coconut trees

| Ordo/Spesies | Abundance of Insects in wild plants around Coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Aulacophora* sp. | 14.67a | 8.00b | 7.00b | $9.09 \times 10^{-3}$ | 18.98* | 0.71 |
| *Eumorphus westwoodi* | 12.33a | 8.33b | 3.00c | $3.21 \times 10^{-4}$ | 109.67* | 0.42 |
| **Isoptera** | | | | | | |
| *Captotermes* sp. | 18.00a | 13.67b | 0.00c | $3.52 \times 10^{-5}$ | 335.07* | 0.53 |
| **Orthoptera** | | | | | | |
| *Conocephalus* sp. | 17.00a | 12.00b | 10.00c | $38.9 \times 10^{-4}$ | 99.47* | 0.24 |
| *Dianemobius fascipes* | 16.67a | 13.00b | 9.00c | $6.50 \times 10^{-5}$ | 246.00* | 0.17 |
| *Tettigidea lateralis* | 10.67a | 8.33ab | 6.67b | $8.19 \times 10^{-3}$ | 20.10* | 0.39 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

**Characteristics of insect communities found in coconut trees**

The characteristics of the insect community on coconuts aged 8 years, 5 years and 2 years that were analyzed included the diversity index, evenness index and dominance index. The results showed that the community characteristics of each coconut plant aged 8 years, 5 years and 2 years increased with each observation. The diversity, evenness and dominance index of 8-year-old coconut plants was higher than that of 5- and 2-year-old coconut plants (Table 3). This shows that the age of the coconut affects the number of insects found in the field. The higher the diversity index value, the more diverse the species that exist in the community. This index reflects the biological richness of the community. If the evenness index shows a high value, the individuals in the community have a more even distribution among species, while a low value indicates an uneven distribution. Meanwhile, the dominance index measures the extent to which one or several species have significant dominance or ownership in the community.

**Table 3.** Characteristics of insect communities found in coconut trees

| Coconut plants (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Coconut plants (8 years old) | Number of Individuals | 847.00 | 853.00 | 761.00 |
| | Diversity Index (H') | 1.90 | 1.95 | 2.04 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.31 |
| | Dominance Index (D) | 0.34 | 0.32 | 0.28 |
| Coconut plants (5 years old) | Number of Individuals | 754.00 | 734.00 | 695.00 |
| | Diversity Index (H') | 1.86 | 1.90 | 1.97 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.30 |
| | Dominance Index (D) | 0.16 | 0.16 | 0.17 |
| Coconut plants (2 years old) | Number of Individuals | 622.00 | 617.00 | 544.00 |
| | Diversity Index (H') | 1.75 | 1.76 | 1.80 |
| | Eveness Index (E) | 0.27 | 0.27 | 0.29 |
| | Dominance Index (D) | 0.16 | 0.15 | 0.18 |

**The characteristics of insects on wild plants around coconut trees**

Based on the results, it was found that the highest index was found in coconut fields ~~that were~~of 8 years old. Meanwhile, at the age of 2 years, the analysis results were lower (Table 4). This also proves that the age of the coconut greatly influences the number of species found in wild plants around the coconut. The diversity, evenness and dominance indices in coconut plants aged 8 years, 5 years and 2 years experienced increases and decreases in population numbers. The diversity index in wild plants around 8-year-old coconut plants is higher compared to 5- and 2-year-old coconut plants. Meanwhile, the evenness and dominance index of wild plants around 2-year-old coconut plants was higher than that of 8- and 5-year-old coconut plants.

**Table 4.** Characteristics of insect communities in wild plants around coconut trees

| Wild plants around the coconut trees (age) | Community characteristics | Index values |
|---|---|---|

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| | | July | August | September |
|---|---|---|---|---|
| Wild plants around the coconut plants (8 years old) | Number of Individuals | 99.00 | 92.00 | 77.00 |
| | Diversity Index (H') | 1.78 | 1.77 | 1.77 |
| | Eveness Index (E) | 0.39 | 0.39 | 0.41 |
| | Dominance Index (D) | 0.19 | 0.22 | 0.21 |
| Wild plants around the coconut plants (5 years old) | Number of Individuals | 72.00 | 65.00 | 53.00 |
| | Diversity Index (H') | 1.77 | 1.75 | 1.76 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.44 |
| | Dominance Index (D) | 0.21 | 0.23 | 0.23 |
| Wild plants around the coconut plants (2 years old) | Number of Individuals | 42.00 | 37.00 | 28.00 |
| | Diversity Index (H') | 1.54 | 1.53 | 1.54 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.46 |
| | Dominance Index (D) | 0.26 | 0.30 | 0.32 |

**Relative abundance of insects found in coconut trees**

The relative abundance of insects on coconuts aged 8 years, 5 years and 2 years varied greatly. At plant ages of 8 years and 5 years, the abundance of insects in the Order Hemiptera was found, namely 59.00% and 58.00%, respectively. while the lowest order is the Order Coleoptera which is only 3.00% and 4.00% respectively. In contrast to the age of 2 years, the most insect species ~~found~~ were recorded from the Order Hymenoptera, namely 48.00% and the lowest number of species were recorded in the Orders Lepidopeta and Hymenoptera, which was only 7.00% (Figure 2).

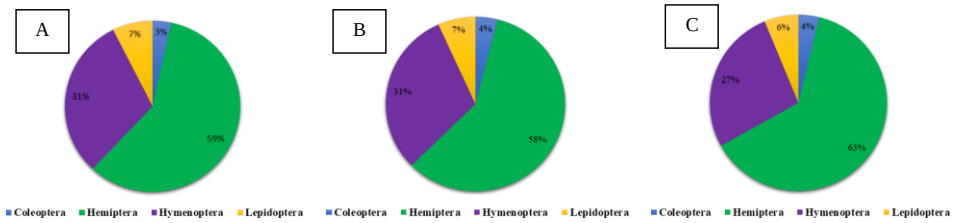


**Figure 2.** Abundance of insects found in coconut trees at: A) 8 years old, B) 5 years old, C) 2 years old.

**Relative abundance of insects found in wild plants around coconut trees**

The relative abundance of insects in wild plants around coconut plants was only found in 3 orders, namely the orders Coleoptera, Isoptera and Orthoptera. In plants aged 8 years, 5 years, and 2 years, the most Orthoptera orders were found, namely 50.00%, 53.00% and 72.00%, respectively. Meanwhile, in the area around 2-year-old coconuts, only two orders were found, namely Coleoptera and Orthoptera (Figure 3).

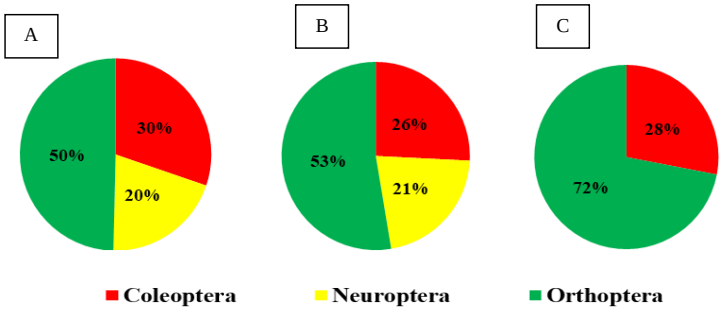


**Figure 3.** Abundance of insects on wild plants around coconut trees at different age of coconut: A) 8 years old, B) 5 years old, C) 2 years old.

The results of observations found 18 species of insects associated with coconut plants and surrounding wild plants. The 18 insect species act as phytophagous, pollinators and natural enemies. The dominant insects belong to the orders Hemiptera and Hymenoptera. The insects are *Aspidiotus destructor* (Figure 4a), *Nipaecoccus nipae* (Figure 4b), *Aleurocanthus* sp. (Figure 4c), *Polyrhachis dives* (Figure 4d), *Oecophylla* sp. (Figure 4e).

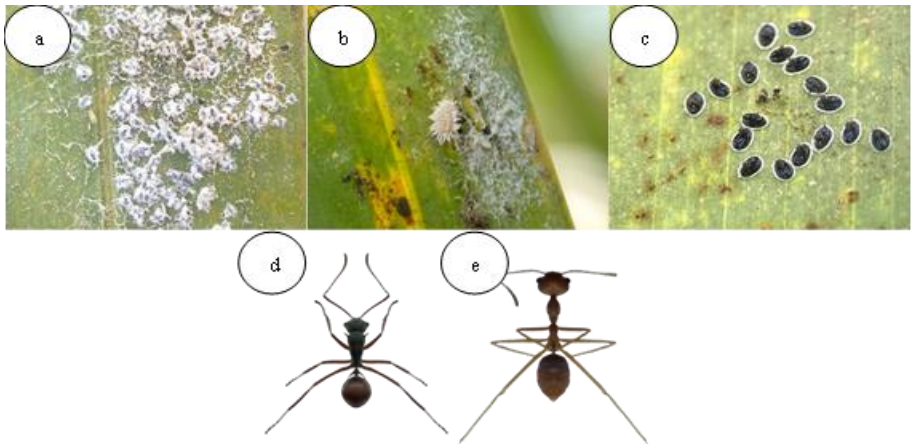


**Figure 3.** The dominant insects are found on coconut plants and surrounding plants. *Aspidiotus destructor* (a), *Nipaecoccus nipae* (b), *Aleurocanthus* sp. (c), *Polyrhachis dives* (d) dan *Oecophylla* sp. (e)

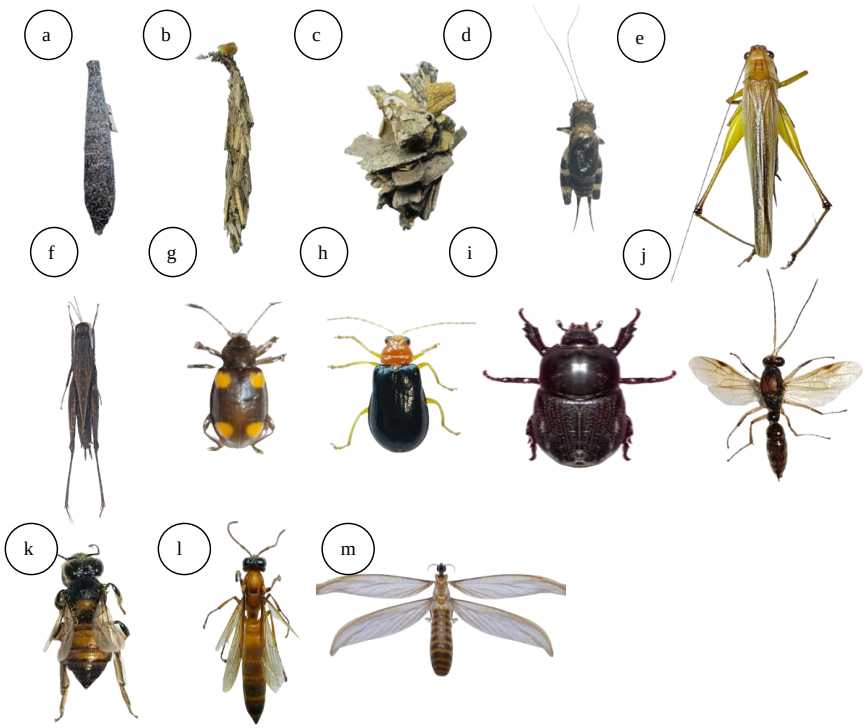


**Figure 4.** The non-dominant insects are found on coconut plants and surrounding plants. *Pteroma pendula* (a), *Cenephora hirsuta* (b), *Metisa plana* (c), *Dianemobius fascipes* (d), *Conocephalus* sp. (e), *Tettigidea lateralis* (f), *Eumorphus westwoodi* (g), *Aulacophora* sp. (h), *Oryctes rhinoceros* (i), *Cotesia congregata* (j), *Aphis cerana* (k) *Polistes carnifex* (l) and *Mactrotermes* sp. (m).

## Discussion

The results of observations in the field showed that the number of insects caught using traps in coconut plantations was identified as 7 orders, 18 species with a total of 2330.67 individuals. However, this research observation was divided into two parts, namely on coconut plants and on wild plants around coconuts which have various ages. Observations on coconuts of various ages showed findings of 4 orders and 12 species of insects. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* which comes from the order Hemiptera, namely 256.33 individuals. supported by research by Ganganalli et al. (2023), that the species of aphids that are most often found on coconuts. Meanwhile, in the wild plants around coconut, there are 3 orders and 6 species. The 6 insect species belong to the orders Coleoptera, Isoptera and Orthoptera. *Captotermes* sp dominated coconuts aged 8 years. Meanwhile, coconuts aged 2 years old, the most common insects were *Conocephalus* sp. which comes from the order Orthopetra. The seven orders found, including the orders Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Coleoptera, Isoptera and Orthoptera, have various roles in the ecosystem. This coconut plants species were found that have roles as pests, predators, parasitoids and also pollinators (Kavitha et al. 2023). Direct observation was carried out by recording the condition or behavior of the object being observed (Vislobokov 2017). There were species *A. destructor, N. nipae, Aleurocanthus* sp., *P. pendula, C. hirsuta*, and *M. Plana* recorded by using the direct observation method. On the other hand, the traps were used to collected the fly or active insects such as insect nets, light traps and pheromones traps (Haneda et al. 2017). According to Iswara et al. (2022), traps are designed based on insect behaviour and attraction to certain lights, shapes and colours. The species obtained using the insect nets and the light trap were *E. westwoodi*. *Aulacophora* sp., *A. cerana, P. carnifex, Conocephalus* sp., and *T. lateralis.* Meanwhile, *O. rhinoceros* was found in the pheromone trap. Pheromones traps are traps used to attract male insects (Maruthadurai and Ramesh, 2020). Pheromones trap was effectively to monitor and control the adults of *O. rhinoceros* (Paudel et al. 2023).

*Aspidiotus destructor* Signoret (Hemiptera: Diaspididae) is an coconut scale (Serrana et al. 2023). The coconut scale was found in the highest numbers at every age of coconut. The insect scale had also been confirmed to cause significant economic losses to the coconut industry in the Philippines (Serrana et al. 2019). Moreover, coconut bud borer beetles (*O. rhinoceros* L) were found at all ages of coconut. *O. rhinoceros* is one of the main pests that causes damage to germplasm in coconut (Paudel et al. 2022). In Indonesia, *O. rhinoceros* is a threat to both coconut and oil palm plants (Rahayuwati et al. 2020). These beetles are known to attack palm trees by boring into the crown and eating developing fronds (leaves that have not yet opened), which can cause death or stunted growth in young palm trees if the infestation is severe (Chalapathi Rao et al. 2018; Paudel et al. 2021, 2023). For mature oil palm trees, this damage can result in reduced productivity. This was also confirmed by Parnidi et al. (2022), that the average damage caused by this pest investment ranges from 0 to 16.7%. This study showed that there were different insects at each age of coconut. The plant age can influence the number of species and the number of individuals (Myers and Sarfraz, 2017; Santi et al. 2023). As plants grow and mature, they provide different habitats and resources that can support a variety of insects species (Schowalter 2016). Older plants tend to have more developed and complex ecosystems with greater insects species diversity (Schowalter 2017). Additionally, mature plants are often larger and have more resources, so they can support more individuals in their ecosystem (Lindenmayer and Laurance 2016). However, the specific impact of plant age on insect species and the number of insect individuals may vary depending on plant species, environmental conditions, and other factors (Myers and Sarfraz 2017).

The insect diversity index on coconut plants and surrounding wild plants in Sri Tiga Village from week 1 to week 3 shows a diversity value of $1 < H' < 3$, this is in the medium category. This criterion shows the diversity of pests and natural enemies which increases in number as the population increases towards balance. According to Hasibuan et al. (2019), there are 3 criteria for insect species diversity, namely low species diversity if $H < 1$ (unstable environmental conditions), desang species diversity if H 1-3 (medium environmental conditions), and high species diversity if $H > 3$ (stable environmental conditions). The results of the dominance index calculation obtained on coconut plants and surrounding wild plants from week 1 to week 3 showed a dominance value of $0 < D < 0.5$. This means that the dominance of these insects is relatively low. The Evenness Index (E) value is 0.29-0.31 in the depressed category. According to Hasibuan et al. (2019), there are 3 criteria for the community environment based on its evenness value, namely if $E < 0.50$ then the community is in a depressed condition. If $0.50 < E' 0.75$ then society is in a stable condition, while $0.75 < E' 1.00$ means society is in an unstable condition. The evenness index value (E') can describe the stability of a community. The smaller the value of E' or closer to zero, the more uneven the distribution of organisms in a community that is dominated by a certain type and conversely, the greater the value of E' or close to one, the organisms in that community will be evenly distributed (Ambarwati et al. 2023). Apart from being influenced by plant age, insect diversity can be influenced by climate and weather factors (Subedi et al. 2023). From July to September 2023, Sri Tiga Village faced the dry season. The dry season is characterized by decreased rainfall and increased temperatures, disrupting the life cycle of insects. According to Paliama et al. (2022), increasing global temperatures can affect the life cycle of insects. In addition, dry seasons can cause drought and reduce water availability for insects (Benoit et al. 2023). This condition may affect the ability of insect to tolerate climatic factors in an ecosystem.

## ACKNOWLEDGEMENTS

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## REFERENCES

Ambarwati M, Dewi K, Aurina DM, Faturrahman AD, Fatikha LAY, Rachmalia F, Ainaya FA, Kinanthi A, Rohman, CM, Pradhana F, Fadzilah A, Pramudita DA, Ramadhan MF, Mahajoeno E, Nugroho GDWI, Sujarta P, Yap CK, Adha K, Rahim BINA, Setyawan ADWI. 2023. Ecological index and economic potential of mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia. Biodiversitas 24: 1231–1241. DOI: 10.13057/biodiv/d240265

Arumugam T. (2022). Improving coconut using modern breeding technologies. Plants 11: 1-22. DOI: 10.3390/plants11243414

Aulia AN, Chasanah N, Prasetyo AS, Nalawati AN. 2020. Competitiveness and export similairity of Indonesia's coconut oil. J Agribest 04: 123–132. DOI: 10.32528/agribest.v4i2.3546

Badan Pusat Statistik. 2023. Luas Areal dan Produksi Perkebunan Kelapa Rakyat Menurut Kecamatan. https://banyuasinkab.bps.go.id/indicator/54/151/1/luas-areal-dan-produksi-perkebunan-kelapa-rakyat-menurut-kecamatan.html

Benoit JB, Mccluney KE, Degennaro MJ. (2023). Dehydration dynamics in terrestrial arthropods: from water sensing to trophic interactions. Annu Rev Entomol 68: 129–149. DOI: 10.1146/annurev-ento-120120-091609

Chalapathi Rao NBV, Snehalatharani A, Nischala A, Ramanandam G, Maheswarappa HP. 2018. Management of rhinoceros beetle (Oryctes rhinoceros L.) by biological suppression with Oryctes baculovirus in Andhra Pradesh. J Plant Crops 46: 124-127. DOI: 10.25081/jpc.2018.v46.i2.3725

Chandra R., Abdul M, Sharma N, Bharathi K, Singh S. 2023. The role of insects in ecosystems, an in-depth review of entomological. International J Environ and Climate Change 13:4340–4348. DOI: 10.9734/IJECC/2023/v13i103110

Chowdhury S, Dubey VK, Choudhury S, Kumar N, Semwal A, Kumar V. 2023. Insects as bioindicator : A hidden gem for environmental monitoring. Front. Environ. Sci 11: 1–16. DOI: 10.3389/fenvs.2023.1146052

Ganganalli SM, Bhaskar H, Joshi, S, Vidya CV. 2023. Diversity of Aphid Fauna (Hemiptera: Aphididae) of Kerala. Indian J Entomol 1–8. DOI: 10.55446/ije.2023.742
Haneda NF, Wibowo C, Hasbi M. 2017. Peranan arthropoda di ekosistem ekoton dan kelapa sawit. J Silvikultur Tropika 8: 116–122. DOI: 10.29244/j-siltrop.8.2.116-122
Hasibuan EW, Siregar AZ, Pinem MI. 2019. Diversity of insect in coconut plant in Kelurahan Besar, Medan Labuhan District, North of Sumatra. Inter J Trend in Research and Develop 6: 7–13.
Henrietta HM, Kalaiyarasi K, Raj AS. 2022. Coconut tree (Cocos nucifera) products : a review of global cultivation and its coconut tree (Cocos nucifera) products : a review of global cultivation and its benefits. J Sus and Environ Manage. DOI: 10.3126/josem.v1i2.45377
Hoe TK. 2019. The Current Scenario and Development of the Coconut Industry. February
Iswara D, Afifah L, Abadi S, Prabowo D, Irfan B, Widiawan AB. 2022. Kelimpahan serangga pada berbagai perangkap dengan beberapa teknik pengendalian berbeda pada pertanaman jagung pioneer 36. J Agroplasma 9: 213–224
Lindenmayer DB, Laurance WF. 2016. The ecology, distribution, conservation and management of large old trees. Biological Reviews 93: 1434-1458. DOI: 10.1111/brv.12290
Manosathiyadevan M, Bhuvaneshwari V, Latha R. 2017. Impact of insects and pests in loss of crop production: a review. in a Dhanarajan (Ed.). Springer Singapore 57-67. DOI: 10.1007/978-981-10-6647-4_4
Maruthadurai R, Ramesh, R. 2020. Mass trapping of red palm weevil and rhinoceros beetle in coconut with aggregation pheromone. Indian J Entomol 82: 439–441. DOI: 10.5958/0974-8172.2020.00114.5
Moreira MM, Reitas LF. 2020. Review of the pollination system by small diverse insects. Neotrop Entomol, 472–481. DOI: 10.1007/s13744-020-00779-6
Myers JH, Sarfraz RM. 2017. Impacts of insect herbivores on plant populations. Annu. Rev. Entomol. DOI: 10.1146/annurev-ento-010715-023826
Paliama HG, Latumahina FS, Wattimena CMA. 2022. Keanekaragaman serangga dalam kawasan hutan mangrove di Desa Ihamahu. Jurnal Tengkawang 12: 94–104. DOI: 10.26418/jt.v12i1.53861
Parnidi P, Sunarto DA, Marjani M. 2022. Shoot borers beetle pest of coconut (Oryctes rhinoceros L.) investment at Agave spp. Bioeduscience 6: 89–95. DOI: 10.22236/j.bes/616282
Paudel S, Jackson TA, Mansfield S, Ero M, Moore A, Marshall SDG. 2023. Use of pheromones for monitoring and control strategies of coconut rhinoceros beetle (Oryctes rhinoceros): A review. Crop Protection . DOI: 10.1016/j.cropro.2023.106400
Paudel S, Mansfield S, Villamizar LF, Jackson TA, Marshall SDG. 2021. Can biological control overcome the threat from newly invasive coconut rhinoceros beetle populations (Coleoptera: Scarabaeidae)? A review. Annals Entomol Society of America 114: 247–256. DOI: doi.org/10.1093/aesa/saaa057
Paudel S, Marshall SDG, Richards NK, Hazelman G, Tanielu P, Jackson TA. 2022. Coconut rhinoceros beetle in Samoa: review of a century-old invasion and prospects for control in a changing future. Insects 1–15. DOI: 10.3390/insects13050487
Purnomo H, Okarda B, Dermawan A, Pebrial Q, Pacheco P, Nurfatriani F, Suhendang E. 2020. Forest policy and economics reconciling oil palm economic development and environmental conservation in Indonesia: a value chain dynamic approach. Forest Policy and Economics, 111: 1-12. DOI: 10.1016/j.forpol.2020.102089
Rahayuwati S, Kusumah YM, Prawirosukarto S, Dadang, Santoso T. 2020. The status of Oryctes rhinoceros nudivirus (OrNV) infection in oryctes rhinoceros (Coleoptera: Scarabaeidae) in Indonesia. Journal of Oil Palm Research 32: 582–589 [Indonesian]
Santi I, Tarmadja S, Priambada KJ, Elfatma O. 2023. Keanekaragaman serangga perkebunan kelapa sawit di Provinsi Kalimantan Tengah. Jurnal Ilmiah Hijau Cendekia 8:45. DOI: 10.32503/hijau.v8i1.2917
Schowalter TD. 2017. Arthropod diversity and functional importance in old-growth forests of North America. Forests. DOI: 10.3390/f8040097
Schowalter TD. 2016. Insect Ecology: An Ecosystem Approach. Academic press.
Serrana JM, Almarinez BJM, Barrion AT, Amalin DM. 2023. Ultrastructural characterization of the scale cover of cryptic Aspidiotus spp. (Hemiptera: Diaspididae) and the ovipositor of their parasitoids. Microscopy and Microanalysis 29: 825–831. DOI: 10.1093/micmic/ozac041
Serrana JM, Ishitani N, Carvajal TM, Almarinez BJM, Barrion AT, Amalin DM, Watanabe K. 2019. Unraveling the genetic structure of the coconut scale insect pest (Aspidiotus rigidus Reyne) outbreak populations in the Philippines. Insects. DOI: 10.3390/insects10110374
Stam JM, Kroes A, Li Y, Gols R, Loon JJAV, Poelman EH, Dicke M. 2014. Plant interactions with multiple insect herbivores : from community to genes. Annu. Rev. Plant Biol 65: 689–713. DOI: 10.1146/annurev-arplant-050213-035937
Subedi B, Poudel A, Aryal S. 2023. The impact of climate change on insect pest biology and ecology : Implications for pest management strategies, crop production , and food security. J Agriculture and Food Research. DOI: 10.1016/j.jafr.2023.100733
Thomas GV, Krishnakumar V, Dhanapal R, Srinivasa Reddy DV. 2018. Preharvest approaches to control insect infestation in fruit. Elsevier. DOI: 10.1007/978-981-13-2754-4_7
Tiemann TT, Donough CR, Lim YL, Härdter R, Norton R, Tao HH, Jaramillo R, Satyanarayana T, Zingore S, Oberthür T. 2018. Chapter four-feeding the palm: a review of oil palm nutrition. Advances in Agronomy 152: 149–243). DOI: 10.1016/bs.agron.2018.07.001
Vislobokov NA. 2017. Flowering biology of Aspidistra (a sparagaceae): new data on pollination by dipteran insects. Plant Species Biology 32: 412–422. DOI: 10.1111/1442-1984.12175
Ximenes R, Nurmalina R, Rifin A. 2021. Demand analysis of Indonesia's coconut crude oil in Germany. Review of Economics and Finance 19: 281–285. DOI: 10.55365/1923.x2021.19.39
Zainol FA, Arumugam N, Norhayate W, Daud W, Aisyah N, Suhaimi M. 2023. Coconut value chain analysis : a systematic review. Agriculture. DOI: 10.3390/agriculture13071379

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## TO WHOM IT MAY CONCERN

Number: 0425/UN9/UPT.BHS/2024

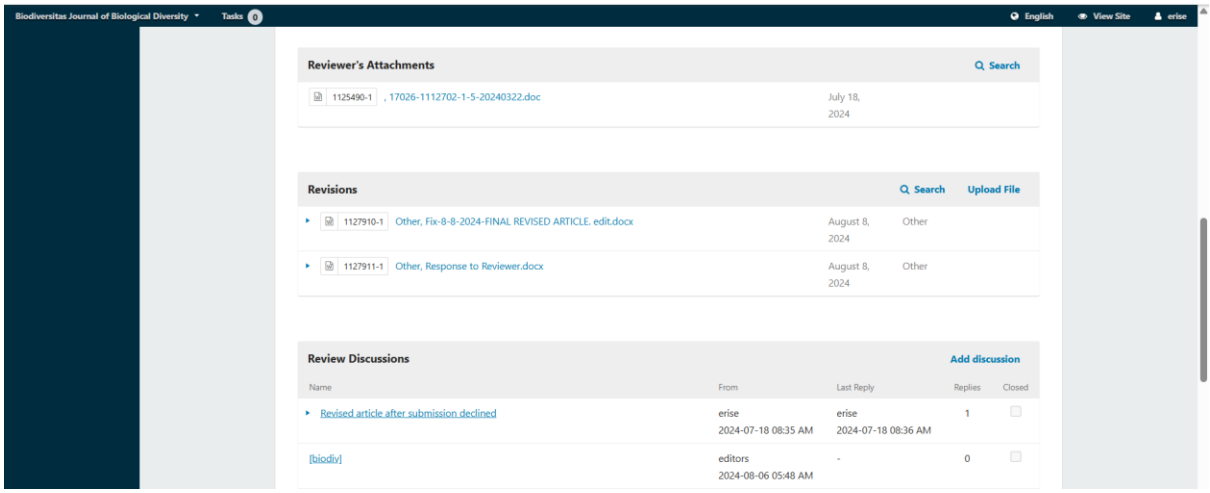
UPT Bahasa Universitas Sriwijaya, hereby verifies that the scientific paper entitled **"Insect Species among Viridis Coconut Trees of Different Ages in Sri Tiga Village, Banyuasin District, South Sumatra, Indonesia"** has been professionally proofread so that the English used in the paper is completely free of grammatical errors (e.g., subject–verb agreement problems, incorrect word choices, improper punctuation usage, and incorrect spelling) as well as formatting and typographical errors.

Thus this certificate is made for proper use.

Palembang, March 18th, 2024
Head,

**Dr.Drs. Djunaidi, MSLS**
NIP. 196203021988031004

## *Peer review round 8 (18 Juli 2024)*



# Insects found in different ages of coconut viridis variety in Sri Tiga Village, Banyuasin District South Sumatra, Indonesia

**Abstract.** Coconut (*Cocos nucifera*) is a valuable export commodity and has good prospects in the international market. Coconut cultivation is inseparable from the presence of insect species. The presence of insects in plants is interrelated because plants are places for insects to live and eat. However, not everyone knows the relationship between plants and insects. An inventory of insect biodiversity in an ecosystem needs to be conducted. This information shows the community structure of insects associated with coconut plants and plants that grow around coconut plants. Therefore, this field practice aims to find out the insects associated with coconut plants. Field practice was carried out with a survey in a coconut plantation owned by the people in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency, South Sumatera, Indonesia. The observation was conducted from July to September. Data collection was done by determining 3 coconut plantations with different ages of coconut trees. Data collection was carried out using the purposive sampling method by direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was conducted by collecting insects directly during direct observation and in traps. Specimens that have been collected were identified using a macroscope in the Laboratory of Entomology, Department of Plant Pests and Disease, Faculty of Agriculture, Sriwijaya University. The results of this field practice found 12 species namely *Aleurocanthus* sp., *Aphis cerana*, *Aspidiotus destructor*, *Aulacophora* sp., *Cenephora hirsuta*, *Conocephalus* sp., *Cotesia congregata*, *Dianemobius fascipes*, *Eumorphus westwoodi*, *Macrotermes* sp., *Metisa plana*, *Nipaecoccus nipae*, *Oecophylla* sp., *Oryctes rhinoceros*, *Polistes carnifex*, *Polyrhachis dives*, *Pteroma pendula*, *Tettigidea lateralis*.

**Key words:** *Cocos nucifera*, viridis variety, coconut, insects

**Running title:** Insects Found in Coconut Viridis Variety and Surrounding Wild Plants

## INTRODUCTION

Indonesia has various agricultural sectors such as plantations, horticulture, food crops and forestry plants. The plantation sector in Indonesia makes a significant contribution to the country's economy (Purnomo et al. 2020). In Indonesia, coconut plantations have been widely developed and have become the main income for coconut farmers. Coconut plays a role in the economy, social and state income from non-oil and gas commodities (Ximenes et al. 2021). Coconut production is mostly used for consumption and industry (Hoe 2019). Products resulting from the development of coconut plants that have been widely managed include coconut oil, coconut sugar, dried grated coconut, coconut milk, shells, coconut juice and coconut fiber (Henrietta et al. 2022). Coconut (*Cocos nucifera*) is a tropical plantation commodity that is widespread in Indonesia, the Philippines, India, and several Asia Pacific countries (Hoe 2019). Coconut is a high-value export commodity and has good prospects in the international market. Indonesia is the first considerable coconut-producing country worldwide, followed by the Philippines and India (Zainol et al. 2023). The area of coconut plantations in Banyuasin Regency, Indonesia, in 2022 was 42,599,00 Ha (Badan Pusat Statistik, 2023). The productivity of coconut plants in Banyuasin Regency, Indonesia 2022 reached 46,760,00 tons (Badan Pusat Statistik, 2023).

In coconut cultivation, it is important to understand the life cycle of the plant from seeding to harvest. This stage requires consistent care and monitoring. In coconut cultivation, the process involves selecting quality seeds, proper soil

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**Commented [BA2]:** This sentence should be written in a better way in the context of the actual study, since it is supposed to provide the rationale here in the abstract. Perhaps it can be integrated with the following sentence.

**Commented [BA3]:** What "field practice" is this supposed to refer to? Perhaps the authors mean the study being reported in this manuscript? If so, I suggest that the authors avoid using "field practice".

**Commented [BA4]:** I suppose "observations were" would be more appropriate here. I assume that multiple surveys, and thereby multiple observations, were made across the 3-month period.

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**Commented [BA6]:** Either "This study…" or "The field surveys…" would perhaps be more appropriate.

**Commented [BA7]: I believe this should be *Apis cerana*, unless this is referring to a new aphid species under genus *Aphis*.**

cultivation, and proper care (Thomas et al. 2018). Coconuts thrive in sufficient sunlight, appropriate rainfall, and nutrient-rich soil with effective drainage (Tiemann et al. 2018). The optimal range for coconut plant growth is between pH 5-8 (Fauzana et al. 2021). A deep understanding of these factors can result in sustainable coconut plantations. Furthermore, regular pruning, fertilizing, and managing pests and diseases are things that need attention (Aulia et al. 2020). A deep understanding of these factors can lead to profitable and sustainable coconut production. On the other hand, In many coconut producing areas, especially in smallholder coconut plantations, fertilizer use and insect management are often not carried out intensively (Zainol et al. 2023). Furthermore, the process of cultivating coconut cannot be separated from the presence of insect species. The existence of insects on plants is interrelated because plants are a place for insects to live and eat (Stam et al. 2014). Insects are also needed by plants during plant pollination (Moreira and Reitas 2020). In addition, insects can cause damage to cultivated plants (Manosathiyadevan et al. 2017).

In coconut plantations, the age of coconut trees varies in each area. This results in differences in plant growth and development from one tree to another, affecting not only nutritional requirements but also harvest patterns and overall productivity (Arumugam 2022). Management appropriate to the coconut plant's age is essential to maximize its health and yield. Coconut trees at varying stages of growth may attract different insect pests, which may prefer specific developmental stages of the trees due to physiological differences. It's essential to identify and manage these pests appropriately, considering the age of the coconut trees for effective pest control. Moreover, insects play various roles in ecosystems and significantly impact human society and the environment, such as pollinators, decomposers, and pests (Chandra et al. 2023). Recent information about insects on coconut trees, especially regarding the different ages of the trees, has yet to be recorded. Therefore, an inventory of insect biodiversity in different plant ages of coconut plantation ecosystem needs to be carried out. The diversity of insect species can be used to indicate changes occurring in the ecosystem (Chowdhury et al. 2023). Identifying the presence of different species of coconut trees of different ages is important. Understanding the insect species can guide integrated pest management strategies.

## MATERIALS AND METHODS

### Study area

Field practice was carried out in people's coconut plantations in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency (Figure 1). Field practice is also conducted at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University. Field practice is carried out from July to September 2023.

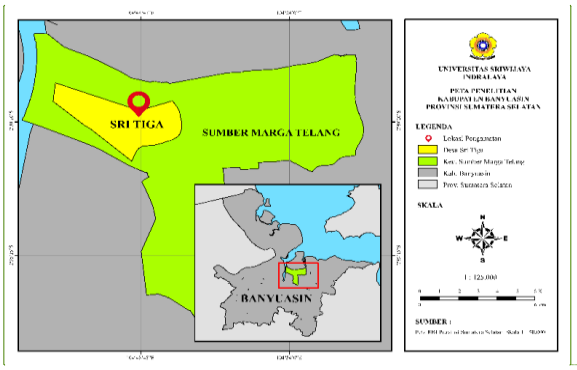


**Figure 1.** Sampling location

### Procedures

Initial preparations are carried out by conducting a survey to find out the research location and preparing the tools and materials used. Apart from that, a survey was conducted to find out information from the community regarding the use of coconut in Sri Tiga Village, Banyuasin Regency. Data collection was initially carried out by determining three coconut plantations as objects of observation, and then these gardens were observed. Data was collected using the purpose sampling method by making direct observations and using traps such as insect nets, light traps, and pheromone traps. Sampling was done by collecting insects directly, either during direct observation or in traps. Documentation was carried out in the form of photographs of insects found on coconut plants and wild plants around the coconut plants. Identification of insects found was done by examining insects that are common and have been studied previously. The things studied were similar in terms of color, shape, size, and morphological characteristics of the insects found. The observation

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**Commented [BA15]:** Perhaps "an initial survey"?

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**Commented [BA17]:** Were the coconut trees planted in "gardens"? Please use the appropriate word.

**Commented [BA18]:** "collected"

**Commented [BA19]:** What do the authors mean by this? What was the "previous study" being referred to here? Or could they be implying that they only focused on common and already studied/reported taxa for identification, and perhaps set aside those that appear to be unfamiliar or new? I insist that this should be clarified.

**Commented [BA20]:** This statement is confusing. What "things" are the authors referring to? Attributes or characteristics of the insect specimens? If so, perhaps the more appropriate way of stating this idea would be something like "Color, shape, size, and other diagnostic morphological characters of the insects were examined and compared."

parameters in this field practice were the insects caught in each trap. All insects found are then identified. Insect identification was carried out based on morphological characteristics such as head, abdomen, antennae, wings, and others. Each insect found then determines its role in the ecosystem.

**Data analysis**

The data obtained from the observations are presented in the table. The data was then analyzed using R Statistic software.

The species diversity index was used to describe the diversity of insect species found in the research area. The diversity index was expressed using the Shannon-Wiener species diversity formula:

$$H' = -\sum \text{Pi In pi}$$

Information:
H': Shannon-Wiener Diversity Index
Pi: ni/N (Comparison between the number of a species and all species)
Description of criteria:
H' < 1 : Low diversity
1 < H' < 3 : Medium diversity
H' > 3 : High diversity

The species evenness index was used to describe the degree of evenness of insect species found in the research area. The evenness index was expressed using the formula:

$$E = \frac{H'}{In\ S}$$

Information:
E : Evenness index (value between 0-1)
H' : Shannon-Wiener diversity index
S : Number of types
Description of criteria:
E < 0.4 : Small population uniformity
0.4 < E < 0.6 : Moderate population uniformity
E > 0.6 : High population uniformity

The species dominance index was used to describe the level of dominance of insect species found in the research area. The dominance index is expressed using the formula:

$$D = \sum Pi^2$$

Information:
D: Simpson Dominance Index
Pi: ni/N (Comparison between the number of a species and all species)
Description of criteria:
0 < D < 0.5 : Low dominance
0.5 < D < 0.75 : Moderate dominance
0.75< D < 1.0 : High dominance

## RESULTS AND DISCUSSION

**Abundance of insects found in coconut trees**

The insect species found in three coconut fields with varying plant ages, namely 8 years, 5 years and 2 years, were very diverse. There are 12 species from 4 orders. The four orders found most frequently include the orders Coleoptera, Hemiptera, Hymenoptera and Lepidoptera. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* which comes from the Hemiptera Order, namely 256.33 individuals. This result also found the same thing in coconut fields that were 5 years old, namely dominated by *Nipaecoccus nipae*, with as many as 265.67 individuals. Meanwhile, on 2 year old coconut fields, the insect species that were frequently encountered were Aspidiotus destructor from the Hemiptera Order, namely 96,000. Based on the results of comparing the number of species found in coconut fields of different ages, it was found that there were also different numbers of species (Table 1). In the 2 year old plantation, *Aphis cerana* and *Polistes carnifex* species were not found.

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**Commented [BA23]:** This section can be subdivided into at least two:
Field survey and sampling
Identification of specimens

**Commented [BA24]:** The exact nature of the data being referred to here should be mentioned. Are the authors referring to count data? If so, what variables do the counts pertain to?

**Commented [BA25]:** What table are the authors referring to here?

**Commented [BA26]:** "R statistics software", version used should be indicated.

**Commented [BA27]:** This formula needs to be corrected, particularly the variable "p sub i" (p with subscript "i") and "ln" (the current presentation uses a capital letter i instead of small L for the natural logarithm).

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**Commented [BA29]:** This should be "p sub i" (it is not possible to type a subscript here in the comment box), not "Pi". Please indicate subscripts properly.

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**Commented [BA31]:** "where:"

**Commented [BA32]:** "species"

**Commented [BA33]:** Same comments as the previous ones on the lack of proper use of subscripts on the variables pertaining to proportional abundance "p" and "n".

**Commented [BA34]:** Delete this, since "four orders" was already mentioned in the earlier part of the sentence.

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**Table 1.** Abundance of Insects on Coconuts

| Ordo/Spesies | Abundance of insects on coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Oryctes rhinoceros* | 28.00 | 29.00 | 22.67 | $3.20 \times 10^{-1}$ | $1.54^{ns}$ | - |
| **Hemiptera** | | | | | | |
| *Aspidiotus destructor* | 173.33a | 116.33b | 96.00b | $3.62 \times 10^{-3}$ | $31.24^{*}$ | 1.55 |
| *Nipaecoccus nipae* | 256.33a | 265.67a | 18.00b | $5.16 \times 10^{-5}$ | $276.40^{*}$ | 2.07 |
| *Planococcus sp.* | 50.67a | 44.33a | 27.67b | $58.7 \times 10^{-4}$ | $80.55^{*}$ | 0.54 |
| **Hymenoptera** | | | | | | |
| *Aphis cerana* | 5.67a | 4.33b | 0.00c | $3.13 \times 10^{-5}$ | $355.22^{*}$ | 0.25 |
| *Cotesia congregata* | 30.00a | 25.33b | 18.00c | $6.14 \times 10^{-4}$ | $78.70^{*}$ | 0.35 |
| *Dolichoderus thoracicus* | 113.33a | 103.67a | 81.33b | $45.1 \times 10^{-3}$ | $27.78^{*}$ | 0.81 |
| *Oecophylla* sp. | 98.00a | 87.33a | 60.33b | $1.15 \times 10^{-3}$ | $56.91^{*}$ | 0.75 |
| *Polistes carnifex* | 4.00a | 2.33b | 0.00c | $4.52 \times 10^{-4}$ | $92.12^{*}$ | 0.38 |
| **Lepidoptera** | | | | | | |
| *Metisa plana* | 16.33a | 13.67ab | 10.00b | $2.64 \times 10^{-2}$ | $10.31^{*}$ | 0.68 |
| *Pteroma pendula* | 20.67a | 16.67ab | 13.00b | $6.15 \times 10^{-3}$ | $23.50^{*}$ | 0.48 |
| *Pteroma plagiophleps* | 24.00a | 19.00ab | 14.00b | $6.78 \times 10^{-3}$ | $22.28^{*}$ | 0.61 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

**Abundance of insects found in wild plants around coconut trees**

Insect species found in wild plants around coconuts were also observed. There are 6 species of insects from 3 orders. The orders found include Coleoptera, Isoptera and Orthoptera. In wild plants around 8 year old and 5 year old coconuts, the most Captotermes sp insects were found. originating from the Order Isoptera, namely 18.00 individuals and 13.67 individuals respectively. Meanwhile, it was very different when the coconuts were 2 years old and no similar species were found at all. In the plants around coconuts that are 2 years old, the most common insects are Conocephalus sp. which came from the Order Orthopetra, namely 10,00 individuals (Table 2).

**Table 2.** Average abundance of insects in wild plants around coconut trees

| Ordo/Spesies | Abundance of Insects in wild plants around Coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old | 5 years old | 2 years old | | | |
| **Coleoptera** | | | | | | |
| *Aulacophora* sp. | 14.67a | 8.00b | 7.00b | $9.09 \times 10^{-3}$ | $18.98^{*}$ | 0.71 |
| *Eumorphus westwoodi* | 12.33a | 8.33b | 3.00c | $3.21 \times 10^{-4}$ | $109.67^{*}$ | 0.42 |
| **Isoptera** | | | | | | |
| *Captotermes* sp. | 18.00a | 13.67b | 0.00c | $3.52 \times 10^{-5}$ | $335.07^{*}$ | 0.53 |
| **Orthoptera** | | | | | | |
| *Conocephalus* sp. | 17.00a | 12.00b | 10.00c | $38.9 \times 10^{-4}$ | $99.47^{*}$ | 0.24 |
| *Dianemobius fascipes* | 16.67a | 13.00b | 9.00c | $6.50 \times 10^{-5}$ | $246.00^{*}$ | 0.17 |
| *Tettigidea lateralis* | 10.67a | 8.33ab | 6.67b | $8.19 \times 10^{-3}$ | $20.10^{*}$ | 0.39 |

Note: ns= not significantly different; *= very significantly different; This original data was transformed using the Square Root transformation before analysis

**Characteristics of insect communities found in coconut trees**

The characteristics of the insect community on coconuts aged 8 years, 5 years and 2 years that were analyzed included the diversity index, evenness index and dominance index. The results showed that the community characteristics of each coconut plant aged 8 years, 5 years and 2 years increased with each observation. The diversity, evenness and dominance index of 8-year-old coconut plants was higher than that of 5- and 2-year-old coconut plants (Table 3). This shows that the age of the coconut affects the number of insects found in the field. The higher the diversity index value, the more diverse the species that exist in the community. This index reflects the biological richness of the community. If the evenness index shows a high value, the individuals in the community have a more even distribution among species, while a low value indicates an uneven distribution. Meanwhile, the dominance index measures the extent to which one or several species have significant dominance or ownership in the community.

**Commented [BA39]:** This table title should be contextualized; "Abundance of insects on coconuts in… _____".

**Commented [BA40]:** "Order/Species"

**Commented [BA41]:** What exactly are these columns for if the table is supposed to present the abundance of insects? There was no mention of any inferential statistical test in the methodology.

**Commented [BA42]:** What exactly do these refer to? The age of the coconut trees? The age of the plots? This should be clarified.

**Commented [BA43]:** What do the letters beside the numbers mean? It should be clearly indicated in the table title or in the footnote.

**Commented [BA44]:** This table title should provide the proper context as well.

**Commented [BA45]:** "Order/Species"

**Commented [BA46]:** Same comment on these columns as in the earlier table.

**Commented [BA47]:** Same comment on these column headings as in the earlier table.

**Commented [BA48]:** Same comment on the letters beside the numbers as in the earlier table.

**Commented [BA49]:** Categorization of the coconuts where the insects were collected was not mentioned in the methodology.

**Commented [BA50]:** Comparison of insect community characteristics across ages of coconut trees was not mentioned in the methodology.

**Commented [BA51]:** What exactly does "each observation" here mean?

**Commented [BA52]:** This is not immediately evident in Table 3 as it is currently presented. I suggest that the authors present the pertinent results through a graph instead.

**Commented [BA53]:** These sentences are more appropriate in the methods section after the description of the indices.

**Table 3.** Characteristics of insect communities found in coconut trees

| Coconut plants (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Coconut plants (8 years old) | Number of Individuals | 847.00 | 853.00 | 761.00 |
| | Diversity Index (H') | 1.90 | 1.95 | 2.04 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.31 |
| | Dominance Index (D) | 0.34 | 0.32 | 0.28 |
| Coconut plants (5 years old) | Number of Individuals | 754.00 | 734.00 | 695.00 |
| | Diversity Index (H') | 1.86 | 1.90 | 1.97 |
| | Eveness Index (E) | 0.28 | 0.29 | 0.30 |
| | Dominance Index (D) | 0.16 | 0.16 | 0.17 |
| Coconut plants (2 years old) | Number of Individuals | 622.00 | 617.00 | 544.00 |
| | Diversity Index (H') | 1.75 | 1.76 | 1.80 |
| | Eveness Index (E) | 0.27 | 0.27 | 0.29 |
| | Dominance Index (D) | 0.16 | 0.15 | 0.18 |

**Commented [BA54]:** Same comment as those regarding the titles of the earlier two tables.

**Commented [BA55]:** The comparison that the authors apparently attempt to show in this table here would be easier to appreciate and understand if the data here were presented in the form of a graph.

**The characteristics of insects on wild plants around coconut trees**

Based on the results, it was found that the highest index was found in coconut fields that were 8 years old. Meanwhile, at the age of 2 years, the analysis results were lower (Table 4). This also proves that the age of the coconut greatly influences the number of species found in wild plants around the coconut. The diversity, evenness and dominance indices in coconut plants aged 8 years, 5 years and 2 years experienced increases and decreases in population numbers. The diversity index in wild plants around 8-year-old coconut plants is higher compared to 5- and 2-year-old coconut plants. Meanwhile, the evenness and dominance index of wild plants around 2-year-old coconut plants was higher than that of 8- and 5-year-old coconut plants.

**Table 4.** Characteristics of insect communities in wild plants around coconut trees

| Wild plants around the coconut trees (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Wild plants around the coconut plants (8 years old) | Number of Individuals | 99.00 | 92.00 | 77.00 |
| | Diversity Index (H') | 1.78 | 1.77 | 1.77 |
| | Eveness Index (E) | 0.39 | 0.39 | 0.41 |
| | Dominance Index (D) | 0.19 | 0.22 | 0.21 |
| Wild plants around the coconut plants (5 years old) | Number of Individuals | 72.00 | 65.00 | 53.00 |
| | Diversity Index (H') | 1.77 | 1.75 | 1.76 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.44 |
| | Dominance Index (D) | 0.21 | 0.23 | 0.23 |
| Wild plants around the coconut plants (2 years old) | Number of Individuals | 42.00 | 37.00 | 28.00 |
| | Diversity Index (H') | 1.54 | 1.53 | 1.54 |
| | Eveness Index (E) | 0.41 | 0.42 | 0.46 |
| | Dominance Index (D) | 0.26 | 0.30 | 0.32 |

**Commented [BA56]:** Same comment as those regarding the titles of the earlier two tables.

**Commented [BA57]:** Like the information in Table 3, I suppose the information here and the comparison that the authors apparently would like to show would be easier to appreciate and understand if the data were presented in a graph.

**Relative abundance of insects found in coconut trees**

The relative abundance of insects on coconuts aged 8 years, 5 years and 2 years varied greatly. At plant ages of 8 years and 5 years, the abundance of insects in the Order Hemiptera was found, namely 59.00% and 58.00% respectively. while the lowest order is the Order Coleoptera which is only 3.00% and 4.00% respectively. In contrast to the age of 2 years, the most insect species found were from the Order Hymenoptera, namely 48.00% and the lowest species were in the Orders Lepidopeta and Hymenoptera, which was only 7.00% (Figure 2).

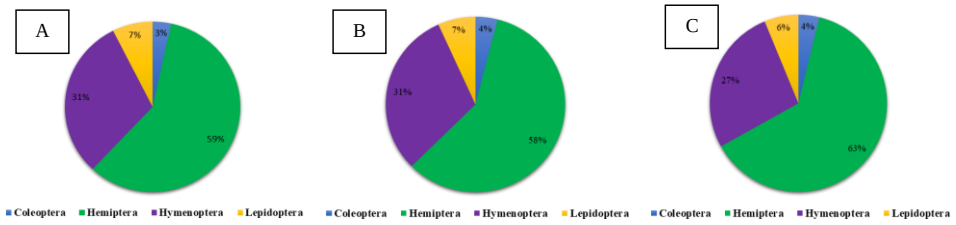


**Figure 2.** Abundance of insects found in coconut trees at: A) 8 years old, B) 5 years old, C) 2 years old.

**Commented [BA58]:** Same comment/concern on contextualization as in the titles of the tables.

**Relative abundance of insects found in wild plants around coconut trees**

The relative abundance of insects in wild plants around coconut plants was only found in 3 orders, namely the orders Coleoptera, Isoptera and Orthoptera. In plants aged 8 years, 5 years, and 2 years, the most Orthoptera orders were found, namely 50.00%, 53.00% and 72.00% respectively. Meanwhile, in the area around 2-year-old coconuts, only two orders were found, namely Coleoptera and Orthoptera (Figure 3).

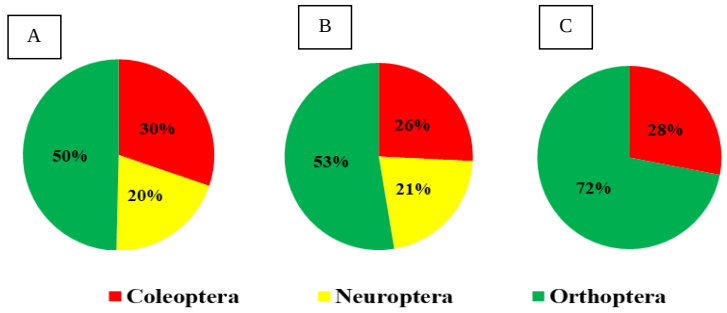



**Figure 3.** Abundance of insects on wild plants around coconut trees at different age of coconut: A) 8 years old, B) 5 years old, C) 2 years old.

**Commented [BA59]:** Same comment/concern on contextualization as in the titles of the tables and the earlier figure.

The results of observations found 18 species of insects associated with coconut plants and surrounding wild plants. The 18 insect species act as phytophagous, pollinators and natural enemies. The dominant insects belong to the orders Hemiptera and Hymenoptera. The insects are *Aspidiotus destructor* (Figure 4a), *Nipaecoccus nipae* (Figure 4b), *Aleurocanthus* sp. (Figure 4c), *Polyrhachis dives* (Figure 4d), *Oecophylla* sp. (Figure 4e).

**Commented [BA60]:** "phytophages" or "herbivores"

**Commented [BA61]:** This is very broad. Could they be parasitoids? Predators?

**Commented [BA62]:** Were there no scavengers or detritivores? There were ants among the insects, right?

**Commented [BA63]: What is shown in Fig. 4a is NOT *Aspidiotus destructor*!** Additionally, the one in Fig. 4b is not very clear if it really is *Nippaecoccus nipae*.

**Commented [BA64]:** Instead of indicating "Figure 4x" (x is a letter from a to e) in parentheses beside each insect species, just indicate "Figure 4" in parentheses after the last species and before the period at the end of the sentence.

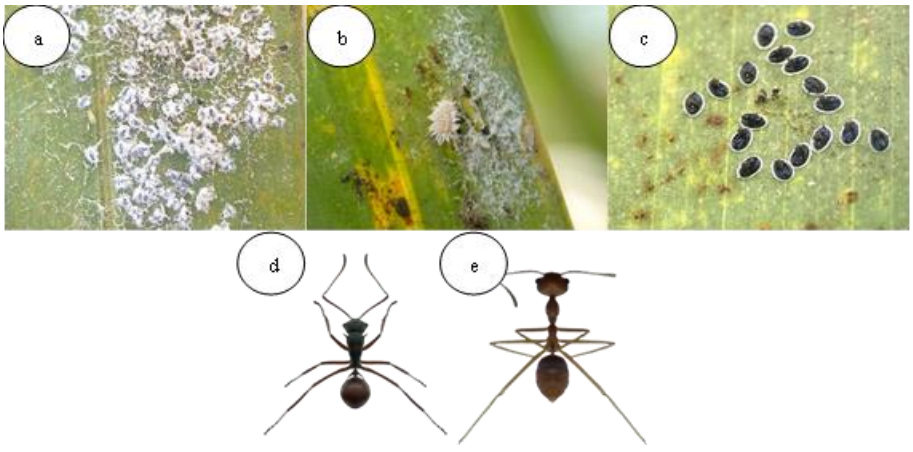



**Figure 3.** The dominant insects are found on coconut plants and surrounding plants. *Aspidiotus destructor* (a), *Nipaecoccus nipae* (b), *Aleurocanthus* sp. (c), *Polyrhachis dives* (d) dan *Oecophylla* sp. (e)

**Commented [BA65]:** This should be "Figure 4".

**Commented [BA66]: What is shown in Fig. 4a is NOT *Aspidiotus destructor*!** The one in Fig. 4b is not very clear if it really is *Nippaecoccus nipae*. If the authors insist on the identities of what are shown in the photos for a and b, they have to use a higher resolution photo that would more clearly show the insects, or present a photomicrograph of a slide-mounted specimen of these supposed coccoids.

**I am very sure, though, that what is shown in Fig. 4a as it is in this figure is NOT *As. destructor*.**

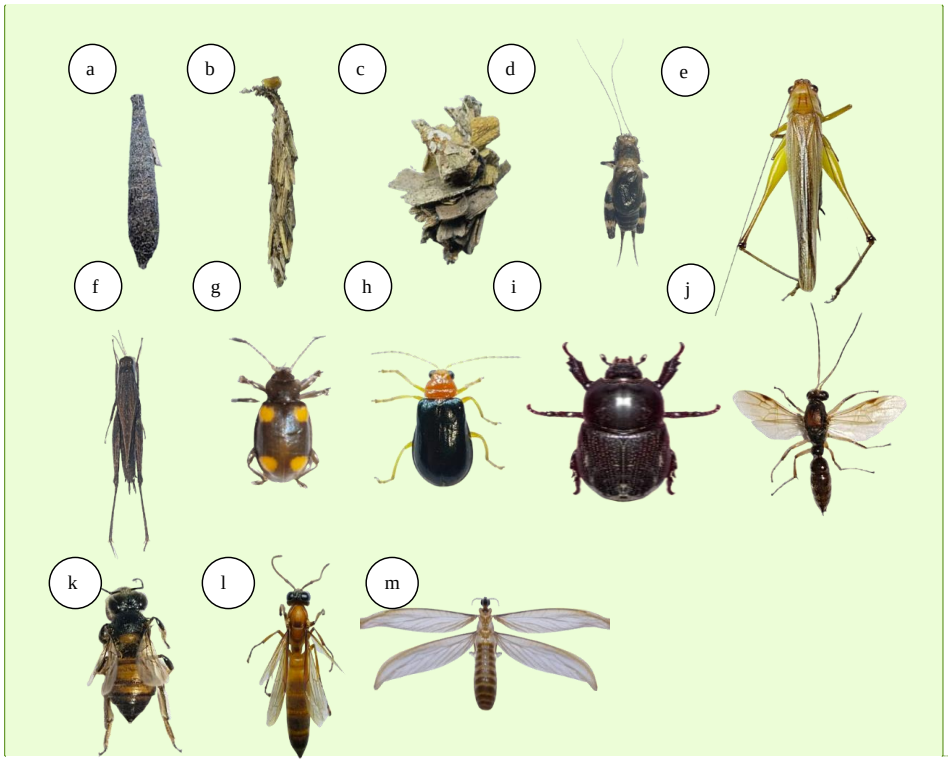



**Figure 4.** The non-dominant insects are found on coconut plants and surrounding plants. *Pteroma pendula* (a), *Cenephora hirsuta* (b), *Metisa plana* (c), *Dianemobius fascipes* (d), *Conocephalus* sp. (e), *Tettigidea lateralis* (f), *Eumorphus westwoodi* (g), *Aulacophora* sp. (h), *Oryctes rhinoceros* (i), *Cotesia congregata* (j), *Aphis cerana* (k) *Polistes carnifex* (l) and *Mactrotermes* sp. (m).

## Discussion

The results of observations in the field showed that the number of insects caught using traps in coconut plantations was identified as 7 orders, 18 species with a total of 2330.67 individuals. However, this research observation was divided into two parts, namely on coconut plants and on wild plants around coconuts which have various ages. Observations on coconuts of various ages showed findings of 4 orders and 12 species of insects. The highest number of species found in 8 year old coconut fields was *Nipaecoccus nipae* which comes from the order Hemiptera, namely 256.33 individuals. supported by research by Ganganalli et al. (2023), that the species of aphids that are most often found on coconuts. Meanwhile, in the wild plants around coconut, there are 3 orders and 6 species. The 6 insect species belong to the orders Coleoptera, Isoptera and Orthoptera. *Captotermes* sp dominated coconuts aged 8 years. Meanwhile, coconuts aged 2 years old, the most common insects were *Conocephalus* sp. which comes from the order Orthopetra. The seven orders found, including the orders Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Coleoptera, Isoptera and Orthoptera, have various roles in the ecosystem. This coconut plants species were found that have roles as pests, predators, parasitoids and also pollinators (Kavitha et al. 2023). Direct observation was carried out by recording the condition or behavior of the object being observed (Vislobokov 2017). There were species *A. destructor*, *N. nipae, Aleurocanthus* sp., *P. pendula, C. hirsuta*, and *M. Plana* recorded by using the direct observation method. On the other hand, the traps were used to collected the fly or active insects such as insect nets, light traps and pheromones traps (Haneda et al. 2017). According to Iswara et al. (2022), traps are designed based on insect behaviour and attraction to certain lights, shapes and colours. The species obtained using the insect nets and the light trap were *E. westwoodi*. *Aulacophora* sp., *A. cerana, P. carnifex, Conocephalus* sp., and *T. lateralis.* Meanwhile, *O. rhinoceros* was found in the pheromone trap. Pheromones traps are traps used to attract male insects (Maruthadurai and Ramesh, 2020). Pheromones trap was effectively to monitor and control the adults of *O. rhinoceros* (Paudel et al. 2023).

**Commented [BA67]:** It seems that some of the images in this collage have been resized without maintaining the proportions. Please use maintain the proportions so that the morphometrics of the insects (at least in the images) would appear accurate.

Scale bar(s) should also be added.

The letter labels should be placed either right on top or right below each insect image, rather than being offset to the upper left.

**Commented [BA68]:** This should be "Figure 5".

**Commented [BA69]:** Please correct the generic epithet: *Apis*, not *Aphis*.

**Commented [BA70]:** It would be clearer if the letter labels were placed before the scientific names, and not after.

I also cannot help but doubt the correctness of the identification of some of the insects, particularly of the one identified by the authors as supposedly *Polistes carnifex*. The insect in the image labeled as Fig. 5l does not look like *P. carnifex* at all. The lack of one or more scale bars in the figure does not help clear this doubt, although it is obvious that the images of the insects are not of the same scale.

The authors also failed to mention or cite in the methodology the identification keys they used, thus I cannot also help but ask which between the following applies in the case of the authors and the study:
(a) one or more of the authors of this paper is a competent insect taxonomist/systematist who examined and identified the specimens himself/herself/themselves; or
(b) the authors had the identity of the insects validated by a competent taxonomist in case (a) does not apply but one or more of them did the examination and identification of specimens; or
(c) if the authors had the examination and identification of the specimens done by a competent taxonomist who is not among them.

**Commented [BA71]:** What exactly does this number mean? What does it mean by 2330.67 total individuals? There is no such thing as 0.67 individual insect, is there?

**Commented [BA72]:** "most abundant species"

**Commented [BA73]:** Same comment/question on the numbers pertaining supposedly to individuals but with decimals.

**Commented [BA74]:** The study's finding/identification of *As. destructor* needs to be revisited, since the image in Fig. 4a definitely does NOT show that species.

**Commented [BA75]:** "Pheromone"

*Aspidiotus destructor* Signoret (Hemiptera: Diaspididae) is an coconut scale (Serrana et al. 2023). The coconut scale was found in the highest numbers at every age of coconut. The insect scale had also been confirmed to cause significant economic losses to the coconut industry in the Philippines (Serrana et al. 2019). Moreover, coconut bud borer beetles (*O. rhinoceros* L) were found at all ages of coconut. *O. rhinoceros* is one of the main pests that causes damage to germplasm in coconut (Paudel et al. 2022). In Indonesia, *O. rhinoceros* is a threat to both coconut and oil palm plants (Rahayuwati et al. 2020). These beetles are known to attack palm trees by boring into the crown and eating developing fronds (leaves that have not yet opened), which can cause death or stunted growth in young palm trees if the infestation is severe (Chalapathi Rao et al. 2018; Paudel et al. 2021, 2023). For mature oil palm trees, this damage can result in reduced productivity. This was also confirmed by Parnidi et al. (2022), that the average damage caused by this pest investment ranges from 0 to 16.7%. This study showed that there were different insects at each age of coconut. The plant age can influence the number of species and the number of individuals (Myers and Sarfraz, 2017; Santi et al. 2023). As plants grow and mature, they provide different habitats and resources that can support a variety of insects species (Schowalter 2016). Older plants tend to have more developed and complex ecosystems with greater insects species diversity (Schowalter 2017). Additionally, mature plants are often larger and have more resources, so they can support more individuals in their ecosystem (Lindenmayer and Laurance 2016). However, the specific impact of plant age on insect species and the number of insect individuals may vary depending on plant species, environmental conditions, and other factors (Myers and Sarfraz 2017).

The insect diversity index on coconut plants and surrounding wild plants in Sri Tiga Village from week 1 to week 3 shows a diversity value of $1 < H' < 3$, this is in the medium category. This criterion shows the diversity of pests and natural enemies which increases in number as the population increases towards balance. According to Hasibuan et al. (2019), there are 3 criteria for insect species diversity, namely low species diversity if $H < 1$ (unstable environmental conditions), desang species diversity if H 1-3 (medium environmental conditions), and high species diversity if $H > 3$ (stable environmental conditions). The results of the dominance index calculation obtained on coconut plants and surrounding wild plants from week 1 to week 3 showed a dominance value of $0 < D < 0.5$. This means that the dominance of these insects is relatively low. The Evenness Index (E) value is 0.29-0.31 in the depressed category. According to Hasibuan et al. (2019), there are 3 criteria for the community environment based on its evenness value, namely if $E < 0.50$ then the community is in a depressed condition. If 0.50 < E' 0.75 then society is in a stable condition, while 0.75 < E' 1.00 means society is in an unstable condition. The evenness index value (E') can describe the stability of a community. The smaller the value of E' or closer to zero, the more uneven the distribution of organisms in a community that is dominated by a certain type and conversely, the greater the value of E' or close to one, the organisms in that community will be evenly distributed (Ambarwati et al. 2023). Apart from being influenced by plant age, insect diversity can be influenced by climate and weather factors (Subedi et al. 2023). From July to September 2023, Sri Tiga Village faced the dry season. The dry season is characterized by decreased rainfall and increased temperatures, disrupting the life cycle of insects. According to Paliama et al. (2022), increasing global temperatures can affect the life cycle of insects. In addition, dry seasons can cause drought and reduce water availability for insects (Benoit et al. 2023). This condition may affect the ability of insect to tolerate climatic factors in an ecosystem.

**Commented [BA76]:** These information presented in these two sentences can be condensed into a single sentence.

**Commented [BA77]: It was NOT *Aspidiotus destructor* that Serrana *et al.* (2019) reported in their 2019 paper, but *As. rigidus*.** Please revisit this statement and its apparent reference.

**Commented [BA78]:** The methods and results section indicated monthly observations and sampling, not weekly. Did the study have weekly observations as well, hence this statement?

**Commented [BA79]:** "experienced"

**Commented [BA80]:** Currently, this subsection does not end with a clear conclusion statement that describes the implication of the findings at the local scale (within Sri Tiga Village) or beyond, and specifically on the viridis variety of coconut. Published information on the occurrence of the insects on viridis variety in other areas in or outside Indonesia, or on other coconut varieties in Sri Tiga or in other parts of Indonesia, may be included here for comparison with the findings in Sri Tiga Village viridis variety coconut plantations.

## ACKNOWLEDGEMENTS

The authors thank to farmers of smallholding coconut plantation in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia to allow the authors observed the insect in coconut trees. This research was part of a research project, and the chairman of the research project was Erise Anggraini, with contract number 0094.073/UN9/SB3.LP2M.PT/2023.

## REFERENCES

Ambarwati M, Dewi K, Aurina DM, Faturrahman AD, Fatikha LAY, Rachmalia F, Ainaya FA, Kinanthi A, Rohman, CM, Pradhana F, Fadzilah A, Pramudita DA, Ramadhan MF, Mahajoeno E, Nugroho GDWI, Sujarta P, Yap CK, Adha K, Rahim BINA, Setyawan ADWI. 2023. Ecological index and economic potential of mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia. Biodiversitas 24: 1231–1241. DOI: 10.13057/biodiv/d240265

Arumugam T. (2022). Improving coconut using modern breeding technologies. Plants 11: 1-22. DOI: 10.3390/plants11243414

Aulia AN, Chasanah N, Prasetyo AS, Nalawati AN. 2020. Competitiveness and export similairity of Indonesia's coconut oil. J Agribest 04: 123–132. DOI: 10.32528/agribest.v4i2.3546

Badan Pusat Statistik. 2023. Luas Areal dan Produksi Perkebunan Kelapa Rakyat Menurut Kecamatan. https://banyuasinkab.bps.go.id/indicator/54/151/1/luas-areal-dan-produksi-perkebunan-kelapa-rakyat-menurut-kecamatan.html

Benoit JB, Mccluney KE, Degennaro MJ. (2023). Dehydration dynamics in terrestrial arthropods: from water sensing to trophic interactions. Annu Rev Entomol 68: 129–149. DOI: 10.1146/annurev-ento-120120-091609

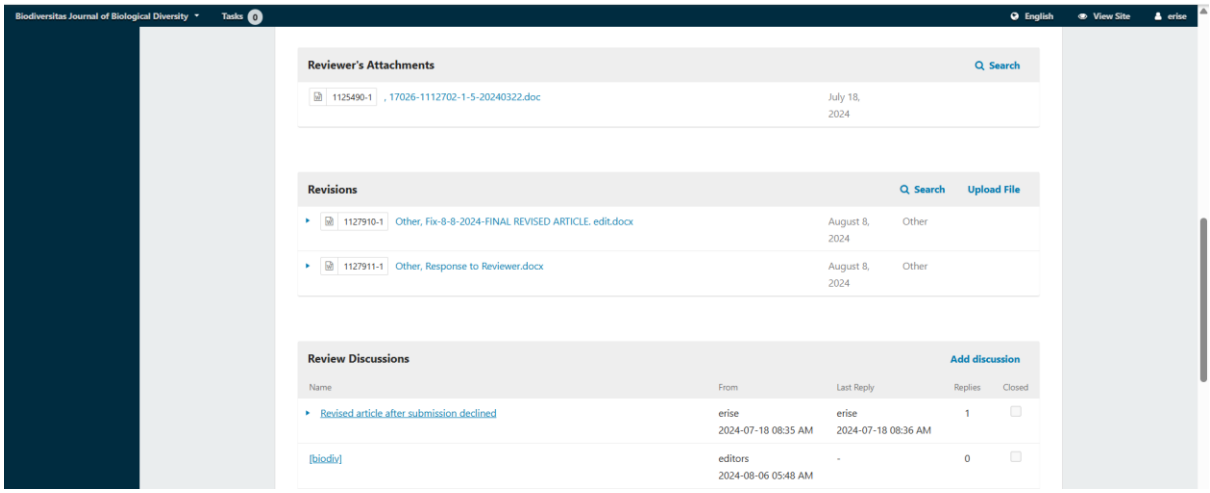
Chalapathi Rao NBV, Snehalatharani A, Nischala A, Ramanandam G, Maheswarappa HP. 2018. Management of rhinoceros beetle (Oryctes rhinoceros L.) by biological suppression with Oryctes baculovirus in Andhra Pradesh. J Plant Crops 46: 124-127. DOI: 10.25081/jpc.2018.v46.i2.3725

Chandra R., Abdul M, Sharma N, Bharathi K, Singh S. 2023. The role of insects in ecosystems, an in-depth review of entomological. International J Environ and Climate Change 13:4340–4348. DOI: 10.9734/IJECC/2023/v13i103110

Chowdhury S, Dubey VK, Choudhury S, Kumar N, Semwal A, Kumar V. 2023. Insects as bioindicator: A hidden gem for environmental monitoring. Front. Environ. Sci 11: 1–16. DOI: 10.3389/fenvs.2023.1146052

Ganganalli SM, Bhaskar H, Joshi, S, Vidya CV. 2023. Diversity of Aphid Fauna (Hemiptera: Aphididae) of Kerala. Indian J Entomol 1–8. DOI: 10.55446/ije.2023.742
Haneda NF, Wibowo C, Hasbi M. 2017. Peranan arthropoda di ekosistem ekoton dan kelapa sawit. J Silvikultur Tropika 8: 116–122. DOI: 10.29244/j-siltrop.8.2.116-122
Hasibuan EW, Siregar AZ, Pinem MI. 2019. Diversity of insect in coconut plant in Kelurahan Besar, Medan Labuhan District, North of Sumatra. Inter J Trend in Research and Develop 6: 7–13.
Henrietta HM, Kalaiyarasi K, Raj AS. 2022. Coconut tree (Cocos nucifera) products : a review of global cultivation and its coconut tree (Cocos nucifera) products : a review of global cultivation and its benefits. J Sus and Environ Manage. DOI: 10.3126/josem.v1i2.45377
Hoe TK. 2019. The Current Scenario and Development of the Coconut Industry. February
Iswara D, Afifah L, Abadi S, Prabowo D, Irfan B, Widiawan AB. 2022. Kelimpahan serangga pada berbagai perangkap dengan beberapa teknik pengendalian berbeda pada pertanaman jagung pioneer 36. J Agroplasma 9: 213–224
Lindenmayer DB, Laurance WF. 2016. The ecology, distribution, conservation and management of large old trees. Biological Reviews 93: 1434-1458. DOI: 10.1111/brv.12290
Manosathiyadevan M, Bhuvaneshwari V, Latha R. 2017. Impact of insects and pests in loss of crop production: a review. in a Dhanarajan (Ed.). Springer Singapore 57-67. DOI: 10.1007/978-981-10-6647-4_4
Maruthadurai R, Ramesh, R. 2020. Mass trapping of red palm weevil and rhinoceros beetle in coconut with aggregation pheromone. Indian J Entomol 82: 439–441. DOI: 10.5958/0974-8172.2020.00114.5
Moreira MM, Reitas LF. 2020. Review of the pollination system by small diverse insects. Neotrop Entomol, 472–481. DOI: 10.1007/s13744-020-00779-6
Myers JH, Sarfraz RM. 2017. Impacts of insect herbivores on plant populations. Annu. Rev. Entomol. DOI: 10.1146/annurev-ento-010715-023826
Paliama HG, Latumahina FS, Wattimena CMA. 2022. Keanekaragaman serangga dalam kawasan hutan mangrove di Desa Ihamahu. Jurnal Tengkawang 12: 94–104. DOI: 10.26418/jt.v12i1.53861
Parnidi P, Sunarto DA, Marjani M. 2022. Shoot borers beetle pest of coconut (Oryctes rhinoceros L.) investment at Agave spp. Bioeduscience 6: 89–95. DOI: 10.22236/j.bes/616282
Paudel S, Jackson TA, Mansfield S, Ero M, Moore A, Marshall SDG. 2023. Use of pheromones for monitoring and control strategies of coconut rhinoceros beetle (Oryctes rhinoceros): A review. Crop Protection . DOI: 10.1016/j.cropro.2023.106400
Paudel S, Mansfield S, Villamizar LF, Jackson TA, Marshall SDG. 2021. Can biological control overcome the threat from newly invasive coconut rhinoceros beetle populations (Coleoptera: Scarabaeidae)? A review. Annals Entomol Society of America 114: 247–256. DOI: doi.org/10.1093/aesa/saaa057
Paudel S, Marshall SDG, Richards NK, Hazelman G, Tanielu P, Jackson TA. 2022. Coconut rhinoceros beetle in Samoa: review of a century-old invasion and prospects for control in a changing future. Insects 1–15. DOI: 10.3390/insects13050487
Purnomo H, Okarda B, Dermawan A, Pebrial Q, Pacheco P, Nurfatriani F, Suhendang E. 2020. Forest policy and economics reconciling oil palm economic development and environmental conservation in Indonesia: a value chain dynamic approach. Forest Policy and Economics, 111: 1-12. DOI: 10.1016/j.forpol.2020.102089
Rahayuwati S, Kusumah YM, Prawirosukarto S, Dadang, Santoso T. 2020. The status of Oryctes rhinoceros nudivirus (OrNV) infection in oryctes rhinoceros (Coleoptera: Scarabaeidae) in Indonesia. Journal of Oil Palm Research 32: 582–589 [Indonesian]
Santi I, Tarmadja S, Priambada KJ, Elfatma O. 2023. Keanekaragaman serangga perkebunan kelapa sawit di Provinsi Kalimantan Tengah. Jurnal Ilmiah Hijau Cendekia 8:45. DOI: 10.32503/hijau.v8i1.2917
Schowalter TD. 2017. Arthropod diversity and functional importance in old-growth forests of North America. Forests. DOI: 10.3390/f8040097
Schowalter TD. 2016. Insect Ecology: An Ecosystem Approach. Academic press.
Serrana JM, Almarinez BJM, Barrion AT, Amalin DM. 2023. Ultrastructural characterization of the scale cover of cryptic Aspidiotus spp. (Hemiptera: Diaspididae) and the ovipositor of their parasitoids. Microscopy and Microanalysis 29: 825–831. DOI: 10.1093/micmic/ozac041
Serrana JM, Ishitani N, Carvajal TM, Almarinez BJM, Barrion AT, Amalin DM, Watanabe K. 2019. Unraveling the genetic structure of the coconut scale insect pest (Aspidiotus rigidus Reyne) outbreak populations in the Philippines. Insects. DOI: 10.3390/insects10110374
Stam JM, Kroes A, Li Y, Gols R, Loon JJAV, Poelman EH, Dicke M. 2014. Plant interactions with multiple insect herbivores : from community to genes. Annu. Rev. Plant Biol 65: 689–713. DOI: 10.1146/annurev-arplant-050213-035937
Subedi B, Poudel A, Aryal S. 2023. The impact of climate change on insect pest biology and ecology : Implications for pest management strategies, crop production , and food security. J Agriculture and Food Research. DOI: 10.1016/j.jafr.2023.100733
Thomas GV, Krishnakumar V, Dhanapal R, Srinivasa Reddy DV. 2018. Preharvest approaches to control insect infestation in fruit. Elsevier. DOI: 10.1007/978-981-13-2754-4_7
Tiemann TT, Donough CR, Lim YL, Härdter R, Norton R, Tao HH, Jaramillo R, Satyanarayana T, Zingore S, Oberthür T. 2018. Chapter four-feeding the palm: a review of oil palm nutrition. Advances in Agronomy 152: 149–243). DOI: 10.1016/bs.agron.2018.07.001
Vislobokov NA. 2017. Flowering biology of Aspidistra (a sparagaceae): new data on pollination by dipteran insects. Plant Species Biology 32: 412–422. DOI: 10.1111/1442-1984.12175
Ximenes R, Nurmalina R, Rifin A. 2021. Demand analysis of Indonesia's coconut crude oil in Germany. Review of Economics and Finance 19: 281–285. DOI: 10.55365/1923.x2021.19.39
Zainol FA, Arumugam N, Norhayate W, Daud W, Aisyah N, Suhaimi M. 2023. Coconut value chain analysis : a systematic review. Agriculture. DOI: 10.3390/agriculture13071379

## *Peer review round 8 (18 Juli 2024)*



# Insects found in different ages of coconut viridis variety in Sri Tiga Village, Banyuasin District South Sumatra, Indonesia

**Abstract.** Coconut (Cocos nucifera) is a high-value export commodity and has promising potential on the global market. The existence of insect species is very important in coconut cultivation. The coexistence of insects and plants is interconnected because plants provide habitat and food sources for insects. However, the correlation between plants and insects still needs to be discovered to many people. Therefore, a comprehensive assessment of insect biodiversity in an environment is important to be carried out. This study revealed the structure of the insect community associated with coconut plants and plants that grow around coconut plants. Therefore, this is a novel and pioneering study that aims to determine the insects associated with coconut plants. This study was conducted by surveying community-owned coconut plantations in ~~The coconut (*Cocos nucifera*) is a valuable item for export and holds promising potential on the global market. The existence of bug species is crucial to coconut cultivation. The coexistence of insects and plants is interconnected as plants provide as habitats and food sources for insects. Nevertheless, the correlation between plants and insects remains unknown to many individuals. A comprehensive assessment of insect biodiversity within an environment must be carried out. This information shows the community structure of insects associated with coconut plants and plants that grow around coconut plants. Therefore, the aim of this study was to find out the insects associated with coconut plants. This study was carried out with a survey in a coconut plantation owned by the people in~~ Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency, South Sumatera, Indonesia. The observation was carried out during July and September of 2023. ~~The data gatheringdata-gathering~~ process involved identifying three coconut plantations with varying ages of coconut trees (8, 5, and 2 years old). Data collection was carried out using the purposive sampling method by direct observations and using traps such as insect nets, light traps, and pheromone traps. Collected specimens were identified using a ~~macroscope~~ microscope in the Laboratory of Entomology, Department of Plant Pests and Disease, Faculty of Agriculture, Sriwijaya University. The results of this study found 12 species, namely *Oryctes rhinoceros*, *Aspidiotus* sp., *Nipaecoccus nipae*, *Aleurocanthus* sp., *Apis cerana*, *Cotesia congregata*, *Dolichoderus thoracicus*, *Oecophylla smaragdina*., *Provespa* sp., *Pteroma pendula*, *Metura* sp., *Metisa plana*. The predominant insect pests identified were *Aspidiotus* sp., *Nipaecoccus nipae*, and *Aleurocanthus* sp.. Furthermore, the most predominant insects that served as insect scavengers were *Polyrhachis* sp. and *Oecophylla smaragdina*. According to this study, *Oryctes rhinoceros* showed ~~not significantly different average number of individual~~no significantly different average number of individuals at coconut tree ages of 8, 5, and 2 years. In contrast, the sucking insects *Aspidiotus* sp. and *Nipaecoccus nipae* were found in large numbers on coconut plants that were 8 and 5 years old. In contrast, only a few individuals were identified on two-year-old coconut plants, ~~whereas only a few individuals were identified on coconut plants that were two years old.~~

~~Key words~~**Keywords:** *Cocos nucifera*, viridis variety, coconut, insects
**Running title:** Insects Found in Coconut Viridis Variety

## INTRODUCTION

Indonesia encompasses diverse agricultural sectors, including plantations, horticulture, food crops, and forestry. The plantation sector in Indonesia plays a substantial role in the nation's economy (Purnomo et al. 2020). Coconut plantations in Indonesia have undergone extensive development and now serve as the primary source of income for coconut farmers. Coconut contributes significantly to the economy, social fabric, and government revenue derived from non-oil and gas commodities (Ximenes et al. 2021). The primary utilization of coconut production is for consumption and industrial purposes (Hoe 2019). The cultivated coconut plants have yielded various products, such as coconut oil, coconut sugar, desiccated coconut, coconut milk, coconut shells, coconut juice, and coconut ~~fibre~~ fiber (Henrietta et al. 2022). Coconut (*Cocos nucifera*) is a tropical plantation commodity that is widespread in Indonesia, the Philippines, India, and several Asia Pacific

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countries (Hoe 2019). Coconut is a lucrative export product with promising opportunities in the global market. Indonesia is the leading coconut-producing nation globally, with the Philippines and India ranking second and third, respectively (Zainol et al. 2023). In 2022, the Banyuasin Regency in Indonesia had a total area of coconut plantations measuring 42,599~~,~~00 hectares, which yielded a productivity of 46,760~~,~~00 tons (Badan Pusat Statistik~~,~~ 2023).

Understanding the life cycle of the plant from germination to harvest is crucial in the cultivation of coconuts. This stage necessitates consistent monitoring and care. Coconut cultivation necessitates ~~the~~ selecti~~o~~ng ~~of~~ high-quality seedlings, the cultivation of appropriate soil, and the provision of appropriate care (Thomas et al. 2018). Coconuts thrive in sufficient sunlight, appropriate rainfall, and nutrient-rich soil with effective drainage (Tiemann et al. 2018). The ideal pH range for coconut plant growth is between 5 and 8 (Fauzana et al. 2021). A deep understanding ~~Acquiring a profound comprehension~~ of these elements can lead to the establishment of coconut plantations that can be maintained over a long ~~period of time~~period. In addition, it is necessary to give attention to frequent pruning, fertilizing, and managing pests and diseases (Aulia et al. 2020)~~; a. Gaining a~~ thorough understanding of these characteristics can lead to profitable and sustainable coconut production. However, in many coconut-producing locations, especially in small-scale coconut farms, there is a lack of intensive fertilizer application and insect management (Zainol et al. 2023). This need for improvement should motivate us to strive for better practices. Coconut cultivation is closely related to the ~~Moreover, the cultivation of coconuts is inherently linked to the presence of insect species. The~~ presence of insects on plants and i~~i~~s interconnected since plants serve as both a habitat and a source of sustenance for insects (Stam et al. 2014). Plants rely on insects for the process of plant pollination (Moreira and Reitas 2020). Furthermore, insects have the ability to inflict harm upon cultivated plants (Manosathiyadevan et al. 2017).

The age of coconut trees in coconut plantations varies across different regions. This leads to variations in plant growth and development among different trees, impacting not only their nutritional needs but also the timing of harvest and total production (Arumugam 2022). Effective management practices tailored to the age of the coconut plant are crucial for optimizing its overall health and productivity. Coconut trees at different phases of growth may attract distinct insect pests, which may prefer specific developmental stages of the plants due to physiological disparities. It is crucial to accurately identify and effectively manage these pests, considering the age of the coconut trees, in order to achieve successful pest control. In addition, insects fulfill diverse functions within ecosystems and exert substantial influence on human culture and the environment, serving as pollinators, decomposers, and pests (Chandra et al. 2023). Current information regarding the prevalence of insects on coconut trees still needs to be improved, especially regarding their age. Therefore~~There is a lack of recent information regarding the prevalence of insects on coconut trees, particularly in relation to their age. Consequently~~, it is imperative to conduct an inventory of insect biodiversity in the coconut plantation ecosystem at various plant ages. The ecosystem's alterations can be inferred from the diversity of insect species (Chowdhury et al. 2023)~~. . The number of insect populations is influenced by the season (Tougeron et al. 2020). Hence, it is crucial to identify insects on coconut trees at various phases of development. This research was conducted in July and September 2023 that was dry season in South Sumatera, Indonesia. Acquiring information about different insect species can offer valuable understanding for~~The number of insect populations is influenced by the season (Tougeron et al. 2020). Hence, it is crucial to identify insects on coconut trees at various phases of development. This research was conducted in July and September 2023, during the dry season in South Sumatera, Indonesia. Obtaining information about different insect species can provide valuable insight into formulating integrated pest management strategies, which can be directly applied in coconut plantation management ~~formulating integrated pest management strategies~~.

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## MATERIALS AND METHODS

### Study area

The study was carried out in people's coconut plantations in Sri Tiga Village, Sumber Marga Telang District, Banyuasin Regency (Figure 1). Insect identification was conducted at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Sriwijaya University. The study was carried out from July to September 2023. Three coconut plantations of different ages, specifically 8 years, 5 years, and 2 years~~,~~ were selected as observation sites. Each plantation covers an area of around 5 hectares.

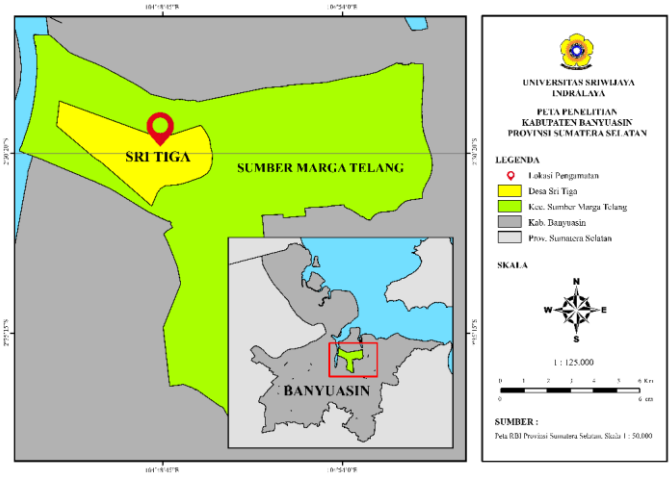


**Figure 1.** The sampling location is in Sri Tiga Village, Banyuasin District, South Sumatra, Indonesia. The samples are taken from different ages of the coconut viridis variety.

## Procedures

### Field survey and sampling

An initial survey ~~were~~ was undertaken to choose the sampling sites. In addition, a study was undertaken to gather information from the community regarding the utilization of coconut in Sri Tiga Village, Banyuasin Regency. Data was collected using the purpose sampling method. ~~Insects~~ Insect sampling was carried out weekly for three months, started July to September 2023. A total of 12 observations were made, and t~~. T~~he collection of arthropods was conducted during the early morning hours, specifically from 06:00 to 07:00 a~~.~~m. The insects were collected by sweep nets, which had a net handgrip length of 100 cm, a length of 75 cm, and a diameter of 30 cm. This collection method was based on the techniques described by Karenina et al. (2019). ~~The~~ swinging net was intentionally contacted with weeds around coconut trees. The arthropods were caught by employing a swinging net in a single motion, utilizing two swings that align ~~in a linear fashion~~linearly~~,~~ at a depth of 30 cm towards the interior of weeds. The light traps were employed to gather the nocturnal insects. A total of four light traps were utilized by three coconut plantations of varying ages, namely 8 years, 5 years, and 2 years. The nocturnal insects were captured in light traps throughout the period from 7 to 9 pm. A synthetic pheromone trap containing ethyl-4-methyloctanoate as the active ingredient was used to capture adults of *Oryctes rhinoceros* beetles. Each of the three coconut plantations utilized a total of four *Oryctes* pheromone traps. The collected insects were stored in glass vials containing a solution of 70% alcohol. They were then labeled and transported to the Entomology Laboratory at the Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Sriwijaya, South Sumatra, Indonesia.

### Identification

Dr. Chandra Irsan, an insect taxonomist, was assigned the responsibility of identifying the insect specimens. The collected insects were visually identified using the references by Heinrichs (1994), (Borror 1971), Hill (1994; 1997), Howard et al. (2001), Kalshoven (1981), and McAlpine et al. (1987). The collected insects were classified according to their roles.

### Data analysis

The total individual of collected ~~insect~~ insects was recorded and presented in the table. The insect abundance data (average number of individuals) was subsequently transformed using the Square Root transformation ~~and the~~. The transformed data was examined using R Statistical software version 4.4.0 (de Micheaux et al. 2013). The species diversity index was used to describe the diversity of insect species found in the research area. The diversity index was expressed using the Shannon-Wiener species diversity formula (Keylock~~,~~ 2005):

$$H' = -\sum pi * (Ln\ pi)$$

Where H' is Shannon-Wiener Diversity Index, Pi: ni/N (comparison between the number of a species and all species). The description of criteria: H' < 1 is low diversity, 1 < H' < 3 is medium diversity, and H' > 3 is high diversity.

The species evenness index was used to describe the degree of evenness of insect species found in the research area. The evenness index was expressed using the formula:

$$E = \frac{H'}{Ln\ S}$$

Where E is the Evenness index (value between 0-1), H' is the Shannon-Wiener diversity index, and S is the number of species. The dDescription of criteria: E < 0.4 is small population uniformity, 0.4 < E < 0.6 is moderate population uniformity, and E > 0.6 is high population uniformity.

The species dominance index was used to describe the level of dominance of insect species found in the research area. The dominance index is expressed using the formula:

$$D = \sum_{i=1}^{s} \left(\frac{ni}{N}\right)^2$$

Where, ni is the number of individuals in species i, N = total number of individuals of all species, and ni/N = pi (proportion of individuals of species i), and S = species richness. Description of criteria: 0 < D < 0.5 is low dominance, 0.5 < D < 0.75 is moderate dominance, 0.75< D < 1.0 is high dominance.

## RESULT AND DISCUSSION

### Abundance of insects found in coconut trees

The insect species found in three coconut fields with varying plant ages, namely 8 years, 5 years, and 2 years, were very diverse. There were 12 species from 4 orders. The most frequently observed orders were Coleoptera, Hemiptera, Hymenoptera, and Lepidoptera. The most abundant species discovered in coconut plantations that were 8 years old was *N.ipaecoccus nipae*, belonging to the Hemiptera order, with an average number of population density of approximately 256.33 individuals. The findings of this study also observed a similar pattern in coconut fields that had reached the age of 5 years. Specifically, the dominant species seen was *N. nipae*, with an average number of populationpopulation density of up to 265.67 individuals. On 2-year-old coconut fields, the insect species commonly found were *Aspidiotus* sp., belonging to the Hemiptera Order, with an average number of populationpopulation of approximately 96,000 individuals. There were no *Apis cerana* or *Provespa* sp. species in the 2two-year-old plantation. The comparison of species abundance in coconut fields of varying ages revealed significant variations in species diversity (Table 1).

**Table 1.** An abundance of insects (average number of individualindividuals) found on coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Order/Species | Abundance of insects on coconuts (average number of individualindividuals/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old Coconut tree | 5 years old Coconut tree | 2 years old Coconut tree | | | |
| **Coleoptera** | | | | | | |
| *Oryctes rhinoceros* | 28.00 | 29.00 | 22.67 | $3.20 \times 10^{-1}$ | $1.54^{ns}$ | - |
| **Hemiptera** | | | | | | |
| *Aspidiotus* sp. | 173.33a | 116.33b | 96.00b | $3.62 \times 10^{-3}$ | $31.24^{*}$ | 1.55 |
| *Nipaecoccus nipae* | 256.33a | 265.67a | 18.00b | $5.16 \times 10^{-5}$ | $276.40^{*}$ | 2.07 |
| *Aleurocanthus* sp. | 50.67a | 44.33a | 27.67b | $58.7 \times 10^{-4}$ | $80.55^{*}$ | 0.54 |
| **Hymenoptera** | | | | | | |
| *Apis cerana* | 5.67a | 4.33b | 0.00c | $3.13 \times 10^{-5}$ | $355.22^{*}$ | 0.25 |
| *Cotesia congregata* | 30.00a | 25.33b | 18.00c | $6.14 \times 10^{-4}$ | $78.70^{*}$ | 0.35 |
| *Dolichoderus thoracicus* | 113.33a | 103.67a | 81.33b | $45.1 \times 10^{-3}$ | $27.78^{*}$ | 0.81 |
| *Oecophylla smaragdina* | 98.00a | 87.33a | 60.33b | $1.15 \times 10^{-3}$ | $56.91^{*}$ | 0.75 |
| *Provespa* sp. | 4.00a | 2.33b | 0.00c | $4.52 \times 10^{-4}$ | $92.12^{*}$ | 0.38 |
| **Lepidoptera** | | | | | | |
| *Pteroma pendula* | 16.33a | 13.67ab | 10.00b | $2.64 \times 10^{-2}$ | $10.31^{*}$ | 0.68 |
| *Metura* sp. | 20.67a | 16.67ab | 13.00b | $6.15 \times 10^{-3}$ | $23.50^{*}$ | 0.48 |
| *Metisa plana* | 24.00a | 19.00ab | 14.00b | $6.78 \times 10^{-3}$ | $22.28^{*}$ | 0.61 |

Note: ns= not significantly different; *= significantly different; This original data was transformed using the Square Root transformation before the analysis

### Abundance of insects found in weeds around coconut trees

Insect species found in weeds around coconuts were also observed. There were 6 species of insects from 3 orders. The orders found include Coleoptera, Isoptera, and Orthoptera. In weeds around 8 year old and 5 year old coconuts, the most *Captotermes* sp insects were found. originating from the Order Isoptera, namely 18.00 individuals and 13.67 individuals8-

year-old and 5-year-old coconuts, the most Captotermes sp insects were found, originating from the Order Isoptera, namely 18.00 individuals and 13.67 individuals, respectively. Meanwhile, in the plants around coconuts that are 2 years old, the most common insects are *Conocephalus* sp. from the Order ~~Orthopetra~~Orthoptera, namely 10.00 individuals (Table 2).

**Table 2.** An abundance of insects (average number of ~~individual~~individuals) found in weeds around coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Order/Species | Abundance of Insects in weeds around Coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old coconut tree | 5 years old coconut tree | 2 years old Coconut tree | | | |
| **Coleoptera** | | | | | | |
| *Aulacophora lewisii* | 14.67a | 8.00b | 7.00b | $9.09 \times 10^{-3}$ | 18.98* | 0.71 |
| *Eumorphus westwoodi* | 12.33a | 8.33b | 3.00c | $3.21 \times 10^{-4}$ | 109.67* | 0.42 |
| **Isoptera** | | | | | | |
| *Mactrotermes* sp. | 18.00a | 13.67b | 0.00c | $3.52 \times 10^{-5}$ | 335.07* | 0.53 |
| **Orthoptera** | | | | | | |
| *Conocephalus* sp. | 17.00a | 12.00b | 10.00c | $38.9 \times 10^{-4}$ | 99.47* | 0.24 |
| *Dianemobius* sp. | 16.67a | 13.00b | 9.00c | $6.50 \times 10^{-5}$ | 246.00* | 0.17 |
| *Tettigidea* sp. | 10.67a | 8.33ab | 6.67b | $8.19 \times 10^{-3}$ | 20.10* | 0.39 |

Note: ns= not significantly different; *= significantly different; This original data was transformed using the Square Root transformation before the analysis

**Characteristics of insect communities found in coconut trees**

The investigated characteristics of the insect community on coconuts of different ages (8 years, 5 years, and 2 years) comprised the diversity index, evenness index, and dominance index. The findings indicated that the community attributes of coconut plants at the ages of 8 years, 5 years, and 2 years exhibited a progressive increase with each assessment. The diversity, evenness, and dominance indices of 8-year-old coconut plants were greater than those of 5- and 2-year-old coconut plants (Table 3). The results revealed a direct relationship between the age of the coconut and the number of insects observed in the field. A higher diversity index value indicates a greater range of species within the community. This indicator quantifies the level of biodiversity within the community. A high evenness index signifies a more balanced distribution of individuals among species within the group, whereas a low value suggests an uneven distribution. The dominance index quantifies the degree to which one or more species exert substantial influence or possess ownership within a community.

**Table 3.** Characteristics of insect communities found in coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Coconut trees (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| 8 years old | Number of Individuals | 847.00 | 853.00 | 761.00 |
| | Diversity Index (H') | 1.90 | 1.95 | 2.04 |
| | ~~Eveness~~ Evenness Index (E) | 0.28 | 0.29 | 0.31 |
| | Dominance Index (D) | 0.34 | 0.32 | 0.28 |
| 5 years old | Number of Individuals | 754.00 | 734.00 | 695.00 |
| | Diversity Index (H') | 1.86 | 1.90 | 1.97 |
| | ~~Eveness~~ Evenness Index (E) | 0.28 | 0.29 | 0.30 |
| | Dominance Index (D) | 0.16 | 0.16 | 0.17 |
| 2 years old | Number of Individuals | 622.00 | 617.00 | 544.00 |
| | Diversity Index (H') | 1.75 | 1.76 | 1.80 |
| | ~~Eveness~~ Evenness Index (E) | 0.27 | 0.27 | 0.29 |
| | Dominance Index (D) | 0.16 | 0.15 | 0.18 |

**The characteristics of insects on weeds around coconut trees**

The analysis revealed that the coconut farms that were 8 years old had the highest index. At the age of 2 years, the analysis results were shown to be lower (Table 4). This finding demonstrates that the age of the coconut has a significant impact on the diversity of weed species found in its vicinity. The diversity, evenness, and dominance indices of coconut plants at ages 8, 5, and 2 years exhibited fluctuations in population numbers. The diversity index of weeds surrounding 8-year-old coconut plants is greater than that of 5- and 2-year-old coconut plants. Conversely, the level of uniformity and prevalence of weeds surrounding coconut plants that are 2 years old was greater compared to coconut plants that are 8 and 5 years old.

**Table 4.** Characteristics of insect communities in weeds around coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Insect community in the weeds around the coconut trees (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Insect community in the weeds around the coconut trees (8 years old) | Number of Individuals | 99.00 | 92.00 | 77.00 |
| | Diversity Index (H') | 1.78 | 1.77 | 1.77 |
| | ~~Eveness~~ Evenness Index (E) | 0.39 | 0.39 | 0.41 |
| | Dominance Index (D) | 0.19 | 0.22 | 0.21 |
| Insect community in the weeds around the coconut trees (5 years old) | Number of Individuals | 72.00 | 65.00 | 53.00 |
| | Diversity Index (H') | 1.77 | 1.75 | 1.76 |
| | ~~Eveness~~ Evenness Index (E) | 0.41 | 0.42 | 0.44 |
| | Dominance Index (D) | 0.21 | 0.23 | 0.23 |
| Insect community in the weeds around the coconut trees (2 years old) | Number of Individuals | 42.00 | 37.00 | 28.00 |
| | Diversity Index (H') | 1.54 | 1.53 | 1.54 |
| | ~~Eveness~~ Evenness Index (E) | 0.41 | 0.42 | 0.46 |
| | Dominance Index (D) | 0.26 | 0.30 | 0.32 |

**The role of the insects found on coconut trees and weeds around coconut trees**

According to this study, insects found on coconut palms are often phytophagous and predatory, whereas insects located ~~on~~ in weeds frequently operate as phytophagous and decomposers (Table 5).

Table 5. The role of the insects found on coconut trees and weeds around coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Insects found in weeds around coconut trees (Order/Species)) | ~~The role of I~~nsect role in environment | Collection method |
|---|---|---|
| **Coleoptera** | | |
| *Oryctes rhinoceros* | Phytophagous | pheromone (ethyl-4-~~methyloctanoate~~methyl octanoate) trap |
| **Hemiptera** | | |
| *Aspidiotus* sp. | Phytophagous | Direct observation |
| *Nipaecoccus nipae* | Phytophagous | Direct observation |
| *Aleurocanthus* sp. | Phytophagous | Direct observation |
| **Hymenoptera** | | |
| *Apis cerana* | Pollinator | Sweep net |
| *Cotesia congregata* | Parasitoid | Sweep net |
| *Dolichoderus thoracicus* | Predatory insect | Direct observation |
| *Oecophylla smaragdina*. | Predatory insect | Direct observation |
| *Provespa* sp. | Predatory insect | Sweep net |
| **Lepidoptera** | | |
| *Pteroma pendula* | Phytophagous | Direct observation |
| *Metura* sp. | Phytophagous | Direct observation |
| *Metisa plana* | Phytophagous | Direct observation |
| **Insects found in weeds around coconut trees (Ordo/Spesies)** | ~~The role of insect in environment~~ Insect role in environment | |
| **Coleoptera** | | |
| *Aulacophora lewisii* | Phytophagous | Sweep net |
| *Eumorphus westwoodi* | Pollinator | Sweep net |
| **Isoptera** | | |
| *Mactrotermes* sp. | Decomposer | Light trap |
| **Orthoptera** | | |
| *Conocephalus* sp. | Phytophagous | Sweep net |
| *Dianemobius* sp. | Phytophagous | Sweep net |
| *Tettigidea* sp. | Phytophagous | Sweep net |

**Relative abundance of insects found in coconut trees**

There was a significant variation in the relative number of insects on coconuts of different ages, specifically 8 years, 5 years, and 2 years. The abundance of insects in the Order Hemiptera was observed at plant ages of 8 years and 5 years, with percentages of 59.00% and 58.00% correspondingly. The Order Coleoptera has the lowest representation, accounting for only 3.00% and 4.00%, respectively. At the age of 2 years, most insect species discovered belonged to the Order Hymenoptera, specifically 48.00%, while the lowest number of species were found in the Orders Lepidoptera and Hymenoptera, accounting for only 7.00% (Figure 2).

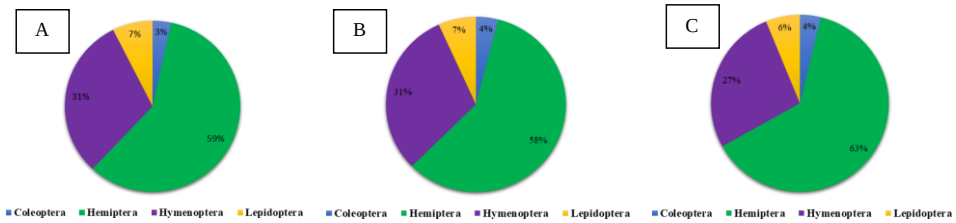


**Figure 2.** An abundance of insects was seen in coconut trees at three different stages of growth: A) 8-year-old coconut tree, B) 5-year-old coconut tree, and C) 2-year-old coconut tree.

**Relative abundance of insects found in weeds around coconut trees**

The insects identified in weeds around coconut plants were limited to three orders: Coleoptera, Isoptera, and Orthoptera. The highest proportions of Orthoptera orders were observed in coconut trees that were 8 years old (50.00%), 5 years old (53.00%), and 2 years old (72.00%). Meanwhile, in the weeds area near 2-year-old coconut trees, only ~~found two orders of insects~~two orders of insects were found, namely Coleoptera and Orthoptera (Figure 3).

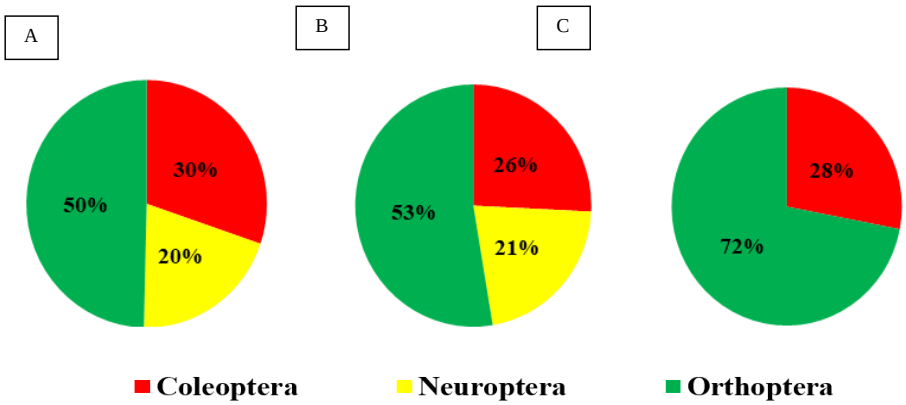


**Figure 3.** Abundance of insects on weeds around coconut trees at different ~~age~~ ages of coconut: A) 8 years old, B) 5 years old, C) 2 years old.

This study revealed the presence of 18 insect species that are closely linked to coconut palms and the vegetation in their vicinity. The 18 insect species serve as phytophagous, pollinators, and predators. The most abundant insects collected in this study were categorized into Hemiptera and Hymenoptera (Figure 4). The most abundant insects found belonged to the order Homoptera, specifically *Aspidiotus* sp. (Figure 4a), *Nipaecoccus nipae* (Figure 4b), and *Aleurocanthus* sp. (Figure 4c). Additionally, the most abundant insects observed belonged to the Hymenoptera order, specifically *Polyrhachis* sp. (Figure 4d) and *Oecophylla smaragdina*. (Figure 4e).

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**Commented [A4]:** Please check these statements, the most abundant insects on Homoptera, specifically Aspidiotus sp. (Figure 4a), and Hymenoptera order, specifically Polyrhachis sp. (Figure 4d) and Oecophylla smaragdina (Figure 4e) that differ by Figure 2 (Hemiptera) and Figure 3 (Orthoptera).

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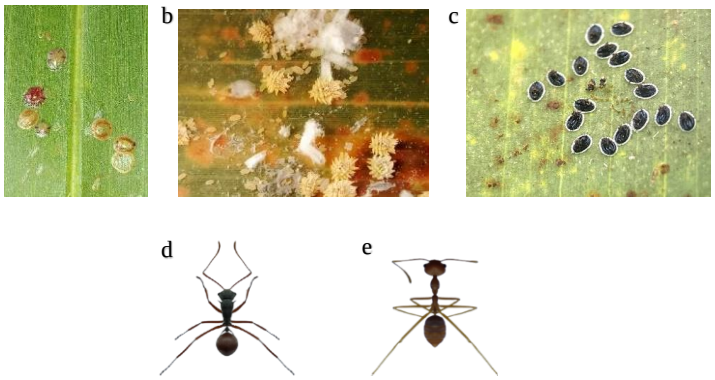


**Figure 4. Coconut plants and surrounding plants host the dominant insects.** (a) *Aspidiotus* sp., (b) *Nipaecoccus nipae*, (c) *Aleurocanthus* sp., (d) *Polyrhachis* sp. dan (e) *Oecophylla smaragdina*.

The less numerous insects collected in this study were classified as Lepidoptera, Orthoptera, Coleoptera, Hymenoptera, and Isoptera (Figure 5). The Lepidoptera species identified in this study were bagworms, specifically *P. ~~teroma~~ pendula*, *Metura* sp., and *Metisa plana.* The Orthoptera species identified in this study were *Dianemobius* sp., *Conocephalus* sp., and *Tettigidea lateralis*. The Coleoptera species identified in this study include *Eumorphus westwoodi*, *Aulacophora* sp., and *Oryctes rhinoceros*. The Hymenoptera species identified in this study were *Cotesia congregata*, *Apis cerana*, and *Provespa* sp. The Isoptera discovered in this investigation were of the species *Mactrotermes* sp.

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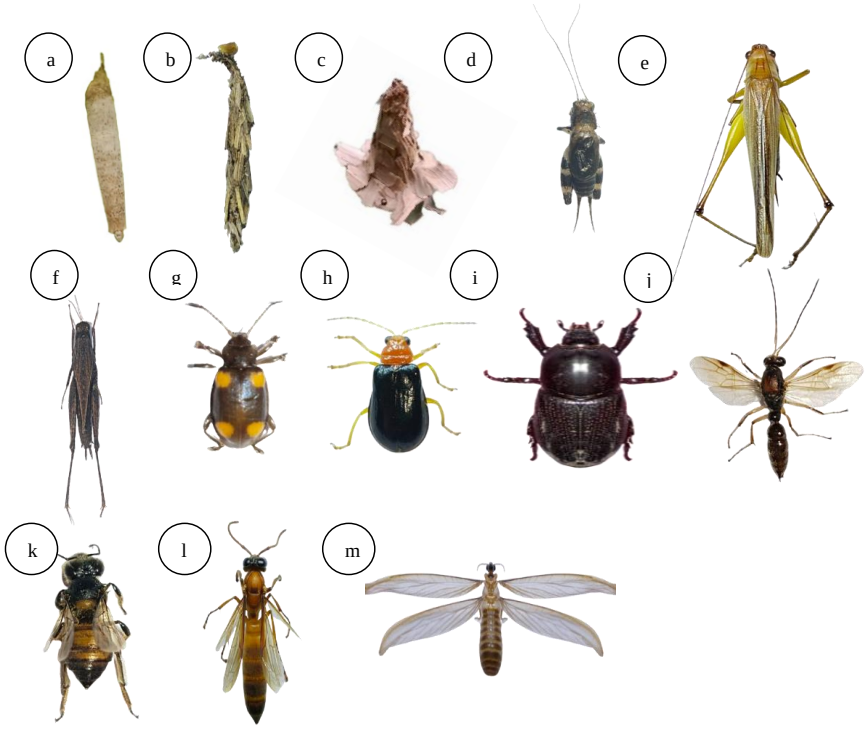


**Figure 5.** The non-dominant insects are found on coconut plants and surrounding plants. (a) *Pteroma pendula*, (b) *Metura* sp., (c) *Metisa plana*., (d) *Dianemobius* sp., (e) *Conocephalus* sp., (f) *Tettigidea sp*., (g) *Eumorphus westwoodi*, (h) *Aulacophora lewisii*., (i) *Oryctes rhinoceros*, (j) *Cotesia congregata*, (k) *Apis cerana*, (l) *Provespa* sp. and (m) *Mactrotermes* sp.

**Discussion**

The results of observations in the field showed that the number of insects caught using traps in coconut plantations was identified as 7 orders, 18 species with a total of 2,330.67 individuals. However, this research observation was divided into two parts, : namely on coconut plants and on weeds around coconuts, which have various ages. Observations on coconuts of various ages showed findings of 4 orders and 12 species of insects. The highest number of species found in 8 year old8-year-old coconut fields was *Nipaecoccus nipae*, which comes from the order Hemiptera, namely 256.33 individuals. This finding was ssupported upported by research by Ganganalli et al. (2023), that the species of aphids are most often found on coconuts. Meanwhile, in the weeds plants around coconut, there are 3 orders and 6 species. The 6 insect species belong to the orders Coleoptera, Isoptera, and Orthoptera. *Captotermes* sp dominated coconuts aged 8 years. Meanwhile, coconuts aged 2 years old, the most common insects were *Conocephalus* sp. which comes from the order Orthopterain coconuts aged 2 years old, the most common insect was *Conocephalus sp.*, which comes from the order Orthoptera. The seven orders found, including the orders Coleoptera, Hemiptera, Hymenoptera, Lepidoptera, Coleoptera, Isoptera, and Orthoptera, have various roles in the ecosystem. This These coconut plants plant species were found that have roles as pests, predators, parasitoids, and also pollinators (Kavitha et al. 2023). Direct observation was carried out by recording the condition or behavior of the object being observed (Vislobokov 2017). There were species *Aspidiotus* sp., *N. nipae*, *Aleurocanthus* sp., *P. pendula*, *Metura* sp., and *Metisa plana*. were recorded by using the direct observation method. On the other hand, the traps were used to collected collect the fly or active insects, such as insect nets, light traps, and pheromones pheromone traps (Haneda et al. 2017). According to Iswara et al. (2022), traps are designed based on insect behaviour and attraction to certain lights, shapes and colours, or colors. The species obtained using the insect nets, and the light trap were *E. westwoodi. Aulacophora* sp., *A. cerana*, *Provespa* sp., *Conocephalus* sp., and *T. lateralis.* Meanwhile, *O. rhinoceros* was found in the pheromone trap. A syntheticSynthetic pheromones pheromone traps are traps used to attract male insects (Maruthadurai and

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Ramesh, 2020). Pheromones The pheromones trap was effectively effective to monitorin monitoring and control controlling the adults of *O. rhinoceros* (Paudel et al. 2023).

The present study revealed that *Aspidiotus* sp. exhibited the largest population densities across all three age groups of coconut trees, namely 8 years old, 5 years old, and 2 years old: 8-year-old, 5-year-old, and 2-year-old. *Aspidiotus* sp. (Hemiptera: Diaspididae) is a scale insect (Serrana et al. 2023). The genus of Aspidiotus, namely *Aspidiotus rigidus* Reyne (Hemiptera: Diaspididae), hasd also been confirmed, to causinge significant economic losses to the coconut industry in the Philippines (Serrana et al. 2019). Moreover, coconut bud borer beetles (*O. rhinoceros* L) were found at all ages of coconut. *O. rhinoceros* is one of the main pests that causes damage to germplasm in coconut (Paudel et al. 2022). In Indonesia, *O. rhinoceros* is also a threat to both coconut and oil palm plants (Rahayuwati et al. 2020). These beetles are known to attack palm trees by boring into the crown and eating developing fronds (leaves that have not yet opened), which can cause death or stunted growth in young palm trees if the infestation is severe (Chalapathi Rao et al. 2018; Paudel et al. 2021, 2023). For mature oil palm trees, this damage can result in reduced productivity. This was also confirmed by Parnidi et al. (2022), that the average damage caused by this pest investment ranges from 0 to 16.7%. This study showed that there were different insects at each age of coconut. The plant age can influence the number of species and the number of individuals (Myers and Sarfraz, 2017; Santi et al. 2023). As plants grow and mature, they provide different habitats and resources that can support a variety of insects insect species (Schowalter 2016). Older plants tend to have more developed and complex ecosystems with greater insects insect species diversity (Schowalter 2017). Additionally, mature plants are often larger and have more resources; hence, so, they can support more individuals in their ecosystem (Lindenmayer and Laurance 2016). However, the specific impact of plant age on insect species and the number of insect individuals may vary depending on plant species, environmental conditions, and other factors (Myers and Sarfraz 2017).

This current study also identified another abundant insect species, namely *N. ipaecoccus nipae* (Maskell). *N. nipae* is a mealybug that serves as an insect pest in coconut plantations (Hassan et al. 2023). Additionally, the mealybug's secretion of honeydew has the potential to attract ants and other insects, which may result in the establishment of sooty mold (Souza et al. 2008). This mold can induce further damage to plants. The genus *Aleurocanthus* Quaintance & Baker (Hemiptera: Aleyrodidae) also as is also a dominant insect found in coconut in this research. *Aleurocanthus sp.* is an important pest that inflicts substantial economic damage on numerous crops (Kapantaidaki et al. 2019). They subsist on plant sap and can induce yellowing, wilting, and general plant stress (Mohan et al. 2022). *Aleurocanthus* can also act as vectors for plant pathogens (da Silva Santos et al. 2023). They produce honeydew, which can attract other pests and cause sooty mold (Melone et al. 2024). The Aleurocanthus genus found in this study, potentially associated with the arecatnut whitefly, was first identified in coconut trees in 2003 in aArecanut palm palms located in Karnataka and Andhra Pradesh (David and& Manjunatha, 2003). The insect was subsequently identified as the Arecanut whitefly, with its scientific name being *Aleurocanthus arecae* (David and& Manjunatha, 2003); i. The puparium is characterized by its blackish-brown colourts blackish-brown color characterizes the puparium and has a limited amount of powdered wax. The colonies of *Aleurocanthus* found in coconut are located on the lower surface of arecanut leaves, whereas they are similar to *Aleurocanthus arecae*.

Two dominant ants found in this study were *Polyrhachis* sp. and *Oecophylla smaragdina*. The genus *Polyrhachis* Fr. Smith often protect protects plants from insect pests, acting as biological control agents (Ofer 1970). In some cases, these ants have mutualistic relationships with plants, protecting them from pests in exchange for shelter or food resources like nectar (Andersen et al. 2013). *Oecophylla smaragdina*. (Weaver Ant) are also found in this research. The ant is highly effective biological control agent (Exélis et al.a highly effective biological control agent (Exélis et al. 2023). *Oecophylla smaragdina* ants have shown the foraging and predation behaviors in oil palm plantations in Southeast Asia. The initial study specifically examined the use of weaver ants as a potential biological control agent to manage the population of dominant bagworm defoliators (*P. teroma pendula*) (Exélis et al. 2023). In this current research, *Oecophylla smaragdina*. being present on coconut trees indicates that these ants feed on insect pests, such as bagworms, that are prevalent on the coconut trees. This, in turn, offers a natural method of controlling pests. This study found bagworms, namely *Pteroma pendula, Metura* sp., *Metisa plana*, *Pteroma pendula* and *Metisa plana* are insect pest defoliators in oil palm (Egonyu et al. 2022). *P. pendula* was also found infested Sago Palm in the Philippines (Okazaki et al. 2012). The bagworm is a highly destructive insect pest that feeds on leaves and is classified as a voracious eater. It is particularly challenging to control these pests due to their habit of hiding inside their bags (Manurung and Anwar, 2023). In this study, in the coconut, the bagworms found aswere found to be a minor insect pest.

The diversity index of insect insects found on coconut trees and the diversity index of insects found in weeds around the coconut trees in Sri Tiga Village showed a diversity value of $1 < H' < 3$, which means the diversity of the insects found was in the medium category. This criterion showed the diversity of pests and natural enemies, which increased in number as the population increased towards balance. According to Hasibuan et al. (2019), there are 3 criteria for insect species diversity, namely low species diversity if $H < 1$ (unstable environmental conditions), moderatedesang species diversity if H 1-3 (medium environmental conditions), and high species diversity if $H > 3$ (stable environmental conditions). The results of the dominance index calculation obtained on coconut plants and surrounding weeds from week 1 to week 3 showed a dominance value of $0 < D < 0.5$; t. This means that these insects' dominance was relatively low. The Evenness Index (E) value is 0.29-0.31 in the depressed category. According to Hasibuan et al. (2019), there are 3 criteria for the community environment based on its evenness value, namely if E < 0.50, if E < 0.50, then the community is in a depressed condition. If E 0.50 < 0.75, then society is in a stable condition, while E 0.75 < 1.00 means society is in an unstable condition. The evenness index

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value (E') can describe the stability of a community. The smaller the value of E' or closer to zero, the more uneven the distribution of organisms in a community that is dominated by a certain species, and conversely, the greater the value of E' or close to one, the organisms in that community will be evenly distributed (Ambarwati et al. 2023). Apart from being influenced by plant age, insect diversity can be influenced by climate and weather factors (Subedi et al. 2023). From July to September 2023, Sri Tiga Village faced the dry season. The dry season is characterized by decreased rainfall and increased temperatures, disrupting the life cycle of insects. According to Paliama et al. (2022), increasing global temperatures can affect the life cycle of insects. In addition, dry seasons can cause drought and reduce water availability for insects (Benoit et al. 2023). Nevertheless, additional research is necessary to verify the data and to facilitate comparisons across various seasons and climate conditions.

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## REFERENCES

Ambarwati M, Dewi K, Aurina DM, Faturrahman AD, Fatikha LAY, Rachmalia F, Ainaya FA, Kinanthi A, Rohman, CM, Pradhana F, Fadzilah A, Pramudita DA, Ramadhan MF, Mahajoeno E, Nugroho GDWI, Sujarta P, Yap CK, Adha K, Rahim BINA, Setyawan ADWI. 2023. Ecological index and economic potential of mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia. Biodiversitas 24: 1231–1241. DOI: 10.13057/biodiv/d240265

Andersen AN, Kohout RJ, Trainor CR. 2013 Biogeography of Timor and Surrounding Wallacean Islands: Endemism in Ants of the Genus *Polyrhachis* Fr. Smith. *Diversity*. 5(1):139-148. DOI10.3390/d5010139

Arumugam T. (2022). Improving coconut using modern breeding technologies. Plants 11: 1-22. DOI: 10.3390/plants11243414

Aulia AN, Chasanah N, Prasetyo AS, Nalawati AN. 2020. Competitiveness and export ~~similairity~~ similarity of Indonesia's coconut oil. J Agribest 04: 123–132. DOI: 10.32528/agribest.v4i2.3546

Badan Pusat Statistik. 2023. Luas Areal dan Produksi Perkebunan Kelapa Rakyat Menurut Kecamatan. https://banyuasinkab.bps.go.id/indicator/54/151/1/luas-areal-dan-produksi-perkebunan-kelapa-rakyat-menurut-kecamatan.html

Benoit JB, Mccluney KE, Degennaro MJ. (2023). Dehydration dynamics in terrestrial arthropods: from water sensing to trophic interactions. Annu Rev Entomol 68: 129–149. DOI: 10.1146/annurev-ento-120120-091609

Borror DJ, Delong DM. 1971. An Introduction to the study of insect. 3rd. ed. Holt. Rinehard and Winston: New York.

Chalapathi Rao NBV, Snehalatharani A, Nischala A, Ramanandam G, Maheswarappa HP. 2018. Management of rhinoceros beetle (Oryctes rhinoceros L.) by biological suppression with Oryctes baculovirus in Andhra Pradesh. J Plant Crops 46: 124-127. DOI: 10.25081/jpc.2018.v46.i2.3725

Chandra R., Abdul M, Sharma N, Bharathi K, Singh S. 2023. The role of insects in ecosystems, an in-depth review of entomological. International J Environ and Climate Change 13:4340–4348. DOI: 10.9734/IJECC/2023/v13i103110

Chowdhury S, Dubey VK, Choudhury S, Kumar N, Semwal A, Kumar V. 2023. Insects as bioindicator : A hidden gem for environmental monitoring. Front. Environ. Sci 11: 1–16. DOI: 10.3389/fenvs.2023.1146052

de Micheaux PL, Drouilhet R, Liquet B. 2013. The R software. *Fundamentals of Programming and Statistical Analysis*, 978-1. DOI: 10.1007/978-1-4614-9020-3

da Silva Santos AC, Pedroso SKB, Alves AL, Diniz AG, de Oliveira NT, Tiago PV. 2023. *Fusarium* species associated with citrus blackfly (*Aleurocanthus woglumi*) from an agroecological polyculture in Brazil, including an augmented description of *F. volatile*. *Mycologia*, *116*(1):92–105. https://doi.org/10.1080/00275514.2023.2283944

David BV, Manjunatha M. 2003. A new species of Aleurocanthus Quaintance & Baker (Homoptera: Aleyrodidae) from Areca catechu in India, with comments on the status of Aleurodes nubilans Buckton. *Zootaxa*, *173*(1), 1-4. DOI: 10.11646/zootaxa.173.1.1

Egonyu, J. P., Baguma, J., Martínez, L. C., Priwiratama, H., Subramanian, S., Tanga, C. M., ... & Niassy, S. (2022). Global advances on insect pest management research in oil palm. *Sustainability*, *14*(23), 16288. DOI: 10.3390/su142316288

Exélis MP, Ramli R, Ibrahim RW, Idris AH. 2023.Foraging Behaviour and Population Dynamics of Asian Weaver Ants: Assessing Its Potential as Biological Control Agent of the Invasive Bagworms *Metisa plana* (Lepidoptera: Psychidae) in Oil Palm Plantations. *Sustainability*. 15(1):780. DOI : 10.3390/su15010780

Ganganalli SM, Bhaskar H, Joshi, S, Vidya CV. 2023. Diversity of Aphid Fauna (Hemiptera: Aphididae) of Kerala. Indian J Entomol 1–8. DOI: 10.55446/ije.2023.742

Haneda NF, Wibowo C, Hasbi M. 2017. Peranan arthropoda di ekosistem ekoton dan kelapa sawit. J Silvikultur Tropika 8: 116–122. DOI: 10.29244/j-siltrop.8.2.116-122

Hasibuan EW, Siregar AZ, Pinem MI. 2019. Diversity of insect in coconut plant in Kelurahan Besar, Medan Labuhan District, North of Sumatra. Inter J Trend in Research and Develop 6: 7–13.

Hassan R, Attia SSS, Elhefny A. 2023. Insecticidal Effects and Chemical Composition of Lemongrass and Peppermint Essential Oils Against the Coconut Mealybug, *Nipaecoccus nipae* (Maskell), (Hemiptera: Pseudococcidae). *Egyptian Academic Journal of Biological Sciences, F. Toxicology & Pest Control*, *15*(1), 47-61. DOI: 10.21608/eajbsf.2023.287294

Heinrichs EA. 1994. Biology and management of rice insect. International Rice Research Institute. Philippines.

Henrietta HM, Kalaiyarasi K, Raj AS. 2022. Coconut tree (Cocos nucifera) products : a review of global cultivation and its coconut tree (Cocos nucifera) products : a review of global cultivation and its benefits. J Sus and Environ Manage. DOI: 10.3126/josem.v1i2.45377

Hill DS. 1994. Agricultural entomology. Timber Press. Portland Oregon.

Hill DS. 1997. The Economic importance of insect. Chapman & Hall.

Hoe TK. 2019. The Current Scenario and Development of the Coconut Industry. February

Howard FW, Moore D, Giblin-Davis RM, Abad RG. 2001. Insect on palms. CABI Publishing

Iswara D, Afifah L, Abadi S, Prabowo D, Irfan B, Widiawan AB. 2022. Kelimpahan serangga pada berbagai perangkap dengan beberapa teknik pengendalian berbeda pada pertanaman jagung pioneer 36. J Agroplasma 9: 213–224

Kalshoven LG. 1981. The pest of crops in Indonesia. Van Hoeve. Jakarta.

Kapantaidaki DE, Antonatos S, Kontodimas D, Milonas P, Papachristos DP. 2019. Presence of the invasive whitefly *Aleurocanthus spiniferus* (Hemiptera: Aleyrodidae) in Greece. *EPPO Bulletin. 49*(1): 127-131. DOI : 10.1111/epp.12533

Karenina T, Herlinda S, Irsan C, Pujiastuti Y. 2019. Abundance and species diversity of predatory arthropods inhabiting rice of refuge habitats and synthetic insecticide application in freshwater swamps in South Sumatra, Indonesia. *Biodiversitas Journal of Biological Diversity*, *20*(8): 2375-2387. DOI: 10.13057/biodiv/d200836

Keylock C. (2005). Simpson diversity and the Shannon–Wiener index as special cases of a generalized entropy. *Oikos*, *109*(1), 203-207. DOI:10.1111/j.0030-1299.2005.13735.x

Lindenmayer DB, Laurance WF. 2016. The ecology, distribution, conservation and management of large old trees. Biological Reviews 93: 1434-1458. DOI: 10.1111/brv.12290

Manosathiyadevan M, Bhuvaneshwari V, Latha R. 2017. Impact of insects and pests in loss of crop production: a review. in a Dhanarajan (Ed.). Springer Singapore 57-67. DOI: 10.1007/978-981-10-6647-4_4

Manurung CF, Anwar R. 2023. Population Dynamics of The Bagworm, *Clania tertia* Templeton (Lepidoptera: Psychidae) on Immature Oil Palm at Pelalawan Regency, Riau. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1208, No. 1, p. 012019). IOP Publishing. DOI 10.1088/1755-1315/1208/1/012019

Mcalpine JF, Peterson BV, Shewel GE, Teskey HJ, Vockeroth JR, Wood DM. 1987. Manual of neartic Diptera. Agriculture Canada. Research Branch.

Maruthadurai R, Ramesh, R. 2020. Mass trapping of red palm weevil and rhinoceros beetle in coconut with aggregation pheromone. Indian J Entomol 82: 439–441. DOI: 10.5958/0974-8172.2020.00114.5

Melone G, Ascolese R, Nugnes F, Porcelli F, Rapisarda C, Farina A, Picciotti U, Garganese F, Laudonia S. 2024. An *Eretmocerus* Species, Parasitoid of *Aleurocanthus spiniferus*, Was Found in Europe: The Secret Savior of Threatened Plants. *Sustainability*. 16(7): 2970. DOI : 10.3390/su16072970

Mohan C, Josephrajkumar A, Prathibha PS, Sujithra M, Sajan JV, Anes KM. 2022. Pests and Their Management in Coconut. In: Mani, M. (eds) Trends in Horticultural Entomology. Springer, Singapore. DOI: 10.1007/978-981-19-0343-4_60

Moreira MM, Reitas LF. 2020. Review of the pollination system by small diverse insects. Neotrop Entomol, 472–481. DOI: 10.1007/s13744-020-00779-6

Myers JH, Sarfraz RM. 2017. Impacts of insect herbivores on plant populations. Annu. Rev. Entomol. DOI: 10.1146/annurev-ento-010715-023826

Ofer J. 1970. Polyrhachis simplex The Weaver Ant of Israel. *Ins. Soc* 17: 49–81. DOI: doi.org/10.1007/BF02223772

Okazaki M, Kimura SD, Suzette LB, Igura M, Quevedo MA, Ando T, Yonebayashi K. 2012. Bagworm (*Pteroma pendula*) Infestation of Sago Palm (Metroxylon sagu Rottb.) in Leyte, Philippines. *Sago Palm*, *20*(2), 69-75. DOI: 10.57418/sagopalm.20.2_69

Paliama HG, Latumahina FS, Wattimena CMA. 2022. Keanekaragaman serangga dalam kawasan hutan mangrove di Desa Ihamahu. Jurnal Tengkawang 12: 94–104. DOI: 10.26418/jt.v12i1.53861

Parnidi P, Sunarto DA, Marjani M. 2022. Shoot borers beetle pest of coconut (Oryctes rhinoceros L.) investment at Agave spp. Bioeduscience 6: 89–95. DOI: 10.22236/j.bes/616282

Paudel S, Jackson TA, Mansfield S, Ero M, Moore A, Marshall SDG. 2023. Use of pheromones for monitoring and control strategies of coconut rhinoceros beetle (Oryctes rhinoceros): A review. Crop Protection . DOI: 10.1016/j.cropro.2023.106400

Paudel S, Mansfield S, Villamizar LF, Jackson TA, Marshall SDG. 2021. Can biological control overcome the threat from newly invasive coconut rhinoceros beetle populations (Coleoptera: Scarabaeidae)? A review. Annals Entomol Society of America 114: 247–256. DOI: doi.org/10.1093/aesa/saaa057

Paudel S, Marshall SDG, Richards NK, Hazelman G, Tanielu P, Jackson TA. 2022. Coconut rhinoceros beetle in Samoa: review of a century-old invasion and prospects for control in a changing future. Insects 1–15. DOI: 10.3390/insects13050487

Purnomo H, Okarda B, Dermawan A, Pebrial Q, Pacheco P, Nurfatriani F, Suhendang E. 2020. Forest policy and economics reconciling oil palm economic development and environmental conservation in Indonesia: a value chain dynamic approach. Forest Policy and Economics, 111: 1-12. DOI: 10.1016/j.forpol.2020.102089

Rahayuwati S, Kusumah YM, Prawirosukarto S, Dadang, Santoso T. 2020. The status of Oryctes rhinoceros nudivirus (OrNV) infection in oryctes rhinoceros (Coleoptera: Scarabaeidae) in Indonesia. Journal of Oil Palm Research 32: 582–589 [Indonesian]

Santi I, Tarmadja S, Priambada KJ, Elfatma O. 2023. Keanekaragaman serangga perkebunan kelapa sawit di Provinsi Kalimantan Tengah. Jurnal Ilmiah Hijau Cendekia 8:45. DOI: 10.32503/hijau.v8i1.2917

Schowalter TD. 2017. Arthropod diversity and functional importance in old-growth forests of North America. Forests. DOI: 10.3390/f8040097

Schowalter TD. 2016. Insect Ecology: An Ecosystem Approach. Academic press.

Serrana JM, Almarinez BJM, Barrion AT, Amalin DM. 2023. Ultrastructural characterization of the scale cover of cryptic Aspidiotus spp. (Hemiptera: Diaspididae) and the ovipositor of their parasitoids. Microscopy and Microanalysis 29: 825–831. DOI: 10.1093/micmic/ozac041

Serrana JM, Ishitani N, Carvajal TM, Almarinez BJM, Barrion AT, Amalin DM, Watanabe K. 2019. Unraveling the genetic structure of the coconut scale insect pest (Aspidiotus rigidus Reyne) outbreak populations in the Philippines. Insects. DOI: 10.3390/insects10110374

Souza E, Follett PA, Price DK, Stacy EA. 2008. Field suppression of the invasive ant *Wasmannia auropunctata* (Hymenoptera: Formicidae) in a tropical fruit orchard in Hawaii. *Journal of Economic Entomology*, *101*(4), 1068-1074. DOI: 10.1093/jee/101.4.1068

Stam JM, Kroes A, Li Y, Gols R, Loon JJAV, Poelman EH, Dicke M. 2014. Plant interactions with multiple insect herbivores : from community to genes. Annu. Rev. Plant Biol 65: 689–713. DOI: 10.1146/annurev-arplant-050213-035937

Subedi B, Poudel A, Aryal S. 2023. The impact of climate change on insect pest biology and ecology : Implications for pest management strategies, crop production , and food security. J Agriculture and Food Research. DOI: 10.1016/j.jafr.2023.100733

Thomas GV, Krishnakumar V, Dhanapal R, Srinivasa Reddy DV. 2018. Preharvest approaches to control insect infestation in fruit. Elsevier. DOI: 10.1007/978-981-13-2754-4_7

Tiemann TT, Donough CR, Lim YL, Härdter R, Norton R, Tao HH, Jaramillo R, Satyanarayana T, Zingore S, Oberthür T. 2018. Chapter four-feeding the palm: a review of oil palm nutrition. Advances in Agronomy 152: 149–243. DOI: 10.1016/bs.agron.2018.07.001

Tougeron K, Brodeur J, Le Lann C, van Baaren J. 2020. How climate change affects the seasonal ecology of insect parasitoids. Ecol Entomol, 45: 167-181. DOI: 10.1111/een.12792

Vislobokov NA. 2017. Flowering biology of Aspidistra (a sparagaceae): new data on pollination by dipteran insects. Plant Species Biology 32: 412–422. DOI: 10.1111/1442-1984.12175

Ximenes R, Nurmalina R, Rifin A. 2021. Demand analysis of Indonesia''s coconut crude oil in Germany. Review of Economics and Finance 19: 281–285. DOI: 10.55365/1923.x2021.19.39

Zainol FA, Arumugam N, Norhayate W, Daud W, Aisyah N, Suhaimi M. 2023. Coconut value chain analysis : a systematic review. Agriculture. DOI: 10.3390/agriculture13071379

12 August 2024

Dear Editors,
BIODIVERSITAS Journal of Biological Diversity

As requested, this is our response to the reviewers' comments and suggestions.

Thank you so much for the very kind attention and the great help provided by the editorial team of BIODIVERSITAS Journal of Biological Diversity.

**"Letter on responses to reviewers' comments and suggestions"**

| Lines | Reviewer Comments/Suggest | Answer |
|---|---|---|
| 16-33, 54-60, 70-77, 261-278, 305-309, 318-330, | Review the modifications made in this paragraph for accuracy and relevance to the topic. | The sentences have been revised |
| 84-87 | Figure 1 uses Indonesian. | We removed the Indonesia language |
| 221-224 | Please check these statements, the most abundant insects on Homoptera, specifically Aspidiotus sp. (Figure 4a), and Hymenoptera order, specifically Polyrhachis sp. (Figure 4d) and Oecophylla smaragdina (Figure 4e) that differ by Figure 2 (Hemiptera) and Figure 3 (Orthoptera). | Here we just explained about the most abundant of insect found in coconut that similar to figure 2 (Order Homoptera and Hymenoptera) |
| 261, 269 | Please check that there are six (not seven) Orders in Tables 1 and 2 consisting of Coleoptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, and Orthoptera | We removed 1 Coleoptera |
| 261 | There are as many as 2,330.67 individuals; it should be an average with two digits after the dot, which is not an average without decimals. | We rewrite to 2,330 individuals |
| 318-320 | Please check this sentence that Metisa plana and Pteroma pendula were doubled. | We revised the sentence |
| 247-258 | Scientific names are in italics, and the complete terminology is provided in the initial presentation. Subsequent references should use an abbreviated form, which applies throughout the manuscript. | Already revised |
| 194-195 | It would be more fascinating if Table 5 added one column showing the individuals. | Already revised |

| | | |
|---|---|---|
| | Plagiarism is under 5% without references, and the shading sentences need more attention. This study was edited with minor corrections on grammar structures and non-influential wording that must be approved. Word deletion, insertion, and paraphrasing were incorporated into the manuscript, maintaining its thought and flow. | Already revised |
| | These statements below do not necessarily require a response that would enrich the analysis and are for counterargument purposes. | Already revised |
| | Could the insect biodiversity in coconut trees of different ages be influenced by factors other than just their age, such as environmental changes or agricultural practices? | Insect biodiversity in coconut trees is influenced by various factors beyond tree age, including climate, microhabitats, agricultural practices, crop rotation, tree health, human activity, proximity to urban areas, pollution levels, and land development. However, in this study, we didn't observe the other factors, therefore, we can't explain the factors. |
| | Have you considered the potential impact of seasonal variations on insect populations in the different age groups of coconut trees? | Yes, during the rainy season, insect pests such as sucking insects tend to decrease in population. Furthermore, because coconut plantations in South Sumatra are still traditional, visiting the area during the wet season is challenging. Therefore, we detect insect problems in the dry season. However, it does not rule out further research on insect biodiversity in two seasons (rainy and dry). |
| | What about the possibility of other unidentified factors contributing to the varying insect populations in the different age groups of coconut trees? | Unidentified factors may affect the varying insect's insect populations in the different age groups of coconut trees, such as climate, microhabitats, agricultural practices, crop rotation, tree health, human activity, proximity to urban areas. |
| | What specific methods were used to identify the 12 insect species found in the study? | Direct observation and collect the insect, light trap, swing net and using Pheromone traps, |
| | What were the specific findings related to the impact of different ages of coconut trees on the abundance of the identified insect species? | According to this study, *Oryctes rhinoceros* showed no significantly different average number of individuals at coconut tree ages of 8, 5, and 2 years. In contrast, the sucking insects *Aspidiotus* sp. and *Nipaecoccus nipae* were found in large numbers on coconut plants that were 8 and 5 years old. In contrast, only a few individuals were identified on two-year-old coconut. |
| | Were there any recommendations provided in the study for mitigating the impact of the predominant insect pests on coconut plantations? | The dominant insect found in this study was the sucking insect (Homoptera Order). To mitigate the pest infestation, trim infested branches or coconut fronds, introduce beneficial insects like ladybugs, lacewings, or |

| | | |
|---|---|---|
| | | parasitic wasps, and prevent the spread of the infestation to other parts of the tree. |
| | Consider the possibility that the presence of other plant species growing around coconut plants may be influencing insect biodiversity rather than just the age of the coconut trees. | In this area, the coconut trees were surrounded the weeds, we also observed the insect in weeds. |
| | Address the argument that the insect biodiversity findings may not be representative of other locations due to the specific environmental conditions in Sri Tiga Village. | In this article, we identified a species of bagworm, namely *Metura* sp. that was not observed in coconut trees in any other published article. This information can serve as a new reference for other authors who are conducting in-depth research on insect diversity. |
| | Acknowledge the potential impact of seasonal variations on insect biodiversity in the coconut plantation and discuss how this might affect the study's findings. | The sentences were added in last alenia |

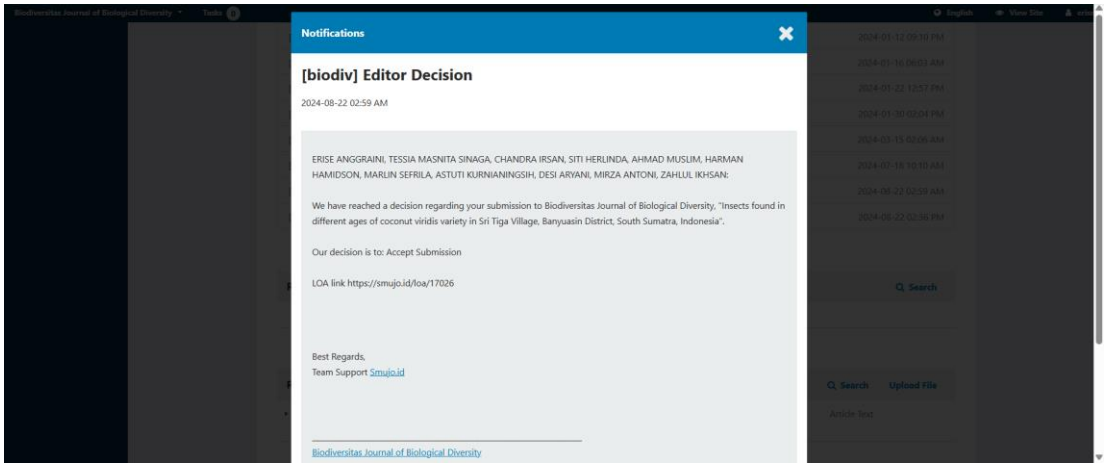
Best regards,

Corresponding author,

Erise Anggraini

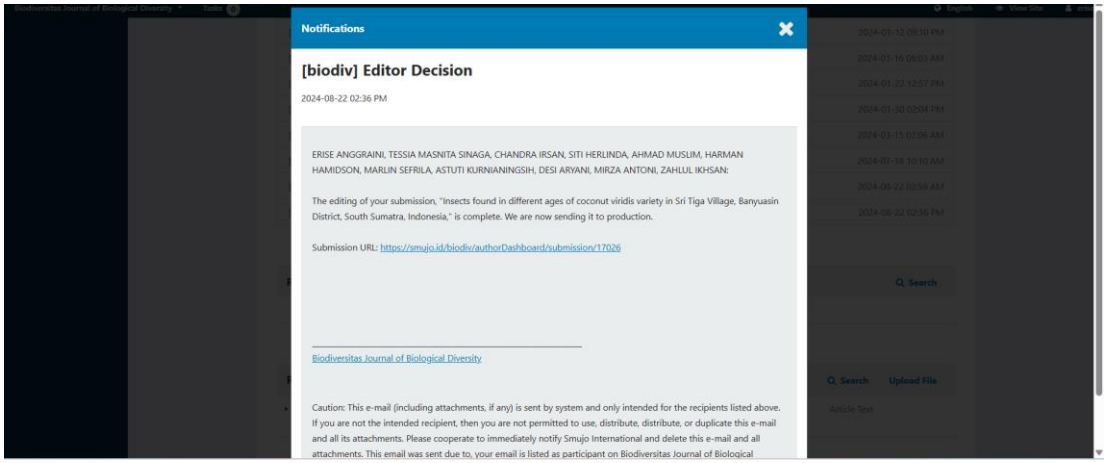
## 3. Editor DecisionFinal Paper

***Accept Submission (22 Agustus 2024***




## 4. Final Paper

***Final Paper (22 Agustus 2024)***



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# Insects found in different ages of coconut viridis variety in Sri Tiga Village, Banyuasin District, South Sumatra, Indonesia

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[2]Study Program of Agroecotechnology, Faculty of Agriculture, Universitas Sriwijaya. Jl. Raya Palembang Prabumulih Km.32 Ogan Ilir, South Sumatera Indonesia
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**Abstract.** *Anggraini E, Sinaga TM, Irsan C, Herlinda S, Muslim A, Hamidson H, Sefrila M, Kurnianingsih A, Aryani D, Antoni M, Ikhsan Z. 2024. Insects found in different ages of coconut viridis variety in Sri Tiga Village, Banyuasin District, South Sumatra, Indonesia. Biodiversitas 25: 2637-2647.* Coconut (*Cocos nucifera* L.) is a high-value export commodity and has promising potential on the global market. The existence of insect species is very important in coconut cultivation. The coexistence of insects and plants is interconnected because plants provide habitat and food sources for insects. However, the correlation between plants and insects still needs to be discovered to many people. Therefore, a comprehensive assessment of insect biodiversity in an environment is important to be carried out. This study revealed the structure of the insect community associated with coconut plants and weeds around coconut trees. Therefore, this is a novel and pioneering study that aims to determine the insects associated with coconut plants. This study was conducted by surveying community-owned coconut plantations in Sri Tiga Village, Sumber Marga Telang Sub-district, Banyuasin District, South Sumatera, Indonesia. The observation was carried out during July and September of 2023. The data-gathering process involved identifying three coconut plantations with varying ages of coconut trees (8, 5, and 2 years old). Data collection was carried out using the purposive sampling method by direct observations and using traps such as insect nets, light traps, and pheromone traps. Collected specimens were identified using a microscope in the Laboratory of Entomology, Department of Plant Pests and Disease, Faculty of Agriculture, Universitas Sriwijaya. The results of this study found 12 insect species in coconut trees, namely *Oryctes rhinoceros* Linnaeus 1758, *Aspidiotus* sp., *Nipaecoccus nipae* Maskell 1893, *Aleurocanthus* sp., *Apis cerana* Fabricius 1793, *Cotesia congregata* Say 1836, *Dolichoderus thoracicus* Smith 1860, *Oecophylla smaragdina* Fabricus 1775, *Provespa* sp., *Pteroma pendula* de Joannis 1929, *Metura* sp., *Metisa plana* Walker 1883. The predominant insect pests identified were *Aspidiotus* sp., *N. nipae*, and *Aleurocanthus* sp. Furthermore, the most predominant insects that served as insect scavengers were *Polyrhachis* sp. and *O. smaragdina*. Meanwhile, in the weeds around coconut trees, there were found six insect species, namely *Aulacophora lewisii* Baly 1866, *Eumorphus westwoodi* Guérin 1858, *Mactrotermes* sp., *Conocephalus* sp., *Dianemobius* sp., and *Tettigidea* sp.

**Keywords:** Coconut, *Cocos nucifera*, insects, viridis variety

## INTRODUCTION

Indonesia encompasses diverse agricultural sectors, including plantations, horticulture, food crops, and forestry. The plantation sector in Indonesia plays a substantial role in the nation's economy (Purnomo et al. 2020). Coconut plantations in Indonesia have undergone extensive development and now serve as the primary source of income for coconut farmers. Coconut contributes significantly to the economy, social fabric, and government revenue derived from non-oil and gas commodities (Ximenes et al. 2021). The primary utilization of coconut production is for consumption and industrial purposes (Hoe 2019). The cultivated coconut plants have yielded various products, such as coconut oil, coconut sugar, desiccated coconut, coconut milk, coconut shells, coconut juice, and coconut fiber (Henrietta et al. 2022). Coconut (*Cocos nucifera* L.) is a tropical plantation commodity that is widespread in Indonesia, the Philippines, India, and several Asia Pacific countries (Hoe 2019). Coconut is a lucrative export product with promising opportunities in the global market. Indonesia is the leading coconut-producing nation globally, with the Philippines and India ranking second and third, respectively (Zainol et al. 2023). In 2022, the Banyuasin District in Indonesia had a total area of coconut plantations measuring 42,599.00 hectares, which yielded a productivity of 46,760.00 tons (Badan Pusat Statistik 2023).

Understanding the life cycle of the plant from germination to harvest is crucial in the cultivation of coconuts. This stage necessitates consistent monitoring and care. Coconut cultivation necessitates selecting high-quality seedlings, the cultivation of appropriate soil, and

the provision of appropriate care (Thomas et al. 2018). Coconuts thrive in sufficient sunlight, appropriate rainfall, and nutrient-rich soil with effective drainage (Tiemann et al. 2018). The ideal pH range for coconut plant growth is between 5 and 8 (Henrietta et al. 2022). A deep understanding of these elements can lead to the establishment of coconut plantations that can be maintained over a long period. In addition, it is necessary to give attention to frequent pruning, fertilizing, and managing pests and diseases (Aulia et al. 2020); a thorough understanding of these characteristics can lead to profitable and sustainable coconut production. However, in many coconut-producing locations, especially in small-scale coconut farms, there is a lack of intensive fertilizer application and insect management (Zainol et al. 2023). This need for improvement should motivate us to strive for better practices. Coconut cultivation is closely related to the presence of insects on plants and is interconnected since plants serve as both a habitat and a source of sustenance for insects (Stam et al. 2014). Plants rely on insects for the process of plant pollination (Moreira and Reitas 2020). Understanding the insects that contribute to pollination can assist in increasing coconut production by preserving and protecting these pollinators. Conversely, insects possess the capacity to cause damage to cultivated plants (Manosathiyadevan et al. 2017). Therefore, identifying the insect pest species in coconut is critical for developing effective pest management strategies. Understanding which insects are harmful and which are beneficial can assist farmers in controlling pest populations while protecting beneficial insects.

The age of coconut trees in coconut plantations varies across different regions. This leads to variations in plant growth and development among different trees, impacting not only their nutritional needs but also the timing of harvest and total production (Arumugam 2022). Effective management practices tailored to the age of the coconut plant are crucial for optimizing its overall health and productivity. Coconut trees at different phases of growth may attract distinct insect pests, which may prefer specific developmental stages of the plants due to physiological disparities. It is crucial to accurately identify and effectively manage these pests, considering the age of the coconut trees, in order to achieve successful pest control. In addition, insects fulfill diverse functions within ecosystems and exert substantial influence on human culture and the environment, serving as pollinators, decomposers, and pests (Chandra et al. 2023). Current information regarding the prevalence of insects on coconut trees still needs to be improved, especially regarding their age. Therefore, it is imperative to conduct an inventory of insect biodiversity in the coconut plantation ecosystem at various plant ages. The ecosystem's alterations can be inferred from the diversity of insect species (Chowdhury et al. 2023). The number of insect populations is influenced by the season (Tougeron et al. 2020). The study was conducted in South Sumatera, Indonesia, during the dry season in July and September 2023. Hence, it is crucial to identify insects on coconut trees at various stages of development in dry season. Acquiring data on various insect species can provide valuable knowledge to develop integrated pest management strategies that can be directly applied to the management of coconut plantations.

## MATERIALS AND METHODS

### Study area

The study was carried out in people's coconut plantations in Sri Tiga Village, Sumber Marga Telang Sub-district, Banyuasin District, South Sumatra, Indonesia (Figure 1). Insect identification was conducted at the Entomology Laboratory, Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Sriwijaya, South Sumatra. The study was carried out from July to September 2023. Three coconut plantations of different ages, specifically 8 years, 5 years, and 2 years, were selected as observation sites. Each plantation covers an area of around 5 hectares.

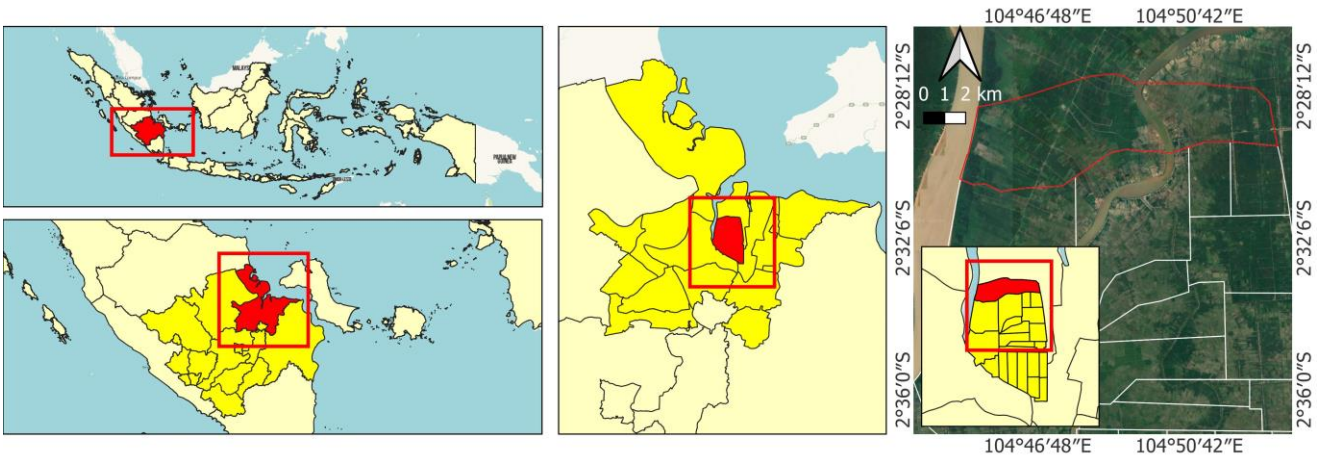


**Figure 1.** The sampling location is in Sri Tiga Village, Banyuasin District, South Sumatra, Indonesia. The samples are taken from different ages of the coconut viridis variety

**Procedures**

*Field survey and sampling*

An initial survey was undertaken to choose the sampling sites. In addition, a study was undertaken to gather information from the community regarding the utilization of coconut in Sri Tiga Village, Banyuasin District. Data was collected using the purpose sampling method. Insect sampling was carried out weekly for three months, started July to September 2023. A total of 12 observations were made, and the collection of arthropods was conducted during the early morning hours, specifically from 06:00 to 07:00 AM. The insects were collected by sweep nets, which had a net handgrip length of 100 cm, a length of 75 cm, and a diameter of 30 cm. This collection method was based on the techniques described by Karenina et al. (2019). The swinging net was intentionally contacted with weeds around coconut trees. The arthropods were caught by employing a swinging net in a single motion, utilizing two swings that align linearly at a depth of 30 cm towards the interior of weeds. The light traps were employed to gather the nocturnal insects. A total of four light traps were utilized by three coconut plantations of varying ages, namely 8 years, 5 years, and 2 years. The nocturnal insects were captured in light traps throughout the period from 7 to 9 pm. A synthetic pheromone trap containing ethyl-4-methyloctanoate as the active ingredient was used to capture adults of *Oryctes rhinoceros* Linnaeus 1758 beetles. Each of the three coconut plantations utilized a total of four *Oryctes* pheromone traps. The collected insects were stored in glass vials containing a solution of 70% alcohol. They were then labeled and transported to the Entomology Laboratory at the Department of Plant Pests and Diseases, Faculty of Agriculture, Universitas Sriwijaya, South Sumatra, Indonesia.

**Identification**

Dr. Chandra Irsan, an insect taxonomist, was assigned the responsibility of identifying the insect specimens. The collected insects were visually identified using the references by (Borror and Delong 1971), Kalshoven (1981), McAlpine et al. (1987), Heinrichs (1994), Hill (1994, 1997), Howard et al. (2001). The collected insects were classified according to their roles.

**Data analysis**

The total individual of collected insects was recorded and presented in the table. The insect abundance data (average number of individuals) was subsequently transformed using the Square Root transformation. The transformed data was examined using R Statistical software version 4.4.0 (de Micheaux et al. 2013). The species diversity index was used to describe the diversity of insect species found in the research area. The diversity index was expressed using the Shannon-Wiener species diversity formula (Keylock 2005):

$$H' = -\sum pi * (Ln\ pi)$$

Where:

H' : Shannon-Wiener Diversity Index,

Pi : ni/N (comparison between the number of a species and all species)

The description of criteria: H'<1 is low diversity; 1 <H'<3 is medium diversity; and H'>3 is high diversity.

The species evenness index was used to describe the degree of evenness of insect species found in the research area. The evenness index was expressed using the formula:

$$E = \frac{H'}{Ln\ S}$$

Where:

E : the Evenness index (value between 0-1)

H' : the Shannon-Wiener diversity index, and S is the number of species.

The description of criteria: E < 0.4 is small population uniformity, 0.4 < E < 0.6 is moderate population uniformity, and E > 0.6 is high population uniformity.

The species dominance index was used to describe the level of dominance of insect species found in the research area. The dominance index is expressed using the formula:

$$D = \sum_{i=1}^{s} \left(\frac{ni}{N}\right)^2$$

Where:

ni : The number of individuals in species i

N : Total number of individuals of all species

ni/N : pi (proportion of individuals of species i

S : Species richness.

Description of criteria: 0<D<0.5 is low dominance, 0.5<D<0.75 is moderate dominance, 0.75<D< 1.0 is high dominance.

## RESULTS AND DISCUSSION

**Abundance of insects found in coconut trees**

The insect species found in three coconut fields with varying plant ages, namely 8 years, 5 years, and 2 years, were very diverse. There were 12 species from 4 orders. The most frequently observed orders were Coleoptera, Hemiptera, Hymenoptera, and Lepidoptera. The most abundant species discovered in coconut plantations that were 8 years old was *Nipaecoccus nipae* Maskell 1893, belonging to the Hemiptera order, with an average population density of approximately 256.33 individuals. The findings of this study also observed a similar pattern in coconut fields that had reached the age of 5 years. Specifically, the dominant species seen was *N. nipae*, with an average population density of up to 265.67 individuals. On 2-year-old coconut fields, the insect species commonly found were *Aspidiotus* sp., belonging to the Hemiptera Order, with an average population of approximately 96,000 individuals. There were no *Apis cerana* Fabricius 1793 or *Provespa* sp. species in the 2-year-old plantation. The comparison of species abundance in coconut fields of varying ages revealed significant variations in species diversity (Table 1).

**Abundance of insects found in weeds around coconut trees**

Insect species found in weeds around coconuts were also observed. Six species of insects from three orders were found. The orders include Coleoptera, Isoptera, and

Orthoptera. In weeds around 8-year-old and 5-year-old coconuts, the most *Mactrotermes* sp. insects were found, originating from the Order Isoptera, namely 18.00 individuals and 13.67 individuals, respectively. Meanwhile, in the plants around coconuts that are 2 years old, the most common insects are *Conocephalus* sp. from the Order Orthoptera, namely 10.00 individuals (Table 2).

**Characteristics of insect communities found in coconut trees**

The investigated characteristics of the insect community on coconuts of different ages (8 years, 5 years, and 2 years) comprised the diversity index, evenness index, and dominance index. The findings indicated that the community attributes of coconut plants at the ages of 8 years, 5 years, and 2 years exhibited a progressive increase with each assessment. The diversity, evenness, and dominance indices of 8-year-old coconut plants were greater than those of 5- and 2-year-old coconut plants (Table 3). The results revealed a direct relationship between the age of the coconut and the number of insects observed in the field. A higher diversity index value indicates a greater range of species within the community. This indicator quantifies the level of biodiversity within the community. A high evenness index signifies a more balanced distribution of individuals among species within the group, whereas a low value suggests an uneven distribution. The dominance index quantifies the degree to which one or more species exert substantial influence or possess ownership within a community.

**Table 1.** An abundance of insects (average number of individuals) found on coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Order/Species | Abundance of insects on coconuts (average number of individuals/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old Coconut tree | 5 years old Coconut tree | 2 years old Coconut tree | | | |
| Coleoptera | | | | | | |
| *Oryctes rhinoceros* Linnaeus 1758 | 28.00 | 29.00 | 22.67 | $3.20\times10^{-1}$ | $1.54^{ns}$ | - |
| Hemiptera | | | | | | |
| *Aspidiotus* sp. | 173.33a | 116.33b | 96.00b | $3.62\times10^{-3}$ | $31.24^{*}$ | 1.55 |
| *Nipaecoccus nipae* Maskell 1893 | 256.33a | 265.67a | 18.00b | $5.16\times10^{-5}$ | $276.40^{*}$ | 2.07 |
| *Aleurocanthus* sp. | 50.67a | 44.33a | 27.67b | $58.7\times10^{-4}$ | $80.55^{*}$ | 0.54 |
| Hymenoptera | | | | | | |
| *Apis cerana* Fabricius 1793 | 5.67a | 4.33b | 0.00c | $3.13\times10^{-5}$ | $355.22^{*}$ | 0.25 |
| *Cotesia congregata* Say 1836 | 30.00a | 25.33b | 18.00c | $6.14\times10^{-4}$ | $78.70^{*}$ | 0.35 |
| *Dolichoderus thoracicus* Smith 1860 | 113.33a | 103.67a | 81.33b | $45.1\times10^{-3}$ | $27.78^{*}$ | 0.81 |
| *Oecophylla smaragdina* Fabricus 1775 | 98.00a | 87.33a | 60.33b | $1.15\times10^{-3}$ | $56.91^{*}$ | 0.75 |
| *Provespa* sp. | 4.00a | 2.33b | 0.00c | $4.52\times10^{-4}$ | $92.12^{*}$ | 0.38 |
| Lepidoptera | | | | | | |
| *Pteroma pendula* de Joannis 1929 | 16.33a | 13.67ab | 10.00b | $2.64\times10^{-2}$ | $10.31^{*}$ | 0.68 |
| *Metura* sp. | 20.67a | 16.67ab | 13.00b | $6.15\times10^{-3}$ | $23.50^{*}$ | 0.48 |
| *Metisa plana* Walker 1883 | 24.00a | 19.00ab | 14.00b | $6.78\times10^{-3}$ | $22.28^{*}$ | 0.61 |

Note: ns: Not significantly different; *: Significantly different; This original data was transformed using the Square Root transformation before the analysis

**Table 2.** An abundance of insects (average number of individuals) found in weeds around coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Order/Species | Abundance of Insects in weeds around Coconuts (individual/plot) | | | P value | F value | Tukey HSD at alpha 0.05 |
|---|---|---|---|---|---|---|
| | 8 years old coconut tree | 5 years old coconut tree | 2 years old Coconut tree | | | |
| Coleoptera | | | | | | |
| *Aulacophora lewisii* Baly 1866 | 14.67a | 8.00b | 7.00b | $9.09\times10^{-3}$ | $18.98^{*}$ | 0.71 |
| *Eumorphus westwoodi* Guérin 1858 | 12.33a | 8.33b | 3.00c | $3.21\times10^{-4}$ | $109.67^{*}$ | 0.42 |
| Isoptera | | | | | | |
| *Mactrotermes* sp. | 18.00a | 13.67b | 0.00c | $3.52\times10^{-5}$ | $335.07^{*}$ | 0.53 |
| Orthoptera | | | | | | |
| *Conocephalus* sp. | 17.00a | 12.00b | 10.00c | $38.9\times10^{-4}$ | $99.47^{*}$ | 0.24 |
| *Dianemobius* sp. | 16.67a | 13.00b | 9.00c | $6.50\times10^{-5}$ | $246.00^{*}$ | 0.17 |
| *Tettigidea* sp. | 10.67a | 8.33ab | 6.67b | $8.19\times10^{-3}$ | $20.10^{*}$ | 0.39 |

Note: ns: Not significantly different; *: Significantly different; This original data was transformed using the Square Root transformation before the analysis

**The characteristics of insects on weeds around coconut trees**

The analysis revealed that the coconut farms that were 8 years old had the highest index. At the age of 2 years, the analysis results were shown to be lower (Table 4). This finding demonstrates that the age of the coconut has a significant impact on the diversity of weed species found in its vicinity. The diversity, evenness, and dominance indices of coconut plants at ages 8, 5, and 2 years exhibited fluctuations in population numbers. The diversity index of weeds surrounding 8-year-old coconut plants is greater than that of 5- and 2-year-old coconut plants. Conversely, the level of uniformity and prevalence of weeds surrounding coconut plants that are 2 years old was greater compared to coconut plants that are 8 and 5 years old.

**The role of the insects found on coconut trees and weeds around coconut trees**

According to this study, insects found on coconut palms are often phytophagous and predatory, whereas insects located in weeds frequently operate as phytophagous and decomposers (Table 5).

**Relative abundance of insects found in coconut trees**

There was a significant variation in the relative number of insects on coconuts of different ages, specifically 8 years, 5 years, and 2 years. The abundance of insects in the Order Hemiptera was observed at plant ages of 8 years and 5 years, with percentages of 59.00% and 58.00% correspondingly. The order Coleoptera has the lowest representation, accounting for only 3.00% and 4.00%, respectively. At the age of 2 years, most insect species discovered belonged to the Order Hymenoptera, specifically 48.00%, while the lowest number of species were found in the Orders Lepidoptera and Hymenoptera, accounting for only 7.00% (Figure 2).

**Relative abundance of insects found in weeds around coconut trees**

The insects identified in weeds around coconut plants were limited to three orders: Coleoptera, Isoptera, and Orthoptera. The highest proportions of Orthoptera orders were observed in coconut trees that were 8 years old (50.00%), 5 years old (53.00%), and 2 years old (72.00%). Meanwhile, in the weeds area near 2-year-old coconut trees, only two orders of insects were found, namely Coleoptera and Orthoptera (Figure 3).

**Table 3.** Characteristics of insect communities found in coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Coconut trees (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| 8 years old | Number of individuals | 847.00 | 853.00 | 761.00 |
| | Diversity index (H') | 1.90 | 1.95 | 2.04 |
| | Evenness index (E) | 0.28 | 0.29 | 0.31 |
| | Dominance index (D) | 0.34 | 0.32 | 0.28 |
| 5 years old | Number of individuals | 754.00 | 734.00 | 695.00 |
| | Diversity index (H') | 1.86 | 1.90 | 1.97 |
| | Evenness index (E) | 0.28 | 0.29 | 0.30 |
| | Dominance index (D) | 0.16 | 0.16 | 0.17 |
| 2 years old | Number of individuals | 622.00 | 617.00 | 544.00 |
| | Diversity index (H') | 1.75 | 1.76 | 1.80 |
| | Evenness index (E) | 0.27 | 0.27 | 0.29 |
| | Dominance index (D) | 0.16 | 0.15 | 0.18 |

**Table 4.** Characteristics of insect communities in weeds around coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Insect community in the weeds around the coconut trees (age) | Community characteristics | Index values | | |
|---|---|---|---|---|
| | | July | August | September |
| Insect community in the weeds around the coconut trees (8 years old) | Number of individuals | 99.00 | 92.00 | 77.00 |
| | Diversity index (H') | 1.78 | 1.77 | 1.77 |
| | Evenness index (E) | 0.39 | 0.39 | 0.41 |
| | Dominance index (D) | 0.19 | 0.22 | 0.21 |
| Insect community in the weeds around the coconut trees (5 years old) | Number of individuals | 72.00 | 65.00 | 53.00 |
| | Diversity index (H') | 1.77 | 1.75 | 1.76 |
| | Evenness index (E) | 0.41 | 0.42 | 0.44 |
| | Dominance index (D) | 0.21 | 0.23 | 0.23 |
| Insect community in the weeds around the coconut trees (2 years old) | Number of individuals | 42.00 | 37.00 | 28.00 |
| | Diversity index (H') | 1.54 | 1.53 | 1.54 |
| | Evenness index (E) | 0.41 | 0.42 | 0.46 |
| | Dominance index (D) | 0.26 | 0.30 | 0.32 |

**Table 5.** The role of the insects found on coconut trees and weeds around coconut trees in Sri Tiga Village, Banyuasin, South Sumatera, Indonesia

| Order/Species | Total Individual | Insect role in environment | Collection method |
|---|---|---|---|
| **Insects found in weeds around coconut trees** | | | |
| Coleoptera | | | |
| *Oryctes rhinoceros* Linnaeus 1758 | 239 | Phytophagous | Pheromone trap |
| Hemiptera | | | |
| *Aspidiotus* sp. | 368 | Phytophagous | Direct observation |
| *Nipaecoccus nipae* Maskell 1893 | 1157 | Phytophagous | Direct observation |
| *Aleurocanthus* sp. | 2320 | Phytophagous | Direct observation |
| Hymenoptera | | | |
| *Apis cerana* Fabricius 1793 | 30 | Pollinator | Sweep net |
| *Cotesia congregata* Say 1836 | 220 | Parasitoid | Sweep net |
| *Dolichoderus thoracicus* Smith 1860 | 737 | Predatory insect | Direct observation |
| *Oecophylla smaragdina* Fabricius 1775 | 19 | Predatory insect | Direct observation |
| *Provespa* sp. | 895 | Predatory insect | Sweep net |
| Lepidoptera | | | |
| *Pteroma pendula* de Joannis 1929 | 151 | Phytophagous | Direct observation |
| *Metura* sp. | 120 | Phytophagous | Direct observation |
| *Metisa plana* Walker 1883 | 171 | Phytophagous | Direct observation |
| **Insects found in weeds around coconut trees** | | | |
| Coleoptera | | | |
| *Aulacophora lewisii* Baly 1866 | 89 | Phytophagous | Sweep net |
| *Eumorphus westwoodi* Guérin 1858 | 71 | Pollinator | Sweep net |
| Isoptera | | | |
| *Mactrotermes* sp. | 95 | Decomposer | Light trap |
| Orthoptera | | | |
| *Conocephalus* sp. | 117 | Phytophagous | Sweep net |
| *Dianemobius* sp. | 116 | Phytophagous | Sweep net |
| *Tettigidea* sp. | 77 | Phytophagous | Sweep net |

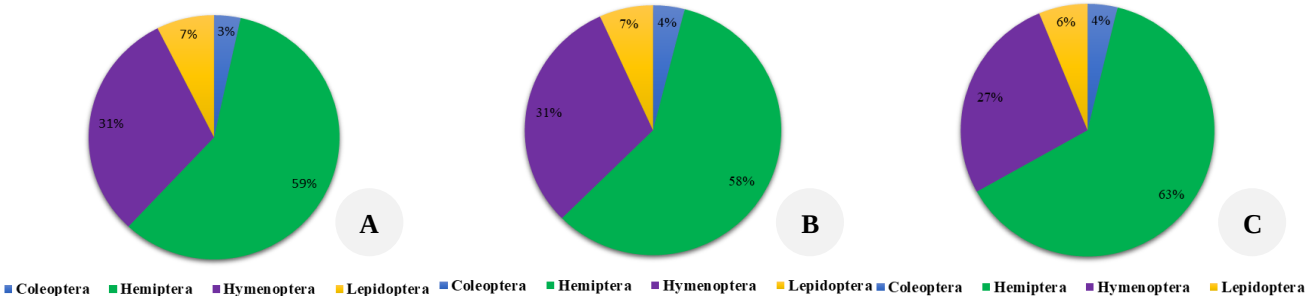


**Figure 2.** An abundance of insects was seen in coconut trees at three different stages of growth: A. 8-year-old coconut tree; B. 5-year-old coconut tree; and C. 2-year-old coconut tree

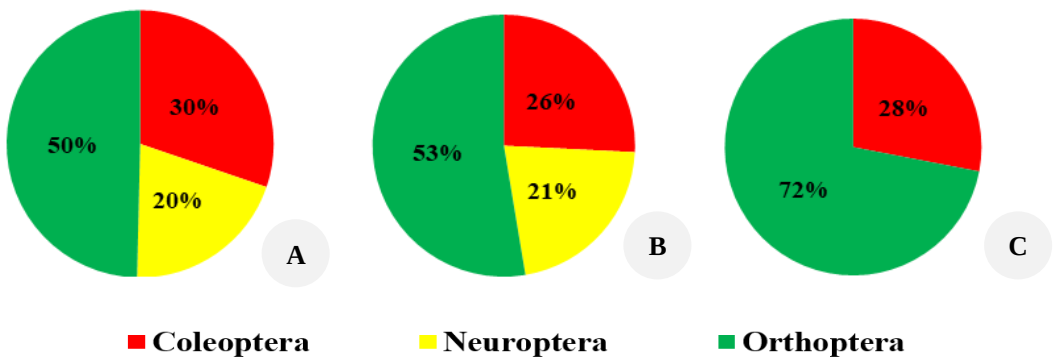


**Figure 3.** Abundance of insects on weeds around coconut trees at different ages of coconut: A. 8 years old; B. 5 years old; C. 2 years old

The insects found in coconut trees and around the weeds revealed the presence of 18 insect species that are closely linked to coconut palms and the vegetation in their vicinity. The 18 insect species serve as phytophagous, pollinators, and predators. The most abundant insects collected in coconut trees were categorized into Hemiptera and Hymenoptera (Figure 4). As shown in Figure 2, the most abundant insects found belonged to the order Homoptera, specifically *Aspidiotus* sp. (Figure 4.A), *N. nipae* (Figure 4.B), and *Aleurocanthus* sp. (Figure 4.C). Additionally, the most abundant insects observed belonged to the Hymenoptera order, specifically *Polyrhachis* sp. (Figure 4.D) and *Oecophylla smaragdina* Fabricus 1775 (Figure 4.E).

The less numerous insects collected in this study were classified as Lepidoptera, Orthoptera, Coleoptera, Hymenoptera, and Isoptera (Figure 5). The Lepidoptera species identified in this study were bagworms, specifically *Pteroma pendula* de Joannis 1929, *Metura* sp., and *Metisa plana* Walker 1883. The Orthoptera species identified in this study were *Dianemobius* sp., *Conocephalus* sp., and *Tettigidea* sp.. The Coleoptera species identified in this study include *Eumorphus westwoodi* Guérin 1858, *Aulacophora lewisii* Baly 1866, and *O. rhinoceros*. The Hymenoptera species identified in this study were *Cotesia congregata* Say 1836, *A. cerana*, and *Provespa* sp. The Isoptera discovered in this investigation were of the species *Mactrotermes* sp.

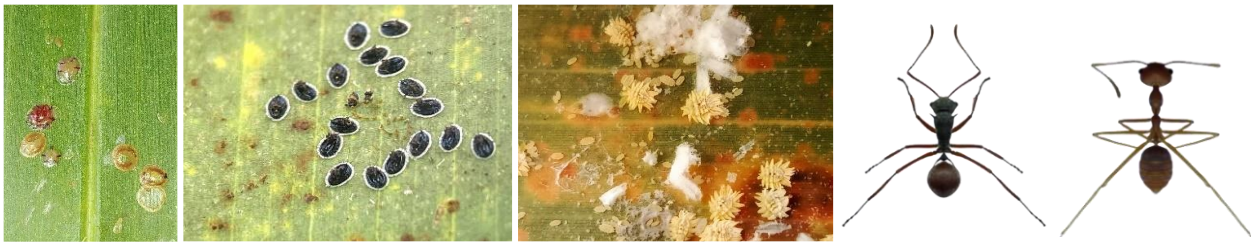


**Figure 4.** Coconut plants and surrounding plants host the dominant insects. A. *Aspidiotus* sp., B. *Nipaecoccus nipae*; C. *Aleurocanthus* sp.; D. *Polyrhachis* sp.; and E. *Oecophylla smaragdina*

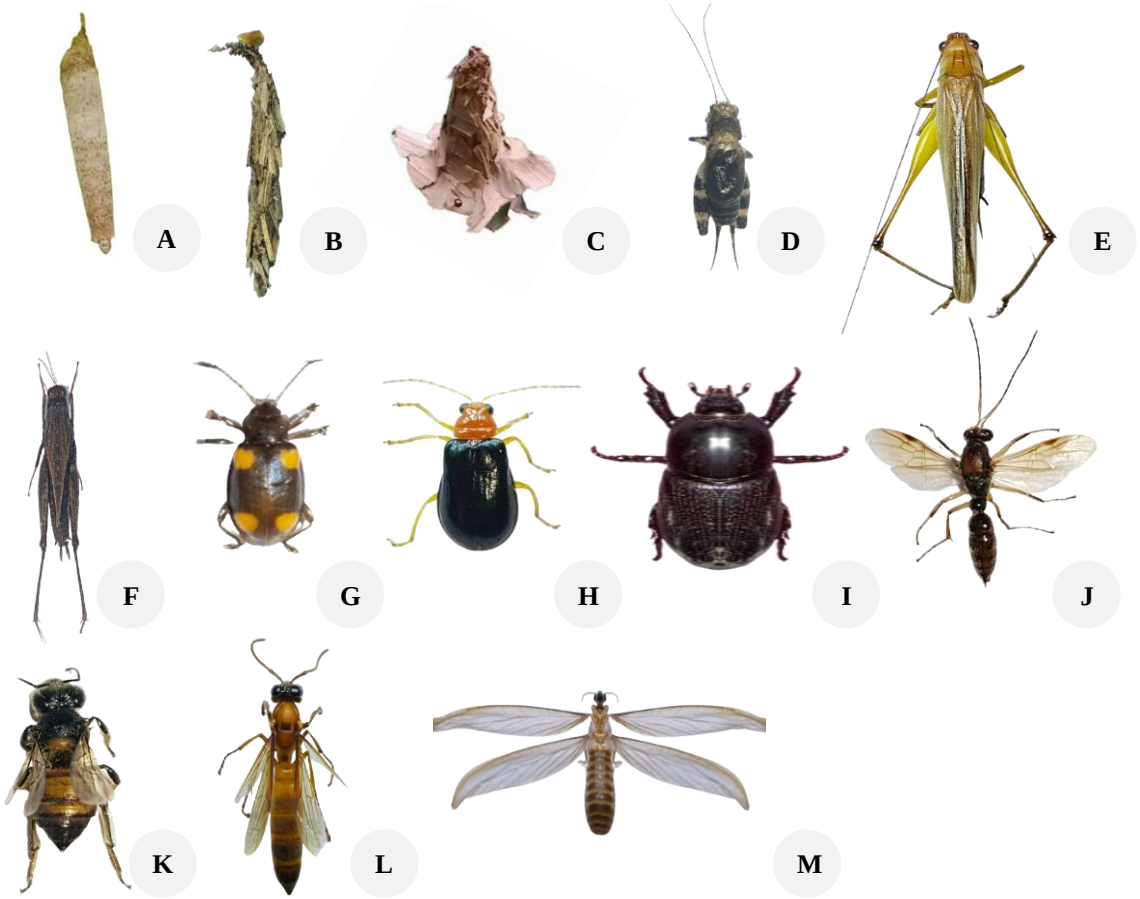


**Figure 5.** The non-dominant insects are found on coconut plants and surrounding plants. A. *Pteroma pendula*; B. *Metura* sp., C. *Metisa plana*.; D. *Dianemobius* sp.; E. *Conocephalus* sp.; F. *Tettigidea* sp.; G. *Eumorphus westwoodi*; H. *Aulacophora lewisii*; I. *Oryctes rhinoceros*; J. *Cotesia congregata*; K. *Apis cerana*; L. *Provespa* sp.; and M. *Mactrotermes* sp.

**Discussion**

The results of observations in the field showed that the number of insects caught using traps in coconut plantations was identified as 6 orders, 18 species with a total of 2,330 individuals. However, this research observation was divided into two parts: on coconut plants and on weeds around coconuts, which have various ages. Observations on coconuts of various ages showed findings of 4 orders and 12 species of insects. The highest number of species found in 8-year-old coconut fields was *N. nipae,* which comes from the order Hemiptera, namely 256 individuals. This finding was supported by Ganganalli et al. (2023), that the species of aphids are most often found on coconuts. Meanwhile, in the weed plants around coconut, there are 3 orders and 6 species. The 6 insect species belong to the orders Coleoptera, Isoptera, and Orthoptera. *Mactrotermes* sp. dominated coconuts aged 8 years. Meanwhile, in coconuts aged 2 years old, the most common insect was *Conocephalus* sp., which comes from the order Orthoptera. The seven orders found, including the orders Hemiptera, Hymenoptera, Lepidoptera, Coleoptera, Isoptera, and Orthoptera, have various roles in the ecosystem. These coconut plant species were found that have roles as pests, predators, parasitoids, and also pollinators (Kavitha et al. 2023). Direct observation was carried out by recording the condition or behavior of the object being observed (Vislobokov 2017). There were species *Aspidiotus* sp., *N. nipae, Aleurocanthus* sp., *P. pendula, Metura* sp., and *M. plana* were recorded using the direct observation method. On the other hand, the traps were used to collect the fly or active insects, such as insect nets, light traps, and pheromone traps (Haneda et al. 2017). According to Iswara et al. (2022), traps are designed based on insect behavior and attraction to certain lights, shapes, or colors. The species obtained using the insect nets and the light trap were *E. westwoodi*. *A. lewisii*, *A. cerana, Provespa* sp., *Conocephalus* sp., and *Tettigidea* sp.. Meanwhile, *O. rhinoceros* was captured using a pheromone trap. According to Maruthadurai and Ramesh (2020), synthetic pheromone traps are designed to attract male insects. These traps proved effective in monitoring and controlling adult *O. rhinoceros* (Paudel et al. 2023).

The present study revealed that *Aspidiotus* sp. exhibited the largest population densities across all three age groups of coconut trees: 8-year-old, 5-year-old, and 2-year-old. *Aspidiotus* sp. (Hemiptera: Diaspididae) is a scale insect (Serrana et al. 2023). The genus of *Aspidiotus*, namely *Aspidiotus rigidus* Reyne, 1947 (Hemiptera: Diaspididae), has also been confirmed, causing significant economic losses to the coconut industry in the Philippines (Serrana et al. 2019). Moreover, Coconut shoot borer beetle (*O. rhinoceros*) were found at all ages of coconut. The *O. rhinoceros* is one of the main pests that damage germplasm in coconut (Paudel et al. 2022). In Indonesia, *O. rhinoceros* is also a threat to both coconut and oil palm plants (Rahayuwati et al. 2020). These beetles are known to attack palm trees by boring into the crown and eating developing fronds (leaves that have not yet opened), which can cause death or stunted growth in young palm trees if the infestation is severe (Rao et al. 2018; Paudel et al. 2021; 2023). For mature oil palm trees, this damage can result in reduced productivity. This was also confirmed by Parnidi et al. (2022), that the average damage caused by this pest investment ranges from 0 to 16.7%. This study showed that there were different insects at each age of coconut. The plant age can influence the number of species and the number of individuals (Myers and Sarfraz 2017; Santi et al. 2023). As plants grow and mature, they provide different habitats and resources that can support a variety of insect species (Schowalter 2016). Older plants tend to have more developed and complex ecosystems with greater insect species diversity (Schowalter 2017). Additionally, mature plants are often larger and have more resources; hence, they can support more individuals in their ecosystem (Lindenmayer and Laurance 2016). However, the specific impact of plant age on insect species and the number of insect individuals may vary depending on plant species, environmental conditions, and other factors (Myers and Sarfraz 2017).

This study also identified another abundant insect species, namely *N. nipae*. The *N. nipae* is a mealybug that serves as an insect pest in coconut plantations (Hassan et al. 2023). Additionally, the mealybug's secretion of honeydew has the potential to attract ants and other insects, which may result in the establishment of sooty mold (Souza et al. 2008). This mold can induce further damage to plants. The genus *Aleurocanthus* (Hemiptera: Aleyrodidae) is also a dominant insect found in coconut in this research. *Aleurocanthus* sp. is an important pest that inflicts substantial economic damage on numerous crops (Kapantaidaki et al. 2019). They subsist on plant sap and can induce yellowing, wilting, and general plant stress (Mohan et al. 2022). *Aleurocanthus* can also act as vectors for plant pathogens (da Silva Santos et al. 2023). They produce honeydew, which can attract other pests and cause sooty mold (Melone et al. 2024). The *Aleurocanthus* genus found in this study, potentially associated with the arecanut whitefly, was first identified in coconut trees in 2003 in arecanut palms located in Karnataka and Andhra Pradesh (David and Manjunatha 2003). The insect was later identified as the Arecanut whitefly, scientifically known as *Aleurocanthus arecae* David & Manjunatha, 2003 (David and Manjunatha 2003). In this current study, colonies of *Aleurocanthus* found in coconut were found on the underside of arecanut leaves and are similar in appearance to *A. arecae*.

Two dominant ants found in this study were *Polyrhachis* sp. and *O. smaragdina*. The genus *Polyrhachis* often protects plants from insect pests, acting as biological control agents (Ofer 1970). In some cases, these ants have mutualistic relationships with plants, protecting them from pests in exchange for shelter or food resources like nectar (Andersen et al. 2013). The *O. smaragdina* (weaver ant) is also found in this research. The ant is a highly effective biological control agent (Exélis et al. 2023). The *O. smaragdina* ants have shown foraging and predation behaviors in oil palm plantations in Southeast Asia. The initial study specifically examined the use of weaver ants as a potential biological control agent to manage the population of dominant bagworm defoliators (*P. pendula*)

(Exélis et al. 2023). In this current research, *O. smaragdina.* being present on coconut trees indicates that these ants feed on insect pests, such as bagworms, that are prevalent on the coconut trees. This, in turn, offers a natural method of controlling pests. This study found bagworms, namely *P. pendula*, *Metura* sp., and *M. plana*. The two species of bagworms, *P. pendula* and *M. plana*, are insect pest defoliators in oil palms (Egonyu et al. 2022). *Metura* sp. was identified in coconut fronds during this investigation. This species is extremely polyphagous, and the larvae have been observed feeding on a diverse array of plants, including both angiosperms and gymnosperms (Beaver 2020). The *P. pendula* was also found infested sago palm in the Philippines (Okazaki et al. 2012). The bagworm is a highly destructive insect pest that feeds on leaves and is classified as a voracious eater. It is particularly challenging to control these pests due to their habit of hiding inside their bags (Manurung and Anwar 2023). In this study, in the coconut, the bagworms were found to be a minor insect pest.

The diversity index of insects found on coconut trees and the diversity index of insects found in weeds around the coconut trees in Sri Tiga Village showed a diversity value of 1<H'<3, which means the diversity of the insects found was in the medium category. This criterion showed the diversity of pests and natural enemies, which increased in number as the population increased towards balance. According to Hasibuan et al. (2019), there are 3 criteria for insect species diversity, namely species diversity if H<1 (unstable environmental conditions), species diversity if H 1-3 (medium environmental conditions), and species diversity if H>3 (stable environmental conditions). The results of the dominance index calculation obtained on coconut plants and surrounding weeds from week 1 to week 3 showed a dominance value of 0<D<0.5; this means that these insects' dominance was relatively low. The Evenness Index (E) value is 0.29-0.31 in the depressed category. According to Hasibuan et al. (2019), there are 3 criteria for the community environment based on its evenness value, namely, if E<0.50, then the community is in a depressed condition. If E 0.50<0.75, then society is in a stable condition, while E 0.75<1.00 means society is in an unstable condition. The evenness index value (E') can describe the stability of a community. The smaller the value of E' or closer to zero, the more uneven the distribution of organisms in a community that is dominated by a certain species, and conversely, the greater the value of E' or close to one, the organisms in that community will be evenly distributed (Dewi et al. 2023). Apart from being influenced by plant age, insect diversity can be influenced by climate and weather factors (Subedi et al. 2023). From July to September 2023, Sri Tiga Village faced the dry season. The dry season is characterized by decreased rainfall and increased temperatures, disrupting the life cycle of insects. According to Paliama et al. (2022), increasing global temperatures can affect the life cycle of insects. In addition, dry seasons can cause drought and reduce water availability for insects (Benoit et al. 2023). However, further research is necessary to understand the diversity of insects in coconuts. In Indonesia, the two main seasons are the rainy season and the dry season. Each season can significantly impact the diversity and abundance of insects in the area.

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## REFERENCES

Andersen AN, Kohout RJ, Trainor CR. 2013. Biogeography of timor and surrounding Wallacean Islands: Endemism in ants of the genus *Polyrhachis* Fr. Smith. Diversity 5 (1): 139-148. DOI: 10.3390/d5010139.

Arumugam T. 2022. Improving coconut using modern breeding technologies. Plants 11: 1-22. DOI: 10.3390/plants11243414.

Aulia AN, Chasanah N, Prasetyo AS, Nalawati AN. 2020. Competitiveness and export similarity of Indonesia''s coconut oil. J Agribest 04: 123-132. DOI: 10.32528/agribest.v4i2.3546.

Badan Pusat Statistik. 2023. Luas Areal dan Produksi Perkebunan Kelapa Rakyat Menurut Kecamatan. https://banyuasinkab.bps.go.id/indicator/54/151/1/luas-areal-dan-produksi-perkebunan-kelapa-rakyat-menurut-kecamatan.html. [Indonesian]

Beaver EP. 2020. Revision of the genus *Metura* (Lepidoptera: Psychidae) with description of two new species. Zootaxa 4861 (2): 188-210. DOI: 10.11646/zootaxa.4861.2.2.

Benoit JB, Mccluney KE, Degennaro MJ. 2023. Dehydration dynamics in terrestrial arthropods: from water sensing to trophic interactions. Annu Rev Entomol 68: 129-149. DOI: 10.1146/annurev-ento-120120-091609.

Borror DJ, Delong DM. 1971. An Introduction To The Study Of Insect 3rd Ed. Holt. Rinehard and Winston, New York.

Chandra R., Abdul M, Sharma N, Bharathi K, Singh S. 2023. The role of insects in ecosystems, an in-depth review of entomological. Intl J Environ Clim Chang 13: 4340-4348. DOI: 10.9734/IJECC/2023/v13i103110.

Chowdhury S, Dubey VK, Choudhury S, Kumar N, Semwal A, Kumar V. 2023. Insects as bioindicator : A hidden gem for environmental monitoring. Front Environ Sci 11: 1-16. DOI: 10.3389/fenvs.2023.1146052.

da Silva Santos AC, Pedroso SKB, Alves AL, Diniz AG, de Oliveira NT, Tiago PV. 2023. *Fusarium* species associated with citrus blackfly (*Aleurocanthus woglumi*) from an agroecological polyculture in Brazil, including an augmented description of *F. volatile*. Mycologia 116 (1): 92-105. DOI: 10.1080/00275514.2023.2283944.

David BV, Manjunatha M. 2003. A new species of *Aleurocanthus* Quaintance & Baker (Homoptera: Aleyrodidae) from *Areca catechu* in India, with comments on the status of *Aleurodes nubilans* Buckton. Zootaxa 173 (1): 1-4. DOI: 10.11646/zootaxa.173.1.1.

de Micheaux PL, Drouilhet R, Liquet B. 2013. The R Software: Fundamentals of Programming and Statistical Analysis. Springer, New York. DOI: 10.1007/978-1-4614-9020-3.

Dewi MAK, Aurina DM, Faturrahman AD, Fatikha LA, Rachmalia F, Ainaya FA, Kinanthi A, Rohman CM, Fadzilah FPA, Pramudita DA, Ramadhan MF, Mahajoeno E, Nugroho GD, Sujarta P, Dadiono MS, Yap CK, Rahim KABA, Setyawan AD. 2023. Ecological index and economic potential of mollusks (Gastropods and Bivalves) in Ayah Mangrove Forest, Kebumen District, Indonesia. Biodiversitas 24 (2): 1231-1241. DOI: 10.13057/biodiv/d240265.

Egonyu JP, Baguma J, Martínez LC, Priwiratama H, Subramanian S, Tanga CM, Anankware JP, Roos N, Niassy S. 2022. Global advances

on insect pest management research in oil palm. Sustainability 14 (23): 16288. DOI: 10.3390/su142316288.
Exélis MP, Ramli R, Ibrahim RW, Idris AH. 2023. Foraging behaviour and population dynamics of asian weaver ants: assessing its potential as biological control agent of the invasive bagworms *Metisa plana* (Lepidoptera: Psychidae) in oil palm plantations. Sustainability 15 (1): 780. DOI : 10.3390/su15010780.
Ganganalli SM, Bhaskar H, Joshi, S, Vidya CV. 2023. Diversity of aphid fauna (Hemiptera: Aphididae) of Kerala. Indian J Entomol 86 (2): 478-485. DOI: 10.55446/ije.2023.742.
Haneda NF, Wibowo C, Hasbi M. 2017. Peranan arthropoda di ekosistem ekoton dan kelapa sawit. Jurnal Silvikultur Tropika 8: 116-122. DOI: 10.29244/j-siltrop.8.2.116-122. [Indonesian]
Hasibuan EW, Siregar AZ, Pinem MI. 2019. Diversity of insect in coconut plant in Kelurahan Besar, Medan Labuhan District, North of Sumatra. Intl J Trend Res Develop 6: 7-13.
Hassan R, Attia SSS, Elhefny A. 2023. Insecticidal Effects and chemical composition of lemongrass and peppermint essential oils against the Coconut Mealybug, *Nipaecoccus nipae* (Maskell), (Hemiptera: Pseudococcidae). Egypt J Biol Sci F Toxicol Pest Cont 15 (1): 47-61. DOI: 10.21608/eajbsf.2023.287294.
Heinrichs EA. 1994. Biology and Management of Rice Insect. International Rice Research Institute. Philippines.
Henrietta HM, Kalaiyarasi K, Raj AS. 2022. (*Cocos nucifera*) products : A review of global cultivation and its benefits. J Sustain Environ Manag 1 (2): 257-264. DOI: 10.3126/josem.v1i2.45377.
Hill DS. 1994. Agricultural Entomology. Timber Press, Portland Oregon.
Hill DS. 1997. The Economic Importance of insect. Chapman & Hall, London. DOI: 10.1007/978-94-011-5348-5.
Hoe TK. 2019. The current scenario and development of the coconut industry. Planter Kuala Lumpur 94 (1108): 413-426. DOI: 10.56333/tp.2018.010.
Howard FW, Moore D, Giblin-Davis RM, Abad RG. 2001. Insect on Palms. CABI Publishing, London. DOI: 10.1079/9780851993263.0000.
Iswara D, Afifah L, Abadi S, Prabowo D, Irfan B, Widiawan AB. 2022. Kelimpahan serangga pada berbagai perangkap dengan beberapa teknik pengendalian berbeda pada pertanaman jagung pioneer 36. Jurnal Agroplasma 9: 213-224. DOI: 10.36987/agroplasma.v9i2.3173. [Indonesian]
Kalshoven LG. 1981. The Pest of Crops in Indonesia. Van Hoeve, Jakarta.
Kapantaidaki DE, Antonatos S, Kontodimas D, Milonas P, Papachristos DP. 2019. Presence of the invasive whitefly *Aleurocanthus spiniferus* (Hemiptera: Aleyrodidae) in Greece. EPPO Bull 49 (1): 127-131. DOI: 10.1111/epp.12533.
Karenina T, Herlinda S, Irsan C, Pujiastuti Y. 2019. Abundance and species diversity of predatory arthropods inhabiting rice of refuge habitats and synthetic insecticide application in freshwater swamps in South Sumatra, Indonesia. Biodiversitas 20 (8): 2375-2387. DOI: 10.13057/biodiv/d200836.
Kavitha K, Preetha G, Selvarani A, Hassan NS, Swarnapriya R. 2023. Occurrence and distribution of major pests and diseases of coconut during roving survey in Kanyakumari district of Tamil Nadu. J Krishi Vigyan 11 (Suppl): 156-160. DOI: 10.5958/2349-4433.2023.00104.6.
Keylock C. 2005. Simpson diversity and the Shannon-Wiener index as special cases of a generalized entropy. Oikos 109 (1): 203-207. DOI: 10.1111/j.0030-1299.2005.13735.x.
Lindenmayer DB, Laurance WF. 2016. The ecology, distribution, conservation and management of large old trees. Biol Rev 93: 1434-1458. DOI: 10.1111/brv.12290.
Manosathiyadevan M, Bhuvaneshwari V, Latha R. 2017. Impact of insects and pests in loss of crop production: a review. In: Dhanarajan (eds). Sustainable Agriculture Towards Food Security. Springer, Singapore 57-67. DOI: 10.1007/978-981-10-6647-4_4.
Manurung CF, Anwar R. 2023. Population dynamics of the bagworm, *Clania tertia* Templeton (Lepidoptera: Psychidae) on immature oil palm at Pelalawan Regency, Riau. IOP Conf Ser: Earth Environ Sci 1208 (1): 012019. DOI 10.1088/1755-1315/1208/1/012019.
Maruthadurai R, Ramesh, R. 2020. Mass trapping of red palm weevil and rhinoceros beetle in coconut with aggregation pheromone. Indian J Entomol 82: 439-441. DOI: 10.5958/0974-8172.2020.00114.5.
Mcalpine JF, Peterson BV, Shewel GE, Teskey HJ, Vockeroth JR, Wood DM. 1987. Manual of neartic Diptera. Agriculture Canada. Research Branch, Canada.
Melone G, Ascolese R, Nugnes F, Porcelli F, Rapisarda C, Farina A, Picciotti U, Garganese F, Laudonia S. 2024. An *Eretmocerus* species, parasitoid of *Aleurocanthus spiniferus*, Was Found in Europe: The Secret Savior of Threatened Plants. Sustainability 16 (7): 2970. DOI: 10.3390/su16072970.
Mohan C, Josephrajkumar A, Prathibha PS, Sujithra M, Sajan JV, Anes KM. 2022. Pests and their management in coconut. In: Mani M (eds). Trends in Horticultural Entomology. Springer, Singapore. DOI: 10.1007/978-981-19-0343-4_60.
Moreira MM, Reitas LF. 2020. Review of the pollination system by small diverse insects. Neotrop Entomol 49 (4): 472-481. DOI: 10.1007/s13744-020-00779-6.
Myers JH, Sarfraz RM. 2017. Impacts of insect herbivores on plant populations. Ann Rev Entomol 62 (1): 207-230. DOI: 10.1146/annurev-ento-010715-023826.
Ofer J. 1970. *Polyrhachis simplex* the weaver ant of israel Insectes Sociaux 17: 49-8117: 49-81. DOI: doi.org/10.1007/BF02223772.
Okazaki M, Kimura SD, Suzette LB, Igura M, Quevedo MA, Ando T, Yonebayashi K. 2012. Bagworm (*Pteroma pendula*) infestation of sago palm (Metroxylon sagu Rottb.) in Leyte, Philippines. Sago Palm 20 (2): 69-75. DOI: 10.57418/sagopalm.20.2_69.
Paliama HG, Latumahina FS, Wattimena CMA. 2022. Keanekaragaman serangga dalam kawasan hutan mangrove di Desa Ihamahu. Jurnal Tengkawang 12: 94-104. DOI: 10.26418/jt.v12i1.53861. [Indonesian]
Parnidi P, Sunarto DA, Marjani M. 2022. Shoot borers beetle pest of coconut (*Oryctes rhinoceros* L.) investment at *Agave* spp. Bioeduscience 6: 89-95. DOI: 10.22236/j.bes/616282.
Paudel S, Jackson TA, Mansfield S, Ero M, Moore A, Marshall SDG. 2023. Use of pheromones for monitoring and control strategies of coconut rhinoceros beetle (*Oryctes rhinoceros*): A review. Crop Protect 174: 106400. DOI: 10.1016/j.cropro.2023.106400.
Paudel S, Mansfield S, Villamizar LF, Jackson TA, Marshall SDG. 2021. Can biological control overcome the threat from newly invasive coconut rhinoceros beetle populations (Coleoptera: Scarabaeidae)? A review. Annals Entomol Soc Am 114: 247-256. DOI: 10.1093/aesa/saaa057.
Paudel S, Marshall SDG, Richards NK, Hazelman G, Tanielu P, Jackson TA. 2022. Coconut rhinoceros beetle in Samoa: Review of a century-old invasion and prospects for control in a changing future. Insects 13 (5): 487. DOI: 10.3390/insects13050487.
Purnomo H, Okarda B, Dermawan A, Pebrial Q, Pacheco P, Nurfatriani F, Suhendang E. 2020. Forest policy and economics reconciling oil palm economic development and environmental conservation in Indonesia: A value chain dynamic approach. For pol Econ 111: 1-12. DOI: 10.1016/j.forpol.2020.102089.
Rahayuwati S, Kusumah YM, Prawirosukarto S, Dadang, Santoso T. 2020. The status of *Oryctes rhinoceros nudivirus* (OrNV) infection in *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) in Indonesia. J Oil Palm Res 32: 582-589.
Rao NBVC, Snehalatharani A, Nischala A, Ramanandam G, Maheswarappa HP. 2018. Management of rhinoceros beetle (*Oryctes rhinoceros* L.) by biological suppression with Oryctes baculovirus in Andhra Pradesh. J Plant Crops 46: 124-127. DOI: 10.25081/jpc.2018.v46.i2.3725.
Santi I, Tarmadja S, Priambada KJ, Elfatma O. 2023. Keanekaragaman serangga perkebunan kelapa sawit di Provinsi Kalimantan Tengah. Jurnal Ilmiah Hijau Cendekia 8: 45. DOI: 10.32503/hijau.v8i1.2917. [Indonesian]
Schowalter TD. 2016. Insect Ecology: An Ecosystem Approach. Academic Press, Cambridge.
Schowalter TD. 2017. Arthropod diversity and functional importance in old-growth forests of North America. Forests 8 (4): 97. DOI: 10.3390/f8040097.
Serrana JM, Almarinez BJM, Barrion AT, Amalin DM. 2023. Ultrastructural characterization of the scale cover of cryptic *Aspidiotus* spp. (Hemiptera: Diaspididae) and the ovipositor of their parasitoids. Microsc Microanal 29: 825-831. DOI: 10.1093/micmic/ozac041.
Serrana JM, Ishitani N, Carvajal TM, Almarinez BJM, Barrion AT, Amalin DM, Watanabe K. 2019. Unraveling the genetic structure of the coconut scale insect pest (*Aspidiotus rigidus* Reyne) outbreak populations in the Philippines. Insects 10 (11): 374. DOI: 10.3390/insects10110374.
Souza E, Follett PA, Price DK, Stacy EA. 2008. Field suppression of the invasive ant *Wasmannia auropunctata* (Hymenoptera: Formicidae) in a tropical fruit orchard in Hawaii. J Econ Entomol 101 (4): 1068-1074. DOI: 10.1093/jee/101.4.1068.

Stam JM, Kroes A, Li Y, Gols R, Loon JJAV, Poelman EH, Dicke M. 2014. Plant interactions with multiple insect herbivores: From community to genes. Ann Rev Plant Biol 65: 689-713. DOI: 10.1146/annurev-arplant-050213-035937.

Subedi B, Poudel A, Aryal S. 2023. The impact of climate change on insect pest biology and ecology: Implications for pest management strategies, crop production , and food security. J Agirc Food Res 14: 100733. DOI: 10.1016/j.jafr.2023.100733.

Thomas GV, Krishnakumar V, Dhanapal R, Srinivasa Reddy DV. 2018. Preharvest Approaches to Control Insect Infestation in fruit. Elsevier, Amsterdam. DOI: 10.1007/978-981-13-2754-4_7.

Tiemann TT, Donough CR, Lim YL, Härdter R, Norton R, Tao HH, Jaramillo R, Satyanarayana T, Zingore S, Oberthür T. 2018. Chapter four-feeding the palm: A review of oil palm nutrition. Adv Agron 152: 149-243. DOI: 10.1016/bs.agron.2018.07.001.

Tougeron K, Brodeur J, Le Lann C, van Baaren J. 2020. How climate change affects the seasonal ecology of insect parasitoids. Ecol Entomol 45: 167-181. DOI: 10.1111/een.12792.

Vislobokov NA. 2017. Flowering biology of Aspidistra (a Sparagaceae): New data on pollination by dipteran insects. Plant Species Biol 32: 412-422. DOI: 10.1111/1442-1984.12175.

Ximenes R, Nurmalina R, Rifin A. 2021. Demand analysis of Indonesia''s coconut crude oil in Germany. Rev Econ Finance 19: 281-285. DOI: 10.55365/1923.x2021.19.39.

Zainol FA, Arumugam N, Norhayate W, Daud W, Aisyah N, Suhaimi M. 2023. Coconut value chain analysis: A systematic review. Agriculture 13 (7): 1379. DOI: 10.3390/agriculture13071379.